1MC04 Main Works - Contract Lot S2

Technical Note - Flood compensation works during Temporary Works - River Pinn Underbridge S2

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C01.2	Cristina Puertes	04/03/2021	Noemí Guerrero	04/03/2021	Carlos Gómez	04/03/2021	Update of the temporary footbridge geometry

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1 Definitions and Abbreviations

Term	Meaning
AEP	Annual Exceedance Probability
DTM	Digital Terrain Model
EA	Environmental Agency
EWCC	Enabling Works Civil Contract
FCA	Flood Compensation Area
GIS	Geographic Information System
HS2	High Speed 2
MWCC	Main Works Civil Contract
NR	Network Rail
WRRE	West Ruislip Retained Embankment

2 Introduction

2.1.1 The present revision of this Technical Note is undertaken to include the updated design of the temporary footbridge, which is placed south of the NR Chiltern Line. The geometries of the River Pinn Underbridge and the West Ruislip Retained Embankment have been also updated to the final design.

2.1.2 This report presents the hydraulic modelling carried out in order to analyse the potential impact of the HS2 scheme temporary works on the River Pinn flood risk. This report also presents the temporary flood compensation works required to mitigate the identified impacts.

2.1.3 According to the Flood Risk Technical Standard (HS2-HS2-EV-STD-000-000011) there are two main requirements when analysing flood risk:

- Hydraulic modelling is required in order to provide evidence that the HS2 design ensures no overall increase in the flood risk (Section 4.3 of TS).
- When ground levels are artificially raised within a floodplain area, the available volume of flood storage can be reduced, increasing peak flood flows and levels. Hence, compensatory flood storage must be provided at the affected location (Section 4.5 of TS).

2.1.4 The assessment contained in this report covers both requirements, being based on the comparison between scenarios. This way, it has been possible to measure the expected impact of the temporary works and the efficiency of the proposed flood compensation works.

2.1.5 The MWCC received the document *WP20 Modelling Report – Ickenham Stream Watercourse Diversion* (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017) developed by EWCC, which included a complete hydrologic and hydraulic assessment of the River Pinn. For this reason, the analysis presented in the following sections is based on this previous work.

2.1.6 The TUFLOW model carried out by EWCC in order to reproduce the current situation has been used as the Baseline scenario for the new analysis included in this report. In addition, the TUFLOW model representing the Temporary scenario carried out by EWCC has been used as a starting point for the analysis of the temporary works included in this report.

2.1.7 The Temporary scenario carried out by EWCC represents the scheme for the temporary diversion of the Ickenham Stream. It includes the blockage of specific channels of the Ickenham Stream that currently allow flows to pass through the NR Chiltern Line Culvert. Therefore, the Ickenham Stream would be diverted upstream of the HS2 works along the existing drainage channels connecting to the River Pinn across the Ruislip Golf Course.

2.1.8 In the analysis presented in this report, two temporary scenarios have been assessed, being the model geometry of the proposed scenarios updated in order to reflect the construction of the HS2 scheme. The rest of the model parameters remain the same.

3 Assumptions

3.1.1 The following assumptions were made at the moment of the development of this model:

1. For a matter of consistency between the River Pinn temporary works model and the River Pinn baseline model, the fluvial hydraulic model has been developed using the 2017 DTM of the EA (50 cm spatial resolution, +-15cm vertical accuracy).
2. The fluvial model temporary works for the River Pinn considers the Golf Course temporary scheme (geometry and discharges) described in the document WP20 Modelling Report - Ickenham Stream Watercourse Diversion (Document no:1EW02-CSJ-DS-REP-SS05_SL07-000017).
3. The water table is assumed to be lower than the lowest point of the FCA so digging without water emerging is feasible.
4. Along the FCA boundary with Breakspear Road South, assumption that the existing hedgerow type planting is to be retained, and that the footprint of the FCA excavation will not intrude within any root protection area (RPA) zone.

4 Simulation scenarios

4.1.1 The most unfavourable scenarios during the construction of the HS2 scheme have been modelled, allowing measurement of the expected impact of the works and analysis of the performance of the proposed mitigation measures.

4.1.2 The following scenarios have been analysed:

- **Baseline scenario.** This scenario was previously developed by EWCC and fully explained in the *WP20 Modelling Report – Ickenham Stream Watercourse Diversion* (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017). It represents the current state regarding flood risk, without any of the works that the HS2 scheme involves. It is the main comparison scenario to measure flood risk impact.
- **Scenario 1.** Developed by MWCC (SCS – Design House) starting from the Temporary scenario developed by EWCC and fully explained in the *WP20 Modelling Report – Ickenham Stream Watercourse Diversion* (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017). This scenario includes the blockage of specific channels of the Ickenham Stream that currently allow flows to pass under the NR Chiltern Line Culvert. Therefore, the Ickenham Stream would be diverted upstream of the HS2 works along the existing drainage channels connecting to the River Pinn across Ruislip Golf Course. Additionally, Scenario 1 incorporates the following features:
    - Haul road. Temporary vehicle access including:
        - Temporary road.
        - Temporary bridge over the River Pinn.

        - Culvert over FCA canal feeder (FCA *neck*).
    - Temporary footbridge over the River Pinn, located south of the NR Chiltern Line.
- **Scenario 2.** Identical to the Scenario 1, except that it includes the most updated design of the HS2 structures and the proposed mitigation measures:
    - River Pinn Underbridge (wingwalls and abutments).
    - West Ruislip Retained Embankment (WRRE).
    - Removal of the footbridge currently placed over the River Pinn immediately upstream of the NR Chiltern Line overbridge (over the River Pinn). The removal of the bridge is required to allow the flood compensation, as explained in detail in the document 1MC04-SCJ_SDH-EV-REP-SS05_SL07-000003, Flood Risk Assessment Report - Flood Compensation Area - River Pinn Underbridge S2 (Scheme Design).
    - Flood Compensation Area (FCA).

4.1.3 Therefore, geometry in Scenario 1 and Scenario 2 differs from the Baseline scenario developed by EWCC as described in Table 1.

Table 1 Summary of geometry differences between scenarios

Scenario	Ickenham Stream diversion	Golf course filled in channels	Haul Road and temporary bridge	Existing footbridge	Temporary footbridge (south of NR Chiltern Line)	Culvert over FCA discharge	FCA	River Pinn Underbridge wingwalls and abutments *	WRRE
Baseline	No	No	No	In current place	No	No	No	No	No
Scenario 1	Yes	Yes	Yes	In current place	Yes	Yes	No	No	No
Scenario 2	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes

* The River Pinn Underbridge has only been considered as a modification of the DTM in order to represent the wingwalls and abutments of the bridge. It is not necessary to include the deck of the bridge as water levels do not reach it during the design events.

4.1.4 Figure 1, Figure 2 and Figure 3 show the Baseline scenario, Scenario 1 and Scenario 2 model schematisation, respectively.

Figure 1 Baseline scenario model schematisation. Downstream model extent set at the B467 Swakeleys Road in this figure. Real downstream model extent is set at the A40 Road Bridge.

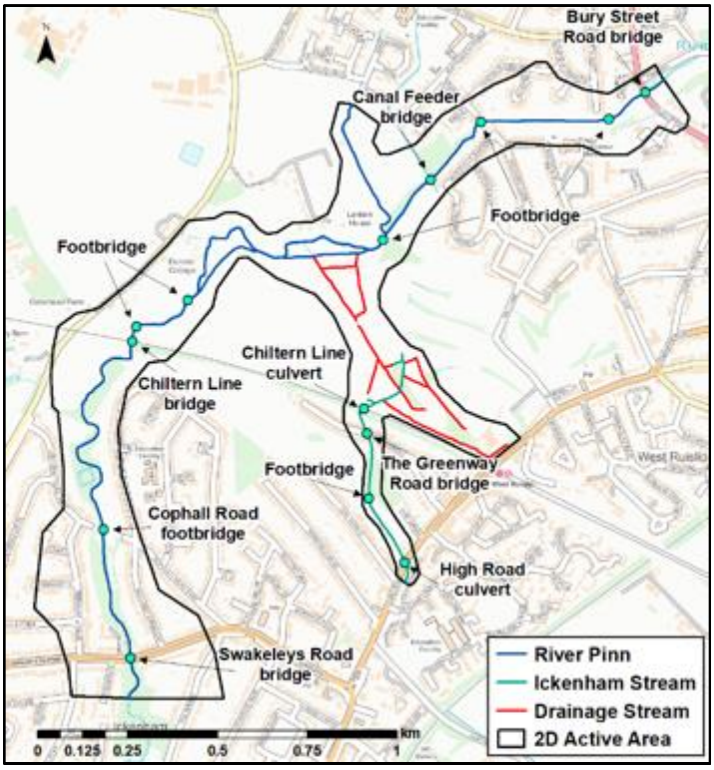


Figure 2 Scenario 1 model schematisation. Downstream model extent set at the B467 Swakeleys Road in this figure. Real downstream model extent is set at the A40 Road Bridge.

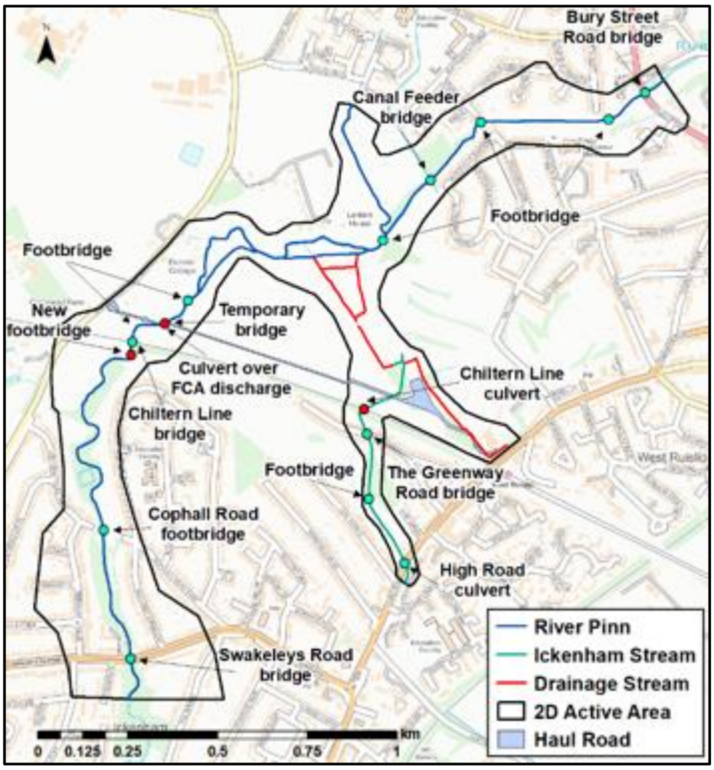
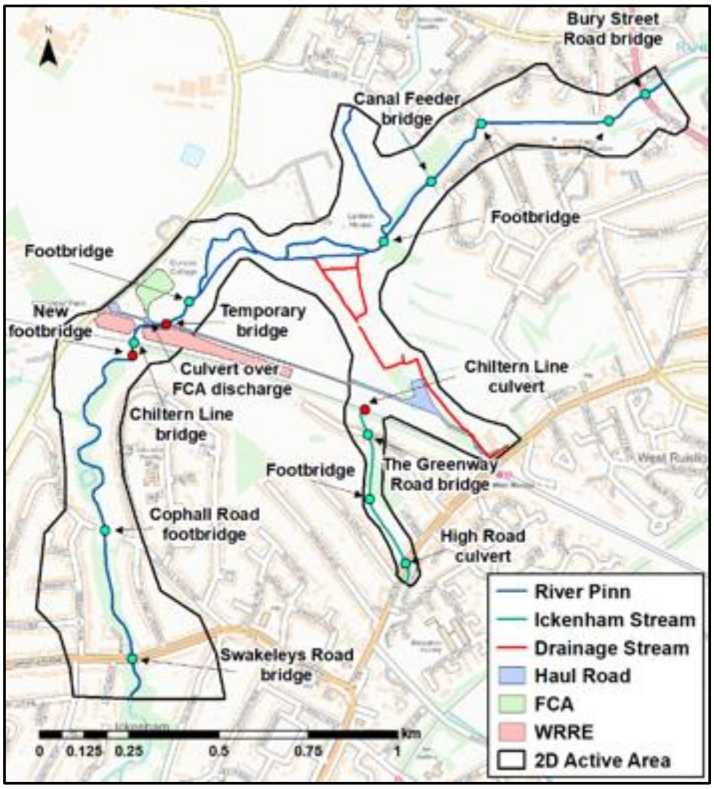


Figure 3 Scenario 2 model schematisation. Downstream model extent set at the B467 Swakeleys Road in this figure. Real downstream model extent is set at the A40 Road Bridge.



5 Model setup

5.1 Previous information

5.1.1 The following tables sum up the available data used to implement the different model scenarios. This data can be classified in two groups:

- Previous hydraulic models (Table 2).
- Main data used in these models (Table 3). Topographic, hydraulic and hydrological data.

Table 2 Previous models.

Data	Source	Format	Comments
ISIS-TUFLOW	EA	ISIS-TUFLOW	ISIS-TUFLOW hydraulic model developed in 2016, reviewed and accepted by the EA for flood mapping.
ESTRY-TUFLOW model	EWCC	ESTRY-TUFLOW	ESTRY-TUFLOW hydraulic model developed in 2018 by EWCC (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017).

Table 3 Summary of the main data used for the studies WP20 Modelling Report – Ickenham Stream Watercourse Diversion.

Data	Source	Format	Comments
DTM	EA – Open Government License	GIS-Ascii	Created from a 50-cm LIDAR with 1 m resolution. Downloaded in December 2018.
DTM of NR Chiltern Railway culvert surface	EWCC	GIS-Ascii	-
DTM of golf course filled in channels	EWCC	GIS-Ascii	Channels were filled in using modelling interpolation techniques and using a TIN of bank levels extracted from 50cm filtered LIDAR data.
River Pinn cross section data	EA EWCC	Shapefile (positions) and csv files (cross sections)	EA ISIS-TUFLOW 2016 model (1989 to 2014). Cross section survey data (December 2018).
Ickenham Stream cross section data	EWCC	Shapefile (positions) and csv files (cross sections)	Cross section survey data (December 2018).
Drainage ditches across the golf course cross sections	EWCC	Shapefile (positions) and csv files (cross sections)	Cross sections were derived from the 50 cm filtered LIDAR (EA December 2018).
Bank levels	EA EWCC	Shapefile	EA ISIS-TUFLOW 2016 model. New bank level data was created for the River Pinn using the 50 cm filtered LIDAR and considering the new cross section survey data.
River network	EWCC	Shapefile	Different river networks for each model scenario.
Hydrology	EWCC	ISIS input files	Detailed hydrological study of the River Pinn catchment used to provide the hydrological inflows for the hydraulic model.
Hydraulic roughness values	EA EWCC	Text file defining a value for each land use	The 2016 roughness values were informed from various guidance documents. The roughness values for the Ickenham stream and drainage ditches were informed from channel observation, survey data and the same guidance documents used by the EA in the EA ISIS-TUFLOW 2016 model.

5.2 Model update

5.2.1 The Temporary scenario TUFLOW model carried out by EWCC and fully explained in the *WP20 Modelling Report – Ickenham Stream Watercourse Diversion* (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017), was updated in order to include the new key structures of Scenario 1 and Scenario 2.

5.2.2 The document *WP20 Modelling Report – Ickenham Stream Watercourse Diversion* (Document no: 1EW02-CSJ-DS-REP-SS05_SL07-000017) shall be consulted for more details about:

- Topographic survey.
- Hydrological assessment.
- Calculation approach and general discussion of parameters used.
- Hydraulic model build.
- Model proving.

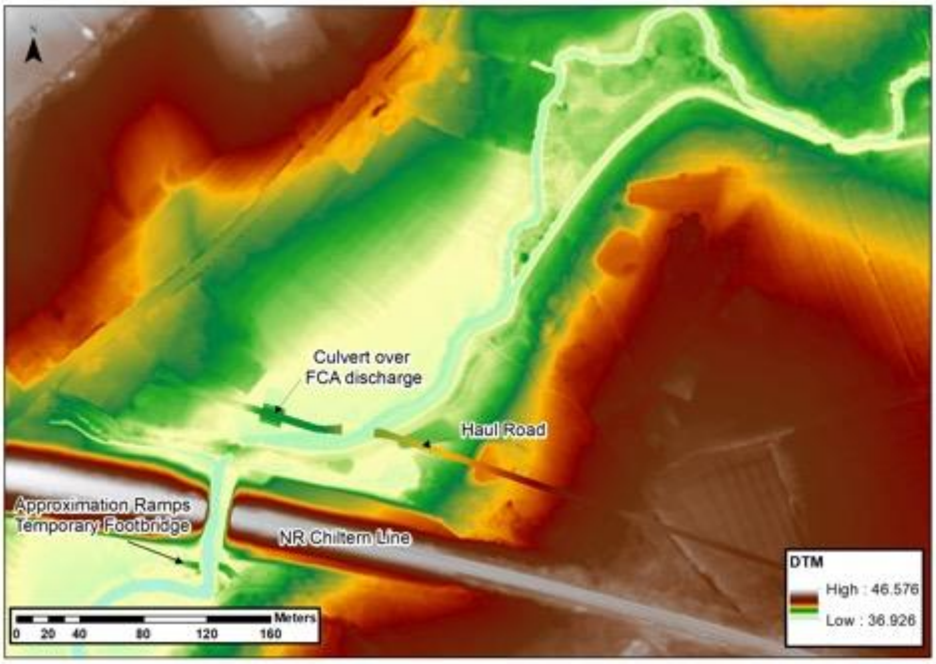
5.2.3 Table 4 shows the pieces of geometry used to update the model in order to reflect these new structures.

Table 4 Summary of the new geometry data.

Data	Source	Format	Comments
West Ruislip Haul Road geometry data	SCS	CAD (dgn)	Geometry of the temporary road (1MC04-SCJ-CL-DM3-SS05_SL07-905331; design of June 2020). Used to update the DTM of Scenario 1 and Scenario 2. Vertical earthworks are assumed.
Haul Road temporary bridge geometry data	SCS	CAD (dgn)	Geometry of the temporary bridge (design of January 2020). Used to set the bridge cross sections for its 1D modelling in Scenario 1 and Scenario 2. For the hydraulic modelling as the soffit level has been set 600 mm above the 1 in 30 years event according to the baseline scenario, water levels do not reach the deck of the bridge and only the abutments are modelled.
Temporary footbridge	SCS	CAD (dgn)	Geometry of the temporary bridge (1MC04-SCJ-EN-DM3-SS05_SL07 590009; design of February 2021). Used to set the bridge cross sections for its 1D modelling and to update the DTM with the approximation ramps in both Scenario 1 and Scenario 2.
Culvert over FCA discharge	SCS	CAD (dgn)	Geometry of the culvert (1MC04-SCJ-CL-DM3-SS05_SL07-905332; design of June 2020). Used to set its 1D modelling in Scenario 1 and Scenario 2.
River Pinn underbridge	SCS - Design House	CAD (dgn)	3D model of the geometry of the WRRE (1MC04-SCJ_SDH-ST-DM3-SS05_SL07-592311; design of November 2020). Water levels do not reach the deck of the bridge and only the wingwalls of the bridge are modelled. Used to update the DTM in Scenario 2.
West Ruislip Retained Embankment	SCS - Design House	CAD (dgn)	3D model of the geometry of WRRE (1MC04-SCJ_SDH-GT-DM3-SS05_SL07-531211; design of November 2020). Used to update the DTM in Scenario 2.
FCA	SCS - Design House	CAD (dgn)	Geometry of the temporary FCA (1MC04-SCJ_SDH-DR-DM3-SS05_SL07-590521; design of May 2020). Used to update the DTM in Scenario 2.

5.2.4 The DTM was updated for each scenario in order to include the new geometry. For Scenario 1 Figure 4 shows the appearance of the DTM in the surroundings of the WRRE, where most updates were done. Minor adjustments were done to the DTM of the golf course filled in channels in order to make it consistent with Haul Road proposed geometry.

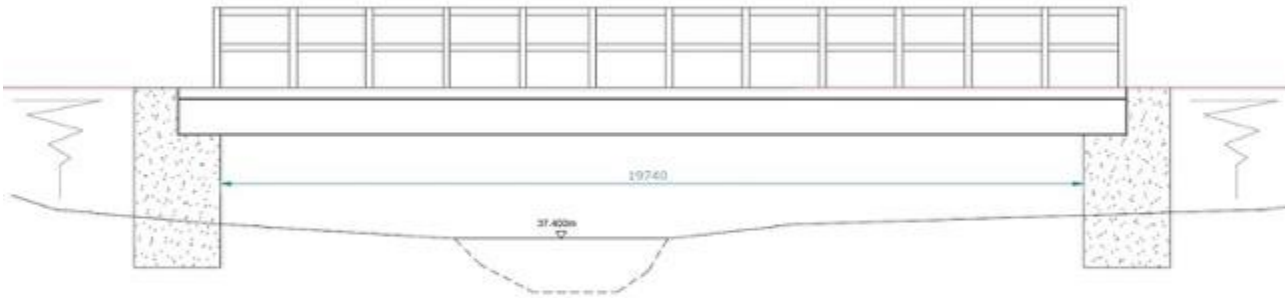
Figure 4 Appearance of the DTM for Scenario 1 after the updates. Surroundings of the WRRE. (DTM in m AOD).



5.2.5 Figure 5 and Figure 6 show a schematic representation of the characteristics of the Haul Road temporary bridge over the River Pinn and the temporary footbridge over the River Pinn south of the NR Chiltern Line, respectively.

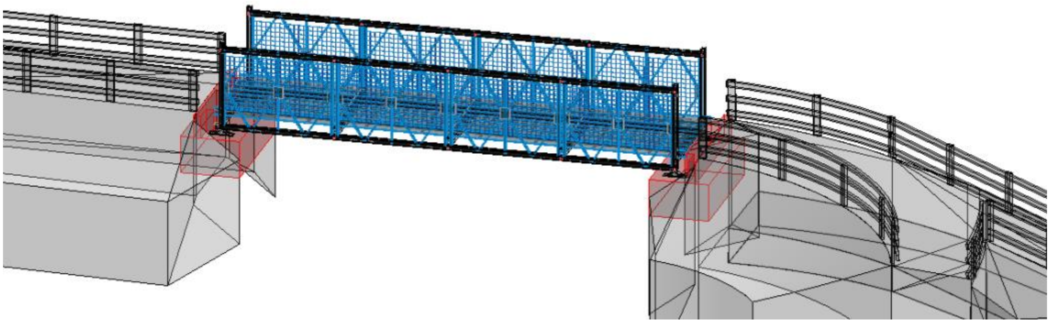
5.2.6 For the hydraulic modelling, the soffit level of the Haul Road temporary bridge has been set 600 mm above the 1 in 30 years event (Section 5.3) according to the baseline scenario. Minimum soffit level has been set at 39.22 m AOD.

Figure 5 Schematisation of the Haul Road temporary bridge over the River Pinn.



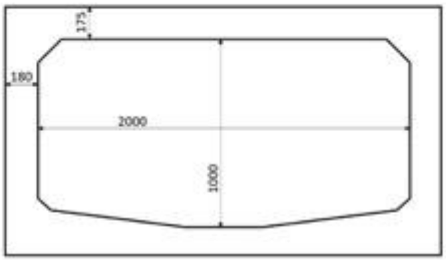
5.2.7 The temporary footbridge has a free span of 11 m and the soffit level is at 38.977 m AOD.

Figure 6 Schematisation of the temporary footbridge over the River Pinn south of the NR Chiltern Line.



5.2.8 Culvert structure over FCA discharge in Scenario 1 and Scenario 2 will be composed of 6 barrels with internal dimensions of 2.0 x 1.0m (Figure 7).

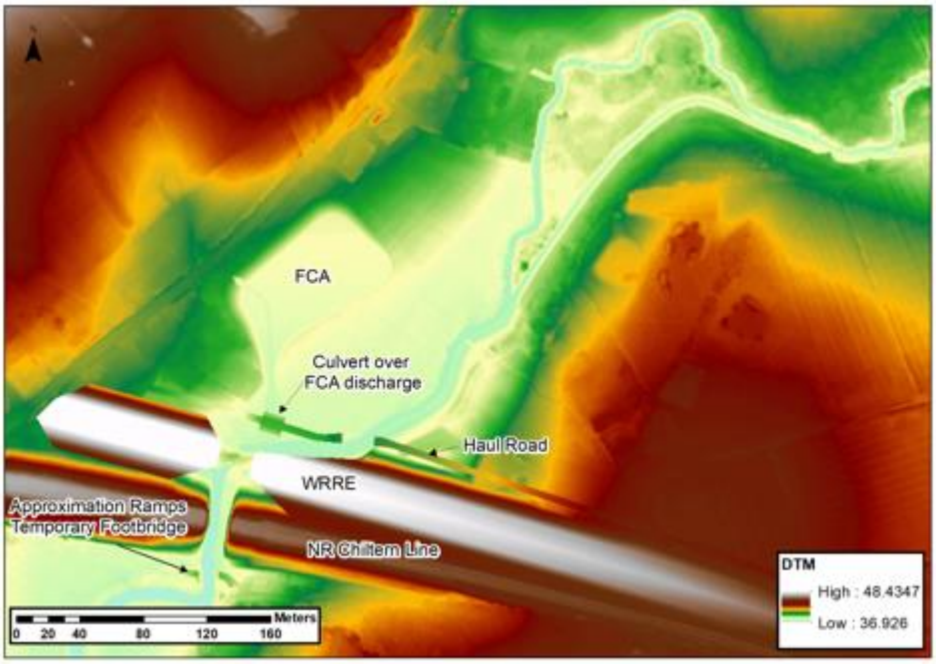
Figure 7 Box culvert drawing (dimensions in mm)



5.2.9 Figure 8 shows a schematic representation of the position and arrangement of the culverts over the DTM of Scenario 2. Figure 9 shows the appearance of the DTM in the surroundings of the WRRE for Scenario 2.

Figure 8 Culvert structure position. (DTM in m AOD).

Figure 9 Appearance of the DTM for Scenario 2 after the updates. Surroundings of the WRRE. (DTM in m AOD).



5.2.10 The previous DTM (Figure 9) was updated including the geometry of the Flood Compensation Area (FCA). The FCA has the following characteristics:

- It will be located at the right margin of the River Pinn floodplain, between the river and Breakspear Road South. Also, it will be located southwest of a pedestrian path that links the road with the path on the left bank of the river.
- Excavated flood compensation volume is around 3,925 m³.
- Useful flood compensation volume is around 3,668 m^3 (calculated using the 1 in 100 year + Climate Change event)
- Dimensions are approximately 103 m long and 66 m wide.
- Maximum excavation depth is around 1.5 m below ground level.
- Cutting slopes are 1V:8H and 1V:10H in the access area. Cutting slopes in the neck are 1V:4H. Due to the restrictions of the LLAU limits, it is not possible to accommodate 1V:8H slopes in the neck. However, the neck shall not be understood as agricultural land since it is a narrow area that needs to be kept clear to allow the discharge of water.

5.2.11 The following figures show the approximate geometry of the Flood Compensation Area. For more details, see drawings 1MC04-SCJ_SDH-DR-DPL-SS05_SL07-592001 and 1MC04-SCJ_SDH-DR-DSE-SS05_SL07-592201.

Figure 10 Layout of the FCA.

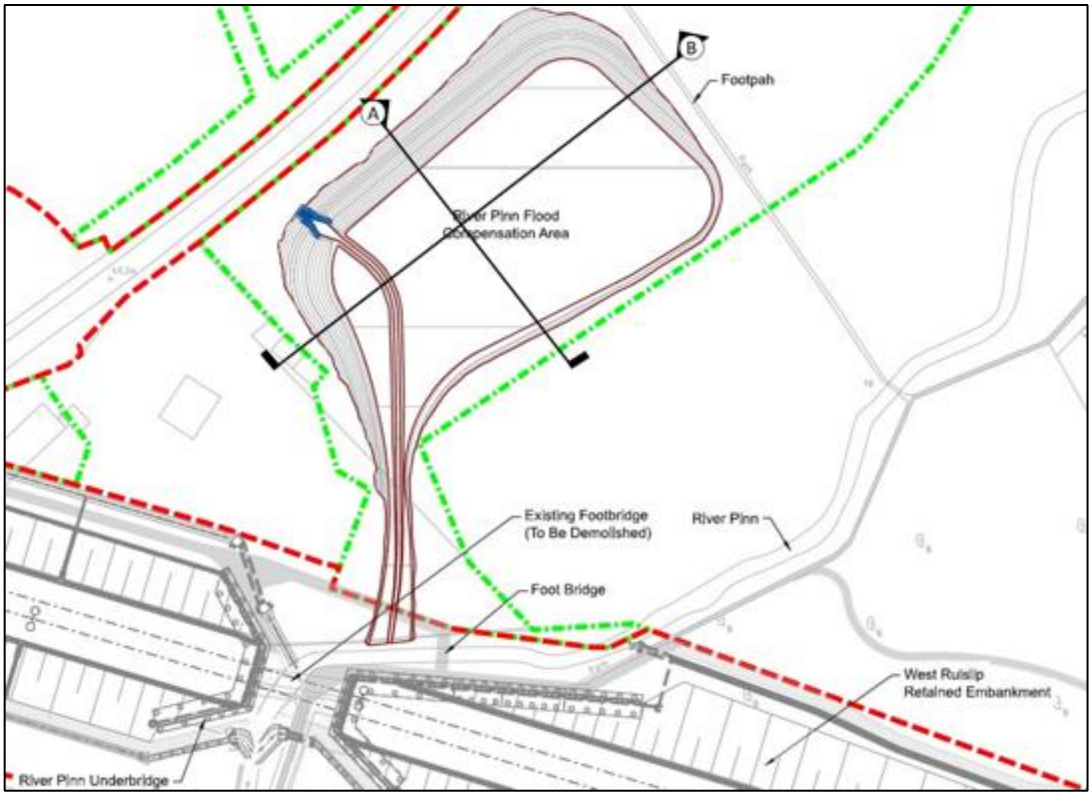
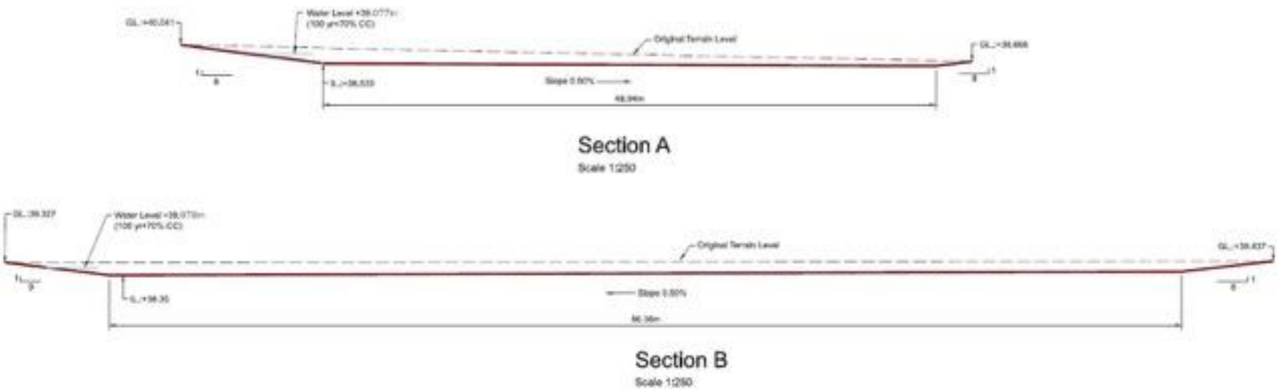


Figure 11 Sections of the FCA along the main axis.



5.3 Design flood event

5.3.1 Construction of HS2 structures in this area is estimated to have a maximum duration of 3 years. Assuming a reasonable 10% chance of exceedance, the 1 in 30 years event has been used as the most suitable return period to evaluate the risks related to the temporary works. In addition, since construction is estimated to last 3 years and to be carried out in the next few years, no climate change has been considered.

5.3.2 Table 5 shows the exceedance probability for different return periods and durations (structure life).

Table 5 Exceedance probability for different return periods.

Return Period	Exceedance probability	
	3 years	120 years
30 years	10%	98%
100 years	3%	70%
1000 years	0.3%	11%

5.3.3 Accordingly, the 1 in 30 years event was selected as a design flood event. This design flood event was used to evaluate the performance of the river and to check that all temporary structures (Haul Road temporary bridge, temporary footbridge and culvert over FCA discharge) accomplish the minimum freeboard requirements (600 mm if the structure is on a main river and 300 mm if it is not).

5.3.4 Additionally, as the study area is a flood zone 3, the performance of the river during the proposed scenarios were evaluated using a 1 in 100 years event.

6 Results

6.1 1 in 30 years event

6.1.1 The model simulation results indicate that the construction of the HS2 scheme does not produce an increase of the flood risk of the River Pinn.

6.1.2 For Scenario 1 a very minor increase in flood extent is expected, but it will not affect the properties located along the right riverbank of the River Pinn or next to Breakspear Road South (Figure 12).

6.1.3 An increase of water depth less than 0.05 m is also expected immediately upstream of the HS2 Haul Road and in the vicinity of the works, which acts as a barrier for the water (Figure 13). A significant increase in water depth is expected in the FCA discharge area, where an excavation will take place in order to accommodate the culverts which allow the FCA discharge.

6.1.4 In terms of hazard, only a few areas are expected to increase their hazard level and all in the vicinity of the works (Figure 14). The hazard has been calculated using the UK Hazard formula:

$$Hazard\ = d\ (v + 0.5) + DF$$

where *d* is depth, *v* is velocity and *DF* a debris factor. Flood hazard categories have been chosen according to the UK Hazard Rating guidance (FD2321) and are shown in Table 6:

Table 6 Flood hazard categories.

Hazard Level	Hazard rating	Hazard to people
0	0	No hazard
1	< 0.75	Very low hazard – Caution
2	075 – 1.25	Danger for some – includes children, the elderly and the infirm
3	1.25 – 2.50	Danger for most – includes the general public
4	> 2.50	Danger for all – includes the emergency services

6.1.5 Water overtops Haul Road on its west part; however, the rest of the area would remain dry. Hence, this shows both high water depth and hazard level reductions. The results of the Haul Road area shall not be compared since its construction makes comparison not effective.

6.1.6 The temporary footbridge has a negligible effect on flood risk, only showing a decrease in water depth and hazard in the area where the approximation ramps will be constructed. Due to the raise of the ground levels, this area will remain dry.

Figure 12 Flood extent comparison between Baseline and Scenario 1 for T30 return period.

Figure 13 Water depth difference between Baseline and Scenario 1 for T30 return period.

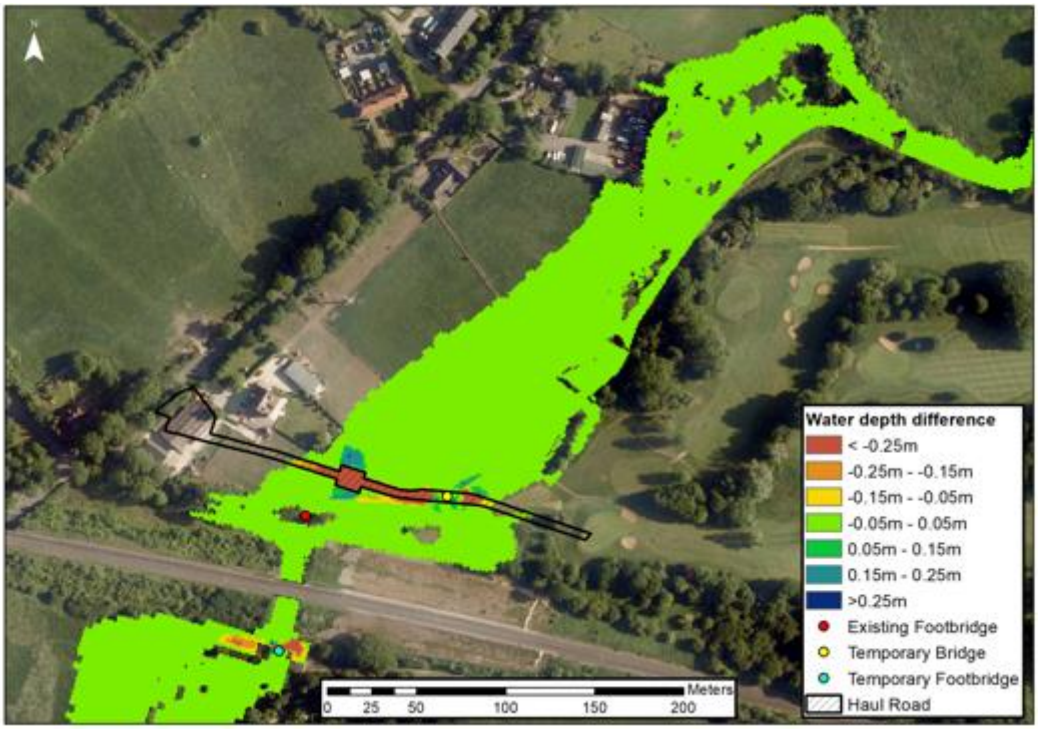
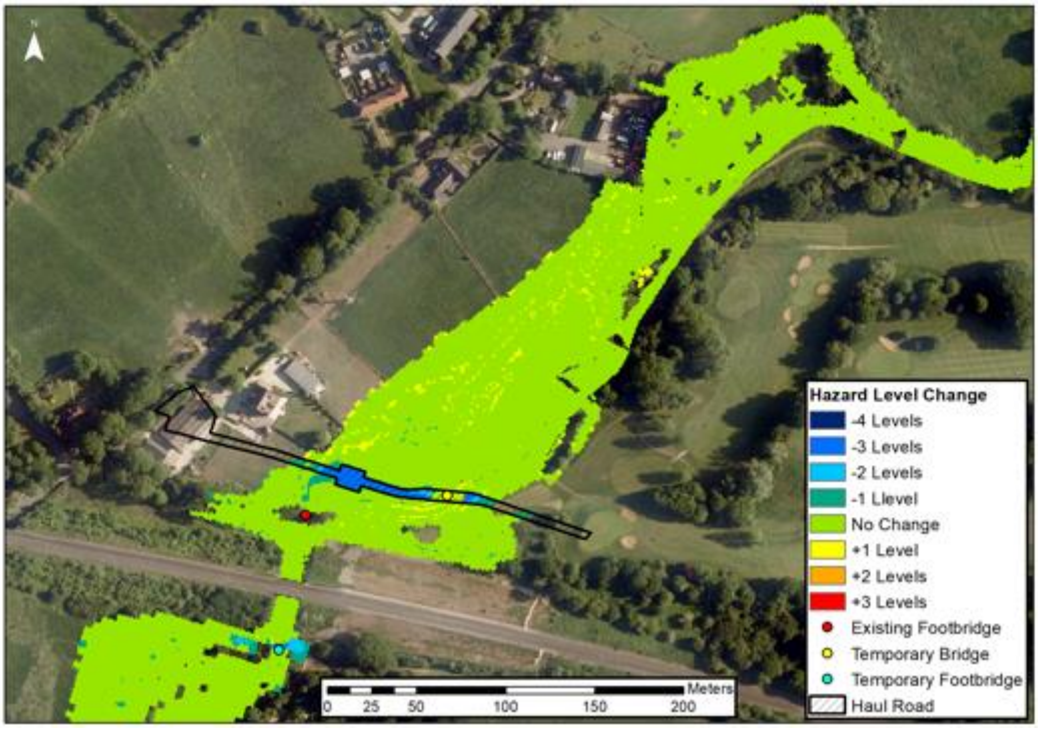


Figure 14 Hazard level change between Baseline and Scenario 1 for T30 return period.



6.1.7 For Scenario 2, the flood extent is restored to the Baseline Scenario (Figure 15). An increase of water depth of less than 0.05 m is expected immediately upstream of the Haul Road and in the vicinity of the works (Figure 16). In terms of hazard, only very limited locations outside the FCA are expected to increase their level and all of them in the vicinity of the works (Figure 17).

Figure 15 Flood extent comparison between Baseline and Scenario 2 for T30 return period.

Figure 16 Water depth difference between Baseline and Scenario 2 for T30 return period.

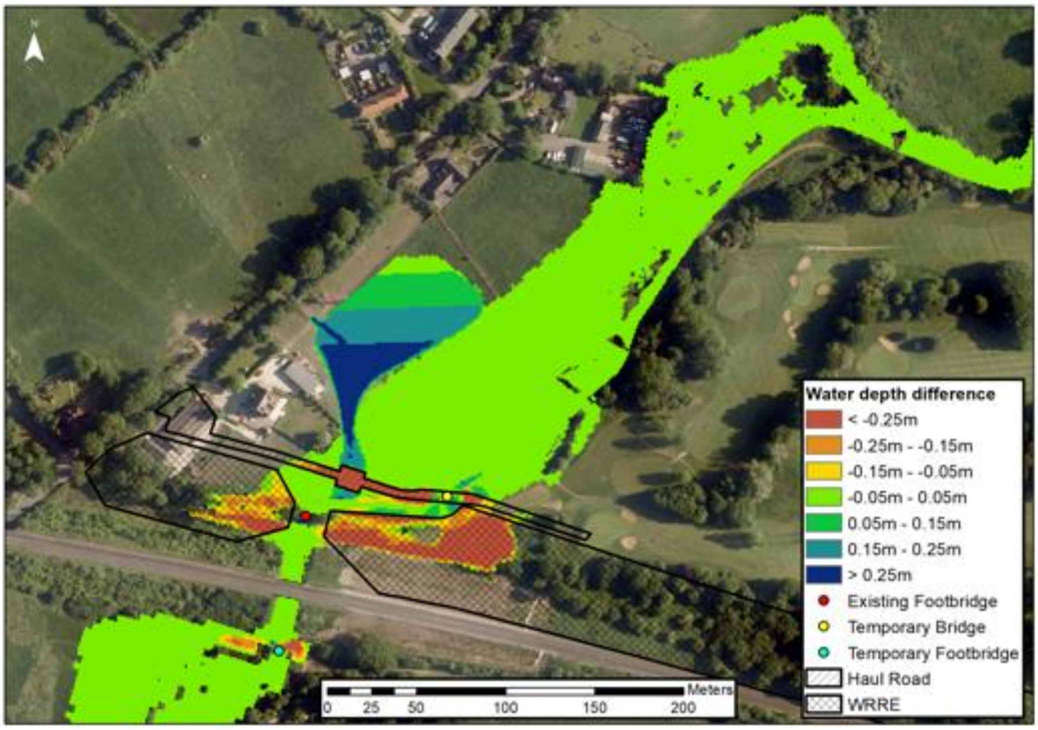
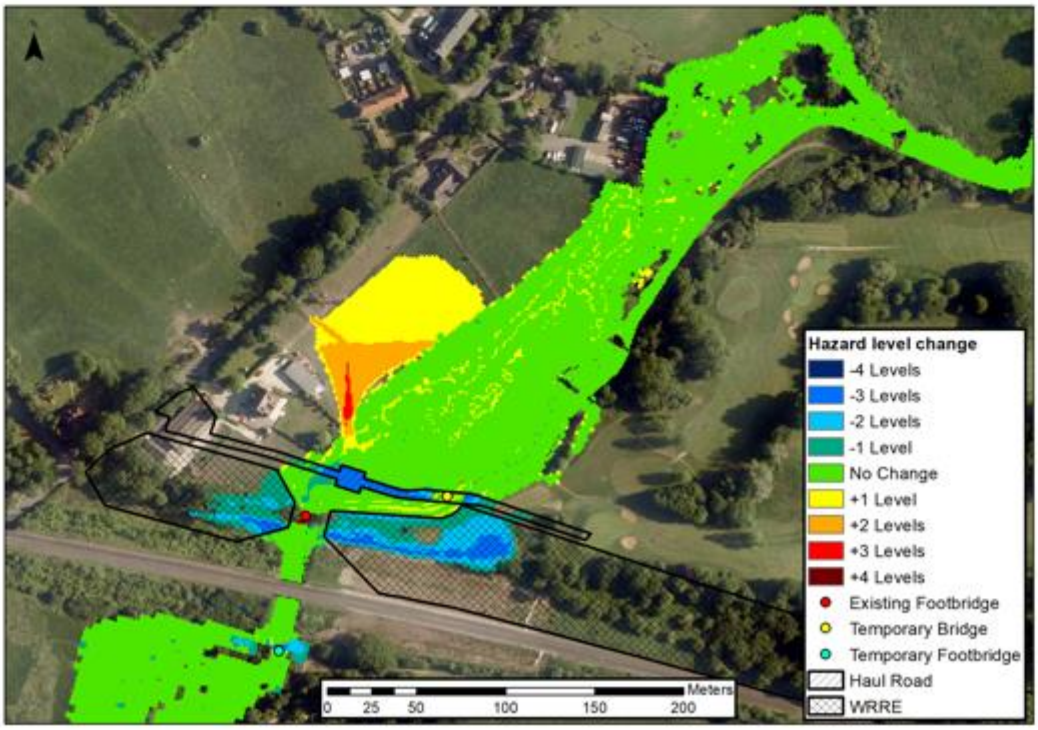


Figure 17 Hazard level change between Baseline and Scenario 2 for T30 return period.



6.1.8 For Scenario 2, water also overtops Haul Road on its west part, the rest of the area would remain dry. Hence, this shows both high water depth and hazard level change reductions. Similarly, the WRRE becomes a barrier for water, meaning that all the area where it will be constructed will remain dry. The results of these areas shall not be compared since their construction makes comparison not effective. The FCA is an area designed to be flooded and therefore, shows increments in water depth and hazard level. The temporary footbridge shows a negligible impact on flood risk and a decrease of water depth and hazard in the area where the approximation ramps will be constructed.

6.1.9 The freeboards for the Haul Road temporary bridge and the temporary footbridge are shown in Figure 18 and Figure 19, respectively. Both structures present the required minimum freeboard of 600 mm for a 1 in 30 years event. In the case of the culvert over FCA discharge, the minimum required freeboard is 300 mm, since it is not on the main channel. Figure 20 shows the freeboards and those are over 300 mm. Table 7 shows the minimum freeboard for each structure.

Table 7 Minimum freeboard for each structure.

Structure	1 in 30 years event		1 in 100 years event	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Haul Road temporary bridge	0.62 m	0.61 m	0.39 m	0.45 m
Temporary footbridge	0.62 m	0.62 m	0.38 m	0.38 m
Culvert over FCA discharge	0.38 m	0.37 m	0.14 m	0.20 m

Figure 18 Freeboards in Haul Road temporary bridge for T30 return period.

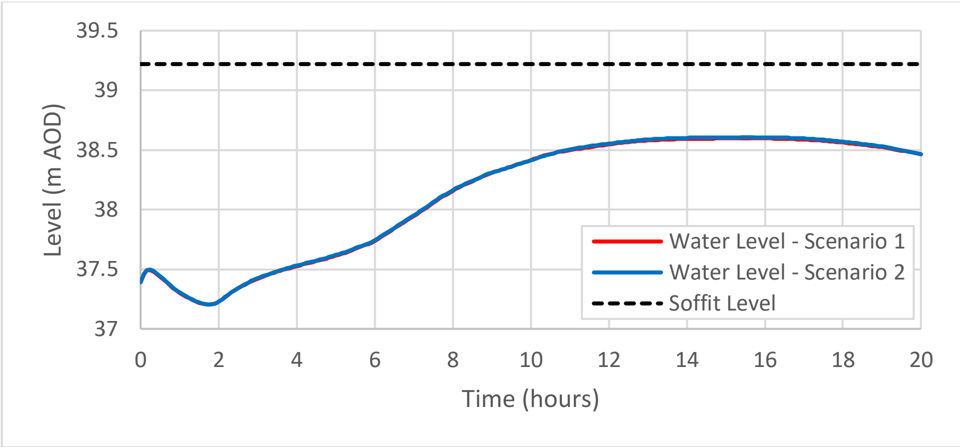


Figure 19 Freeboards in the temporary footbridge for T30 return period.

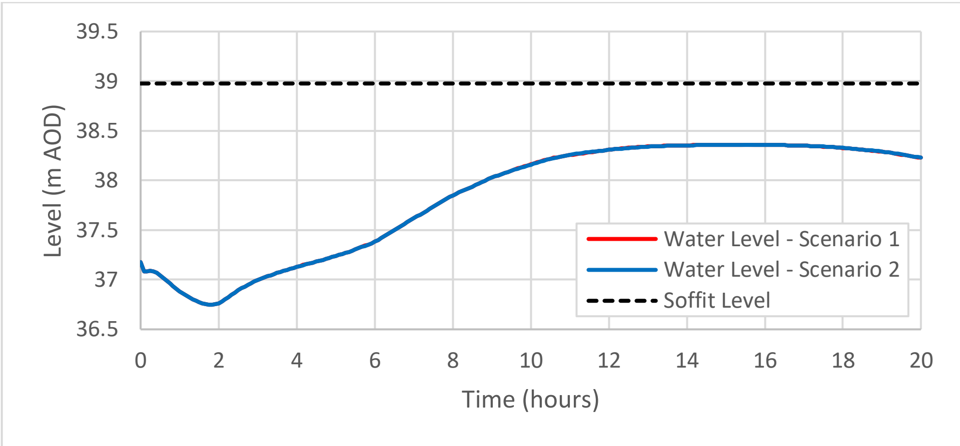
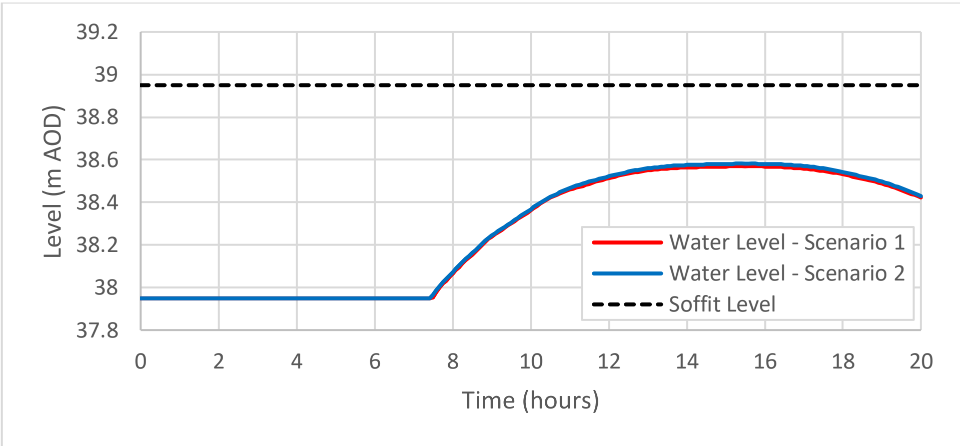


Figure 20 Freeboards in the culvert over FCA discharge for T30 return period.



6.1.10 Effects further upstream of Haul Road and downstream of the River Pinn Underbridge are negligible for both Scenario 1 and Scenario 2.

6.1.11 In the case of the results in the West Ruislip Golf Course area for both Scenario 1 and Scenario 2, water depths and flood extents shall not be compared since the diversion of the Ickenham Stream and the redevelopment of the golf course make comparisons not effective. However, it should be highlighted that the model results indicate that water depths are approximately the same as in the Baseline Scenario and that water extent does not affect any property.

6.1.12 The impact of the HS2 Scheme in the Ickenham Stream is analysed as part of the Flood Risk Assessment in West Ruislip area (WIP at the date of this document submission, document 1MC04-SCJ_SDH-EV-ASM-SS05_SL07-000005, Flood Risk Assessment - West Ruislip Portal and Retained Embankment - West Ruislip Area Structures S2). The temporary works in West Ruislip Retained Embankment and the River Pinn Underbridge (which are the ones analysed in this report) have no impact on the Ickenham Stream flood risk.

6.2 1 in 100 years event

6.2.1 As previously stated, both scenarios were also evaluated using a 1 in 100 years event. The results indicate that the construction of the HS2 scheme does not produce an increase in flood risk.

6.2.2 For Scenario 1 a very minor increase in flood extent is expected (Figure 21). An increase of water depth less than 0.05 m is expected immediately upstream of the HS2 Haul Road and in the vicinity of the works (Figure 22). Only a few areas are expected to increase their hazard level and all are in the vicinity of the works (Figure 23). The temporary footbridge shows a negligible impact on flood risk.

Figure 21 Flood extent comparison between Baseline and Scenario 1 for T100 return period

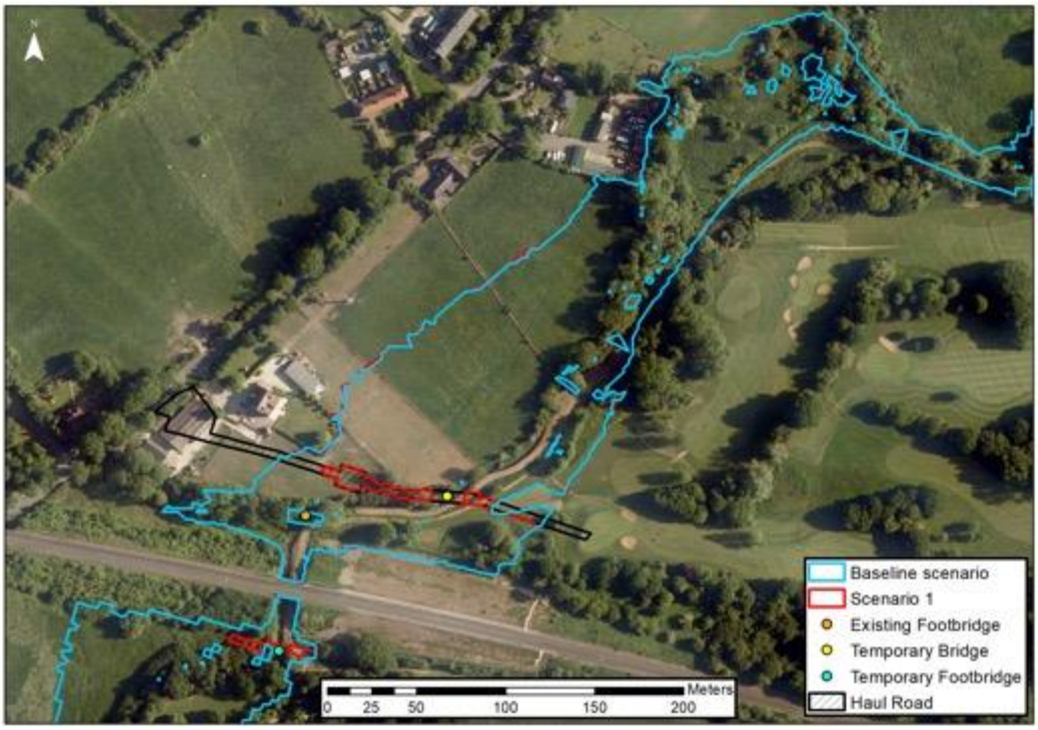
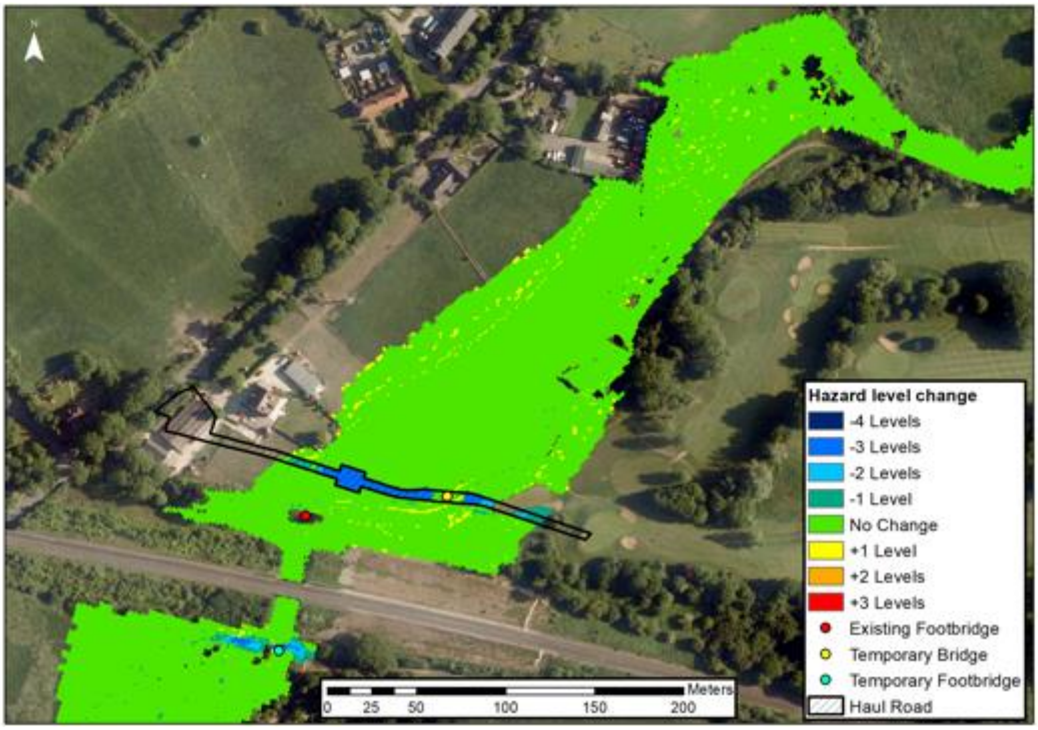


Figure 22 Water depth difference between Baseline and Scenario 1 for T100 return period.

Figure 23 Hazard level change between Baseline and Scenario 1 for T100 return period.



6.2.3 For Scenario 2, the flood extent is restored to the Baseline Scenario (Figure 24) and an increase of water depth of less than 0.05 m is expected immediately upstream of the HS2 Haul Road and in the vicinity of the works (Figure 25). In terms of hazard, only very limited locations outside the FCA and WRRE are expected to increase their hazard level and all of them are in the vicinity of the works (Figure 26). The temporary footbridge shows a negligible impact on flood risk.

Figure 24 Flood extent comparison between Baseline and Scenario 1 for T100 return period

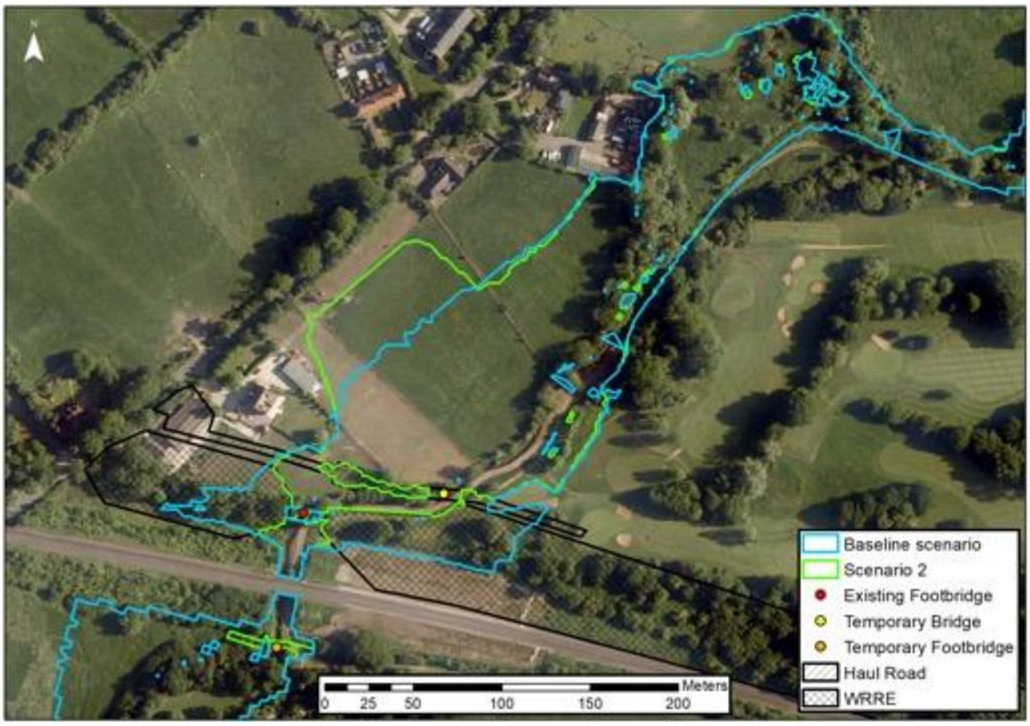


Figure 25 Water depth difference between Baseline and Scenario 2 for T100 return period.

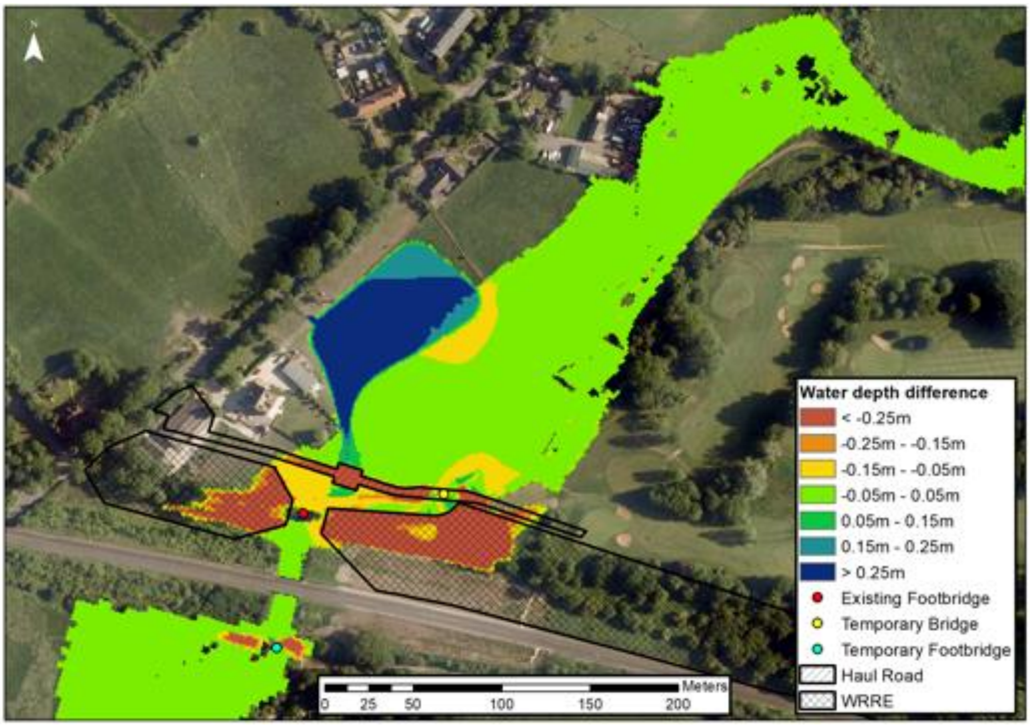
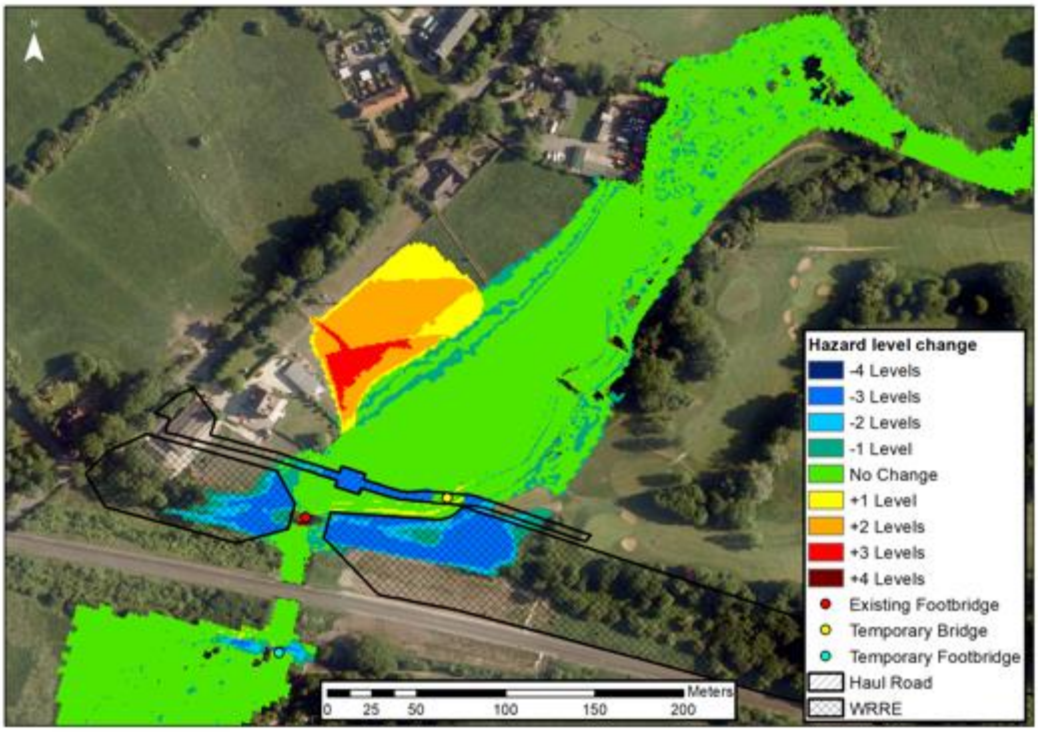


Figure 26 Hazard level change between Baseline and Scenario 2 for T100 return period.



6.2.4 The minimum freeboards in the case of the 1 in 100 years event are not met, however, it should be highlighted that it is not the design event.

6.2.5 Figure 27, Figure 28 and Figure 29 show the freeboards for the Haul Road temporary bridge, the temporary footbridge and the culvert over FCA discharge, respectively. Table 7 shows the minimum freeboard for each structure.

Figure 27 Freeboards in Haul Road temporary bridge for T100 return period.

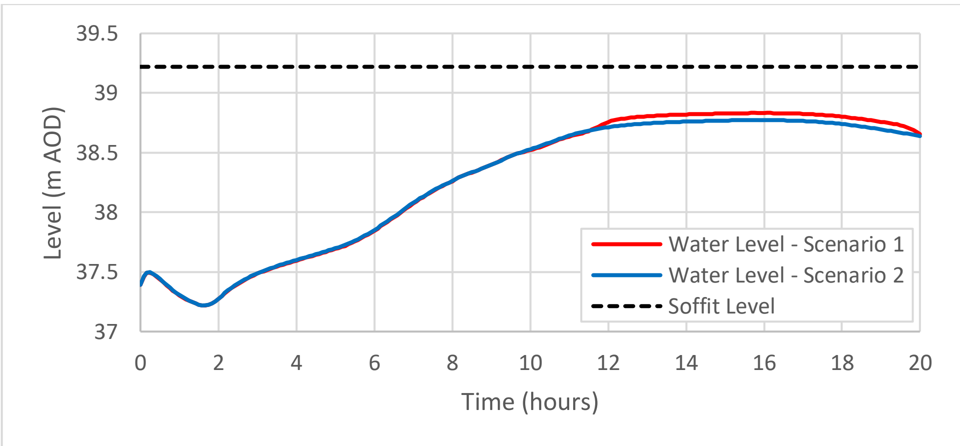


Figure 28 Freeboards in the temporary footbridge for T100 return period.

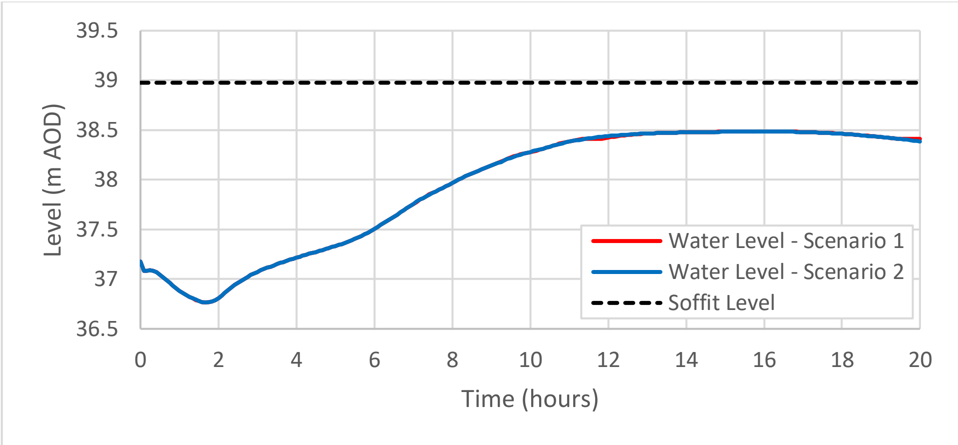
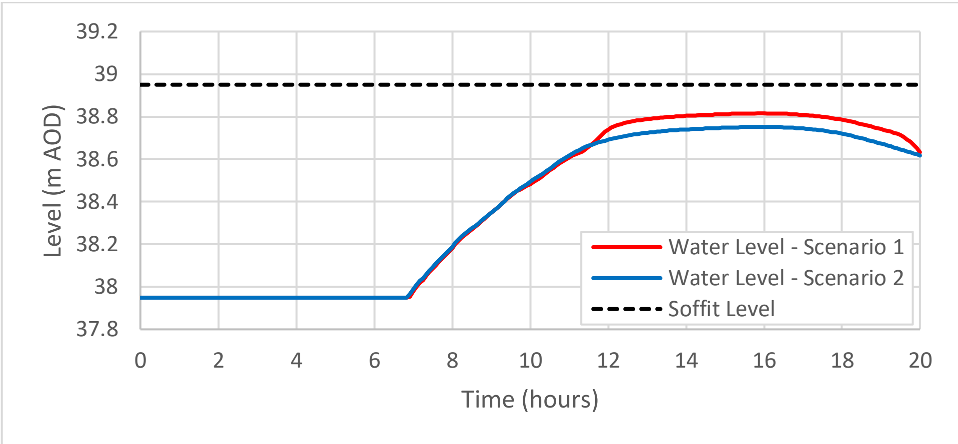


Figure 29 Freeboards in culvert over FCA discharge for T100 return period.



6.2.6 Effects further upstream of Haul Road and downstream of the River Pinn Underbridge are negligible for both Scenario 1 and Scenario 2.

6.2.7 In the case of the results in the West Ruislip Golf Course area for both Scenario 1 and Scenario 2, water depths and flood extents shall not be compared since the diversion of the Ickenham Stream and the redevelopment of the golf course make comparisons not effective. However, it should be highlighted that the model results indicate that water depths are approximately the same as in the Baseline Scenario and that water extent modification does not affect any property.

6.2.8 The impact of the HS2 Scheme in the Ickenham Stream is analysed as part of the Flood Risk Assessment in West Ruislip area (WIP at the date of this document submission, document 1MC04-SCJ_SDH-EV-ASM-SS05_SL07-000005, Flood Risk Assessment - West Ruislip Portal and Retained Embankment - West Ruislip Area Structures S2). The temporary works in West Ruislip Retained Embankment and River Pinn Underbridge (which are the ones analysed in this report) have no impact on the Ickenham Stream flood risk.

6.3 Graphic results

6.3.1 Graphic results have been included in Appendix A, below. The results comprise a number of maps for the three scenarios, including the following maps:

Table 8 Summary of maps included in Appendix A

Section	Map	Scenario
1	Maximum flood extent	Baseline
2	Maximum flood extent	Scenario 1
3	Maximum flood extent	Scenario 2
4	Model node points	Baseline
5	Model node points	Scenario 1
6	Model node points	Scenario 2
7	Model points 1D results	Baseline
8	Model points 1D results	Scenario 1
9	Model points 1D results	Scenario 2
10	Maximum flood depth	Baseline
11	Maximum flood depth	Scenario 1
12	Maximum flood depth	Scenario 2
13	Maximum velocity	Baseline
14	Maximum velocity	Scenario 1
15	Maximum velocity	Scenario 2
16	Flood hazard	Baseline
17	Flood hazard	Scenario 1
18	Flood hazard	Scenario 2
19	Maximum flood extent comparison	Baseline – Scenario 1
20	Maximum flood extent comparison	Baseline – Scenario 2
21	Maximum flood extent comparison	Baseline – Scenario 1 – Scenario 2
22	Flood depth difference	Scenario 1 - Baseline
23	Flood depth difference	Scenario 2 - Baseline
24	Hazard level change	Scenario 1 - Baseline
25	Hazard level change	Scenario 2 - Baseline

7 Main conclusions

7.1.1 The most unfavourable scenarios during the construction of the HS2 scheme have been modelled. The results indicate that the temporary works required for the construction of the HS2 scheme do not produce an increase in flood risk of the River Pinn.

7.1.2 Although Scenario 1 does not include any mitigation measure, the effect produced by the construction of Haul Road, the temporary bridge over the River Pinn and the temporary footbridge over the River Pinn south of NR Chiltern Line is negligible in terms of flood risk.

7.1.3 Scenario 2, which already includes the most updated design of the HS2 structures, includes two mitigation measures:

- Removal of the footbridge currently placed over the River Pinn immediately upstream of the NR Chiltern Line overbridge (over the River Pinn).
- Flood Compensation Area.

7.1.4 The existing footbridge over the River Pinn is placed on the location where the new HS2 River Pinn Underbridge is proposed. The hydraulic interaction between both, represents a constraint to the river flow, since the hydraulic capacity of the river section decreases.

7.1.5 It has been checked that it is not possible to completely mitigate the water level increase by means of a Flood Compensation Area located inside the LLAU. For this reason, removal of the footbridge is essential. More details can be found in document 1MC04-SCJ_SDH-EV-REP-SS05_SL07-000003, Flood Risk Assessment Report - Flood Compensation Area - River Pinn Underbridge S2 (Scheme Design).

7.1.6 After removing the existing footbridge, the proposed Flood Compensation Area is able to mitigate the effects of the construction of the River Pinn Underbridge and the West Ruislip Retained Embankment during the temporary works.

8 Standards and references

8.1.1 The references shown in Table 10 have been reviewed in order to guarantee that the network design meets both the mandatory standards and the good practices guidelines:

Table 9 Standards and references.

HS2 Standards and Guidelines	
HS2-HS2-DR-STD-000-000001	Technical Standard - Cross Drainage
HS2-HS2-EV-STD-000-000011	Technical Standard - Flood Risk
HS2-HS2-DR-STD-000-000003	Technical Standard - Railway Drainage
HS2-HS2-DR-STD-000-000005	Technical Standard – Land Drainage
HS2-HS2-EV-STD-000-0000013	Technical Standard Fluvial Hydraulic Modelling
HS2-HS2-EV-STR-000-000022	Approach Document: Climate Change Allowances for Flood Risk Assessments and Drainage Design.
HS2-HS2-EV-STR-000-000028	Quality Assurance framework for Hydraulic Modelling.
Previous studies	
1EW02-CSJ-DS-REP-SS05_SL07-000017	*WP20 Modelling Report – Ickenham Stream Watercourse Diversion*
Related Flood Risk Assessments	
1MC04-SCJ_SDH-EV-REP-SS05_SL07-000003	*Flood Risk Assessment Report – Flood Compensation Area – River Pinn Underbridge S2*
1MC04-SCJ_SDH-EV-ASM-SS05_SL07-000005	*Flood Risk Assessment - West Ruislip Portal and Retained Embankment - West Ruislip Area Structures S2*

Appendix A. Layouts from the model

1 Maximum flood extent map. Baseline scenario

2 Maximum flood extent map. Scenario 1

3 Maximum flood extent map. Scenario 2

4 Model node points map. Baseline scenario

5 Model node points map. Scenario 1

6 Model node points map. Scenario 2

7 Model points 1D result map. Baseline scenario

8 Model points 1D result map. Scenario 1

9 Model points 1D result map. Scenario 2

10 Maximum flood depth map. Baseline Scenario

11 Maximum flood depth map. Scenario 1

12 Maximum flood depth map. Scenario 2

13 Maximum velocity map. Baseline Scenario

14 Maximum velocity map. Scenario 1

15 Maximum velocity map. Scenario 2

16 Flood hazard mapping. Baseline Scenario

17 Flood hazard mapping. Scenario 1

18 Flood hazard mapping. Scenario 2

19 Maximum flood extent comparison map. Baseline – Scenario 1

20 Maximum flood extent comparison map. Baseline – Scenario 2

21 Maximum flood extent comparison map. Baseline – Scenario 1 – Scenario 2

22 Maximum flood depth difference map. Baseline – Scenario 1

23 Maximum flood depth difference map. Baseline – Scenario 2

24 Flood hazard change map. Baseline – Scenario 1

25 Flood hazard change map. Baseline – Scenario 2

Appendix B. Hydraulic modelling log

1 File logs

- **Return Period:** 30 and 100 years
- **Event File:** 23480_EST.tef
- **Geometry:** 23480_EST_Dom1_001.tgc
  23480_EST_Dom2_001.tgc
- **Hydraulic parameters:** 23480_EST.tmf
- **Boundaries:** 23480_EST_Dom1_001.tbc
  23480_EST_Dom2_001.tbc
- **Simulation:** 23480_EST_~s1~_~e1~.tcf
- **Scenarios:**
  - Baseline BAS_DES
  - Scenario 1 TEM1_DES
  - Scenario 2 TEM2_DES

2 Simulation summary

2.1 Simulation characteristics are common for all scenarios:

- **Software**
  - Software 1D-2D ESTRY-TUFLOW model
  - Version 2018-03-AD
- **Design events**
  - 30 years 0030
  - 100 years 0100
- **Simulation**
  - Model schematisation
    - 2D domain grid size 2m
  - Run settings
    - Start time 0 hours

    - End time 20 hours
    - 1D Timestep 0.5 seconds
    - 2D Timestep 1 second
  - Initial conditions
    - Initial water level in river watercourse
    - 2D floodplain cells start dry

3 Run performance

3.1 This ESTRY-TUFLOW model presents Final Cumulative Mass Error within the range ±1% in all scenarios and return periods. This range is normally used to define a healthy model.

3.2 A spike is observed in the 1D ESTRY domain at the start of the simulation, but this quickly returns to oscillate around 0%. A spike is also observed in the 2D TUFLOW domain in domain 1 but returns to zero before the flood peak.

3.3 Model results are stable with smooth changes in the model simulated volume.