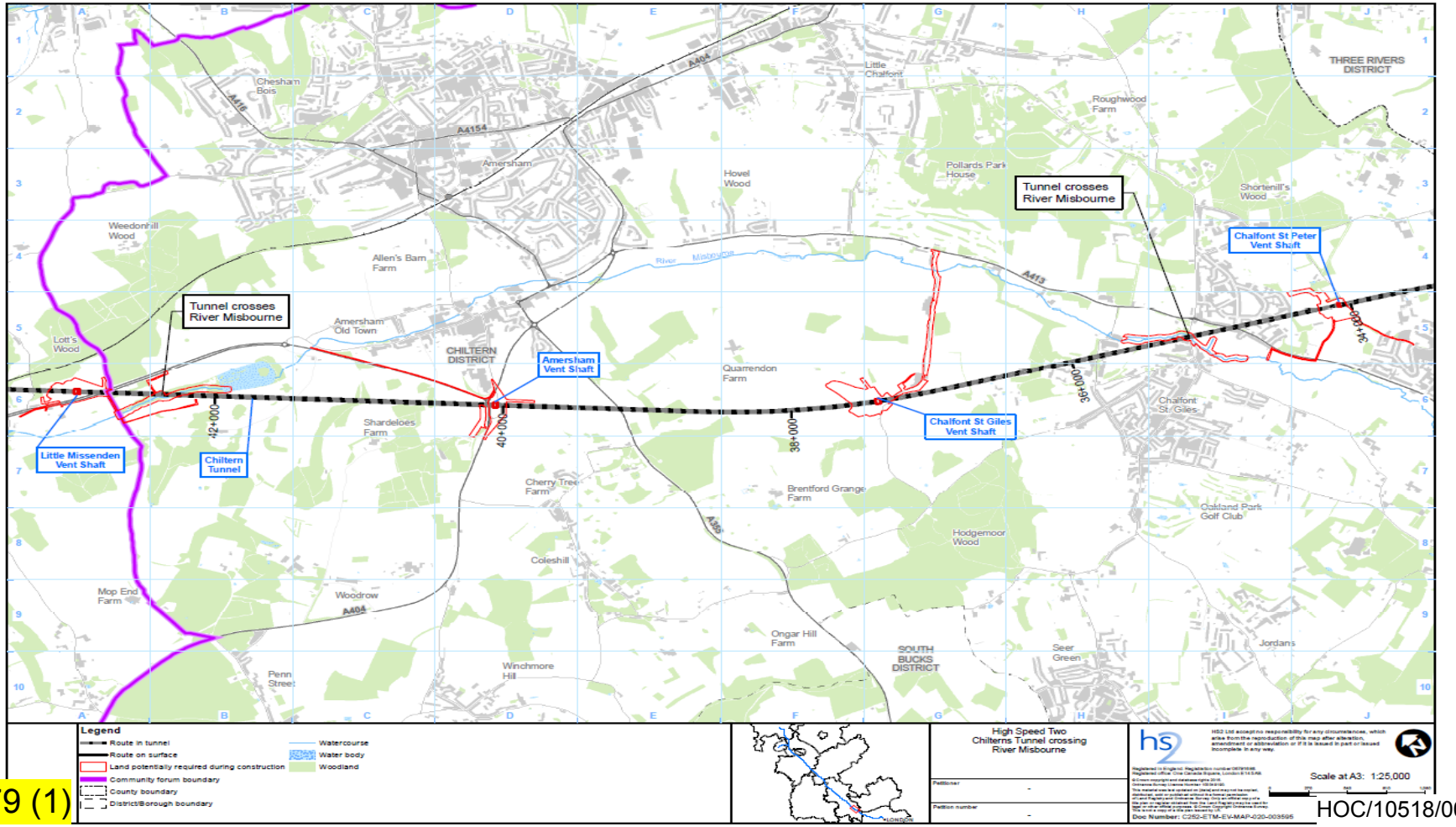
EXHIBIT LIST

Chilterns Tunnel - mitigation options for the River Misbourne

The Proposed Scheme will be predominantly in tunnel throughout the Chalfonts and Amersham area, with three above-ground vent shaft locations. The tunnels will cross under the River Misbourne in two locations, at chainages Ch. 35+600 and Ch. 42+000 (Shardeloes lake).



P7579 (1)

HOC/10518/0002

Chilterns Tunnel - mitigation options for the River Misbourne

Summary:

- All the Chilterns tunnel proposals cross under the River Misbourne in two locations.
- There will be at least two tunnel diameters depth between the river bed and the top of the tunnel.
- There is a low risk that tunnelling will induce settlement producing enhanced permeability and loss of water from the river and lake.
- Mitigation measures include monitoring of ground settlement, lake levels and river flows where the route passes beneath the River Misbourne and Shardeloes Lake and for a suitable distance up and downstream, in order to underpin prompt decision making should further mitigation be necessary.
- The potential for the tunnel to obstruct groundwater flow and exacerbate flooding has been identified, however the tunnel is very small in comparison to the overall thickness and extent of the aquifer so the impact on river flows is considered to be negligible.

High Speed Two Ltd
25th Floor, One Canada Square
Canary Wharf
London
E14 5AB
E-mail: _____

Our Ref: HNL-150430 HS2

Your Ref:

Date: 19 May 2015

Dear Simon

Re: River Misbourne crossing

Thank you for your e-mail of 4 April 2015.

As described in the Environmental Statement (ES) submitted in support of the Hybrid Bill for Phase One, the route is proposed to cross beneath the River Misbourne in a tunnel at two locations – east of Chalfont St Giles, and north of Shardeloes Lake.

As set out in the ES, a number of avoidance and mitigation measures are proposed to be incorporated into the design of the route in this area, including:

- a minimum cover of two tunnel diameters depth being provided between the river bed of the River Misbourne and the top of the tunnel
- operating the tunnel boring machine in a closed face mode within water bearing parts of the aquifer, and designing the tunnel lining to keep leakage rates to a minimum
- closely monitoring river flows during construction, immediately upstream and downstream of crossing points – and working with us to agree appropriate trigger levels to prompt where further mitigation could be required

The ES identified a potential significant effect in relation to the proximity of the works to local public water supply sources. Alongside Affinity Water we will continue to provide advice (in line with our statutory role) to ensure a management strategy and mitigation measures are agreed. This will have to demonstrate that Affinity Water is able to maintain the resilience of public water supplies at all times both during construction, and in the longer term, in accordance with their Water Resources Management Plan.

Ultimately, before we could approve applications in line with the Protective Provisions within the Hybrid Bill and other UK legislation, we will need to be satisfied that all potential risks to the river and the surrounding environment have been mitigated. This will need to be supported by evidence from your ground investigation programme.

We will continue to provide advice to ensure the proposed mitigation will be acceptable, and that approvals can be issued.

Yours sincerely

Jim Kitchen
Project Manager

C252 – Country South

Wendover Green Tunnel and North Cutting Hydrogeological Impact Assessment - Technical Note

Document Number: C252-ETM-EV-NOT-020-000161

Document History:

Revision	Date	Prepared by	Checked by	Approved by	Reason for Issue
P01	12/06/2015	Alison Carruthers	Sally Watson	Chris Thomas	Draft
P02	26/06/2015				
P03	02/07/2015	Alison Carruthers	Sally Watson	Chris Thomas	Final

Contents

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1 Introduction

1.1 Purpose

1.1.1 This technical note has been prepared in response to a report provided to HS2 Ltd regarding the impacts of Wendover green tunnel and Wendover north cutting on water resources receptors.

1.1.2 Wendover Town Council (WTC) commissioned Malvern Hills Hydro (MHH) to review the hydrological and hydrogeological impacts of the Proposed Scheme around Wendover. The review includes comments on perceived omissions and technical mistakes contained in the Environmental Statement (ES) and a comparison of a long tunnel option against the Proposed Scheme.

1.1.3 This technical note provides comment on these reports and provides clarification on the purpose of the ES and future investigations.

1.1.4 The review considers previous work undertaken for the Canal and River Trust in relation to the Weston Turville Site of Special Scientific Interest (SSSI) / Reservoir, sift work on long tunnels, the main ES itself and assurances given in the Environmental Minimum Requirements (EMR) and Protective Provisions.

1.2 Report content

1.2.1 This report includes the following aspects:

- Summary of the purpose of the ES for Phase One and the mechanisms that are in place to safeguard the environment, including surface water features and groundwater;
- Summary of the Malvern Hills Hydro reports;
- Review of HS2's current position, relative to the Malvern Hills Hydro reports; and
- Conclusions and summary of further work.

2 High Speed Two Phase One Environmental Assessment

2.1 Purpose and methodology

2.1.1 The design of the Proposed Scheme to date provides the level of detail necessary for the purposes of the Bill and the requirements of the Environmental Impact Assessment Regulations.

2.1.2 The purpose of the Environmental Impact Assessment is to identify likely significant effects and to allow determination of any mitigation measure requirements and facilitate informed judgements as to the impact of the Proposed Scheme in its entirety.

2.1.3 The Environmental Impact Assessment, the main ES was principally produced using published guidance, desk based information, professional judgement and the incorporation of conservative assumptions (i.e. reasonable worst case), where appropriate, to reflect uncertainty. There were two principal conservative assumptions incorporated within the assessment:

- The 75th percentile for hydraulic conductivity; and
- The maximum level of groundwater drawdown. This difference in itself is composed of two individual conservative assumptions, the maximum cutting depth and the maximum groundwater level. Further, data collected from the Environment Agency monitoring borehole indicates that the groundwater elevation could vary by 20m. This means that throughout the year (and indeed between years) the amount of dewatering will be highly variable; to the extent that at certain times of the year the groundwater level is likely to fall below the base of the cutting and green tunnel and hence dewatering would not occur. This variation is not accounted for within the calculation adopted for the ES, which simply assumes the maximum drawdown throughout the year.

2.1.4 The Canal and River Trust and Environment Agency were stakeholders and were engaged in discussions about the assessment methodology.

2.2 The hybrid Bill

Introduction

2.2.1 Once the hybrid Bill receives Royal Assent (and becomes law), some key sections of environmental statutes would no longer apply, or else would be dis-applied by the new Act of Parliament. In common with normal practice for projects of national importance, includes protective provisions giving the relevant drainage authority the ability to approve detailed plans and otherwise protect their interests.

2.2.2 Schedule 31 of the Bill contains the protective provisions, two sections of which are important to this Technical Note:

- Part 4: Canal & River Trust; and

- Part 5: Water

Canal and River Trust

2.2.3 The below is an extract from Schedule 31 Part 4 of the hybrid Bill:

> *40 (2) In this Part – "specified work" means so much of any permanent or temporary work authorised by this Act as is in, across, under or within 15 meters of, or may in any way affect, the canal.*
>
> *43 (1) Any specified work, and any protective works required by Canal & River Trust under paragraph 42(3)(b), must be constructed with all reasonable despatch to the reasonable satisfaction of Canal & River Trust, and in such manner as to cause as little damage to the canal as may be reasonably practicable and as little interference as may be reasonably practicable with passage of vessels using the canal and use of the towpath, and Canal & River Trust is to be entitled by its officer at all reasonable times, on giving such notice as may be reasonable in the circumstances, to inspect the construction of such work or works.*

Therefore, no works which could in any way affect the canal can be constructed without the reasonable satisfaction of the Canal and River Trust.

Environment Agency

2.2.4 Any works likely to impact upon groundwater or surface water requires the prior approval from the appropriate drainage authority. The appropriate drainage authority with respect to groundwater is the Environment Agency, and with regards to surface water is explained in HS2 Information Paper E27: Authorising works affecting watercourses.

2.2.5 The watercourses associated with the Wendover section of the Proposed Scheme are identified in the main ES with their details and status set out in Volume 5 Appendix WR-002-010 Table 1: of the main ES

Process

2.2.6 Any works undertaken which are likely to affect a canal, surface water feature or groundwater require approval prior to being constructed. Therefore, no works can commence until the appropriate drainage authority is satisfied that the impacts from construction are properly understood and any required mitigation and or monitoring is adequate. HS2 Ltd has begun to engage with drainage authorities, through a new sub-group to the Planning Forum to discuss the process for these approvals.

2.3 Environmental Minimum Requirements

2.3.1 The Environmental Minimum Requirements (EMRs) is a suite of documents that set out how the Nominated Undertaker will behave and how the Proposed Scheme will be delivered, these are committed via an undertaking to Parliament.

2.3.2 The purpose of the EMRs is to supplement the other controls set out in the Bill and contained in general legislation so as to ensure that the effects assessed in the Environmental Statement are not exceeded. A breach of which would result in breach

of a contractual commitment to the Secretary of State. The Secretary of State is answerable to Parliament for enforcing the obligations of the Nominated Undertaker.

2.3.3 The controls contained in the EMRs, along with powers contained in the HS2 Bill and the Undertakings given by the Secretary of State, will ensure that impacts which have been assessed in the ES will not be exceeded, unless any new impact or impacts in excess of those assessed in the ES:

- results from a change in circumstances which was not likely at the time of the ES;
- would not be likely to be environmentally significant;
- results from a change or extension to the project, where that change or extension does not itself require environmental impact assessment under either (i) article 4(1) of and paragraph 24 of Annex 1 to the EIA Directive; or (ii) article 4(2) of and paragraph 13 of Annex 2 to the EIA Directive4; or
- would be considered as part of a separate consent process (and therefore further EIA if required).

2.3.4 These are set out in the Draft General Principles and further information is contained in Information Paper E1.

2.4 Future Investigations

2.4.1 As the project matures and transits through to detailed design the level of information, assessments and investigations will be commensurate with the level of design. For example, Hs2 is already undertaking a comprehensive ground investigation programme to obtain a more detailed understanding of ground conditions along the route. The ground investigation programme includes (but is not limited to); boreholes, subsequent groundwater monitoring and hydraulic rock parameter testing, as required, along the route of the Proposed Scheme.

2.4.2 Where relevant, the results from this ground investigation will be interpreted and fed back into ongoing impact assessments, to confirm the Environmental Statement conclusions. These assessments are likely to be required by approving bodies to discharge their statutory responsibilities as outlined in Section 2. It is also likely that through its' own monitoring of the Environmental Minimum Requirements, that the Nominated Undertaker will require this assurance.

2.4.3 Baseline monitoring will be undertaken, where required, in order to identify and quantify impacts to flow in the surface water features local to the Wendover green tunnel and north cutting. This monitoring will need to focus on improving the understanding of seasonal variations in groundwater and stream levels, as well as stream flows.

3 Malvern Hills Hydro Reports

3.1 Report 1

3.1.1 Report 1 focusses on providing a critique of the assessment and methodology applied for the Wendover north cutting and Wendover green tunnel. The principal criticism in the report is the belief that the assessment methodology undertaken was inadequate as it only assessed impact on groundwater levels and not flows. There is also discussion regarding several other assumptions.

3.1.2 Report 1 provides information supporting the conclusions by reference to the Environment Agency guidance on dewatering abstractions (Science Report SC040020/SR1, 2007).

3.2 Report 2

3.2.1 Report 2 focusses on providing an assessment of the hydrogeological risks posed by the Wendover green tunnel and Wendover north cutting in comparison to the risks posed by the Chilterns Long Tunnel proposal.

3.2.2 The assessment methodology undertaken is more complex than that used in the Proposed Scheme EIA, with additional data requirements. Site specific data was collected as part of the investigation.

3.2.3 The report considers a risk categorisation based on the likelihood and consequence of risk and considers the risks to four of the spring fed receptors to be a medium risk, with one receptor (Stoke Brook) as a high risk.

3.2.4 The report includes an assessment of the quantity of flow likely to be intercepted, based on a simple river-aquifer equation:

- $Q_{RIV} = C_{RIV} (h – H_{RIV})$, where;
  - Q_{RIV} = change of flow in river (L^3/T)
  - C_{RIV} = river coefficient based on the connectivity and resistance between the stream water and groundwater (L^2/T).
  - H_{RIV} = Base of the cutting (or dewatering water elevation) (L)
  - h = Groundwater elevation (L).

3.2.5 Report 2 contains an estimate of flow intercepted during construction of both the green tunnel and cutting as 24 mega litres per day (Ml/d) (with a range of 6 – 47 Ml/d). Post construction of the green tunnel, Malvern Hills Hydro acknowledges that the risks associated with dewatering will be negligible as the tunnel will be sealed, as described in the Environmental Statement. Report 2 therefore indicates that post-construction the flows would be impacted to a lesser degree, i.e. reduction of 13 Ml/d (range 3 – 26 Ml/d).

3.2.6 Fieldwork was completed by Malvern Hills Hydro on 20th February 2015 with flows in each spring-fed stream measured to derive an estimate of total groundwater discharge in the Wendover Area of ~31 Ml/d.

3.2.7 Using these observed flows and the estimated discharge, the overall impact of reducing the 31 Ml/d spring discharge by 24 Ml/d due to dewatering at the cutting/green tunnel, would result in an approximate reduction in flows of 75%.

3.2.8 The Chilterns Long Tunnel option was also explored in the same way to understand potential risks to the spring-fed streams. The risk categorisation identified a medium risk associated with the Chilterns Long Tunnel.

3.2.9 Report 2 concludes that a Tier 1 estimation of flow impacts are:

- ~75% reduction in flow to the Wendover Arm and therefore the Tring Summit of the Grand Union Canal;
- ~75% reduction in flow to the Weston Turville SSSI;
- ~75% reduction in flows to springs feeding into the Stoke Brook;
- ~200% increase in flow to Stoke Brook, below the discharge point flowing into Aylesbury.

3.2.10 The report also states that additional work would be required to better understand the impacts to the groundwater table, including validated computer groundwater modelling to identify if the flow impacts of the Wendover green tunnel and north cutting will be delayed and smoothed by groundwater storage in the Chalk aquifer.

4 Discussion

4.1.1 The following section provides a discussion of the two Malvern Hills Hydro reports relative to the purpose of the ES and the level of assessment required by the hybrid Bill.

Report 1

4.1.2 There are four criticisms of the ES presented in Report 1, which are discussed, with regard to HS2's position:

One: There is a lack of discussion on flows

4.1.3 As already presented above, the purpose of the ES was not to numerically quantify impacts, but to qualitatively assess potential effects and define mitigation measures. The conservative assessment approach undertaken is considered sufficient for this purpose.

4.1.4 Connectivity and the seasonal variability can only be determined through baseline monitoring and the use of models following acquisition of this information.

Two: The use of the Sichardt formula is not acceptable for flow impacts

4.1.5 The Sichardt formula is widely used in the construction industry for determination of the approximate extent of influence on groundwater elevation, which is how it has been applied in the ES. The Sichardt formula is one of the most widely adopted approaches used for engineering design when determining the spatial extent of impacts, as presented in Construction Industry Research and Information Association (CIRIA) C515[1] and CIRIA R113. At this stage of assessment, as appropriate for the ES, and the level of conservatism incorporated in the approach, the Sichardt formula is considered to be acceptable.

Three: The misuse of spring catchments for the assessment of flow impacts

4.1.6 In the ES springs have been used as an indication of groundwater emergence that feeds into spring fed streams, rather than as an indicator of a catchment of flow.

Four: The misconception that only downstream water features will be impacted

4.1.7 The ES considers whether potential impacts are likely to be significant to a water receptor. For the Wendover green tunnel and north cutting, the most sensitive receptors were identified as the Weston Turville SSSI, the spring fed streams and five licensed groundwater abstractions. The ES methodology ensures that upstream receptors are included, such as the spring fed streams and licensed abstractions, which are up-gradient of the cutting, which could have permanent impacts compared to the temporary impacts from the green tunnel.

[1] Preene, M. Roberts, T. Powrie, W. Dyer, M R, 2000. Groundwater Control Design & Practice, Construction Industry Research and Information Association (CIRIA) C515, London

4.1.8 Figure 1 (Section 6) shows the proximity of the Wendover green tunnel and north cutting relative to the springs, streams and the nearest Environment Agency monitoring borehole.

Report 2

4.1.9 Report 2 focuses on providing a quantitative assessment of the potential impact to stream flows within the catchment surrounding the Wendover green tunnel and north cutting.

4.1.10 The Malvern Hills Hydro assessment incorporates the same conservative assumptions as the Proposed Scheme EIA, as outlined within Section 2.1. These assumptions alone are considered sufficiently conservative that they are likely to overestimate impacts.

4.1.11 The assessment and discussion presented in Report 2 appears to incorporate a single set of spot gauging data. The spot gauging was undertaken in February 2015 and would be expected to represent high flows; consequently it is a conservative assumption to extrapolate these single values to calculate a year round impact.

4.1.12 It is considered that the compounding of another conservative assumption within the Malvern Hills Hydro assessment has led to an overestimation of impact.

4.2 Potential mitigation

4.2.1 Due to the conservative assumptions adopted as part of the Environmental Impact Assessment, the conclusions are considered valid and robust. However, to provide confidence to this discussion, mitigation options have briefly been explored, which could be adopted, even if further investigations and assessments reveal different conditions. It is noted that this is not considered likely and has been done for illustrative purposes only.

A portion of the abstracted groundwater, for the purposes of dewatering the cutting, could be could be pumped up-gradient, through the cutting, to a discharge point close to where the where the streams emerge, as indicated in

4.2.2 Figure 2 (Section 6). This would require pumping, and so would be undesirable due to sustainability reasons, but may only be required at certain times of year.

4.2.3 However, by implementing this type of solution (i.e. discharge of abstracted water in targeted areas, where we have the powers to do so) it is considered feasible to mitigate impacts on water resources receptors if the impact predicted from the ground investigations and monitoring is greater than assessed in the ES.

5 Conclusion

5.1.1 HS2 considers that the methodology applied as part of the Environmental Impact Assessment provides an appropriate level of assessment to fulfil the objectives of the Environmental Statement and level of detail for the level of available data at this stage in the assessment process. Where uncertainties in the data existed conservative (reasonable worst case) assumptions were adopted for the ES. The Canal and River Trust and Environment Agency were stakeholders and engaged in discussions about the assessment methodology.

5.1.2 The Malvern Hills Hydro assessment incorporates those same conservative assumptions as used in the ES, with an additional conservative assumption regarding spring flows. It is considered that the compounding of another conservative assumption (single spot gauge during a period of expected high flows) within the Malvern Hills Hydro assessment has led to an overestimation of impact.

5.1.3 The Bill contains Protective Provisions for the Canal and River Trust and the Environment Agency. Prior to works affecting either, both parties will have to be satisfied that any investigation and assessment has been undertaken to the appropriate level and that any monitoring requirements are adequate. In addition, should any later assessments indicate that mitigation measures are required then these would also have to be considered adequate by the Canal and River Trust or the Environment Agency?

5.1.4 The hybrid Bill and Environmental Minimum Requirements contain measures and controls to ensure that the project does not exceed the level of impact identified within the Environmental Statement. Furthermore, information paper E1 states that :

5.1.5 *'The nominated undertaker will in any event, and apart from the controls and obligations set out in Paragraph 1,1.3 (of the draft general principles), use reasonable endeavours to adopt mitigation measures that will further reduce any adverse environmental impacts caused by the Proposed Scheme, insofar as these mitigation measures do not add unreasonable costs to the project or unreasonable delays to the construction programme;'*

5.1.6 Ground investigation and monitoring are planned to allow more detailed assessments to confirm the level of impact, as identified within the ES, on the groundwater and stream flows. Monitoring, where required, will be undertaken prior to, during and after construction.

5.1.7 HS2 believe that the conclusions from the ES are valid. To provide confidence, however, mitigation options were reviewed during the ES assessment process which could be adopted, if further investigations and assessments reveal different conditions.

6 Figures

Figure 1: Map of the Wendover area.

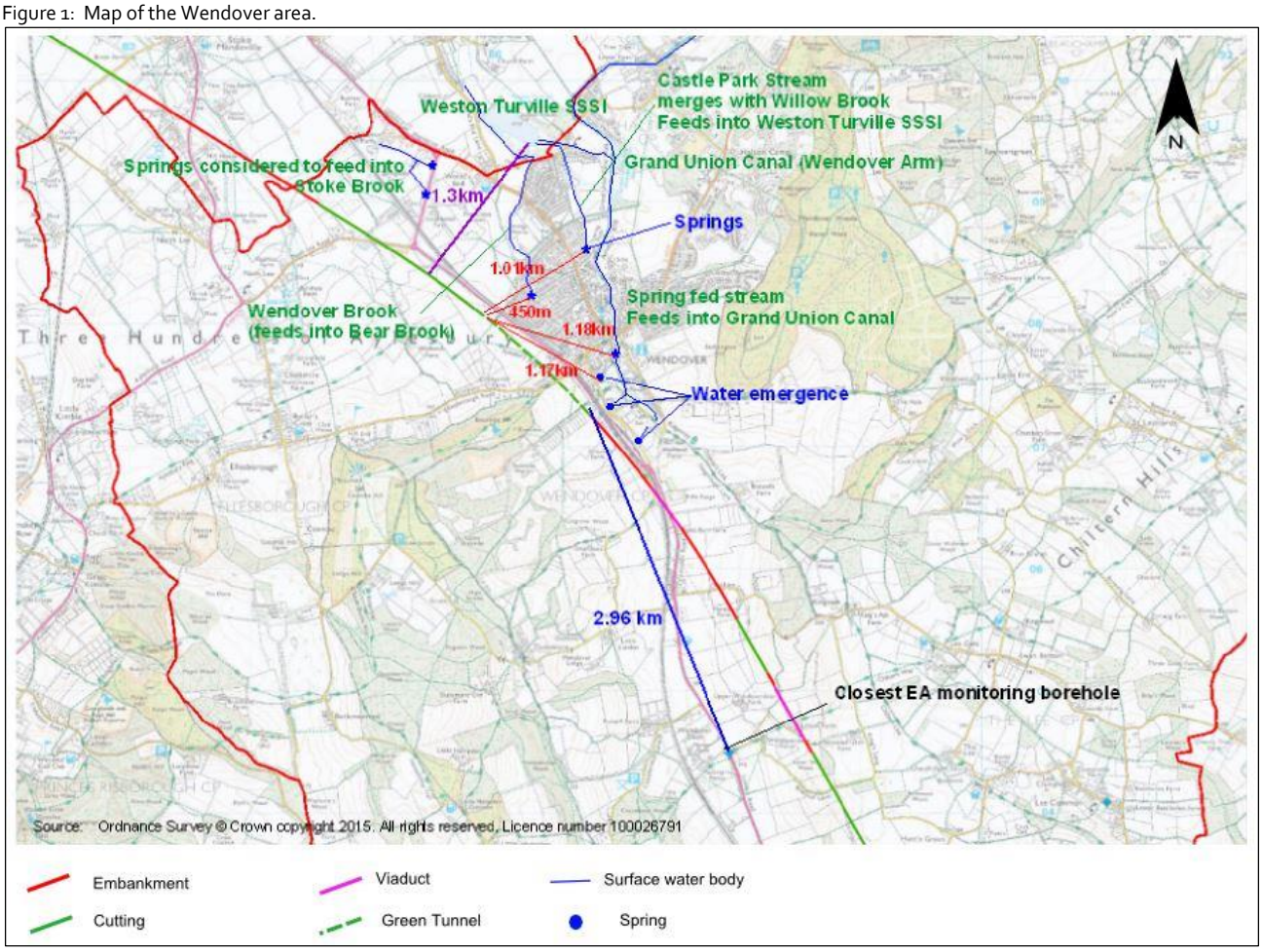
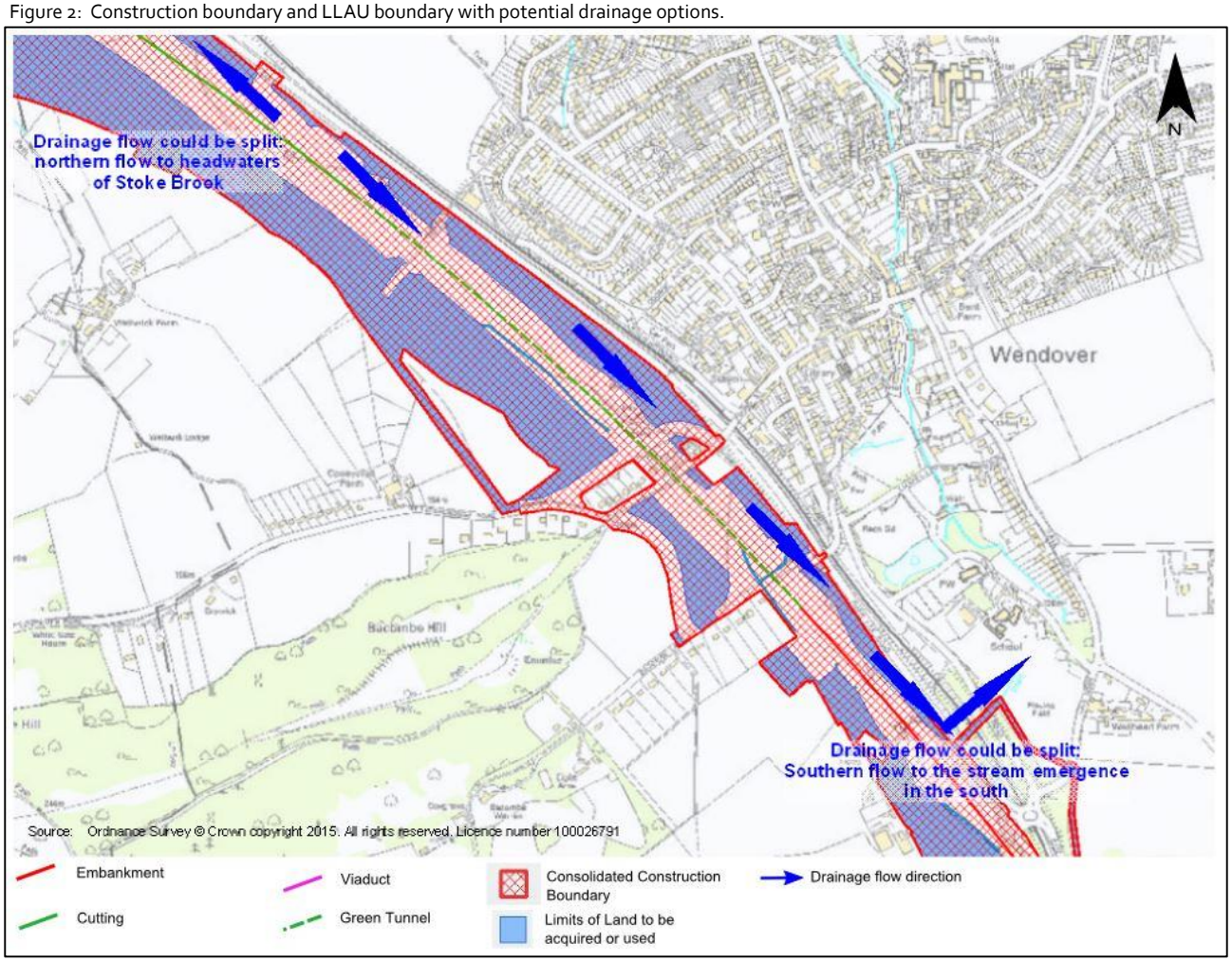


Figure 2: Construction boundary and LLAU boundary with potential drainage options.



C252 – Country South

Groundwater Flooding in Buckinghamshire

Document Number: C252-ETM-EV-NOT-020-000017

Document History:

Revision	Date	Prepared by	Checked by	Approved by	Reason for Issue
P01	03/06/2015	Megan Durrant	Sally Watson Richard Mitchener		
P02	23/06/2015	Megan Durrant	Sally Watson Richard Mitchener	Chris Thomas	Update following client comments
P03	29/06/2015	Megan Durrant	Sally Watson	Chris Thomas	Final

Contents

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1 Introduction

1.1.1 The purpose of this technical note is to describe the potential impact of the Proposed Scheme on groundwater flood risk and describe the specific engineering options which may be utilised to ensure no significant impact. Specifically this report will focus on the background to the conclusions reached within the main Environmental Statement (ES) of negligible impact from the Proposed Scheme on groundwater flooding in Buckinghamshire.

1.1.2 This document will set out case studies (using examples from the Buckinghamshire area) highlighting the different mechanisms by which the Proposed Scheme could impact on groundwater flooding, and examples of the design or mitigation measures which will be used to ensure that the Proposed Scheme will not have an adverse impact on the risk of groundwater flooding.

2 What is groundwater flooding?

2.1.1 Groundwater flooding occurs when the groundwater level reaches the ground surface and can occur when:

- The rate of water entering the aquifer (for example, due to rainfall infiltration) exceeds the rate of discharge from the aquifer (usually to a surface water feature, the sea or other aquifer), and eventually the groundwater level in the aquifer rises above ground level;
- Permeable superficial deposits (e.g. sands and gravels) are in hydraulic continuity with high water levels in a river which can lead to low-lying areas becoming flooded; and
- A below ground and below groundwater level obstruction (such as a shaft, tunnel, cutting etc.) blocks previous groundwater flow paths, causing the groundwater to flow around the obstruction; this can result in a mound on the upstream side and a depression on the down gradient side.

3 Assessment

3.1 Assessment to date

3.1.1 The assessment presented as part of the main ES utilised existing data sources, including the lead local flood authority's (LLFA), in this example the Buckinghamshire County Council (BuCC), Preliminary Flood Risk Assessment (PFRA). The data defines the historic flood risk and the potential for groundwater flooding.

3.1.2 The PFRA confirms that the most significant historical groundwater flood event in Buckinghamshire was caused by high groundwater levels across the Chalk aquifers that resulted in high river flows and widespread groundwater flooding in the valleys of the Chiltern Hills in the winter of 2000/2001. In the area affected by this groundwater flooding the Proposed Scheme will be largely in tunnel.

3.1.3 The main ES assessment reviews the impact of the Proposed Scheme on groundwater flooding; based upon the inclusion of any proposed mitigation and utilising the groundwater flooding data sets available. These assessments are contained within the Volume 5 technical appendices, Flood Risk Assessment for each Community Forum Area (CFA).

3.1.4 In addition to assessing the impact of groundwater flooding, in some locations calculations have been carried out using guidance set out in Construction Industry Research and Information Association, CIRIA C515 (2000)[1] and CIRIA C113 (1986)[2] in order to establish the extent to which the route may reduce groundwater levels (potentially reducing the risk of groundwater flooding in the surrounding area). These assessments are contained within the Volume 5 technical appendices, Water Resource Assessments for each CFA.

3.2 Additional data collection

3.2.1 The detailed design of mitigation measures has not yet been carried out but will form later stages of the project. In order to complete the detailed design, additional groundwater level monitoring data will be collected, where required, as part of the ground investigation works. This monitoring data, combined with available longer term records such as from the Environment Agency, will show the range of natural variation in groundwater levels. This data will be used, where required, to size mitigation measures, such as land drains, to ensure they are at the correct depth and have sufficient capacity to maintain suitable groundwater levels in the aquifer such that there is no significant change in groundwater flood risk.

4 Case Study scenarios

4.1 Introduction

4.1.1 This section presents case studies (using examples from the Buckinghamshire area) highlighting the different mechanisms by which the Proposed Scheme could impact on groundwater flooding. In each case, this report highlights the design features and/or proposed mitigation measures which will be used to help ensure that the route will not have an adverse impact on the risk of groundwater flooding.

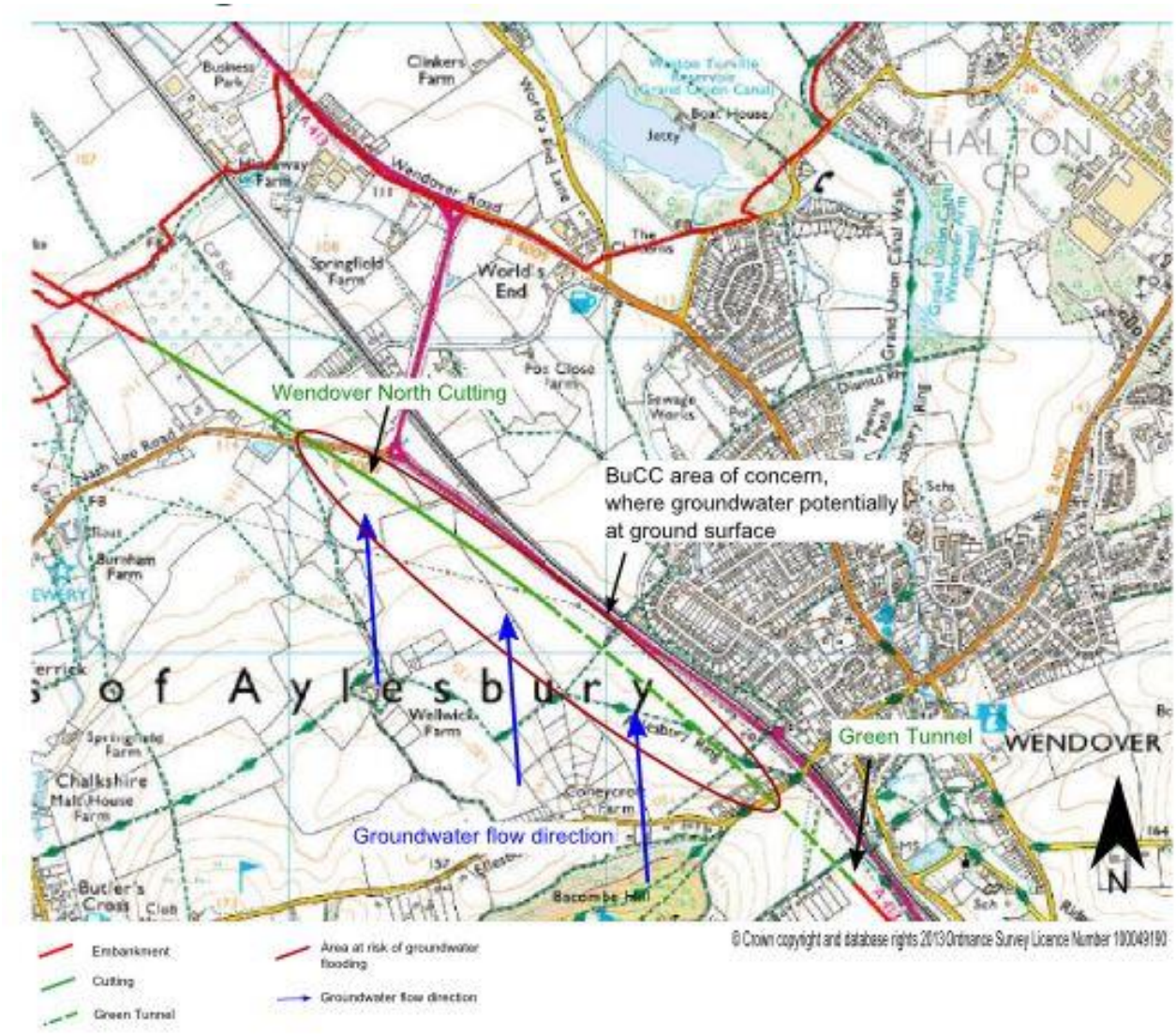
4.2 Risks and Mitigation for Green Tunnel - Wendover Green Tunnel in the Chalk aquifer

The Wendover Green Tunnel passes through the Chalk escarpment to the south of Wendover.

4.2.1 Figure 1 shows the assumed groundwater flow direction in the Chalk is to the north and therefore would currently flow across the path of the Proposed Scheme. BuCC have highlighted that the area between Ellesborough Road and Nash Lee Road are currently susceptible to groundwater flooding (as highlighted in the map below).

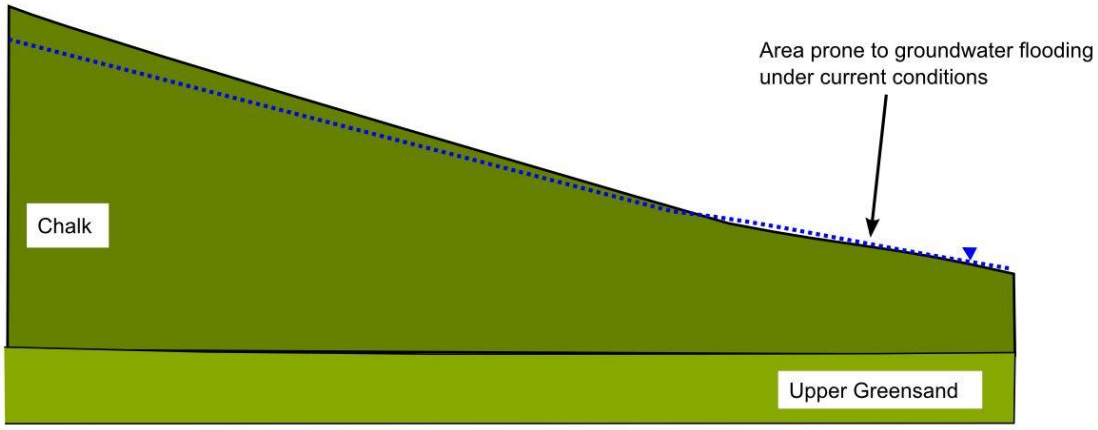
[1] CIRIA, (2000), CIRIA C515: Groundwater control – design and practice.
[2] CIRIA, (1986), CIRIA C113: Control of groundwater for temporary works.

Figure 1 - Map of HS2 route in area around Wendover



4.2.2 Figure 2 presents a cross section conceptual schematic of the potential for groundwater flooding in this area under current conditions, perpendicular to the Proposed Scheme, based on the information currently available. Groundwater levels in the Chalk are at ground surface and there is the potential for groundwater flooding.

Figure 2 - Schematic representation of potential for groundwater flooding near Wendover green tunnel under current conditions

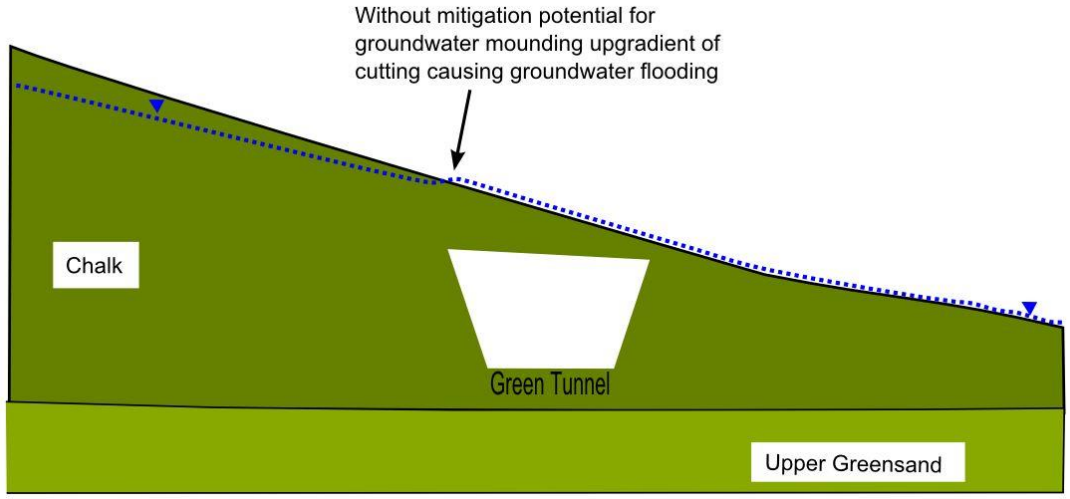


4.2.3 Figure 3 presents a schematic of the potential impact of the Proposed Scheme on groundwater flooding, without mitigation measures. The proposed green tunnel would be constructed as a cast in-situ twin box cut and cover structure and is estimated to be below groundwater level for the southernmost 600m (approximately half the tunnel distance). The potential for impacts depends on the position of the water table relative to the Proposed Scheme.

4.2.4 In the temporary condition during construction the cutting for the green tunnel would act as a drain where the cutting is below the water table. During this condition there will be drawdown of surrounding groundwater and therefore, a reduced risk of groundwater flooding. During construction the draft CoCP would be applied to ensure water is discharged to an appropriate location and will avoid an increase the risk of flooding. However, once the Wendover green tunnel is completed the walls and invert (top of tunnel) will be sealed (and hence no associated drawdown) but there is potential for obstruction of groundwater flow were the tunnel is below water table. Therefore, discussion here after will focus on the permanent position, once construction is complete.

4.2.5 Where the green tunnel passes through the Chalk aquifer, the aquifer will continue beneath the route allowing groundwater flow to continue below the constructed tunnel, however there will be a restriction to the flow of water and it may not be possible for water to flow around the tunnel, if no mitigation is in place. Therefore, there is the potential for groundwater to mound on the upstream side of the tunnel, causing more extensive groundwater flooding.

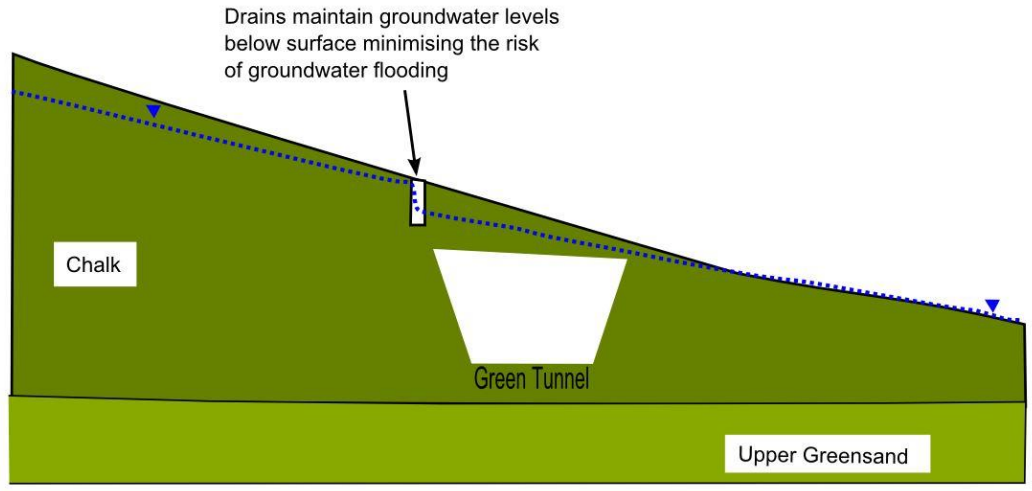
Figure 3 - Schematic representation of impact of proposed cutting/green tunnel on groundwater flooding without mitigation



4.2.6 In order to help ensure that groundwater flooding risk is not increased, land drains are planned, along the up-gradient side of the Proposed Scheme (southern side). These drains have been included in the preliminary design. Monitoring data collected as part of the ground investigation works will be used to provide an indication of the groundwater level range. The data can then be reviewed with the EA monitoring in the area during periods of groundwater flooding, such as 2001 and 2013.

4.2.7 Figure 4 presents the schematic representation of the impact of the mitigation land drains on groundwater levels. The land drains will aim to reduce groundwater levels on the up-gradient (south) side of the tunnel helping to reduce the risk of groundwater flooding. Water collected by the land drains around the green tunnel are planned to be drained north to a land drainage pond located at Chainage 56+700 (outside the area at risk from groundwater flooding). The water is then discharged into a diverted watercourse at the head of the Nash Lee Orchard culvert, into the Stoke Brook at circa Chainage 56+800.

Figure 4 - Schematic representation of impact of proposed green tunnel on groundwater flooding with mitigation



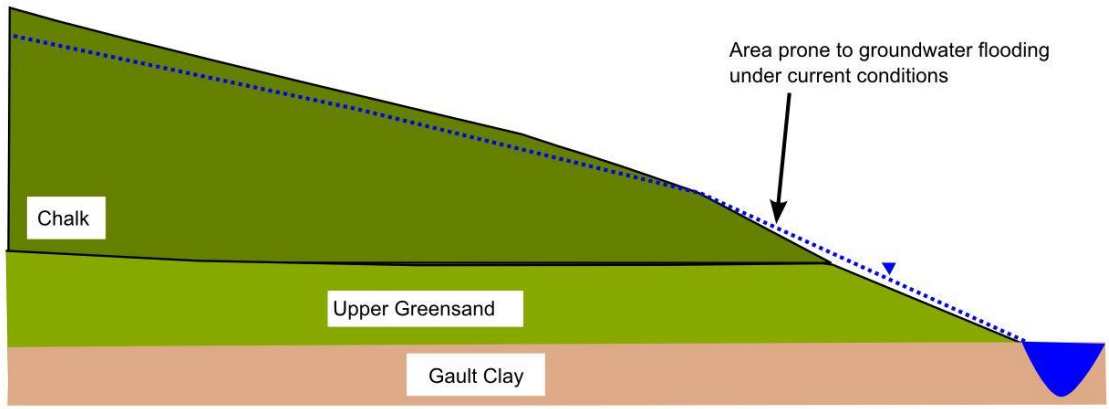
4.3 Risks and Mitigation for Cuttings - Wendover North Cutting in the Chalk aquifer

The Wendover North Cutting passes through the Chalk escarpment and into the Upper Upper Greensand aquifer to the south of Wendover.

4.3.1 Figure 1 shows the estimated groundwater flow direction in the Chalk is to the north and therefore would currently flow across the path of the Proposed Scheme. BuCC has highlighted that the area between Ellesborough Road and Nash Lee Road are currently susceptible to groundwater flooding (as highlighted in the map below).

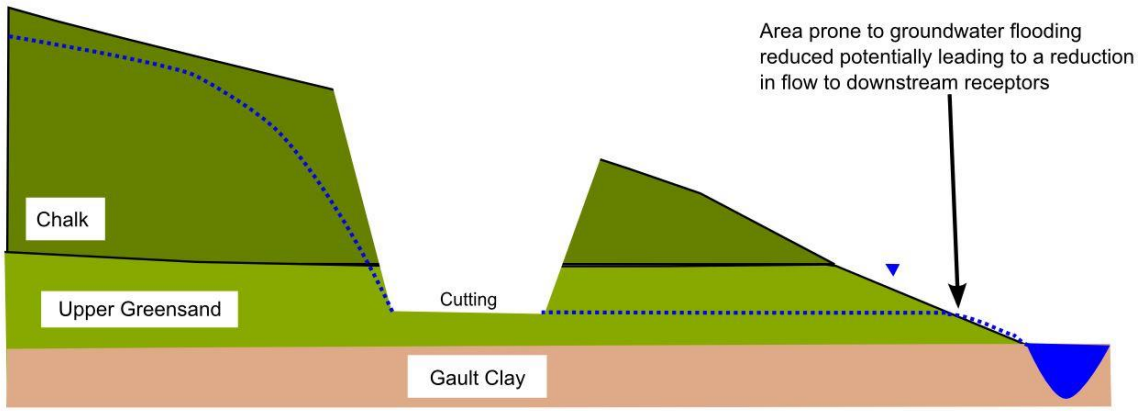
4.3.2 Figure 5 presents a cross section conceptual schematic of the potential for groundwater flooding in this area under current conditions, perpendicular to the Proposed Scheme, based on the information currently available. Groundwater levels in the Chalk/Upper Greensand are at ground surface and there is the potential for groundwater flooding.

Figure 5 - Schematic representation of potential for groundwater flooding near Wendover North Cutting under current conditions



4.3.3 Figure 6 presents a schematic of the potential impact of the Proposed Scheme on groundwater flooding, without mitigation measures. The Proposed Scheme would potentially act as a groundwater drain, reducing groundwater levels around the cutting and reducing the risk of groundwater flooding in this area. Therefore, the cutting will help to reduce groundwater levels, but has the potential to impact on flow to downstream receptors.

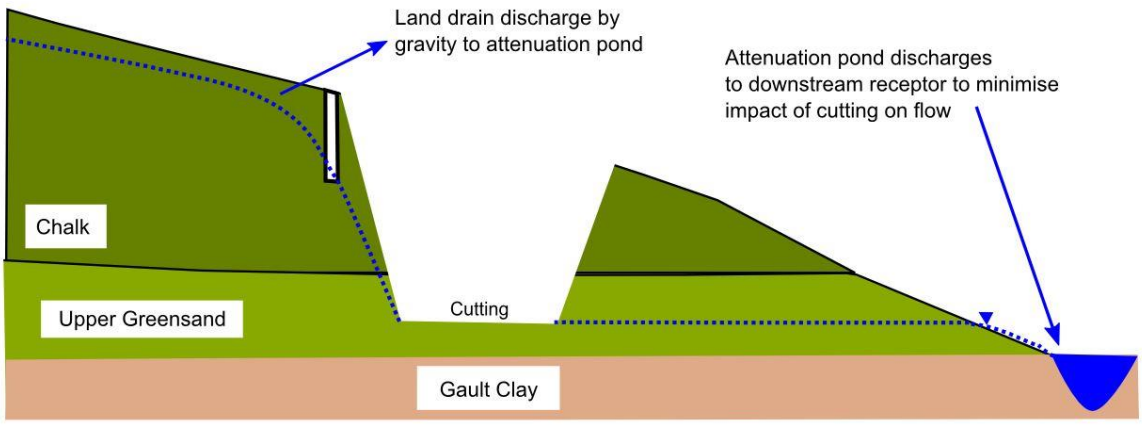
Figure 6 - Schematic representation of impact of proposed cutting on groundwater flooding without mitigation



4.3.4 In order to ensure that the reduction in groundwater levels around the cutting does not have an adverse impact on downstream receptors (in this case the Stoke Brook) land drains have been included in the preliminary design along the up-gradient side of the Proposed Scheme (southern side). Monitoring data, collected where required as part of the ground investigation works, will be used to provide an indication of the groundwater level range. The data can then be reviewed with the EA monitoring in the area during periods of groundwater flooding, such as 2001 and 2013. The drains will be designed during the detailed design phase, to intersect groundwater before it reaches the cutting, if required.

4.3.5 Figure 7 presents the schematic representation of the impact of the mitigation land drains on groundwater levels. Water collected by the land drains around the cutting are planned to be drained north to a pond located at Chainage 56+700 (outside the area at risk from groundwater flooding). The water is then discharged into a diverted watercourse at the head of the Nash Lee Orchard culvert, into the Stoke brook at circa 56+800. The Stoke Brook would naturally have been the receiving water for the natural groundwater discharge downstream from this location. The balancing pond will attenuate the discharge and aim to ensure that the risk of flooding is not increased on the Stoke Brook.

Figure 7 - Schematic representation if impact of proposed cutting on groundwater flooding with mitigation



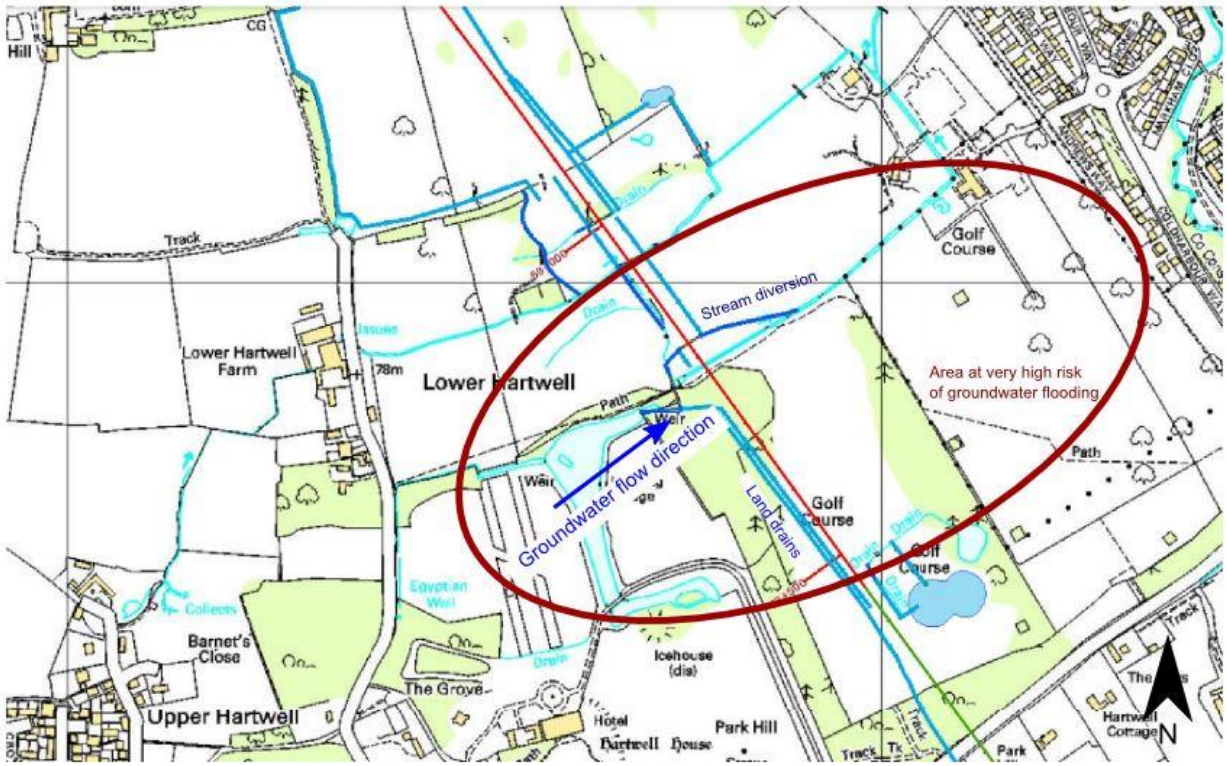
4.3.6 The removal of material to from the cutting will change the storage of the aquifer in this area. Although the cutting is relatively large the effective porosity of the aquifer

is small compared to that of the land drains. Basic calculations show that the cross sectional area of the cutting (at 11m deep, 19m wide at the base with a slope angle of 2:1) is 270m^3 per metre of cutting. Assuming a worst case effective porosity in the Chalk of 3% the construction of the cutting would lead to a loss of approximately 8m^3 water per metre of cutting. Assuming that the land drains are perforated pipes surrounded by gravel then we can assume an effective porosity of around 50% for the land drains. Therefore, for example a land drain of around 4 by 4 m would provide the same effective storage of water as the removed aquifer.

4.4 Risks and mitigation for Embankments

4.4.1 To the south west of Aylesbury, the Proposed Scheme will pass Lower Hartwell on the Oxford Road Embankment. Figure 8 presents a map of the embankment (the embankment is denoted by the red section of the Proposed Scheme line below), which will be built over an area classified as at high risk of flooding from superficial deposits by the LLFA; specifically Alluvium and Head deposits (as shown by the red area).

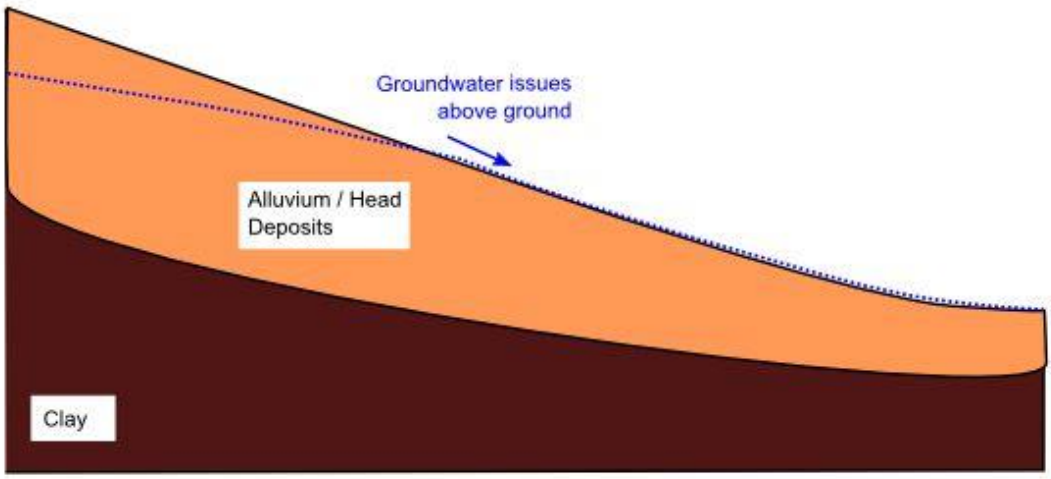
Figure 8 - Map of Oxford Road Embankment, detailed assumed groundwater flow direction and highlighting area potentially susceptible to groundwater flooding



4.4.2 In this area, groundwater is likely to be present in the Alluvium and Head deposits and in connection with the local water courses. Therefore, groundwater flow is likely to be towards and along the direction of flow in the local water course, i.e. to the north east. Figure 9 shows a schematic illustration of the mechanism for groundwater flooding in this area, under current conditions. The cross-section shows that groundwater levels in the superficial deposits can potentially rise to ground surface causing groundwater flooding. It is conceptualised that if groundwater flooding occurs then groundwater is

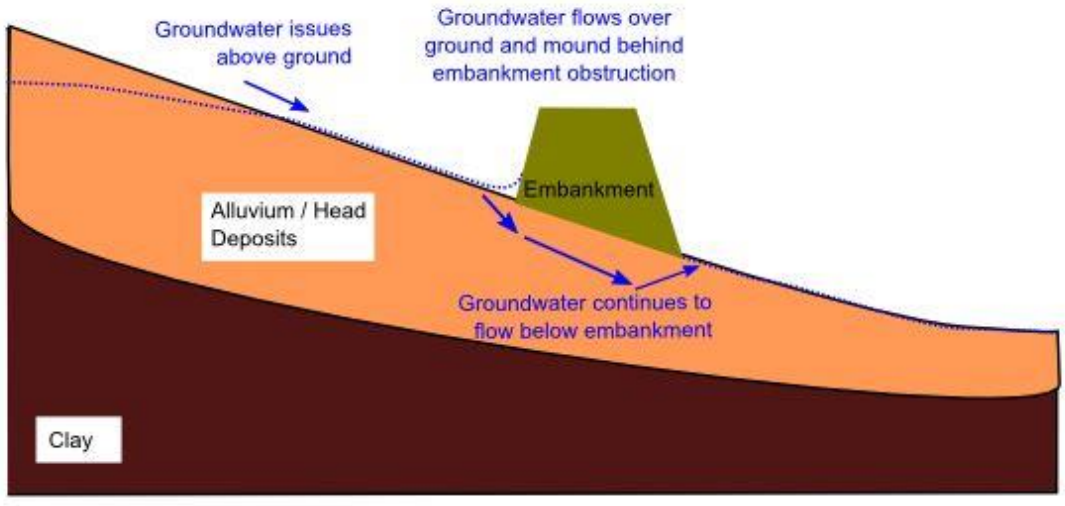
likely to flow over the surface and into the bottom of the valley and subsequently into the Bear Brook.

Figure 9 - Schematic of current groundwater flooding mechanisms around Lower Hartwell



4.4.3 Figure 10 presents a schematic of the potential impact of the Proposed Scheme on groundwater flooding, without mitigation measures. Since the Proposed Scheme is on embankment there will only be minor obstruction of the groundwater flow paths below ground, caused by consolidation in the underlying geology reducing the permeability of the aquifer. However, the Proposed Scheme would potentially act as an above ground obstruction, blocking previous overland flow paths and causing the flood water to mound and pond on the up-gradient side of the embankment.

Figure 10 - Schematic of potential impact of proposed embankment without mitigation measures in place

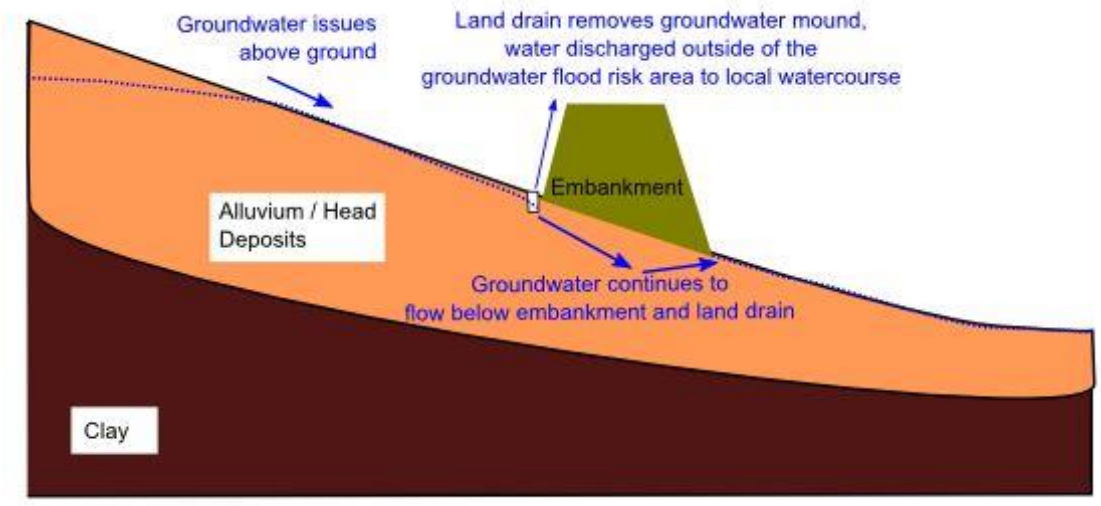


4.4.4 To avoid an increase of the flood level up-gradient of the embankment land drains could be constructed adjacent to the embankment to intercept groundwater, as shown in Figure 11. These land drains are planned to discharge into the network of drainage ditches, and watercourses (including the proposed Lower Hartwell ditch diversion) downstream of the embankment.

4.4.5 Land drains have already been included in the preliminary design. Monitoring data, collected where required, as part of the ground investigation works will be used to provide an indication of the groundwater level range. The drains will then be designed during the detailed design phase, to avoid any increases in groundwater flooding.

4.4.6 In addition, if monitoring data suggests it is necessary then a starter layer (a high permeability bed of gravel) could be placed beneath the embankment to encourage groundwater flow beneath the embankment.

Figure 11 - Schematic representing proposed groundwater flooding mitigation around Lower Hartwell

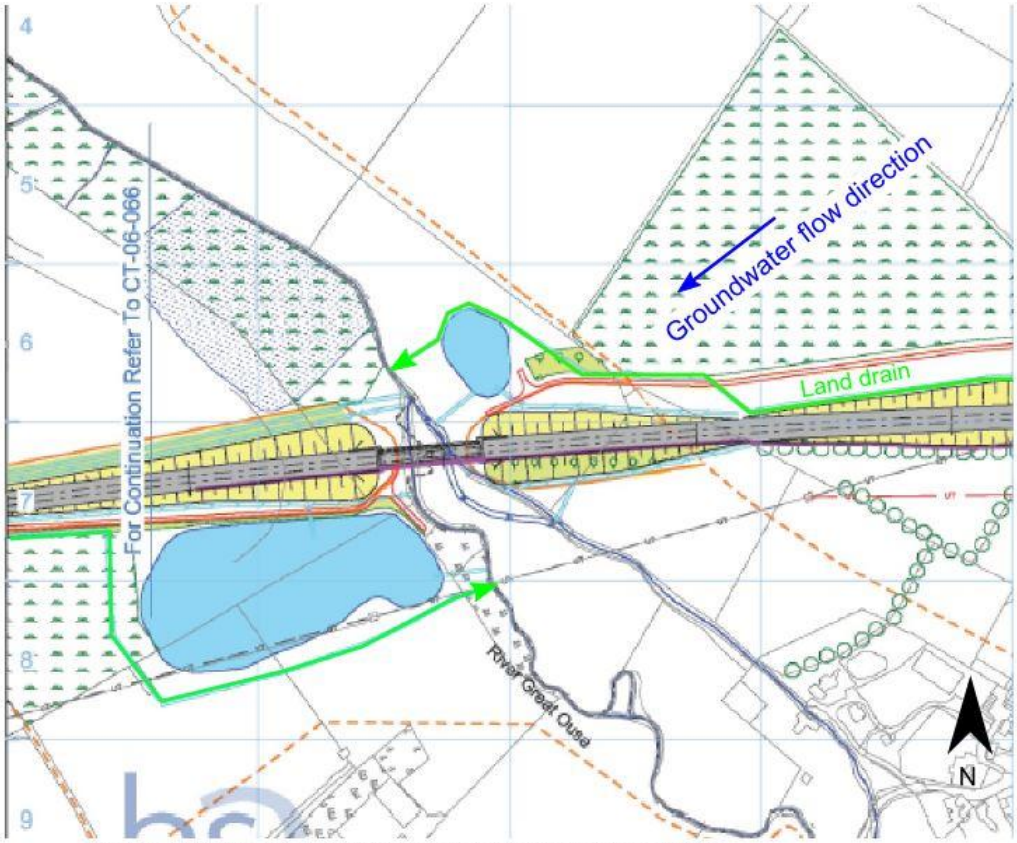


4.5 Risks and mitigation for reduced capacity of balancing ponds (Balancing ponds near River Great Ouse (CFA14))

4.5.1 The Proposed Scheme crosses the River Great Ouse to the north west of Turweston on a viaduct. Either side of the viaduct the Helmdon and Turweston embankments will extend to the valley slopes, to the east of this the Proposed Scheme passes through a section of cutting (Turweston cutting).

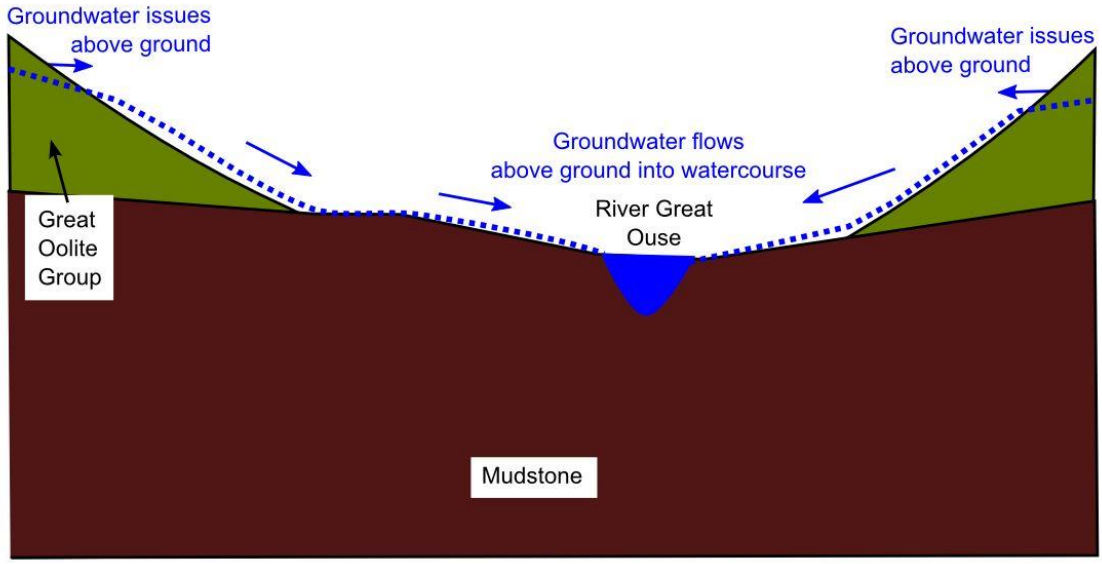
4.5.2 Two balancing ponds, one either side of the River Great Ouse, are planned to receive drainage from the embankments and cutting via parallel drainage ditches. In addition to the balancing ponds there are also new land drains planned running parallel to the Proposed Scheme on both sides. This arrangement is shown in Figure 12 below.

Figure 12 - Plan view of proposed HS2 route, drainage arrangements and balancing pond in the valley of the River Great Ouse.



4.5.3 The BuCC PFRA suggests that in this area the Great Ouse valley is at risk of groundwater flooding. Figure 13 shows a schematic illustration of the mechanism for groundwater flooding in this area, under current conditions. The cross-section shows that groundwater levels in the aquifer can potentially rise to ground surface causing groundwater flooding. It is conceptualised if groundwater flooding does occur then groundwater is likely to flow over the surface and into the bottom of the valley and subsequently into the River Great Ouse.

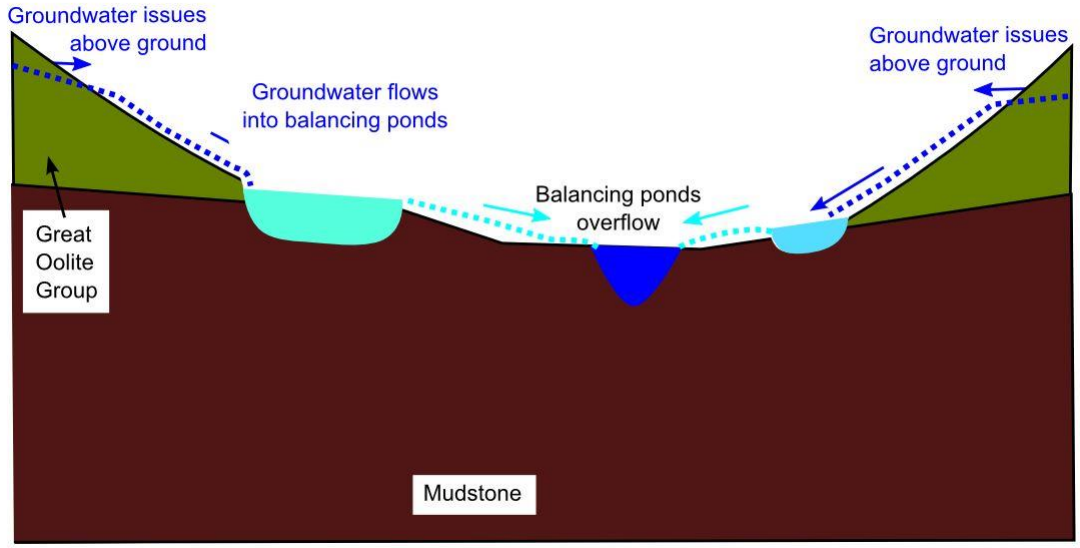
Figure 13 - Schematic of current groundwater flooding mechanisms in the River Great Ouse Valley



4.5.4 The Proposed Scheme passes across the River Great Ouse on a viaduct and is on embankment on either side of the valley. In the area close to the river two balancing ponds are proposed, to receive drainage from the embankments. These balancing ponds are designed to provide mitigation for the receiving water body (the River Great Ouse) to provide attenuation for peaks in flow as well acting to improve water quality during less-extreme events.

4.5.5 Figure 14 presents the schematic illustration of the potential risks of groundwater flooding reducing the capacity of the balancing ponds. Without groundwater flooding mitigation there is the potential that any groundwater flooding would be intercepted by the balancing ponds, in addition to the drainage from the Proposed Scheme. This would reduce the capacity of the ponds to provide their intended function to deal with the peaks in rail drainage flow. This could lead to an increase in the risk of the overflow channels being overloaded and the ponds overflowing a mixture of groundwater and HS2 drainage water directly into the River Great Ouse without sufficient attenuation.

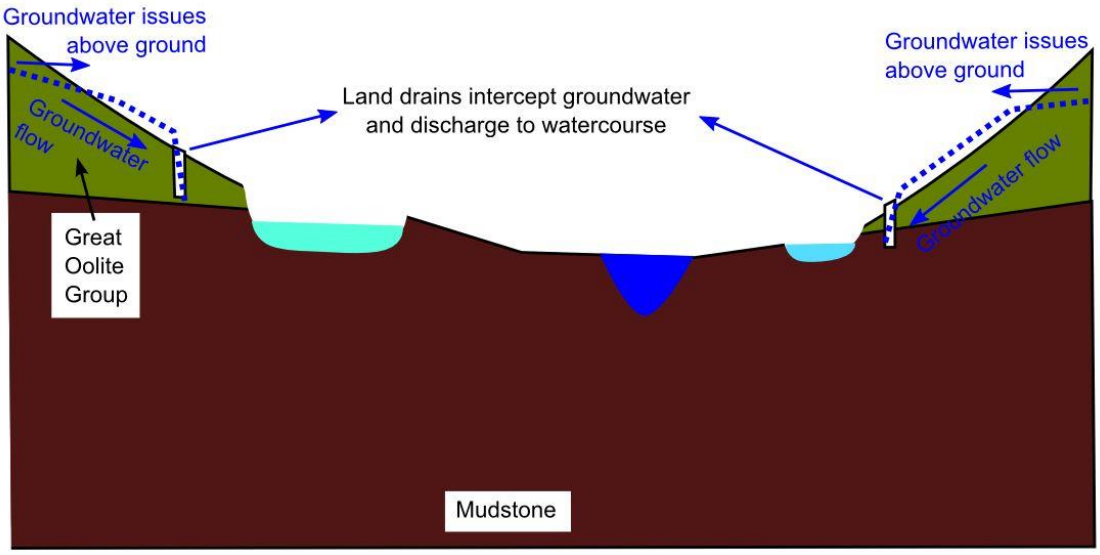
Figure 14 - Schematic representation of loss of balancing pond capacity due to interception of groundwater flood flows.



4.5.6 In order to mitigate against groundwater flood flow overloading the balancing ponds, the proposed HS2 design includes land drains. Figure 15 shows that the land drains are proposed to be situated up-gradient of the drainage ditches and the balancing ponds in order to intercept groundwater and discharge it directly to the River Ouse (also see Figure 12). The interception of groundwater by the land drains will cause a localised loss of storage in the aquifer, and may mean that groundwater reaches the river faster than would occur under current conditions.

4.5.7 The design of these land drains (depth etc.) will be carried out as part of the detailed design. Groundwater monitoring data, collected where required, as part of the ground investigation works will be used to calculate the potential range of groundwater level variation in the area, and the drains will be designed to maintain groundwater levels at a depth where they will not interfere with the designed function of the balancing pond.

Figure 15 - Schematic representing proposed groundwater flooding mitigation in River Great Ouse valley



5 Conclusions

5.1.1 Groundwater flooding occurs when groundwater reaches the ground surface. Groundwater flooding can occur due to natural rises in water levels (caused by high levels of rainfall) or due to the introduction of a below groundwater level obstruction which blocks flow paths and causing mounding on the upgradient side.

5.1.2 The main ES assessment utilises the data sets available from the lead local flood authority (LLFA). This data set defines the historic flood risk and the potential for groundwater flooding. The current assessment takes into account the preliminary design of the Proposed Scheme and any mitigation measures (such as land drains) included.

5.1.3 The detailed design of mitigation measures (such as land drains) has not yet been carried out. In order to complete the detailed design additional groundwater level monitoring data will be collected, where required, as part of the ground investigation works. This monitoring data will be used, where required, to help ensure mitigation measures have sufficient capacity to maintain suitable groundwater levels in the aquifer, with the aim that groundwater flooding risk is not increased and that measures do not cause an adverse effect on the groundwater system.

5.1.4 The case studies presented show that mitigation measures, such as the inclusion of land drains and the sizing of culverts, will be designed to avoid impact on the risk of flooding from groundwater arising from the Proposed Scheme.

Affinity Water

HS2 Select Committee
House of Commons Private Bill Office
House of Commons
London
SW1A 0AA

22 June 2015

Dear Chair

Affinity Water position on High Speed Rail 2 (HS2)

We are the largest water-only supplier in the UK and we are committed to delivering a high quality water service to all our customers. We provide 900 million litres of water each day to a population of more than 3.5 million people across North West London and the Home Counties.

We take seriously our responsibility to provide high quality water to our customers while managing the local water environment and have confirmed in our plans a 69Ml/d or 7 per cent reduction in abstraction by 2023.

Mitigation

We are working closely with HS2 to review all potential impacts to our network and water sources, posed by the construction and running of the proposed HS2 route. It is our view that the mitigation of these impacts will be agreed with HS2, and that any costs associated with them will be borne by HS2. We have petitioned against aspects of the current Bill to ensure that sufficient provision is made by HS2 to allow this to happen. We expect to withdraw our petition provided we reach an acceptable agreement with HS2.

Water supply

We have identified solutions to ensure our supplies remain unaffected by HS2 and are currently reviewing these in more detail. For example, we believe that additional treatment at our sources and a possible additional import of water from one of our neighbouring water companies will be necessary for the duration of construction works.

Environmental monitoring

The monitoring of the local water environment and our sources will form part of a larger environmental monitoring regime, to be undertaken by HS2. This will allow baseline conditions to be established so that we can maintain effective long term monitoring.

The Environment Agency has a duty to ensure that there is no significant environmental pollution from HS2 activities and this includes consideration of potential effects on water supply. The Code of Construction Practice will be one of the vehicles that is used to ensure safe and non polluting activities are enforced on the contractor.

We have made it clear we expect those provisions to be implemented in such a way to prevent spillage and pollution rather than just provide a procedure for remediation after an event. We will be monitoring construction activities very closely to ensure best practice is applied to minimise the risk of pollution.

If you would like to explore any of these issues in greater detail, please do not hesitate to get in touch.

Yours sincerely

M. I. Pocock

Mike Pocock
Physical Assets Strategy Manager

Note: Delivered via Simon Dale-Lace, Water Resources and Flood Risk Manager HS2 Ltd, as requested.

Simon Dale-Lace
High Speed Two Ltd
25th Floor
One Canada Square
Canary Wharf
London
E14 5AB
E-mail: Simon.Dale-Lace@hs2.org.uk

Our Ref: HNL-150812 HS2

Your Ref:

Date: 12th August 2015

Dear Simon

Re: Wendover Dean and Small Dean Viaducts

Thank you for your e-mail of 11 August 2015.

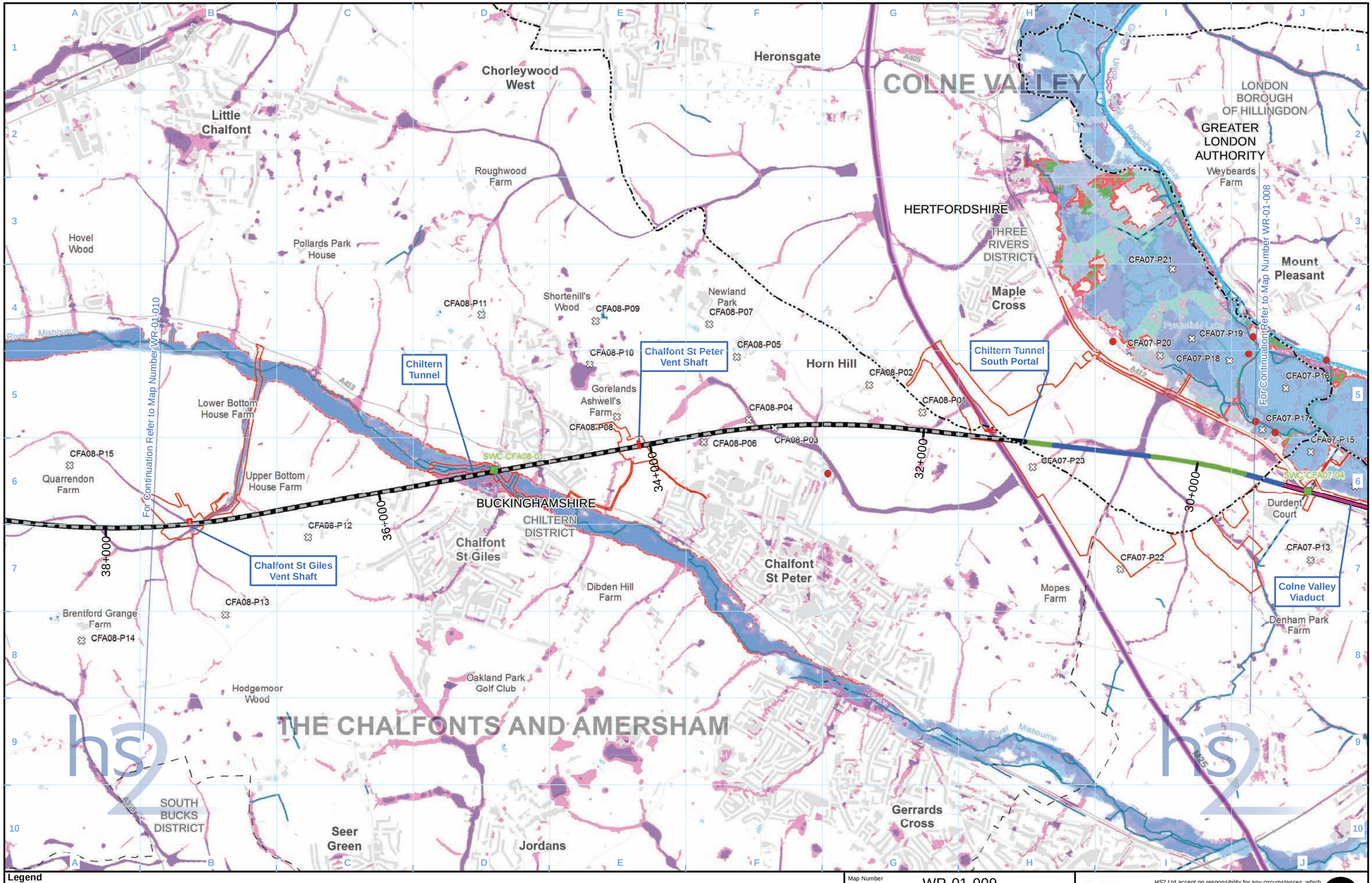
The Environmental Statement (ES) submitted in support of the Hybrid Bill for Phase One includes a Flood Risk Assessment (FRA) for CFA10, Dunsmore, Wendover and Halton. We believe the FRA submitted accurately reflects the local flooding regime.

Under the Protective Provisions proposed in the Hybrid Bill we will, along with Lead Local Flood Authorities, have a role to approve the detailed design of Main River and Non Main River crossings - to ensure flood risk is not increased to people or communities. As we have previously discussed, we will expect to be consulted at an early stage to ensure that any proposed crossings will be appropriate from a flood risk and Water Framework Directive perspective.

Yours sincerely

Roy Stokes
Project Manager

Tel: 07802335003
Direct e-mail: roy.stokes@environment-agency.gov.uk



Legend

- Route on embankment
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- Surface water crossing location
- Surface water discharge location
- Historic flooding area
- Flood Zone 2
- Flood Zone 3
- Flood Map for Surface Water - (200yr) Shallow (+0.1m)
- Flood Map for Surface Water - (200yr) Deep (+0.3m)
- Reservoir inundation area

Map Number: WR-01-009

Map Name: Surface Water Baseline

Community Forum Area CFA8: The Chalfonts and Amersham

Registered in England. Registration number 06791686.
Registered office: Eland House, Bressenden Place, London SW1E 5DU.

Scale at A3: 1:25,000

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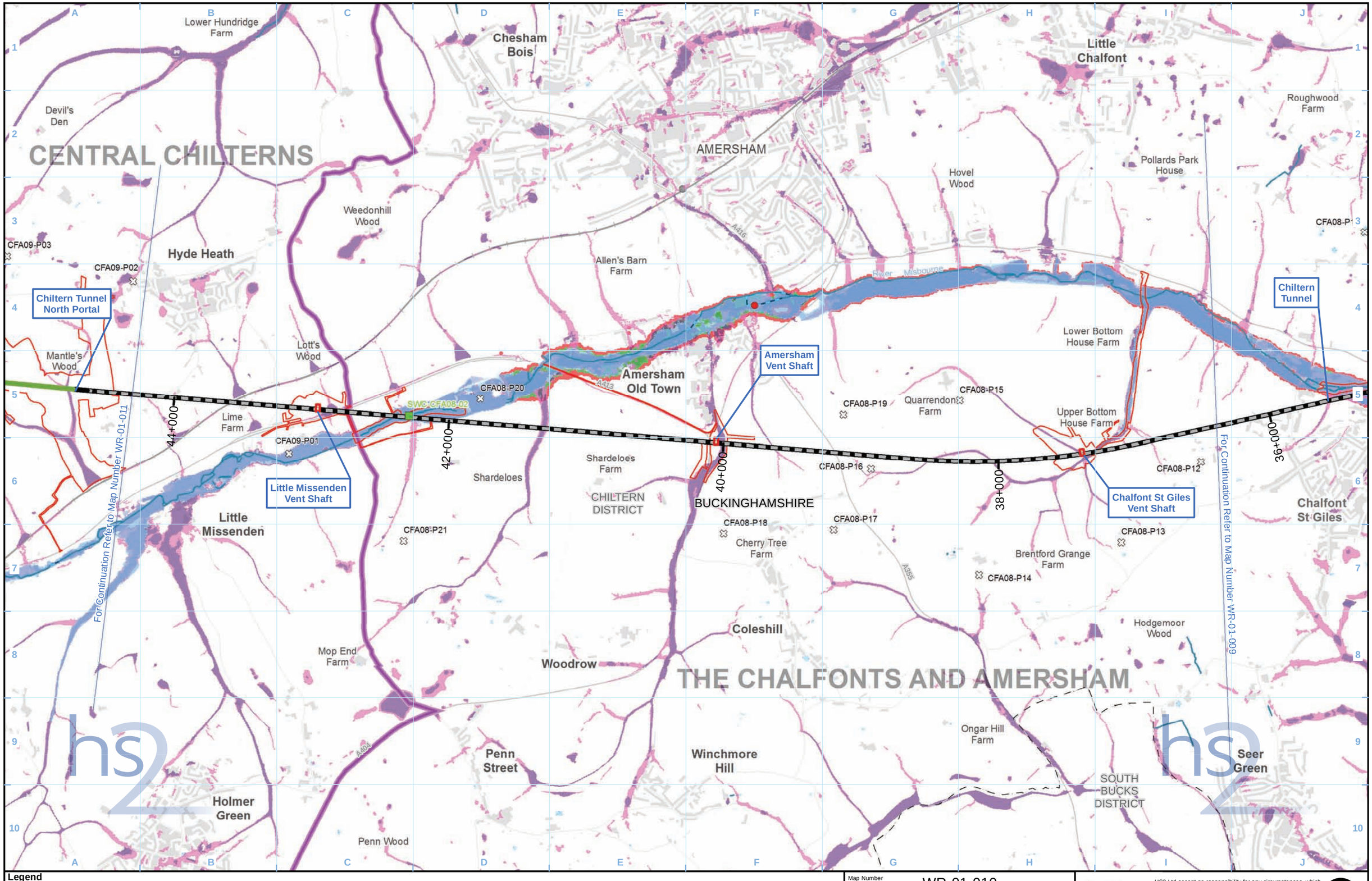

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Map Number: WR-01-010

Map Name: Surface Water Baseline

Community Forum Area CFA8: The Chalfonts and Amersham

Scale at A3: 1:25,000

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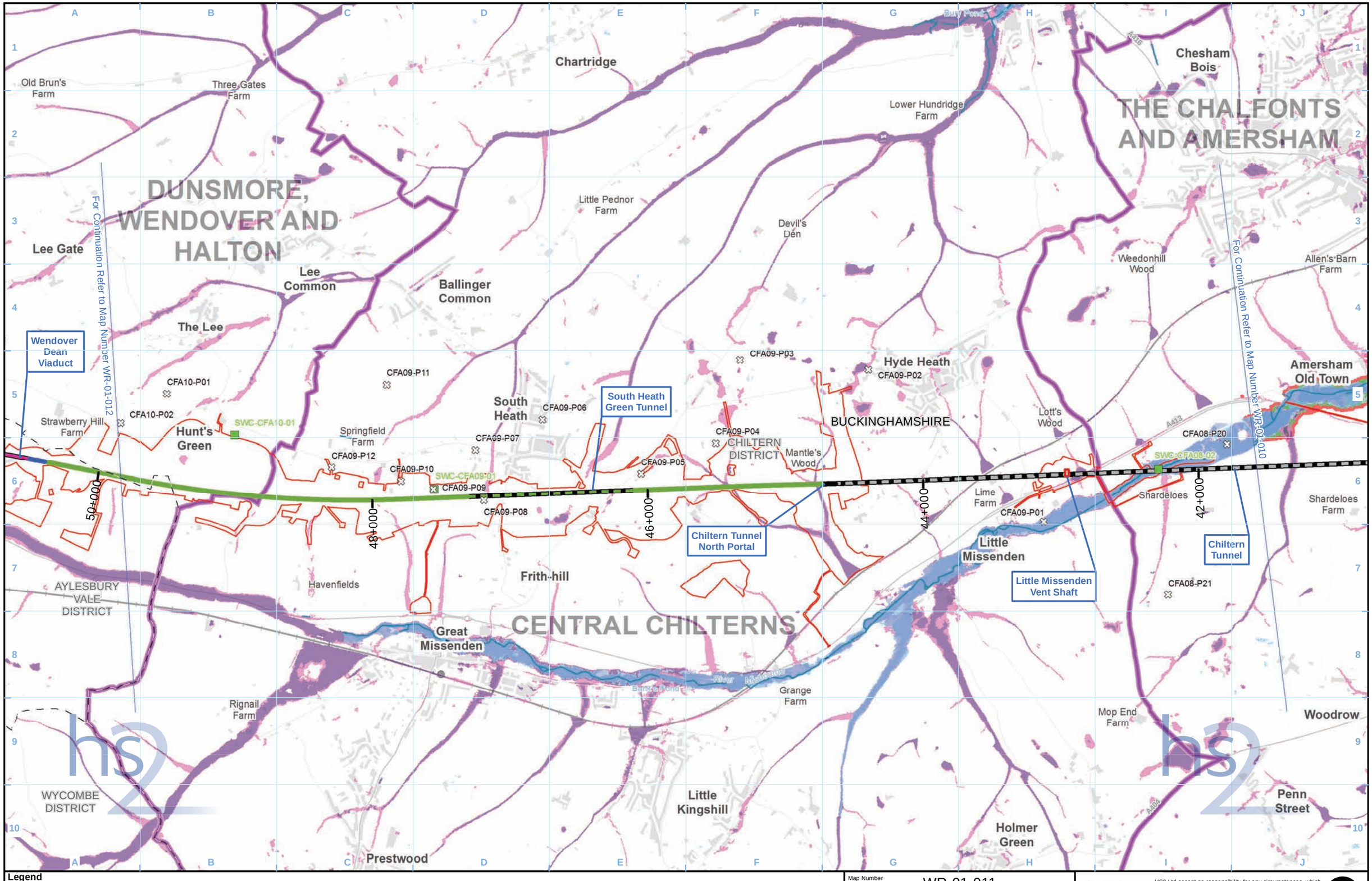

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Map Number: WR-01-011

Map Name: Surface Water Baseline

Community Forum Area CFA9: Central Chilterns

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Registered office: Eland House, Bressenden Place, London SW1E 5DU.

Scale at A3: 1:25,000

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Doc Number: C252-ETM-EV-MAP-020-001430-P06.00

DUNSMORE, WENDOVER AND HALTON

Halton
Wendover Woods
Lanes End
Old Brun's Farm
Three Gates Farm
Chartridge
Cock's Hill
Boddington Hill
Grand Union Canal (Wendover Arm)
Weston Turville Reservoir
Little Pednor Farm
Lee Gate
AYLESBURY VALE DISTRICT
WENDOVER
World's End
Lee Common
Ballinger Common
Kingsash
CFA10-P04
The Lee
CFA10-P07
CFA10-P06
Wellhead Farm
CFA10-P08
A413
BUCKINGHAMSHIRE
Wendover Dean Viaduct
CHILTERN DISTRICT
CFA10-P01
CFA09-P11
South Heath
For Continuation Refer to Map Number WR-01-011
54+000
52+000
50+000
48+000
43+000
CFA10-P09
Wellwick Farm
Bacombe Hill
CFA10-P05
Smalldean Farm
Small Dean Viaduct
Durham Farm
CFA10-P02
Hunt's Green
SWC-CFA10-01
Springfield Farm
CFA09-P12
CFA09-P10
CFA09-P09
CFA09-P07
CFA09-P06
CFA09-P05
Upper Wendoverdean Farm
Wendover Green Tunnel
For Continuation Refer to Map Number WR-01-013
Wendover Dean
CFA10-P03
SWC-CFA09-01
CFA09-P08
Butler's Cross
Coombe Hill
Dunsmore
Dutchlands Farm
Havenfields
Frith-hill
South Heath Green Tunnel
Lodge Hill Farm
Dunsmore Old Farm
Great Missenden
River Misbourne
Ellesborough
WYCOMBE DISTRICT
Rignall Farm
Little Hampden
CENTRAL CHILTERNS
Beacon Hill
Chequers
Buckmoorend
Hampden Bottom
Andlows Farm

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- Reservoir inundation area

Map Number: WR-01-012

Map Name: Surface Water Baseline

Community Forum Area CFA10: Dunsmore, Wendover and Halton

Registered in England. Registration number 06791686.
Registered office: Eland House, Bressenden Place, London SW1E 5DU.

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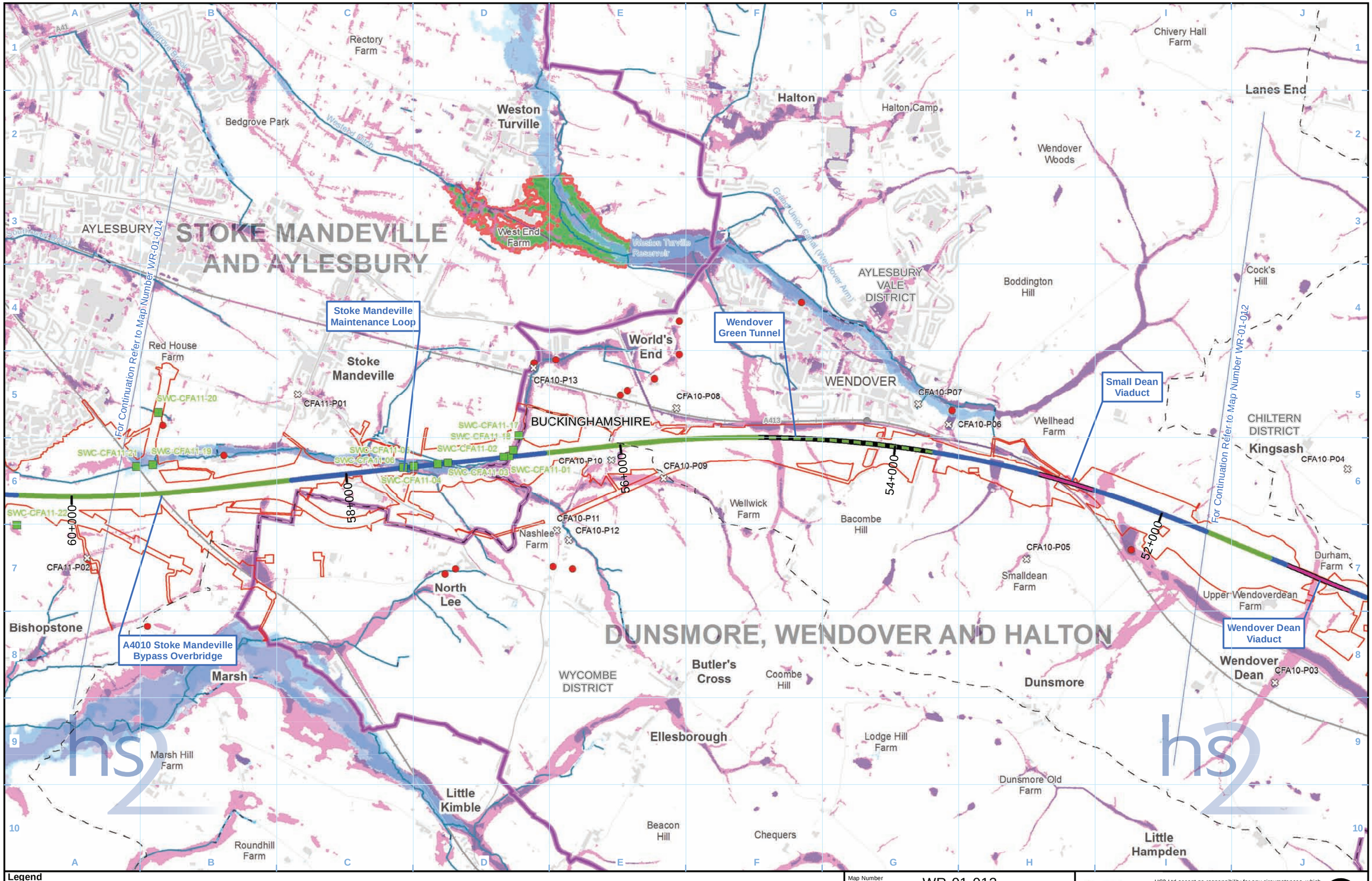

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Map Number: WR-01-013

Map Name: Surface Water Baseline

Community Forum Area CFA10: Dunsmore, Wendover and Halton

Scale at A3: 1:25,000

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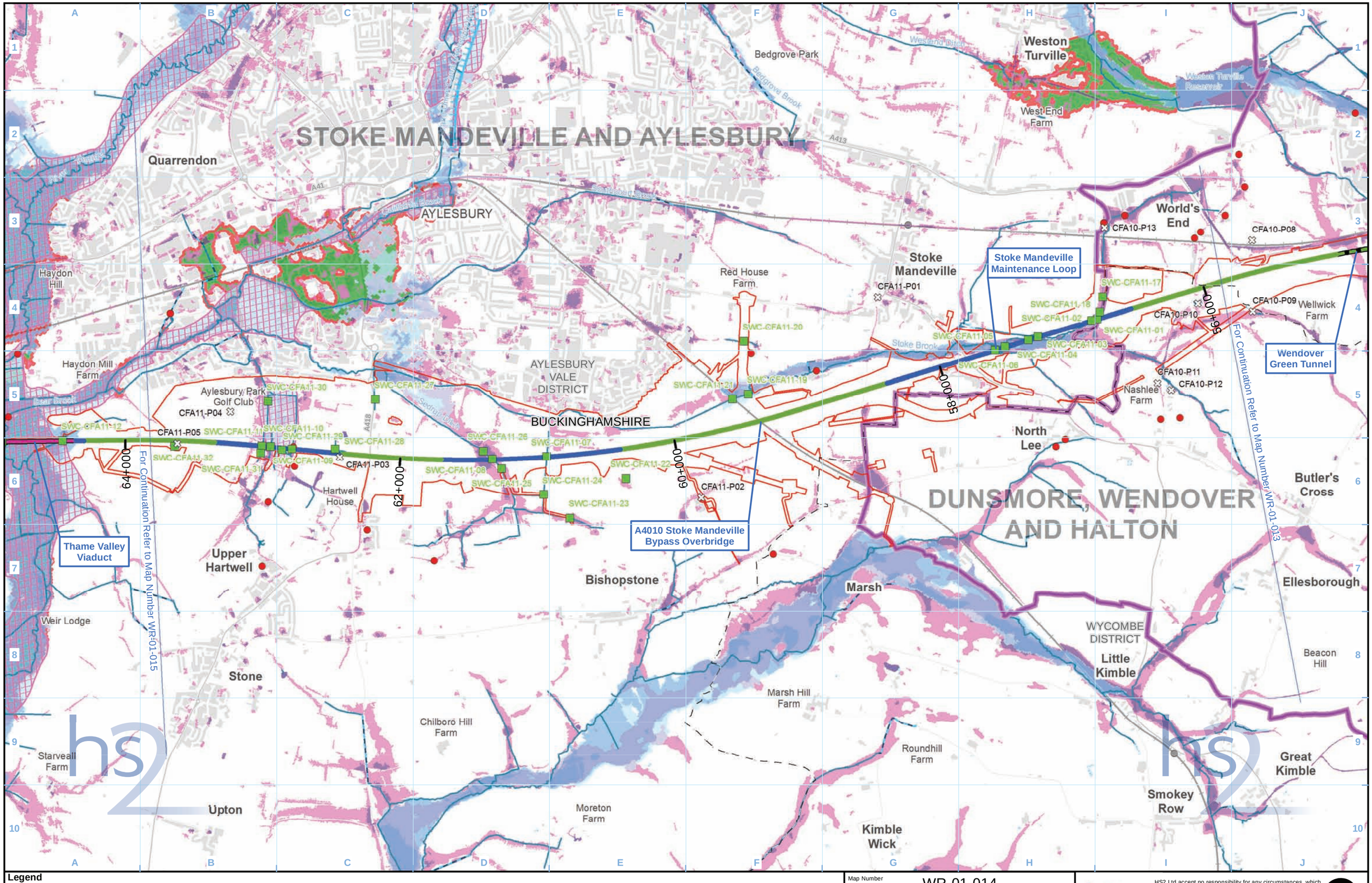

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Map Number: WR-01-014

Map Name: Surface Water Baseline

Community Forum Area CFA11: Stoke Mandeville and Aylesbury

Scale at A3: 1:25,000

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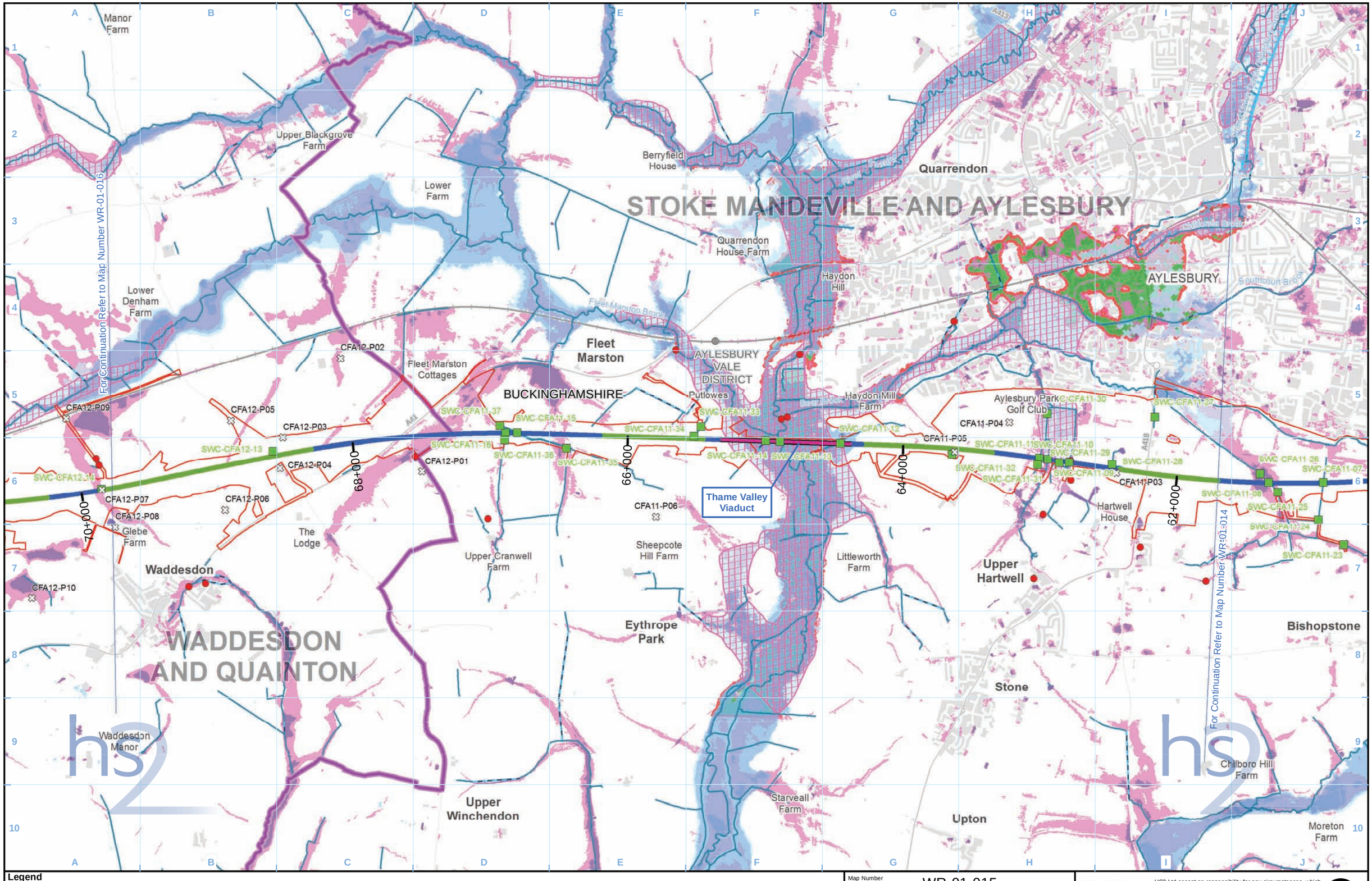

Legend

- Route on embankment
- Route in bored tunnel
- Route in cutting
- Route in green tunnel
- Route in retaining wall
- Route in station
- Tunnel portal
- Route on viaduct
- Depot, station, headhouse or portal building
- Land potentially required during construction
- Community forum boundary
- County boundary
- District/Borough boundary
- Licensed surface water abstraction (exc. public water supplies)
- Pond location (label example: CFA01-P01)
- Open water
- Watercourse
- Culverted watercourse
- Canal
- Canal tunnel
- Surface water crossing location
- Surface water discharge location
- Historic flooding area
- Flood Zone 2
- Flood Zone 3
- Flood Map for Surface Water - (200yr) Shallow (+0.1m)
- Flood Map for Surface Water - (200yr) Deep (+0.3m)
- Reservoir inundation area

Map Number: WR-01-015

Map Name: Surface Water Baseline

Community Forum Area CFA11: Stoke Mandeville and Aylesbury

Scale at A3: 1:25,000

0 250 500 750 1,000 Metres

Doc Number: C252-ETM-EV-MAP-020-001434-P06.00