Flood Risk Assessment

Wallingford Mineral Workings

Revision D

14 November 2023

Greenfield enviro

EdenvaleYoung

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Glossary of Terms

- +CC - Return period inclusive for the predicted effects of Climate Change
- 1D - One-Dimensional
- 2D - Two-Dimensional
- AMAX - A series containing the peak flows recorded at a gauge from each year
- AOD - Above Ordnance Datum (0m sea level, Newlyn, UK)
- Channel Cross Section - profile view of a river channel, normally obtained by surveying a line across the watercourse
- Critical Storm - A storm that produces peak run off in the watershed
- Culvert - A device used to channel water, similar to a pipe though may be larger
- Defended - A scenario in which river defences are used
- FEH - Flood Estimation Handbook
- Fluvial - Referring to the processes associated with rivers and streams
- FRA - Flood Risk Assessment
- GIS - Geographic Information System
- Hydraulic Model - The mathematical process of analysing the interaction of water and the connected environment
- Hydrology - The calculation of catchment based flow rates
- Inflow - Source of water within a modelled domain
- ISIS Software - One-Dimensional hydraulic model – Representation of watercourses
- ISIS-TUFLOW - Hydraulic program that dynamically links ISIS and TUFLOW (1D-2D)
- LiDAR - Light Detection And Ranging, remote sensing technology to measure distance typically used to obtain topographic data over a large area
- Outflow - The method by which water may leave a modelled area
- Overtopping - Where water has passed over a feature that might ordinarily prevent flow
- f100 - 1% annual probability fluvial event
- f1000 - 0.1% annual probability fluvial event
- f100CC - 1% annual probability fluvial event with an allowance for the predicted effects of climate change
- fMED - The median of the set of annual maximum flow data (AMAX)
- TUFLOW Software - Two-Dimensional hydraulic model – Representation of floodplain
- Undefended - A scenario in which river defences are ignored

1 Introduction

1.1 Background

Edenvale Young Associates was commissioned by Greenfield Environmental to undertake a Flood Risk Assessment (FRA) for a proposed mineral extraction scheme at White Cross Farm on the River Thames to the south of Wallingford in Oxfordshire (see Figures 1.1 and 1.2). The objective of the FRA is to support a planning application for the removal of sand and gravel with restoration to agriculture and ecological end uses.

The site is situated on greenfield agricultural land on the right bank of the River Thames to the south of Nosworthy Way (A4130) and to the east of the Reading Road (A329). Minerals will be extracted over a period of approximately five years and the resulting excavation will be backfilled with inert material in four phases with the land restored to the original levels.

The scope of the Flood Risk Assessment includes:

- A description of the development proposals
- A review of historical flood risk to the site
- A review of the Strategic Flood Risk Assessment for the area
- An assessment of flood risk from the River Thames, surface water, reservoirs, groundwater and sewers
- A discussion on the application of the National Planning Policy Framework (NPPF)
- Hydraulic modelling to evaluate impact of the works on flood risk

This document does not address issues associated with drainage.

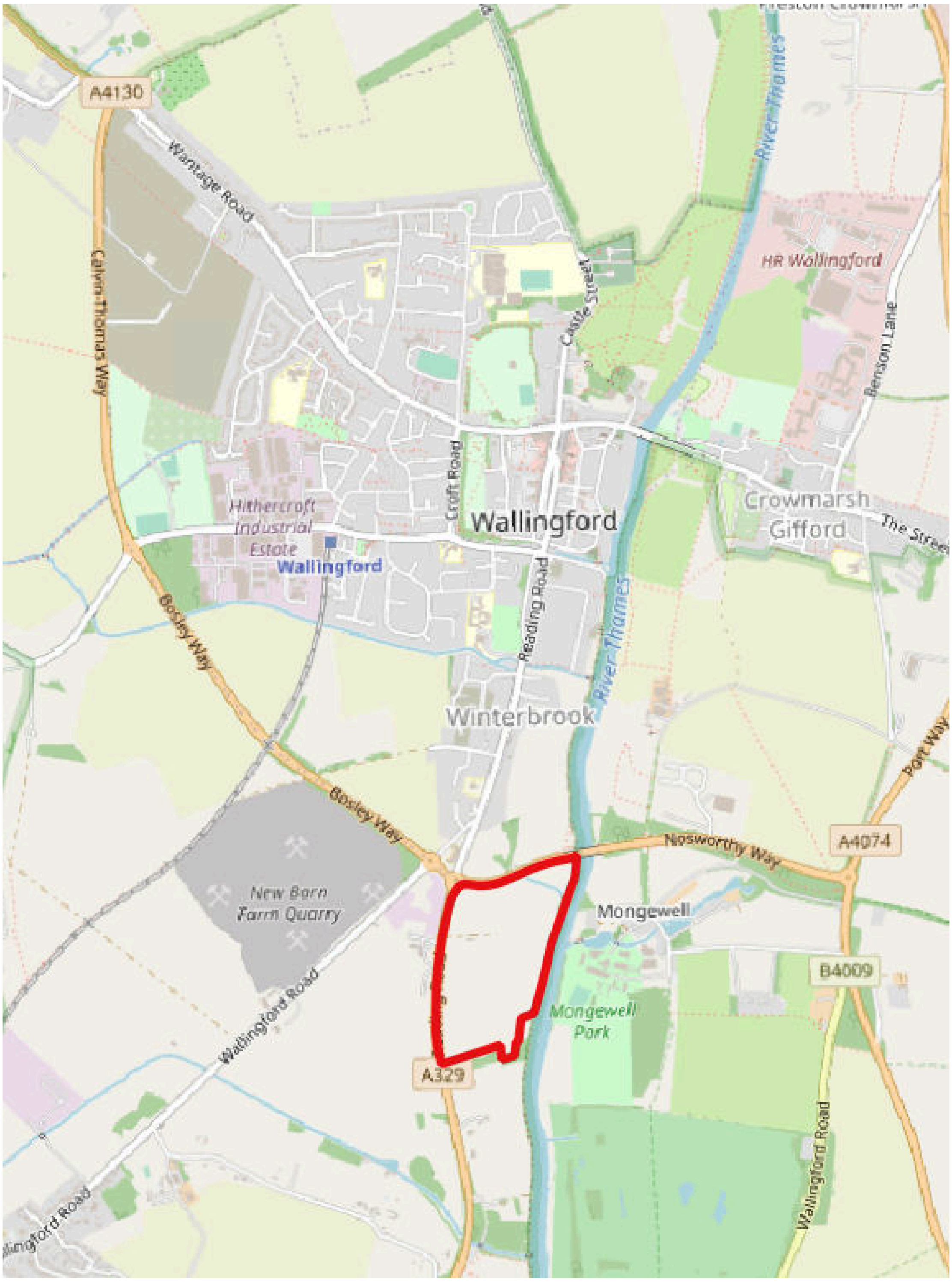


Figure 1.1: Location (Grid Reference 460420,187940

Figure 1.2: Development Outline (red)

1.2 Consultation with the EA

A range of documentation has been exchanged during the period of the planning application in relation to the FRA and hydraulic modelling. As a result a number of changes have been implemented including the incorporation of an updated climate change allowance for the 2020s. In April Edenvale Young issues a Technical Note associated with the modelling which addressed a number of issues raised by the EA. This is included as Appendix C.

In June of 2023 the EA undertook their second formal review of the model and issued the review together with a letter confirming their continuing objection to the scheme. In relation to the hydraulic modelling review the EA highlighted two significant points of concern. The first page of the review stated that:

"There is one major concern with the model which is the increase in the cell size from 10m to 20m. This is a very large cell size which may not be accurately representing flow paths. Please return the cell size to 10m or provide evidence that the increase in cell size is not negatively impacting the models ability to accurately represent reality (also see amber comment under calibration on comparing with previous model). Please also see other amber (LiDAR date, model boundary glass walling and lowered zpt warning) and green comments for other concerns."

The Environment Agency also highlighted the fact that the hydraulic modelling indicates that water levels would increase during the excavation of minerals on the flood plain. The Environment Agency considers this to be unacceptable stating that:

"Also, it is stated that the impact on third parties will be negligible, but we cannot accept any increase in flood level and therefore we maintain our position that the applicant should demonstrate there are no offsite impacts."

In response to the above Edenvale Young and Simon Heaton met with the Environment Agency and the Local Planning Authority On the 23 August 2023 to discuss the way forward. The discussion was recorded by Simon Heaton and his notes are given below.

Simon Heaton's notes of the meeting with the EA and LPA

Those present

- Mary Hudson - Oxfordshire County Council
- Judith Johnson - EA
- Neil Landricombe - EA
- Simon Heaton - Planning Consultant
- John Young - Edenvale Young
- Peter Aylett - Edenvale Young

The notes given below relate to specific points attributed to Neil Landicombe (a flood risk expert brought in to help on the case). As follows:

- Neil Landicombe is interested in seeing the latest results presented in a revised FRA, rather than undertaking a re-review of the model. The FRA should include the explanation of modelling issues (mass balancing) and tolerances, explain any adjustments to the scheme, demonstrate no off-site 1 in 100 year increase in flooding outside a tolerance of 10mm and demonstrate some overall improvement in flood water storage capacity.
- Neil Landicombe would welcome some adjustment to the site/scheme configuration (phasing/timescales/stockpiles?)/restoration (a little more wet woodland/swale within the floodplain grazing marsh in the NE corner?)to demonstrate that we are creating additional flood water storage capacity.
- Neil Landicombe stated that if we can demonstrate that any off site increase in flood levels are within a 10mm tolerance then the EA's objection will be removed.
- Neil Landicombe has no issue with the use of the 20m grid in the latest modelling and acknowledges the benefit of doing this in relation to mathematical anomalies.

Revision C of the FRA discuss the accuracy of the model in relation to third party flood risks, the 10m and 20m grid selection and LiDAR. Responses to matters relating to glass walling, zpts and the green comments contained in the review document, were addressed in the spreadsheet.

However, it should be noted that glass walling and many of the green comments are present within the baseline model supplied to Edenvale Young by the Environment Agency.

1.3 Hydraulic Modelling

Hydraulic modelling has been undertaken using the existing 1D-2D FMP-TUFLOW hydraulic model for the River Thames which was developed by JBA and supplied by the Environment Agency to Edenvale Young following a Product 7 request. The short five year duration of the sand and gravel extraction phase means that the model has been run for existing baseline and ten excavation stages for the, 1% AEP (1 in 100 year) with an allowance for climate change.

1.4 Appendices

The FRA should be read in conjunction with the following Appendices:

- Appendix A – Development Proposals
- Appendix B – Hydraulic Modelling Results

2 Scheme Proposal

The development proposals are included in Appendix A. Extracts from the drawings contained in the appendices are shown in Figures 2.1 to 2.3. As noted in the introduction, the scheme comprises:

- Establishment of the site
- Excavation of minerals (sand and gravel) in ten excavation stages.
- Placing of inert fill within the excavation formed during Phases 1 to 4.
- Restoration and landscaping.

Plant and supporting infrastructure will be established on site before excavation commences. The processing area will include: a lagoon, stockpile, loading facilities, a weighbridge and offices on the north western corner of the site. In addition three earth bunds will be constructed on the north and western edge of the site to shield the works from the highway. The stockpiles, bunds, loading facilities, a weighbridge and offices will be located Flood Zone 1 and are at low risk of flooding. Earth moving equipment and diesel generators will be moved to higher ground on receipt of a flood warning.

Figure 2.1 shows the phasing of the work activities which will be programmed over a period of five years. There are ten excavation stages to the works and within the four phases of work. Figure 2.2) shows the excavation stages SP1 to SP10. As noted above each area would be opened, minerals reclaimed and backfilled before the next phase. These excavation stages have been modelled in detail.

The works will proceed systematically with areas excavated and then backfilled in sequence. Phase 1 will be excavated and backfilled to within 0.5m of the finished level by the end of the Phase 2 excavation stage. The final restored level for Phase 1 would be completed by the end of Phase 3.

Stockpiling area will remain in situ for the duration of the mineral working with sand and gravel moved into the areas before being exported from the site. At no stage during the mineral workings will there be a hydraulic connection to the River Thames.

Figure 2.3 shows the final restoration plan. The restored site will include an area of sunken wet woodland to the north which will be left below the general lie of the adjacent land by approximately 0.5m. This will function as an area of flood storage but will avoid problems associated with the gathering of wading birds and the risk of bird strike with aircraft from RAF Benton. Accordingly, the Thames will benefit from additional flood storage.

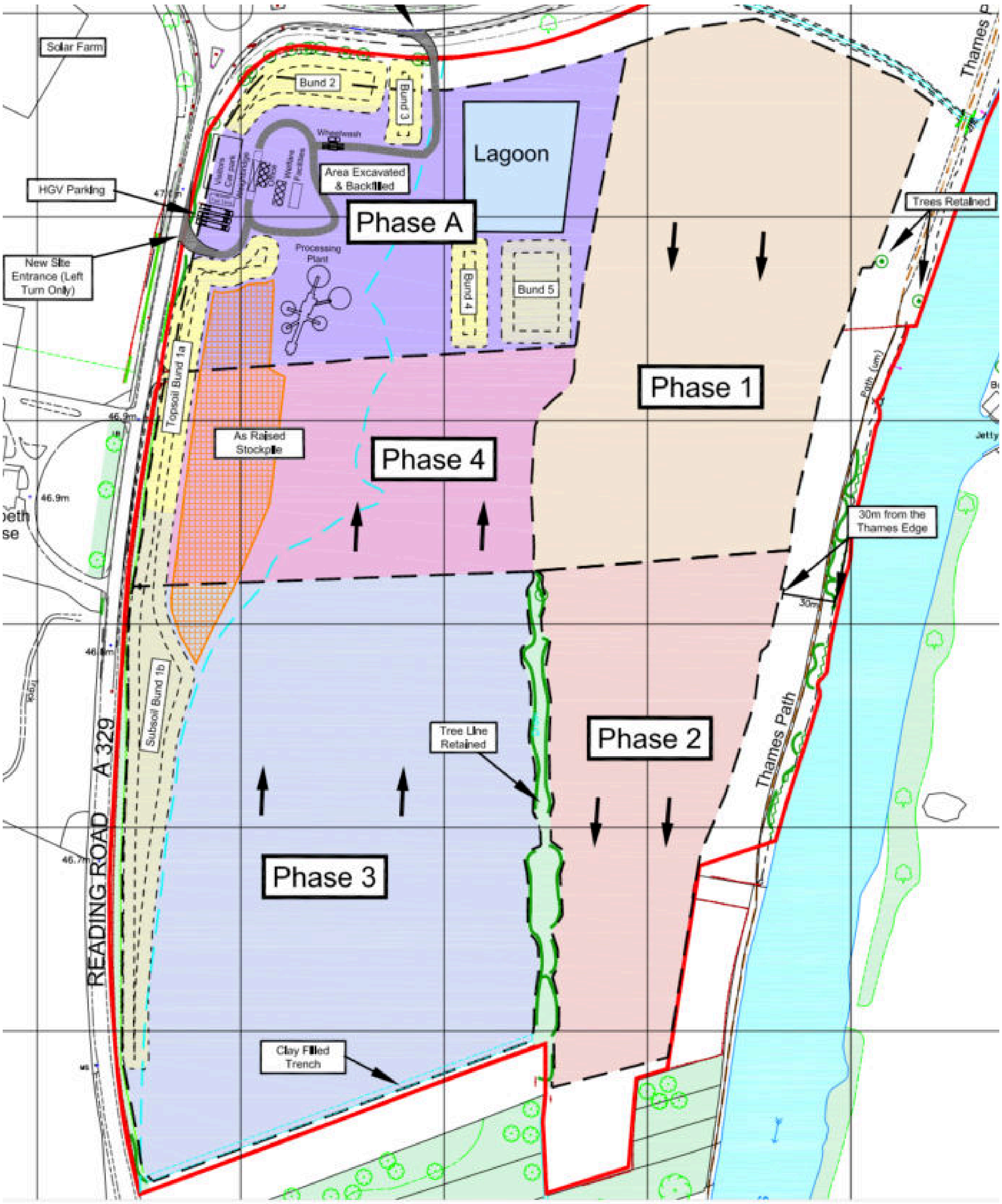


Figure 2.1: Sand and Gravel Extraction Phasing (v3 25 March 2022)

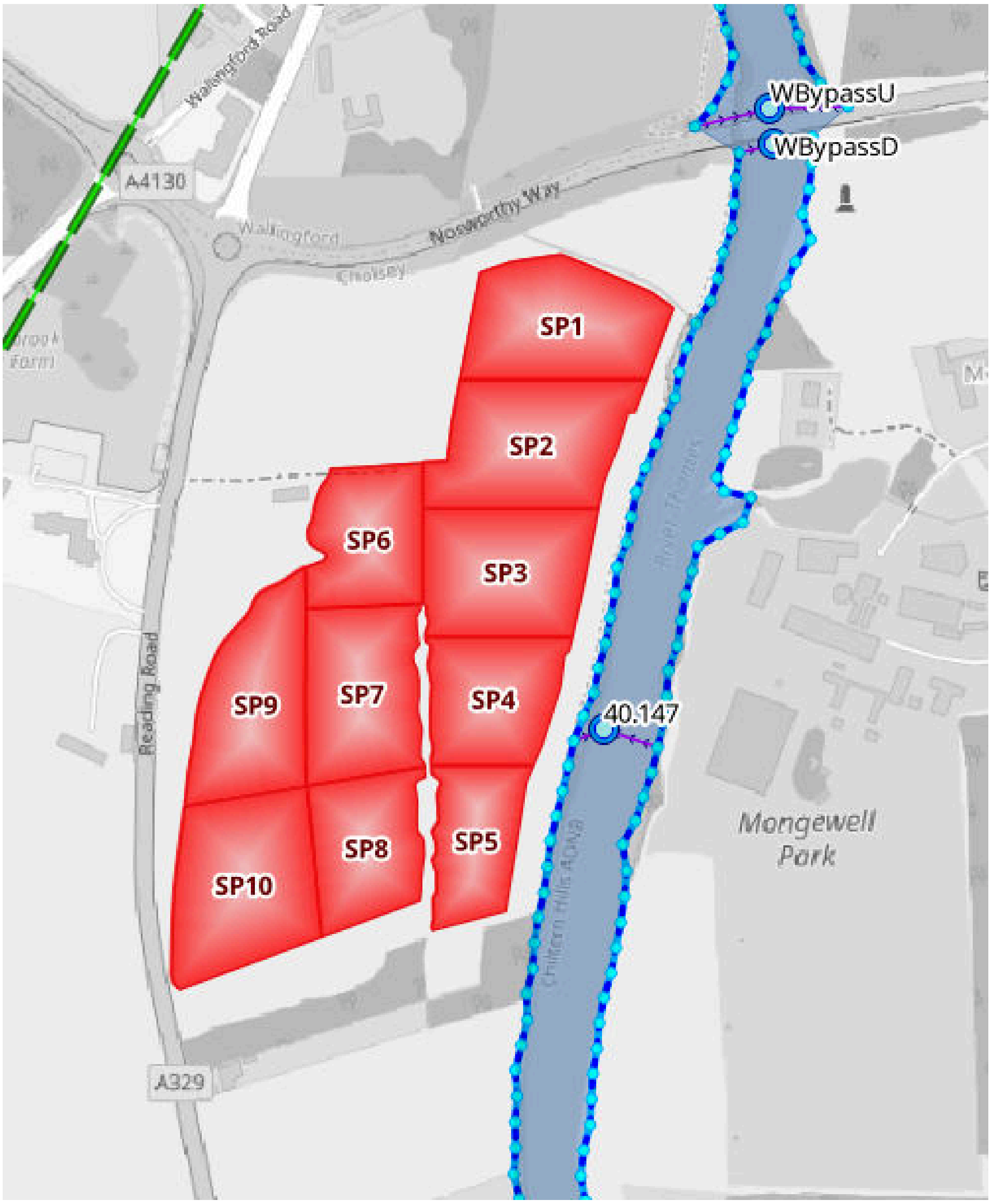


Figure 2.2: Excavation Stages

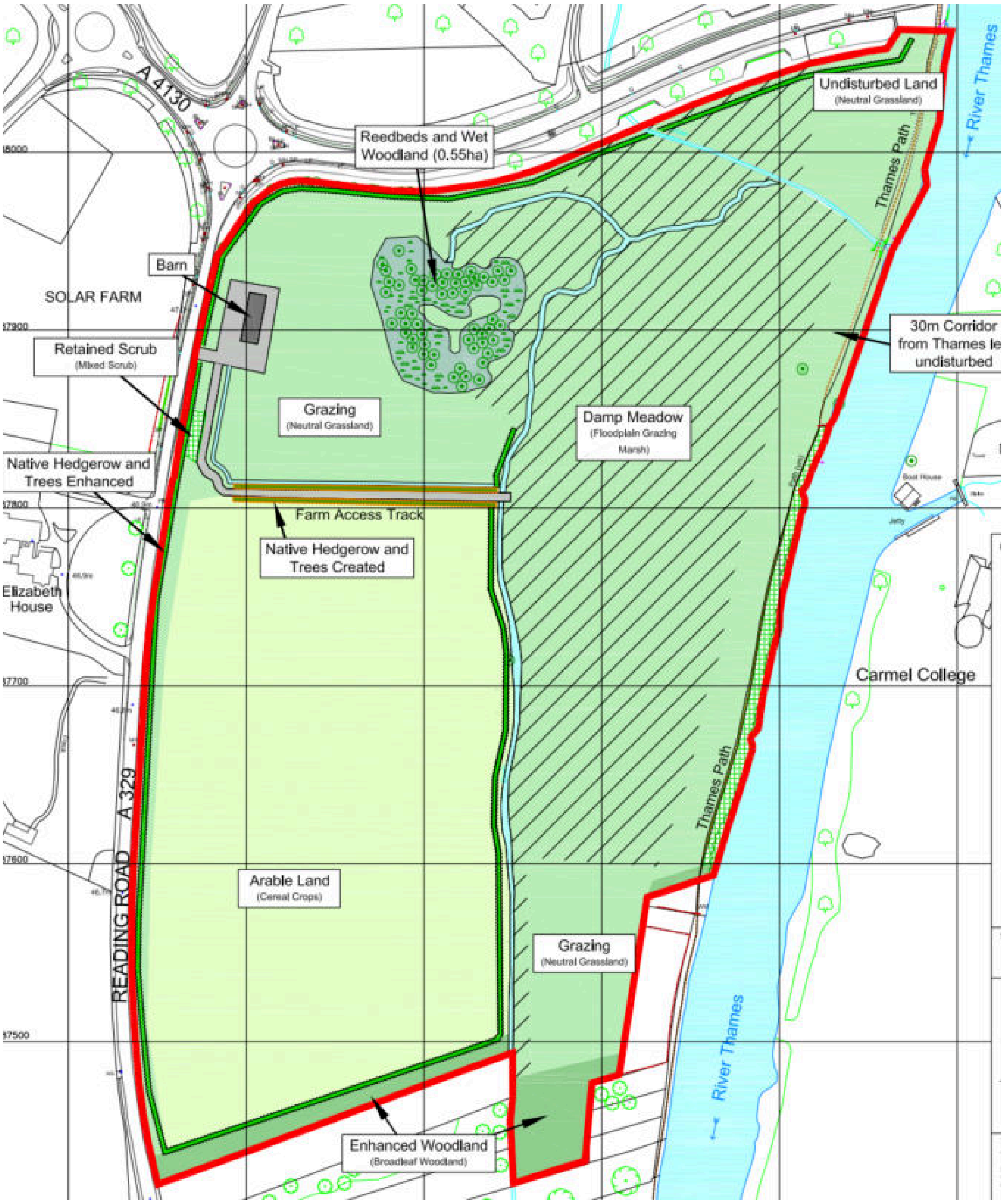


Figure 2.3: Site Restoration

3 Flood Risk Mapping

3.1 Historical Flood Risk

Figure 3.1 shows the historical flood mapping which is based on recorded flood information held by the Environment Agency. The mapping indicates that the site was inundated during the winter of 2013 and 2014 but it is highly likely that flooding to the site will have occurred frequently in the past fifty years.

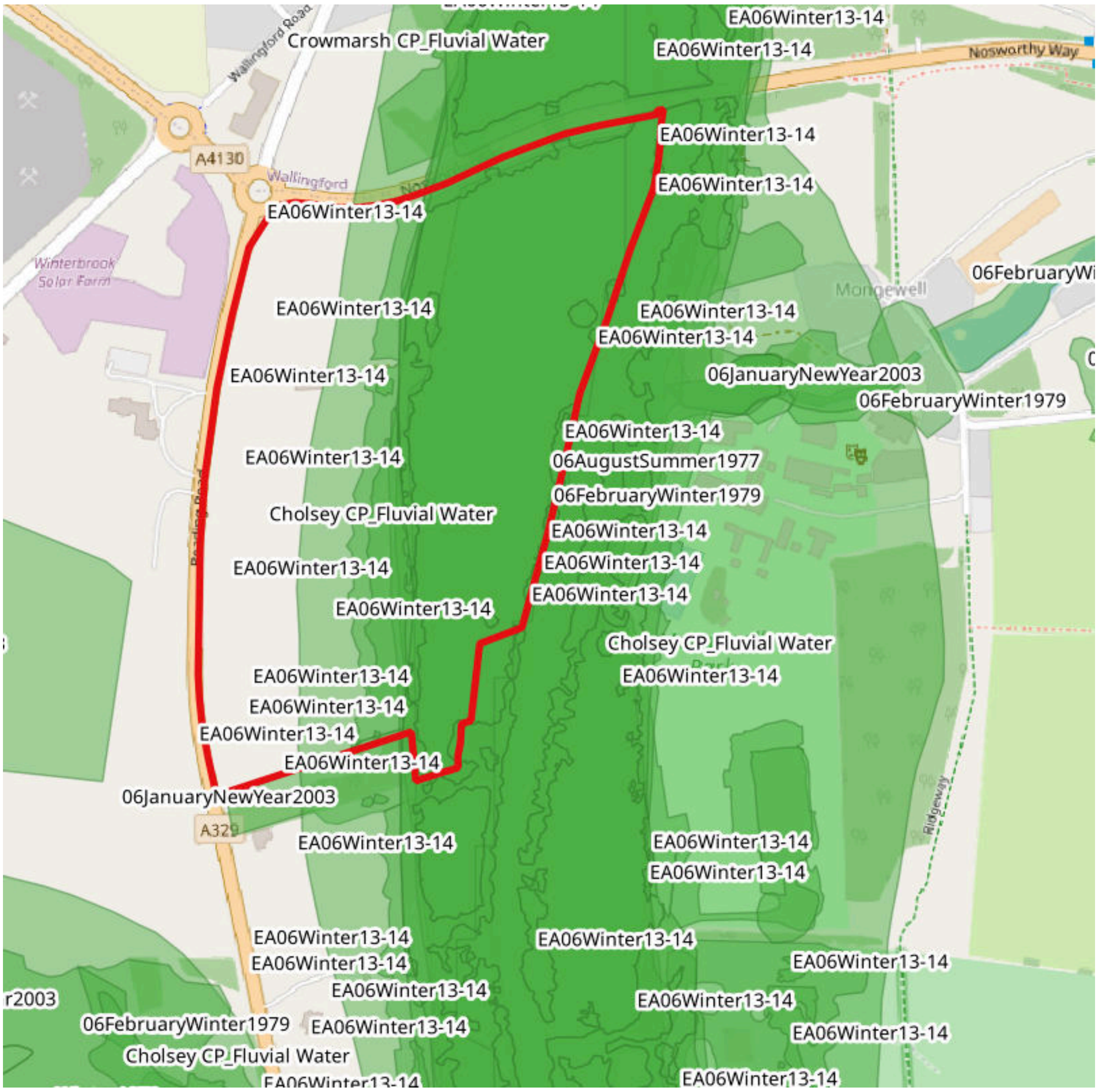


Figure 3.1: Recorded Flood Outline - Environment Agency

3.2 Flood Zone Classification

Figures 3.2 to 3.4 show the flood zone classification for the sand and gravel working. Figure 3.2 has been extracted from the UK Government's flood map for planning[1] which confirms that the site is within Flood Zone 2 and 3.

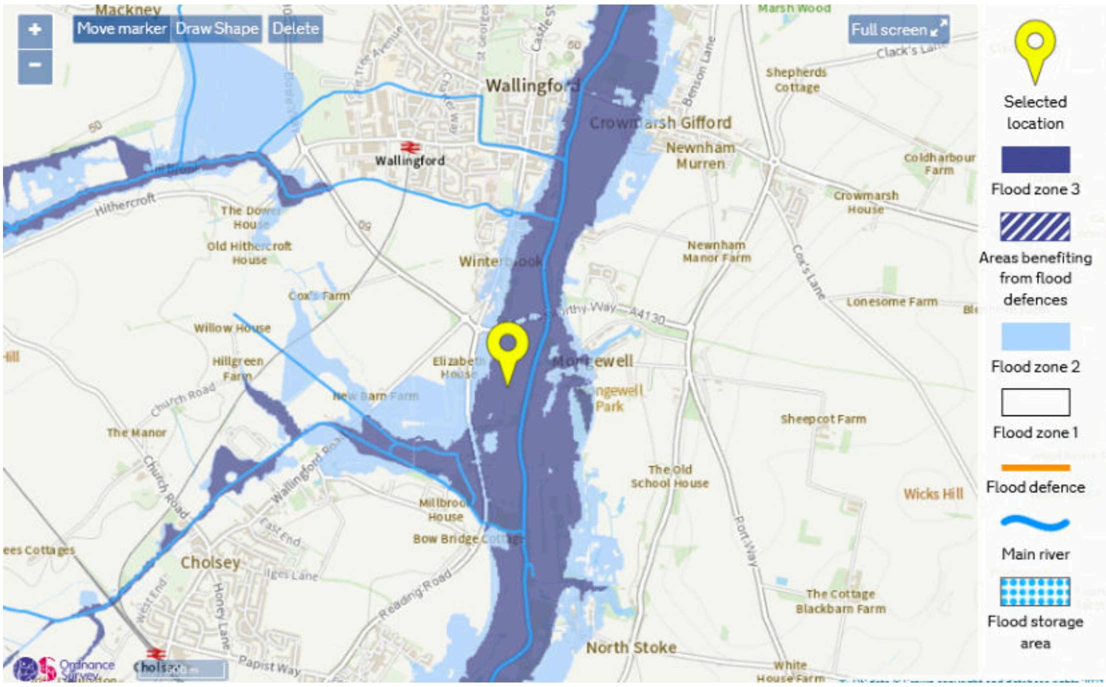


Figure 3.2: Flood Risk for Planning

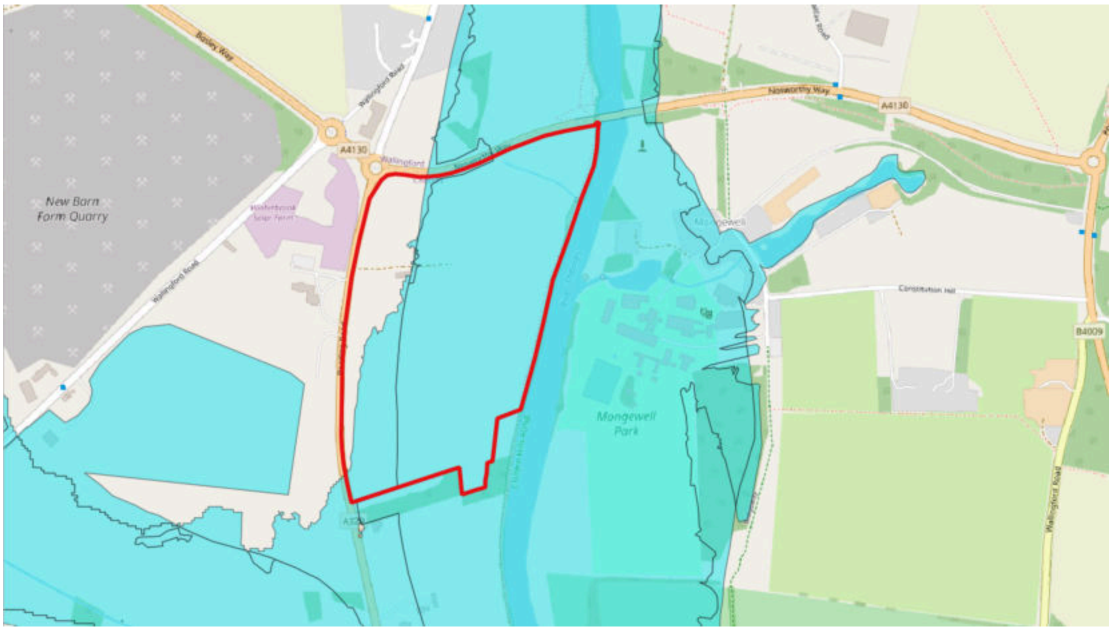


Figure 3.3: Flood Zone 2

[1] https://flood-map-for-planning.service.gov.uk/

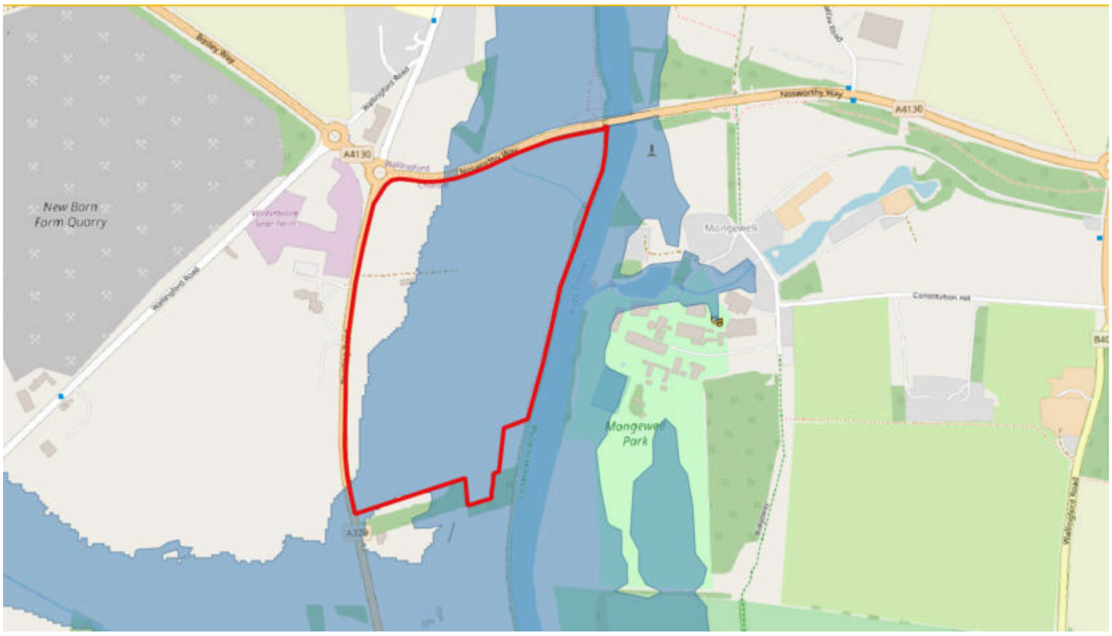


Figure 3.4: Flood Zone 3

3.3 Rivers and Seas

A copy of the "long term flood risk mapping" downloaded from the UK government website[2] is illustrated on Figure 3.5. The figure indicates the extent of the long term flood risk from the Thames to the sand and gravel working site. The development is deemed to be at a Medium to High risk of fluvial flooding (i.e. greater 1% AEP). Fluvial flooding is discussed in more detail in Section 6.

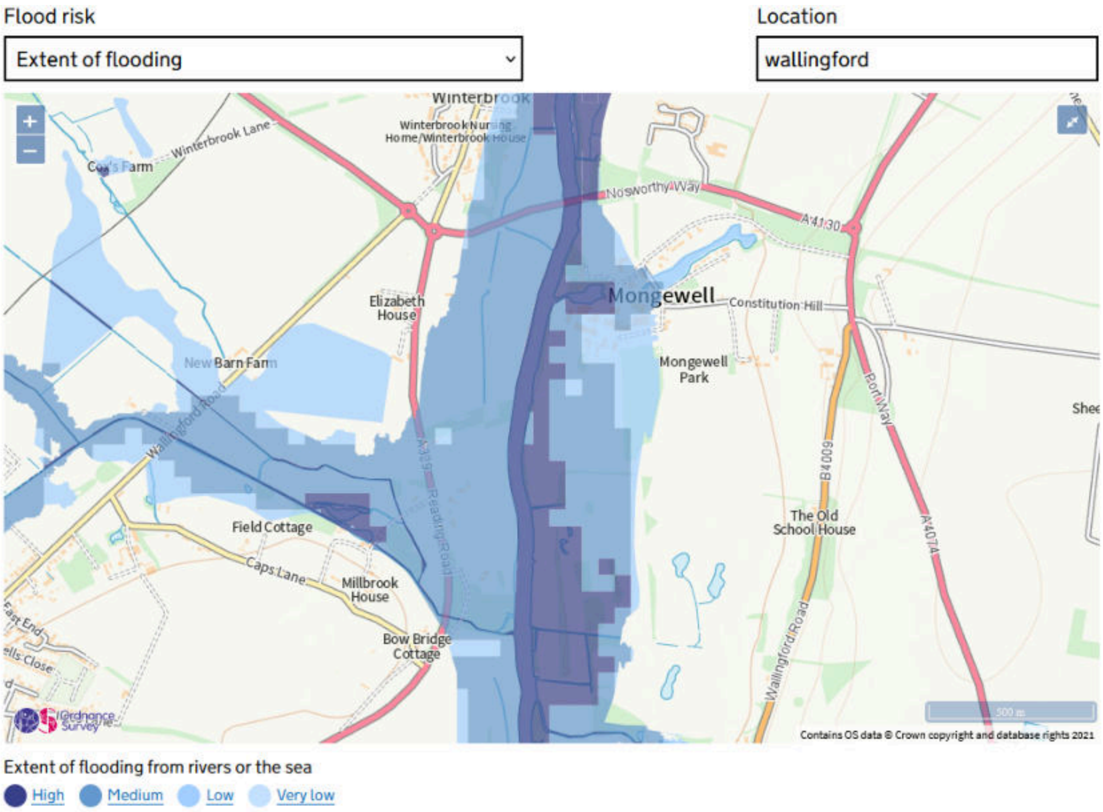


Figure 3.5: Long Term Flood Risk

3.4 Surface Water Flood Risk

Surface water flooding occurs following intense rainfall events, when water is unable to infiltrate the ground or cannot discharge to a watercourse. Figures 3.6 to 3.8 show the surface water flood risk[3]. The mapping gives flood depths on the site for high, medium and low risks which are quantified in Table 3.1. Importantly it should be recognised that the depths shown on the figures reflect the existing risk and not the risk to the proposed sand and gravel working.

The predicted depth of surface water is not considered to present a flood risk to the sand and gravel working.

[2]https://flood-warning-information.service.gov.uk/long-term-flood-risk/map
[3]https://flood-warning-information.service.gov.uk/long-term-flood-risk

Risk	Depth
Low Risk	none
Medium Risk	none
High Risk	none

Table 3.1: Surface Water Flood Depths

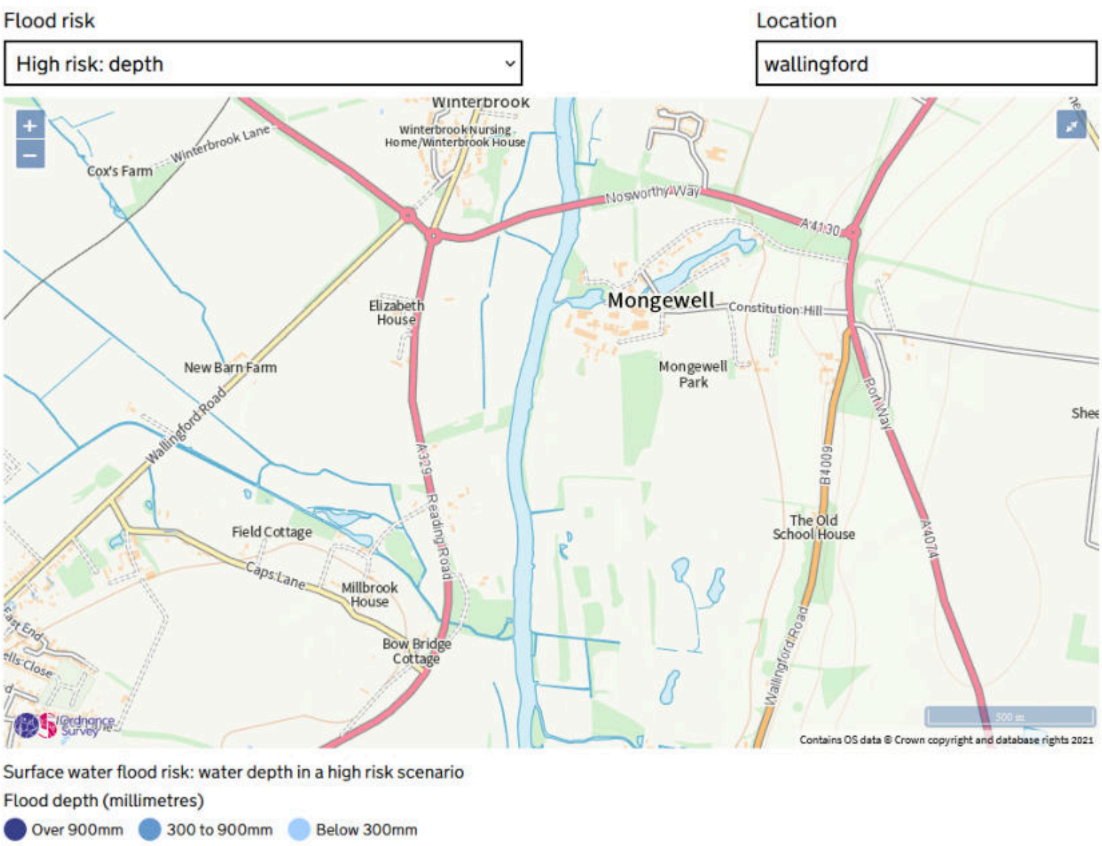


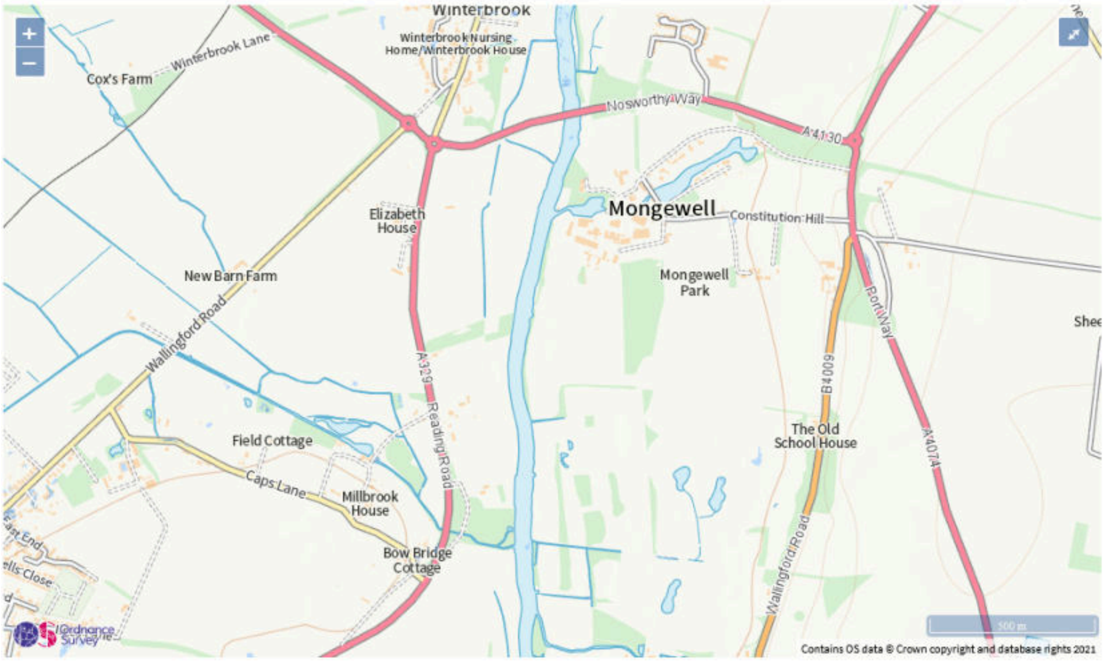
Figure 3.6: Surface Water Flood Risk (High <3.3%)

Flood risk

Medium risk: depth

Location

wallingford



Surface water flood risk: water depth in a medium risk scenario

Flood depth (millimetres)

Over 900mm 300 to 900mm Below 300mm

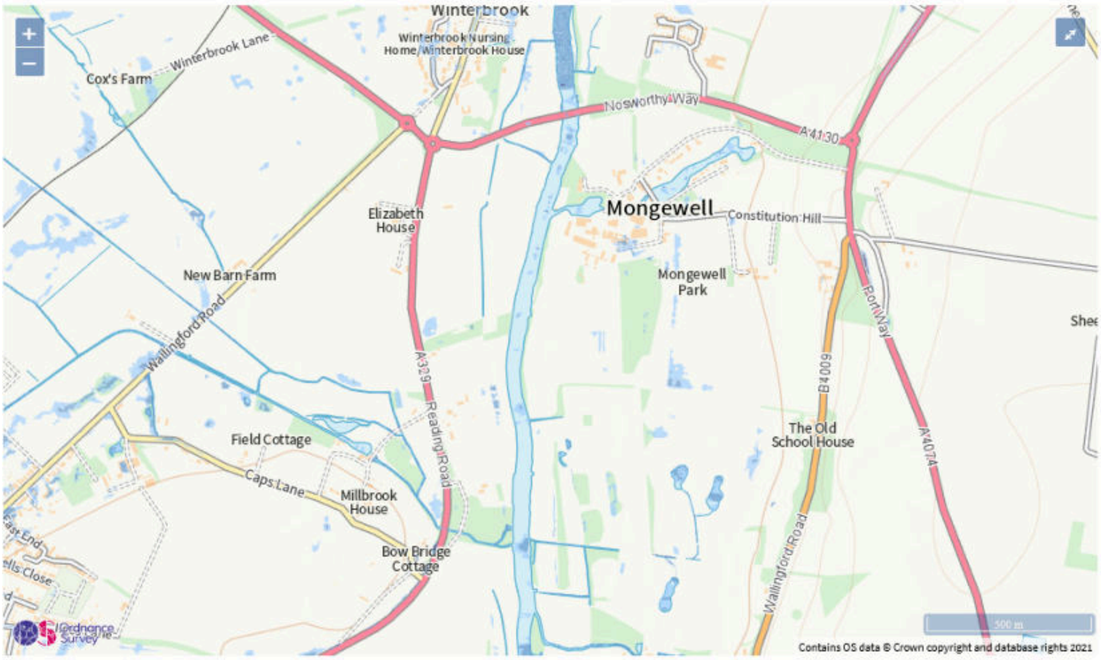
Figure 3.7: Surface Water Flood Risk (Medium 3.3% to 1%)

Flood risk

Low risk: depth

Location

wallingford



Surface water flood risk: water depth in a low risk scenario

Flood depth (millimetres)

Over 900mm 300 to 900mm Below 300mm

Figure 3.8: Surface Water Flood Risk (Low 0.1% to 1%)

3.5 Reservoirs

A copy of the Reservoir Inundation mapping is shown in Figure 3.9. There are no issues associated with reservoir inundation.

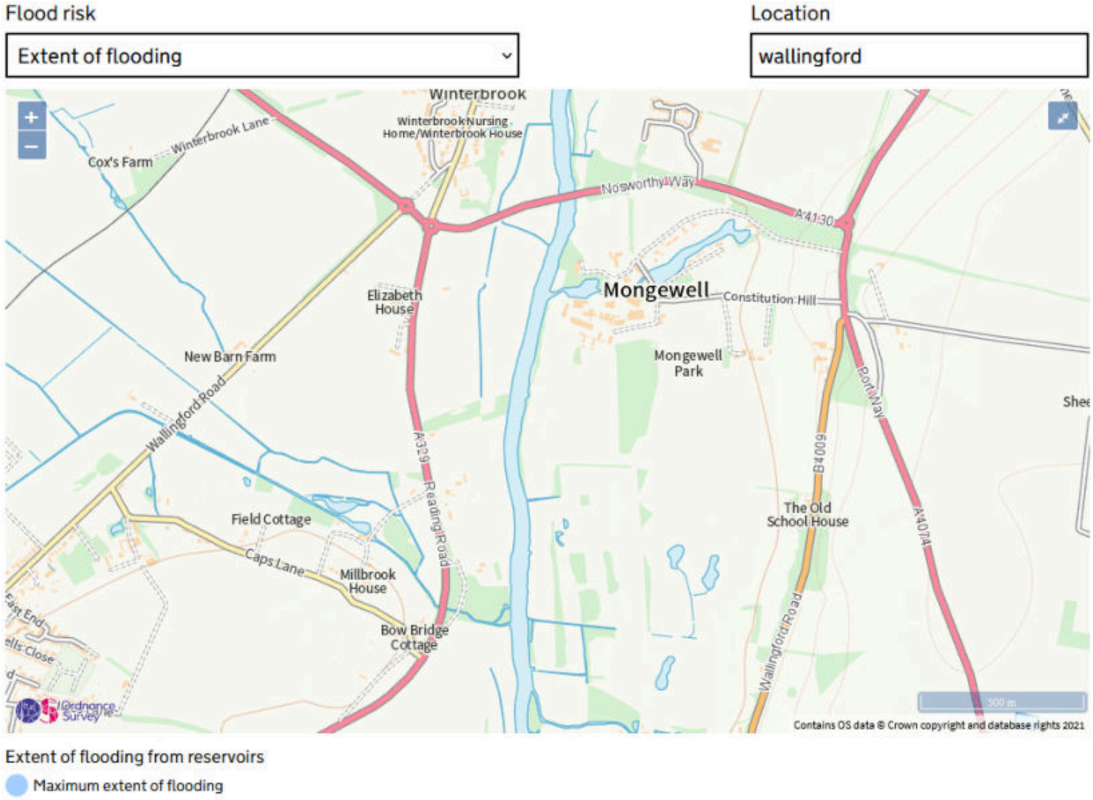


Figure 3.9: Reservoir Inundation

4 Strategic Flood Risk Assessment

4.1 Flood Risk Mapping

Oxfordshire County Council has undertaken a Strategic Flood Risk Assessment (SFRA) to inform local planning policy in relation to flood risk. This includes a specific policy document on minerals and waste which is available on Oxfordshire County Council's website:

- Oxfordshire County Council, Minerals and Waste Strategic Flood Risk Assessment: Addendum Report AECOM March 2019

The SFRA document has been reviewed in the context of this study and used where applicable to inform the findings and recommendations of the FRA. It is confirmed that:

- The flood zone mapping given in the SFRA is in broad agreement with the flood risk mapping shown in Figures 3.2 to 3.5.
- The SFRA mapping places the site within the functional flood plain (Flood Zone 3b) which is defined as the flood extent for a 5% AEP event (1 in 20 year return period).
- There are no records within the SFRA report of sewer flooding to the site.
- Groundwater susceptibility mapping is not included in the SFRA.

5 National Planning Policy

5.1 Vulnerability

Flood Risk Vulnerability is determined by the use of the development and falls into one of five classifications which ranges from from Highly Vulnerable to Water Compatible. Annex 3 of the NPPF and Table 2 of the Flood Risk and Coastal Change Guidance gives the Flood Risk Vulnerability for a range of different types of development. More common examples are given below:

- Essential Infrastructure - Essential transport infrastructure (including mass evacuation routes).
- Highly Vulnerable - Basement dwellings; operational police and ambulance stations.
- More Vulnerable - Housing, halls of residence and hospitals.
- Less Vulnerable - Shops, restaurants, cafes and offices.
- Water Compatible - Sand/gravel extraction, water-based recreation, nature conservation and biodiversity.

The vulnerability classifications are used to determine whether a proposed development is compatible with the flood zone in which the scheme is located. In the context of White Cross Farm, Table 2 of the Flood Risk and Coastal Change Guidance indicates that sand and gravel working is classified as Water Compatible. Table 3 of the same guidance confirms that Water Compatible development is appropriate development in Flood Zone 2 and 3.

Based on the above assessment, there is no requirement for Sequential and Exception tests but in relation to sand and gravel working the guidance also states that:

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

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

In this case there is no requirement for the sand and gravel working to remain operational during flooding and ground levels in the post development condition will be set at, or below, existing ground levels. Accordingly there will be no loss of flood storage and there will be no change in flood risk or third party impacts between the baseline and restored condition.

5.1.1 Climate Change

Technical Guidance for climate change gives the allowances appropriate to the development is given on the peak river flow map which is shown in Figure 5.1. The relevant percentage to applied is dependent on the development type, life span of the development and the flood zone in which the scheme is located. The relevant information is summarised below:

- Development Type sand and gravel working.
- Development Lifespan - 5 years.
- Flood Zone - Flood Zone 2 and 3.

Table 5.1 shows the Central climate change allowances for fluvial flow are applicable to the scheme. It should be noted that the development lifespan in in the order of 5 years and the application of an allowance of 12% for the 2020s is therefore considered to be appropriate in relation to testing the development for flood risk.

Climate Change Epoch	Percentage
2020s	12%

Table 5.1: Central Climate Change Allowances for Flow

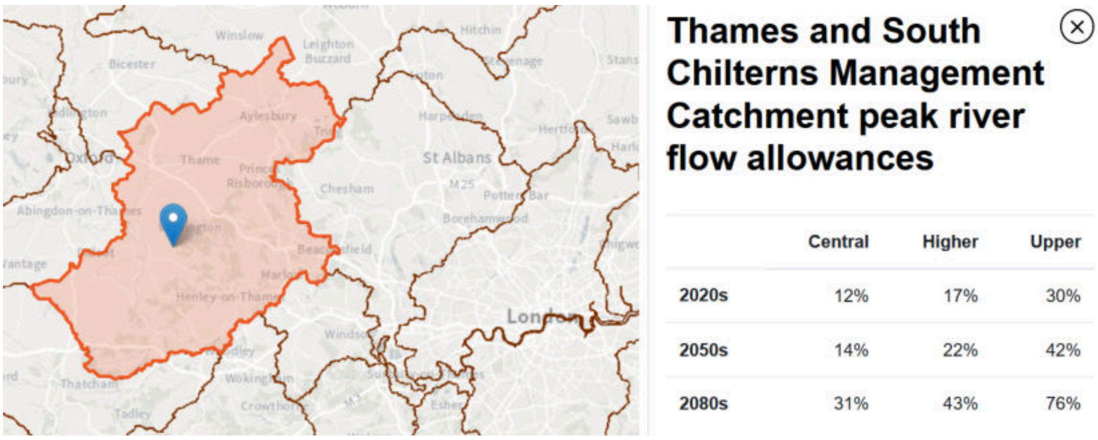


Figure 5.1: Fluvial Climate Change Allowances

6 Fluvial Flood Risk

6.1 Fluvial Flood Risk -Overview

The programme of works involves the phased excavation and backfilling of holes within the flood plain to extract sand and gravel as shown in Figure 2.2. After the completion of each excavation stage each hole will be backfilled such that, the floodplain is restored to its original ground levels. It is not possible to leave open water across the site on completion because of the danger to aircraft using RAF Benson resulting from bird strikes. It should also be noted that works will be undertaken in summer to avoid winter flooding and boggy conditions for plant operating on the flood plain.

The works will be completed in five years at which point the entire site will be restored to original levels. Accordingly, there will be no change in flood risk following the completion of the works by comparison to today. The only concern are changes in flood risk in the temporary condition over the period of five years during the excavation works.

The fact that the development lifetime is five years is hugely significant in relation to flood risk. The probability of 1 in 100 year event occurring or being exceeded in the next 100 years is 63%. However, the probability that a 1 in 100 year event occurring or being exceeded in a period of 5 years is significantly lower at 5% (i.e. the lifetime of the scheme).

Accordingly, the flood risk profile for this scheme, is significantly reduced by comparison to a conventional commercial or housing development which is generally tested for a 50 or 100 year lifespan. The fact that a 1 in 100 year event would have an annual 5% chance of occurring in five years would categorise the scheme as being at low risk of flooding. Due consideration should therefore be given to this fact in evaluating the flood risk to the scheme and third parties. It is envisaged that mechanism of flooding to the site would be as follows:

- Flood water would rise in the Thames until it overtops the riverbank with flood water flowing across the floodplain to the excavation.
- The excavation would fill with water and continue rising until it reaches a peak. After peak the water levels would fall leaving the excavation full.
- Water within the excavation with gradually infiltrate or evaporate until groundwater levels were reached.

Excavation or lowering of levels on a flood plain will increase the overall flood storage and it is generally accepted that increasing flood storage will decrease flood risk elsewhere and to third parties. This is the well-known principle of flood storage compensation which is used within flood risk management to minimise third party impacts.

In contrast flood levels would be expected to rise, and adverse third-party impact would occur if:

- There was filling on the floodplain which would displace flood water elsewhere.
- A barrier was constructed on the floodplain which deflected water changing the pattern of flooding. This could include, for example, a flood defence.

The proposed works do not include filling which would displace of flood water. Moreover, there are no proposals to construct embankments or other barriers on the flood plain which would deflect water onto third party land. Given that the mineral working will not incorporate raised features within flood zone 3 it is considered that the scheme should not have an adverse impact on flood levels. The absence of raised features means that there should be no adverse impact upstream.

In summary:

- In the event of a major flood event and the closure of the quarry, the open quarry workings will provide additional flood water storage capacity in this part of the Thames Valley for approximately 5 years of the operational development.
- The restored scheme will result in a permanent increase in flood water storage capacity as a consequence of:
  - An increased area of proposed wet woodland and reedbed – which is below original ground levels.
  - The creation of damp meadow with open ditching connecting to the River Thames.

An increased area of proposed wet woodland and reedbed – which is below original ground levels. The creation of damp meadow with open ditching connecting to the River Thames

6.2 Hydrology and Hydraulic Modelling

6.2.1 Hydrology

Hydrological estimates have been adopted from the incoming hydraulic model of the River Thames. No changes have been made to the model inflow boundaries.

6.2.2 Hydraulic Modelling

The 1D-2D FMP-TUFLOW model of the Thames at Wallingford was supplied by the Environment Agency for the purposes of the project in order to establish the flood risks to the site and assess whether there are any third-party impacts during the mineral working excavation stages of the scheme. The incoming model is known as the "Abingdon Flood Schemes – River Thames Model".

The model extends from upstream of Sandford Lock to Reading Bridge, as shown in Figure 6.1 and adequately encompasses the site of interest. The model and has been accepted by the Environment Agency as being suitable for the use of assessing flood risk along this portion of the Thames and forms the basis of the modelling presented in this report. The model is reported by the Environment Agency as having been calibrated to an acceptable standard.

Cross sections are sparse, but commensurate for a model of this scale, with a typical spacing in excess of 500m. There is an FMP node just upstream and second near the downstream end of the site. As such, there is limited scope for the water surface to capture subtle variations by the site. The report accompanying the model states:

"Comparisons of the model results have been made against the peak water levels from telemetry data. Over the 4 events there is good agreement, under the interim model observed levels are within +/- 0.15m (83 out of 88 records) and peak flows are within 8% when compared to the high flow rating at Mapledurham (preferred to the Reading Rating). The updated model has observed levels which are within +/- 0.15m (78 out of 88 records) and peak flows are within 10% when compared to the high flow rating at Mapledurham." Note this also gives an indication of model accuracy.

The design hydrology for the supplied model has been re-evaluated using up to date data and techniques from when the modelling was undertaken. This has been reported in June 2017. The Thames is a large and complex catchment; this analysis was undertaken in cooperation with the EA and may be considered to be the best current understanding of flow probabilities for the area.

The supplied modelling was undertaken with latest versions of the modelling software available at the time: Flood Modeller 4.2 and TUFLOW 2016-03-AC-iDP-w64. It is noted that these have since been superseded by the software authors who advise in their release notes that later versions should be used as corrections and enhancements have been made.

Following the initial internal review of the incoming model, it was established that it would be desirable to maintain as much of the model unchanged as possible. The model has been approved and calibrated model to the satisfaction of the Environment Agency and is understood to represent the existing condition with an acceptable accurately.

It is also noted that the process of undertaking new hydrological analysis to determine inflows for the Thames is both complex and time-consuming; this is precisely why the EA undertook the hydrological study and recommend/require its application to any other studies in the area. Accordingly, the Abingdon Flood Schemes – River Thames Model has been used as the basis for this FRA. Limited modifications have been made to the model including:

- Modifying the grid size to 20m to improve model stability in the vicinity of the site.
- Moving SX boundaries associated with the Wallingford Bridge flood relief arches to avoid a conflict with the cells raised by the z-line of the road embankment (those cells now being larger due to the above change); no boundary was moved by more than 1 cell.
- Adjusting model outputs filenames to suit EVY preferences; e.g. results names and locations as well as some additional outputs such as ZUK2.

No changes were made to the model timesteps and the model was run on the latest version of the FMP TUFLOW Software (FMP version FMP 5.0 and TUFLOW version 2020-10-AA-iDP-w64). In all other regards the model used to represent the baseline condition is as supplied by the EA.

The geometry of the excavation and staging of the works has been added to the model using z-shapes. New surface materials were also applied, according to the land uses shown in the appropriate stage (e.g Figure 2.2). No changes were made to the model outside the red line to ensure that the baseline modelling was as close as possible to the phasing modelling with a view to making them directly comparable.

The model has been run for the existing baseline and ten mineral extraction stages for the events shown in Table 6.1. The site will be restored to existing levels following completion of the mineral workings with the post development scenario being the same as the existing baseline with the exception of ground lowering within the wet woodland to provide long term additional flood storage.

Scenario	AEP	Year
Baseline	1% cc 12%	2025
Stage SP1	1% cc 12%	2025
Stage SP2	1% cc 12%	2025
Stage SP3	1% cc 12%	2025
Stage SP4	1% cc 12%	2025
Stage SP5	1% cc 12%	2025
Stage SP6	1% cc 12%	2025
Stage SP7	1% cc 12%	2025
Stage SP8	1% cc 12%	2025
Stage SP9	1% cc 12%	2025
Stage SP10	1% cc 12%	2025

Table 6.1: Model Runs

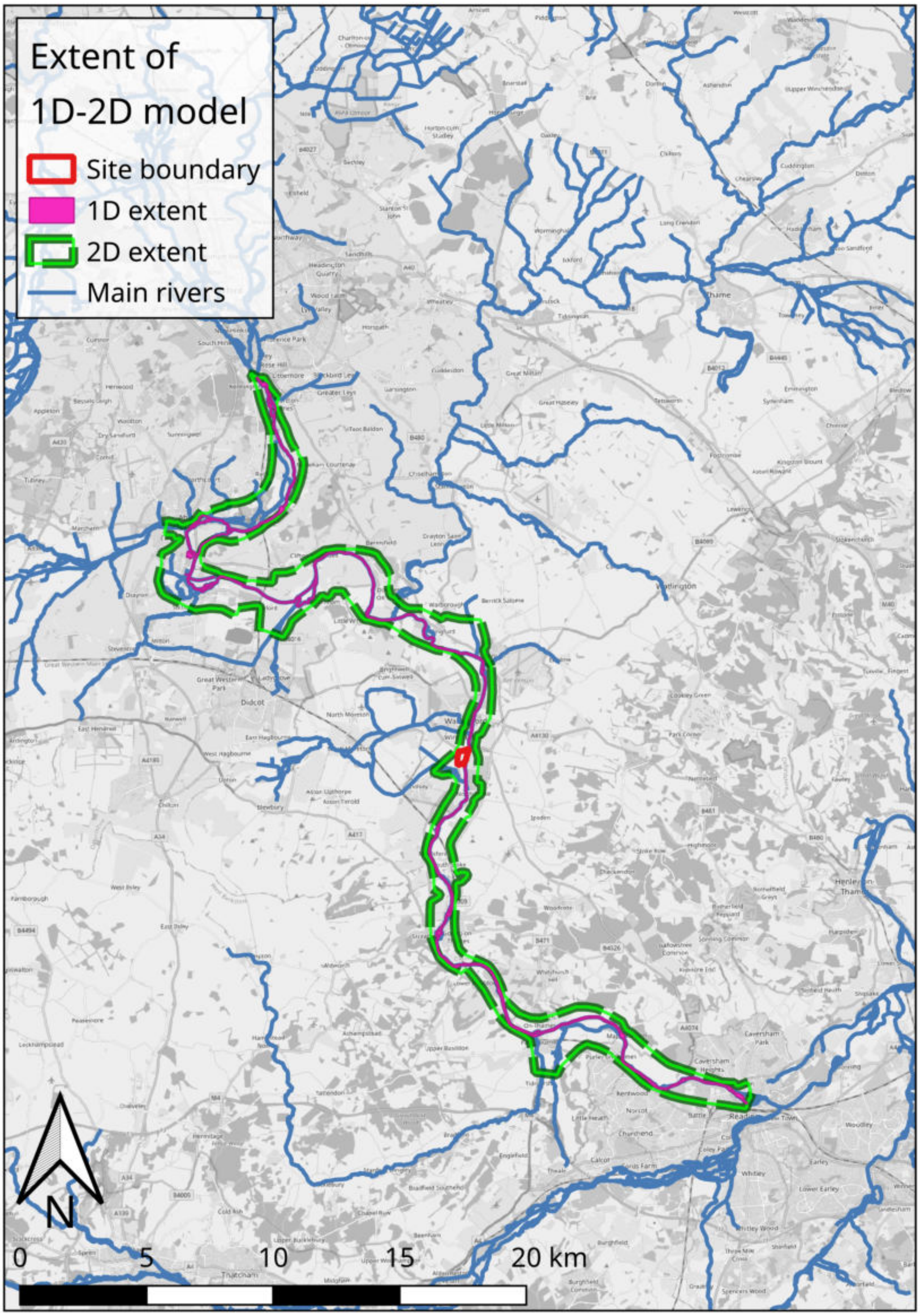


Figure 6.1: Hydraulic Model Extent

6.3 Hydraulic Modelling Results

6.3.1 Overview

The following sections present a selection of results. Due to the number of model runs that have been undertaken, these results have been selected based on the design life of the proposed the temporary mineral extraction and restoration scheme. The results include:

- Water levels
- Flood depths
- Flood differences

A full suite of model results and mapped outputs are included within the appendices and the following sections discussed the pertinent results in relation to the development.

6.3.2 Flood Depth and Level

Table 6.2 gives the maximum flood level within the red line boundary and Figures 6.4 to 6.5 shows the level and depth results of the hydraulic modelling for the baseline and the Stage SP3 excavation scenario (see Figure 2.2).

The results indicates that the site would be partially inundated for the 1% AEP event with an allowance of 12% for climate change in all scenarios with depths varying across the site. The modelling confirms that the processing plant, offices and welfare facilities would be flood free. The size of the stockpiling area would need to be reduced slightly to ensure that the combination of additional flood water storage through the open pits during the operation and the post restoration wet woodland/reedbed/new ditching will ensure both short-term and long-term increase in flood water storage in this part of the Thames Valley.

Baseline / Excavation	Stage	1% AEP cc12% (m AOD)
Baseline		45.490
Post	SP1	45.495
Post	SP2	45.493
Post	SP3	45.481
Post	SP4	45.486
Post	SP5	45.487
Post	SP6	45.487
Post	SP7	45.485
Post	SP8	45.482
Post	SP9	45.495
Post	SP10	45.491

Table 6.2: Peak Flood Levels at Reference Point 3

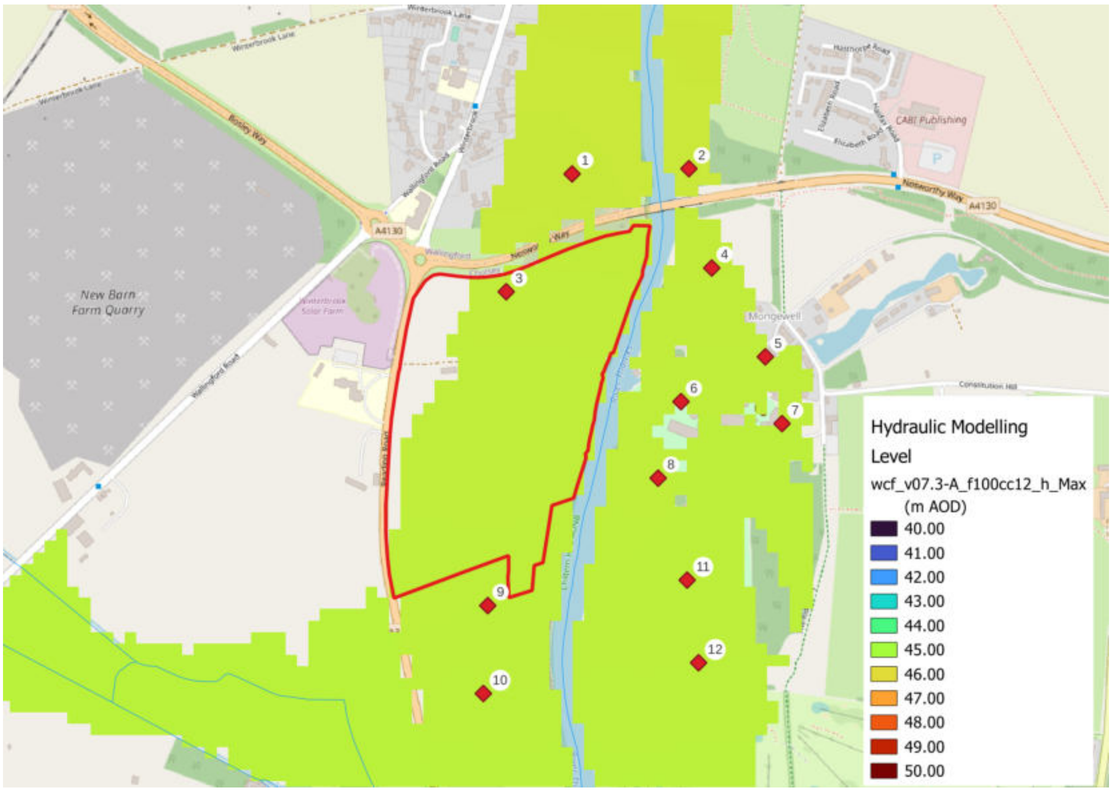


Figure 6.2: Baseline Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

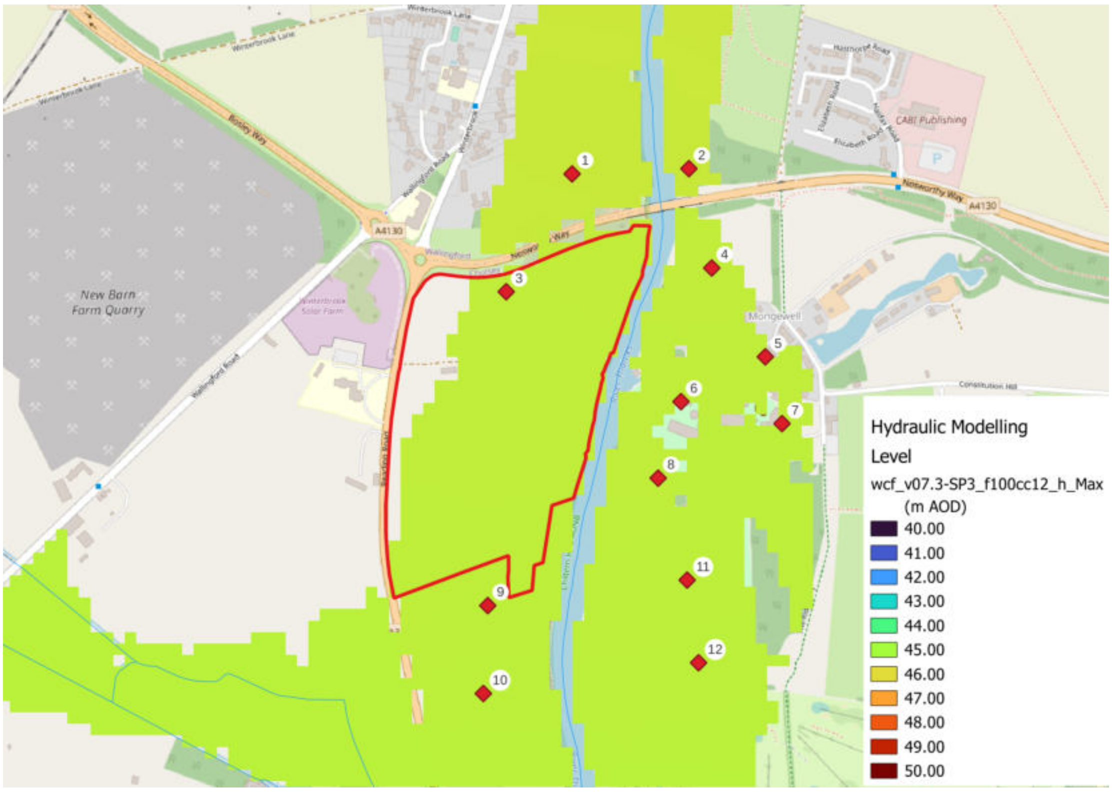


Figure 6.3: Stage SP3 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

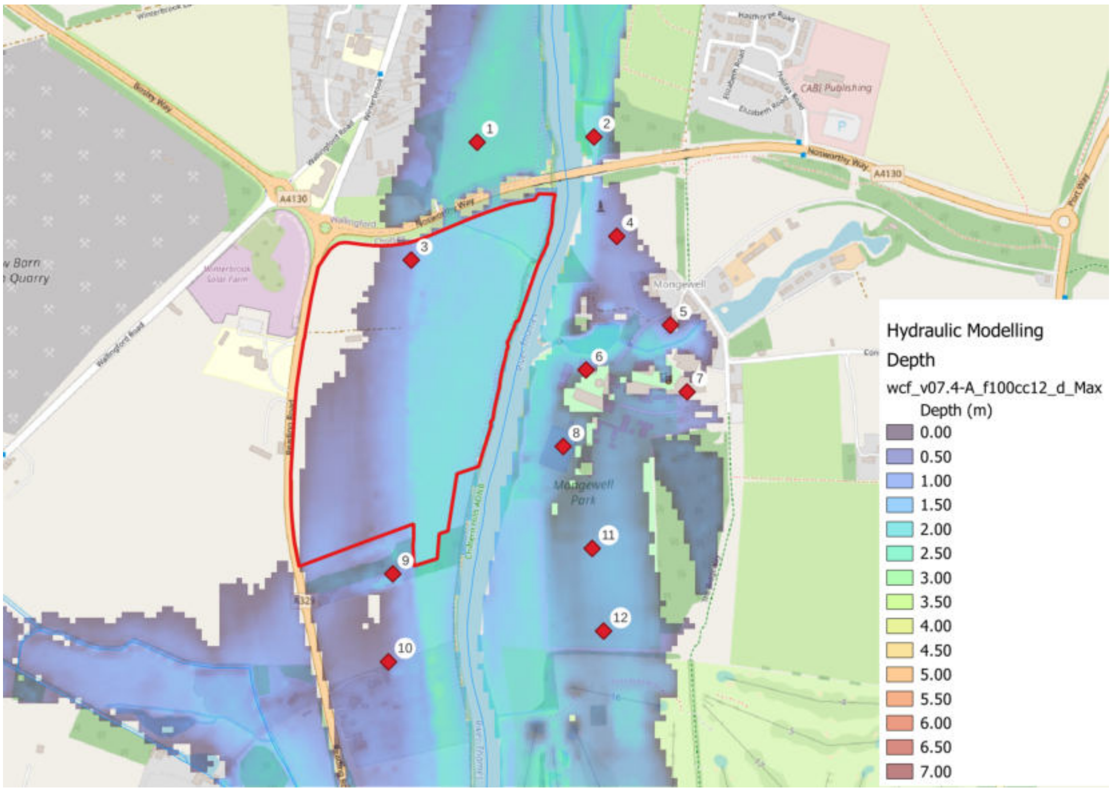


Figure 6.4: Baseline Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

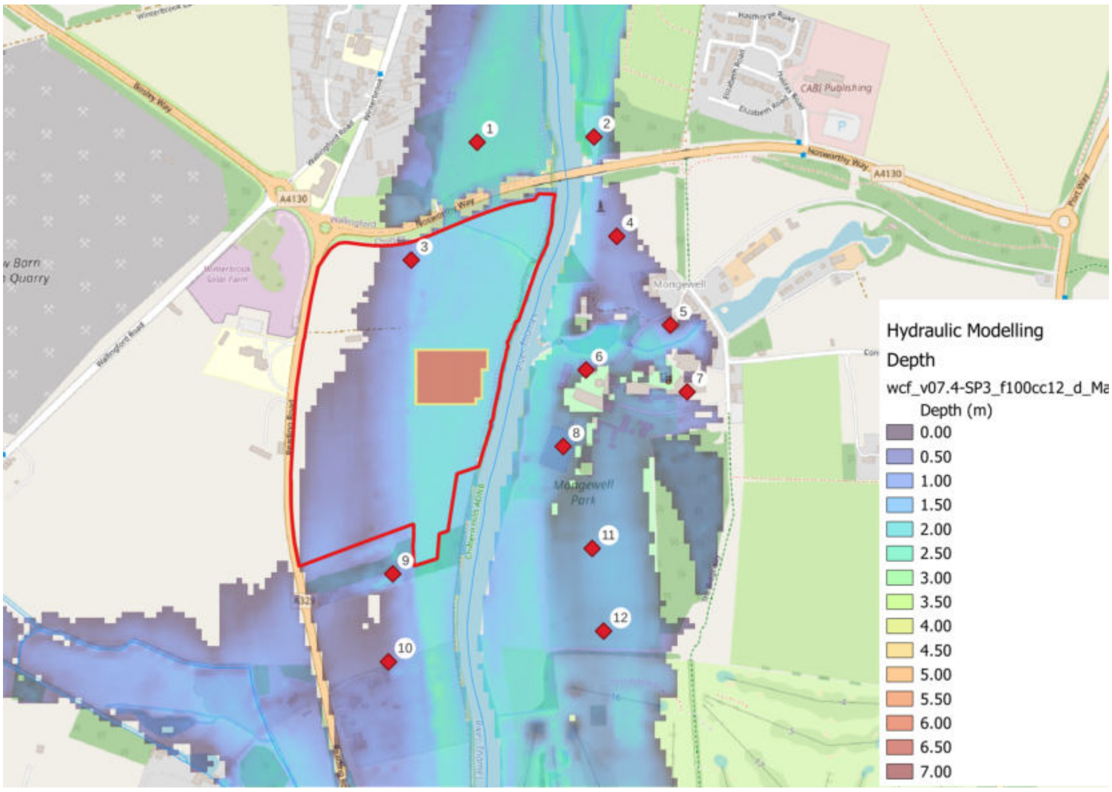


Figure 6.5: Stage SP3 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

6.3.3 Third Party Dis-benefit

Third party dis-benefits have been assessed using difference maps. Figure 6.7 to Figure 6.16 shows the change in flood levels between the baseline and each of the ten excavation stages. The figures shows the numeric difference in level of the pre and post development schemes. Areas shade grey indicate changes in flood level of less than 0.010m as a result of the development. here are no such areas outside the red line. Areas shaded yellow / green show changes in flood level greater than +0.010m and less than -0.010m respectively. T

Twelve reference points have been established to determine the impact of the works on water levels (see Figure 6.6). Table 6.3 and 6.4 show the numeric difference between the water level in the Baseline condition and each of the excavation scenarios (SP1 to SP10). Positive numbers show an averaged increase in water level across the whole model and negative numbers show a decrease in water level. The maximum off-site impact increase in water levels is 0.006m in Stage SP9. However, it should be noted that a 0.006m change in levels is within the tolerance of the model. This is discussed in more detail later in the report.

Stage	RP1	RP2	RP3	RP4	RP5	RP6
SP1	0.001	0.001	0.006	0.002	0.002	0.002
SP2	0.003	0.003	0.003	0.004	0.004	0.004
SP3	-0.009	-0.009	-0.009	-0.009	-0.007	-0.006
SP4	-0.008	-0.008	-0.004	-0.007	-0.002	-0.001
SP5	-0.005	-0.005	-0.003	-0.004	-0.002	-0.001
SP6	-0.003	-0.003	-0.003	-0.003	-0.002	-0.002
SP7	-0.007	-0.007	-0.005	-0.006	-0.004	-0.003
SP8	-0.008	-0.008	-0.008	-0.008	-0.007	-0.007
SP9	0.004	0.004	0.005	0.005	0.005	0.005
SP10	0	0	0.001	0.001	0.001	0.001

Table 6.3: Differences in Flood Levels in Metres at Reference Points RP1 to RP6

Stage	RP7	RP8	RP9	RP10	RP11	RP12
SP1	0.001	0.002	0.002	0.002	0.002	0.002
SP2	0.003	0.005	0.005	0.005	0.005	0.005
SP3	-0.004	-0.005	-0.005	-0.005	-0.005	-0.005
SP4	0	0.003	0.004	0.002	0.003	0.002
SP5	0	0.001	0.003	0.001	0.001	0.001
SP6	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
SP7	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001
SP8	-0.005	-0.007	-0.005	-0.007	-0.007	-0.007
SP9	0.003	0.006	0.006	0.006	0.006	0.006
SP10	0.001	0.001	0.002	0.001	0.001	0.001

Table 6.4: Differences in Flood Levels in Metres at Reference Points RP7 to RP12

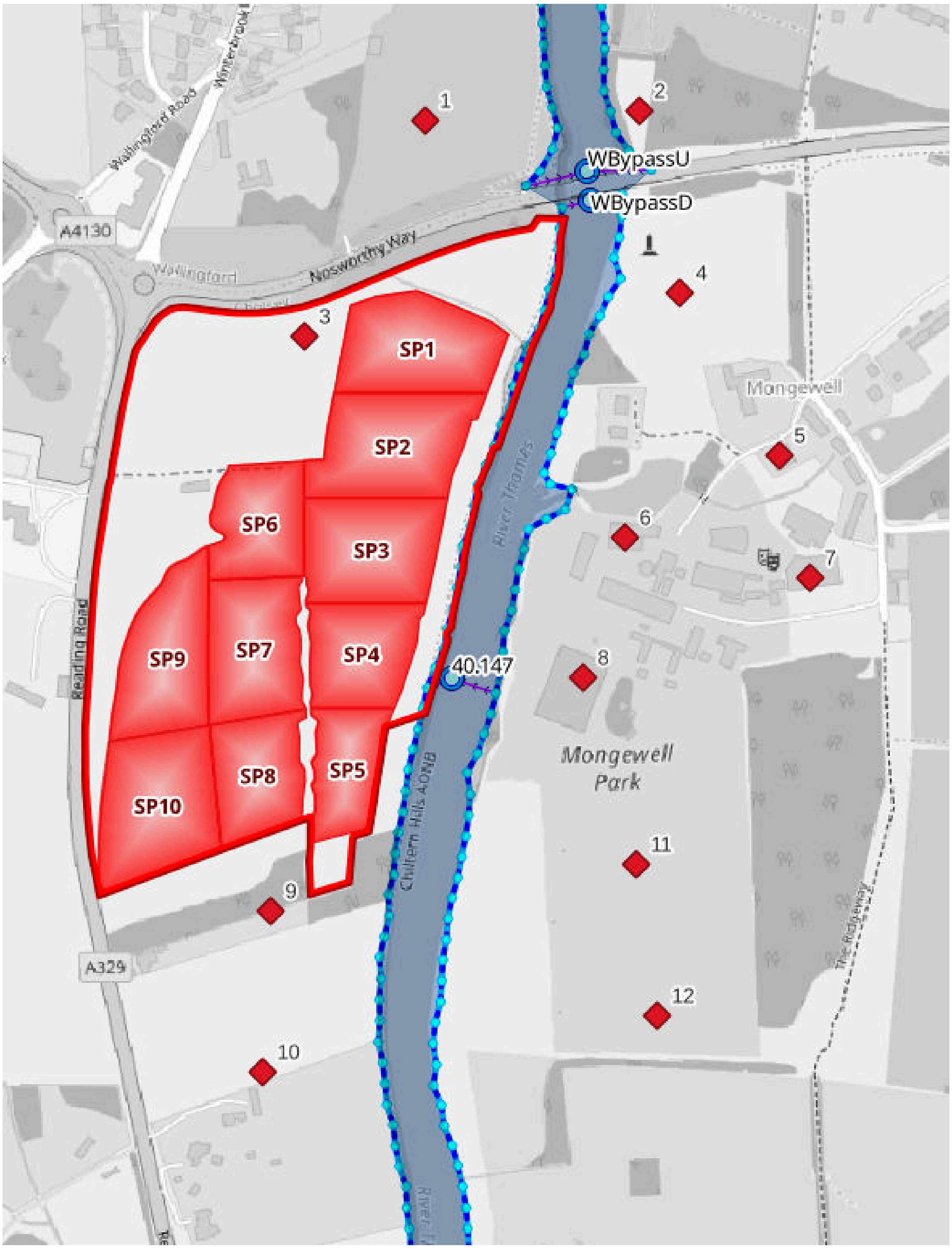


Figure 6.6: Reference Points

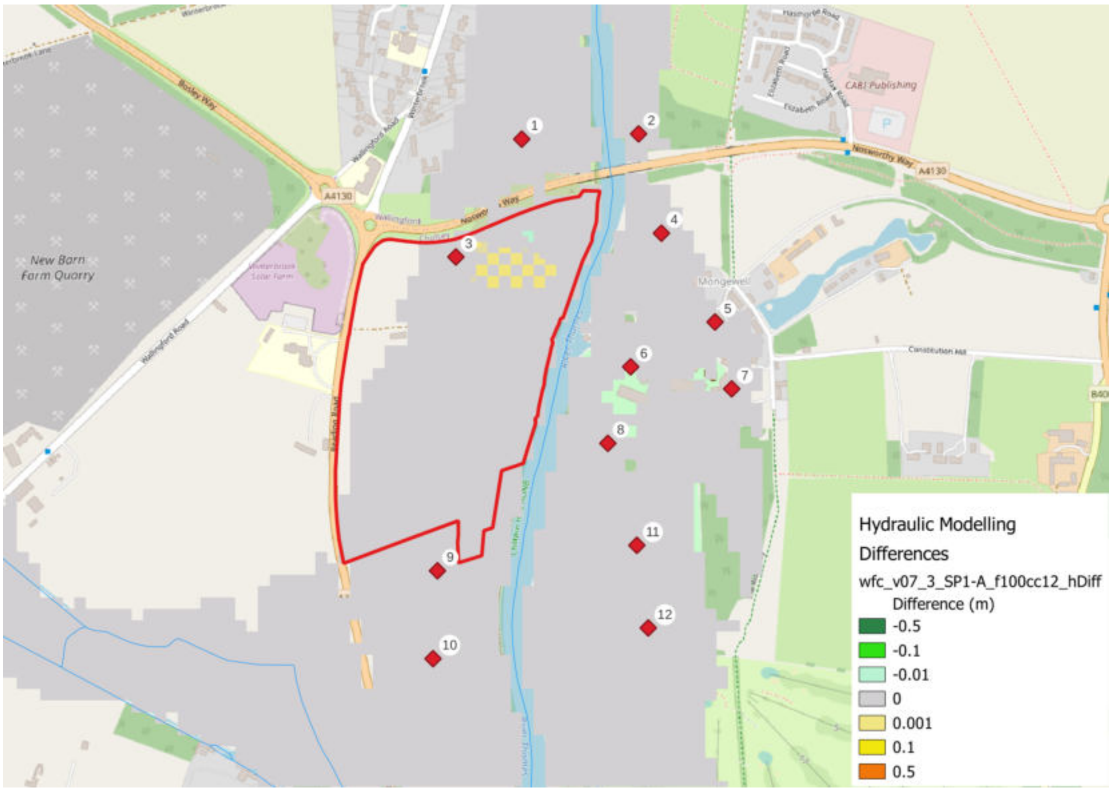


Figure 6.7: Flood Difference Mapping : Stage SP1 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

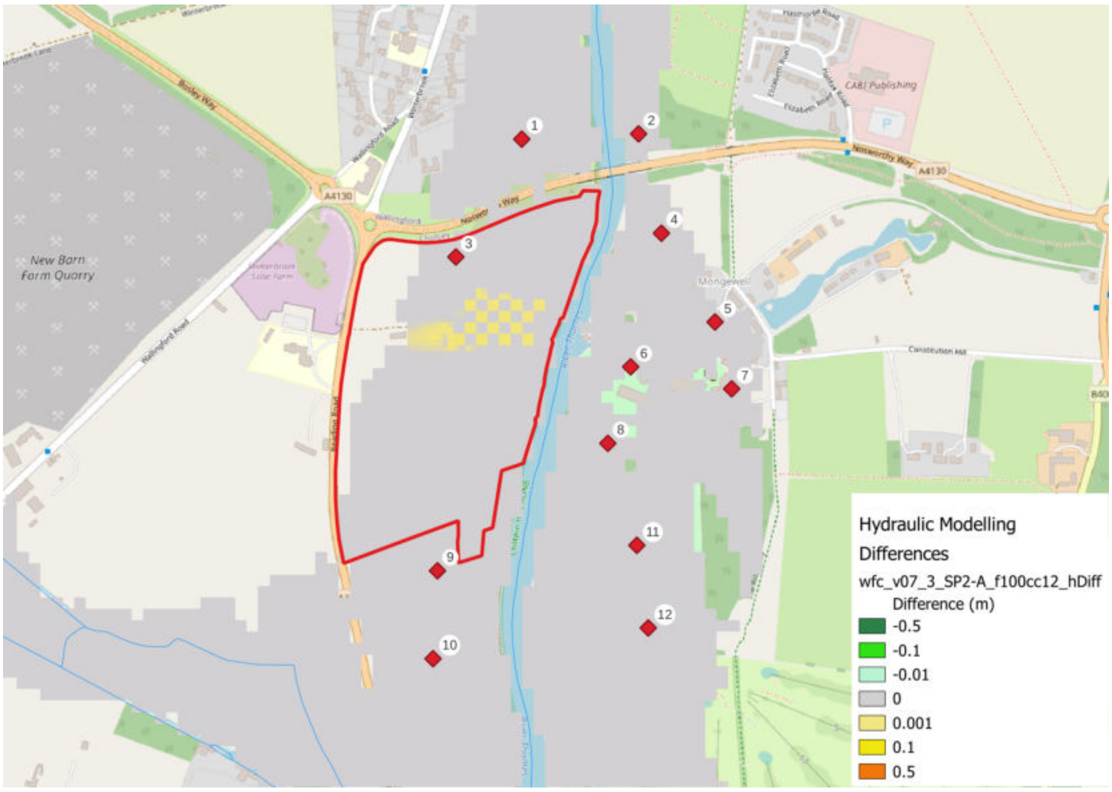


Figure 6.8: Flood Difference Mapping : Stage SP2 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

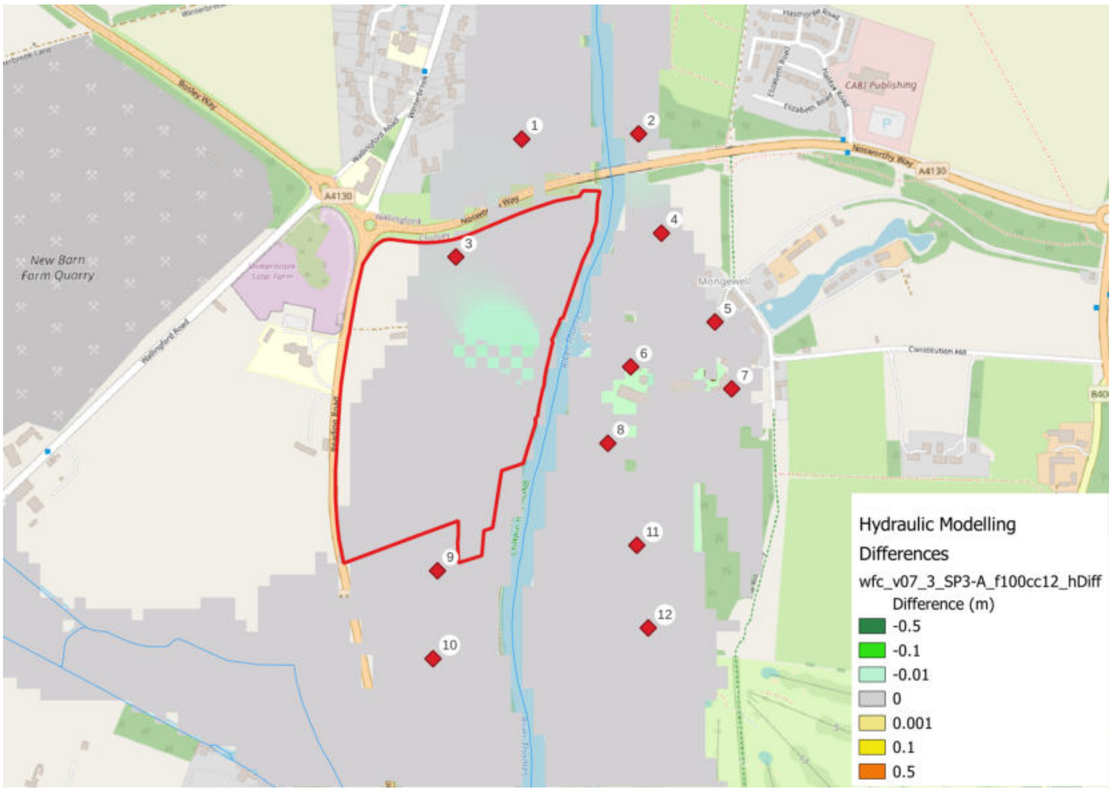


Figure 6.9: Flood Difference Mapping : Stage SP3 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

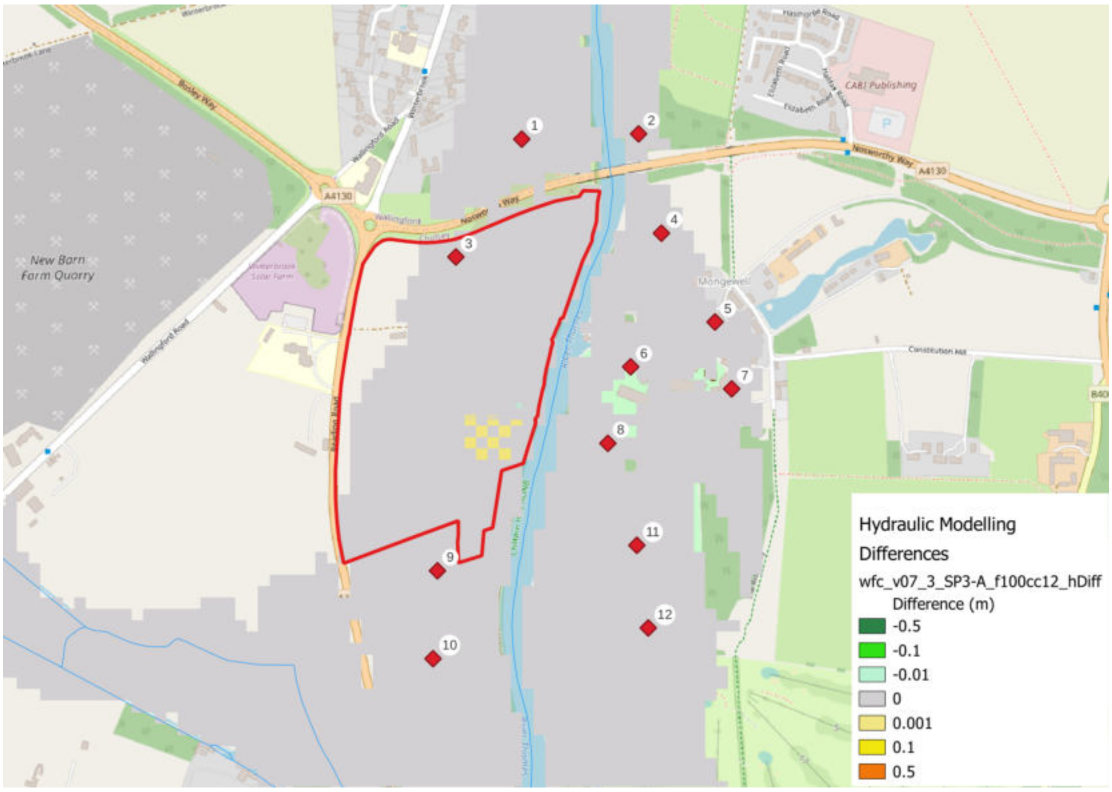


Figure 6.10: Flood Difference Mapping : Stage SP4 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

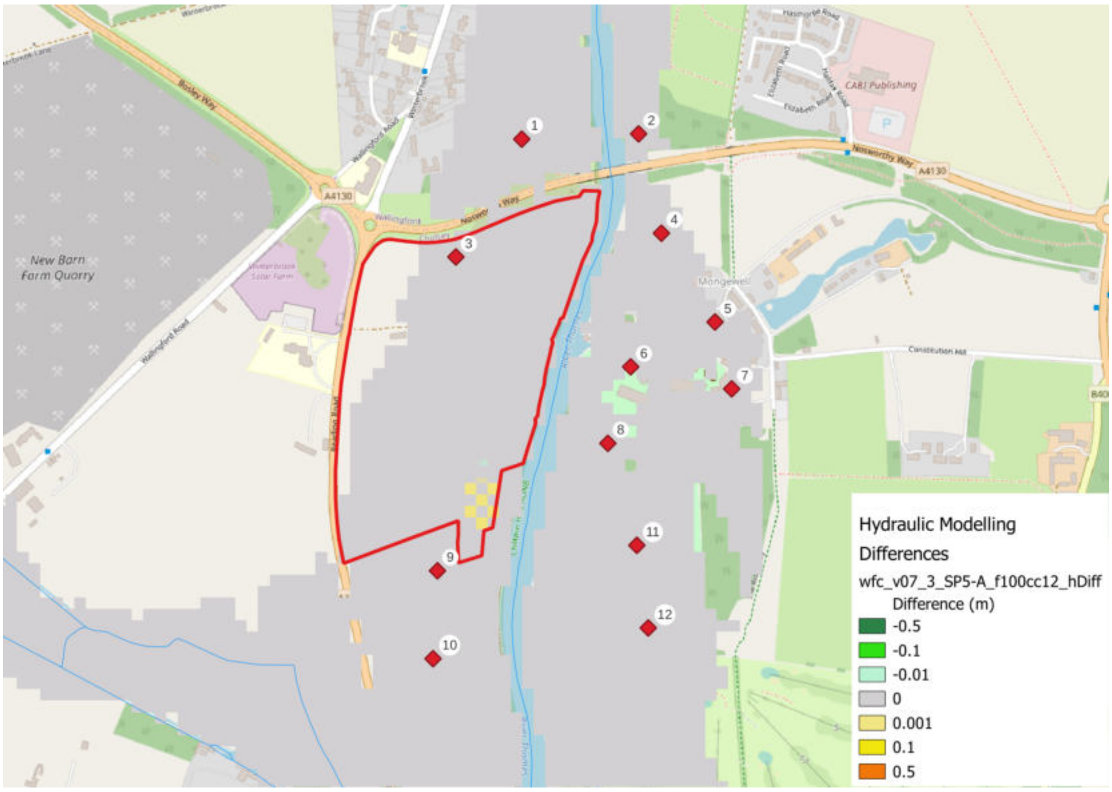


Figure 6.11: Flood Difference Mapping : Stage SP5 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

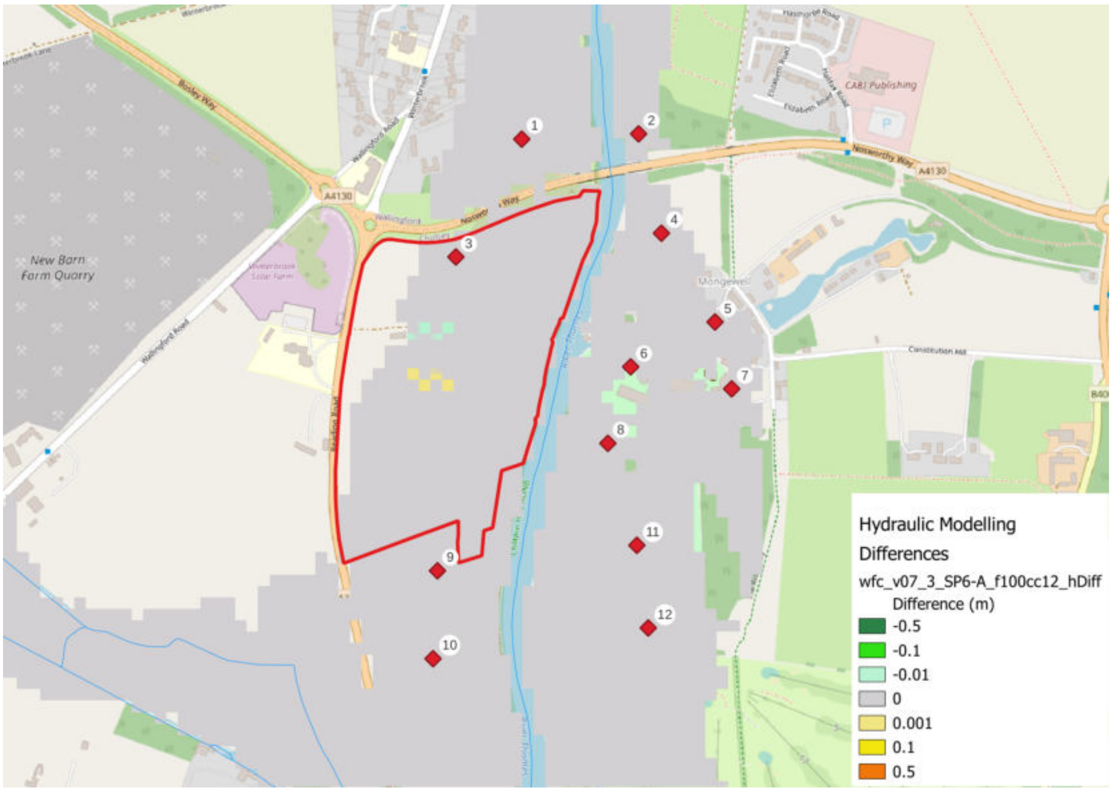


Figure 6.12: Flood Difference Mapping : Stage SP6 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

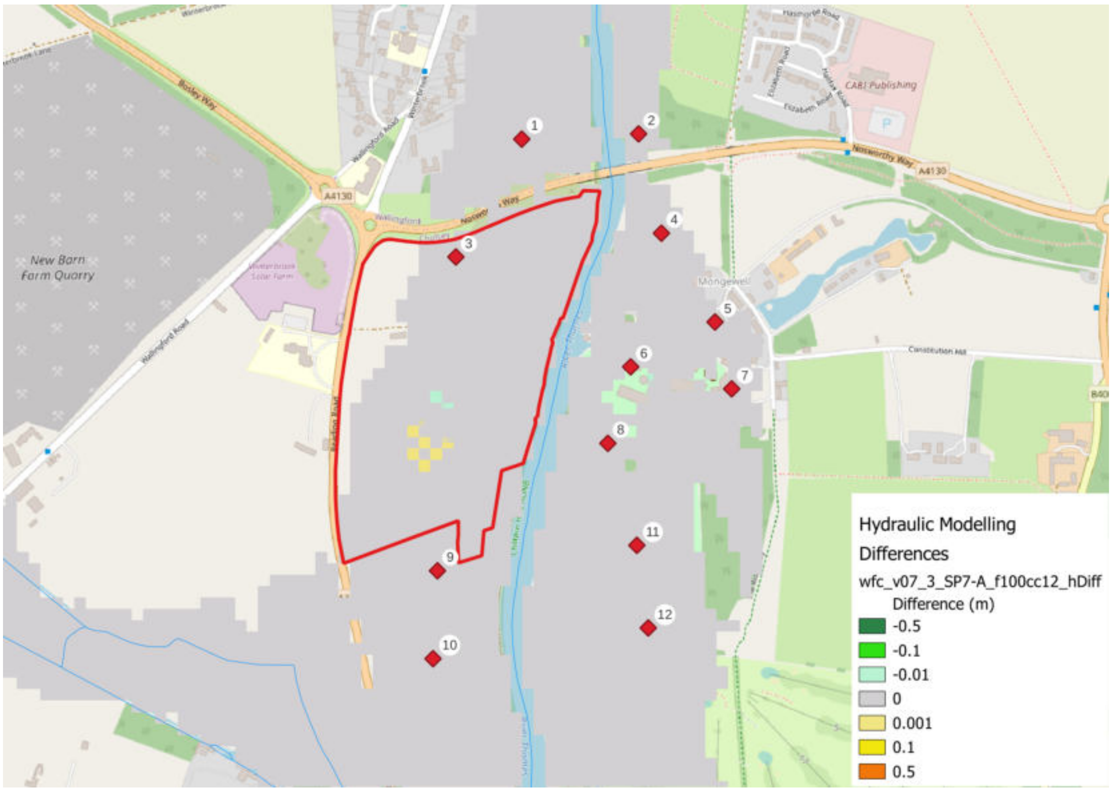


Figure 6.13: Flood Difference Mapping : Stage SP7 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

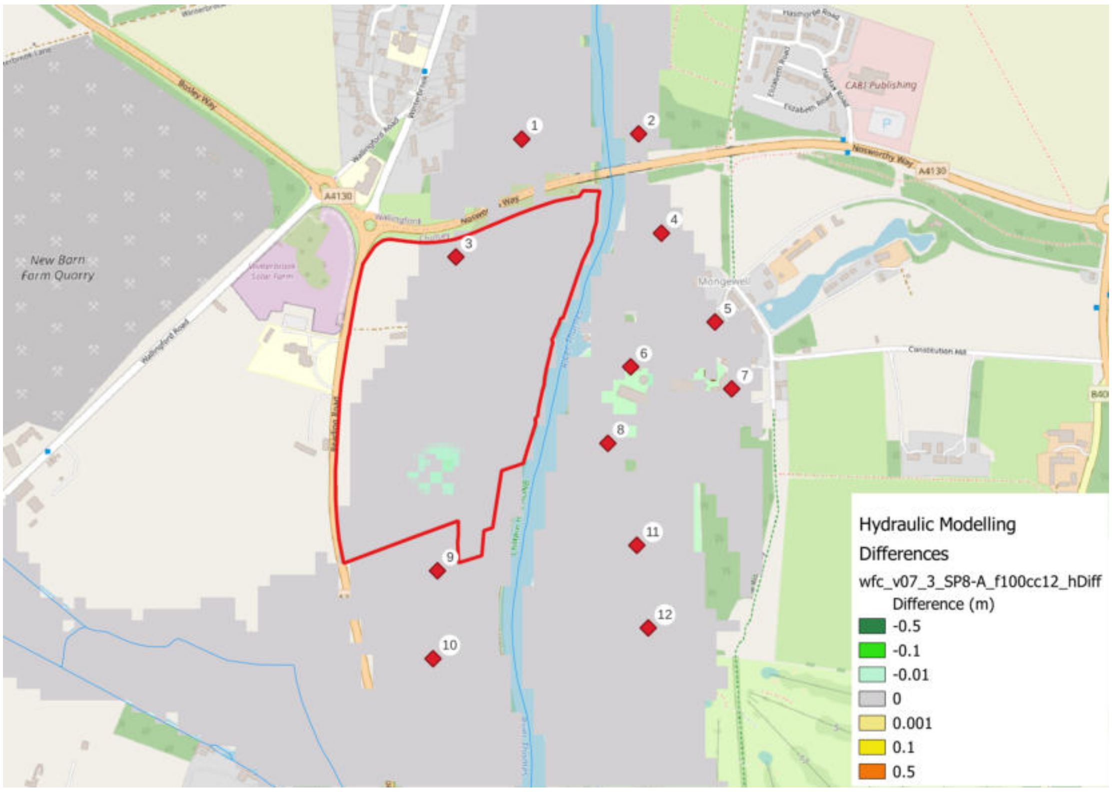


Figure 6.14: Flood Difference Mapping : Stage SP8 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

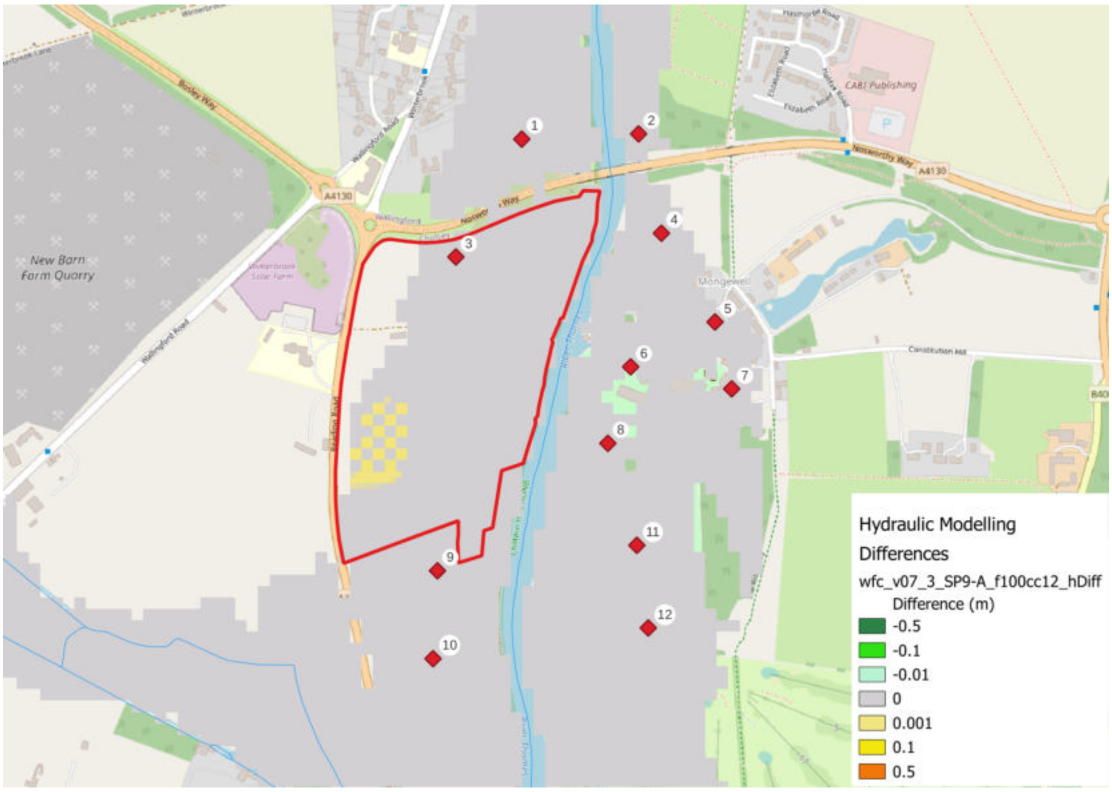


Figure 6.15: Flood Difference Mapping : Stage SP9 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

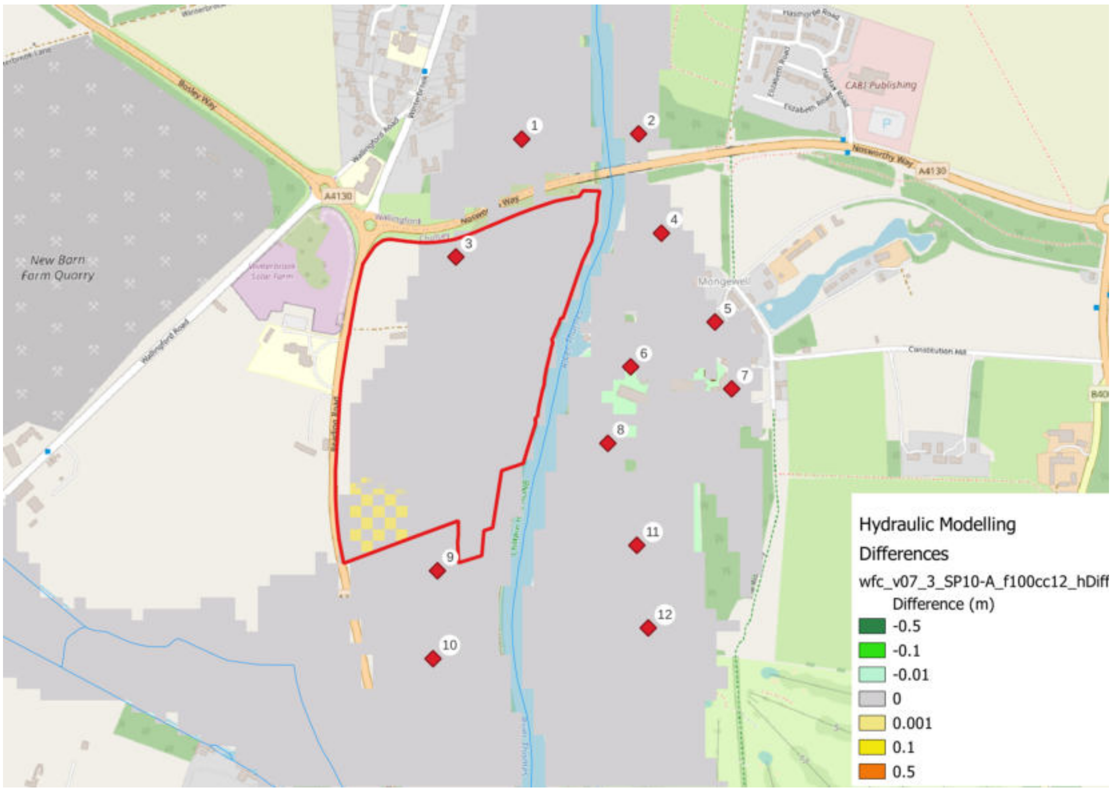


Figure 6.16: Flood Difference Mapping : Stage SP10 Flood Levels minus Baseline Flood Levels for a 1%AEP event with an allowance of 12% for climate change

6.4 Model Stability

The underlying equations which drive FMP-TUFLOW are highly complex. In the context of evaluating flood risk to centimetre / millimetre levels of accuracy, it should be recognised that there is no perfect mathematical solution to the equations and the solution is approached through iterations, which necessarily means some degree of inaccuracy enters the system with every timestep.

These errors can, and do, accumulate over the length of a simulation and are the source of most instabilities found in hydraulic models. These can also be mathematically 'chaotic', which means that similar starting and boundary conditions can yield unpredictable different end states.

There are also computational inaccuracies relating to precision which can introduce small errors which add up over time. This is, in essence, the number of decimal places the computer is able to calculate. Precision can be improved from the default level of precision (single precision) to be significantly more precise (double precision), which should reduce these types of errors. The Whitecross model has been run in double precision.

All of the above is known and understood by the industry and is part of why there it is generally accepted that the result of a given model may not be accurate. The TUFLOW's classic solver is known to and is expected to introduce some degree of error over the course of a simulation.

Instabilities can be identified by rapid changes in velocity or water level and increases / decreases in the mass / volume of water within a simulation. Instabilities can be large, localised and can have a significant and noticeable impact on water levels / velocities in the vicinity of the instability. In some cases, water levels can be many metres higher than the surrounding water level, and this can result in radiating waves propagating from the centre of the instability.

However, in most cases instabilities and errors are small and do not significantly affect water levels within a model, nor have an impact on the results, nor conclusions. Instabilities / errors are present in all models including the Environment Agency's Abingdon Flood Schemes Thames Model

In order to assist hydraulic modellers to understand the 'health' of a hydraulic model, the FMP-TUFLOW software outputs the 'mass balance error' variable throughout the simulation. A perfect hydraulic model would be mass conservative. This means that the volume / mass of water within the system at the end of the simulation would equal that at the start, plus all that has entered through boundaries, minus any water that has left through boundaries.

All models lose or accumulate water volume / mass as a result of computational inaccuracies discussed above. A positive mass balance error means that there is an increase in the volume / mass of water in the model which manifests itself as an anomalous increase in water level. Conversely, a negative mass balance error means that there is an anomalous decrease in the volume of water within the model which gives a reduction in water level. It is generally accepted that as long as the mass balance is less than 1% of the overall flow a model may be considered to be healthy.

The Edenvale Young review of the Middle Thames model as supplied by the Environment Agency concluded that there were no large, localised instabilities within the model. However, the incoming FMP-TUFLOW model configured with a 12% climate change allowance on flow had a mass balance error of -1,652,372m3 at peak water level (See Figure 6.17 approx. 150 hrs simulation time 600 timesteps) for a 1 in 100 year event with a climate change allowance of 12% and a 20m grid using the LiDAR supplied with the model. This is equivalent to an anomalous decrease in water level across the entire model domain of -0.048 m.

Accordingly, it is considered that the stability of the incoming model is not fit for assessing changes in levels to the tolerances of 0.010m required by the Environment Agency.

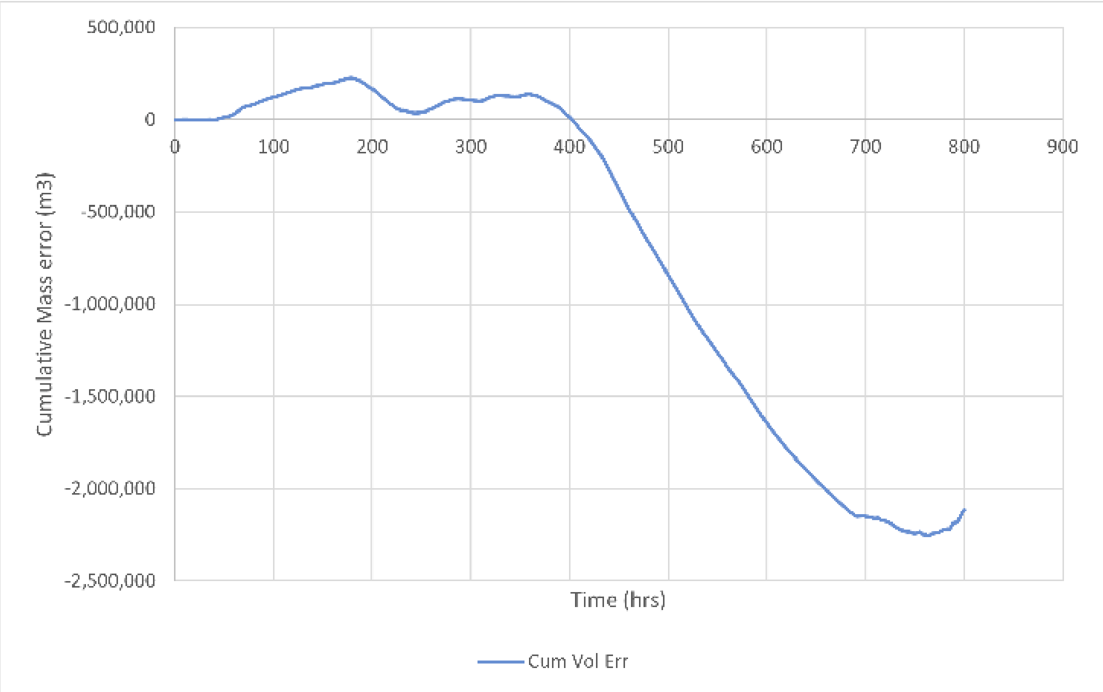


Figure 6.17: Cumulative Mass Balance Error for a 1 in 100 year event with 12% cc

6.5 Sensitivity Testing

6.5.1 Sensitivity to Grid Size and LiDAR

A sensitivity check has been made for 10m and 20m grid sizes for the baseline model for a 1 in 100 year event with 12% climate change. In addition, a comparison has also been made of the impact of using newly available LiDAR within the model. Table 6.5 shows the results of the sensitivity analyses. The mass balance error for to 10m grid is a magnitude greater than the 20m grid and there is very little difference in the application of the old or updated LiDAR.

The discussions in the previous section has already explained that the limiting accuracy, of the baseline model with the 10m grid is 0.048m with a mass balance error of -1,652,372m3 at peak water level. This becomes hugely significant when comparing model scenarios such as pre and excavation stages. This contrasts with a mass balance error of 112,531 m3 for the baseline scenario with a grid size of 20m which is equivalent to an anomalous increase, in water level across the entire model domain of +0.003 m.

This result may seem to be incongruous, and it would seem sensible that smaller grid sizes should give “more accurate” results. However, the finite difference scheme employed by TUFLOW Classic uses the water level difference across a cell to drive the calculation. In circumstances where the water surface is comparatively flat (such as the Thames) and there is a significant change in flow or bed slope then the software algorithm may struggle to iterate to a satisfactory solution, and this will result in larger mass balance errors.

The use of a larger grid size inevitably increases the difference in water level across cells and thus reduces potential computational problems within the program algorithm. In Edenvale Young’s experience, a larger grid size can lessen the probability of large instabilities forming within the simulation and reduce mass balance errors.

Table 6.5 confirms that the 20 grid performs significantly better. Accordingly, the modelling for the FRAhas been based on a 20m grid using the LiDAR which was supplied with the incoming model.

Grid	LiDAR	Cumulative Mass Balance Error (m3)	Average increase in Peak Level (m)
10m	Supplied LiDAR	-1,652,372	-0.048
20m	Supplied LiDAR	112,531	0.003
20m	New LiDAR	93,472	0.003

Table 6.5: Sensitivity analysis on grid size and LiDAR

Finally, it should also be noted that a 20m grid is commensurate with the width and features of the floodplain. At the sand and gravel site the floodplain on the right bank is 340m wide. Accordingly, a 20m grid is perfectly sufficient grid size to represent features in the floodplain.

The cumulative error (joint model tolerance), when comparing the the results of the baseline and phase SP1 to SP10 models, is in the order of 0.012m (0.003m + 0.09m). There are no increases in the modelled peak water level greater than 0.006m. All water level difference results are within the joint model tolerance. It is considered that it is not appropriate to treat values which are smaller than the joint model tolerance as real increases or decreases in water level.

7 Flood Response Planning

During the operational phase of the works, labour and plant will be working on the flood plain. Water depths in areas where mineral workings are being undertaken will be deep and hazardous during flooding. Accordingly, a Flood Response Plan will be required to ensure that all operatives and plant are removed from the flood plain to a place of safety before the onset of flooding. It is recommended that operators of the site:

- Sign up to the EA Flood Warnings Direct service and make sure you know what each flood warning code means.
- Develop a plan for the movement of plant and labour out of the flood plain upon receipt of a flood warning.

8 Conclusions and Recommendations

8.1 Conclusions

Edenvale Young Associates were commissioned by Greenfield Environmental to complete a Flood Risk Assessment for the sand and gravel working scheme at the White Cross Farm to the south of Wallingford. The scope of works has included desktop analysis of published data and hydraulic modelling using the Environment Agency's 1D-2D FMP-TUFLOW hydraulic model of the River Thames to assess flood risk to the site.

The hydraulic modelling has concluded that there would be no increases in the modelled peak water level greater than 0.006m. All water level difference results are within the joint model tolerance and the maximum increase in water level is less than 0.010m as required by the EA during the excavation stages. Based on the analysis, the following conclusions have been drawn:

- Excavation for sand and gravel will be in on the floodplain of the River Thames in Flood Zones 2 and 3.
- Stockpiles, earth bunds, offices, welfare facilities and a weighbridge will be located Flood Zone 1.
- Phases 1 and 2 are wholly within the functional flood plain (Flood Zone 3b).
- Phases 3 and 3 are partially within the functional flood plain (Flood Zone 3b).
- sand and gravel working is classified as Water Compatible development which is compatible with Flood Zones 2 and 3.
- Sequential and Exception Tests are not required for the scheme.
- There are no records within the SFRA report of sewer flooding to the site.
- Surface water flooding and reservoir inundation are not considered to present a flood risk to the scheme.
- Groundwater will be encountered during excavation for the mineral workings which must be managed by the operator.
- Hydraulic modelling indicates that there is no measurable or material change in flood extent as a result of the phasing of the works.

- Hydraulic modelling has demonstrated that there is no increase in off-site water levels for the 1%AEP event with an allowance of 12% for climate change.
- There is no requirement for flood storage compensation as land levels will be restored to existing, or just below existing ground levels.
- The maximum increase in water levels of 0.006m during the excavation stages of the mineral extraction is acceptable based on the discussions with the Environment Agency on the 23 August 2023.

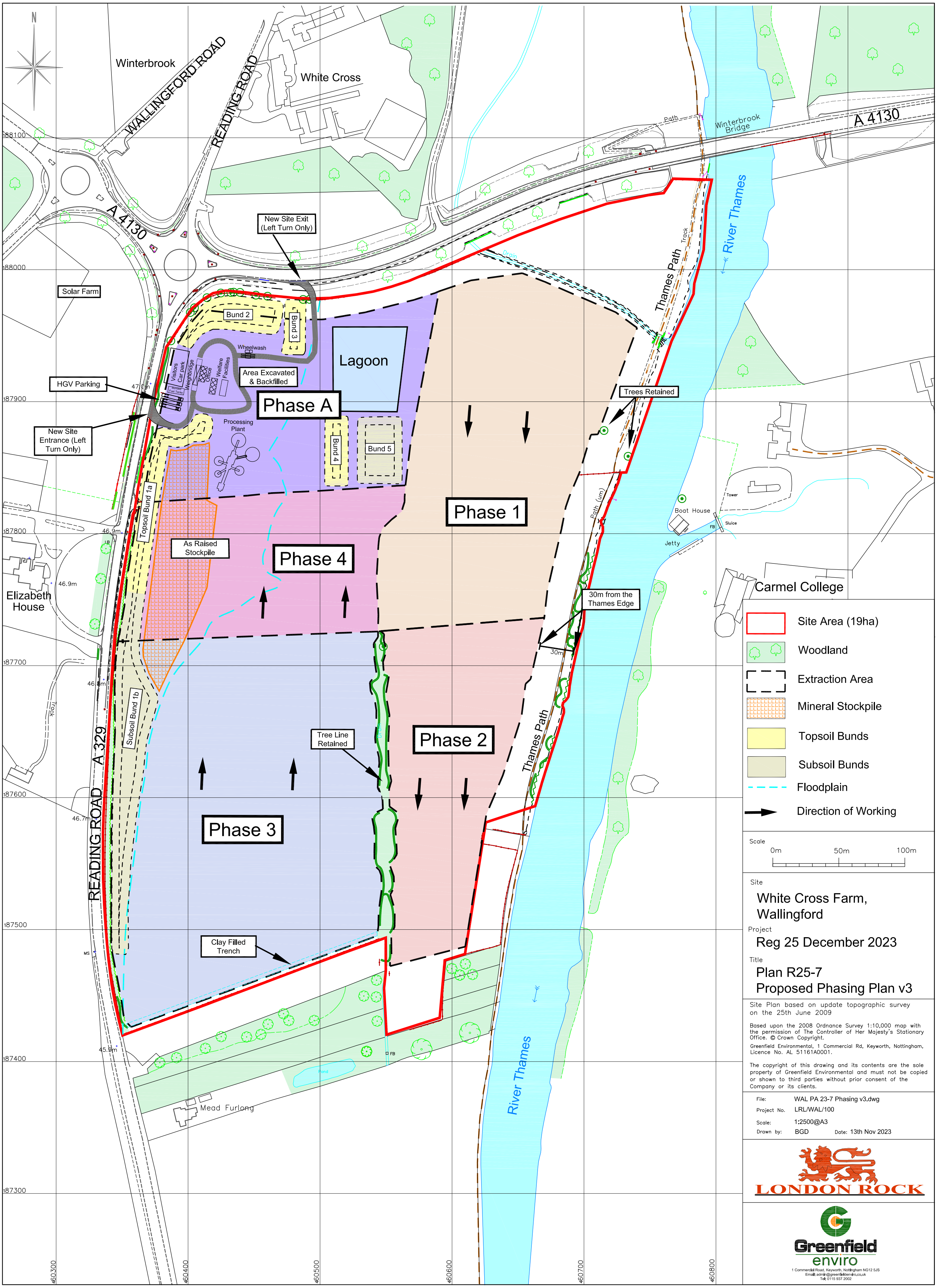
It should also be noted that the final reclamation phase of the works on inclusion of the mineral workings will incorporate an area of approximately 5,000 m2 of wet woodland where ground levels will be reduced by approximately 0.5m giving an increase in flood storage of approximately 2,500 m3.

8.2 Recommendations

It is recommended that:

- Ground levels for the final reclamation phase are no higher than existing.
- Stockpiling areas are sited outside the 1%AEP event with an allowance of 12% climate change.
- A Flood Response Plan is developed to ensure that all operatives, staff, visitors and plant are moved or evacuated from areas which are vulnerable to flooding before the onset of flooding.
- An excavation method statement is developed to ensure that all operatives, staff, visitors are safe from drowning during the operation of the site.
- A drainage plan is prepared to deal with run of from roads, hard standing and processing areas to minimise the impact of the scheme on water quality.

A Development Proposals


N
Winterbrook
WALLINGFORD ROAD
READING ROAD
White Cross
A 4130
Winterbrook Bridge
Path
A 4130
River Thames
Solar Farm
New Site Exit (Left Turn Only)
Bund 2
Bund 3
Wheelwash
Lagoon
Area Excavated & Backfilled
HGV Parking
New Site Entrance (Left Turn Only)
Phase A
Processing Plant
Bund 4
Bund 5
Trees Retained
Thames Path
Track
Phase 1
Topsoil Bund 1a
As Raised Stockpile
Phase 4
Elizabeth House
Boat House
Tower
Sluice
Jetty
Carmel College
30m from the Thames Edge
30m
Subsoil Bund 1b
Tree Line Retained
Phase 2
Thames Path
READING ROAD
A 329
Phase 3
Clay Filled Trench
River Thames
Mead Furlong
Site Area (19ha)
Woodland
Extraction Area
Mineral Stockpile
Topsoil Bunds
Subsoil Bunds
Floodplain
Direction of Working
Scale
0m
50m
100m
Site
White Cross Farm, Wallingford
Project
Reg 25 December 2023
Title
Plan R25-7
Proposed Phasing Plan v3
Site Plan based on update topographic survey on the 25th June 2009
Based upon the 2008 Ordnance Survey 1:10,000 map with the permission of The Controller of Her Majesty's Stationary Office. © Crown Copyright.
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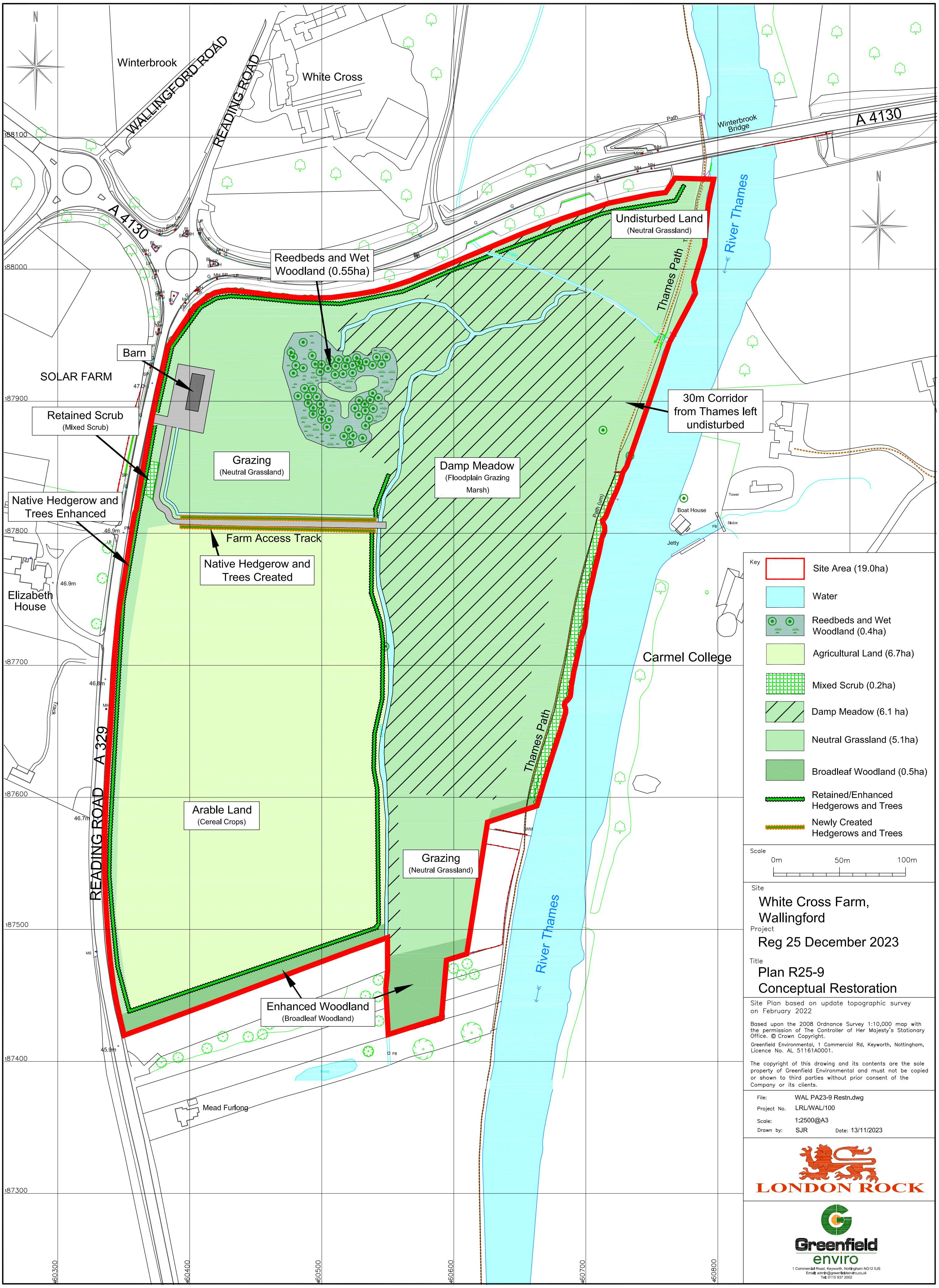
File: WAL PA 23-7 Phasing v3.dwg
Project No. LRL/WAL/100
Scale: 1:2500@A3
Drawn by: BGD
Date: 13th Nov 2023
LONDON ROCK
Greenfield enviro


Winterbrook
WALLINGFORD ROAD
READING ROAD
White Cross
A 4130
Winterbrook Bridge
River Thames
Undisturbed Land
(Neutral Grassland)
Reedbeds and Wet Woodland (0.55ha)
Thames Path
Barn
SOLAR FARM
30m Corridor from Thames left undisturbed
Retained Scrub
(Mixed Scrub)
Grazing
(Neutral Grassland)
Damp Meadow
(Floodplain Grazing Marsh)
Native Hedgerow and Trees Enhanced
Farm Access Track
Native Hedgerow and Trees Created
Boat House
Jetty
Elizabeth House
Carmel College
READING ROAD A 329
Arable Land
(Cereal Crops)
Grazing
(Neutral Grassland)
Enhanced Woodland
(Broadleaf Woodland)
Mead Furlong
Key
Site Area (19.0ha)
Water
Reedbeds and Wet Woodland (0.4ha)
Agricultural Land (6.7ha)
Mixed Scrub (0.2ha)
Damp Meadow (6.1 ha)
Neutral Grassland (5.1ha)
Broadleaf Woodland (0.5ha)
Retained/Enhanced Hedgerows and Trees
Newly Created Hedgerows and Trees
Scale
0m
50m
100m
Site
White Cross Farm, Wallingford
Project
Reg 25 December 2023
Title
Plan R25-9
Conceptual Restoration
Site Plan based on update topographic survey on February 2022
Based upon the 2008 Ordnance Survey 1:10,000 map with the permission of The Controller of Her Majesty's Stationary Office. © Crown Copyright.
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Date: 13/11/2023
LONDON ROCK
Greenfield enviro

B Hydraulic Model Results

B.1 Depth

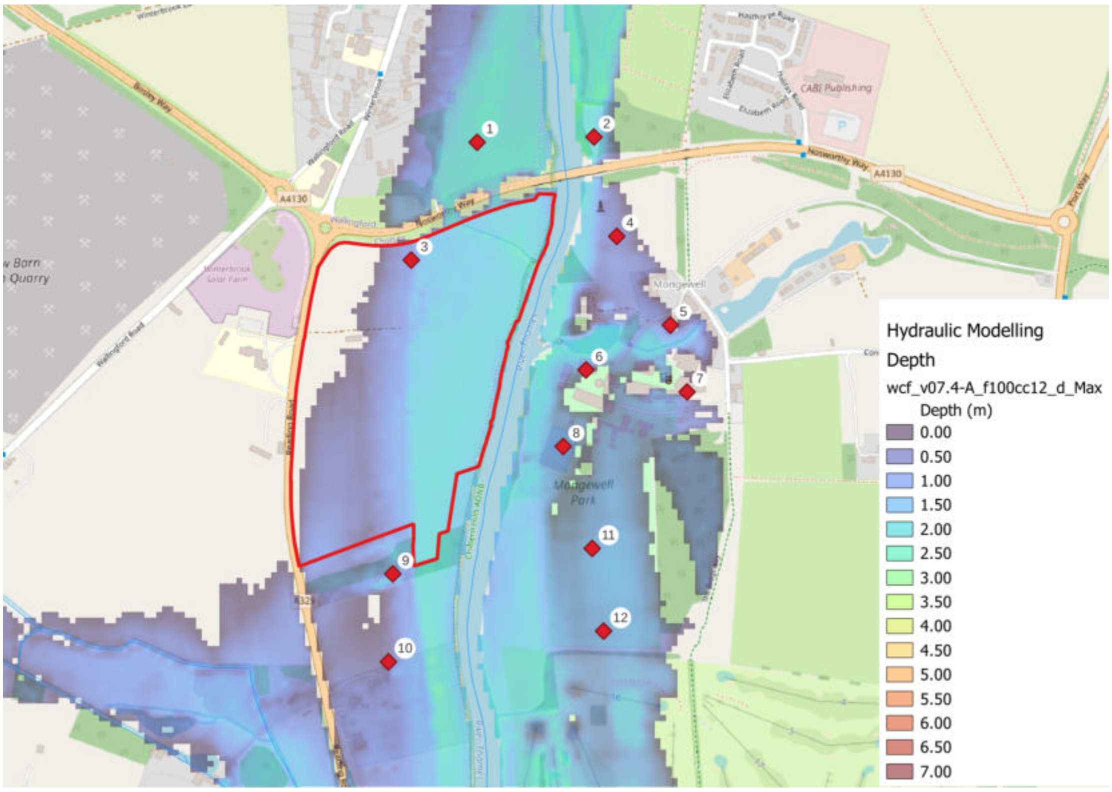

Figure B.1: Baseline Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

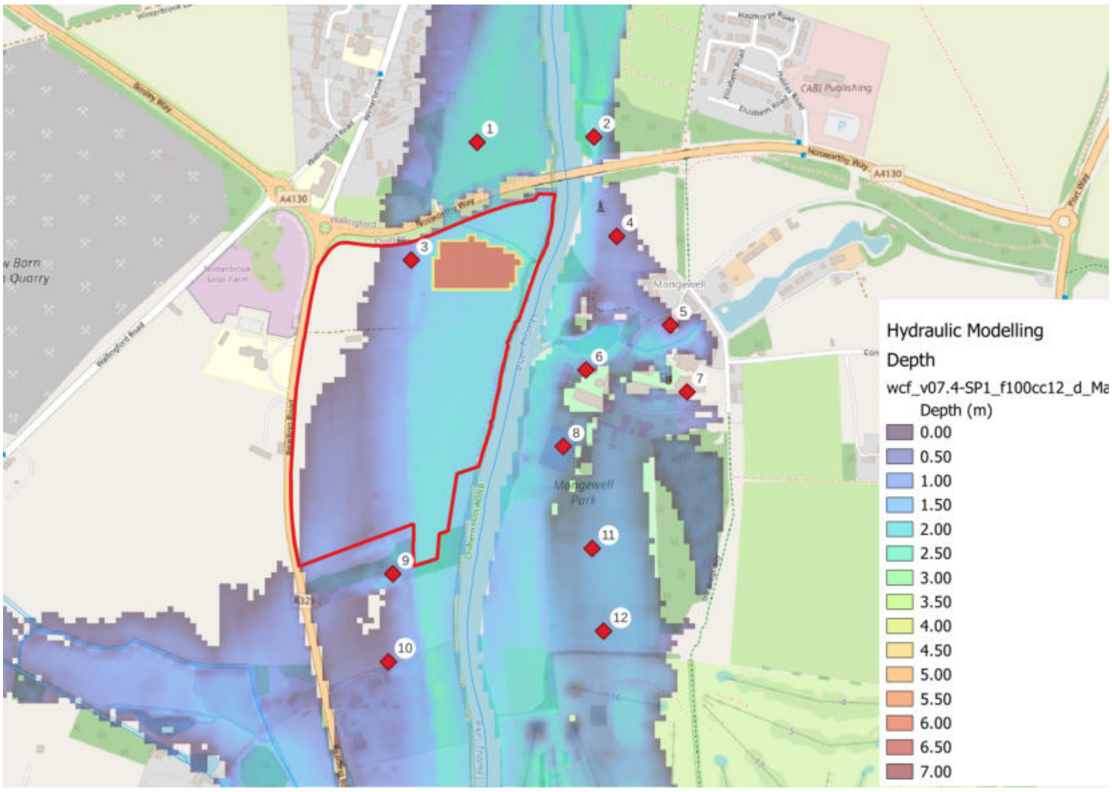

Figure B.2: Stage SP1 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

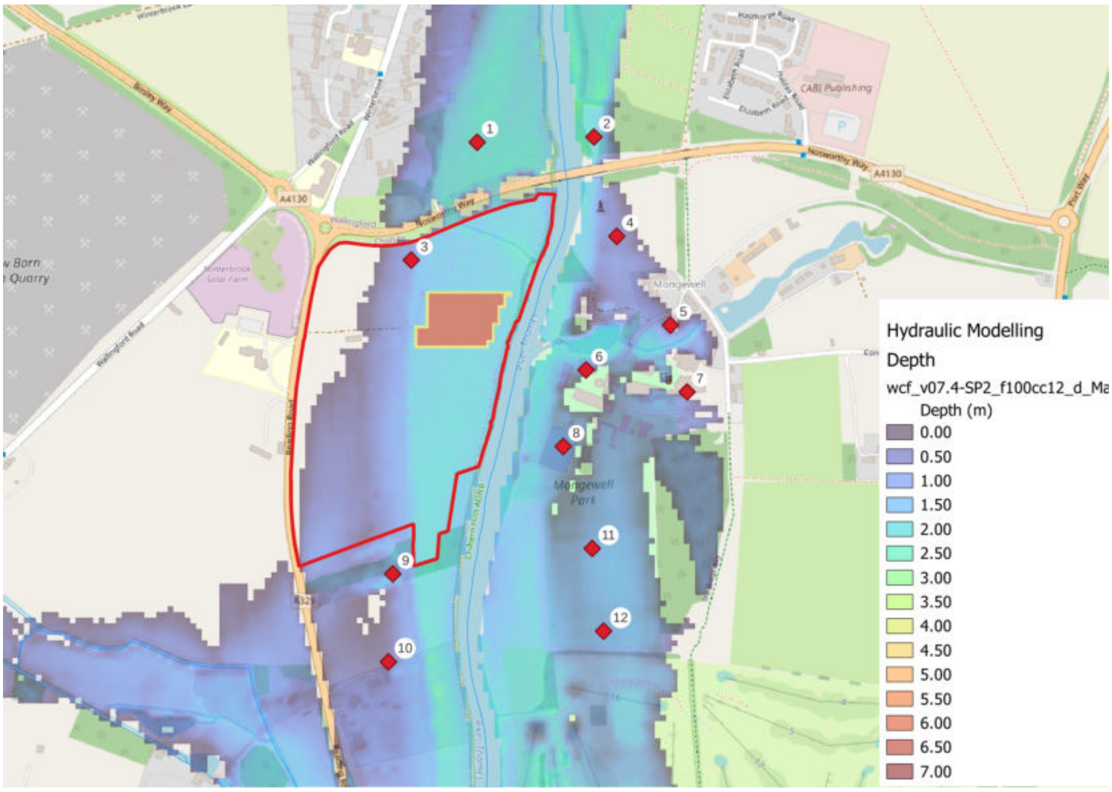

Figure B.3: Stage SP2 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

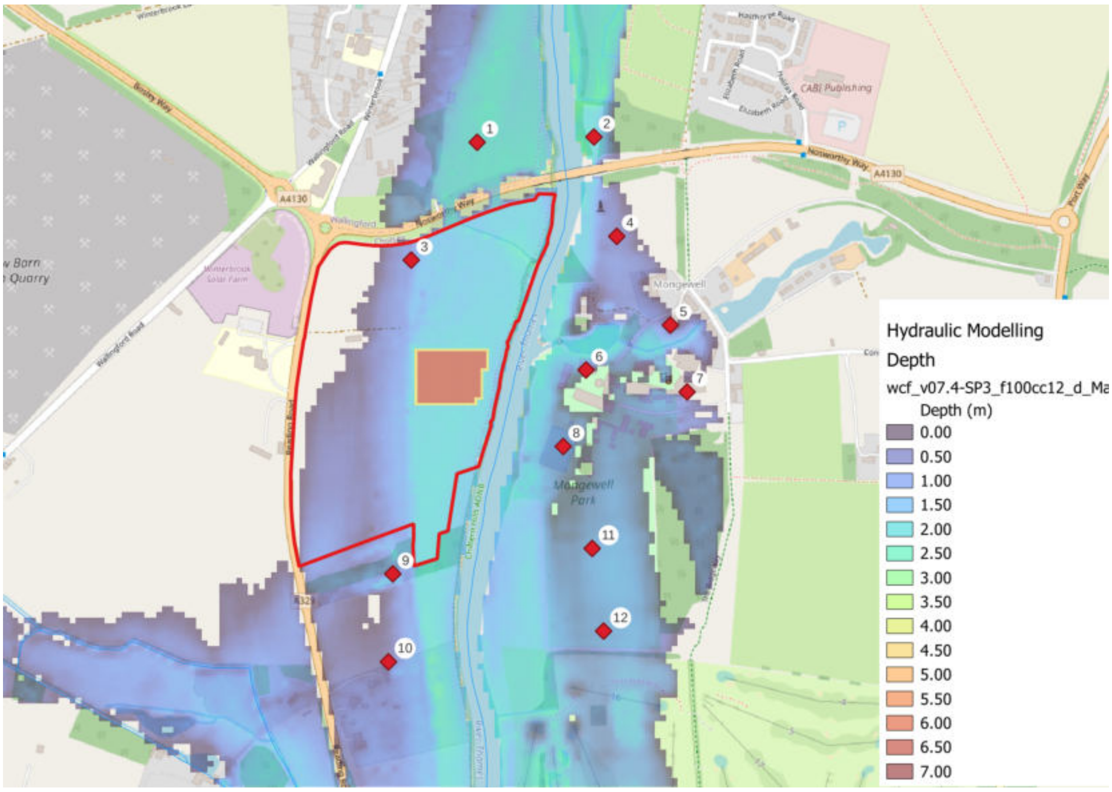

Figure B.4: Stage SP3 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

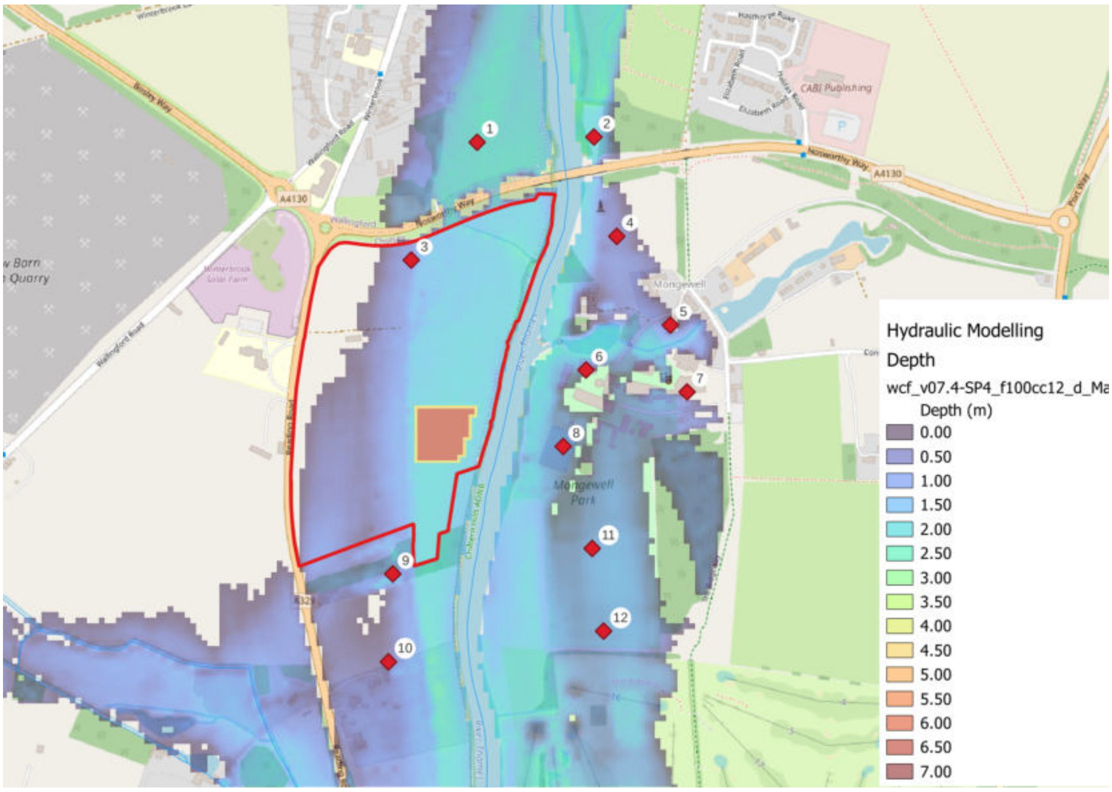

Figure B.5: Stage SP4 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

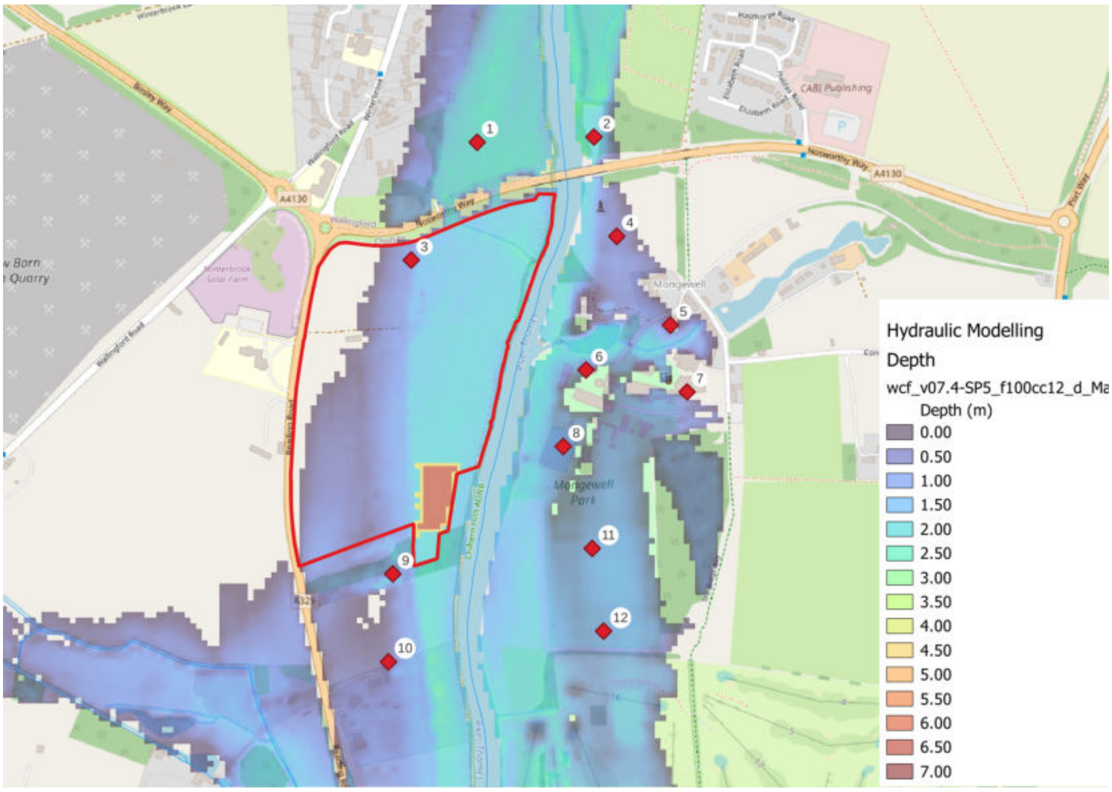

Figure B.6: Stage SP5 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

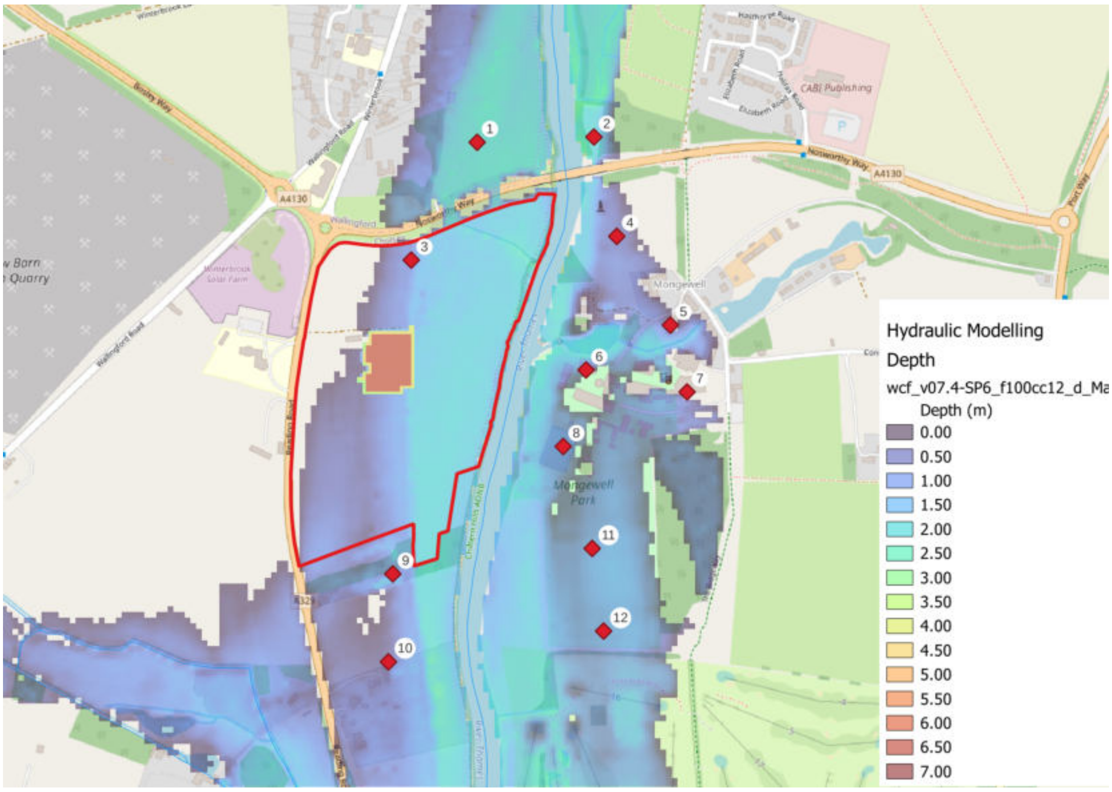

Figure B.7: Stage SP6 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

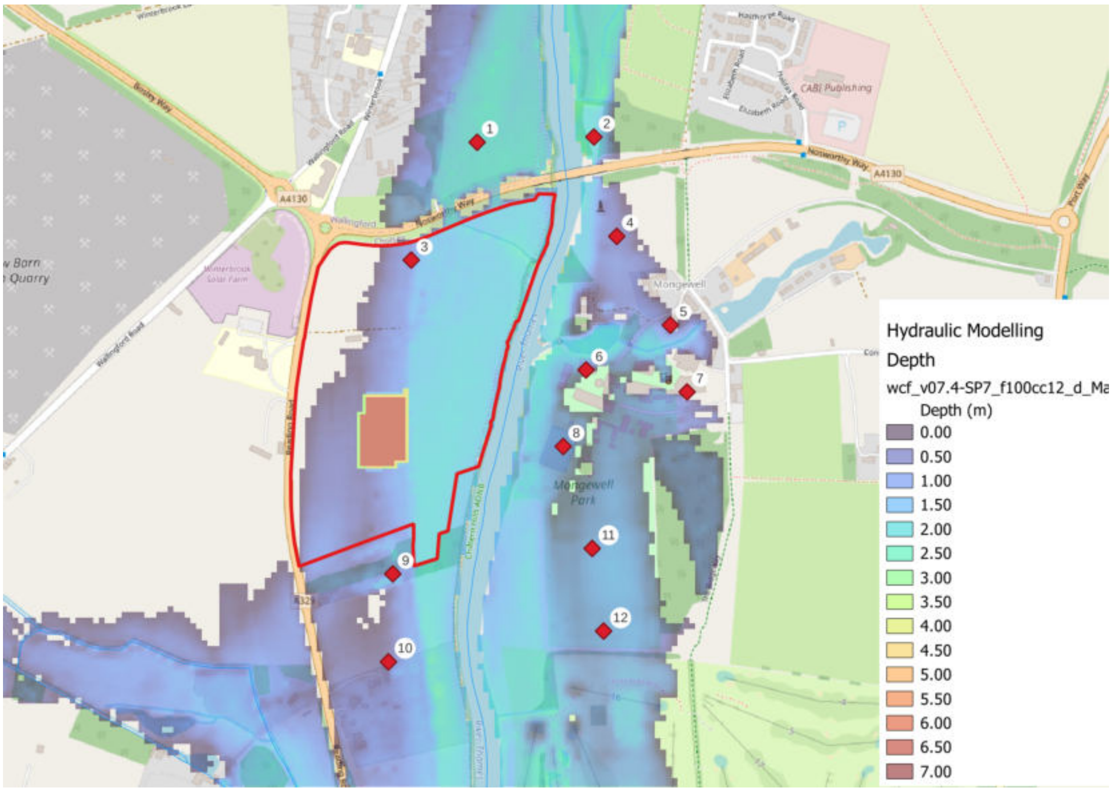

Figure B.8: Stage SP7 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

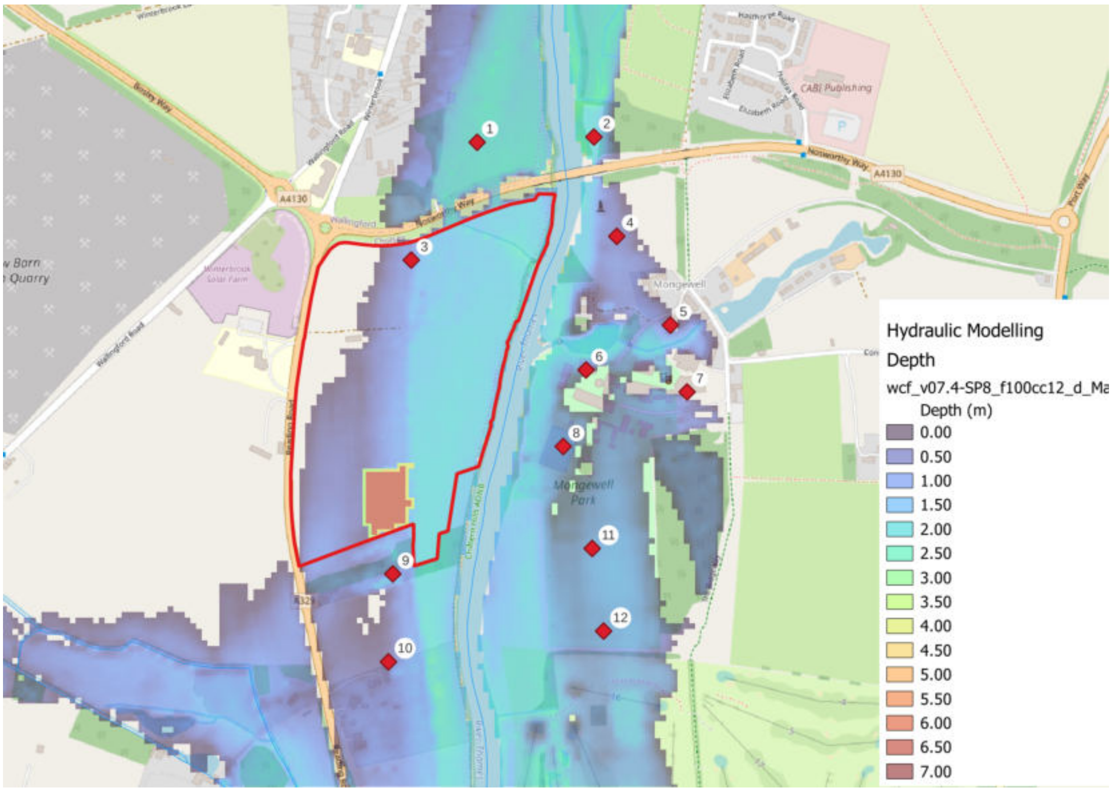

Figure B.9: Stage SP8 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

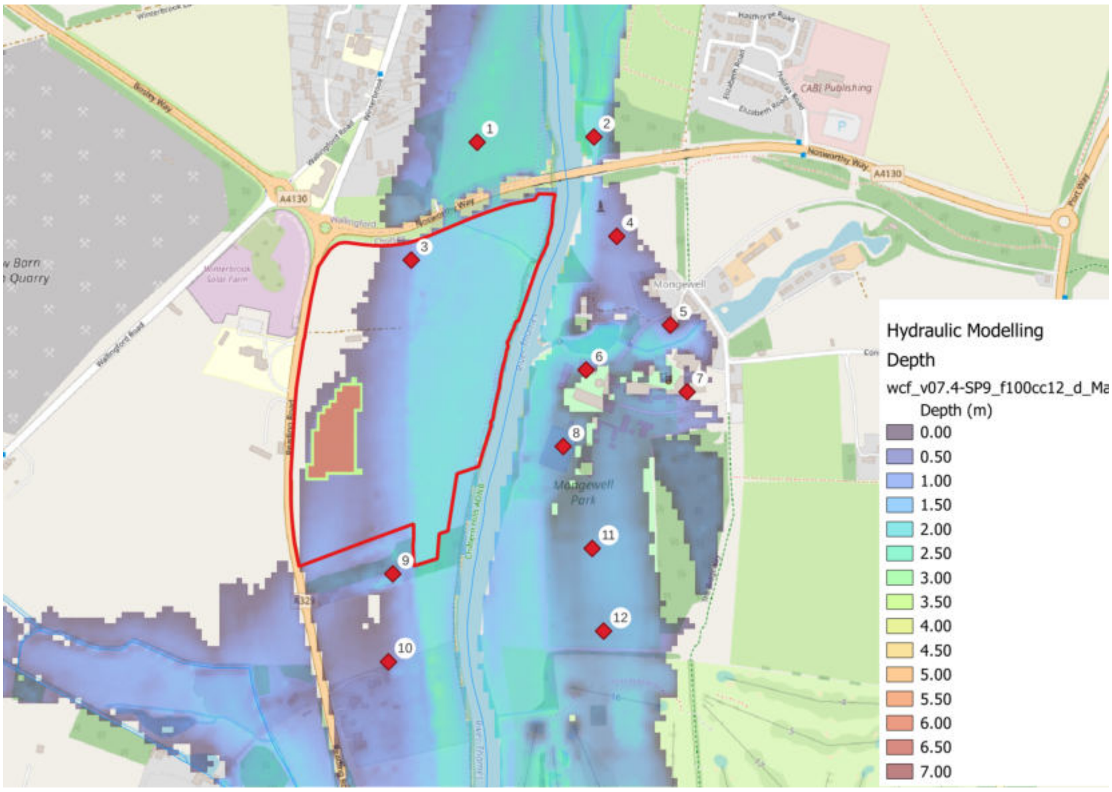

Figure B.10: Stage SP9 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

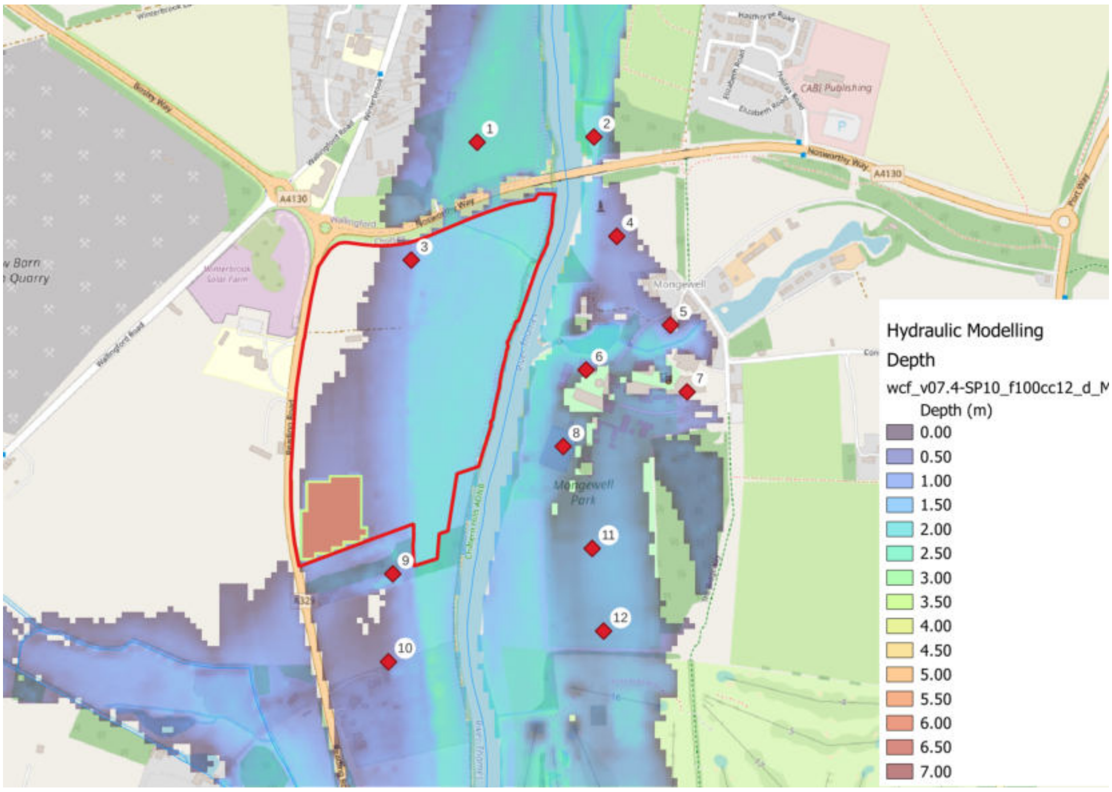

Figure B.11: Stage SP10 Model Results - Peak Water Depth for a 1% AEP event with an allowance of 12% for climate change

B.2 Water Level

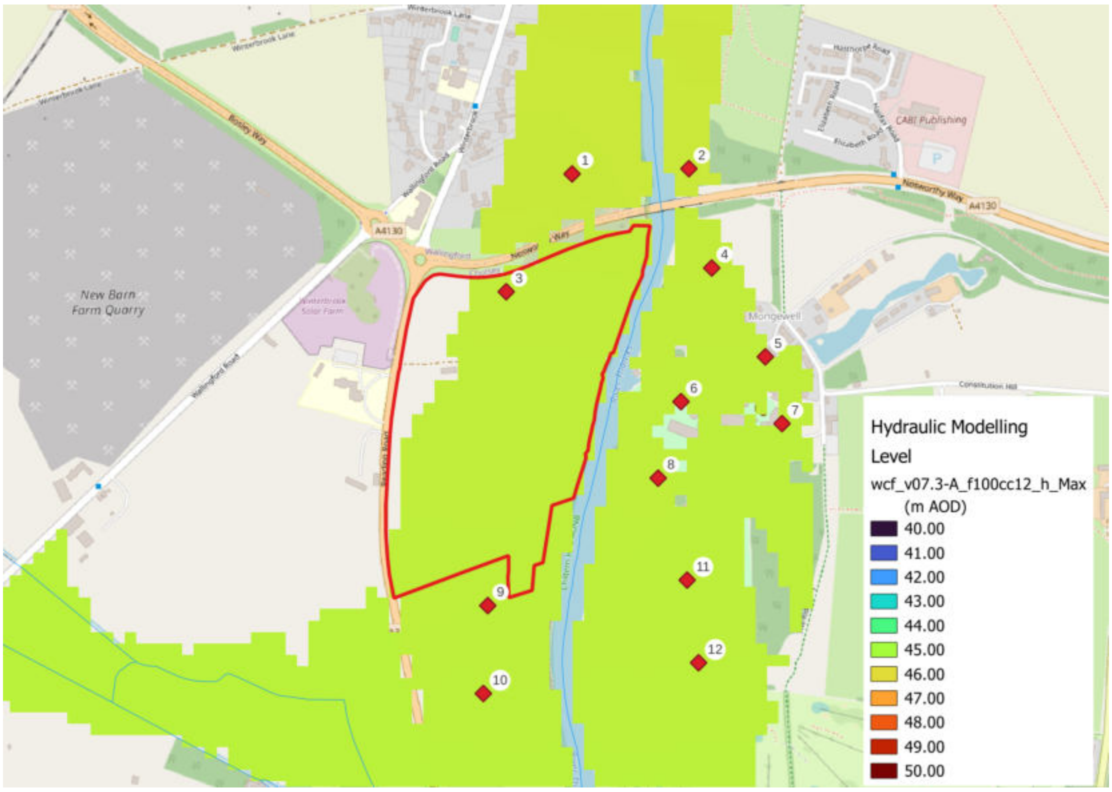

Figure B.12: Baseline Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

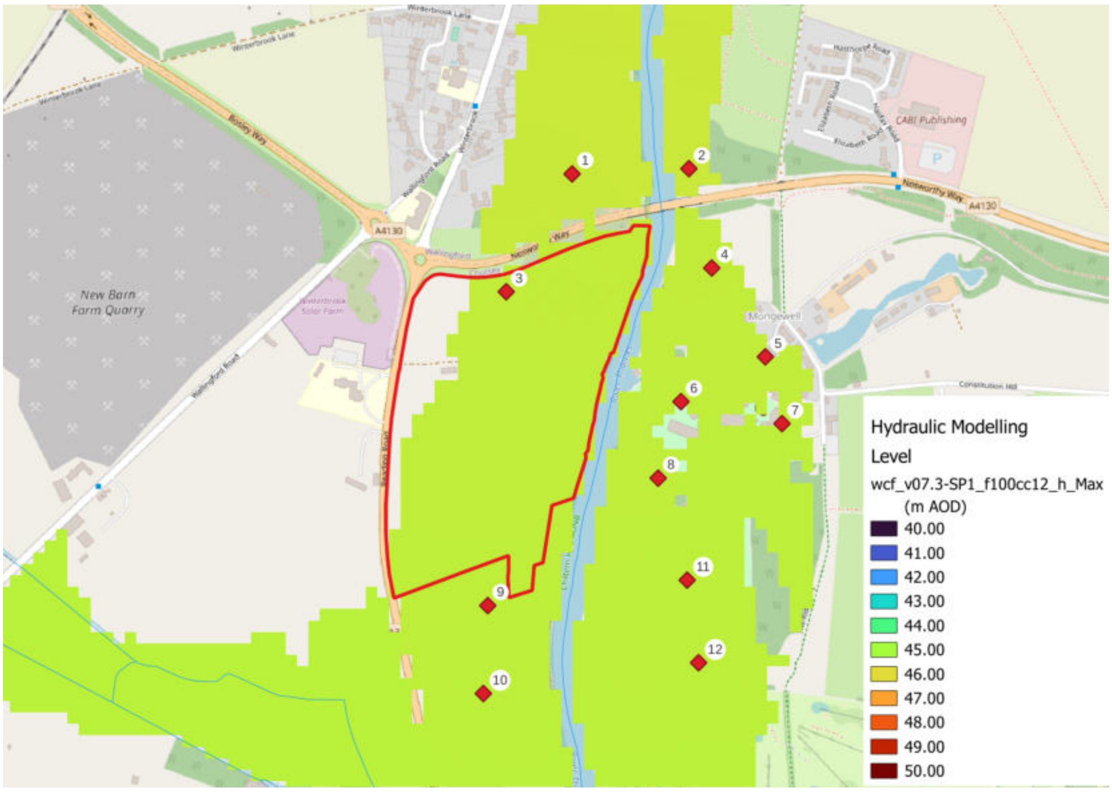

Figure B.13: Stage SP1 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

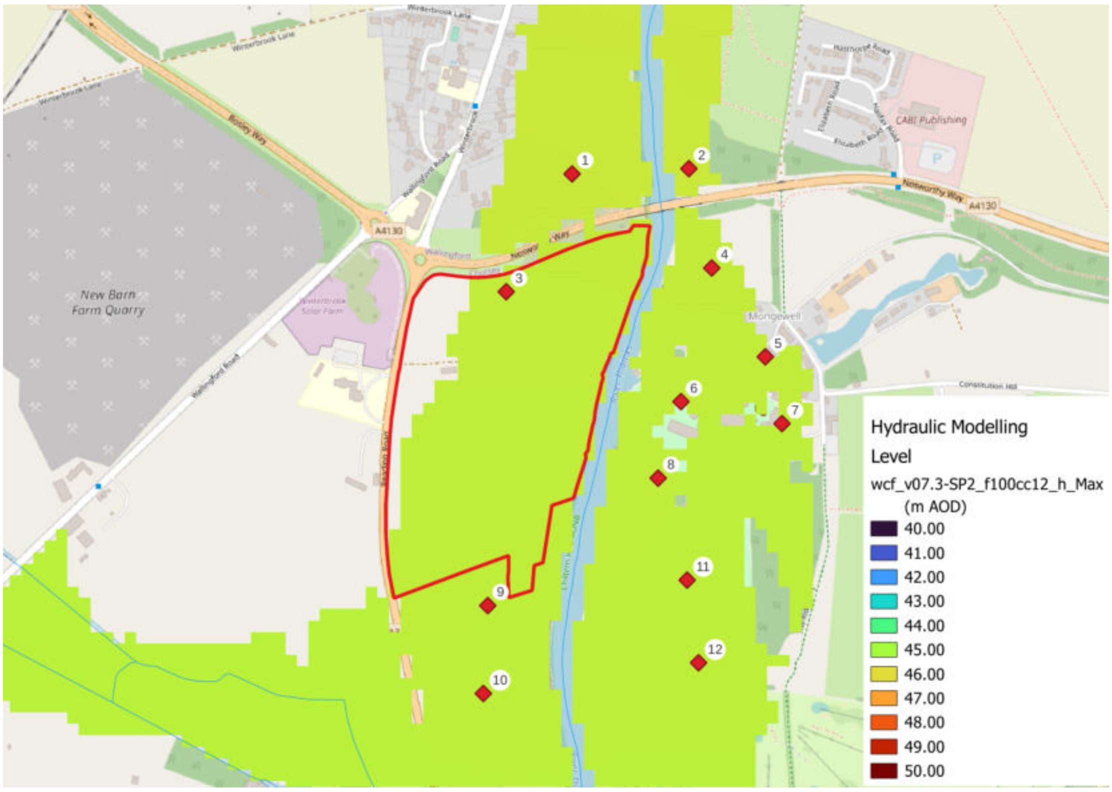

Figure B.14: Stage SP2 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

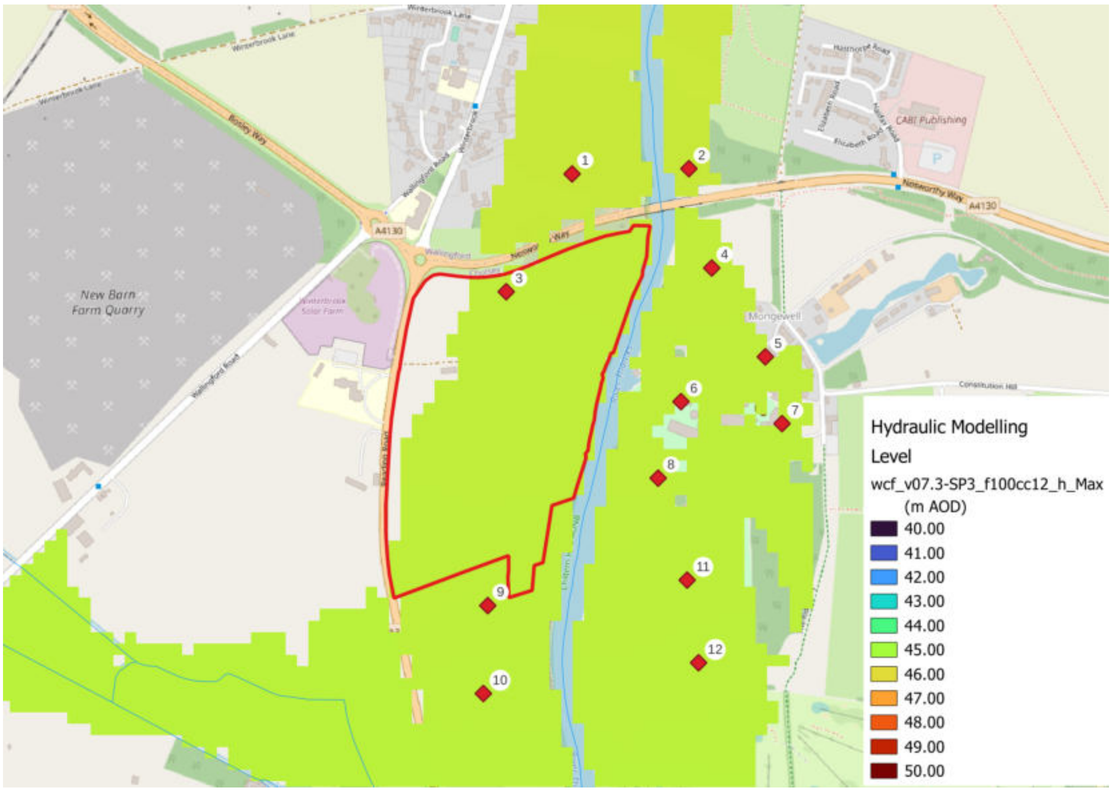

Figure B.15: Stage SP3 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

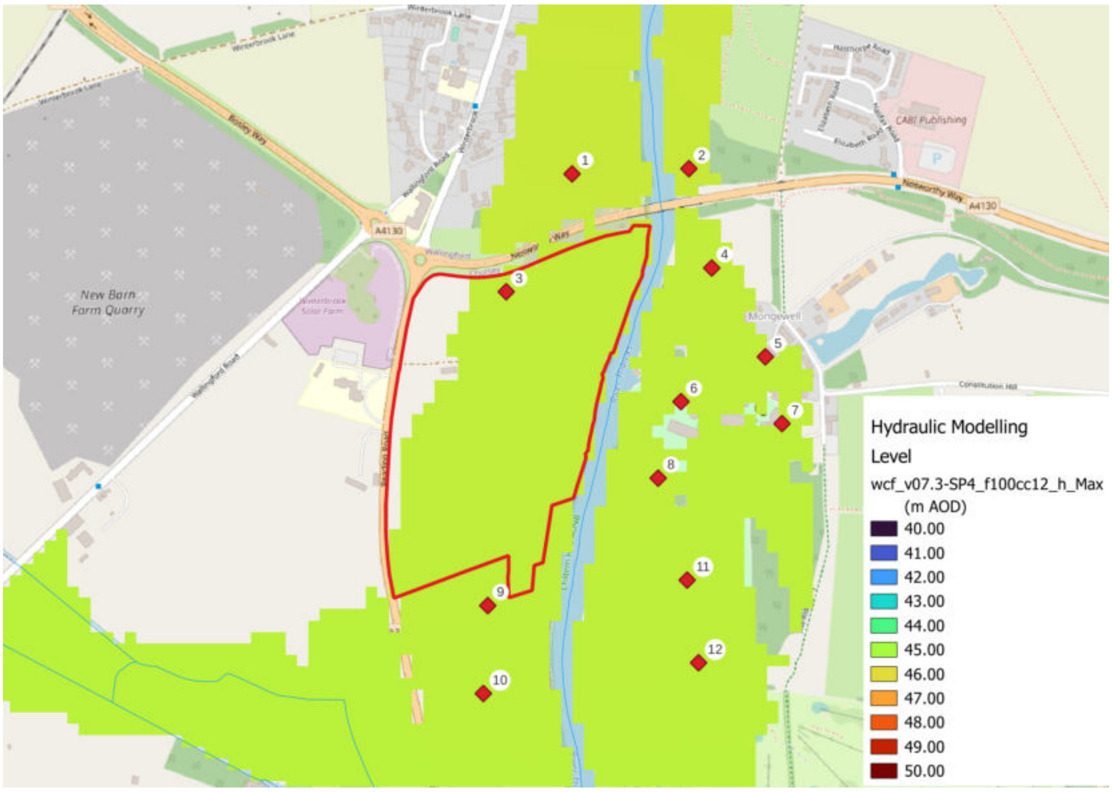

Figure B.16: Stage SP4 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

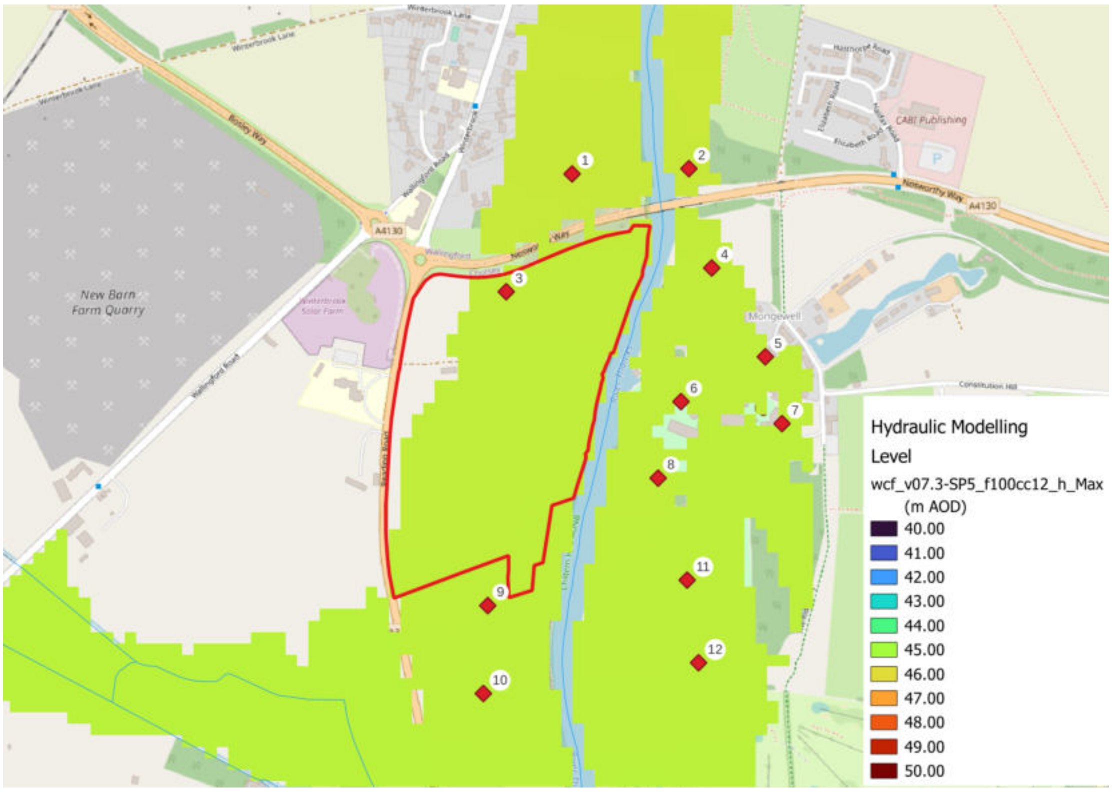

Figure B.17: Stage SP5 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

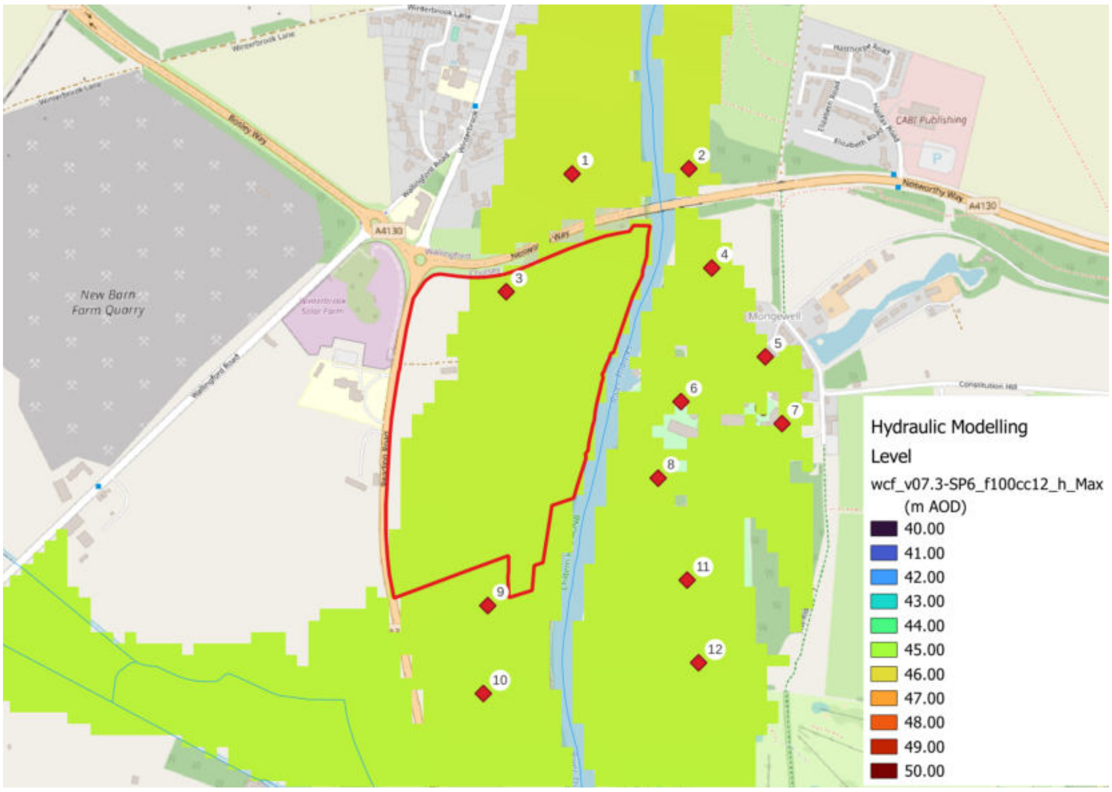

Figure B.18: Stage SP6 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

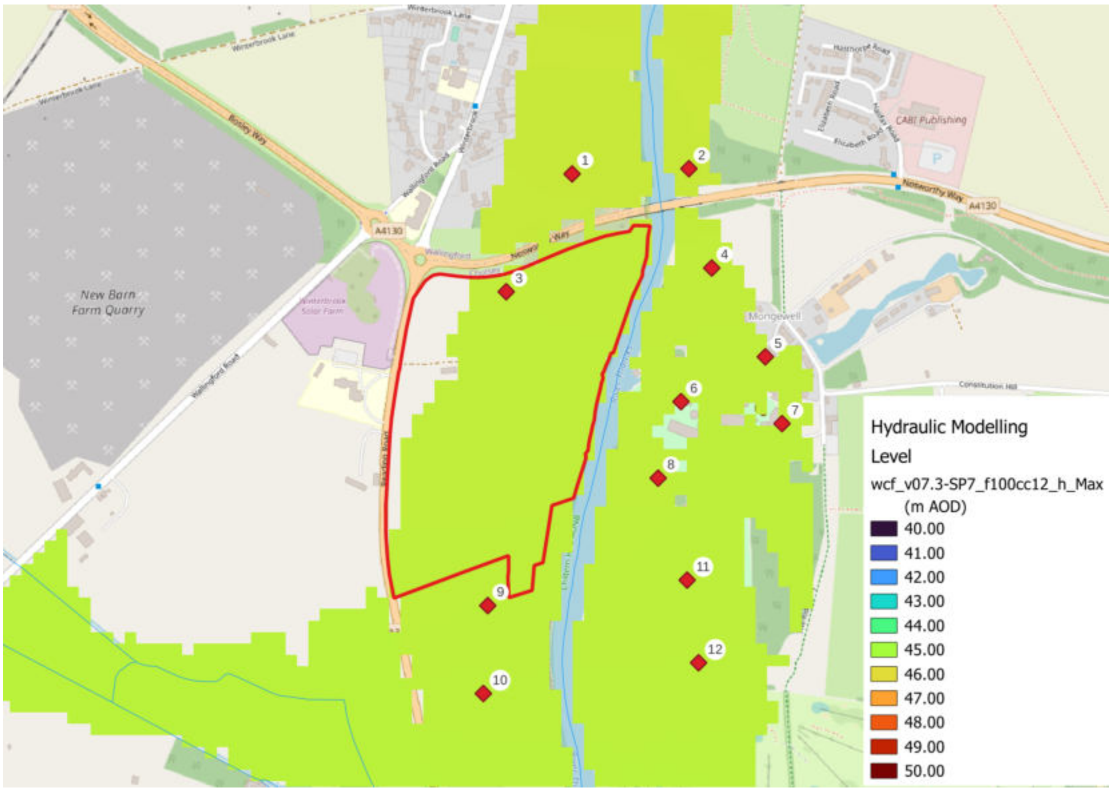

Figure B.19: Stage SP7 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

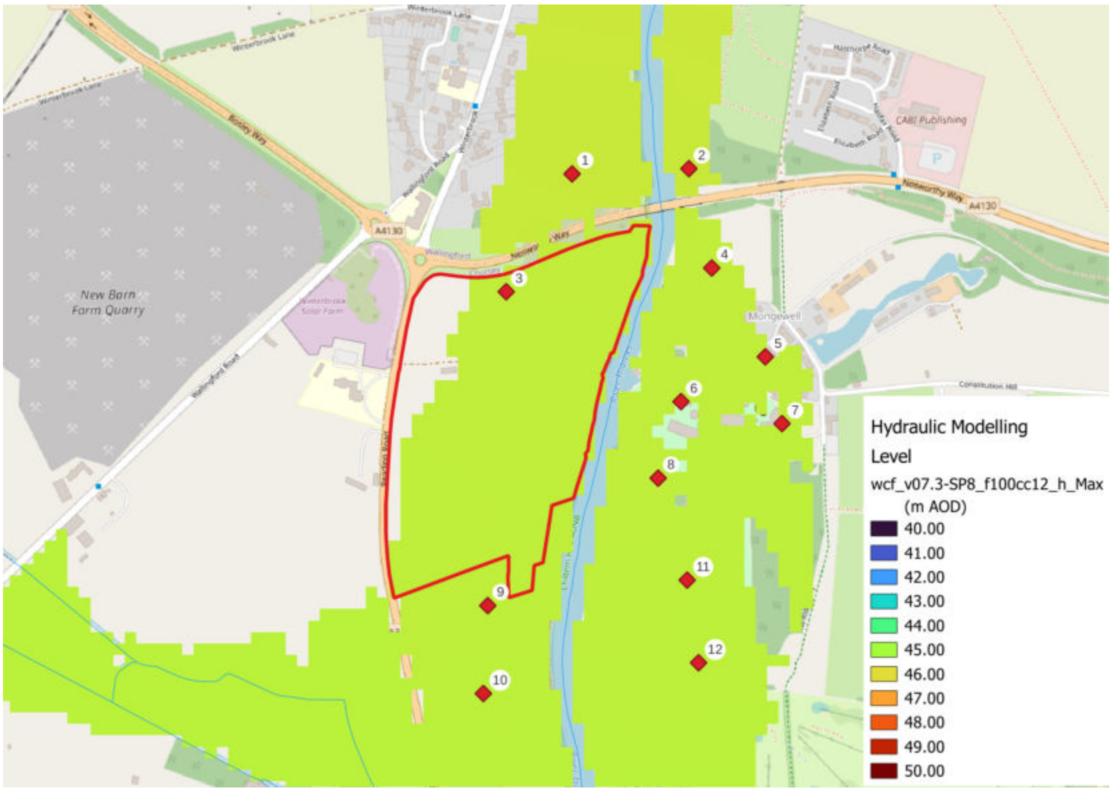

Figure B.20: Stage SP8 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

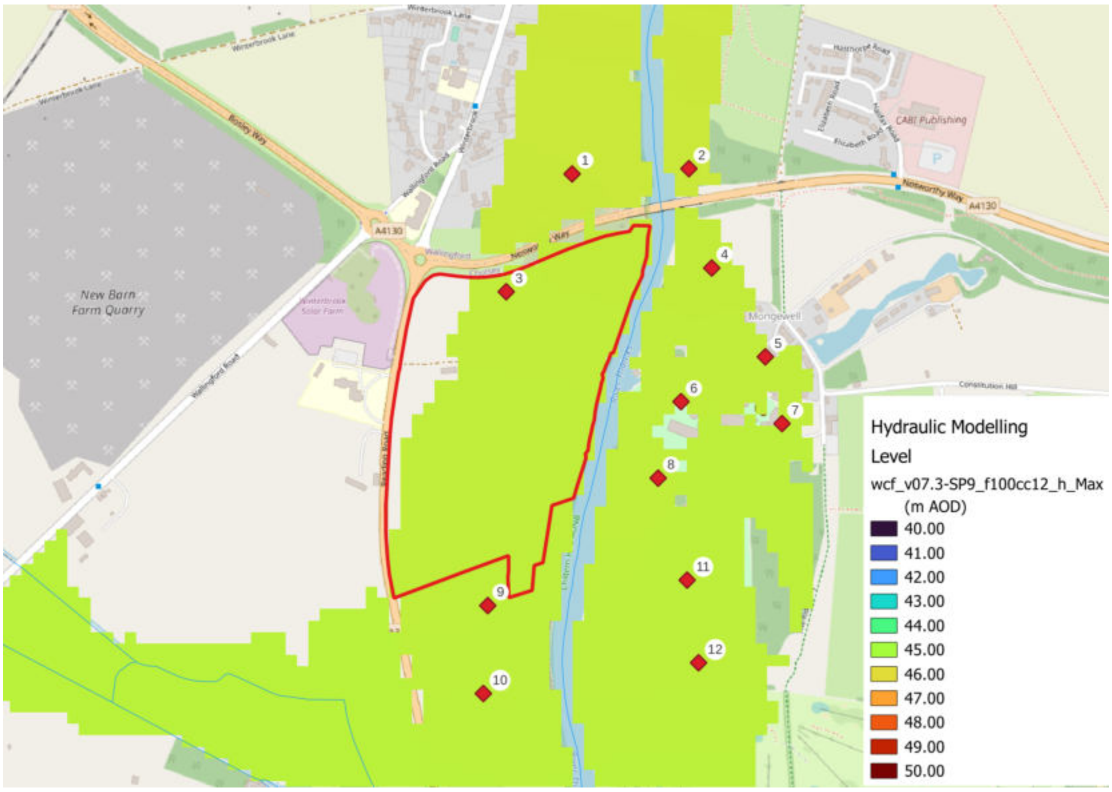

Figure B.21: Stage SP9 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change

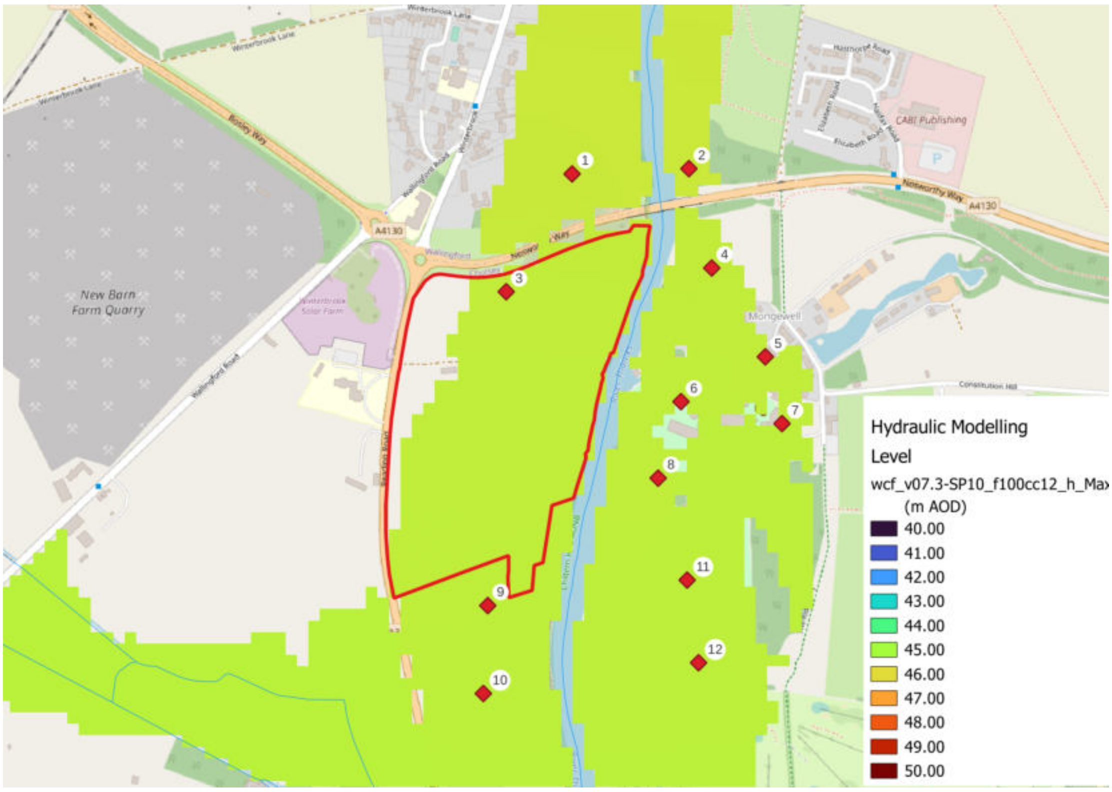

Figure B.22: Stage SP10 Model Results - Peak Water Level for a 1% AEP event with an allowance of 12% for climate change