Carmarthenshire County Council

Machynys Hotel

Flood Consequences Assessment

2024/ ARP-ZZZ-ZZ-RP-C-00002

Rev 1 | 22 October 2024

Job number 278688

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ARUP

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1 Introduction

Carmarthenshire County Council (CCC) has commissioned Ove Arup and Partners Ltd. (Arup) to prepare and submit an outline planning application, with all matters reserved, for a proposed hotel development which forms part of the Llanelli Waterside development. This Flood Consequences Assessment (FCA) has been prepared in support of the planning application and has been undertaken in accordance with Technical Advice Note (TAN) 15 Development and Flood Risk 2004.

2 Existing Site

The site of the proposed hotel development is located near the coast, south of the Llanelli town centre. The site is bound to the north by the B4304 Llanelli Coastal Road and to the west by Pentre Nicklaus Avenue and to the south and east by undeveloped land, with residential development further to the south. Access to the proposed development is proposed from B4304, with a potential second access from Pentre Nicklaus Avenue.

The site comprises open land consisting of rough grass/scrub. A site location plan is included in Appendix A.

Available topographical and LIDAR information indicates that the site is generally flat on the eastern side, locally undulating with site levels varying between 6.0mAOD and 7.0mAOD. The ground rises towards the west with a high point of 16.5m AOD in the south of the site. Two additional mounds are located on the northern part of the site with ground levels rising up to 14.5mAOD; a bund is located along the northern and north-western edges of the site, adjacent to the B4304 and Pentre Nicklaus Avenue rising up to 8.5mAOD. A local area of depression is located in the north of the site with a low of 6.5m AOD.

2.1 TAN15 Development Advice Map

The TAN15 Development Advice Map (DAM) for the Machynys area is included in Appendix C. A snapshot can be seen in Figure 1. The map indicates that the site is within Zone A and Zone C1, see Figure 2. The eastern side of the site is within Zone C1, with this zone extending into the north. The remainder of the site is located within Zone A.

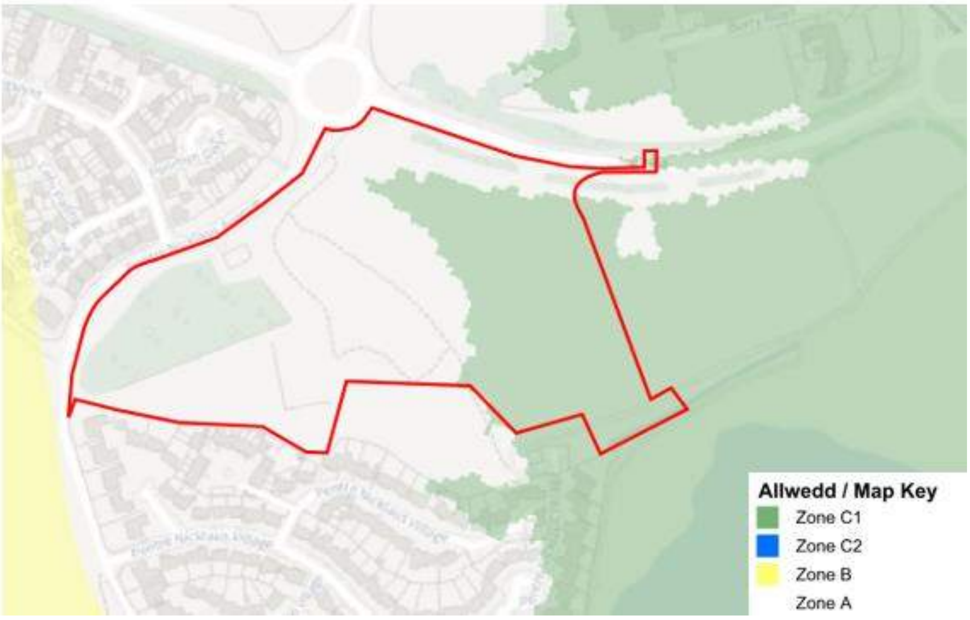

Figure 1: Extract from TAN15 DAM

Definition of the various flood zones as stated in TAN15 Development and Flood Risk are given below.

- Zone A – Defined as an area considered to be at little or no risk of fluvial or tidal/coastal flooding.
- Zone B – Areas known to have been flooded in the past evidenced by sedimentary deposits.
- Zone C1 – Area of floodplain developed and served by significant infrastructure, including flood defences, and liable to flood events with probability of occurrence of 0.1% or greater (i.e. 1 in 1000 year flood event or greater).
- Zone C2 – Area of floodplain without significant flood defence infrastructure, and liable to flood events with probability of occurrence of 0.1% or greater (i.e. 1 in 1000 year flood event or greater).

The current NRW Published Flood and Coastal Erosion Risk Map shows that some of the eastern side of the site is at low risk of flooding from the sea, see extract of NRW Flood Risk Maps in Figure 2. Low risk means that each year the area has a chance of flooding between 1 in 1000 (0.1%) and 1 in 200 (0.5%). The map also shows surface water flood risk. The map shows the majority of the site is not at risk of flooding however there are a few localised areas medium/high risk present. These relate to low spots on the site where surface water run-off could accumulate at shallow depth and will be managed as part of the sustainable drainage strategy for the development.

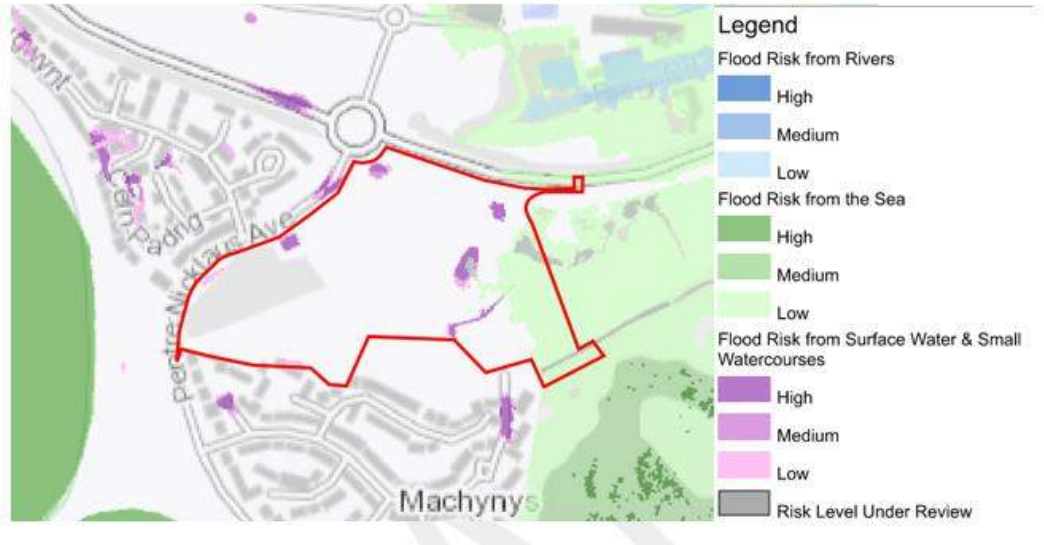

Figure 2 Extract from NRW Flood Risk Maps

Therefore, the main mechanism of flooding at the site is tidal inundation resulting from rising tide level in the Loughor Estuary. The area is protected by sea defences, however there may be a risk of inundation from overtopping and/or a breach in the sea defences. A fluvial event of the Afon Dafen also needs to be considered.

It should be noted that The Welsh Government (WG) is due to implement a revised TAN15. WG have undertaken a consultation on proposed further amendments to the proposed TAN15 document. These proposed changes are currently unknown, therefore there is a level of uncertainty with regards to exact requirements in future. Figure 3 shows an extract of the Flood Map for Planning which shows how climate change will affect flood risk extents over the next century. The Flood Map for Planning has no official status until the WG implements the revised TAN15. The map shows the eastern side of the site is within a Tidal Defended Zone.

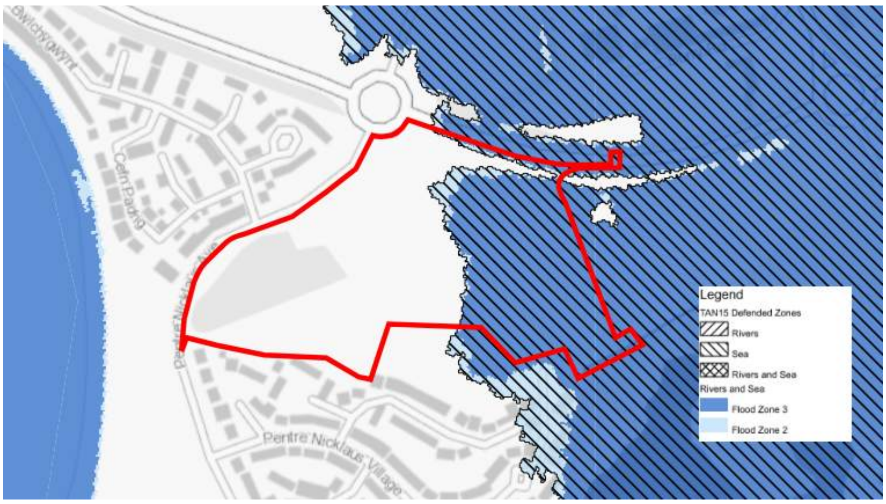

Figure 3 Extract from NRW New Flood Map for Planning

3 Proposed Development

A proposed hotel development is being promoted with the aim of delivering economic, social and environmental benefits to the local area and to Carmarthenshire as a whole. The illustrative site layout is included in Appendix B.

3.1 Vulnerability Classification

Flood risk vulnerability classification for various types of development is given in Figure 2, Section 5 of TAN15 Development and Flood Risk. Developments are classified into the following three categories depending upon the ability of the occupants to decide on whether or not they wish to accept the risk to life and property associated with flooding:

- Emergency Services
- Highly Vulnerable Development; and
- Less Vulnerable Development

The proposed hotel development is classified as a **Highly Vulnerable Development** with the car park classified as Less Vulnerable Development.

TAN15 Development and Flood Risk states that for hotel developments susceptible to tidal flooding, the frequency threshold of flooding (i.e. the threshold below which the development should not be allowed to flood) is the 1 in 200 year return period tidal event including an allowance for climate change and sea level rise.

3.2 Hydraulic Flood Modelling – Pre-Development

Edenvale Young Associates Ltd. (EVY) have undertaken hydraulic modelling of the area as part of the Health and Wellbeing Village proposed to the north, revision L (March 2024) report is included in Appendix D. The model was reviewed and accepted by NRW and has been used to inform the preparation of this FCA.Arup have recently updated the model to take into account an addition 2 years of climate change and assess the post development scenario, the report is presented in Appendix E.

The site and surrounds are protected by a series of coastal defences, typically at a level of around 7.0mAOD. EVY previously examined a combination of fluvial and tidal events, taking into account the effects of climate change, together with breach event. The modelling showed that the site and general area is protected by the sea defences and does not flood during all the extreme tidal and fluvial events apart from the 1 in 1000 tidal event, taking into account climate change, modelling result drawings can be found in Appendix D.

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In summary, the modelling shows the design case flood levels around the site:

· 0.5%+CC Tidal in conjunction with QMED+30% Fluvial = 6.35mAOD

· 0.1%+CC Tidal in conjunction with QMED+30% Fluvial = 6.88mAOD

The baseline modelling showed that the proposed hotel and associated car park do not flood during the extreme fluvial and 1 in 200 +CC year tidal and breach events. However, during the 1 in 1000 year + CC tidal and breach event, the site floods. The worst case predevelopment maximum water level for the 1 in 1000 year return period tidal breach event was estimated at a maximum of 6.88m AOD for the year 2124.

3.3 Hydraulic Flood Modelling -Post Development

It is proposed that the hotel building, is set at a minimum finished level above 6.88m AOD as part of a precautionary approach and to provide development resilience. It is proposed that the site access and car park areas are set as close to the existing ground level as possible to mitigate the potential for flood detriment on the wider area.

Post development modelling, using a minimum development level of 6.4m AOD for the hotel car park rising up towards the site access (minimum level 6.7m AOD) and proposed hotel building with a minimum level of 7.1m AOD was completed by Arup. The results and report can be found in Appendix E.

The results confirmed that the proposed hotel building and western side of the site remained flood free up to and including the 1 in 1000 year return period tidal and breach events for the year 2124 including climate change.

The car park remains flood free up to and including the 1 in 200 year return period but floods during a 1 in 1000 year return period tidal and breach event. The depth of flooding varies from west to east, but the maximum depth of water within the car park is estimated to be 480mm with a maximum velocity of 0.34m/s both occurring in a small area in the southeastern corner. The flood hazard of the majority of the car park is classified as ‘very low’ hazard to ‘danger to some’ with a small area classified as ‘danger to most’.

3.4 Access and Egress

Access to the site is provided via the B4304 located to the north of the site. This road traverses east-west along the northern boundary of the site. To the west, this access and egress route is shown to be largely in Zone A on the TAN15 DAM; with some localised areas along the route shown to be in Zone B. However, to the east, the route is shown to be in Zone C1. Levels along the road in the vicinity of the Machynys roundabout, to the east of the site, are at approximately 5m AOD, rising to over to 8.5m AOD as the road traverses further west. At the location where the proposed access to the hotel development joins the B4304, the existing road level is approximately 6.7m AOD.

The results of the hydraulic model shown on Appendix E indicate that the B4304 at the main access floods by up to 0.18m depth during a 1 in 1000 year return period tidal event, estimated for the year 2124, further west the depth of flooding gradually reduces to zero.

The potential secondary access to the development is proposed from Pentre Nicklaus Avenue to the west. The TAN15 DAM shows this to be located in Flood Zone A. The level of the existing highway at the proposed entrance with Pentre Nicklaus Avenue is approximately 7.9m AOD. Therefore, this access remains flood free up to a 1 in 1000 year return period tidal event plus climate change estimated for the year 2124.

4 Justifying the Location of the Development

TAN15 Development and Flood Risk 2004 states that new development should be directed away from Zone C and towards suitable land in Zone A or B. However, it also recognises the need to be flexible in addressing flood risk whilst considering the negative economic and social consequences if policy were to preclude investment in existing urban areas, and the benefits of reusing previously developed land. It recommends that **Highly Vulnerable Development** and **Emergency Services** should not be permitted in Zone C2. For all other developments in Zone C, the tests outlined in Sections 6 and 7 of TAN15 Development and Flood Risk 2004 should be applied to justify the location of the development and to assess the consequences of flooding.

Section 6 of TAN15 Development and Flood Risk states that development within Zone C will only be justified if it can be demonstrated that:

i. Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; **or**

ii. Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;

and,

iii. It concurs with the aims of Planning Policy Wales (PPW) and meets the definition of previously developed land; and,

iv. The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in Sections 5 and 7, and Appendix 1 found to be acceptable.

Criterion (i) or (ii)

The site of the proposed development is part of the South Llanelli Strategic Zone, which is identified as a strategic site within CCC's Local Development Plan (LDP). Within this Strategic Zone, the application site is within the Machynys mixed-use development allocation (site reference: GA2/MU3). The proposed development therefore complies with criterion (i).

Criterion (iii)

Previously developed land is defined in PPW as,

"...that which is or was occupied by a permanent structure and associated fixed surface infrastructure."

PPW also includes a preference for the re-use of land. It states, in paragraph 3.43

"planning authorities must prioritise the use of suitable and sustainable previously developed land and/or underutilised sites for all types of development. When identifying sites in their development plans planning authorities should consider previously developed land and/or underutilised sites located within existing settlements in the first instance with sites on the edge of settlements considered at the next stage."

Paragraph 3.55, further states,

"Previously developed (also referred to as brownfield) land should, wherever possible, be used in preference to greenfield sites…"

Paragraph 3.55 further states,

"In settlements, such land should generally be considered suitable for appropriate development where its re-use will promote sustainability principles and any constraints can be overcome."

Paragraph 5.4.12 also states:

"Planning authorities should aim to:

- *Promote the re-use of previously developed, vacant and underused land;"*

The Envirocheck reports that have been obtained as part of the geotechnical assessment indicate that the site and its surroundings have a history of industrial and commercial use dating back to 1889. These historical uses included brick works, steel works, tin plate works, engineering works, reservoir and foundry. The site therefore conforms to the definition of previously developed land as contained within PPW.

Criterion (iv)

The potential consequences of a flooding event have been considered within this FCA and are outlined in the following sections.

5 Assessing Flooding Consequences

The following FCA has been undertaken in accordance with the guidance provided in Section 7 and Appendix 1 of TAN15 Development and Flood Risk, and is referenced against the relevant clauses within those sections.

A1.2 The assessment has been undertaken with the objective of:

1. Developing a full appreciation of the consequences of flooding on the development
2. Developing a full appreciation of the consequences of the development on flood risk elsewhere
3. Establishing whether mitigation measures are required to be incorporated within the design to minimise risk to life and property resulting from flooding

A1.3 A hydraulic modelling exercise has been undertaken by Arup for the pre and post development scenarios using the model previously developed by Edenvale Young. The summary note can be found in Appendix D.

The identified mechanism of flooding is a tidal event within the Loughor Estuary reach adjacent to the site and a breach and overtopping of the tidal defences along the coastline in the vicinity of the site. Extreme tide levels, including allowance sea level rise, are given in Section 3.2. The proposed buildings will be set at a minimum of 7.1m AOD, site entrance to be 6.7m AOD and the car park levels rising from a minimum of 6.4m AOD towards the proposed hotel building as outlined in Section 3.3.

A1.4 Extreme tide levels outlined in Section 3.2 of this report include an allowance for climate change and sea level rise in accordance with the Welsh Assembly guidance.

The hydraulic modelling shows that setting the building and western side of the site to be minimum 7.1m AOD enables this area of the development to be flood free for up to and including the 1 in 1000 year return period tidal event plus climate change up to the year 2124.

With the car park and access roads set to a minimum level of 6.4m AOD results in some shallow flooding of these areas during the 1 in 1000 year return period tidal event plus climate change up to the year 2124. The maximum flood depth of 0.48m occurs in a small area in the southeast corner of the car park. The maximum flood depth at the main site access reaches 0.18m.

This demonstrates that a precautionary approach has been adopted in considering the consequences of flooding.

A1.5 Shallow flooding occurs across parts of the car park and hardstanding areas during the 1 in 1000+CC event, the maximum depth of flooding is 0.48m in a small area of the car park. The maximum depth of flooding at the site access is 0.18m. The depth of flooding is below the maximum depth of flooding for general infrastructure of 0.6m. This will ensure that a safe and secure environment is provided to those occupying the site.

A1.6 The mechanism of flooding is tidal inundation resulting from the rising tide level in the Loughor Estuary and a breach and overtopping of the tidal defences located along the coastline in the vicinity of the site. As the mechanism of flooding is tidal, blockages along the flood path, if any, are not likely to increase the tide level. Therefore, such physical changes are not thought to provide an increased risk of flooding.

A1.7 The coastal flood defences in this area provide flood protection to the developments within this region and will therefore be adequately maintained. If the flood defences are overtopped or breached, the hotel development site will be flood free for a 1 in 200 year+CC event and shallow flooding occurs over part of the car park and hardstanding areas during a 1 in 1000+CC event. The proposed location for the hotel building and western side of the site are flood free. The hydraulic modelling exercise has been undertaken assuming a breach and overtopping in the flood defences to provide a conservative approach.

A1.8 In the event of an extreme flood, parts of the hotel development site will remain flood free for up to and including the estimated 1 in 1000 year return period tidal event for the year 2124 including climate change. Parts of the car park and hardstandings will experience shallow flooding, less than 0.5m. As a result, it is assumed that no conditions are required to be attached to the planning permission.

A1.9 The mechanism for flooding for the site is tidal inundation resulting from the rising tide level in the Loughor Estuary and a breach/overtopping of the tidal defences located along the coastline in the vicinity of the site.

The hydraulic modelling concluded that during the breach and overtopping event there is no significant change to the flood risk of third parties as a result of raising the development levels as previously described in Section 3.3. The post development changes in the flood depth for the worst case breach/overtopping scenario combined with a fluvial event only impact levels within the site boundary. The modelling results show there is no change in flood risk to third parties. As highlighted in the modelling report, the model shows very localised detriment present in the Afon Dafen at Pentre Awel, this is considered to be due to model instability and not real.

The developer will undertake changes to ground levels within the site. Flood warning measures, if deemed necessary, will be provided by Natural Resources Wales (NRW) and CCC.

A1.10 The FCA has been undertaken by a suitably qualified professional organisation.

A1.11 The risk of flooding has been fully assessed in the following sections and deemed to be acceptable.

A1.12 No flood defences are proposed for the scheme. It is assumed that flood warning measures, if deemed necessary, will be provided by Natural Resources Wales (NRW) and CCC.

A1.13 The FCA will be submitted to the NRW for its comments/approval via the planning process.

A1.14 TAN15 Development and Flood Risk 2004 indicates that hotel and car park development will remain flood free under a 1 in 200 year return period tidal event. The proposal will provide adequate protection for the proposed hotel development for up to and including the estimated 1 in 1000 year tidal event for the year 2124 including climate change and is therefore considered adequate.

A1.15 Access to the development from the B4304 to the north is shown to experience flooding during the extreme 1 in 1000 year event plus climate change breach/overtopping scenario. The depth of flooding along the B4304 increases from 0m at the western boundary, to 1.5m at the eastern roundabout. At the site entrance the existing level is approximately 6.7m AOD. The 1 in 1000 year flood level plus climate change during a breach or overtopping event is estimated at 6.88mAOD, therefore providing a flood depth of 0.18m at the entrance.

Access to the development from Pentre Nicklaus Avenue to the west is shown to be flood free during the extreme 1 in 1000 year event plus climate change breech scenario.

A1.16 Since parts of the hardstandings and car park will be subject to shallow flooding during a 1 in 1000+CC (0.1%) event, occupiers will be made aware of the flood risk, flood warnings will be provided, escape and evacuation routes identified and will be shown to the developer and a flood emergency plan will be put in place.

A1.17 The following technical requirements have been met in assessing the flooding consequences.

1. A site location plan showing the Loughor Estuary and the tidal flood defences in the area is included in Appendix A.
2. LiDAR survey showing existing site levels is shown in Appendix A. The minimum proposed development level for the proposed hotel, car parks and site roads is 6.4m AOD.
3. Flood defences present in this area will be maintained by NRW.
4. Access and egress from the site is via the B4304 to the north, with a potential secondary access to the west to Pentre Nicklaus Avenue, as shown on the proposed masterplan in Appendix B. Existing levels are shown on the LiDAR survey in Appendix A.
5. The mechanism of flooding for the site has been described in A1.3
6. The site does not have a history of flooding.
7. The mechanism of flooding is tidal inundation resulting from overtopping and a breach in the existing flood defences in the vicinity of the site. Any blockages along the flow path of the tidal flood should not result in an increased tide level.
8. Extreme tide levels have been derived based on published EA guidance and allowance for climate change has been included based on the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowances.*

9. The proposed minimum development level for the hotel car park is 6.4m AOD, rising up towards the site access and the hotel building. Existing levels are shown on the LiDAR survey in Appendix A.
10. The flood velocity in the car park, reaches a maximum of 0.34m/s in the south eastern corner. The hazard rating of the majority of the car park is classed as ‘very low’ hazard with very small area ‘danger to most’.
11. The public sewers within the vicinity of the site are maintained and operated by Dwr Cymru Welsh Water (DCWW). The drainage associated with the proposed hotel development will be designed in accordance with the current statutory guidance. Currently, this includes hydraulic modelling of storm and flood events.
12. The site levels have been carefully considered, the changes proposed do not lead to a reduction in flood storage volume on the site.

    The flood modelling concluded that post development changes in the flood depth for the worst case breach and overtopping scenario combined with a fluvial event only occur within the redline boundary, with the exception of a localised anomaly caused by model instability. Therefore there is no significant change in flood risk to third parties.

    Surface water runoff likely to be generated from the proposed development will be considered in accordance with the hierarchy of discharge from the Welsh Governments Statutory Standards for Sustainable Drainage. If discharging to a watercourse, the rate of discharge will be restricted to appropriate greenfield runoff rate.
13. As noted in item 12 above, changing the site levels as proposed does not result in any displacement of floodwater for events up to and including the worst case breach and overtopping event for the 1 in 1000 year return period tidal event, including allowance for climate change. Therefore, the proposed development will not have adverse impact on flood risk elsewhere.
14. The proposed developments will have no impact on the coastal morphology and the long term stability and sustainability.
15. Climate change allowance has been included in accordance with the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowances.*
16. There are no proposed flood defences or modification to existing as part of the development.

6 Conclusions

A Flood Consequences Assessment (FCA) has been undertaken for a proposed hotel development on the site located to the north of the Machynys Peninsula Golf and Country Club in Llanelli, Carmarthenshire. The FCA has been undertaken in accordance with the guidelines provided in TAN15 Development and Flood Risk 2004. The TAN15 Development Advice Map (DAM) shows that the eastern side of the site is within Zone C1, extending into the north. The remainder of the site is located within Zone A.

Flood modelling for the pre and post development scenarios has been undertaken by Arup, using the flood model developed previously by Edenvale Young, the relevant reports can be found in Appendix D and E. The site does not flood during all fluvial events and tidal events up to a 1 in 1000 year plus climate change, as the site is protected by sea defences and fluvial flows do not reach the site. However, during a 1 in 1000 year plus climate change event, the sea defences may be overtopped or a breach in the sea defences could develop, resulting in flooding. Following consultation with NRW in previous studies in the area, a breach analysis has been undertaken, examining breach event up to a 1 in 1000 year tidal event, taking into account climate change. Extreme tide levels for the Loughor Estuary have been derived and factored for climate change in accordance with the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowance.* The results predict the extreme 1 in 1000 year flood level to be 6.88m AOD for the year 2124 at the site.

The flood modelling incorporated a breach analysis of the flood defences with the aim of testing the sensitivity of the development to potential flood risk arising from a breach. It is proposed to adjust levels on the site such that the minimum level in the car park is 6.4m AOD rising up to the site access onto B4303 at 6.7m AOD and the hotel building with a minimum level of 7.1m AOD. The post development results confirm that the western side of the hotel development site will remain flood free and shallow flooding shall occur in the car park and some areas of hardstanding in the event of a breach and overtopping in the existing defences for events up to and including the 1 in 1000 year tide return period including climate change estimated for the year 2124.

Two access points are proposed for the development. The primary access point is from the B4303 to the north, there is also a potential secondary, service access from the west onto Pentre Nicklaus Avenue. The available topographical information showing existing site levels and an examination of the TAN15 DAM, shows the B4304 to the north west to be outside the extreme flood outline. The B4303 to the north east is shown to be within Zone C1 and hydraulic modelling shows this area to flood during an extreme 1 in 1000 year event. The resultant depth of flooding at the proposed access to the B4303 is approximately 0.18m. Access from Pentre Nicklaus Avenue is shown as Zone A on the DAM, the hydraulic modelling results show that this route remains flood free for the 1 in 1000 year tidal event including climate change up to the year 2124.

The FCA concludes that the risk of flooding for the proposed development is acceptable in accordance with TAN15 Development and Flood Risk. The hydraulic modelling concluded that there is no significant change to the flood risk of third parties as a result of the development.

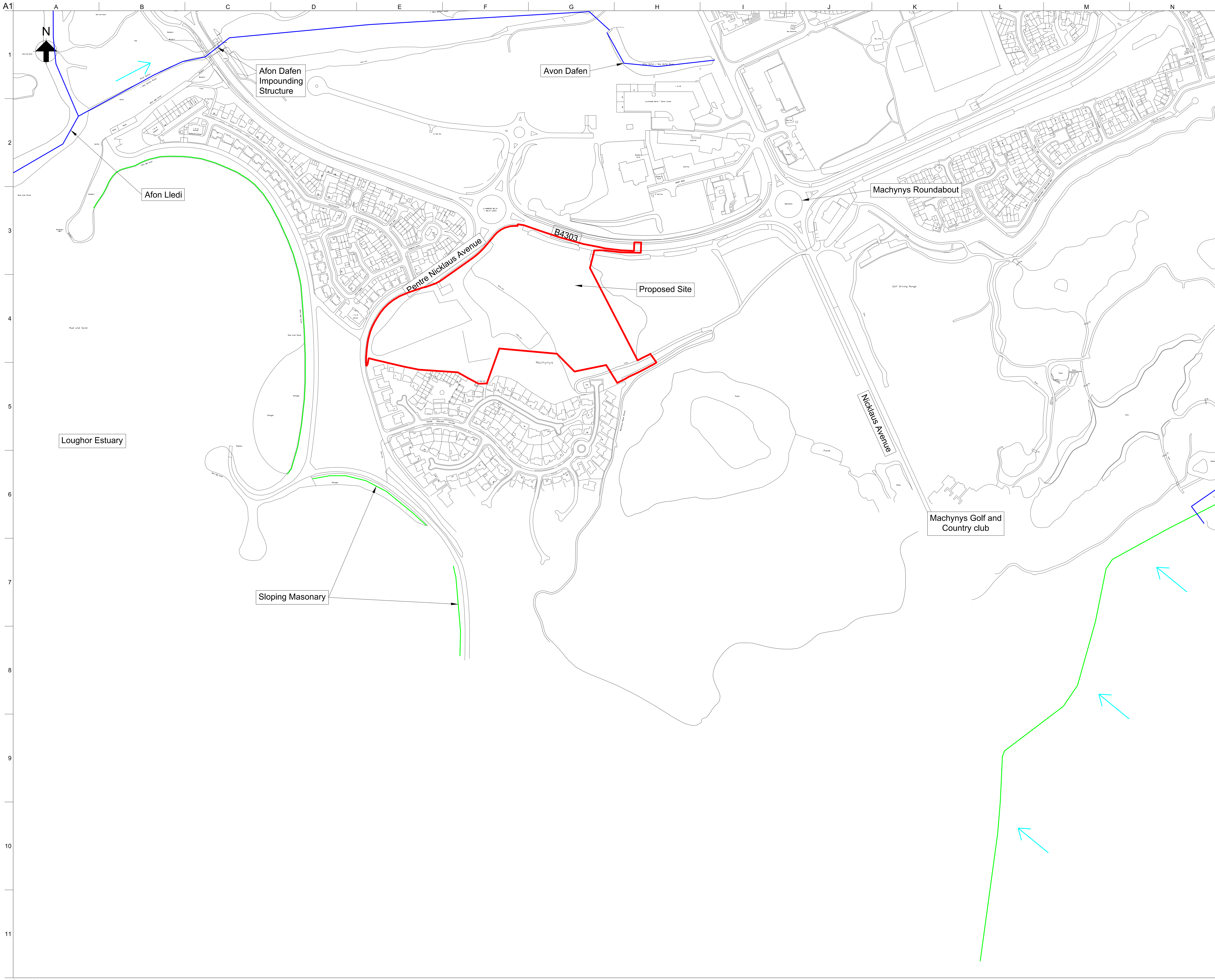
Appendix A

Existing Development

Site Location Plan

Existing Ground Levels

A1



Legend

- Site Boundary
- Open Watercourse
- Tidal Flood Defence
- Possible Tidal Flow paths resulting in overtopping or breach of the defences

Notes

1. All dimensions are in metres unless noted otherwise. Do not scale

Issue	Date	By	Chkd	Appd
I1	17/10/24	KA	KA	JS
Issued for Information				

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Job Title
Machynys Hotel

Drawing Title
Site Location Plan
Appendix A

Scale at A1 1:2500

Discipline Civil

Drawing Status
For Information

Job No	Drawing No	Issue
278688	**Appendix A1**	**I1**

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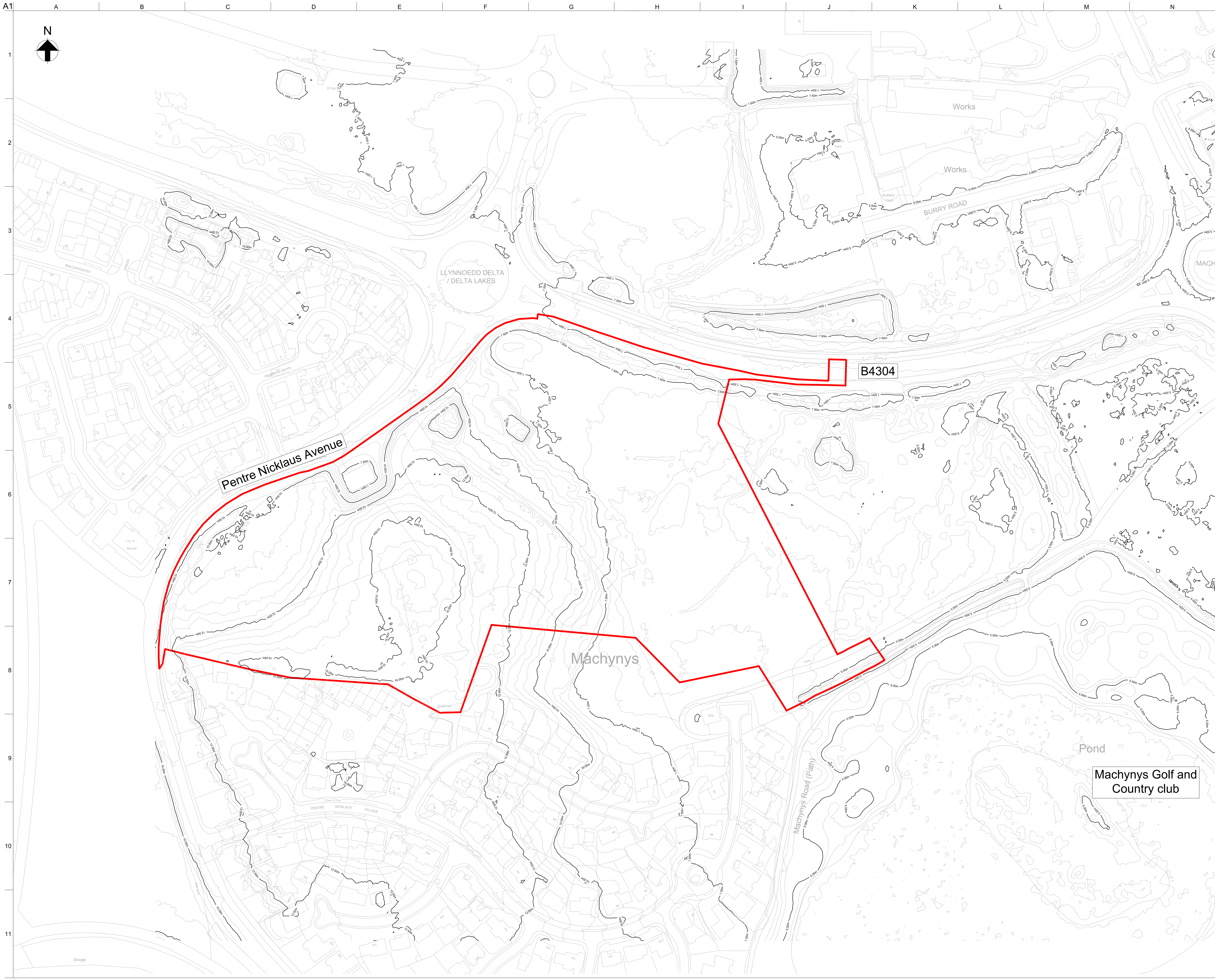

Legend

- Site Boundary
- 5.00m LiDAR Contours (Existing Levels)

Notes

1. All dimensions are in metres unless noted otherwise. Do not scale.

2. Ground level information based on LiDAR, contours shown at 0.5m intervals.

Issue	Date	By	Chkd	Appd
I1	16/10/24	KA	KA	JS
	Issued for Information			

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Client
Carmarthenshire County Council

Job Title
Machynys Hotel

Drawing Title
Existing Ground Levels

Scale at A1: 1:1000

Discipline: Civil

Drawing Status
For Information

Job No	Drawing No	Issue
278688	**Appendix A2**	**I1**

Do not scale

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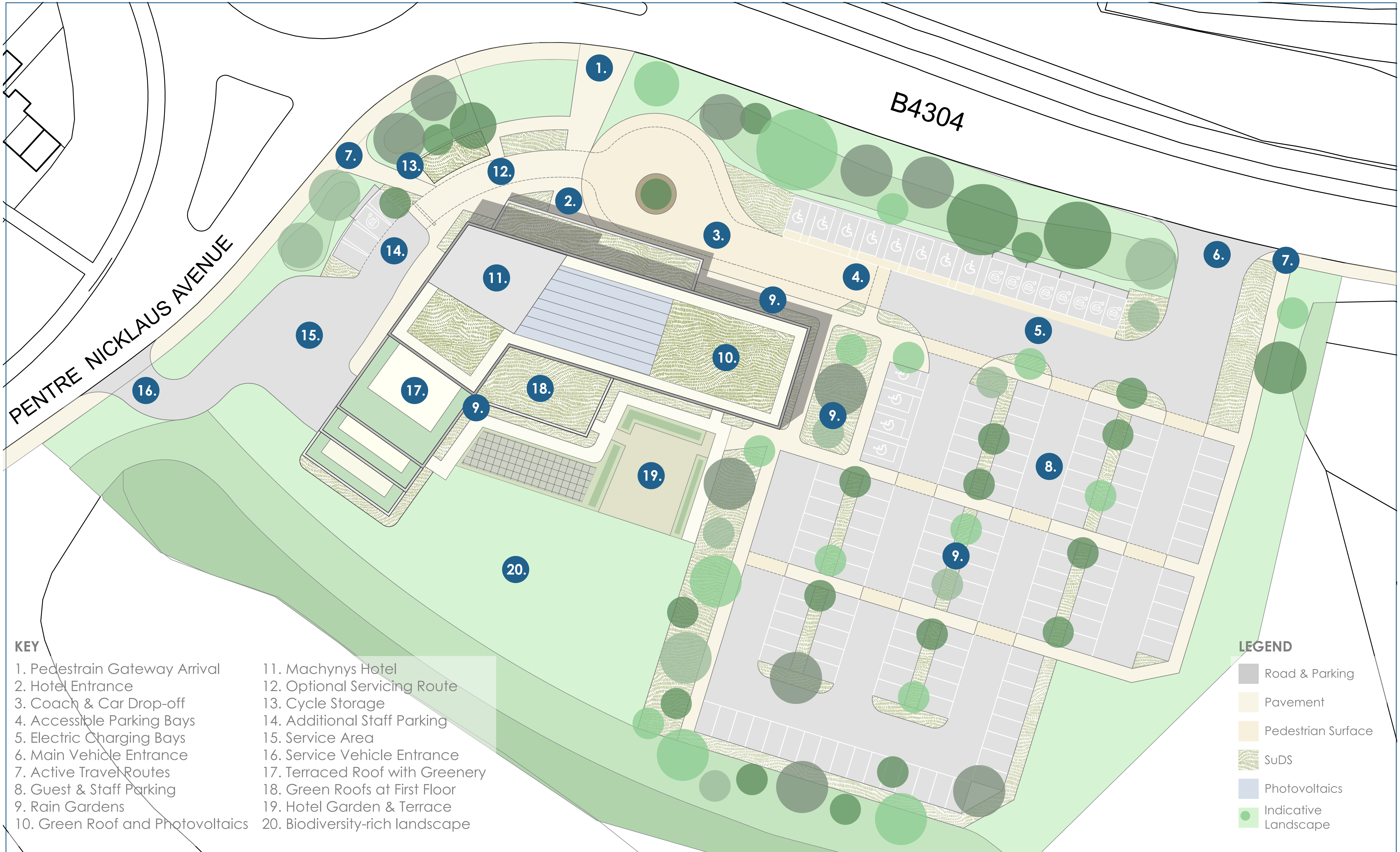
Appendix B

Development Proposals

Proposed Masterplan



CLIENT
Carmarthenshire County Council

JOB TITLE
Machynys Hotel OPA

DRAWING TITLE
Illustrative Masterplan

SCALE @ A3	DATE	DRAWN BY
1:500	September '24	BC
JOB NO.	**DRAWING NO.**	**REVISION**
2475	MH_IMP 01	A

REV.	DESCRIPTION	DATE
A	Legend added	09/10/24

Accommodation Schedule;

Rooms
1B 2P 00

TOTAL **120 UNITS**

PARKING
140 spaces total
120 Visitor spaces, of which:
12 Disabled spaces
10 Electric Charging spaces
20 Staff spaces

0 5 10 25

N

hammond
Architectural Ltd
10 Gold Tops
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NP20 4PH
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www.hammond-ltd.co.uk

Appendix C

TAN 15 Development Advice Map

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Perygl Llifogydd / Flood Risk Map -

Allwedd / Map Key

- Zone C1
- Zone C2
- Zone B
- Zone A

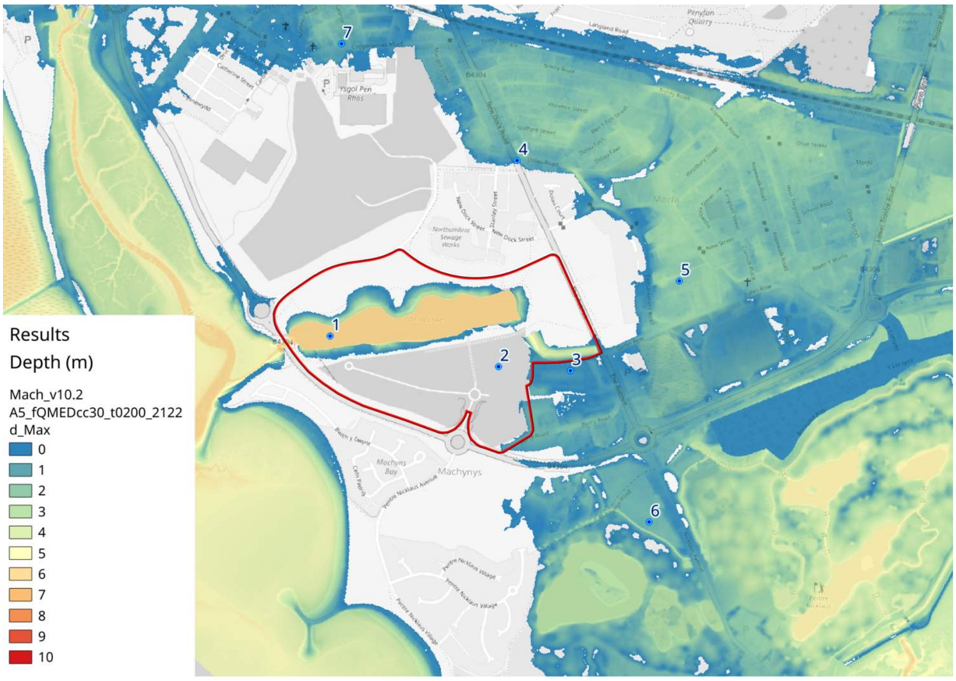
Graddfa / Scale at A3 1: 6,614

Dyddiad / Date
09/10/2024

0.3 0 0.17 0.3
British_National_Grid Kilometers

Appendix D

EdenvaleYoung Hydraulic Modelling Results



Pentre Awel

Hydraulic Modelling Results

Revision L
28th March 2024

ARUP

EdenvaleYoung

New Civil Engineer 100 COMPANIES OF THE YEAR 2018

WINNER Design Innovator

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Document Control

Project Name:	Pentre Awel
Project Number:	EVY0952
Report Revision:	L
Client:	Arup

Written by	John Young	28th March 2024
Checked by	Peter Aylett	28th March 2024
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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
- FMP Software - One-Dimensional hydraulic model – Representation of watercourses
- FMP-TUFLOW - Hydraulic program that dynamically links FMP 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 Project Overview

Edenvale Young Associates Ltd was originally commissioned by Arup to assess flood risk to a development at the Llanelli Welcome and Life Science Village at Delta Lakes in Llanelli. The Llanelli Welcome and Life Science Village work was completed in February 2019 following extensive review by Natural Resources Wales. The modelling detailed in this document has been used to evaluate the risk of flooding to the development site shown in Figure 1.1. The proposed works envisage raising ground levels within the red line and are described in more detail in Section 3.1.

The scope of works includes updating and running the hydraulic model to assess flood risk to the development in the Pre and Post development condition.

1.2 Objectives

The primary objective of the hydraulic modelling is to assess the impact the development on flood risk for the 0.5% AEP and 0.1% AEP tidal / storm surge breach event in combination with a fluvial flow of QMED in 2122. Additionally, the fluvial flood risk was assessed for the 1% with climate change and 0.1% without climate change event in combination with a mean high water spring tidal level.

Figure 1.1: Location Plan

2 Hydrology and Tidal Boundaries

2.1 Fluvial Boundary

There are three watercourses in the vicinity of the site of interest; the Afon Dafen, Lleidi, and the Cilli. The Afon Dafen, which flows through the site, originates 7km upstream of the site and flows south before it runs into a reservoir which has a controlled outlet to the estuary. The hydrological analysis used to derive inflows to the model are contained in Appendix B.

2.2 Tidal / Surge Boundaries

Mean High Water Spring tides and extreme tide/surge water levels are based on the Environment Agency's "Coastal Design Sea Levels - Coastal Flood Boundary Surge Shapes (2018)". Whilst the Llanelli node which is directly adjacent to the site, the Pont-y-cob estuary node has been used to define the peak water level within the model. Pont-y-cob is upstream as shown in Figure 2.1 and has been used for the purposes of the modelling with the extreme water levels shown in Table 2.1. This is considered to be a conservative approach with respect to evaluating flood risk at the site.

Location	0.5% AEP	0.1% AEP
Llanelli Chainage 2924	6.02	6.27
Pont-y-cob	6.10	6.28

Table 2.1: Maximum Still Water Levels

Figure 2.1: Estuary Boundary Node

2.3 Breach Locations

A 50m breach has been incorporated into the model. The configuration of the breach is based on NRW guidance and discussion with the client. This configuration differs from that applied in the original Delta Lakes model and is line with current NRW Breach guidance.

2.4 Climate Change

Table 2.2 gives the climate change allowances to be applied to fluvial flow which have been adopted from the most recent guidance on climate change published by the Welsh Government[1]. The adopted allowances is the central for climate change for the 2080s in west Wales: namely 30%.

The NRW guidance gives sea level rise to 2100 and 2120 for Local Authority Areas across Wales Sea Level as shown in Table 2.3. The predictions shown in Table 2.3 have been extrapolated in accordance with the guidance to 2122 assuming a development lifetime of 100 years. This gives a total sea level rise of 1.01m (70th percentile) for Carmarthenshire to 2122.

Climate Change Allowance	2020s	2050s	2080s
West Wales Change factor/central estimate	15%	25%	30%

Table 2.2: Climate Change Allowances for Flow

Local Authority	Allowance Percentile	Sea Level Rise 2100	Sea Level Rise 2120	Sea Level Rise 2122
Carmarthenshire	70th	0.83	0.99	1.01

Table 2.3: Climate Change Allowances Sea Level Rise

[1] Flood Consequences Assessments: Climate change allowances September 2021

3 Hydraulic Modelling

3.1 Model Modifications

The original modelling for the Delta Lakes Wellness scheme completed in February 2019 and made use of a hydraulic model of the Afon Dafen supplied by NRW. However, the 2D domain was trimmed due to uncertainty in the validity of the survey of the Afon Dafen upstream of the site of interest. In addition, the Afon Lliedi and Cille Stream watercourses were integrated into the NRW model and the 2D domain was extended. The details are given in Edenvale Young's report for Delta Lakes[1]. Subsequently, a number of additional improvements were made to Delta Lakes version of the model to evaluate flooding to the Machynys Hotel site. The modifications included:

- Application of the latest composite LiDAR data available from the NRW website
- Extension of the 2D domain, and other changes at the periphery of the model to accommodate the extension of the domain
- Adjustment to material polygons and modification to roughness values
- Adjustment to the representation of the North Dock and Delta Lake inlet
- Integration of topographic survey at the Machynys site to represent the current condition
- Representation of the development platform at the Machynys East development
- Representation of defences

The Pre-development model used for this study is based on the Machynys Hotel Pre-development version of the model described above. Due to instabilities generated when representing the full lake inlet structure in 1D, and concerns about the accuracy of representing it in 2D, this area has been simplified to represent only the main hydraulic controls in 1D; namely the slot between the seaward-most gate and the road bridge above it and the main tidal defence gate. This representation is both stable and captures these controlling elements more accurately than they could be in 2D. The tide/surge boundary has also been adjusted to incorporate the latest extreme sea level data for the estuary [2] (see Sections 2.1 and 2.2). In addition, the climate

[1] Delta Lakes Llanelli, Modelling Report,Trimmed Model, Revision E, February 2019
[2] Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (2018) extreme sea levels

change allowances for fluvial flow and sea level rise have been updated and this is discussed in Section 2.4.

The Post development model incorporates changes to the ground level as shown in Arup's Sketch SK100 (see Appendix A). This has involved generating a TIN to represent the Post development ground levels shown in Figures 3.1. The proposal also includes increasing the height of the tidal defence gate at the entrance to the lake from 5.94mAOD to 7.56mAOD.

These model modifications have been through extensive model reviews, including by JBA (4 August 2023 and 19 January 2024). This includes the following red review modifications to ensure the model represents structures such as the North Dock and the Delta Lake inlet accurately:

- Modification of the representation of the weirs at the Delta Lake sluice.
- Re-application of the Q1000 flows.
- Modification of reporting errors in Tables 4.1, 4.6 and 4.7.

All green, amber and red comments associated with the modelling have been incorporated into the latest version of the model.

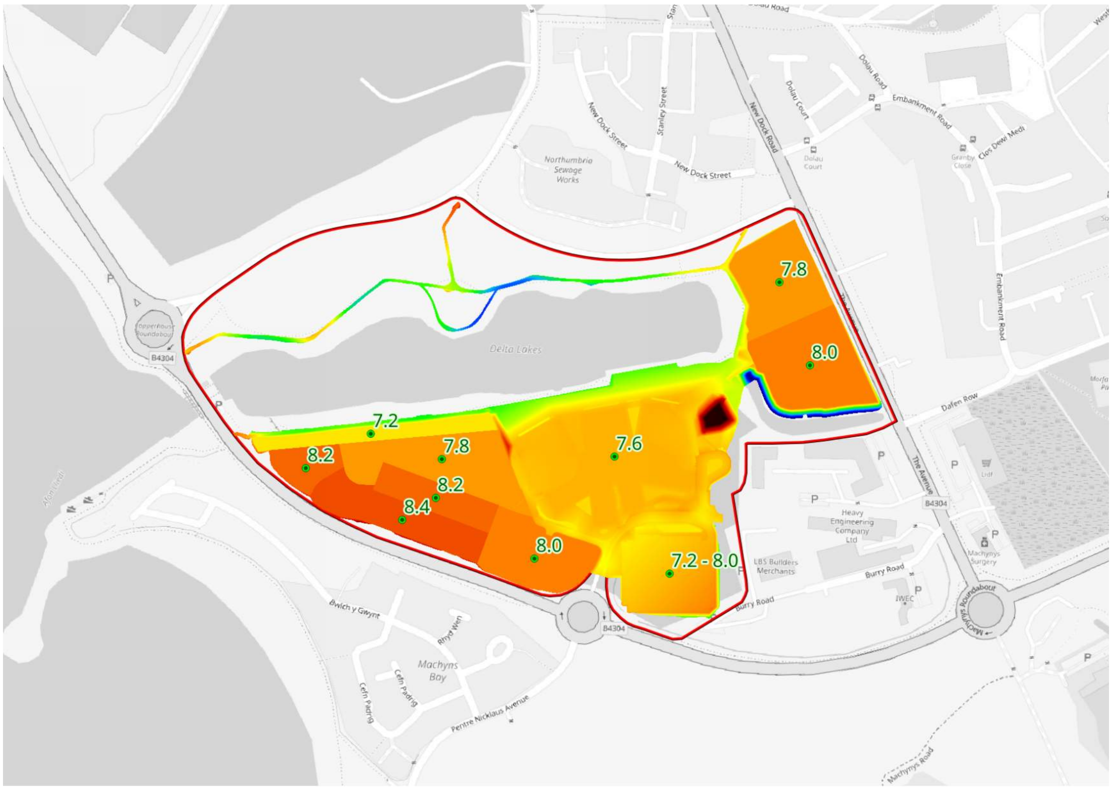


Figure 3.1: Post Development Ground Levels (mAOD)

3.2 Model Scenarios

The model has been run for four scenarios:

- Scenario A5 - Pre-development Tidal Scenario with Breach
- Scenario C - Post-development Tidal Scenario with Breach
- Scenario A6 - Pre-development Fluvial Scenario
- Scenario C6 - Post-development Fluvial Scenario

3.3 Model Runs

The modelling programme comprised assessment of the Pre and Post development scenarios including the following scenarios:

1. Pre-development Tide/surge 0.5% AEP 70th %tile: Fluvial QMED cc 30% to 2122
2. Pre-development Tide/surge 0.1% AEP 70th %tile: Fluvial QMED cc 30% to 2122
3. Post-development Tide/surge 0.5% AEP 70th %tile: Fluvial QMED cc 30% to 2122
4. Post-development Tide/surge 0.1% AEP 70th %tile: Fluvial QMED cc 30% to 2122
5. Pre-development Tide/surge MHWS: Fluvial 0.1% AEP to 2022
6. Pre-development Tide/surge MHWS 70th %tile: Fluvial 1% AEP cc 30% to 2122
7. Post-development Tide/surge MHWS: Fluvial 0.1% AEP to 2022
8. Post-development Tide/surge MHWS 70th %tile: Fluvial 1% AEP cc 30% to 2122

It should be noted that the central allowance for fluvial flows (30%) has been combined with the higher central allowance for sea level rise (70th percentile).

4 Model Results

4.1 Overview

The following sections presents the results of the modelling. The results include:

- Water levels
- Flood depths
- Flood hazard
- Flood differences

4.2 Water Level

Figures 4.2 to 4.5 shows the maximum tidal flood levels for a 0.5% AEP event and 0.1% AEP event in conjunction with a range of climate change scenarios to 2122. Figures 4.6 to 4.9 shows the maximum fluvial flood levels for a 1% AEP + CC 30% event to 2122 and 0.1% AEP event for 2022. Tables 4.1 and 4.2 gives a summary of the maximum Pre and Post development flood levels for the locations shown in Figure 4.1.

Reference Point	0.5% AEP C / HC (m AOD)	0.1% AEP C / HC (m AOD)	1% AEP C / HC (m AOD)	0.1% AEP N/A (m AOD)
1	6.25	6.78	4.64	4.46
2	-	-	-	-
3	6.30	6.84	-	-
4	6.36	6.88	-	-
5	6.35	6.87	4.61	4.86
6	6.30	6.82	-	-
7	6.48	6.92	-	-

Table 4.1: Peak Pre Development Flood Levels at Reference Points ¦UE = Upper End, HC = Higher Central, C = Central, N/A = no climate change¦

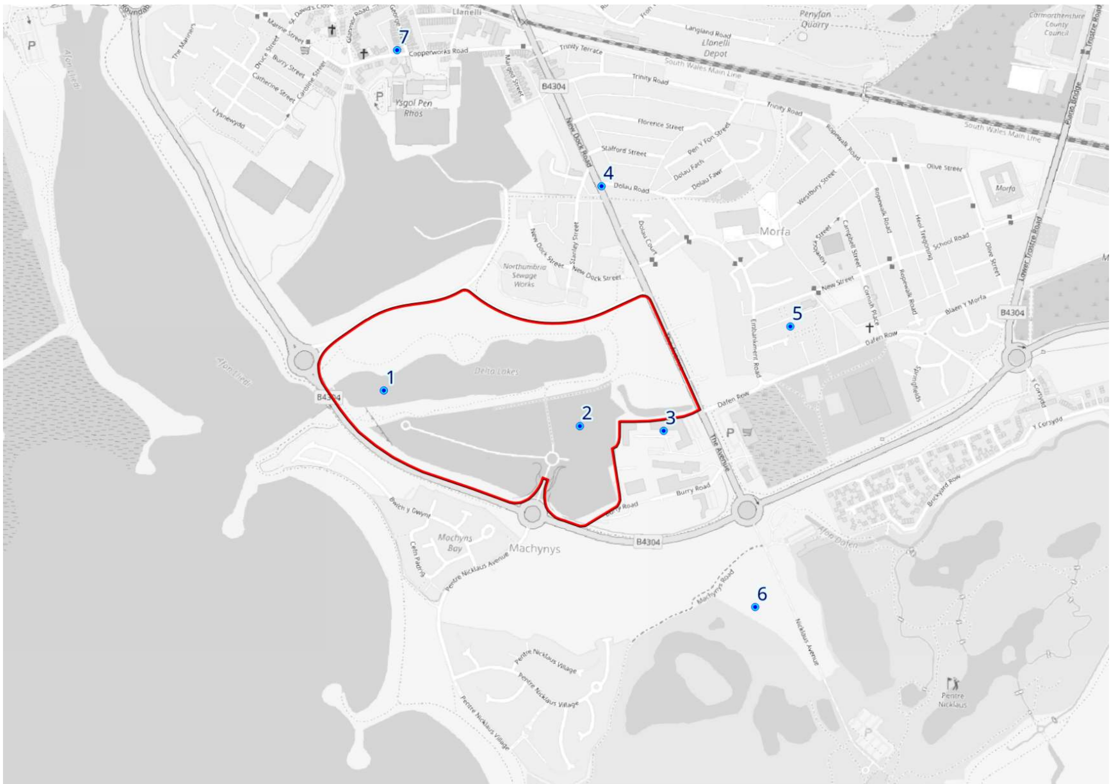


Figure 4.1: Reference Points

Reference Point	0.5% AEP C / HC (m AOD)	0.1% AEP C / HC (m AOD)	1% AEP C / HC (m AOD)	0.1% AEP N/A (m AOD)
1	5.35	6.47	4.64	4.46
2	-	-	-	-
3	6.19	6.82	-	-
4	6.35	6.87	-	-
5	6.34	6.86	4.61	4.86
6	6.29	6.82	-	-
7	6.49	6.92	-	-

Table 4.2: Peak Post Development Flood Levels at Reference Points
¦UE = Upper End, HC = Higher Central, C = Central, N/A = no climate change¦

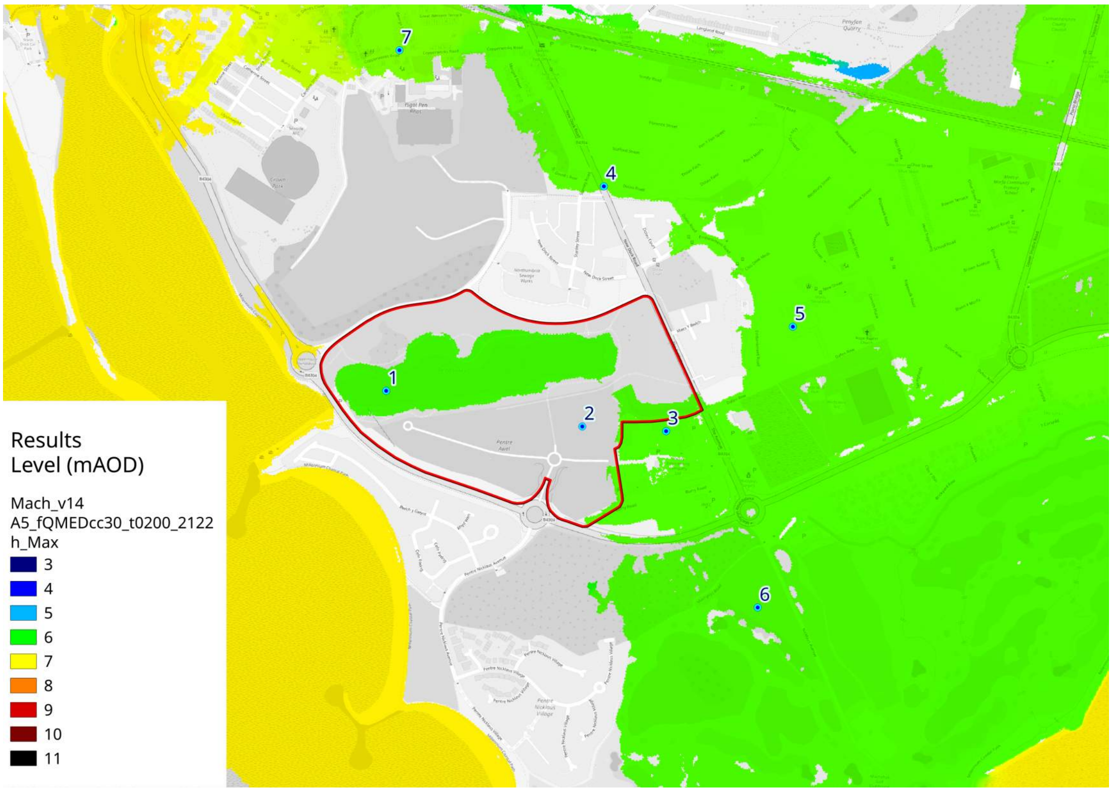


Figure 4.2: Pre-development Results Peak Flood Level for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

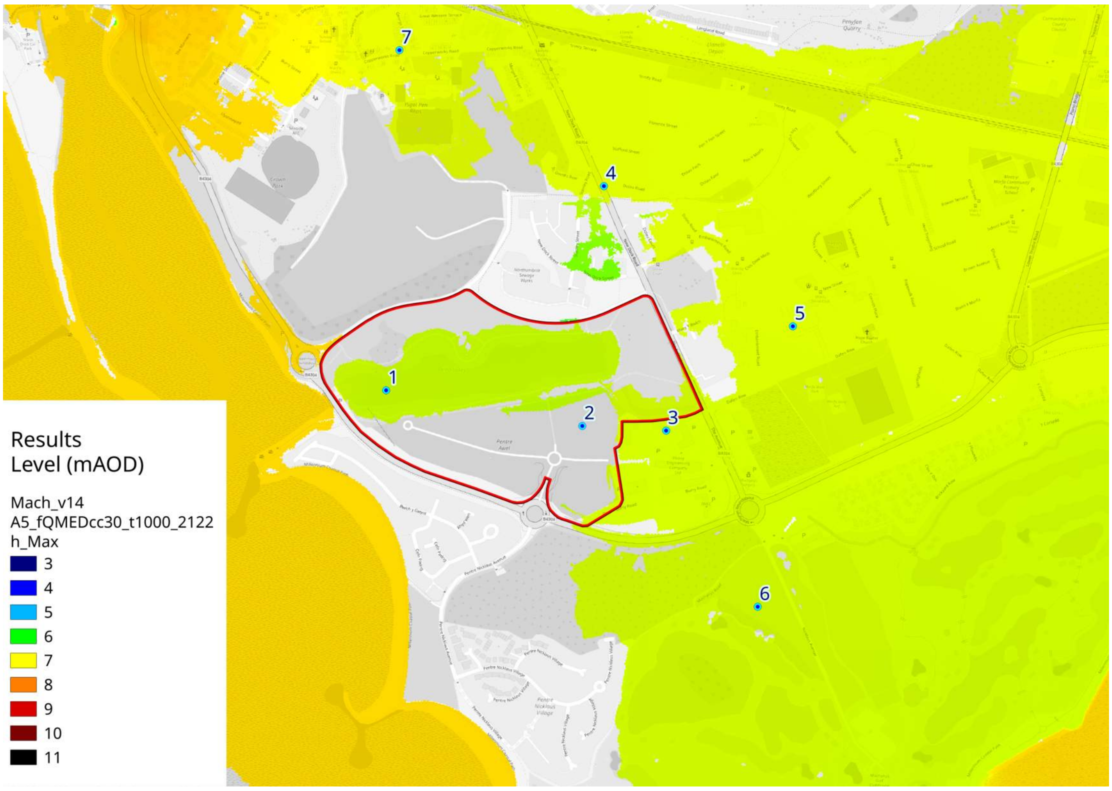


Figure 4.3: Pre-development Results - Peak Water Level for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

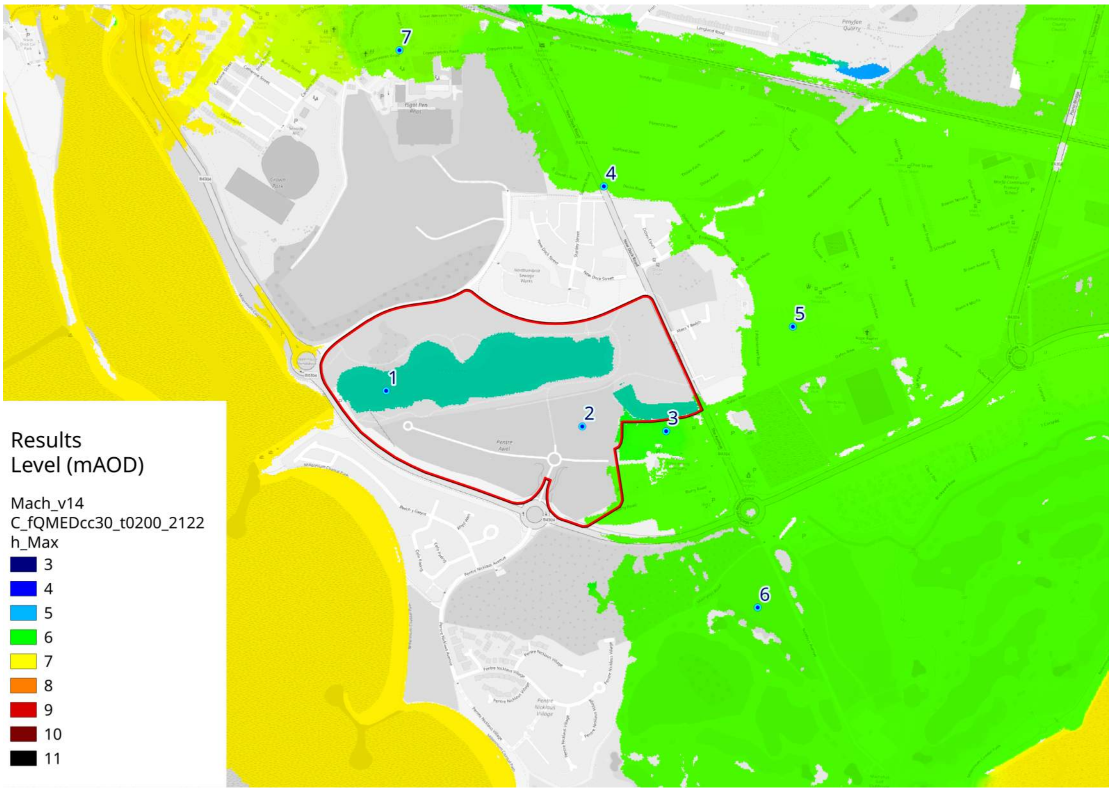


Figure 4.4: Post-development Model Results - Peak Flood Level for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

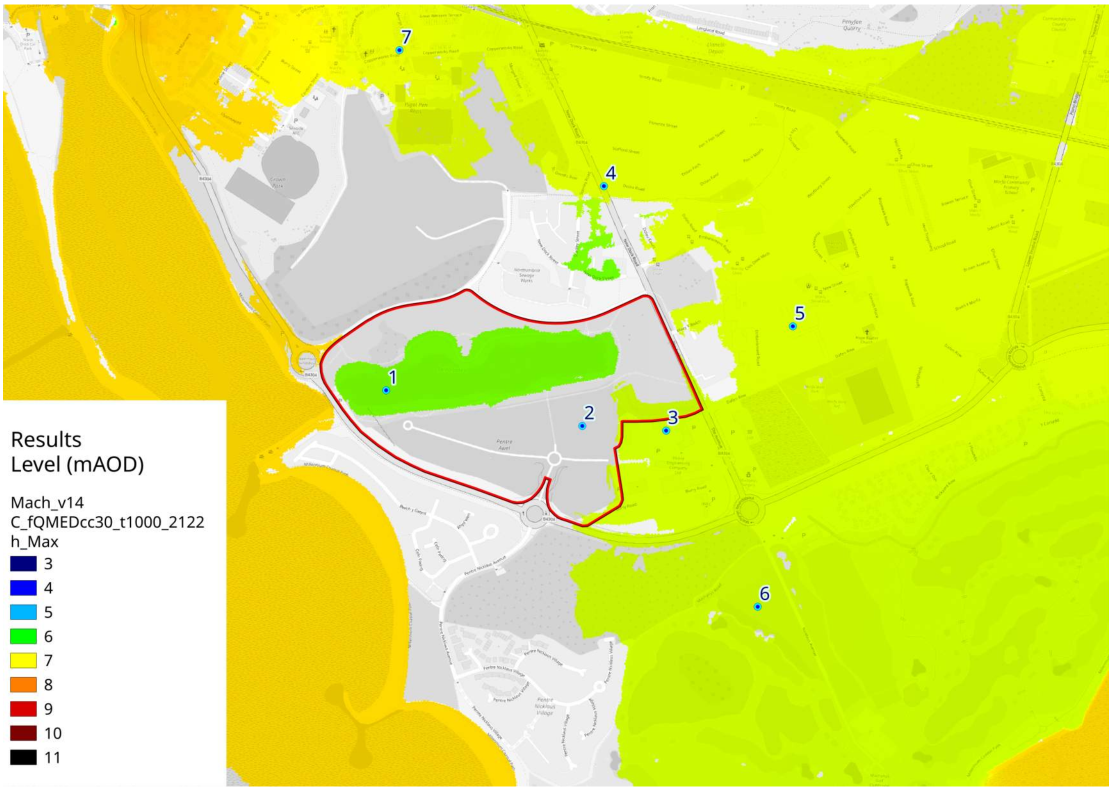


Figure 4.5: Post-development Model Results - Peak Water Level for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

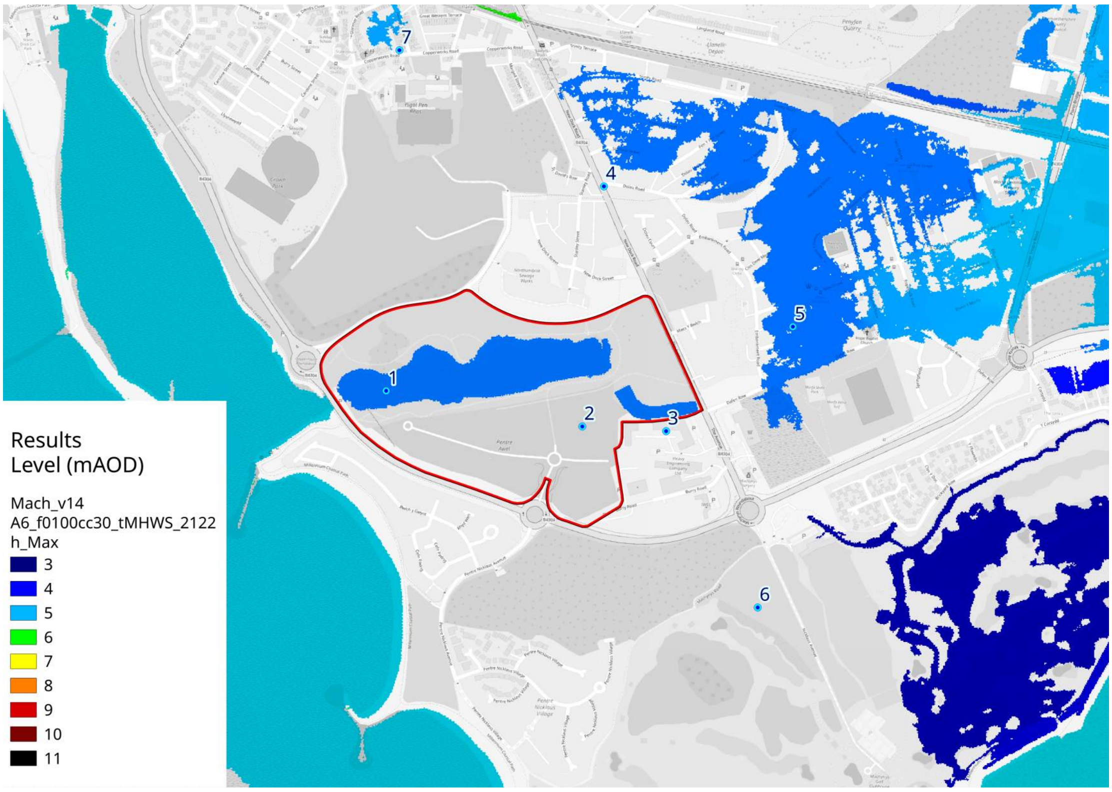


Figure 4.6: Pre-development Results Peak Flood Level for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

Figure 4.7: Pre-development Results Peak Flood Level for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

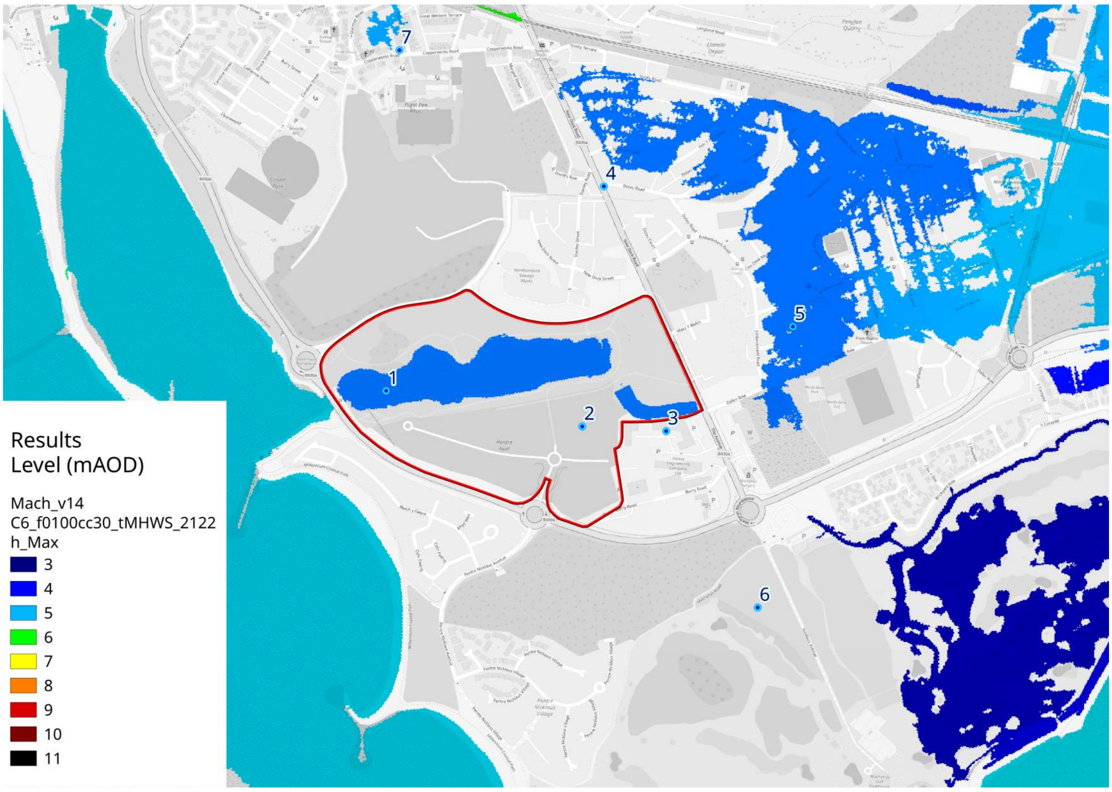


Figure 4.8: Post-development Results Peak Flood Level for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

Figure 4.9: Post-development Results Peak Flood Level for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

4.3 Depth

Figures 4.10 to 4.13 shows the maximum tidal depth results of the hydraulic modelling for the Pre- and Post-development scenarios for a 0.5% AEP event and 1% AEP events. Figures 4.14 to 4.17 shows the maximum fluvial depth for a 1% AEP + CC 30% event to 2122 and 0.1% AEP event for 2022. Tables 4.3 and 4.4 gives a summary of the maximum Pre and Post development flood depths for the locations shown in 4.1.

Reference Point	0.5% AEP C / HC (m AOD)	0.1% AEP C / HC (m AOD)	1% AEP C / HC (m AOD)	0.1% AEP N/A (m AOD)
1	6.06	6.59	4.44	4.26
2	-	-	-	-
3	0.34	0.88	-	-
4	0.31	0.83	-	-
5	1.89	2.42	0.16	0.40
6	1.33	1.86	-	-
7	1.14	1.57	-	-

Table 4.3: Peak Pre-Development Flood Depths at Reference Points
¦UE = Upper End, HC = Higher Central, C = Central, N/A = no climate change¦

Reference Point	0.5% AEP C / HC (m AOD)	0.1% AEP C / HC (m AOD)	1% AEP C / HC (m AOD)	0.1% AEP N/A (m AOD)
1	5.15	6.27	4.44	4.26
2	-	-	-	-
3	0.23	0.86	-	-
4	0.30	0.83	-	-
5	1.89	2.41	0.16	0.40
6	1.33	1.85	-	-
7	1.14	1.57	-	-

Table 4.4: Peak Post Development Flood Depths at Reference Points
¦UE = Upper End, HC = Higher Central, C = Central, N/A = no climate change¦

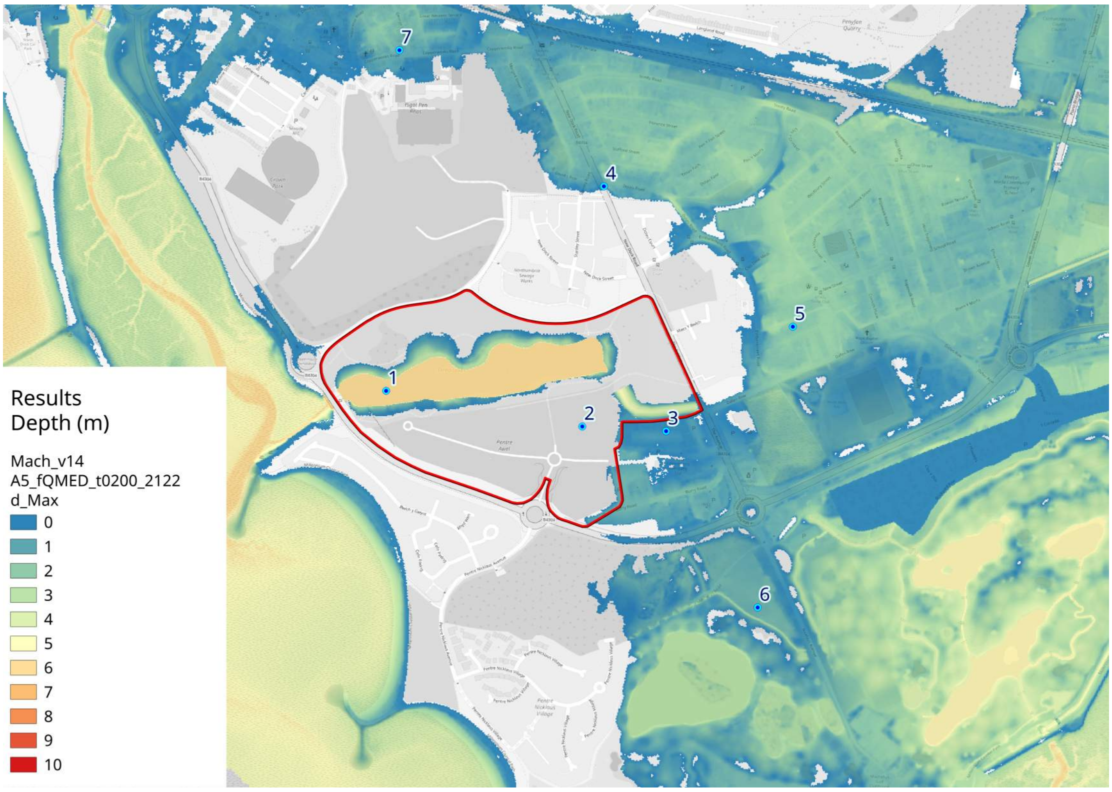


Figure 4.10: Pre-development Results Peak Water Depth for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

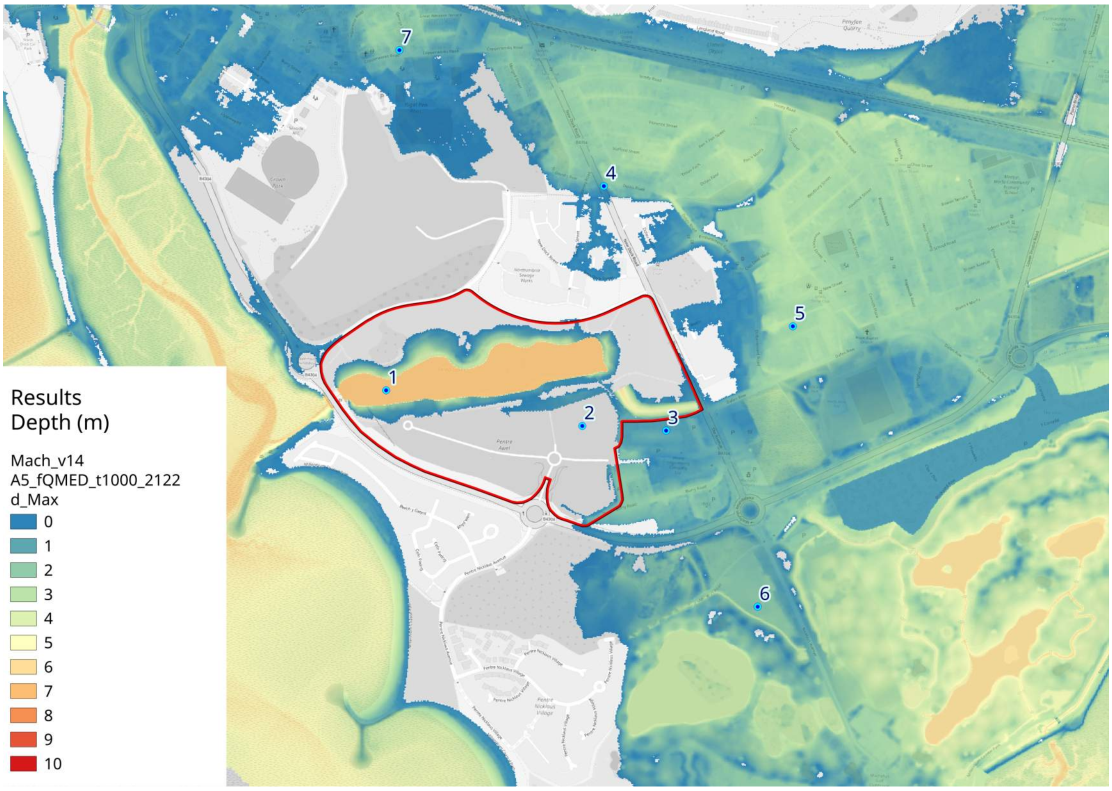


Figure 4.11: Pre-development Results Peak Water Depth for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with 30% allowance for fluvial flow in 2122

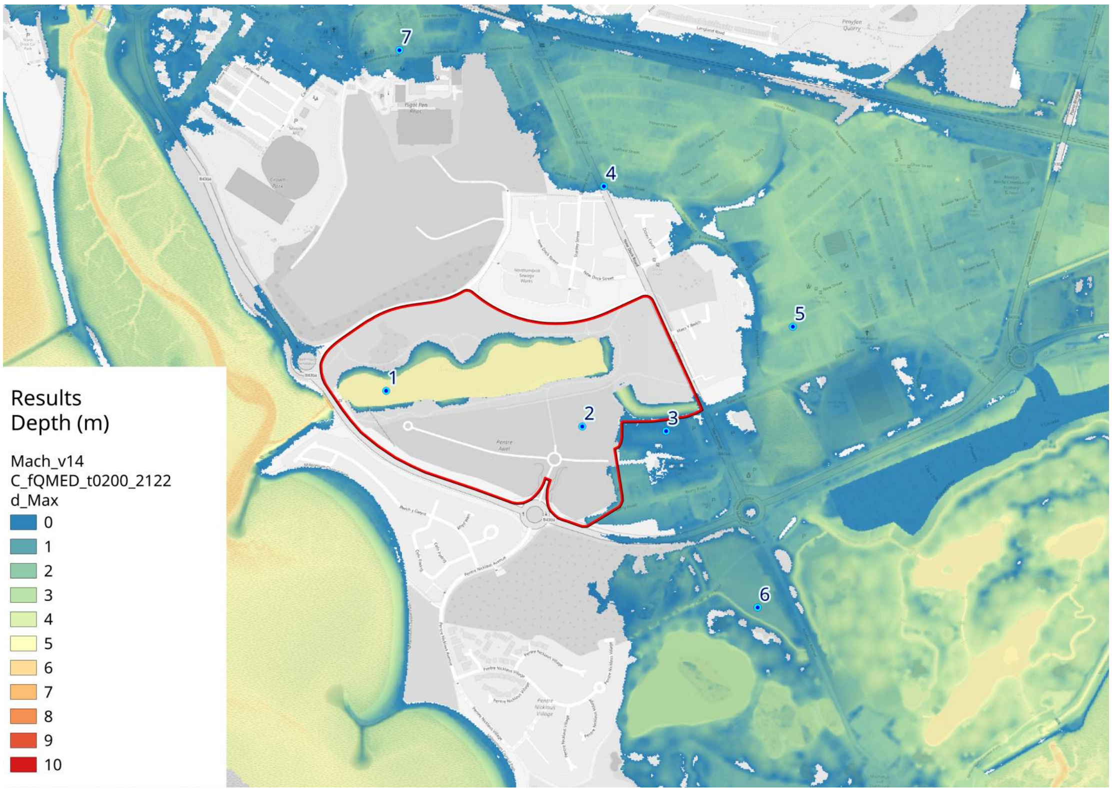


Figure 4.12: Post-development Model Results Peak Water Depth for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

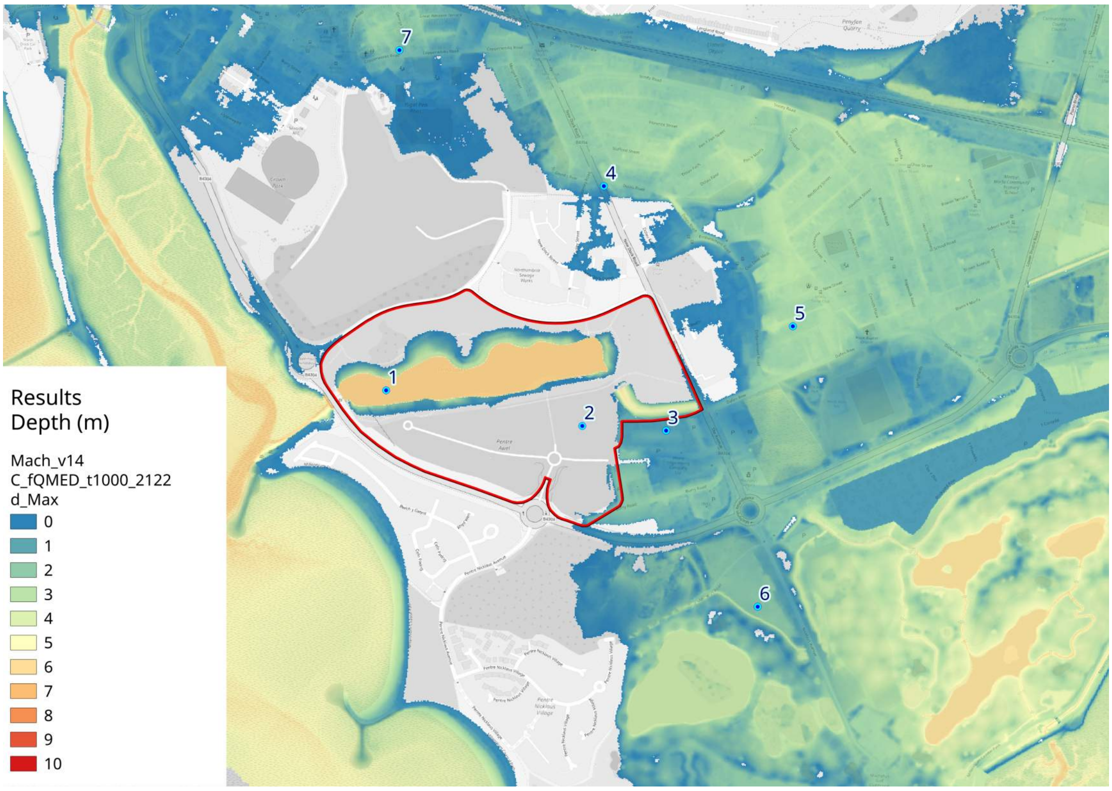


Figure 4.13: Post-development Model Results Peak Water Depth for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

Figure 4.14: Pre-development Results Peak Water Depth for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

Figure 4.15: Pre-development Results Peak Water Depth for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

Figure 4.16: Post-development Results Peak Water Depth for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

Figure 4.17: Post-development Results Peak Water Depth for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

4.4 Flood Hazard and Risks to People

Danger to people is assessed though the concept of hazard. Hazard combines flow velocity and depth. This approach recognises the fact that both deep-still and shallow-fast flowing flood water can be dangerous. Flood Hazard has been considered to evaluate when safe access and egress becomes too hazardous to facilitate evacuation for pedestrians from the development. Figures 4.18 to 4.21 show the results of the modelling for flood hazard in a tidal surge event and figures 4.22 to 4.25 show the results of the modelling for flood hazard in a fluvial event. Hazard is based on the TUFLOW ZUK0 output.

The figures use the scale below.

- Blue - Low risk - Caution advised
- Yellow - Moderate - Dangerous for some
- Brown - Significant - Dangerous for most
- Red - Extreme - Dangerous for all

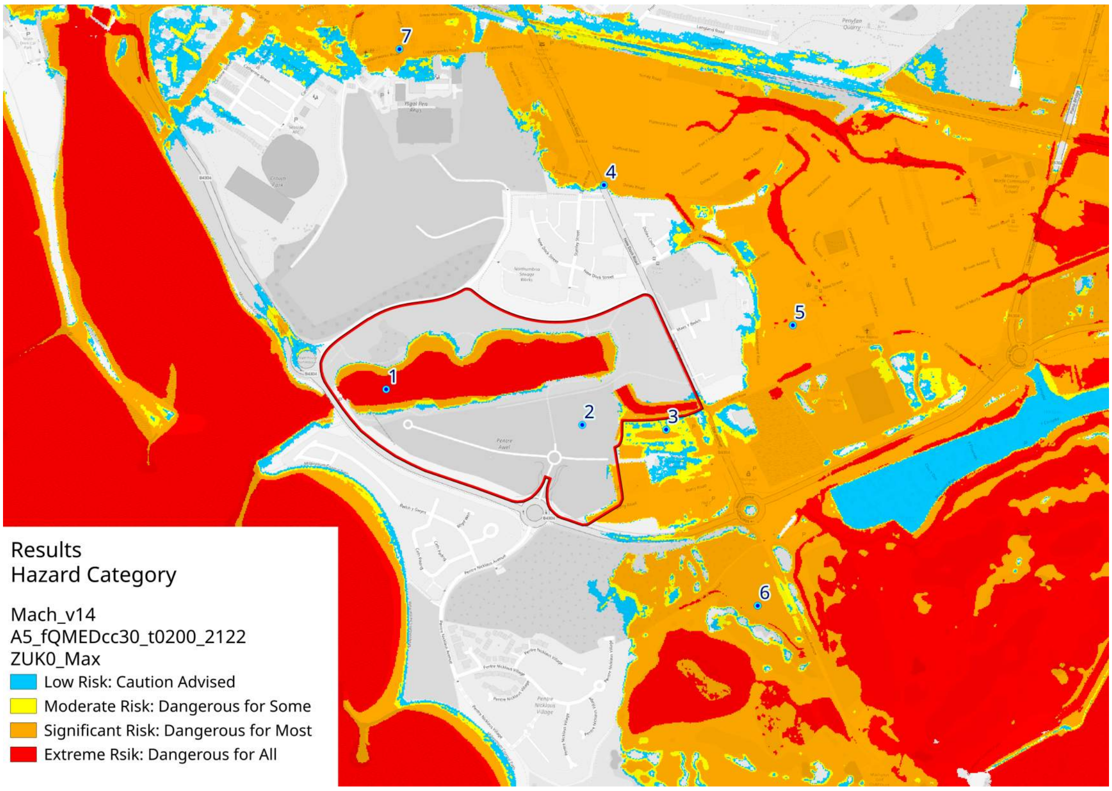


Figure 4.18: Pre-development Results Peak Flood Hazard for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

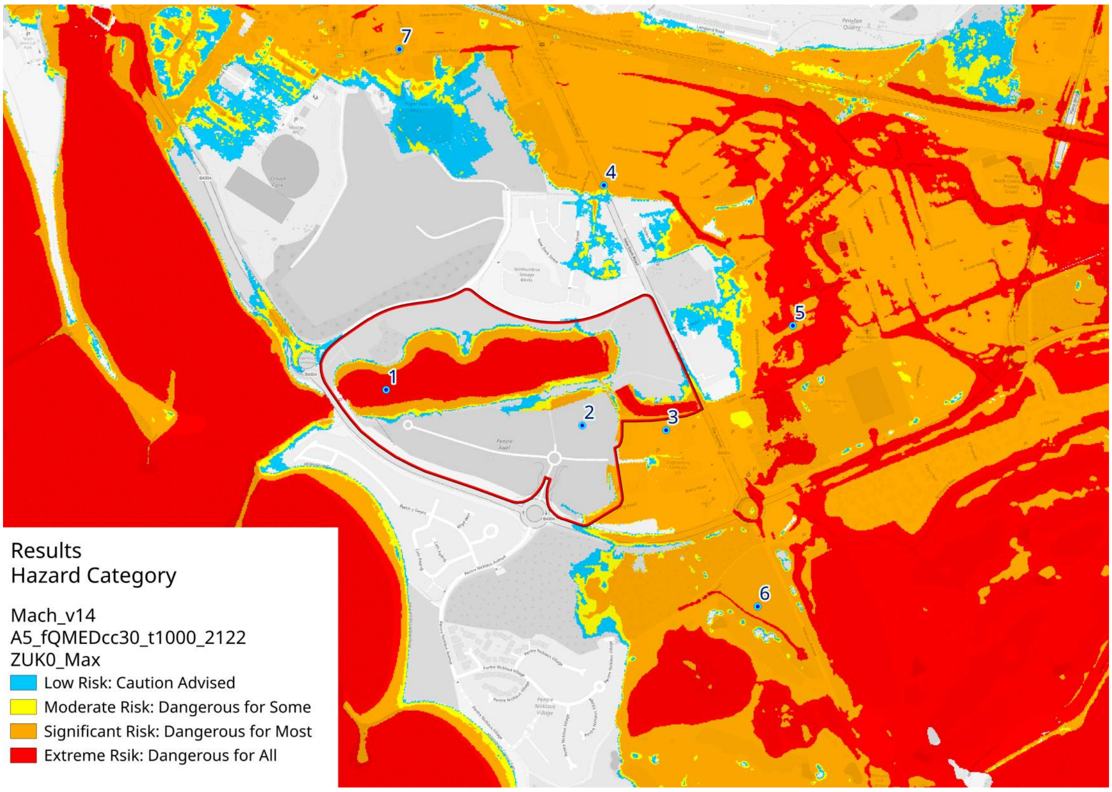


Figure 4.19: Pre-development Results Peak Flood Hazard for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

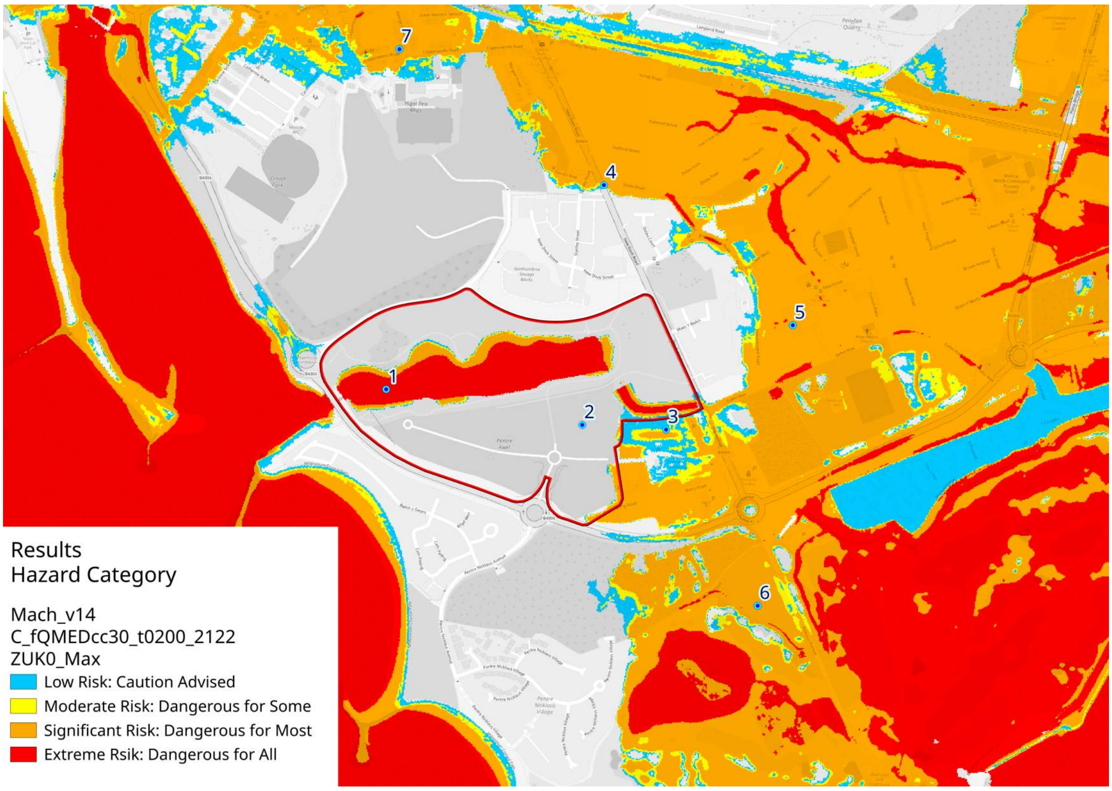


Figure 4.20: Post-development Model Results Peak Flood Hazard for a 0.5% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

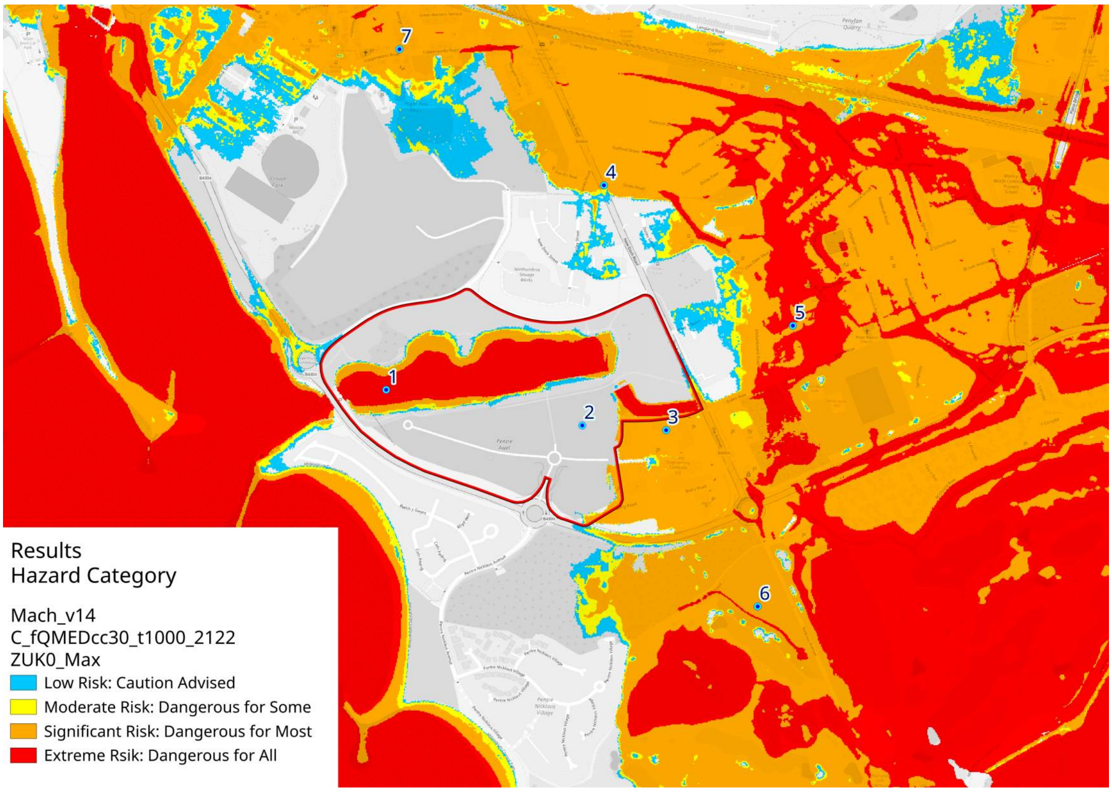


Figure 4.21: Post-development Model Results Peak Flood Hazard for a 0.1% AEP Central tide surge event in conjunction with a QMED fluvial flow with a 30% allowance for fluvial flow in 2122

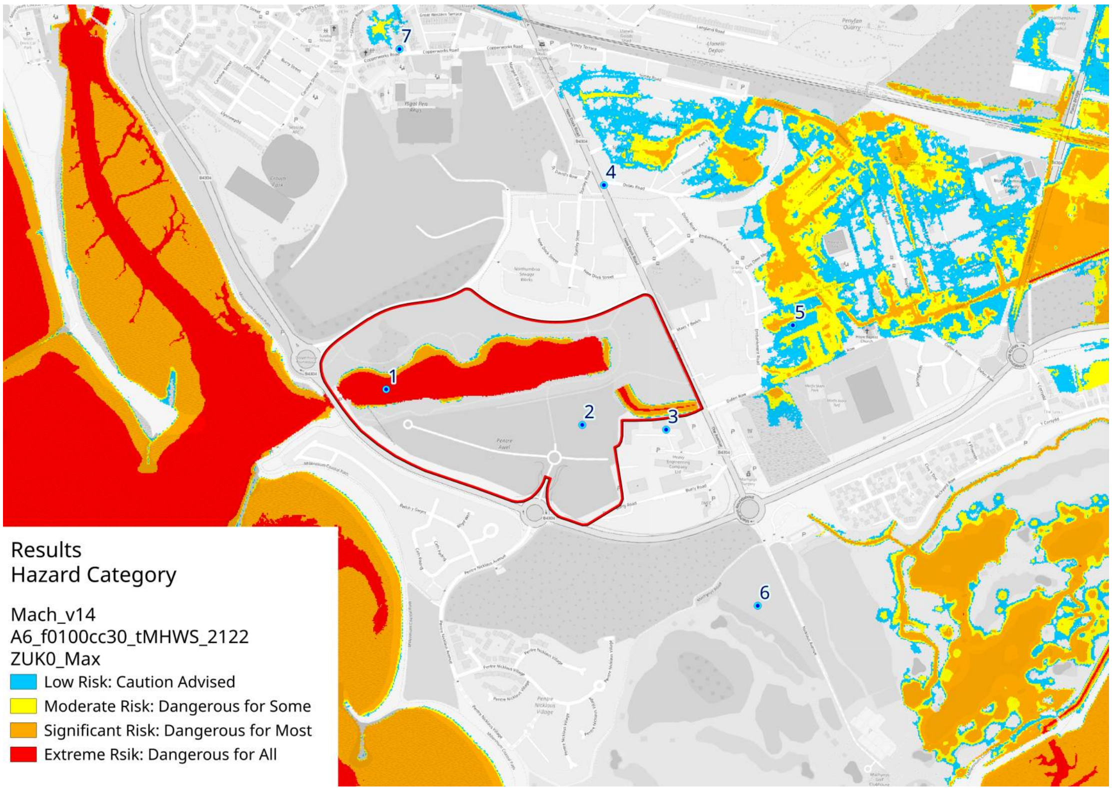


Figure 4.22: Pre-development Results Peak Flood Hazard for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

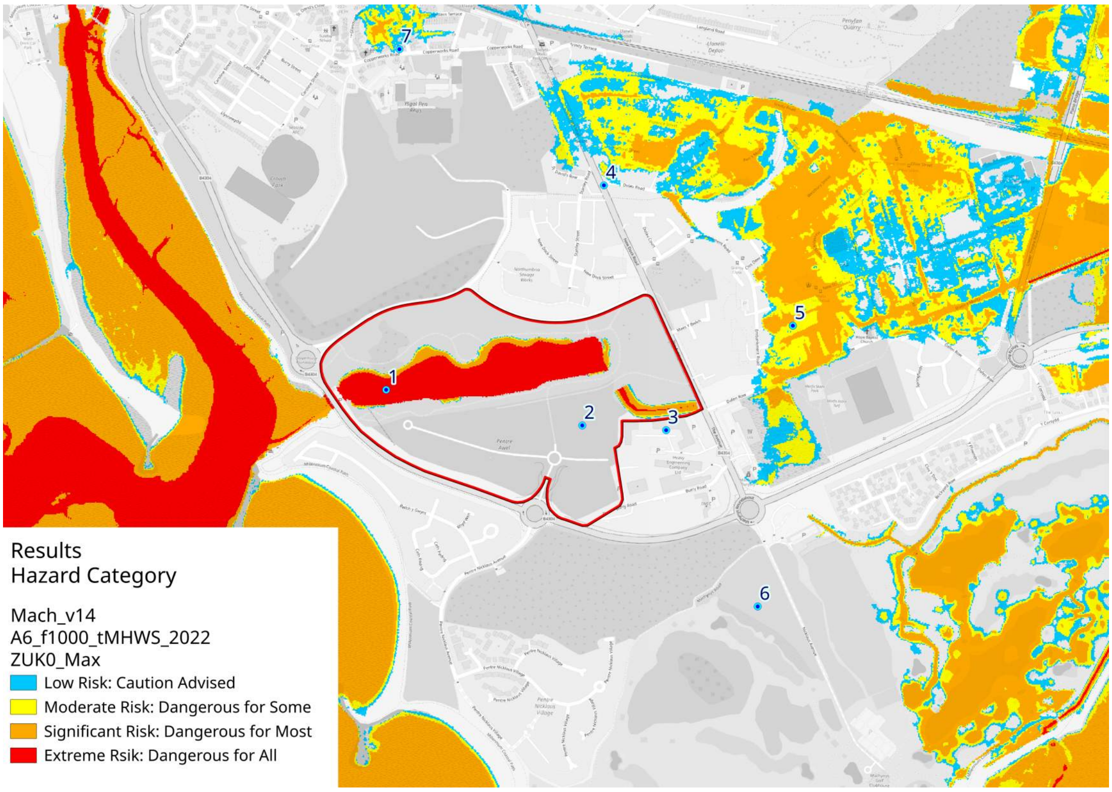


Figure 4.23: Pre-development Results Peak Flood Hazard for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

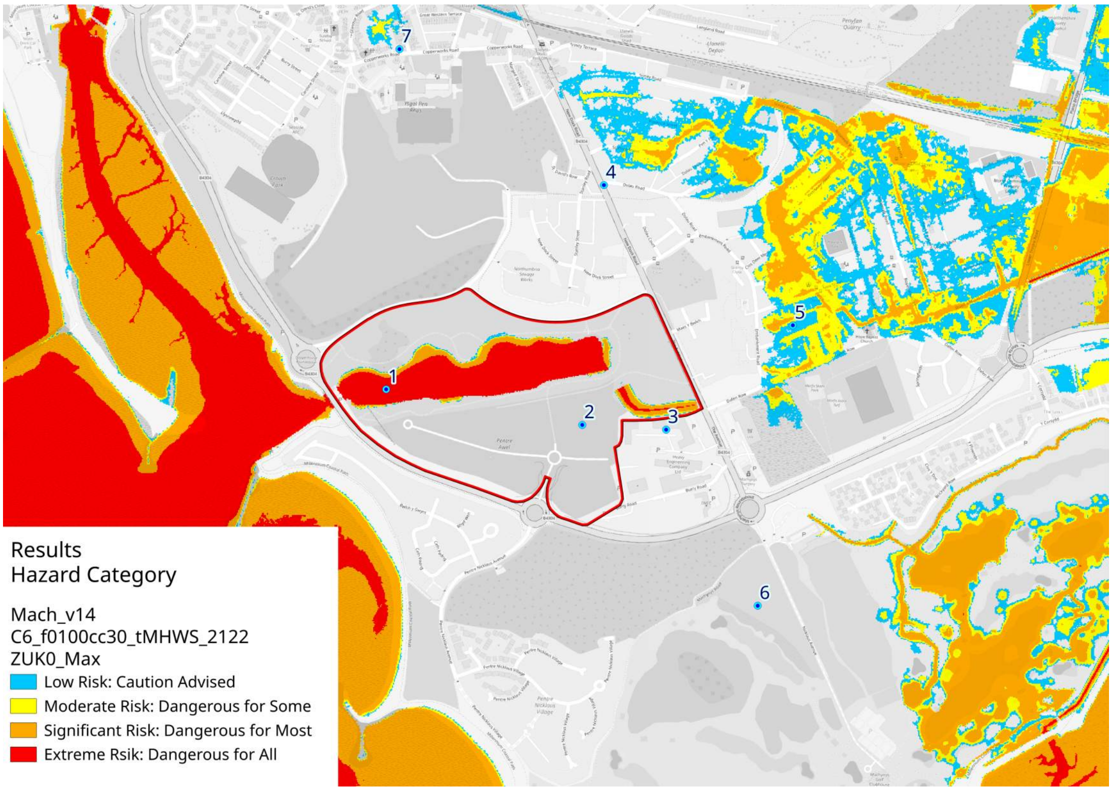


Figure 4.24: Post-development Results Peak Flood Hazard for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

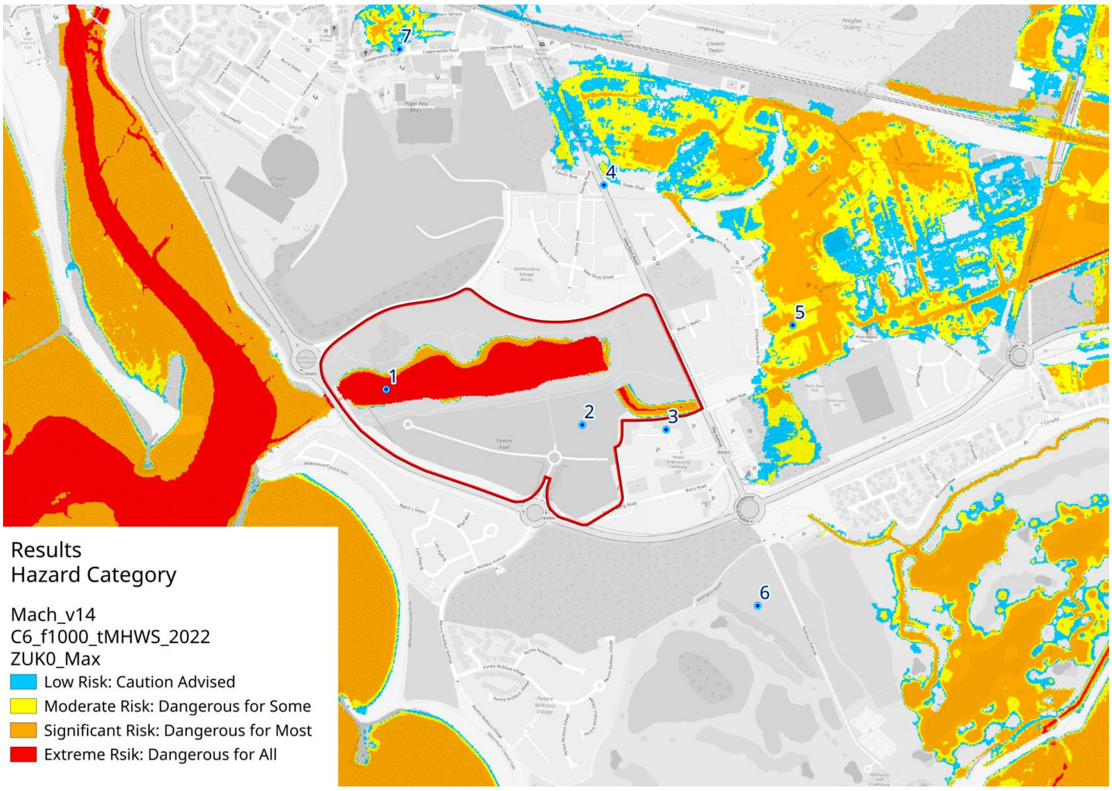


Figure 4.25: Post-development Results Peak Flood Hazard for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

4.4.1 Third Party Dis-benefit

Third party dis-benefits have been assessed using difference maps. Figure 4.26 to Figure 4.27 shows the change in flood levels between the Post and Pre development model results for tidal surge events. While Figure 4.28 to Figure 4.29 shows the change in flood levels between the Post and Pre development model results for fluvial events. The figures show the numeric difference in level of the Pre and Post development schemes. Areas shaded yellow indicate negligible changes (±0.005m) in flood level as a result of the development. Areas shaded orange / green show changes in flood level greater than +0.005m and less than -0.005m respectively.

There is some disbenefit shown in figure 4.27 - this is due to an instability in the 2D which only occurs in the post-development case for the 0.1% AEP tide surge event in conjunction with a QMED fluvial flow (30%) in 2122. The level difference at the location of the instability is in the order of 20mm (though very locally the peak difference is 117mm) and all of this difference is attributable to instability. In anycase, the negative impact is all shown to be in the sea, and hence not impacting any property. Aside from this localised negative impact, there is no increase in water levels in any of the pre- to post-development comparisons. It is of note that having undertaken a number of versions of modelling with minor differences, following various review recommendations, all of them show this same result, that there is no negative impact to third parties and there is some positive impact in the extreme tidal cases. This benefit is due to increasing the height of the tidal defence gate, preventing overtopping and hence no tidal waters enter the lake. There is no change in the fluvially dominated events.

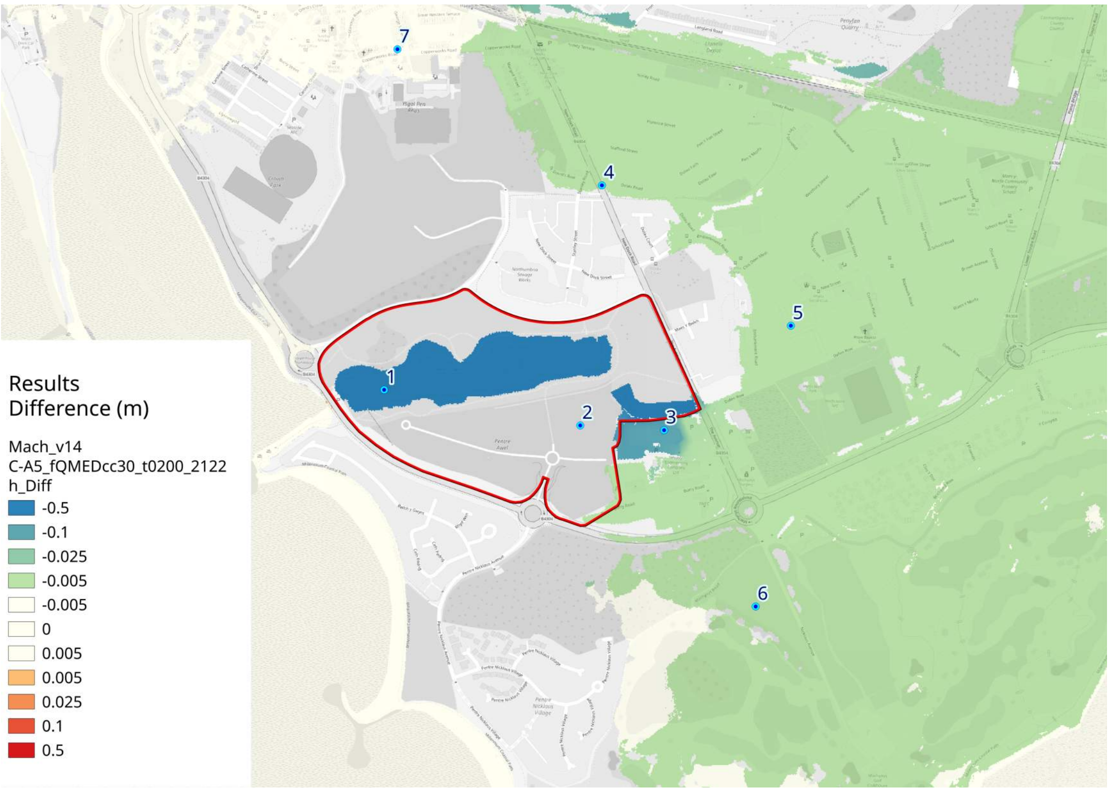


Figure 4.26: Flood Difference Mapping : Post development Levels minus Pre-development Flood Levels for a 0.5% AEP tide surge event in conjunction with a QMED fluvial flow (30%) in 2122

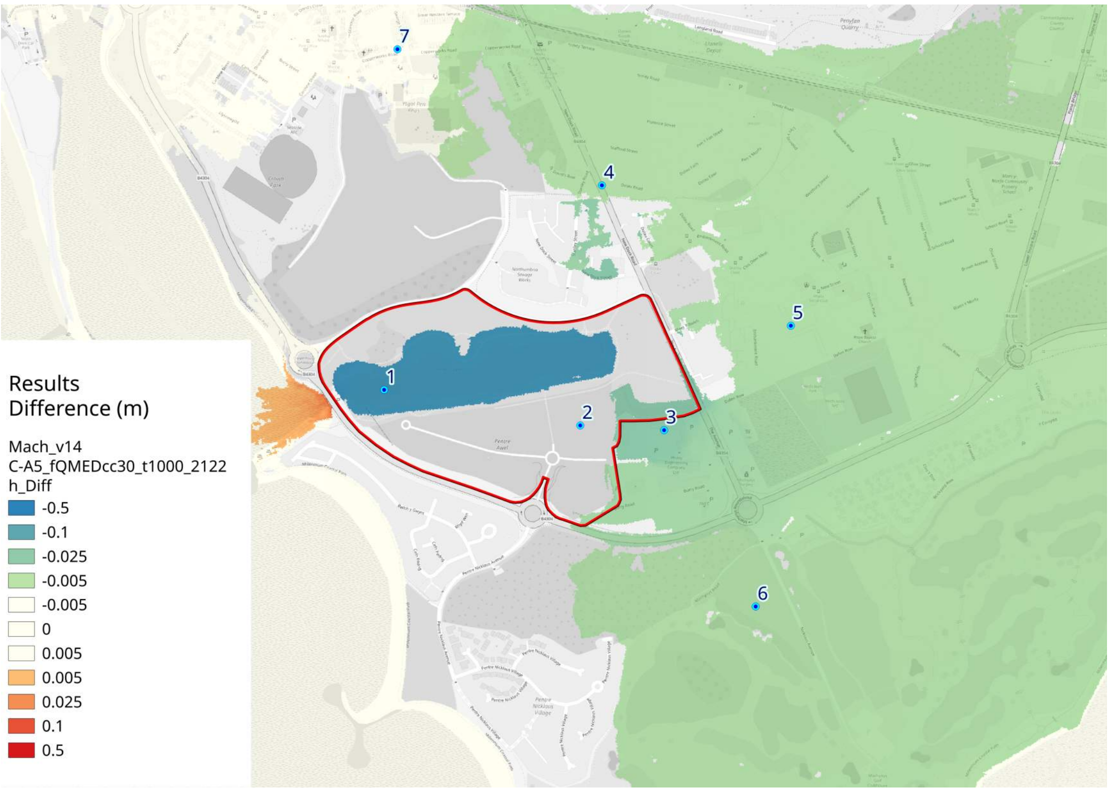


Figure 4.27: Flood Difference Mapping : Post development Flood Levels minus Pre-development Flood Levels for a 0.1% AEP tide surge event in conjunction with a QMED fluvial flow (30%) in 2122

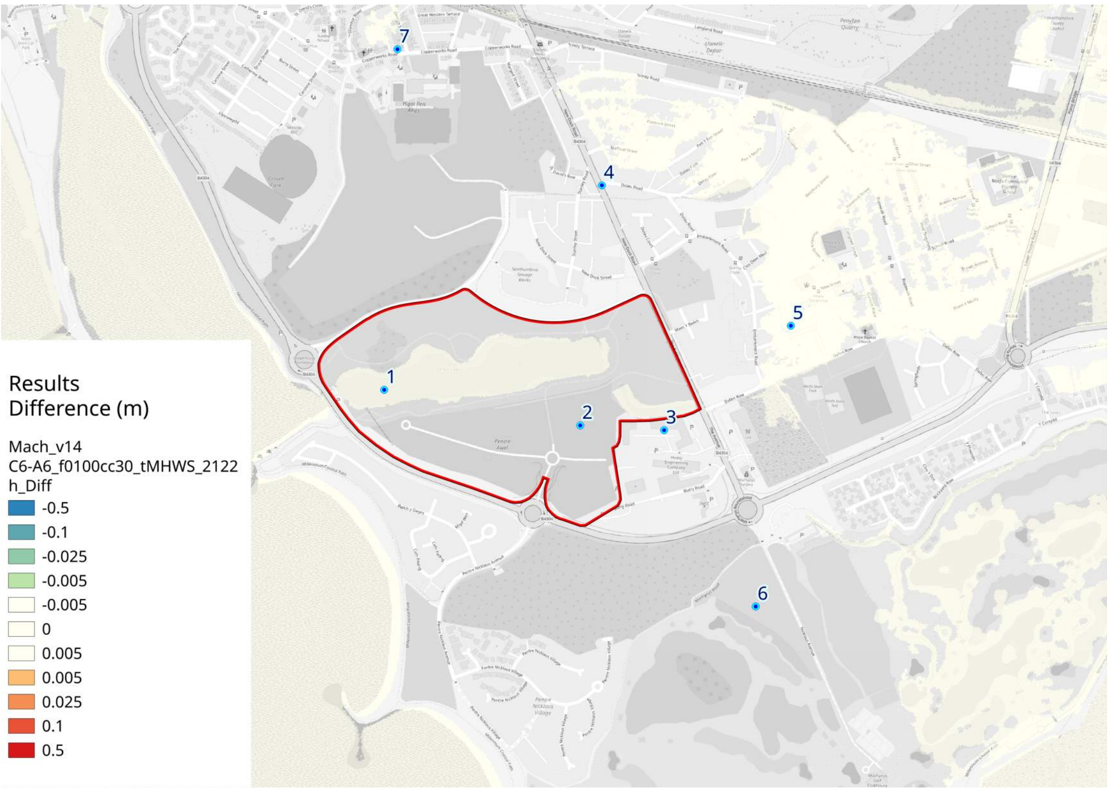


Figure 4.28: Flood Difference Mapping : Post development Levels minus Pre-development Flood Levels for a 1% AEP with a 30% climate change allowance fluvial event in conjunction with a MHWS Central tidal surge in 2122

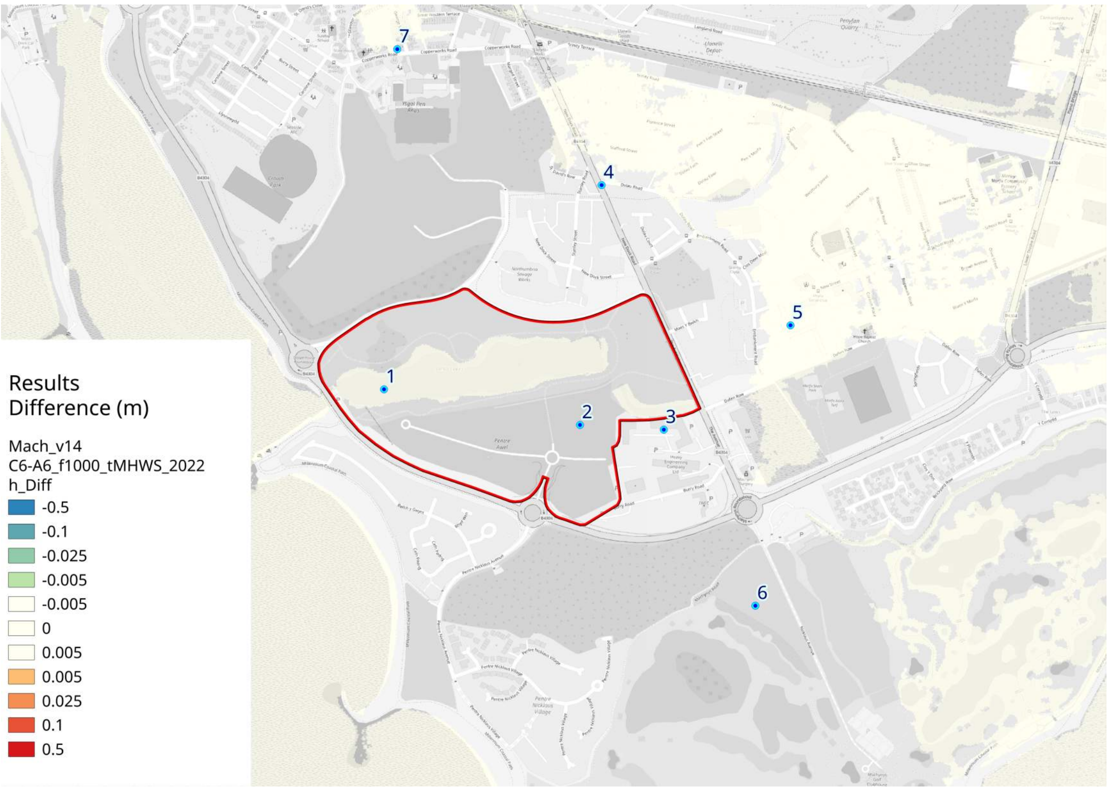
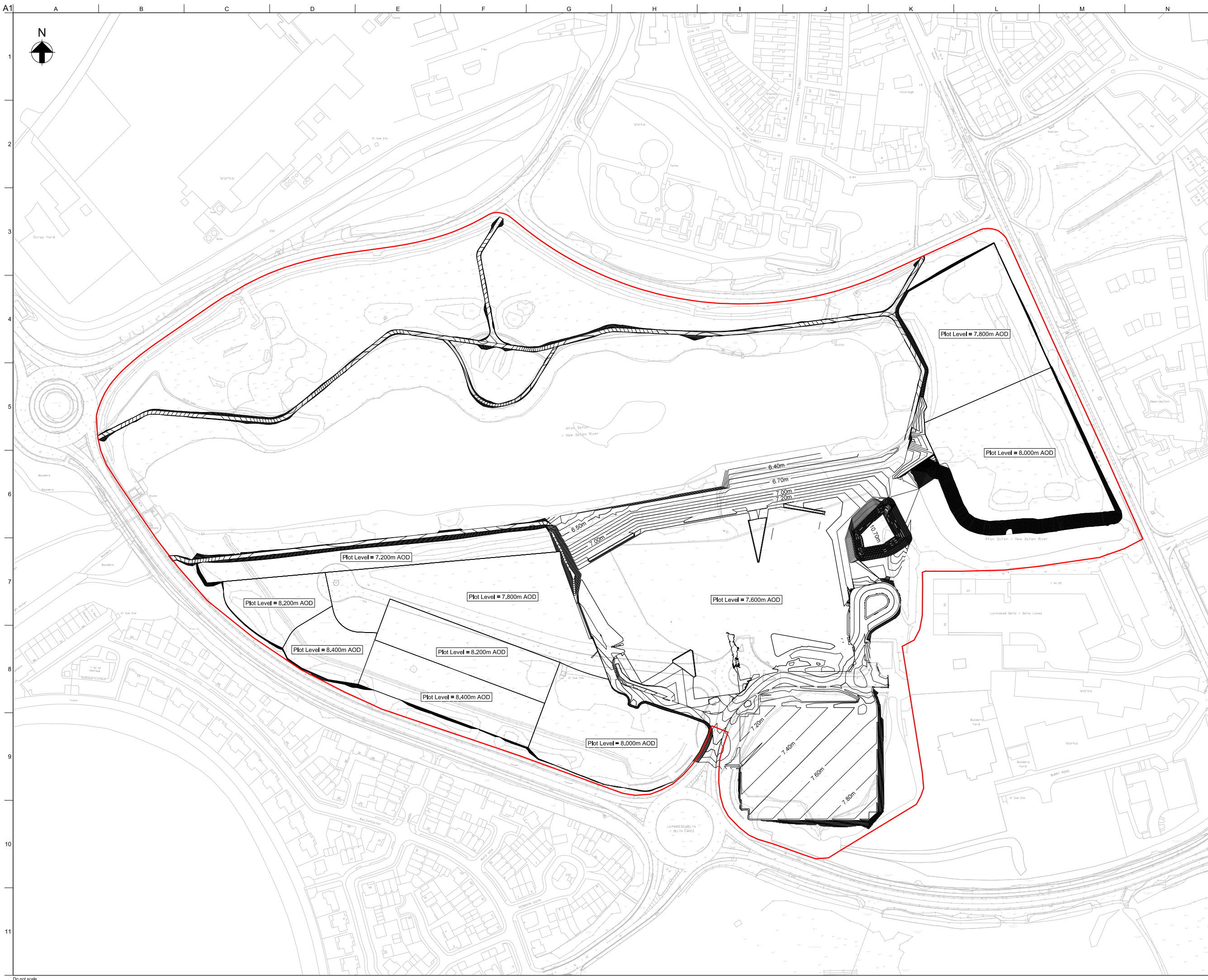


Figure 4.29: Flood Difference Mapping : Post development Levels minus Pre-development Flood Levels for a 0.1% AEP fluvial event in conjunction with a MHWS tidal surge in 2022

A Development Proposals



Legend

Site Boundary

7.00m — Proposed contour

Notes

1. Finished levels shown on tis drawing taken from a combination of Curtins Finished Levels Design for Phase 1 and Arup RIBA Stage 3 and Concept Level Design for areas outside Phase 1.

Issue	Date	By	Chkd	Appd
P01	09/12/22	DS	JS	JS
	Issued for Information			

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Client
Carmarthenshire County Council

Project Title
Pentre Awel

Drawing Title
Updated Finished Levels

Scale at A1: 1:1250
Role: Infrastructure
Suitability: For Information
Job No: 284430
Rev: P01
Drawing No: SK100

Do not scale

J:\284000\284430-00\4 Internal Project Data\4-30 Drawings\4-31 Issue drawings\SK100.dgn

B Hydrological Calculation Record

Flood estimation – calculation record

Site/Project Name:

Date:

Introduction

This document is a supporting document to the Natural Resources Wales (NRW) Flood Estimation Technical Guidance Note V2. It provides a template for recording calculations and decisions made during flood estimation. It will often be complemented by more general hydrological information given in a project report. The information given here should be enough to enable the work to be reproduced in the future.

Note 1: Table, content or page layout can be adapted to best present relevant information. Additional rows should be added to, or removed, from tables as appropriate.

Note 2: Probability of flood occurrence is traditionally expressed within Hydrology as a Return Period, this is the average time between years with at least one larger flood. It can also be expressed as Annual Exceedance Probability (AEP), and this is often more appropriate to use when communicating with the public. Return Period has been retained within this document but can be replaced with AEP is wished.

Contents

Approval

	Name	Qualifications	Date	Competence level
Calculations prepared by:	Sara Liguori 	PhD	27/01/2023	
Calculations checked by:				
Calculations approved by:				

Competence levels:

level 1 – hydrologist with minimum approved experience in flood estimation

level 2 – senior hydrologist

level 3 – senior hydrologist with extensive experience of flood estimation

Abbreviations

AEP	Annual Exceedance Probability
AMAX	Annual maximum
AREA	Catchment area (km^2)
BFI	Base flow index
BFIHOST	Base flow index derived using the HOST soil classification
BFIHOST19	Base flow index derived using the revised (2019) HOST soil classification
DPLBAR	Mean drainage path length (km)
DPSBAR	Mean drainage path slope (m/km)

FARL	FEH index of flood attenuation due to reservoirs and lakes
FEH	Flood Estimation Handbook
FPEXT	Floodplain extent
HOST	Hydrology of soil types
NRFA	National River Flow Archive
NRW	Natural Resources Wales
POT	Peaks over a threshold
QMED	Median annual maximum flow (with Annual Exceedance Probability of 50% / return period 2 years)
ReFH	Revitalised flood hydrograph method – used for rainfall runoff method
SAAR	Standard average annual rainfall (mm)
SPR	Standard percentage run-off
SPRHOST	Standard percentage run-off derived using the HOST soil classification
Tp	Time to peak
URBAN	Flood Studies Report index of fractional urban extent
URBEXT2000	Revised index of urban extent
WINFAP	Windows Frequency Analysis Package – used for FEH statistical method

1. Method statement

1.1 Overview of requirements for flood estimates

Item	Comments
Give an overview which includes: • purpose of study • names of river/s • location • number of calculation points (and if peak flows or hydrographs) • previous relevant calculations • availability of flood history	This document outlines the hydrological analysis of the Afon Lliedi, Cille Stream, and Afon Dafen catchments at Llanelli, Carmarthenshire. The purpose of this study is to produce design hydrographs for use within the hydraulic modelling being undertaken to support the planning documentation for a proposed development south of the urban area of Llanelli. The hydrological assessment outlined in this document aims to update the fluvial hydrological boundaries to the existing 1D/2D hydraulic model of the Afon Lliedi, Cille Stream and Afon Dafen. Existing hydrological boundaries for the Afon Lliedi and Cille Stream were derived by Edenvale Young Ltd in 2019. Existing hydrological boundaries for the Afon Dafen were implemented in the hydraulic modelling undertaken for the North Dafen Attenuation Scheme and were derived by NRW in 2017. The conceptual model and estimate locations that have been implemented for the purposes of the hydrological analysis described in this document are consistent with the existing model and previous hydrological analyses. Design hydrographs are required for use as fluvial boundaries to the existing 1D/2D hydraulic model of the Afon Lliedi, Cille Stream and Afon Dafen. Design hydrographs to be implemented in the hydraulic modelling are to be derived for the following events: 50%AEP+30% and 50%AEP+75%, with 30% and 75% being, respectively, the central and upper end climate change allowances for West Wales 2080s scenario, derived in accordance to current climate change guidance[1]. In addition, peak flow estimates are being derived for the following AEPs(%) for the purposes of this hydrological assessment:

[1] Welsh Government Flood Consequences Assessments: Climate change allowances, updated December 2021

	20, 10, 5, 2, 1, 0.5, 0.2, 0.1. The site location is in the proximity of the River Loughor estuary and tidal flood risk is relevant to the site. The derivation of tidal boundaries is not detailed within this document.

1.2 Overview of catchment

Item	**Comments**
Brief description of catchment, including key features needing consideration or reference to section in accompanying report. Map/s should be presented here or in section 2.1 of this report.	There are three watercourses near the site of interest; the Afon Dafen, Afon Lleidi, and the Cilli Stream (Figure 1).

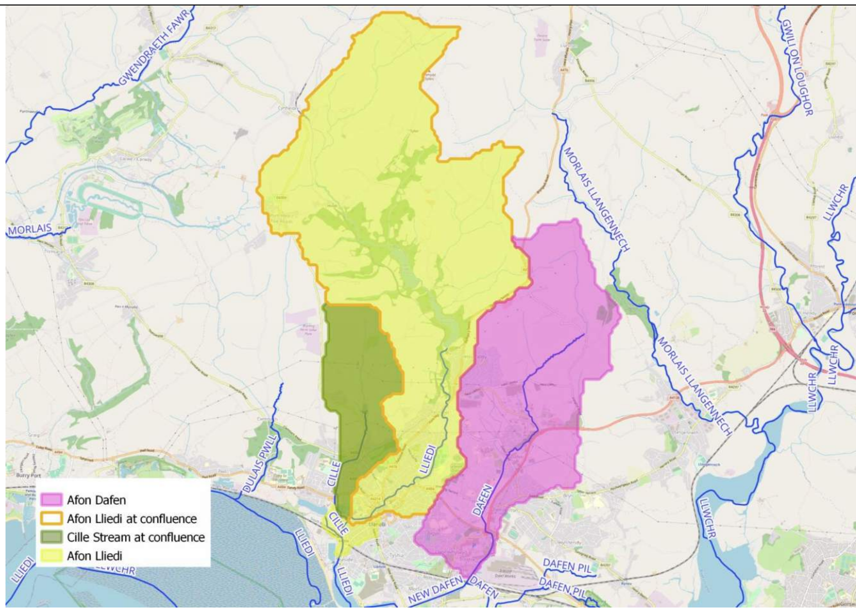


Figure 1 Overview of watercourses and associated hydrological catchments near the area of interest

The Afon Lliedi and Cille Stream catchments lie to the west of the site of interest. The Afon Lliedi originates north of Llanelli about 11km upstream of its tidal limit. It flows in a south-easterly direction throught the Upper and Cwm Lliedi reservoirs and then in a south-westerly direction through the western portion of the urban area of Llanelli. The Cille Stream is a tributary of the Afon Lliedi. The Cille Stream flows in a south easterly direction and joins the Afon Lliedi east of the B4304, with a catchment area of approximately 3.3km^2 at the confluence. The Afon Lliedi catchment area downstream of the confluence with the Cille Stream is approximately 23.9km^2. The Afon Dafen originates approximately 7km upstream of the site of interest and flows south, through the eastern

	urban area of Llanelli and into Delta Lakes, with a controlled outlet to the estuary. The catchment area at the railway line north of the development area is about 10.6km^2.

1.3 Source of flood peak data

Item	Comments
Was the NRFA Peak Flows dataset used? If so, which version?	NRFA v11, released September 2022 and contains data up to the end of September 2021.

1.4 Gauging stations (flow or level)

Within, or near to, the study area. Most stations will be included on National River Flow Archive (NRFA), but other station data may also be available.

Watercourse	Station name	NRFA number	Grid reference	Catchment area (km^2)	Location relative to study area (eg, within), note any significant differences in catchments (eg URBEXT)
Loughor	Tir-y-dail	59002	SN623126	46.4	Outside study area – closest NRFA to all subject catchments

1.5 Data available at each flow gauging station

Station Name	Start and end date on	Update for	Suitability (Pooling/	Data quality	Comments on data availability and quality

	NRFA	this study?	QMED/ Neither)?	check needed?	e.g. use for Tp calculation, QMED calculation from daily mean flow, trends in flood peaks, outliers
Tir-y-dail	1967-2021	No	QMED	Outside scope	Long record; good confidence in rating at QMED; few gaugings to validate rating beyond QMED.

1.6 Rating equations

Station name	Type of rating e.g. theoretical, empirical, degree of extrapolation	Rating review needed?	Reasons e.g. availability of recent flow gaugings, amount of scatter in the rating
Include a link or reference to any rating reviews carried out:			

1.7 Other data available and how it has been obtained

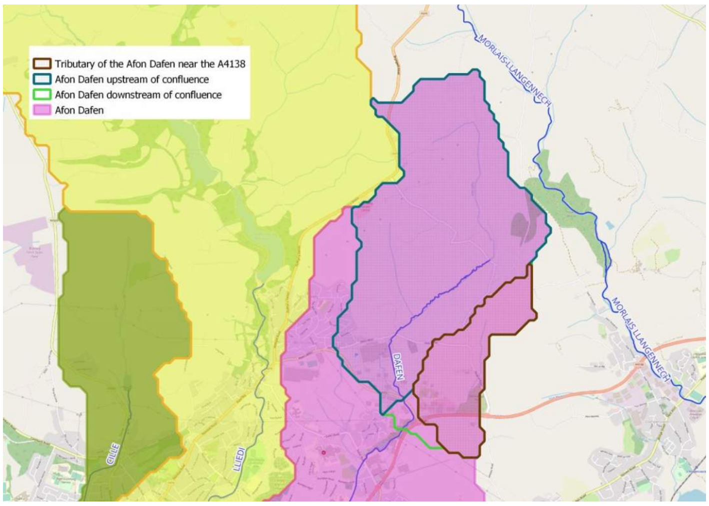
Type of data	Data relevant to this study?	Data available?	Source of data and licence reference from NRW	Details

Type of data	**Data relevant to this study?**	**Data available?**	**Source of data and licence reference from NRW**	**Details**
Historic flood data – give link to historic review if carried out	Historic review outside scope			
Flow data for events (if carrying out Tp or ReFH analysis)	NA			
Rainfall data for events (if carrying out Tp or ReFH analysis)	NA			
Results from previous studies	Yes			Hydrological analysis undertaken by Edenvale Young in 2019 for the Afon Lliedi and Cille Stream. Afon Dafen hydrological boundaries from previous NRW analysis (2017) and summary of analysis provided in the North Dafen Attenuation Scheme hydraulic modelling report (WHS, 2019)
Other data or information e.g. groundwater, tides				NA

1.8 Initial choice of approach

Item	**Comment**

Item	Comment
Outline the conceptual model. Address questions such as: • Where are the main sites of interest? • What is likely to cause flooding at those locations? (e.g. peak flows, flood volumes, combination of peaks, groundwater, snowmelt, tides) • Might those locations flood from runoff generated on part of the catchment only e.g. downstream of a reservoir?	Flood risk to the site is tidal. The analysis outlined in this document does only cover the fluvial hydrological analysis and aims to provide estimates to be used in the hydraulic modelling to assess relevant combined fluvial-tidal events.
Any unusual catchment features to account for? e.g. • highly permeable (BFIHOST> 0.65) – consider permeable catchment adjustment for statistical method if SPRHOST<20% • highly urbanised – consider choice of method carefully; consider method that can account for differing sewer and topographic catchments • small catchment (<40 km^2) – consider use of small catchment pooling method • pumped watercourse – consider lowland catchment version of rainfall-runoff method • major reservoir influence – consider flood routing • extensive floodplain storage – consider choice of method carefully	Both the Afon Lliedi at Cille Stream catchments are classified as small. FARL is 0.853 for the Afon Lliedi catchment at the confluence with the Cille Stream (see Figure 1) due to the presence of the Upper and Cwm Lliedi reservoirs. FARL is 0.886 for the Cille Stream catchment at the confluence with the Afon Lliedi (see Figure 1), due to the presence of two ponds. For the purposes of the statistical analysis carried out as part of this study, it is assumed that reservoirs/ponds do not have any capacity for flood attenuation and FARL is set to 1. This is a conservative assumption. According to their URBEXT2000 representative values, both the Afon Lliedi and Cille Stream catchments are classified as moderately urbanised. The Afon Dafen catchment upstream of the development site at the railway line (see Figure 1) is classified as small and moderately urbanised. The upstream Afon Dafen catchment at the confluence with an unknown tributary near the A4138 roundabout (approximately 4.46km^2) is classified as essentially rural, similarily to the unknown tributary catchment (1.1km^2). Both catchments are shown in Figure 2. The presence of the Dafen pond in the lower catchment impact on the overall FARL value, which, however, has been set to 1 for the purposes of the statistical analysis with a conservative assumption

Item	Comment
	that no attenuation is provided.  **Figure 2 Upstream Afon Dafen subcatchments**
Initial choice of method(s) and reasons • Are FEH statistical and/or ReFH appropriate?	According to current FEH guidelines[2] and NRW technical guidance[3], standard FEH approaches (Statistical method and rainfall-runoff modelling) are appropriate for the hydrological analysis of the

[2] LIT11832 Environment Agency Flood Estimation Guidelines, published 23/12/2022
[3] GN 008 NRW Flood Estimation Technical Guidance, updated November 2021

Item	Comment
• If not appropriate, describe why and give details of the other methods to be used. • Will the catchment be split into sub-catchments/intervening areas? If so, how will flows for intervening areas be estimated?	catchments covered within this assessment. Findings of the small catchment research project[4,5] are summarised in the FEH guidelines[2] and indicate that with respect to the statistical method applied on small catchments: • QMED should be estimated using the standard FEH regression equation and adjusted using a single donor; • the revised SDM intended for small catchments can be implemented in the pooling group selection; the latest advice from the EA is, however, to assess the revised SDM approach against the standard SDM approach when deriving pooling groups using NRFAv11[6]. Current guidance suggests that the urban adjustment should be applied on all sites for the purposes of the statistical method and NRW guidance indicates that the pooling group urban threshold should be changed from the default value of 0.03 to 0.3 (but with pooling group growth curves deurbanised appropriately). Current guidance also suggests that catchments up to moderately urbanised should be treated as rural in ReFH2, with a winter design storm and initial conditions. The hydrological conceptual model has been set up in line with the requirements of the hydraulic modelling and consistently with previous

[4] Faulkner, D., Kjeldsen, T., Packman, J and Stewart, E. (2012). Estimating flood peaks and hydrographs for small catchments: Phase 1. Science Report SC090031/R, Environment Agency..

[5] Stewart, Lisa, Duncan Faulkner, Giuseppe Formetta, Adam Griffin, Tracey Haxton, Ilaria Prosdocimi, Gianni Vesuviano and Andy Young (2022). Estimating flood peaks and hydrographs for small catchments (Phase 2).

[6] Environment Agencty, Flood estimation impacts of updating from NRFA v10 to v11 Evidence & Risk – National Flood Hydrology Team Published: 22/12/2022

Item	Comment
	hydrological analyses. The hydraulic model as configured requires: • 1 lumped inflow as upstream boundary on the Afon Lliedi; • 1 lumped inflow as upstream boundary on the Cille Stream; • 1 lumped inflow as upstream boundary on the Afon Dafen near the A4138 north of the urban area of Llanelli; • 1 lumped inflow for the unknown eastern tributary of the Afon Dafen at the A4138 roundabout north of the urban area of Llanelli; • 1 distributed inflow to represent the contribution of the intervening area between the confluence of Afon Dafen and unknown tributary at the A4138 roundabout and the downstream hydrological check location at the railway line, as identified by previous hydrological analysis. In order to estimate the inflows listed above, the FEH estimate locations shown in Figure 3 have been identified and are detailed as follows: • AL@Conf, Afon Lliedi upstream of the confluence with the Cille Stream, is the estimate location for the upsteam Afon Lliedi inflow; • CS@Conf, Cille Stream upstream of the confluence with the Afon Lliedi, is the estimate location for the upsteam Cille Stream inflow; • AL@DS, Afon Lliedi downstream of the confluence with the Cille Stream, has been selected as check location and for the

Item	Comment
	purposes of the pooled statistical analysis and design storm estimation; • AD@Conf_US, Afon Dafen upstream of the confluence with the unknown tributary at the A4138 roundabout, is the estimate location for the upstream Afon Dafen inflow; • ADTrib@Conf, unknown tributary of the Afon Dafen at their confluence near the A4138 roundabout, is the estimate location for the unknown tributary inflow; • AD@Conf_DS, Afon Dafen downstream of the confluence with the unknown tributary at the A4138 roundabout, has been selected as check location and for the purposes of the pooled statistical analysis and design storm estimation to compare with AD@DS; • AD@DS, Afon Dafen overall catchment at the railway line, has been selected as check location and for the purposes of the pooled statistical analysis and design storm estimation to compare with AD@Conf_DS. It has also been selected to inform the estimation of the contribution of the intervening catchment between AD@Conf_DS and AD@DS. Both the Statistical and ReFH2 approaches will be implemented to derive and compare peak flow estimates at the appropriate locations. It is anticipated that, in line with NRW guidance[3], the preferred method for selecting the final peak flow estimates is going to be considered: • the Statistical method for events with %AEPs equal to or greater than 1%;

Item	Comment
	• the ratio method (ratio of ReFH2 estimate to the 1%AEP ReFH2 estimate applied to the 1% AEP statistical estimate) for any event with %AEPs lower than 1. Design hydrographs are going to be derived by scaling the ReFH2 hydrographs to match the selected final peak flow estimates. For this purpose, consistent design storms are going to be applied across various subcatchments, identified on the basis of the characteristics of the catchments in the area of the study, the hydrological conceptual model, and the location(s) relevant to the estimation of flood risk. Design hydrographs for the intervening area beween AD@Conf_DS and AD_DS are going to be obtained by scaling down the design hydrographs derived and AD@DS by the ratio of catchment areas. For this reason, catchment descriptors other that the catchment area are not detailed for the intervening area in Section 2 of this proforma.
Software to be used (edit as applicable.)	WINFAP5 ReFH2 version3.3

2. Locations where flood estimates are required

2.1 Map of study area, including subject site(s) and gauging stations (where applicable).

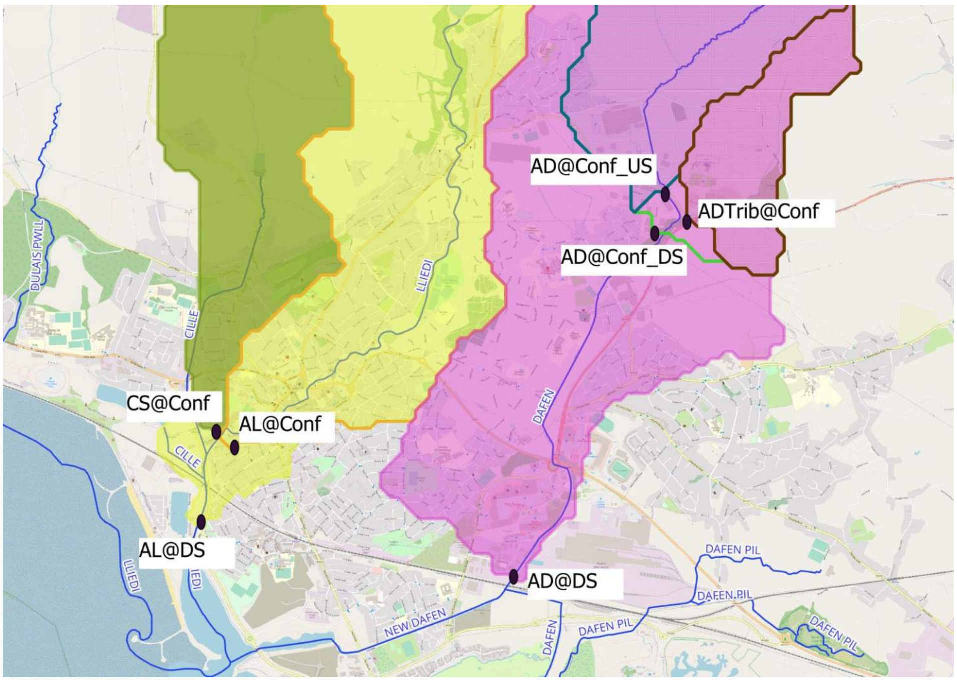


Figure 3 Subject sites selected for the purposes of the FEH analysis

2.2 Summary of subject sites

The table below lists the locations of subject sites. Use site codes in all subsequent tables to save space.

Site code	Watercourse	Site Name (description)	Easting	Northing	AREA on FEH Web Service (km^2)	Revised AREA if altered (km^2)	Peak flow, hydrograph or both required?
AL@Conf	Afon Lliedi	u/s confluence with Cille Stream	250150	200150	20.22		Both
CS@Conf	Cille Stream	u/s confluence with Afon Llliedi	250100	200200	3.28		Both
AL@DS	Afon Lliedi	d/s confluence with Cille Stream	249950	199550	23.92		Peak Flows
AD@Conf_US	Afon Dafen	u/s confluence with unknown tributary	253300	201950	4.458		Both
ADTrib@Conf	Unknown tributary	Confluence with Afon Dafen	253500	201850	1.075		Both
AD@Conf_DS	Afon Dafen	d/s confluence with unknown tributary	253300	201650	5.678		Peak Flows
AD@DS	Afon Dafen	d/s check location at railway	252250	199150	10.598		Both

AD_i	Afon Dafen	Intervening catchment between AD@Conf_DS and AD@DS	252250	199150	4.92		

2.3 Important catchment descriptors at each subject site (incorporating any changes made)

Site code	AREA (km^2)	BFIHOST	BFIHOST19	DPLBAR (km)	DPSBAR (m/km)	FARL	FPEXT	PROPWET	SAAR (mm)	URBEXT 2000
AL@Conf	20.22	0.387	0.361	7.45	96.6	0.853	0.0455	0.52	1416	0.0649
CS@Conf	3.28	0.452	0.414	2.8	109.6	0.886	0.0434	0.52	1292	0.0725
AL@DS	23.92	0.397	0.37	7.44	96.9	0.857	0.0583	0.52	1393	0.0726
AD@Conf_US	4.458	0.429	0.387	2.46	102.1	1	0.0368	0.52	1361	0.0249
ADTrib@Conf	1.075	0.414	0.37	1.01	66.5	1	0.0605	0.52	1293	0
AD@Conf_DS	5.678	0.425	0.383	2.56	93.7	1	0.0527	0.52	1346	0.0267
AD@DS	10.598	0.44	0.407	4.44	70.1	0.978	0.1438	0.51	1299	0.1393

2.4 Checking catchment descriptors

Item	Comment
Record how catchment boundary was checked • describe any changes • refer to maps if needed	FEH catchment boundaries have been against LiDAR DTM and found to be appropriate. No changes to the catchment boundaries have been made.
Record how other catchment descriptors were checked, especially soils • describe any changes • include a before and after table if necessary	URBEXT and FARL have been checked against OS Open Data background maps (1:10000) and have been found to be appropriate. BFIHOST19 has been found to be consistent with geology and soils maps which suggest the area lies on a mudstone, siltstone and sandstone bedrock formation, with a mixture of freely draining slightly acid loamy soils and slowly permeable seasonally wet acid loamy and clayey soils with impeded drainage.
Method for updating URBEXT / URBAN • Refer to WINFAP Urban Adjustment procedures/guidance	URBEXT updated according to UEF to present day. Urban adjustment procedures as implemented in WINFAP5.

3. Statistical method

3.1 Search for donor gauging stations for QMED

Note that donor catchments will usually be rural but may be urban provided the data is deurbanised prior to the adjustment process. Include a map if necessary.

Comment on potential donor sites Mention: • distance from subject site (based on catchment centroid) • whether they are on the same, adjacent or nearby watercourse • features which may impact applicability, eg FARL • quality of flood peak data • length of record	A search for potential suitable QMED donors in the vicinity of the subject sites was undertaken. The closest suitable gauge to all subject sites is NRFA 59002 (Loughor @ Tir-y-dail). The gauge has 54 years on record and is representative of a catchment of approximately 46km^2. The gauged catchment characteristics indicate that on average the gauged catchment is sufficiently hydrologically similar to the subject sites. The gauge was, therefore, selected as single QMED for the purpose of QMED adjustment on all subject sites. This choice is also in line with FEH guidelines recommending using a single QMED donor on small catchments and provide consistency in QMED estimates across the study area.

3.2 Donor stations and QMED adjustment factors

If using WINFAP3 great caution should be taken in urban catchments that are also highly permeable (BFIHOST>0.65). Further details are provided in the EA Flood Estimation Guidelines.

Station Name	**NRFA station number**	**Reasons for choosing or rejecting**	**Record Length**	**QMED from flow data (gauged) (m^3/s)**	**QMED from flow data with urban influence removed (A) (m^3/s)**	**QMEDrural from catchment descriptors (B) (m^3/s)**	**Adjustment ratio (A/B)**
Tir-y-dail	59002	Closest to all subject site; hydrological characteristics on average similar to subject sites	54	58.491	57.53	34.72	1.657

3.3 Overview of estimation of QMED at each subject site

Notes for completing this table

- Methods
    - CD: catchment descriptors alone
    - DT: data transfer
    - BCW: catchment descriptors and bankfull channel width
    - FV: flow variability (using flow duration statistics)
- Urban adjustment procedures should be applied regardless of whether the subject site is rural or urban.
- If using WINFAP3, great caution should be taken in urban adjustment of QMED on catchments that are also highly permeable (BFIHOST>0.65).
- The data transfer procedure is from Science Report SC050050. The QMED adjustment factor A/B for each donor site is given in Table 3.2. This is moderated using the power term, a, which is a function of the distance between the centroids of the subject catchment and the donor catchment. The final estimate of QMED is $(A/B)^a$ times the initial estimate from catchment descriptors.

- If more than one donor has been used, use multiple rows for the site and give the weights used in the averaging. Record the weighted average adjustment factor in the table.

				Data transfer						
Site code	**QMEDrural from CDs (m^3/s)**	**Method**	**NRFA numbers for donor site/s used (see 3.2)**	**Distance between centroids d_{ij} (km)**	**Power term a**	**Moderated QMED adjustment factor (A/B)[a]**	**If more than one donor: Weight (if WINFAP4 (or later versions) method not used)**	**Weighted average QMED adjustment factor**	**Final estimate of QMEDrural (m^3/s)**	**Final estimate of QMEDurban (m^3/s)**
AL@ Conf	19.132	DT	59002	15.42	0.338	1.186			22.695	24.075
CS@ Conf	3.159	DT	59002	17.85	0.322	1.177			3.716	3.991
AL@ DS	21.164	DT	59002	15.82	0.335	1.184			25.069	26.802
AD@ Conf_ US	4.717	DT	59002	14.81	0.342	1.189			5.608	5.743
ADTrib@Conf	1.361	DT	59002	15.81	0.335	1.184			1.612	1.612

AD@ Conf_ DS	5.762	DT	59002	16.19	0.333	1.183			6.844	7.019
AD@ DS	8.790	DT	59002	15.04	0.341	1.188			10.399	11.888

Has the Kjeldsen (2014) urban adjustment method (as used in WINFAP4 or later versions) been applied? If not, why?	Yes
How are the weights derived?	NA. Just one donor selected.
Are the values of QMED and QMED adjustment factors consistent, for example at successive points along the watercourse and at confluences?	QMED estimates are consistent at confluences on both the Afon Lliedi ($QMED_{AL@Conf}$ + $QMED_{CS@Conf}$ >$QMED_{AL@DS}$) and the Afon Dafen ($QMED_{AD@Conf\_US}$ + $QMED_{ADTrib@Conf}$ >$QMED_{AD@Conf\_DS}$).

3.4 Derivation of pooling groups

- Several subject sites may use the same pooling group.
- The composition of pooling groups should be presented in the Annex.
- If Single Site (with or without flood history) was used, add 'N/a' to the last column.

Name of pooling group	**Site code from which pooling group was derived**	**Site codes to which it is applied**	**Method: Single Site / with History, Enhanced Single Site or Pooled / Small Catchment Pooled?** Include reasons for choice of method	**Changes made to default pooling group, with reasons.** Include any sites that were investigated but retained in the group

AL@DS	AL@DS	AL@Conf, CS@Conf	Pooled. Small catchment Method (Comparison with standard method suggests results are consistent, with the standard SDM approach providing a 1% overestimation of the small catchment SDM approach 1%AEP estimate)	The default pooling group is acceptably homogeneous. On the basis of the analysis of the distribution of L-moments within the pooling group, sites 48004, 18014, 47021, 69047 and 48009 were investigated using information available on the NRFA. Sites 18014, 47021, and 69047 were retained in the pooling group. For site 48004 the NRFA suggests to use it with caution as the rating is not validated beyond QMED, with high flows being overestimated. The site was removed from the pooling group. For site 48009, the NRFA indicates that only pre-reservoir (1983) data can be used for pooling but with caution. The site is also discordant and it was removed from the pooling group. The pooling group was refined by including site 72014. It was preferred not to add site 47022 due to its relatively short record compared to 72014, which is the next suitable according to its SDM. The final pooling group is acceptably homogeneous. It should be noted that site 47021 is discordant in the final pooling group, however it was preferred not to remove it from the pooling group as this is a reliable gauge and it is believed that pooling group composition would not improved by removing it.
AD@Conf_DS	AD@Conf_DS	AD@Conf_US, ADTrib@Conf	Pooled. Small catchment Method (Comparison with standard method suggests results are consistent, with the small catchment SDM approach providing a 1% overestimation of the standard SDM approach 1%AEP estimate)	The default pooling group is possibly heterogeneous and a review is optional. The following sites were investigated on the basis of the distribution of L-moments within the pooling group: 45816, 84035, 206006, 49005, 25003, 76011, and 48009. Site 45816, 84035, 206006, 49005, 25003, and 76011 were all retained in the pooling group as the review of the available information on the NRFA did not provide any justification for removing any of them from the pooling group. As for pooling site AL@DS, station 48009 was

				instead removed from the default pooling group due to the unreliability of the gauge record as detailed above. No other site was added to the pooling group as the total number of years on record in the pooling group was already above 500. The final pooling group is still possibly heterogeneous but further changes are not expected to improve the pooled estimates.
AD@DS	AD@DS	AD_i	Pooled. Small catchment Method (Comparison with standard method suggests results are consistent, with the small catchment SDM approach providing a 2% overestimation of the standard SDM approach 1%AEP estimate)	The default pooling group is acceptably homogeneous. On the basis of the analysis of the distribution of L-moments within the pooling group, sites 45816, 84035, 49005, 48007, 48009, and 206006 were investigated. Site 48009 was removed given the assessment outlined for pooling sites AD@Conf_DS and AL@DS. All other sites were reviewed using information on the NRFA and retained in the pooling group. Site 49003 (selected according to its SDM) was added to the pooling group. The final pooling group is acceptably homogeneous.
URBEXT2000 threshold used to create pooling group(s). **Have pooling group growth curves been deurbanised?**			URBEXT2000 threshold set to 0.3. Pooling growth curves have been de-urbanised.	

3.5 Derivation of flood growth curves at subject sites

- A pooling group derived at one location can be applied to estimate growth curves at several ungauged sites. However, each site may have a different urban adjustment, and therefore different growth curve parameters.
- Urban adjustments to growth curves should use the latest methodologies in WINFAP

- Any relevant frequency plots from WINFAP, particularly showing any comparisons between single-site and pooled growth curves (including flood peak data on the plot) should be shown here or in an Appendix.

Site code	Pooling group name	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Growth factor for 100-year return period event
AL@DS	AL@DS	GL - best fit. Despite GEV providing the best fit, GL has been selected as it is most widely applied on UK sites and also for consistency.	Urban	2.507
AD@Conf_DS	AD@Conf_DS	GL - best fit	Urban	2.760
AD@DS	AD@DS	GL - best fit	Urban	2.678

3.6 Flood estimates from the statistical method

	Flood peak (m^3/s) for the following return periods (in years)								
Site code	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**
AL@Conf	24.075	31.586	37.124	43.142	52.291	60.356	68.986	84.988	100.937

CS@Conf	3.991	5.236	6.154	7.152	8.668	10.005	11.436	14.089	16.733
AL@DS	26.802	35.174	41.340	48.039	58.209	67.194	76.801	94.616	112.372
AD@Conf_US	5.743	7.742	9.252	10.923	13.513	15.851	18.153	22.556	27.190
ADTrib@Conf	1.612	2.173	2.597	3.066	3.793	4.449	5.095	6.331	7.632
AD@Conf_DS	7.019	9.463	11.310	13.353	16.519	19.372	22.185	27.566	33.231
AD@DS	11.888	15.875	18.871	22.174	27.269	31.840	36.509	45.286	54.389

4. Revitalised flood hydrograph (ReFH) method for peak flow estimation

This section records calculations for peak flow estimates, if different calculations are subsequently made for hydrographs for modelling, details should be recorded in section 5.

4.1 Parameters for ReFH model for peak flow estimation

If parameters are all estimated from catchment descriptors, they are easily reproducible, so it is not essential to record them here –Just enter 'all' under site code and 'Catchment descriptors' under method. Where values have been calculated from local data, include catchment descriptor values in brackets, or additional columns.

Site code	**Details of method** Catchment descriptors Tp data transfer Optimisation (Calibration Utility)	**Tp (hours)** Time to peak	**C_{max} (mm)** **maximum storage capacity**	**BL (hours)** baseflow lag	**BR** baseflow recharge

AL@DS	CD	2.983	266.443	35.491	1.174
AD@Conf_DS	CD	1.638	275.594	28.719	1.375
AD@DS	CD	2.515	294.525	33.897	1.577
Brief description of any flood event analysis carried out Provide further details either here or give reference to location of documentation					

4.2 Design events for ReFH method for peak flow estimation

Refer to Guidance for latest research regarding choice of summer or winter season based on URBEXT2000, BFIHOST and SAAR. Where values have been calculated from local data, include catchment descriptor values in brackets or additional columns.

Site code	Season of design event (summer or winter)	Recommended Storm duration (hours)	Storm area for ARF (if not catchment area)	Record any adjustment to default parameters
AL@DS	Winter	7.5		
AD@Conf_DS	Winter	3.75		
AD@DS	Winter	5.5		
Source of design rainfall statistic **(FEH13 or FEH99).** If FEH99 has been used		FEH13		

provide justification:	

4.3 Peak flow estimates from the ReFH method

Catchment descriptors

		Flood peak (m^3/s) for the following return periods (in years)									
Site code	**Urban/ rural?**	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**	**100: 1000 ratio**
AL@DS	**Rural**	16.21	20.44	23.29	26.32	30.66	34.55	39.49	48.65	57.78	1.672
AD@Conf_DS	**Rural**	4.47	5.8	6.73	7.69	9.05	10.26	11.75	14.6	17.6	1.715
AD@DS	**Rural**	6.18	7.89	9.08	10.3	12.07	13.64	15.64	19.4	23.3	1.708

4.4 Calibrated (where relevant)

		Flood peak (m^3/s) for the following return periods (in years)											
Site code	**Urban/ rural?**	**2**	**5**	**10**	**20**	**30**	**50**	**75**	**100**	**200**	**500**	**1000**	**100: 1000 ratio**

How do peak flows compare to statistical estimates. If catchment descriptor and calibrated calculations were made, which ReFH estimates are preferred and why	

5. Revitalised flood hydrograph (ReFH) method for model inflow hydrographs

5.1 Parameters for ReFH model for model inflow hydrographs

This section records calculations for model inflow hydrographs, parameters may have been calibrated and storm durations changed.

If parameters are all estimated from catchment descriptors, they are easily reproducible, so it is not essential to record them here –Just enter 'all' under site code and 'Catchment descriptors' under method. Table can be amended as needed.

Site code	**Details of method** Catchment descriptors Tp data transfer Optimisation (Calibration Utility)	**Tp (hours)** Time to peak	**C_{max} (mm)** **maximum storage capacity**	**BL (hours)** baseflow lag	**BR** baseflow recharge
AL@Conf	CD				
CS@Conf	CD				
AD@Conf_US	CD				

ADTrib@Conf	CD				
Brief description of any flood event analysis carried out Provide further details either here or give reference to location of documentation					

5.2 Design events for ReFH method for model inflow hydrographs

Refer to Guidance for latest research regarding choice of summer or winter season based on URBEXT2000, BFIHOST and SAAR.

Storm duration (hours)	ARF	Source of Storm Duration and ARF	Why Chosen
7.5	0.945	AL@DS	Representative of Afon Lliedi catchment – consistent with previous modelling
3.75	0.956	AD@Conf_DS	Representative of upper Afon Dafen catchment – consistent with previous modelling
Where hydrographs scaled to alternative peak flow estimates? If so, give details			**Hydrographs scaled to match final design peak flow estimates**

Provide link/reference to location of hydrographs or provide in appendix	

6. Final Peak Flow and Hydrograph Estimates

6.1 Comparison of peak flow estimates from different methods

This table compares peak flows from the ReFH method, FEH Statistical method and any available previous study at each site for two key return periods. Note and explain any significant difference from previous studies.

	QMED (2-year return period)				**100-year return period**			
Site code	**Statistical**	**ReFH**	**Previous Study**	**Comment**	**Statistical**	**ReFH**	**Previous Study**	**Comment**
AL@DS	26.802	16.21			67.194	34.55		
AD@Conf_DS	7.019	4.47			19.372	10.26		
AD@DS	11.888	6.18			31.840	13.64		

6.2 Final Peak Flow Estimates

	Flood peak (m^3/s) for the following return periods (in years)								
Site code	**2**	**5**	**10**	**20**	**50**	**100**	**200**	**500**	**1000**
AL@Conf	24.075	31.586	37.124	43.142	52.291	60.356	68.986	84.988	100.937
CS@Conf	3.991	5.236	6.154	7.152	8.668	10.005	11.436	14.089	16.733

AL@DS	26.802	35.174	41.340	48.039	58.209	67.194	76.801	94.616	112.372
AD@Conf_US	5.743	7.742	9.252	10.923	13.513	15.851	18.153	22.556	27.190
ADTrib@Conf	1.612	2.173	2.597	3.066	3.793	4.449	5.095	6.331	7.632
AD@Conf_DS	7.019	9.463	11.310	13.353	16.519	19.372	22.185	27.566	33.231
AD@DS	11.888	15.875	18.871	22.174	27.269	31.840	36.509	45.286	54.389
AD_i	5.673	7.576	9.006	10.582	13.014	15.195	17.423	21.612	25.957

Choice of method and reasons Include reference to type of study, nature of catchment, and type of data available	Final peak flow estimates are the: • Statistical estimates for events with %AEPs equal to or greater than 1%; • the ratio method estimates (ratio of ReFH2 estimate to the 1%AEP ReFH2 estimate applied to the 1% AEP statistical estimate) for any event with %AEPs lower than 1; with ReFH2 estimates from rural models on all catchments including moderately urbanised. The choice of final estimates and ReFH2 model selection is line with current guidance for the study catchments as detailed in 1.8 Initial choice of approach. All study catchments are ungauged and QMED has been estimated from catchment descriptors and adjusted by donor transfer using 1 single gauge (59002). This choice is also in line with current guidance on small catchments (see 1.8 Initial choice of approach). UAFs from WINFAP5 have been applied to adjust QMED to take into account urbanisation on all sites.

	Design hydrographs have been derived by scaling ReFH2 hydrographs to match final peak flow estimates on all sites selected as lumped inflow locations (AL@Conf, CS@Conf, AD@Conf_US, ADTrib@Conf). Design hydrographs to be applied as distributed inflow for the intervening area beween AD@Conf_DS and AD_DS have been obtained from scaling down the design hydrographs derived and AD@DS by the ratio of catchment areas ($Area_{AD@DS}/Area_{AD\_i}$=5.058/10.598).

6.3 Hydrographs for Modelling

How were these calculated, for example by scaling ReFH hydrographs to final flow estimates? include link/reference to hydrographs.	**ReFH2 hydrographs scaled to match final peak flow estimates**

How will flows be applied in the model. If intervening areas are used, will hydrographs be adjusted to better match downstream flows, or will best estimate inflows be used and resulting downstream flows accepted?	Design hydrographs applied at AL@Conf, CS@Conf, AD@Conf_US, ADTrib@Conf as lumped inflows obtained from ReFH2 hydrographs scaled to match final peak flow estimates. Design hydrographs for intervening area AD_i obtained from scaling down hydrographs at AD@DS by ratio of catchment areas with resulting downstream flows accepted.

6.4 Checks

Are the results consistent, for example at confluences?	**Yes**
What do the results imply regarding the return periods of floods during the period of record?	NA
What is the 100-year growth factor? Is this realistic? (The guidance suggests a typical range of 2.1 - 4.0)	2.507 at AL@DS 2.760 at AD@Conf_DS 2.678 at AD@DS
If 1000-year flows have been derived, what is the range of ratios for the 1000-year flow over 100-year flow?	1.672 at AL@DS 1.715 at AD@Conf_DS 1.708 at AD@DS
What is the range of specific runoffs (l/s/ha)? Are there any inconsistencies?	NA
How did the results compare with those of other studies? Explain any differences and conclude which results should be preferred	The hydrological conceptual model implemented in this study has been kept consistent with previous analysis. Therefore, it is possible to make a comparative assessment at consistent locations where estimates are provided in the available reports. From Table 1 to Table 3 below, the current study produces peak estimates which are greater than previous estimates on the Cille Stream and the Afon Dafen and smaller than previous estimates on the Afon Lliedi. Previous analyses had been carried out using WINFAP4 and

ReFH2.2 and the following NRFA datasets:

- NRFA v6 for the Afon Lliedi estimates
- NRFA v5.1 for the Afon Dafen estimates

Current estimates are based on WINFAP5, ReFH2 version 3.3 and NRFA v11. Therefore, they are based on the most updated software and currently available peak flow dataset. They also address recommendations based on the latest FEH guidance for flood estimation on small catchments. Therefore, current estimates should be considered more reliable than those based on previous analyses.

Table 1 Comparison of the 1%AEP estimates at inflow estimation nodes in the Afon Lliedi catchment

Afon Lliedi 1%AEP (m^3/s)		
Node	2019 EVY	Current Study
AL@Conf	64.597	60.356
CS@Conf	9.240	10.005

Table 2 Comparison of the 0.1%AEP estimates at inflow estimation nodes in the Afon Lliedi catchment

Afon Lliedi 0.1%AEP (m^3/s)		
Node	2019 EVY	Current Study

	<table><tr><td>AL@Conf</td><td>107.893</td><td>100.937</td></tr><tr><td>CS@Conf</td><td>15.888</td><td>16.733</td></tr></table> **Table 3 Afon Dafen peak flow estimates from current and previous NRW analysis** <table><tr><td colspan="3">Afon Dafen 0.1%AEP (m^3/s)</td></tr><tr><td>Node</td><td>2017 NRW</td><td>Current Study</td></tr><tr><td>AD@Conf_US</td><td>22.4</td><td>27.190</td></tr><tr><td>ADTrib@Conf</td><td>6.5</td><td>7.632</td></tr><tr><td>AD@DS</td><td>41.4</td><td>54.389</td></tr></table>
Are the results compatible with the longer-term flood history?	NA
Describe any other checks on the results	No other checks were carried out

6.5 Assumptions, limitations, and uncertainty

List the main assumptions made specific to the study	QMED and pooling suitability assessed on the basis of information available on the NRFA; no local gauge available.

<table>
<tr>
<td>Discuss any particular limitations

For example, applying methods outside the range of catchment types for which they were developed</td>
<td>Statistical methods used up to the 1000 year return period;
The ReFH2 design hydrographs are derived from the model parameters estimated from catchment descriptors;
Estimation of catchment boundaries from CEH FEH extents compared to LiDAR, no adjustment has been made to account for the urban drainage pathways.</td>
</tr>
<tr>
<td>Give what information you can on uncertainty in the results

For example, using the methods detailed in ‘Making better use of local and historic data, and estimating uncertainty in FEH design flood estimation (FEH Local) SC130009</td>
<td>Table 4 Confidence Intervals based on FEH guidance[2] Section 5.4 Table 2 and Table 3
<table>
<tr><th>Node</th><th>QMED</th><th colspan="2">68%CI</th><th colspan="2">95%CI</th></tr>
<tr><td>AL@Conf</td><td>24.075</td><td>15.16725</td><td>38.0385</td><td>9.63</td><td>38.27925</td></tr>
<tr><td>CS@Conf</td><td>3.991</td><td>2.51433</td><td>6.30578</td><td>1.5964</td><td>6.34569</td></tr>
<tr><td>AL@DS</td><td>26.802</td><td>16.88526</td><td>42.34716</td><td>10.7208</td><td>42.61518</td></tr>
<tr><td>AD@Conf_US</td><td>5.743</td><td>4.0201</td><td>8.15506</td><td>2.8715</td><td>11.60086</td></tr>
<tr><td>ADTrib@Conf</td><td>1.612</td><td>1.1284</td><td>2.28904</td><td>0.806</td><td>3.25624</td></tr>
<tr><td>AD@Conf_DS</td><td>7.019</td><td>4.913</td><td>9.967</td><td>3.510</td><td>14.178</td></tr>
<tr><td>AD@DS</td><td>11.888</td><td>7.489</td><td>18.783</td><td>4.755</td><td>18.902</td></tr>
</table></td>
</tr>
<tr>
<td>Comment on the suitability of the results for future studies

For example, at nearby locations or for different purposes</td>
<td>Results are suitable for the purpose of the assessment of fluvial flood risk associated to the proposed development at the site of interest.</td>
</tr>
</table>

Give any other comments on the study For example, suggestions for additional work	Use of local data should a gauge be installed on any of the watercourses assessed within this study.

Annex – supporting information

Please include details of your pooling group(s)

Pooling group composition

Table 5 WINFAP5 Final poling group at AL@DS

	Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
1	27032 (Hebden Beck @ Hebden)	0.099	53	4.052	0.197	**0.197**	0.202	**0.202**	0.691
2	18014 (Bannock Burn @ Bannockburn)	0.134	29	16.634	0.224	**0.225**	0.162	**0.160**	0.492
3	72007 (Brock @ upstream of A6)	0.228	43	29.917	0.195	**0.195**	0.208	**0.208**	0.628
4	48007 (Kennal @ Ponsanooth)	0.231	53	4.280	0.190	**0.191**	0.214	**0.212**	0.303
5	76023 (Dacre Beck @ Dacre Bridge)	0.287	21	35.854	0.189	**0.189**	0.213	**0.213**	1.537
6	25012 (Harwood Beck @ Harwood)	0.356	52	33.426	0.184	**0.184**	0.223	**0.223**	0.880
7	47021 (Kensey @ Launceston Newport)	0.360	19	13.800	0.205	**0.207**	0.261	**0.258**	2.983
8	69047 (Roch @ Littleborough)	0.390	25	9.484	0.231	**0.236**	0.143	**0.138**	1.404
9	71013 (Darwen @ Ewood)	0.403	48	28.494	0.165	**0.179**	0.292	**0.266**	1.536
10	47009 (Tiddy @ Tideford)	0.434	52	6.890	0.201	**0.202**	0.209	**0.207**	0.218
11	49003 (De Lank @ De Lank)	0.454	55	13.671	0.213	**0.213**	0.165	**0.165**	0.524
12	72014 (Conder @ Galgate)	0.492	53	16.912	0.231	**0.232**	0.145	**0.144**	0.803
13									
14	Rejected Stations								
15	48004 (Warleggan @ Trengoffe)	0.114	52	9.957	0.252	0.252	0.258	0.257	
16	48009 (St Neot @ Craigshill Wood)	0.235	12	8.465	0.245	0.245	0.373	0.372	
17	47022 (Tory Brook @ Newnham Park)	0.457	26	6.649	0.250	0.252	0.149	0.146	
18									
19									

Table 6 WINFAP5 Final poling group at AD@Conf_DS

	Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
1	28033 (Dove @ Hollinsclough)	0.263	46	4.138	0.223	**0.223**	0.379	**0.379**	0.914
2	45816 (Haddeo @ Upton)	0.337	28	3.352	0.293	**0.294**	0.424	**0.423**	2.208
3	25011 (Langdon Beck @ Langdon)	0.685	35	15.647	0.226	**0.226**	0.324	**0.324**	0.621
4	47022 (Tory Brook @ Newnham Park)	0.692	26	6.649	0.250	**0.252**	0.149	**0.146**	0.818
5	69047 (Roch @ Littleborough)	0.757	25	9.484	0.231	**0.236**	0.143	**0.138**	0.866
6	84035 (Kittoch Water @ Waterside)	0.934	30	20.033	0.133	**0.156**	0.054	**0.015**	1.597
7	206006 (Annalong @ Recorder)	1.001	48	15.330	0.189	**0.189**	0.052	**0.052**	1.626
8	71003 (Croasdale Beck @ Croasdale Flu	1.084	37	10.900	0.212	**0.212**	0.323	**0.323**	0.331
9	27032 (Hebden Beck @ Hebden)	1.095	53	4.052	0.197	**0.197**	0.202	**0.202**	0.153
10	49005 (Bolingey Stream @ Bolingey Coc	1.099	11	5.777	0.262	**0.263**	0.207	**0.206**	2.411
11	25003 (Trout Beck @ Moor House)	1.138	48	15.142	0.167	**0.167**	0.291	**0.291**	1.074
12	76011 (Coal Burn @ Coalburn)	1.149	44	1.840	0.168	**0.168**	0.302	**0.302**	0.951
13	18014 (Bannock Burn @ Bannockburn)	1.185	29	16.634	0.224	**0.225**	0.162	**0.160**	0.210
14	49003 (De Lank @ De Lank)	1.190	55	13.671	0.213	**0.213**	0.165	**0.165**	0.219
15									
16	Rejected Stations								
17	48009 (St Neot @ Craigshill Wood)	1.154	12	8.465	0.245	0.245	0.373	0.372	
18									
19									

Table 7 WINFAP5 Final poling group at AD@DS

	Station	Distance (SDM)	Years of data	QMED AM	L-CV Observed	L-CV Deurbanised	L-SKEW Observed	L-SKEW Deurbanised	Discordancy
1	28033 (Dove @ Hollinsclough)	0.252	46	4.138	0.223	**0.223**	0.379	**0.379**	1.538
2	69047 (Roch @ Littleborough)	0.288	25	9.484	0.231	**0.236**	0.143	**0.138**	0.686
3	47022 (Tory Brook @ Newnham Park)	0.290	26	6.649	0.250	**0.252**	0.149	**0.146**	0.812
4	25011 (Langdon Beck @ Langdon)	0.372	35	15.647	0.226	**0.226**	0.324	**0.324**	1.113
5	45816 (Haddeo @ Upton)	0.405	28	3.352	0.293	**0.294**	0.424	**0.423**	1.915
6	84035 (Kittoch Water @ Waterside)	0.452	30	20.033	0.133	**0.156**	0.054	**0.015**	1.967
7	27032 (Hebden Beck @ Hebden)	0.651	53	4.052	0.197	**0.197**	0.202	**0.202**	0.282
8	18014 (Bannock Burn @ Bannockburn)	0.695	29	16.634	0.224	**0.225**	0.162	**0.160**	0.105
9	49005 (Bolingey Stream @ Bolingey Coc	0.708	11	5.777	0.262	**0.263**	0.207	**0.206**	2.291
10	48007 (Kennal @ Ponsanooth)	0.737	53	4.280	0.190	**0.191**	0.214	**0.212**	0.676
11	48004 (Warleggan @ Trengoffe)	0.752	52	9.957	0.252	**0.252**	0.258	**0.257**	0.718
12	206006 (Annalong @ Recorder)	0.815	48	15.330	0.189	**0.189**	0.052	**0.052**	1.419
13	72014 (Conder @ Galgate)	0.840	53	16.912	0.231	**0.232**	0.145	**0.144**	0.306
14	49003 (De Lank @ De Lank)	0.858	55	13.671	0.213	**0.213**	0.165	**0.165**	0.171
15									
16	Rejected Stations								
17	48009 (St Neot @ Craigshill Wood)	0.750	12	8.465	0.245	0.245	0.373	0.372	
18									
19									

Additional supporting information

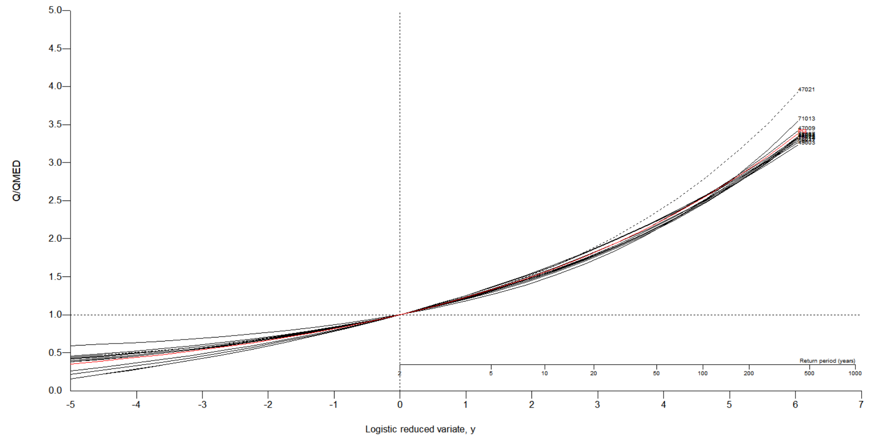


Figure 4 WINFAP5 AL@DS GL pooling group growth curves

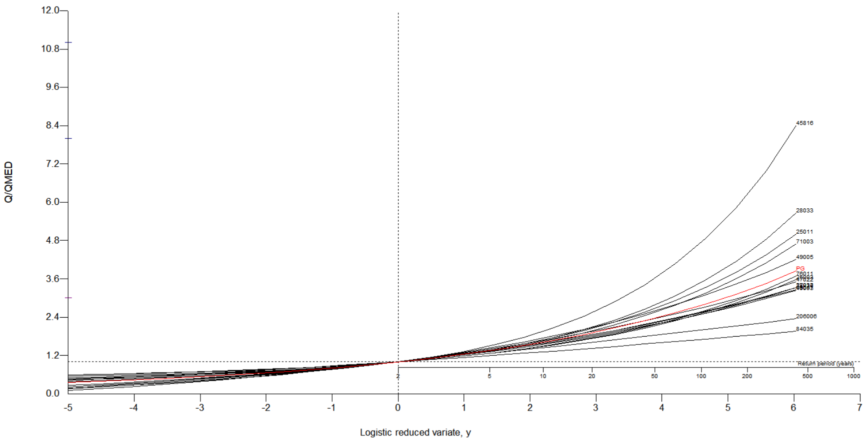


Figure 5 WINFAP5 AD@Conf_DS GL pooling group growth curves

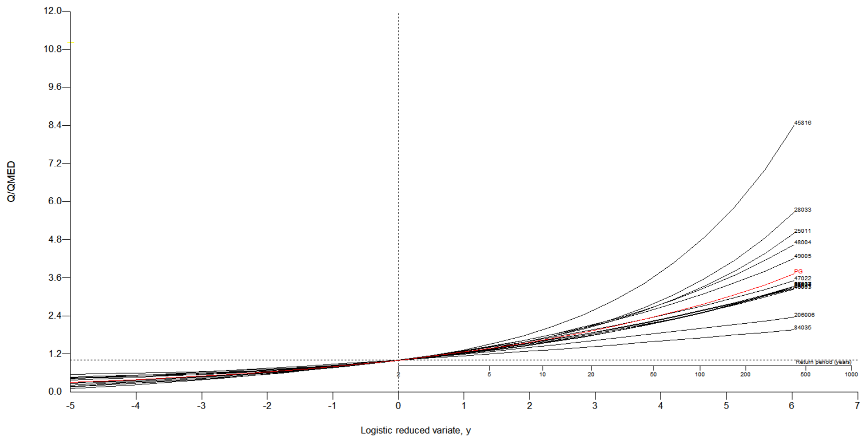


Figure 6 WINFAP5 AD@DS GL pooling group growth curves

Appendix E

Arup Modelling Report

Technical Note

Project title	Machynys East Outline Case
Job number	278688
File reference	
cc	
Prepared by	Zoe Nixon
Date	22 October 2024
Subject	Flood Modelling Note

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1. Introduction

Ove Arup and Partners (Arup) have been commissioned by Carmarthenshire County Council (CCC) to undertake a modelling exercise to support the outline planning application for a proposed hotel development which forms part of the Llanelli Waterside development.

The proposed Lllanelli Waterside development is located on a parcel of land situated on the coast of Machynys. The Afon Dafen is located approximately 300m north of the site and flows in a general westerly direction before discharging to the Afon Lleidi. A tributary of the Pil Dafen is located approximately 300m east of the site and flows south before discharging to the Pil Dafen. The overall proposals consist of a residential development of the south of the site, comprising of 10 houses and associated infrastructure, and a hotel development at the north of the site. The focus of this study is the proposed hotel development.

Flood modelling undertaken by Edenvale Young in 2024 has demonstrated the site to be at risk of tidal flooding. As such, flood modelling is required to assess flood risk to the proposed development, and the likely impact of any displaced water on neighbouring or other locations which might be affected subsequent to the development.

Job number 278688

Date 22 October 2024

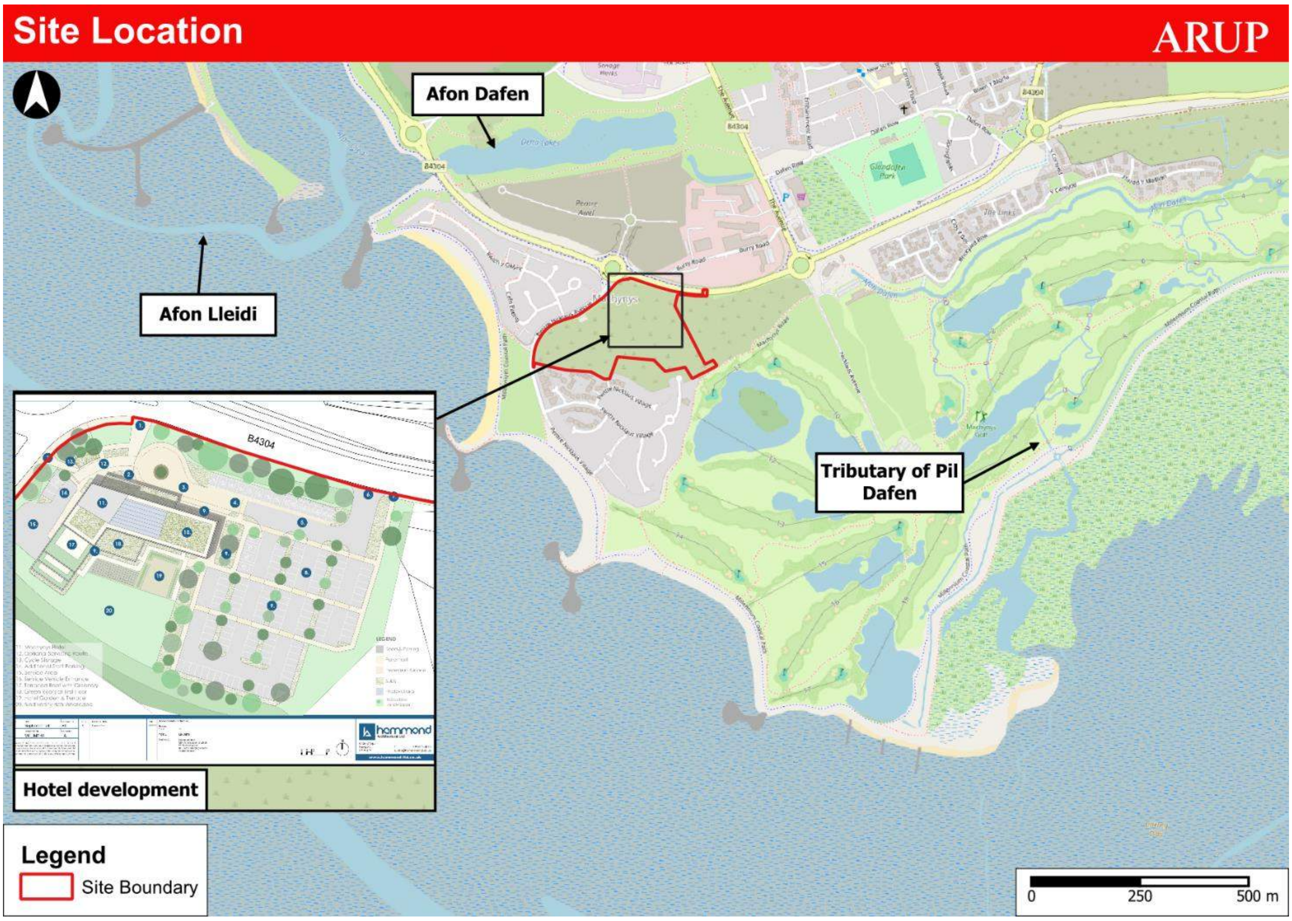

Figure 1. Site location

2. Methodology

2.1 Incoming model

This study uses the incoming Pentre Awel Hydraulic Model developed by Edenvale Young in 2024[1]. The model was built using ESTRY – TUFLOW, which links the 1D hydraulic modelling software ESTRY with the 2D hydraulic modelling software TUFLOW (version 2020-10-AF-iSP-w64).

The model was developed to support and Flood Consequence Assessment (FCA) for the development of the Llanelli Wellness and Life Science Village at Machynys. The model was reviewed and accepted by NRW for use in FCA in 2024.

2.2 Baseline model

The incoming model was re-run using a later version of the software (2023-03-AE-iSP-w64). No other changes were made to the incoming model.

[1] Edenvale Young, Pentre Awel Hydraulic Modelling Results, (Edenvale Young, 2024)

The model results are very similar to the incoming model results, with minor differences due to the changes in the TUFLOW version used.

The Welsh Government[2] has provided sea level rise values up to 2100 and 2120 for the Carmarthenshire Local Authority Area, shown in Table 1. The incoming model extrapolates the sea level rise values to 2122. In this study, the sea level rise values have been extrapolated to 2124, assuming a development lifetime of 100 years. This gives a total sea level rise of 1.02m (70th percentile) for Carmarthenshire in 2124.

Table 1. 70th percentile climate change allowances for Carmarthenshire local authority.

Local Authority	Allowance Percentile	Sea Level Rise 2100	Sea Level Rise 2120	Sea Level Rise 2124
Carmarthenshire	70th	0.83	0.99	1.02

2.3 Post-development model

The proposed topography of the site was provided in an ascii format and read into the .tgc file. A 2d_zsh region is read into the .tgc after the proposed topography to raise the lowest point of the car park to a minimum level 6.4mAOD in order to limit flood depths to below 600mm.

The proposed buildings lie outside of the maximum flood extent and as such, the finished floor levels are not incorporated into the model topography.

[2] Welsh Government, Flood Consequence Assessments: climate change allowances September 2021, (Welsh Government, 2021)

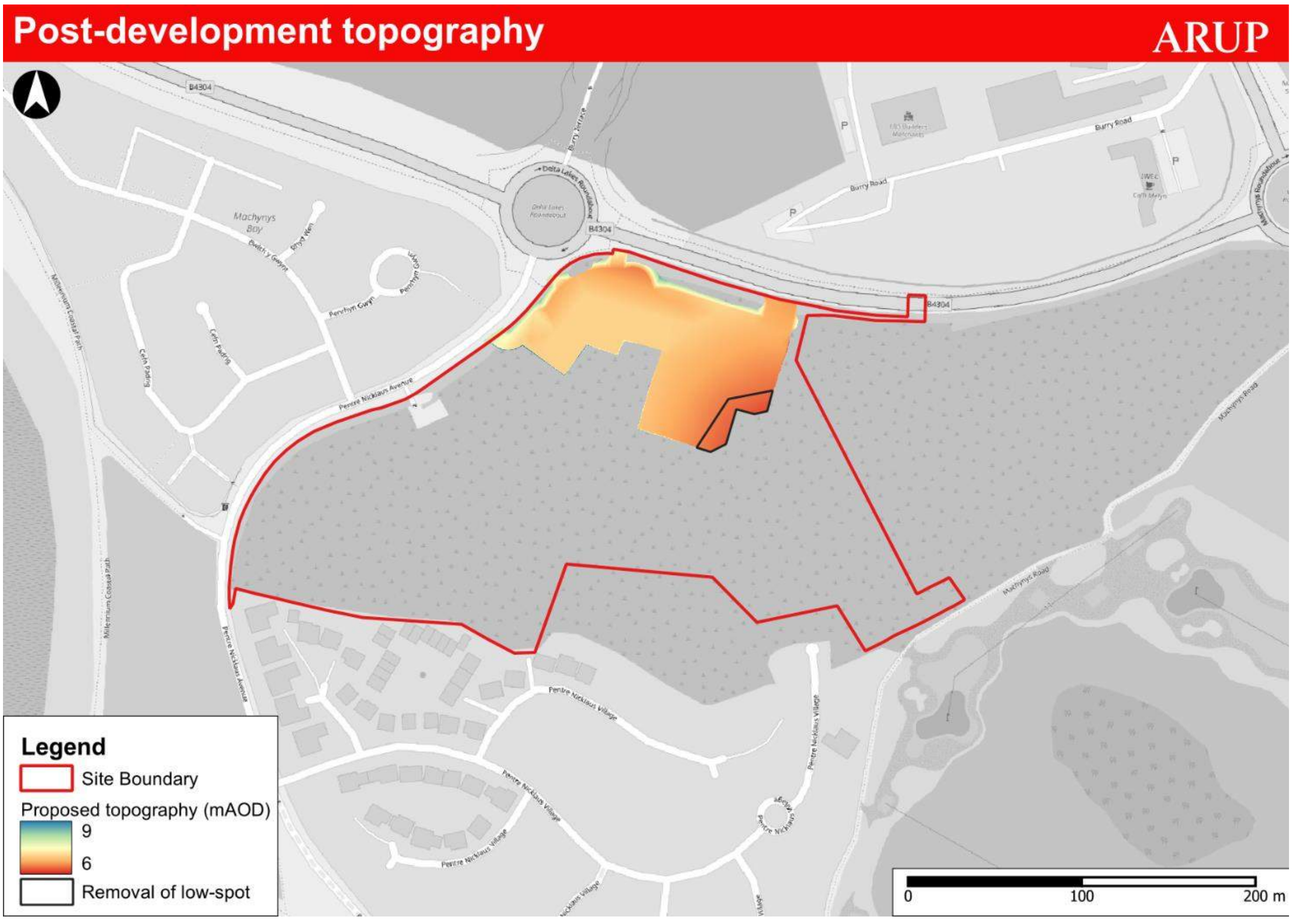

Figure 2. Representation of the post-development topography

The impact of the proposals on roughness is represented using a 2d_mat layer. The paved areas such as roads and pavements are represented with a Manning’s n value of 0.02, and buildings are represented with a Manning’s n value of 0.3.

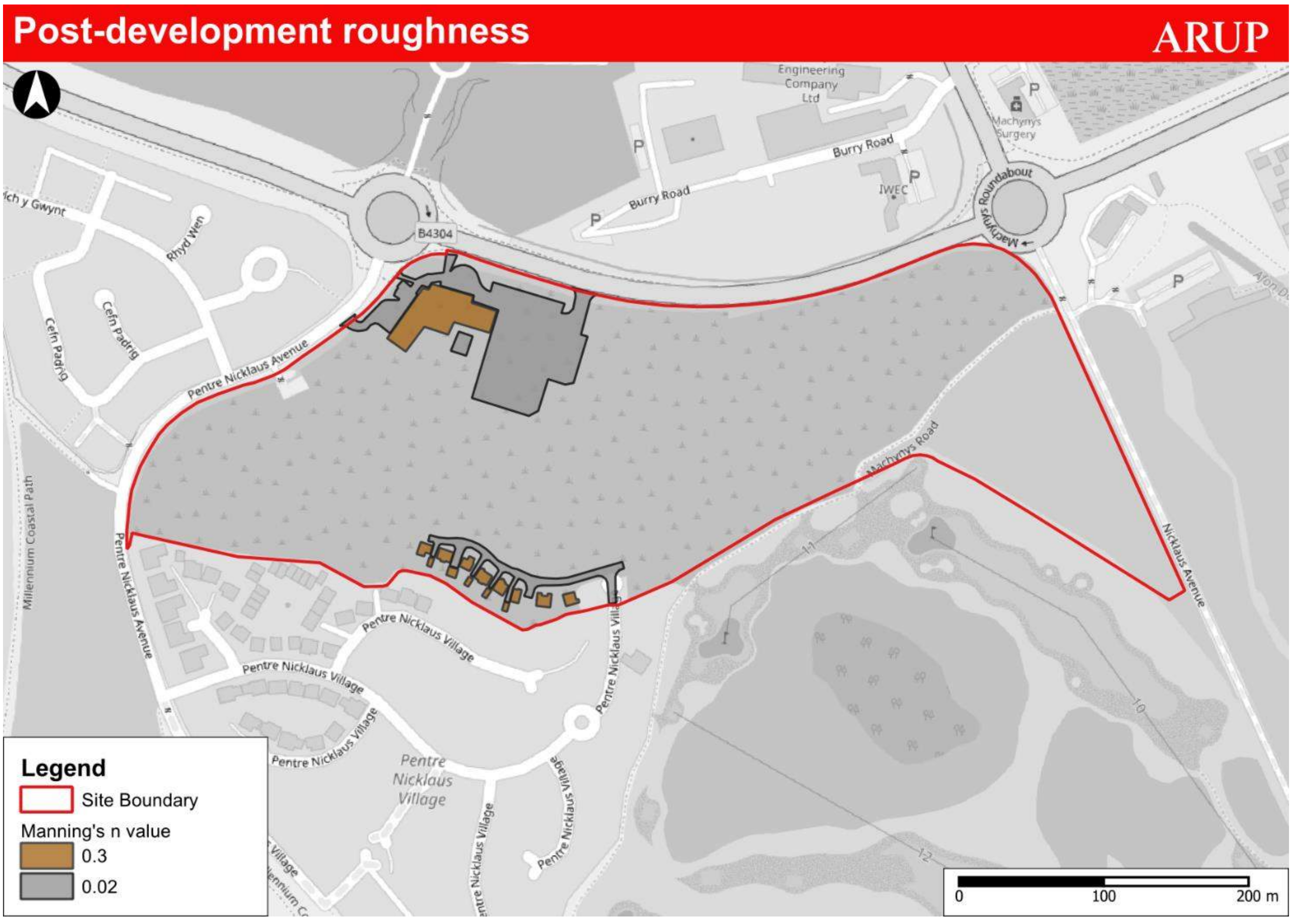

Figure 3. Representation of the post-development roughness.

3. Results

3.1 Modelled events

This study utilises ‘Scenario A5’ from the incoming model, which represents the existing tidal scenario with a 50m breach applied incorporated into the model. The configuration of the breach is based on NRW guidance.

The baseline and post-development models were run for two events:

- **0.5% AEP + CC tidal event:** 0.5% AEP tidal event with 1.02m sea level rise applied in line with the 70th percentile allowance for the 2124 epoch, in conjunction with a QMED fluvial flow with a 30% allowance for climate change.
- **0.1% AEP + CC tidal event:** 0.1% AEP tidal event with 1.02m sea level rise applied in line with the 70th percentile allowance for the 2124 epoch, in conjunction with a QMED fluvial flow with a 30% allowance for climate change.

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3.2 Baseline results

The results of the baseline scenario show the site to be partially inundated in both modelled events. In the 0.5% AEP + CC tidal event, flood extents inundate the eastern portion of the site but do not extend into the area proposed for development.

In the 0.1% AEP + CC tidal event, flooding extends into the proposed car park but does not affect the hotel building in the western portion of the site. The area proposed for the car park is flooded to a maximum flood depth and level of 460mm and 6.88mAOD, respectively. Flood waters are predicted to reach a maximum velocity of 0.14m/s.

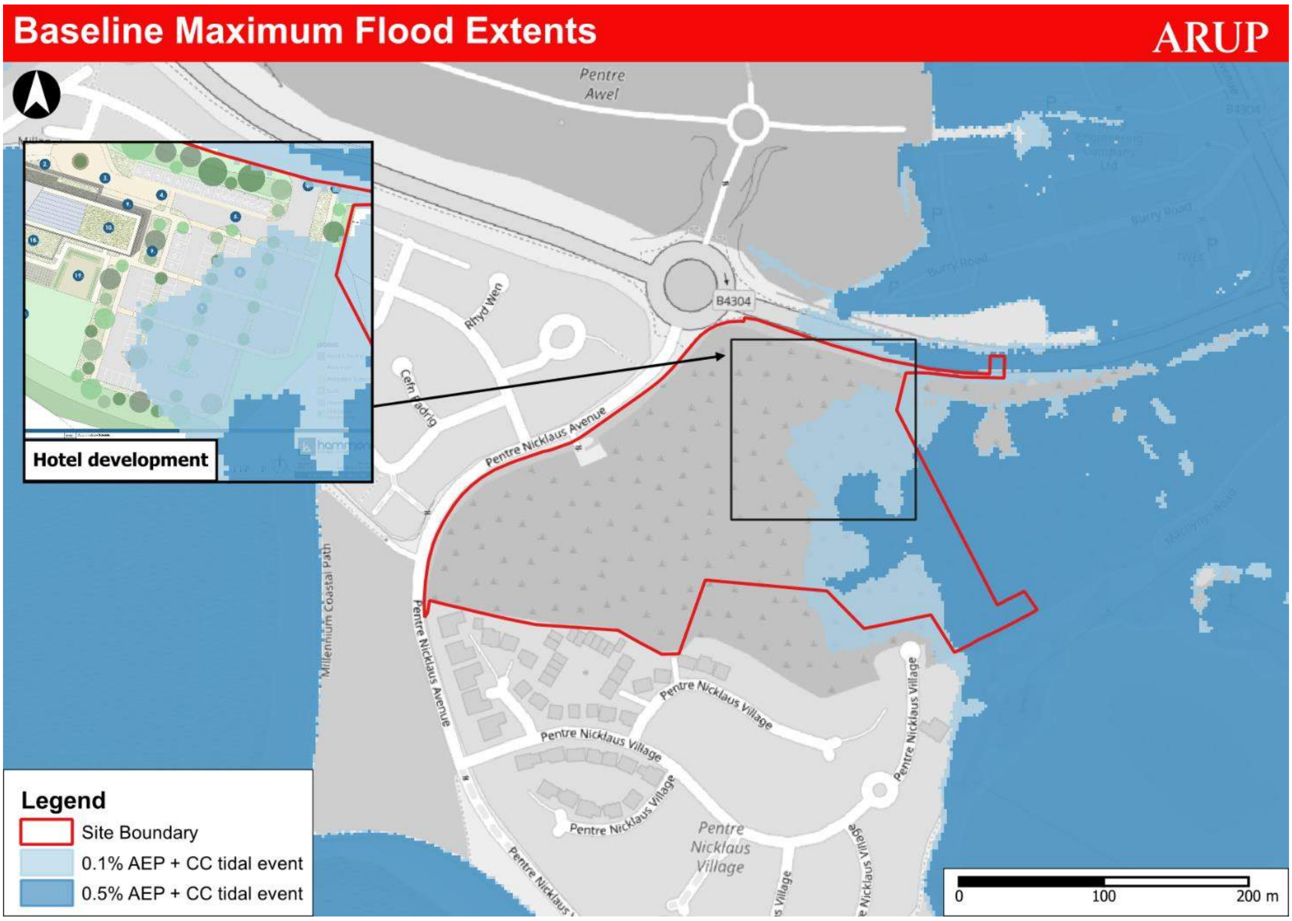

Figure 4. Baseline maximum flood extents

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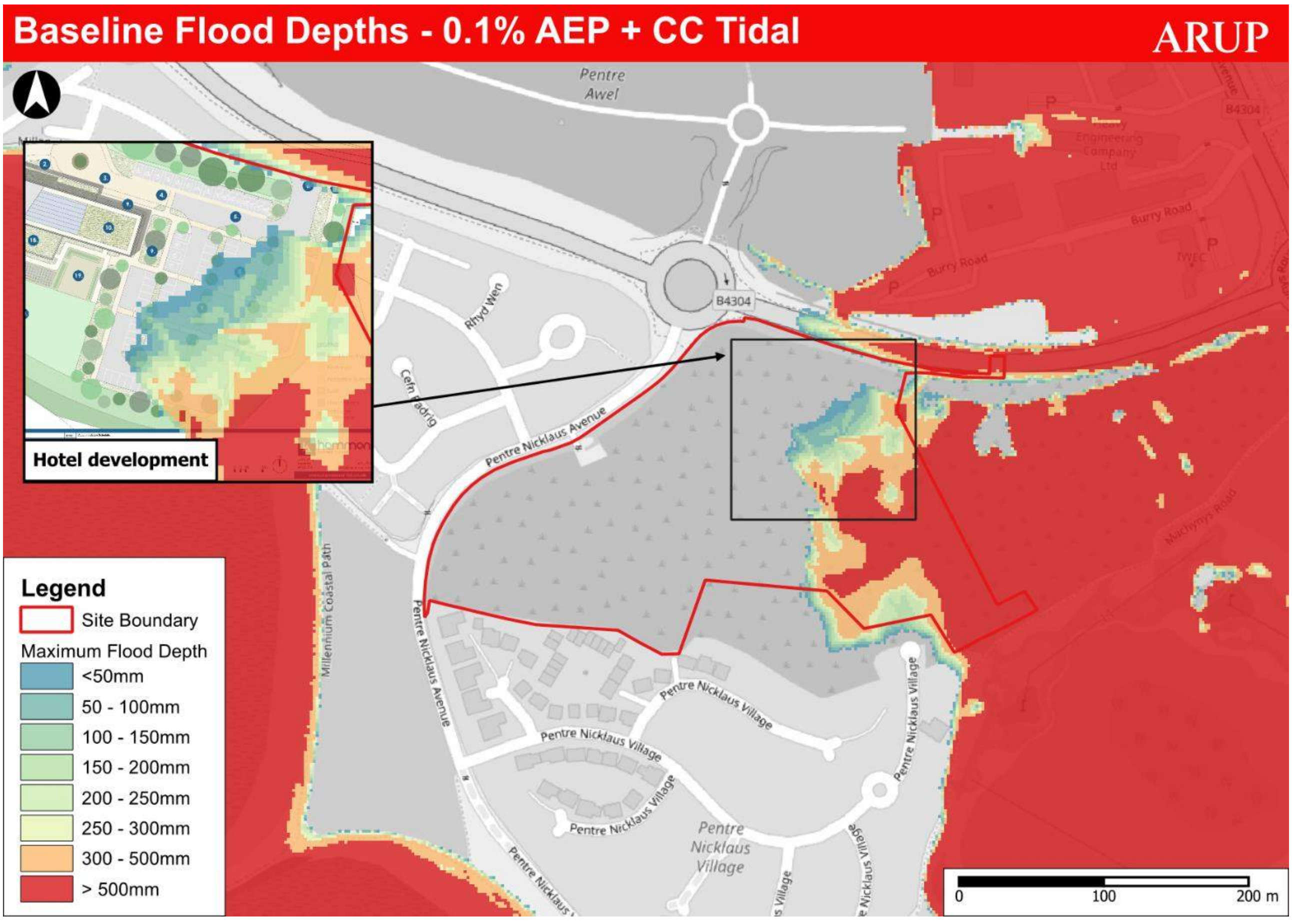

Figure 5. Maximum flood depths in the baseline scenario - 0.1% AEP + climate change tidal event

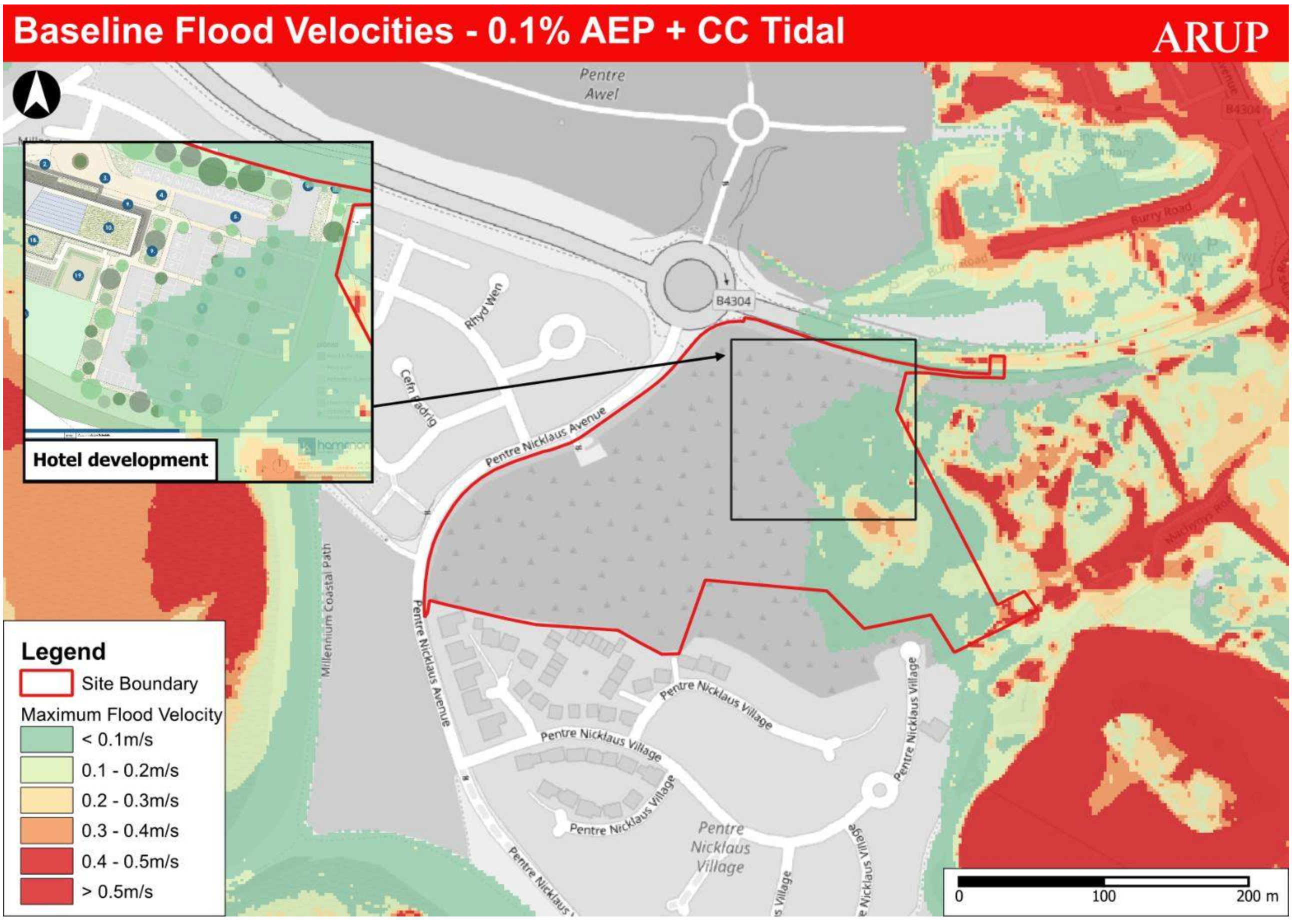

Figure 6. Maximum flood velocities in the baseline scenario - 0.1% AEP + climate change tidal event

3.3 Post-development results

As in the baseline scenario, the maximum flood extends do not inundate the areas of proposed development in the 0.5% AEP + CC tidal event.

In the 0.1% AEP + CC tidal event, flooding extends further into the proposed car park. In this event, the car park is flooded up to a maximum depth of 480mm and a maximum flood level of 6.88mAOD. The velocity of flood waters reaches a maximum of 0.34m/s at the eastern portion of the car park. The ZUK0 hazard rating classifies most of the car park as ‘very low hazard’ to ‘danger for some. On the eastern border of the car park, there is a small area classified as ‘danger for most’.

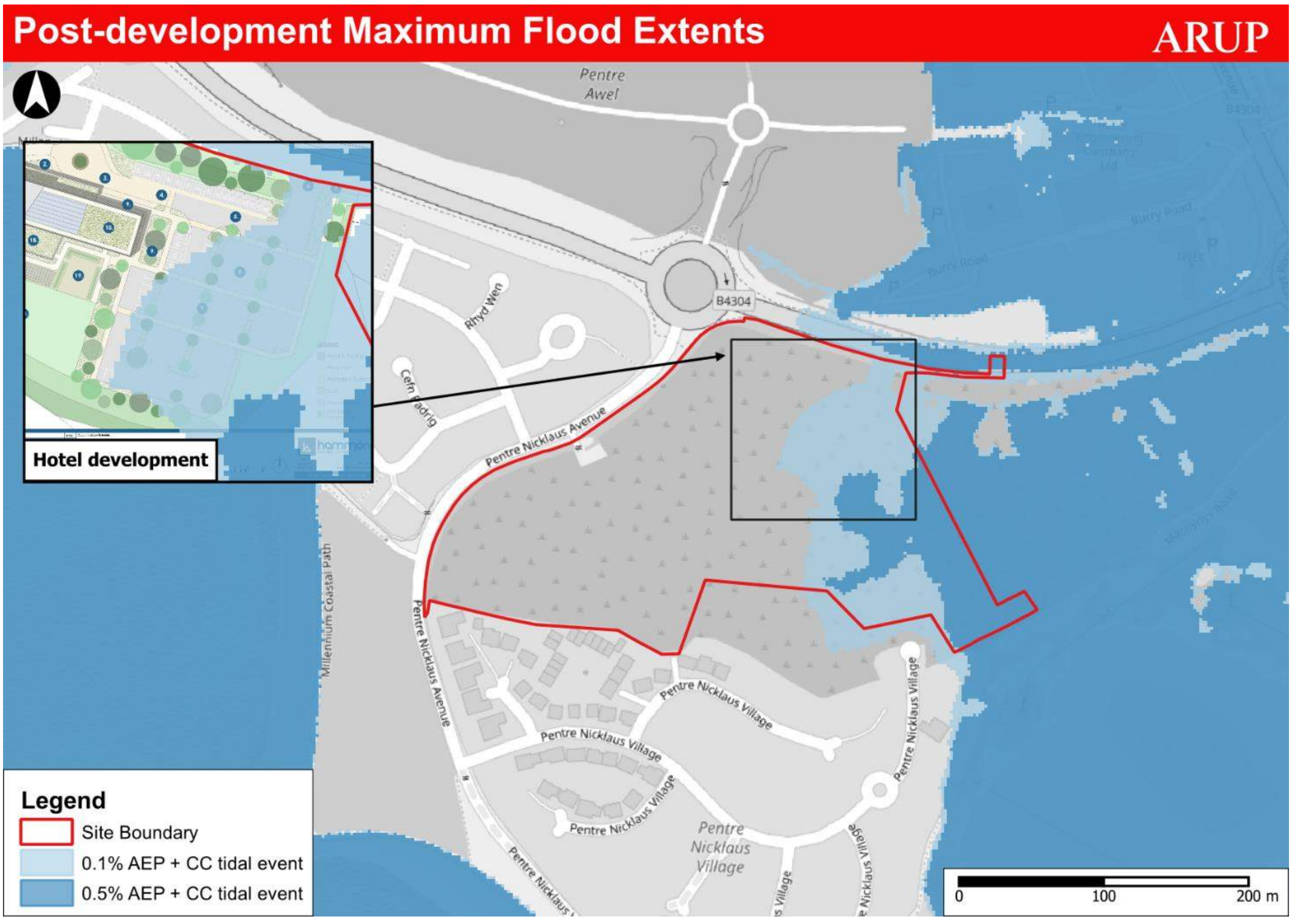

Figure 7. Post-development maximum flood extents

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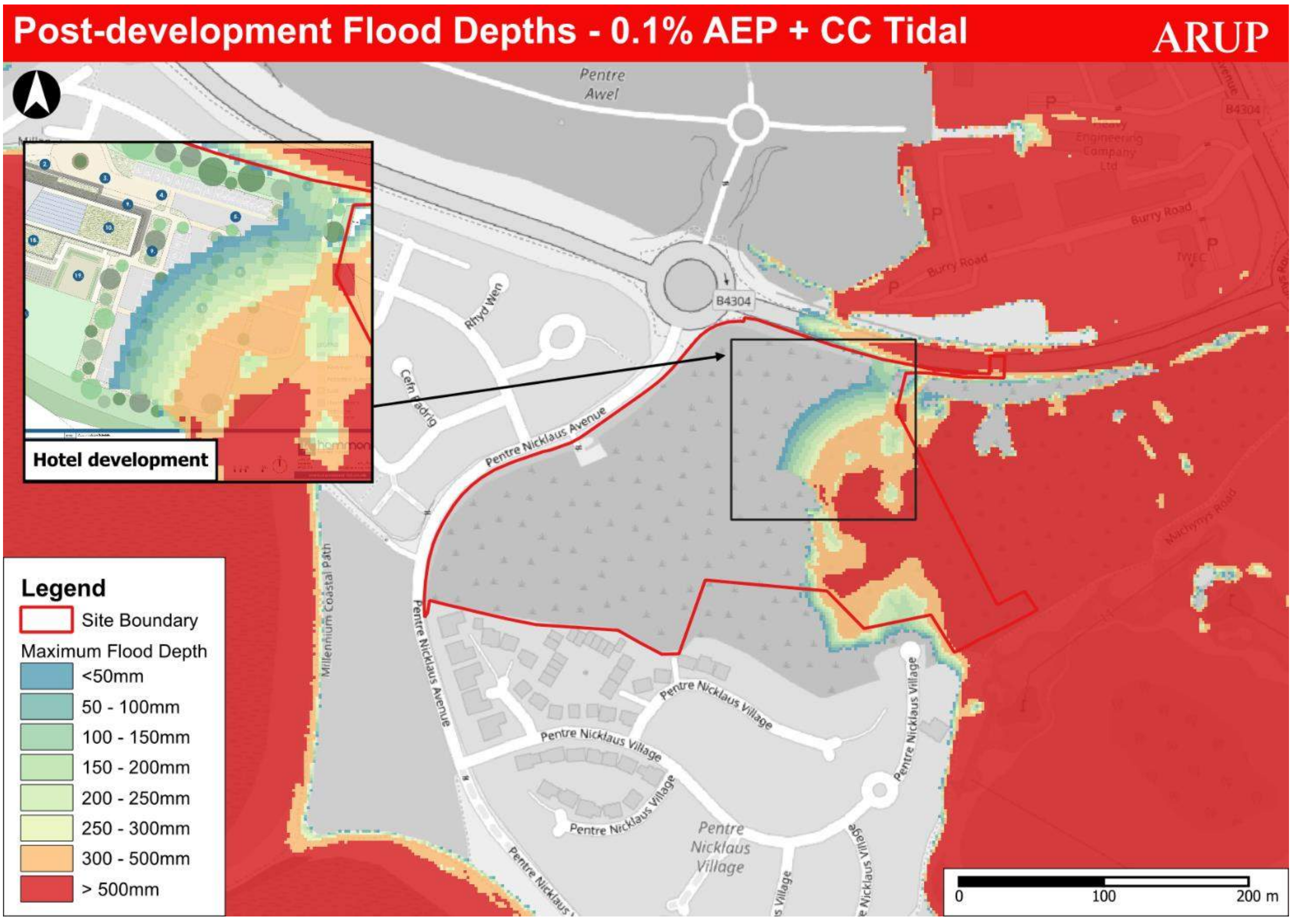

Figure 8. Maximum flood depths in the post-development scenario - 0.1% AEP + climate change tidal event

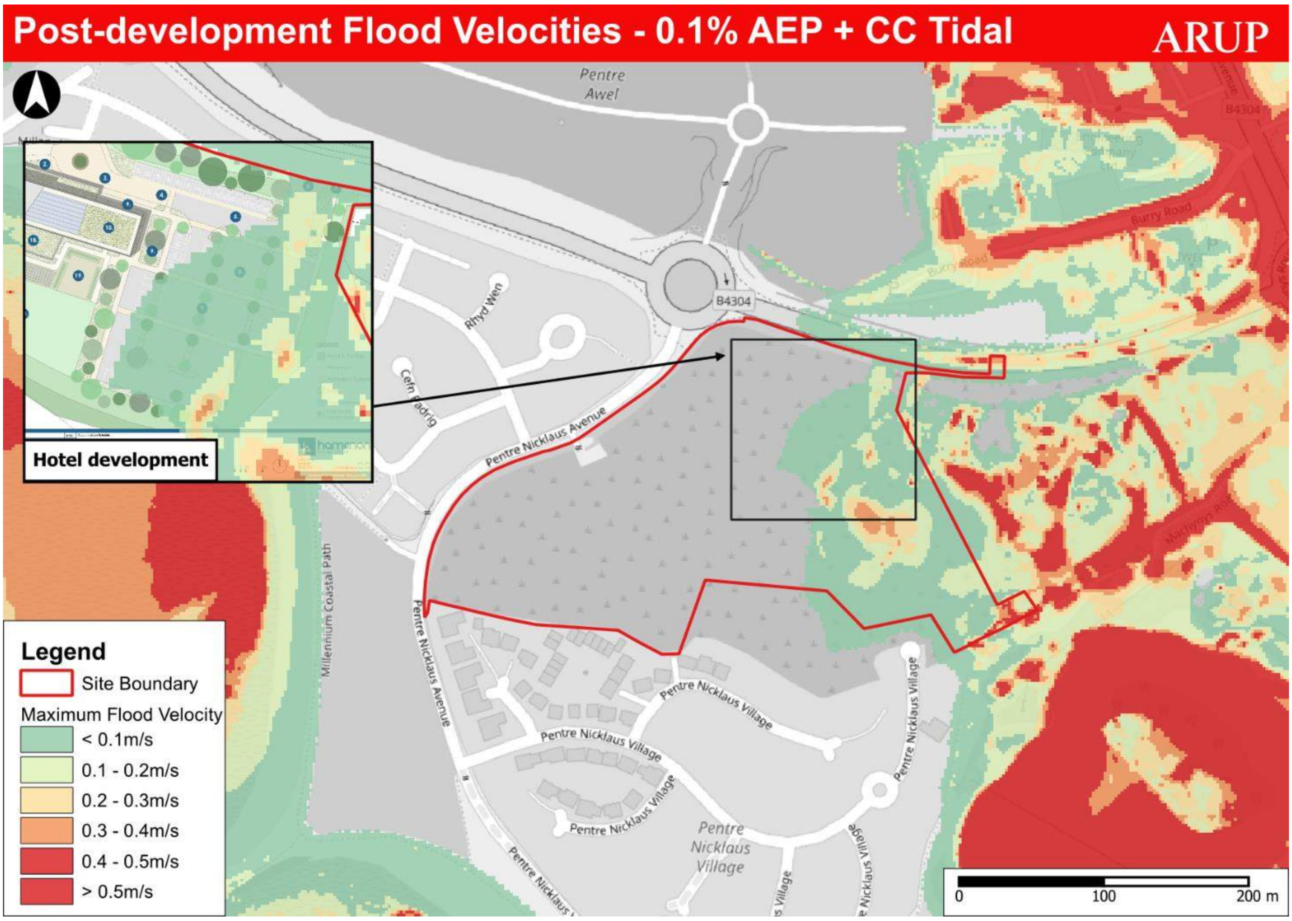

Figure 9. Maximum flood velocities in the post-development scenario - 0.1% AEP + climate change tidal event

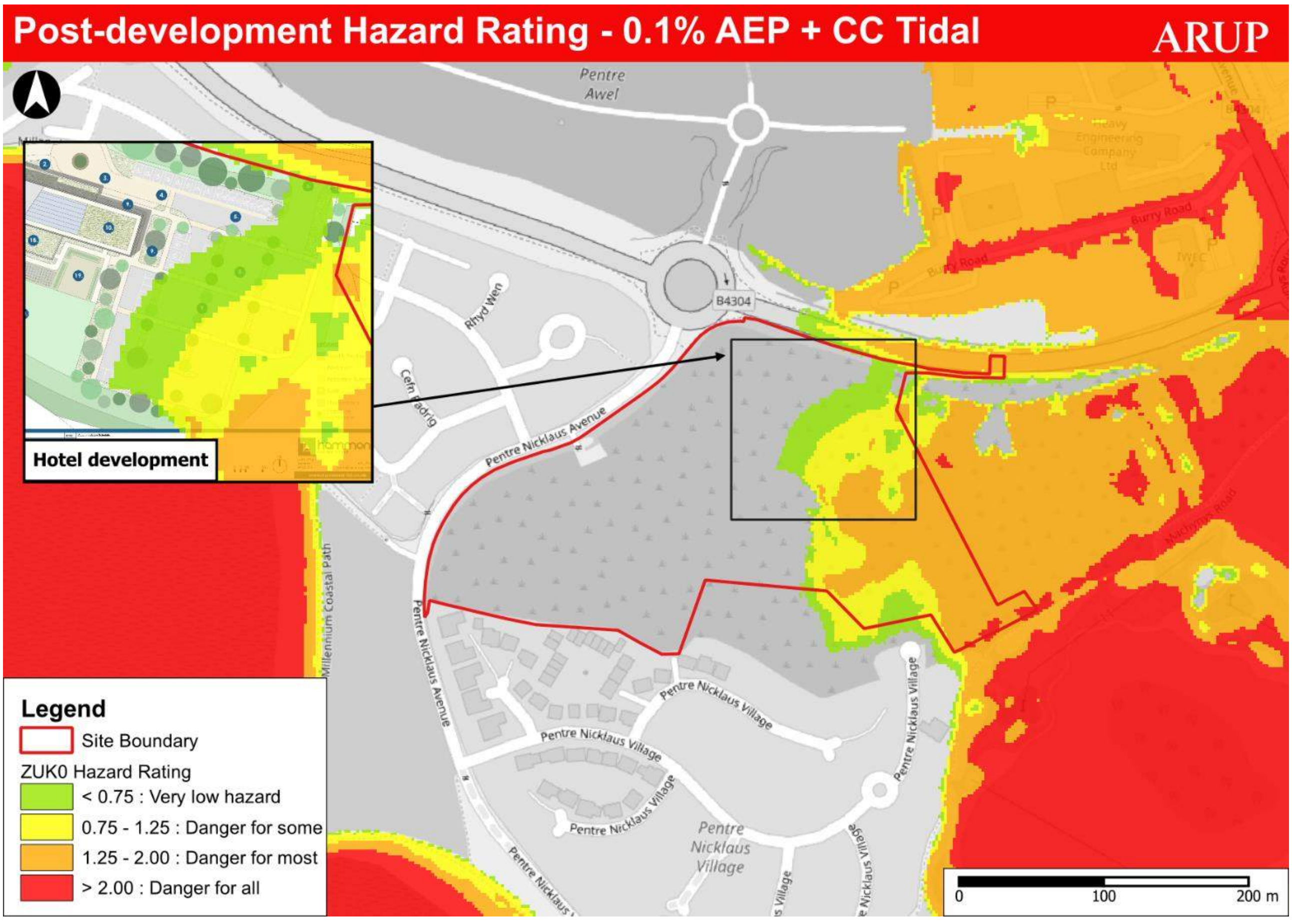

Figure 10. ZUK0 hazard rating in the post-development scenario - 0.1% AEP + climate change tidal event

Impact maps were created for the two modelled flood events by subtracting the baseline maximum flood depths from the post-development maximum flood depths. In the 0.5% AEP event, the development proposals have no impact on maximum flood depths or extents.

In the 0.1% AEP event, the proposals lead to an increase in flood depths at the proposed car park where ground lowering is proposed. Depths increase by a maximum of 260mm, and flooding extends further into the car park but does not reach the hotel.

There is an isolated area 500m north-west of the site where the results show small areas of flood depth increases and decreases. The extent of the detriment is located entirely on the existing New Dafen River. Interrogation of the results suggests that these impacts are due to localised model instability, and do not represent a trend of increased or decreased flood depths in the area. As such, this is not considered to represent a real impact. There are no other impacts off-site.

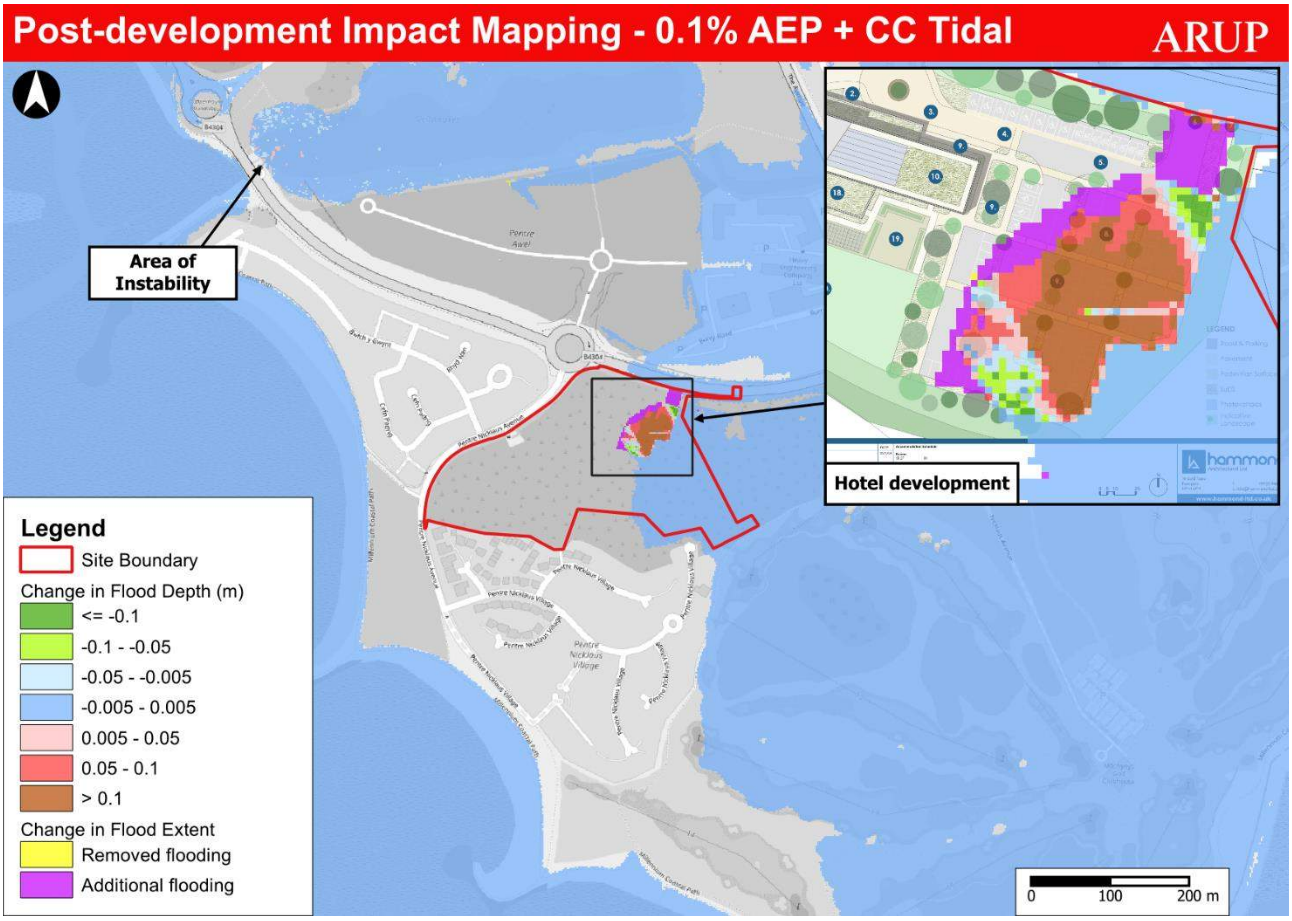

Figure 11. Post-development impact map - 0.1% AEP + climate change tidal event

4. Assumptions and Limitations:

The following assumptions and limitations have been identified:

- The hydrology has not been updated as part of this study, as it was recently completed and accepted by NRW.
- This study only considers the results of the 0.5% AEP + CC, and 0.1% AEP + CC tidal flood events, no other events have been modelled as there is no predicted flooding of the proposed site during these events.

5. Conclusions

This project has assessed flood risk to the proposed hotel development forming part of the Llanelli Waterside development, and investigated the likely impact of any displaced water on neighbouring or other locations which might be affected subsequent to the development. The proposed development is not inundated in the 0.5% AEP + CC tidal event.

In the 0.1% AEP + CC tidal event, parts of the proposed car park are inundated. The maximum flood depth and level reach 480mm and 6.88mAOD, respectively. The maximum flood velocity in the car park is 0.34m/s. The car park is generally classified as ‘very low hazard’ to ‘danger for some’, with a small area classified as ‘danger to most’ at the eastern edge of the car park.

The results demonstrate that the proposed development has no impact on flood risk in the 0.5% AEP + CC tidal event or the 0.1% AEP + CC tidal event.

DOCUMENT CHECKING

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