

Ty Mawr – Flood Consequence Assessment

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Contract

This report describes work commissioned by Andrew Rees, on behalf of Pobl Group, by an email dated the 22nd of February 2021. Hannah Booth of JBA Consulting carried out this work.

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Purpose

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Contents

1	Introduction	1	
1.1	FCA requirements	1	
2	Site description	2	
2.1	Site topography	3	
2.2	Soils, geology and watercourses	3	
2.3	Watercourses and Flood Defences	4	
2.4	Development proposal	4	
3	Planning Policy and flood risk	6	
3.1	Planning context	6	
3.2	DAM Zoning and Vulnerability classification	6	
3.3	Local Development Plan	7	
3.4	Justification test	7	
4	Flood Risk Assessment	10	
4.1	Review of existing flood risk data	10	
4.2	Historical flooding	10	
4.3	Fluvial Flood Risk	11	
4.4	Tidal Flood Risk	12	
4.5	Surface Water and Small Watercourse Flood Risk	12	
4.6	Groundwater Flood Risk	13	
4.7	Reservoirs Flood Risk	13	
4.8	Sewers Flood Risk	13	
5	Detailed Fluvial Flood Risk Assessment	14	
5.1	Hydraulic modelling availability	14	
5.2	Baseline flood modelling	14	
5.2.1	1% AEP plus Climate Change	14	
5.2.2	0.1% AEP	15	
5.3	Post-development flood modelling	16	
5.4	1% AEP plus climate change	16	
5.5	0.1% AEP event	17	
6	Assessment of Acceptability Criteria	20	
6.1	Flood risk summary and compliance with TAN-15	20	
6.2	Acceptability Assessment	20	
7	Conclusions	23	
A	Proposed development site plan		I
B	FEH Calculation Record		II
C	Topographic Survey		III

List of Figures

Figure 2-1 Proposed development site	2
Figure 2-2 Topographical survey	3
Figure 2-3 Watercourses and flood defences around the site	4
Figure 2-4 Proposed development design	5
Figure 3-1 Development Advice Map	7
Figure 4-1 NRW Historic Flooding records	11
Figure 4-2 FRAW- Risk of flooding from the rivers	12
Figure 4-3 FRAW- Risk of Flooding from Surface Water and Small Watercourses	13
Figure 5-1 1% AEP plus climate change maximum baseline depth	15
Figure 5-2 0.1% AEP maximum baseline depth	16
Figure 5-3 1% AEP plus climate change maximum post-development depth	17
Figure 5-4 1% AEP plus climate change flood depth comparison	17
Figure 5-5 0.1% AEP maximum post-development depth	18
Figure 5-6 0.1% AEP flood depth comparison	19

List of Tables

Table 2-1 Site summary	2
Table 3-1 Development categories defined by TAN-15	6
Table 3-2 Justification Test applied to the proposed development	9
Table 4-1 Summary of flood risk	10
Table 6-1 Assessment of accessibility criteria	20

1 Introduction

JBA Consulting were commissioned by Pobl Group in February 2021 to prepare a Flood Consequence Assessment (FCA) to support a planning application for the redevelopment of the existing building and a small extension to the rear of Ty Mawr on Ynysdwerw Road.

Following consultation with NRW, new flood modelling has been completed that has incorporated a new hydrological assessment and updates to the NRW Pontardawe model. The outputs from the new flood modelling have been used within this FCA to provide an improved understanding of flood risk to the proposed development.

This FCA demonstrates the suitability of the proposed development and describes the flood mitigation measures recommended to manage flooding at the site.

1.1 FCA requirements

This FCA follows Welsh Government guidance on development and flood risk set out in the Technical Advice Note 15: Development and Flood Risk (TAN15). Where appropriate, the following aspects of flood risk will be addressed in all planning applications over its expected lifetime in flood risk areas:

- The likely mechanisms of flooding
- The likely source of flooding
- The depths of flooding through the site
- The speed of inundation of the site
- The rate of rise of flood water through the site
- Velocities of flood water across the site
- Overland flow routes
- The effect of access and egress and infrastructure, for example, public sewer outfalls, combined sewer outflows, surface water sewers and effluent discharge pipes from wastewater treatment works
- The impacts of the development in terms of flood risk on neighbouring properties and elsewhere on the floodplain

2 Site description

The site is a former sheltered flats scheme (now vacant) situated on Ynysdwerw Road, in Pontardawe. The site is approximately 0.15 hectares in size and comprises the existing building, a small extension on the south-western side of the building, associated car parking spaces and garden space. Pedestrian access to the existing building is available to the north of the site, and vehicle access is available from the south of the site along Llys Glanrafon Road.

Table 2-1 Site summary

Site name	Ty Mawr
Site area	0.15ha
Existing land use	Disused residential
Purpose of development	Residential
OS NGR	SN 72277 03657
Local Planning Authorities	Neath Port Talbot County Borough Council
Lead Local Flood Authority	Neath Port Talbot County Borough Council

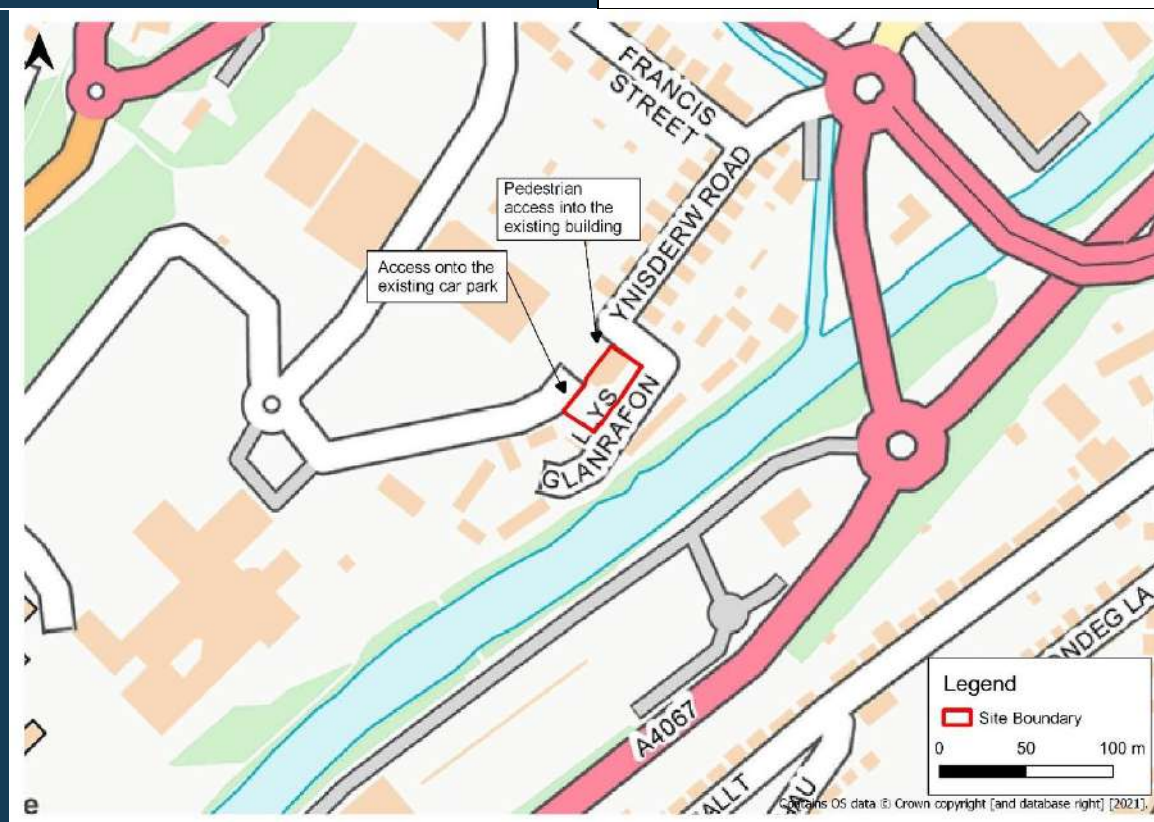


Figure 2-1 Proposed development site

2.1 Site topography

A topographic survey for the site has been made available for this FCA. This shows that the existing building has a minimum finished floor level of 32.18mAOD with the existing car parking area set to 32.05mAOD. The topographical survey is shown in Figure 2-2 and can also be found in Appendix C.

The survey data demonstrates that the site is generally flat, with ground levels ranging from 31.93m AOD in the northern corner, to 33.23m AOD in the southern corner of the site. The elevation of Ynysdwerw Road along the western boundary of the site ranges between 31.84m to 32.47m AOD.

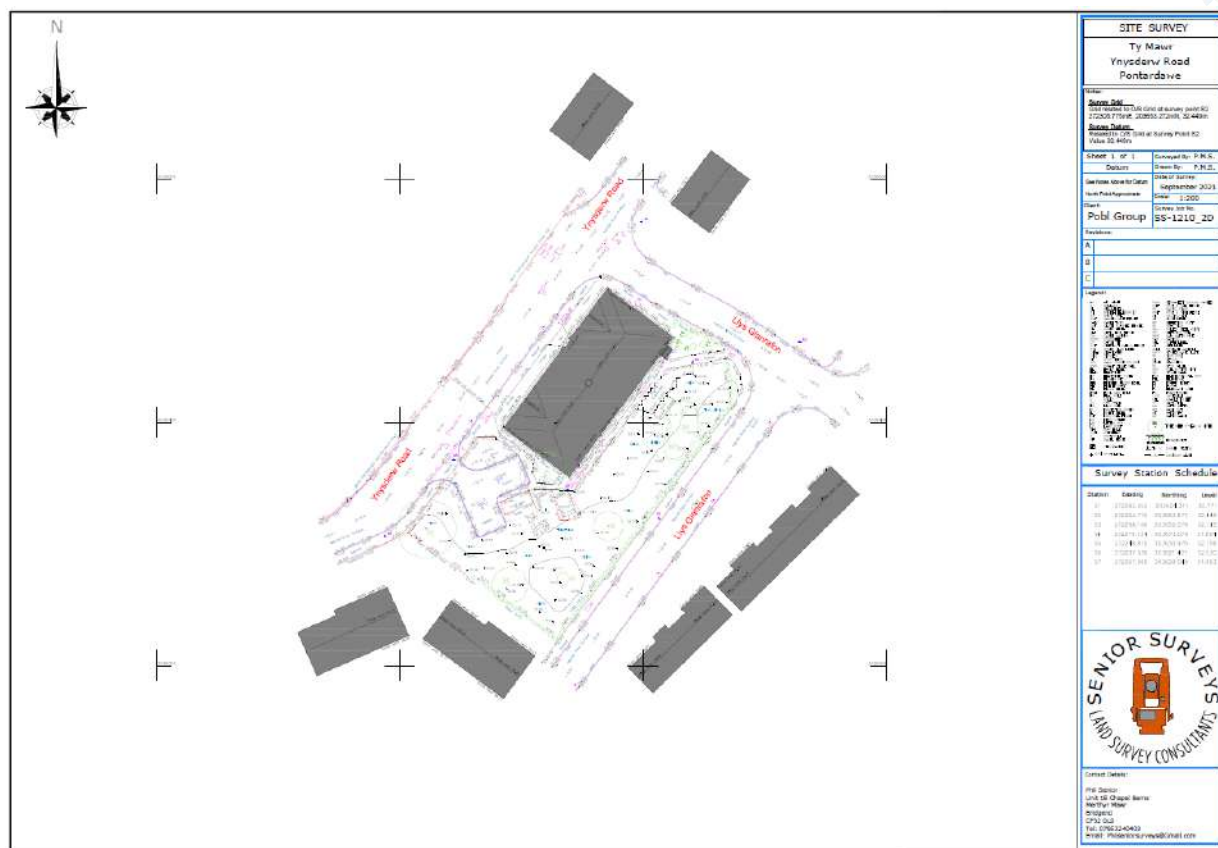


Figure 2-2 Topographical survey

2.2 Soils, geology and watercourses

The Cranfield University Soilscape¹ viewer describes the underlying strata as freely draining floodplain soils. Soils are reported to drain to local groundwater before feeding into the river.

According to the British Geological Survey (BGS) Geology of Britain Viewer², bedrock at the site is described as Brithdir Member comprised of Sandstone. The superficial deposits are identified as being Alluvium and consists of clay, silt, gravel and sand.

1 Cranfield University Soilscales: <http://www.landis.org.uk/soilscales/>

2 BGS Geology of Britain Viewer: <http://mapapps.bgs.ac.uk/geologyofbritain/home.html>?

BGS Geology of Britain viewer: <http://mapapps.bgs.ac.uk/geologyofbritain/home.do>
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2.3 Watercourses and Flood Defences

Two watercourses are located close to the site, as shown in Figure 2-3. The site is located approximately 40m north-west of the River Tawe and 100m to the south-west of the Upper Clydach River. Both of these rivers are NRW designated Main Rivers.

Flood defences are located upstream of the site on the River Tawe and the Upper Clydach River, as shown in Figure 2-3. On the River Tawe, flood defences consisting of raised embankment and flood walls offer protection from the Pontardawe recreational ground to the A474 road bridge. On the Upper Clydach River, there are flood walls located on both the right and left hand side banks between the A474 road bridge and Ynysdwerw Road bridge. There is a further flood wall located on the left hand side bank upstream of the A474 road.

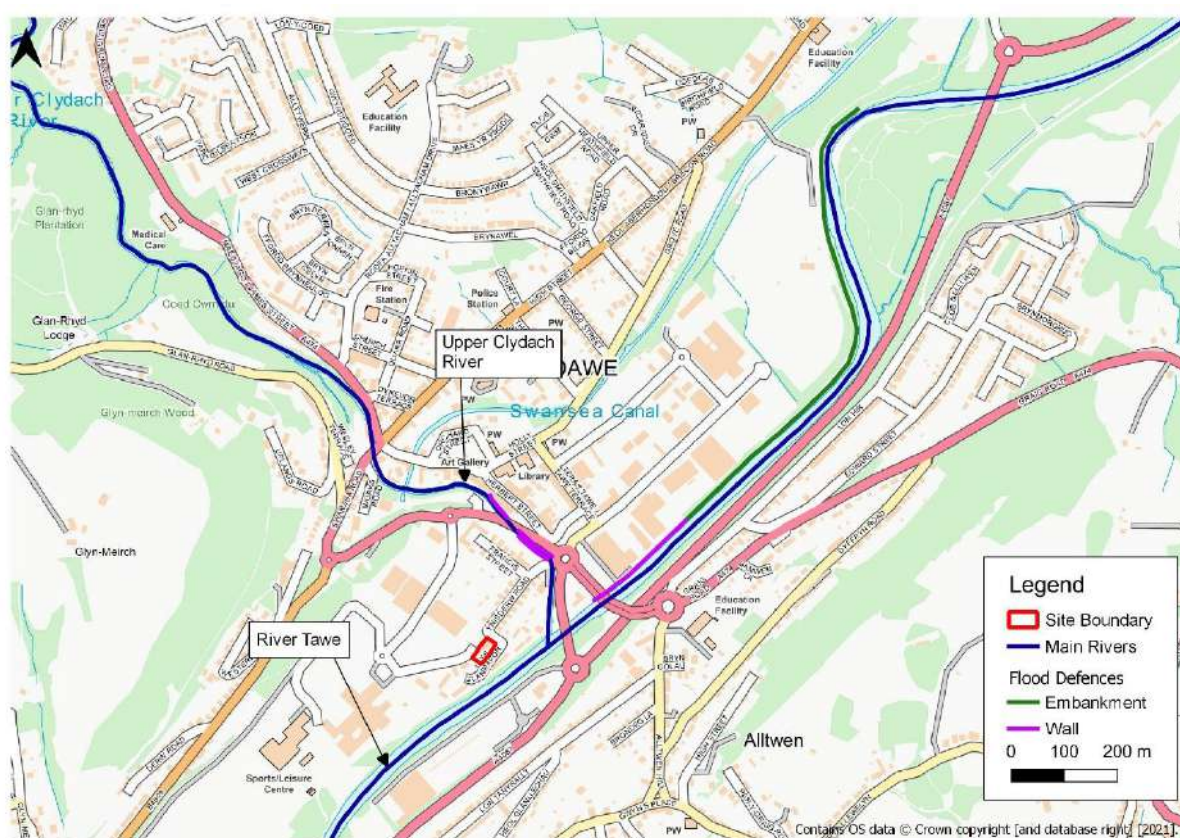


Figure 2-3 Watercourses and flood defences around the site

2.4 Development proposal

The development proposal is for the re-development of the Ty-Mawr building and the additional of a small extension to the south-west. The proposal is to include 8 self contained flats in the existing building and construct 4 new flats in the building extension. The development will be split over two storeys.

The existing car parking area will be extended to accommodate 11 car parking spaces. An area of green amenity space will be provided to the south of the building.

A plan of the proposed development from Chamberlain Moss King Architecture has been included in Figure 2-4. This has also been provided in Appendix A, which also includes the proposed ground floor layout plan.



Figure 2-4 Proposed development design

3 Planning Policy and flood risk

3.1 Planning context

TAN-15 was introduced in 2004 by the Welsh Assembly Government. It is technical guidance related to development planning and flood risk using a sequential characterisation of risk based on the Welsh Government's Development and Flood Risk Advice Map (DAM). Its initial requirement is to identify the flood zones and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

TAN-15 assigns one of three flood risk vulnerability classifications to development, as shown in Table 3-1. The proposed re-development is 'Residential Development'. Consequently, the development is classified as 'highly vulnerable development'.

As the site is presently occupied by residential development there shall be no change in vulnerability classification resulting from the proposed re-development of the site. However, it is arguably the case that the proposed change of planning classification use from Sheltered Accommodation (C3b) to Residential (C3a) could be considered as a reduction in the vulnerability of the occupants and therefore a lowering in risk.

Table 3-1 Development categories defined by TAN-15

Development category	Types
Emergency services	Hospitals, ambulance stations, fire stations, police stations, coastguard stations, command centres, emergency depots and buildings used to provide emergency shelter in time of flood.
Highly vulnerable development	All residential premises (including hotels and caravan parks), public buildings, (e.g. schools, libraries, leisure centres), especially vulnerable industrial development (e.g. power stations, chemical plants, incinerators), and waste disposal sites.
Less vulnerable development	General industrial, employment, commercial and retail development, transport and utilities infrastructure, car parks, mineral extraction sites and associated processing facilities, excluding waste disposal sites.

3.2 DAM Zoning and Vulnerability classification

Figure 3-1 shows that the proposed development site falls into Zone C1 of the DAM. The DAM zone classification is used to trigger different planning actions based on a precautionary assessment of flood risk. Zone C1 is described as areas of the floodplain served by significant infrastructure, including flood defences.

Highly vulnerable development within Zone C1, can take place subject to the application of a Justification Test, including the acceptability of consequences.

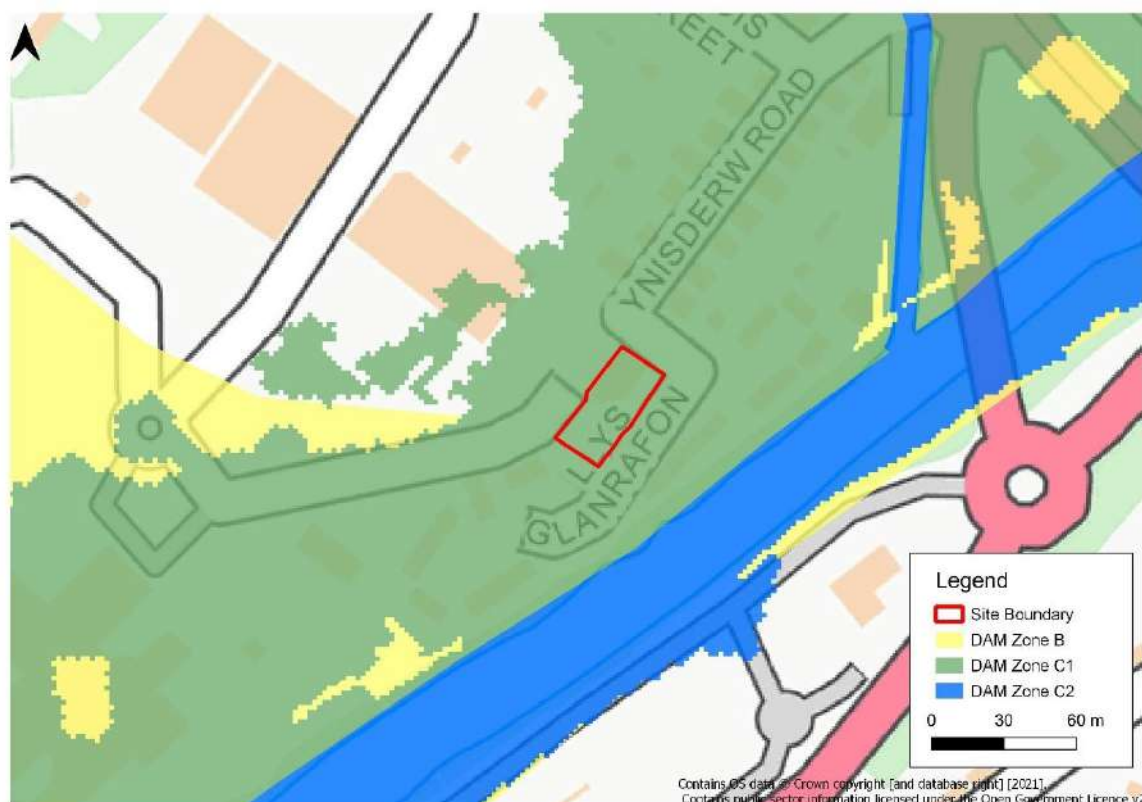


Figure 3-1 Development Advice Map

3.3 Local Development Plan

The Local Development Plan (LDP) is a land-use document in which the County Borough Council sets out its land use development over a 15-year period. The current LDP, entitled 'Neath Port Talbot County Borough Council Local Development Plan (2011-2026)',³ was adopted by Neath Port Talbot County Borough Council in January 2016.

Within the LDP, Pontardawe is identified as a key settlement and a Strategic Growth Area (SGA), playing a critical role in the development aspirations within the county. Policy SP3 of the LDP has highlighted that Pontardawe is the largest settlement in the Valleys Strategy Area and has the facilities and amenities to support significant additional growth over the Plan period. This growth in the wider Pontardawe area will help to support and enhance the town of Pontardawe, its retail and cultural amenities and will support and encourage economic development across the Swansea and Amman Valleys.

The strategy also identifies that large areas of the County Borough are brownfield land (formerly developed land) and that these areas should be prioritised through regeneration schemes to prevent the unnecessary loss of greenfield land. The following policies require that the development of brownfield land is prioritised over greenfield sites.

- Policy SP16
- Policy BE1-C

3.4 Justification test

TAN-15 states that "new development" will be justified if it can be demonstrated that:

³ Neath and Port Talbot County Borough Council (2016) Neath Port Talbot County Borough Council Local Development Plan, Retrieved from: https://www.npt.gov.uk/media/7321/ldp_written_statement_jan16.pdf?v=20170727124344

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

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

It concurs with the aims of Planning Policy Wales and meets the definition of previously developed land;

and,

The potential consequences of a flooding event for the particular type of development have been considered and found to be acceptable.

TAN15 does not specifically explain how the justification test should be applied to a change of use application, particularly where there will be no increase in the vulnerability of the development. Notwithstanding this point, the proposed re-development has been assessed against the requirements of the Justification Test, with the results summarised in Table 3-2. All the criteria have been satisfied with regards to the proposed development.

Table 3-2 Justification Test applied to the proposed development

TAN 15 Justification Criteria	Comments	Achieved
Its location is necessary to assist a local authority regeneration initiative or strategy, or contribute to key employment objectives necessary to sustain an existing settlement or region	The Neath Port Talbot County Borough Council Local Development Plan (LDP) 2011 – 2026 notes that Pontardawe is identified as a key primary settlement and Strategic Growth Area under Strategic Policy SP3. The site also supports Strategic Policy SP16 and BE 1-(C) by making use of an existing building and not building on greenfield land.	✓
The site meets the definition of previously developed land (i.e. it is not a Greenfield site) and concurs with the aims of Planning Policy Wales (i.e. the presumption in favour of sustainable development)	This site currently is currently developed, thus meeting the definition of previously developed land.	✓
A Flood Consequence Assessment has been produced to demonstrate that the potential consequences of a flood event up to the extreme flood event (1 in 1000 chance of occurring in any year) have been considered and meet the [Acceptability Criteria] in order to be considered acceptable	An assessment of the flood risk at the site has been undertaken to demonstrate the proposed development's acceptability. See Section 4 and Section 5.	✓

4 Flood Risk Assessment

This section assesses the risk to the proposed development from all sources of flooding, the risk of increased flooding to others, and how flood risks can be managed. As a Level 1 FCA, the flood risk assessment is based solely on a desk-based analysis of existing flood risk data.

4.1 Review of existing flood risk data

The latest available information of flood risk at the site, published by NRW and Neath Port Talbot County Borough Council, is summarised in Table 4-1.

Table 4-1 Summary of flood risk

Source of Flooding	Onsite Presence	Description
Fluvial	✓	The site is in an area at risk of river flooding.
Tidal	✗	The site is located outside of the area at risk of tidal flooding.
Surface Water and Small Watercourses	✓	The site is at low risk of surface water flooding.
Groundwater	✗	The site is at very low risk of flooding from groundwater.
Reservoirs	✗	The site is at very low risk of flooding from reservoirs.
Sewers	✗	The site is at very low risk of flooding from sewers.

4.2 Historical flooding

NRW's map of recorded flood extents (see Figure 4-1) shows evidence of historic flooding on the site from the River Tawe in 1979. The flood outline shown is considered simplified and may not correlate to a detailed flood extent reconnaissance map.

Major flooding in December 1979 effected large areas of South Wales. Following this event many flood defences were build and improved. It has not been possible to determine the construction dates for the flood defences in the area, but it is likely that they have seen improvements since 1979.

No further records of historic flooding were identified at the site in the Neath Port Talbot County Borough Council Flood Risk Management Plan⁴ and Preliminary Flood Risk Assessment (PFRA)⁵. Although, it was noted in the plan that fluvial flooding in Pontardawe has historically occurred in the town because of its location on the floodplain of the confluence of two rivers and a canal system.

⁴ Neath and Port Talbot Council, (2015), Flood Risk Management Plan. Retrieved from: <https://www.npt.gov.uk/media/5399/floodriskmanagementplan15.pdf?v=20170627002320>

⁵ Neath and Port Talbot Council, Preliminary Flood Risk Assessment, (2011), Retrieved from: https://www.npt.gov.uk/media/4629/pfra_report_2011.pdf?v=20171123145433



Figure 4-1 NRW Historic Flooding records

4.3 Fluvial Flood Risk

NRW's Flood Risk Assessment Wales (FRAW) map for Flood Risk from Rivers shows that the site is at low risk of fluvial flooding from the River Tawe and Upper Clydach River. This means that the site has a 1 in 1,000 (0.1% Annual Exceedance Probability (AEP)) chance of flooding during a flood event, as shown in Figure 4-3.

There are no flood defences present along the right bank of the River Tawe downstream of the A4067 immediately adjacent to the site. However, flood defences are present upstream of the A474 road bridge, this is approximately 225m upstream of the site on the River Tawe. Flood defence walls are also present along the banks of the Upper Clydach River, 180m upstream of the site. Consequently, the site is located within an 'Area Benefitting from Flood Defences' as designated by NRW's Flood Risk Assessment Wales Map.

To better understand the risk of flooding posed by fluvial flooding sources, further assessment using modelled data was undertaken and discussed in Section 5.

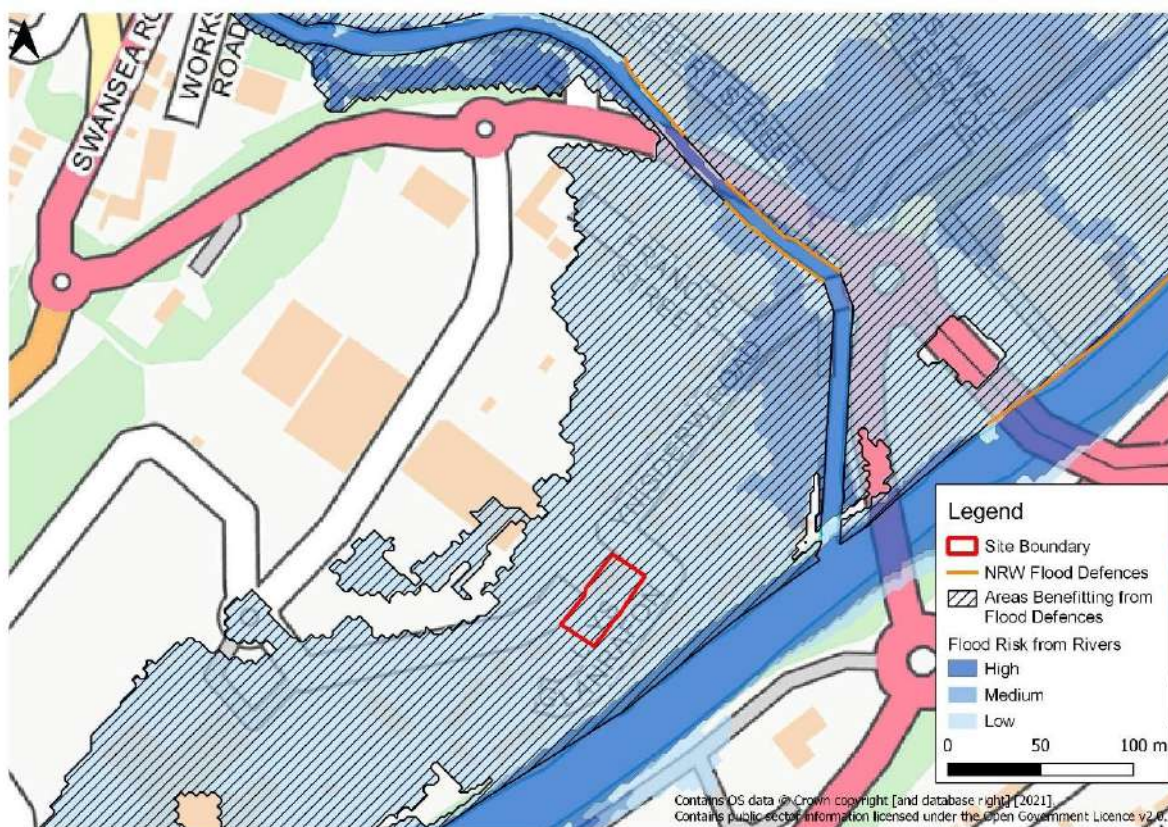


Figure 4-2 FRAW- Risk of flooding from the rivers

4.4 Tidal Flood Risk

The NRW FRAW Flood Risk from the Sea map show that the site is **not at risk of tidal flooding**.

4.5 Surface Water and Small Watercourse Flood Risk

The NRW FRAW Surface Water and Small Watercourses map shows that the site is at **very low risk of flooding** from surface water and small watercourses, meaning that most of the site has less than a 1 in 1,000 (0.1% AEP) chance of flooding from this source, as shown in Figure 4-3. A small area of the site along the edge of the existing building has a 1 in 1,000-year (0.1% AEP) chance of flooding.



Figure 4-3 FRAW- Risk of Flooding from Surface Water and Small Watercourses

4.6 Groundwater Flood Risk

Groundwater flooding is caused by unusually high groundwater levels. It occurs as excess water emerges at the ground surface or within manmade structures such as basements. Groundwater flooding tends to be more persistent than surface water flooding, in some cases lasting for weeks or months, and can result in damage to property. This risk of groundwater flooding depends on the nature of the geological strata underlying the site and the local topography.

The Neath Port Talbot County Borough Council Flood Risk Management Plan⁴, states that 'there are no specific areas of historical groundwater flooding recorded in the Neath and Port Talbot area'.

It can therefore be concluded that the risk of groundwater flooding at the site is **very low**.

4.7 Reservoirs Flood Risk

NRW flood maps indicate that the proposed development site is not at risk of flooding due to reservoir failure. It can therefore be concluded that there is **no risk** of reservoir flooding at the site.

4.8 Sewers Flood Risk

The Neath Port Talbot County Borough Council Flood Risk Management Plan does not show any evidence of historic sewer flooding on or close to the site. It can therefore be concluded that the risk of sewer flooding at the site is **very low**.

5 Detailed Fluvial Flood Risk Assessment

5.1 Hydraulic modelling availability

The current NRW Flood Map for the area is based on modelling undertaken by JBA on behalf of NRW in 2015. The model is a detailed 1D-2D ESTRY-TUFLOW model that is generally appropriate for detailed site assessment.

JBA updated this modelling in 2019 as part of an unrelated FCA for a site off Holly Street, Pontardawe. The planning application reference for this scheme is P2019/5708. The Holly Street flood modelling updated the 2015 model in the following ways:

- Updated the TUFLOW executable to use the most recent available software at the time of that study.
- Updated the flood flow estimates to follow the current Flood Estimation Handbook methods and NRW's flood estimation guidelines.
- Applied the current Welsh Government climate change guidelines (30% to the 1% AEP event).

Following pre-app consultation, NRW objected to the use of the 2019 Holly Street flood modelling results. Their primary concern related to the hydrology estimates being considered out of date. Since the production of the hydrology assessment in 2019, changes have been made to both hydrology datasets and methodology, and therefore NRW have recommended that a new hydrological assessment is completed to inform the flood modelling.

For the assessment of flood risk at the Ty Mawr development, additional updates have been applied to the Pontardawe model. A summary of these updates is provided below:

- The updated flood model utilises the latest version of the TUFLOW software (2020-10-AB). Following the completion of the flood modelling work, TUFLOW released a new executable but the updates to this version of the software are linked to bug fixes not relevant to the Pontardawe model and therefore are not expected to impact on the results.
- A new hydrological assessment has been produced, this was completed in December 2021 and was undertaken in accordance the NRW latest flood estimation technical guidance (GN008)⁶. A new flood estimation guide was released by NRW in November 2021 but given the majority of the works had already been completed, the previous guide has been used which is deemed to be appropriate. The new FEH Calculation Record can be found in Appendix B.
- Topographic survey data for the site has been used to improve the representation of the existing building within the 'baseline' scenario. The existing building has been set to a minimum finished floor level of 32.18mAOD. the topographical survey data is provided in Appendix C.

5.2 Baseline flood modelling

5.2.1 1% AEP plus Climate Change

Figure 5-1 shows the maximum flood depth at the proposed re-development site during the 1% AEP plus climate change event. As shown, the site is predicted to flood in this event with a maximum depth of 0.31m exhibited within the existing building footprint. This correlates to a maximum water level of 32.5mAOD.

⁶ Natural Resources Wales (2017). Flood Estimation: Technical Guidance (GN008) version 1.0.
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Flood water originates from the right bank of the Upper Clydach River where the flood defence wall upstream of Ynisderw Road is bypassed. Once out of bank, floodwater spreads overland until eventually reaching the site.

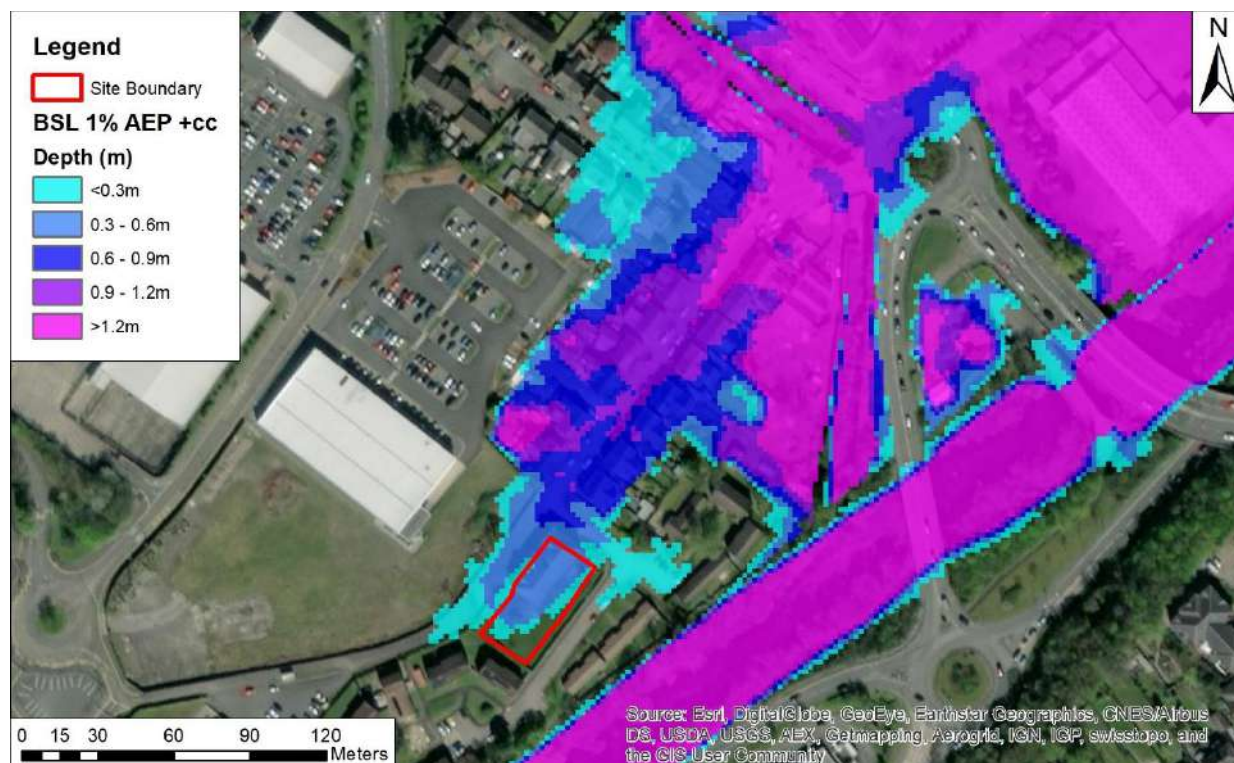


Figure 5-1 1% AEP plus climate change maximum baseline depth

5.2.2 0.1% AEP

Figure 5-2 shows the maximum flood depth at the proposed re-development site during in the 0.1% AEP event. As shown in the figure, the entirety of the site is at risk of flooding with a maximum flood depth of 1.11m experienced within the site boundary. This correlates to a maximum water level of 33.18mAOD.

As with the 1% AEP plus climate change event flood water originates from the right bank of the Upper Clydach River where the flood defence wall upstream of Ynisderw Road is bypassed. However, the flooding seems to be exacerbated in the 0.1% AEP event due to influence from the overland flow from the Afon Tawe.

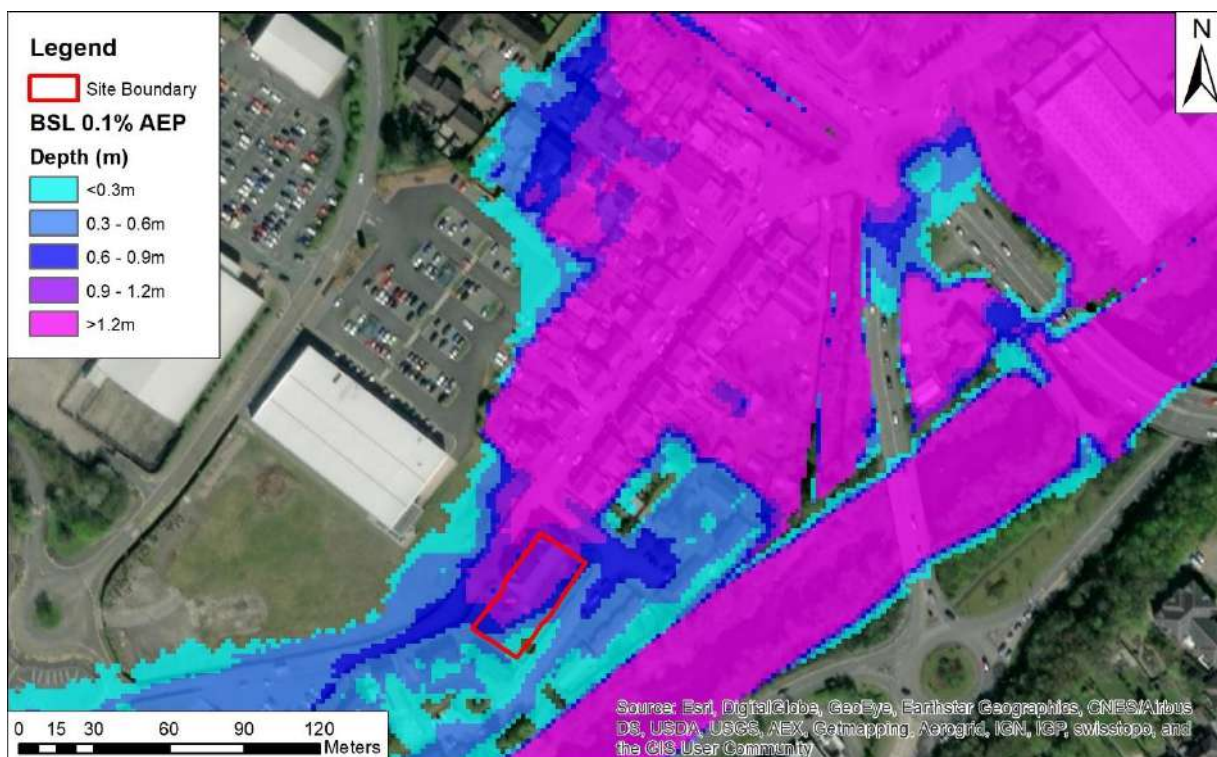


Figure 5-2 0.1% AEP maximum baseline depth

5.3 Post-development flood modelling

Given the new flood modelling shows that the proposed development is at risk of flooding in both the 1% AEP plus climate change and 0.1% AEP events, post-development modelling has been required to mitigate the risk to the site.

The finished floor level of the existing building has been raised to 32.6mAOD as has the building extension to ensure that these parts of the development are flood free in the predicted 1% AEP plus climate change event. Furthermore, the car parking spaces located on the south-western boundary of the building extension have been set to 32.5mAOD so that these areas are flood free in the 1% AEP plus climate change event and can tie into the levels of the Llys Glanrafon access road located to the south.

To represent the raised building thresholds and the car parking areas accurately in the model, 2D zshape layers to specify the elevations and have amended the 2D material codes to reflect the proposed development.

5.4 1% AEP plus climate change

With the buildings raised to 32.6mAOD and the car parking spaces set to a level of 32.5mAOD, the developable parts of the site are now flood free in the 1% AEP plus climate change event as shown in Figure 5-3. Therefore the site is considered compliant with the requirements of Table A1.14 of TAN15.

The raising of the finished floor level to the existing building and construction of the building extension and car parking area has the ability to displace water and increase the risk to neighbouring third parties. Therefore, a depth grid comparison has been produced comparing the baseline and post-development results. Figure 5-4 shows that the proposed development will have no detrimental impact on neighbouring third parties in the 1% AEP plus climate change event.

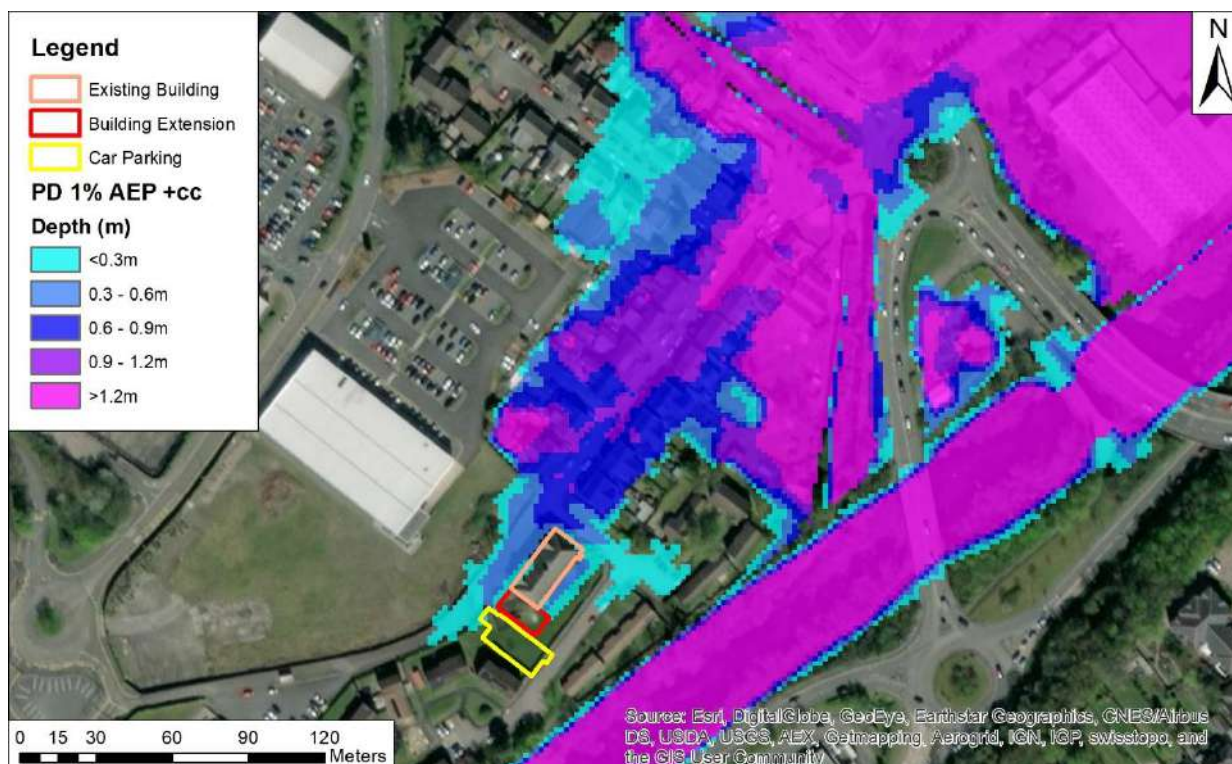


Figure 5-3 1% AEP plus climate change maximum post-development depth



Figure 5-4 1% AEP plus climate change flood depth comparison

5.5 0.1% AEP event

Figure 5-5 shows the modelled flood depths for the 0.1% AEP event post development simulation. In this event, both the existing building and extension experience a maximum depth of 0.58m which correlates to a maximum water level of 33.18mAOD. For highly

vulnerable development a flood depth of 0.58m is compliant with requirements of Table A1.15 of TAN15.

There is already a car parking area present on the south-western edge of the building. The development proposals include updating this car parking area to tie it into the Llys Glanrafon road to the south. Although the updated car parking area is shown to be susceptible to flooding in the 0.1% AEP event with depths of up to 640mm predicted, these flood depths are notably less than would affect the existing car park that it will replace. Therefore, resulting in a net reduction in flood risk for the car park.

Figure 5-6 shows the modelled flood depth comparison between the baseline model scenario and the post-development model scenario for the 0.1% AEP event. The proposed development is shown to provide a significant improvement in flood risk to the majority of its neighbours especially to the south west.

There is a small increase in flood depth of up to 8cm immediately to the south of the development but this is contained to the Llys Glanrafon road. The results indicate that there is a small increase to some properties along this road, however, the use of a 4m grid resolution limits the level of detail to accurately represent the true elevations of the streetscape and these buildings. Given the extreme nature of the flood risk and widespread flooding of area already predicted, it is concluded that these affects, if real, will have negligible impact on the risk and consequences of flooding in the area.

In the top right corner of Figure 5-6, there is evidence of a model instability in the area between the A474 and A4067. Attempts have been made to address this instability, but it has not been possible to entirely resolve the issue. The localised small increases and decreases in flood depths in this area do not relate to the proposed development as the areas surrounding this show no change in flood depths. This is deemed to be an unavoidable and acceptable limitation of the flood model.

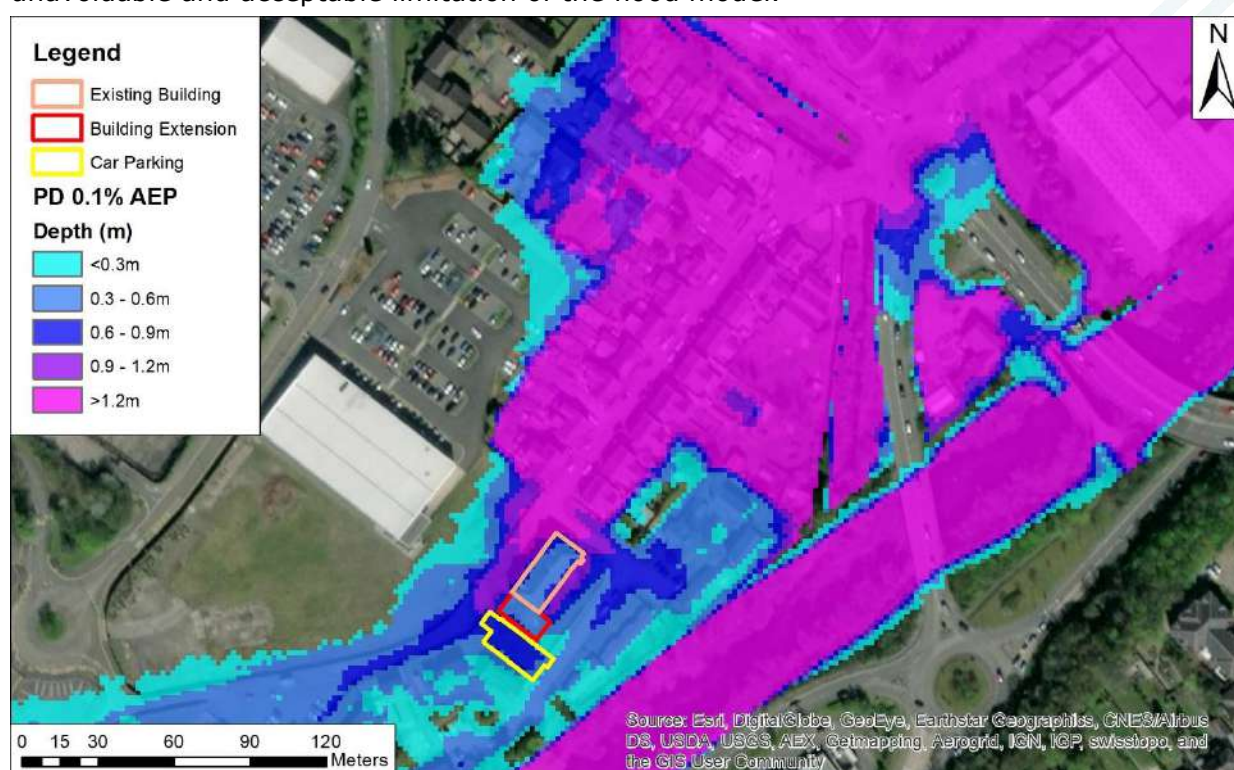


Figure 5-5 0.1% AEP maximum post-development depth

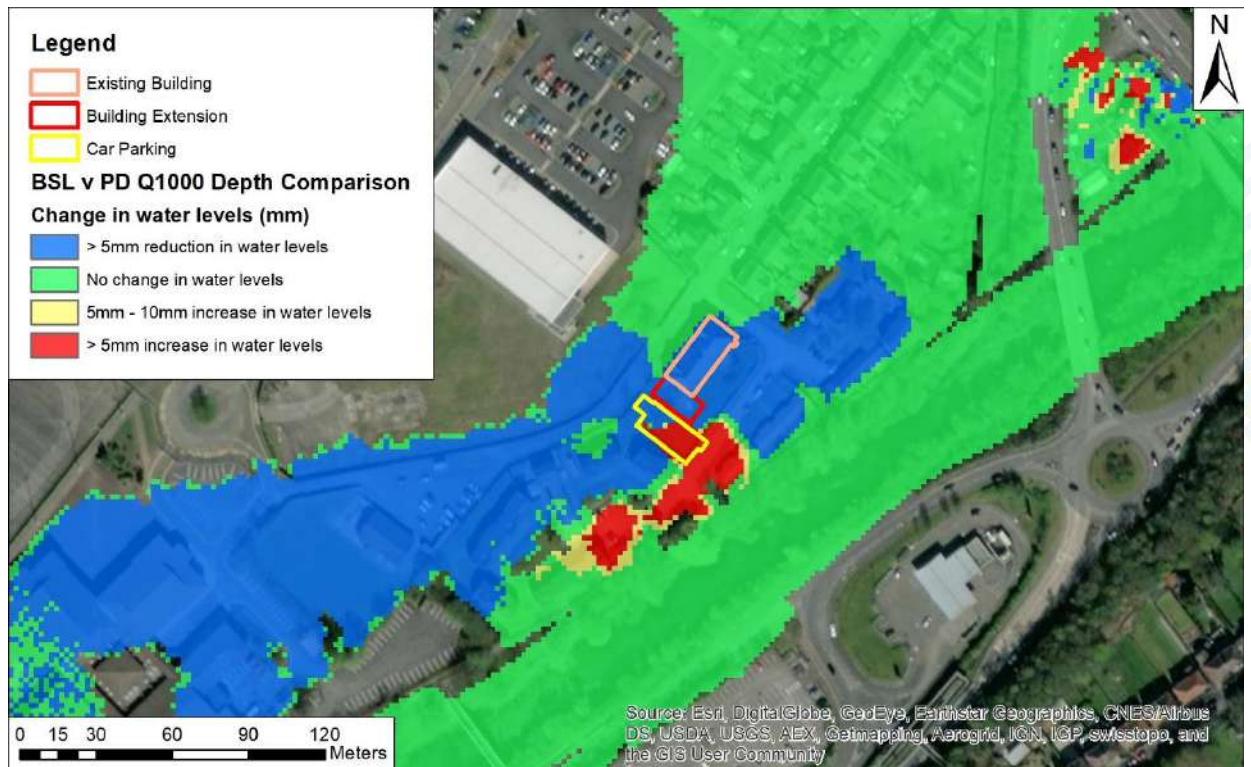


Figure 5-6 0.1% AEP flood depth comparison

6 Assessment of Acceptability Criteria

6.1 Flood risk summary and compliance with TAN-15

The proposed development is flood-free during the 1% AEP plus climate change flood event. In the 0.1% AEP flood event, the majority of the site is at risk of flooding and is predicted to experience depths of up to 0.58m.

A1.14 of TAN-15 outlines the requirement for development to be flood-free in the 1% AEP plus climate change flood event. The site is located above the 1% AEP plus climate change flood level; therefore, it is considered to satisfy A1.14 of TAN-15.

A1.15 of TAN-15 provides indicative guidance concerning the tolerable conditions during the 0.1% AEP event. For residential development, TAN-15 advises that flood depths should not exceed 600mm within the property and the access route. Flood depths for the 0.1% AEP event are a maximum of 580mm on the site. Therefore, the proposed re-development complies with the indicative guidance contained within TAN-15.

TAN-15 requires that any new development does not have an adverse impact on the flood risk to any third-party. Residential buildings surround the site to the east, south and west of the site and commercial buildings to the north. In the 1% AEP event, there is no change in water levels for any of the neighbouring third parties.

In the 0.1% AEP event, widespread benefit is predicted to the east and west of the site. There is a small increase in flood depth of up to 8cm immediately to the south of the development but this is contained to the Llys Glanrafon road. The results indicate that there is a small increase to some properties along this road, however, the use of a 4m grid resolution limits the level of detail to accurately represent the true elevations of the streetscape and these buildings. Given the extreme nature of the flood risk and widespread flooding of area already predicted, it is concluded that these affects, if real, will have negligible impact on the risk and consequences of flooding in the area.

The roads surrounding the development are shown to be at risk of flooding in both the 1% AEP plus climate change and 0.1% AEP events. In the 1% AEP plus climate change event, there is dry pedestrian access and egress to the development via the car parking area onto Llys Glanrafon road, through the neighbouring housing estate and onto Ynisderw Rd. In the 0.1% AEP event, flooding does occur along this route but flood depths remain below 600mm, providing acceptable means of accessible in the event of an emergency.

6.2 Acceptability Assessment

Table 6-1 assesses the proposed re-development against the acceptability requirements required to be met for the development Zone.

Table 6-1 Assessment of accessibility criteria

TAN 15 Justification Criteria	Comments	Achieved
Developer is required to demonstrate that the site is designed to be flood free for the lifetime of development for a 1 in 100 (1%) chance (fluvial) flood event including an allowance for climate change in accordance with TAN-15 table A1.14.	The site is flood-free during the 1% AEP plus climate change event.	Yes

TAN 15 Justification Criteria	Comments	Achieved
The development should be designed so that in an extreme (1 in 1000 chance) event, there would be less than 600mm of water on access roads and within the property.	Flood depths on the site and the site access roads in the 0.1% AEP event are less than 600mm. The model results show a maximum flood depth of 0.58m in the 0.1% AEP event.	Yes
No flooding elsewhere.	As detailed in Section 6.1, in the 1% AEP plus climate change event the proposals are modelled to have no effect on flood risk elsewhere. In the 0.1% AEP event, the model predicts some variation of flood levels around the building. Widespread benefit is predicted to the east and west of the site, and some localised increase in levels to immediate south of the site. The use of a 4m grid resolution limits the level of detail to accurately represent the true elevations of the streetscape and the buildings in the area. Given the extreme nature of the flood risk and widespread flooding of area already predicted, it is concluded that these affects, if real, will have negligible impact on the risk and consequences of flooding in the area.	Yes
Flood defences must be shown by the developer to be structurally adequate particularly under extreme overtopping conditions (i.e. that flood with a 1 in 1000 chance of occurring in any given year).	The proposed re-development benefits from the presence of flood defences upstream of the site. These are NRW owned assets that must be maintained to offer flood protection throughout Pontardawe.	Yes
The developer must ensure that future occupiers of development are aware of the flooding risks and consequences	The developer should ensure future occupiers are aware of the risk of flooding to the site. It is recommended that this done through the preparation and sharing with residents of an emergency flood plan.	Yes

TAN 15 Justification Criteria	Comments	Achieved
Effective flood warnings are provided at the site	The site is included in within the "River Tawe at Ynysderw Road and Cwm-Du, Pontardawe" Flood Warning Area and the "Upper Tawe" Flood Alert Area. It is recommended that building management and occupants sign up for these flood warnings and alerts.	Yes
Escape/evacuation routes are shown by the developer to be operational under all conditions.	There is a pedestrian evacuation route onto Ynysdwerw Road via Llys Glanrafon road which is flood free during the 1% AEP plus climate change flood event. In the 0.1% AEP event, flooding does occur along this route but flood depths remain below 600mm and should be accessible in the event of an emergency.	Yes
The development is designed by the developer to allow the occupier of the facility for rapid movement of goods/possessions to areas away from flood waters.	Flooding, should it occur, will be shallow, but it is recommended that the occupier signs up to the NRW flood warning service so that they are aware of the potential for any flooding and they can prepare for the risk of flooding as guided by an emergency flood plan.	Yes
Development is designed to minimise structural damage during a flooding event and is flood proofed to enable it to be returned to its prime use quickly in the aftermath of the flood.	Flooding, should it occur, will be shallow therefore structural damage is very unlikely and further flood proofing not justified in these circumstances.	Yes

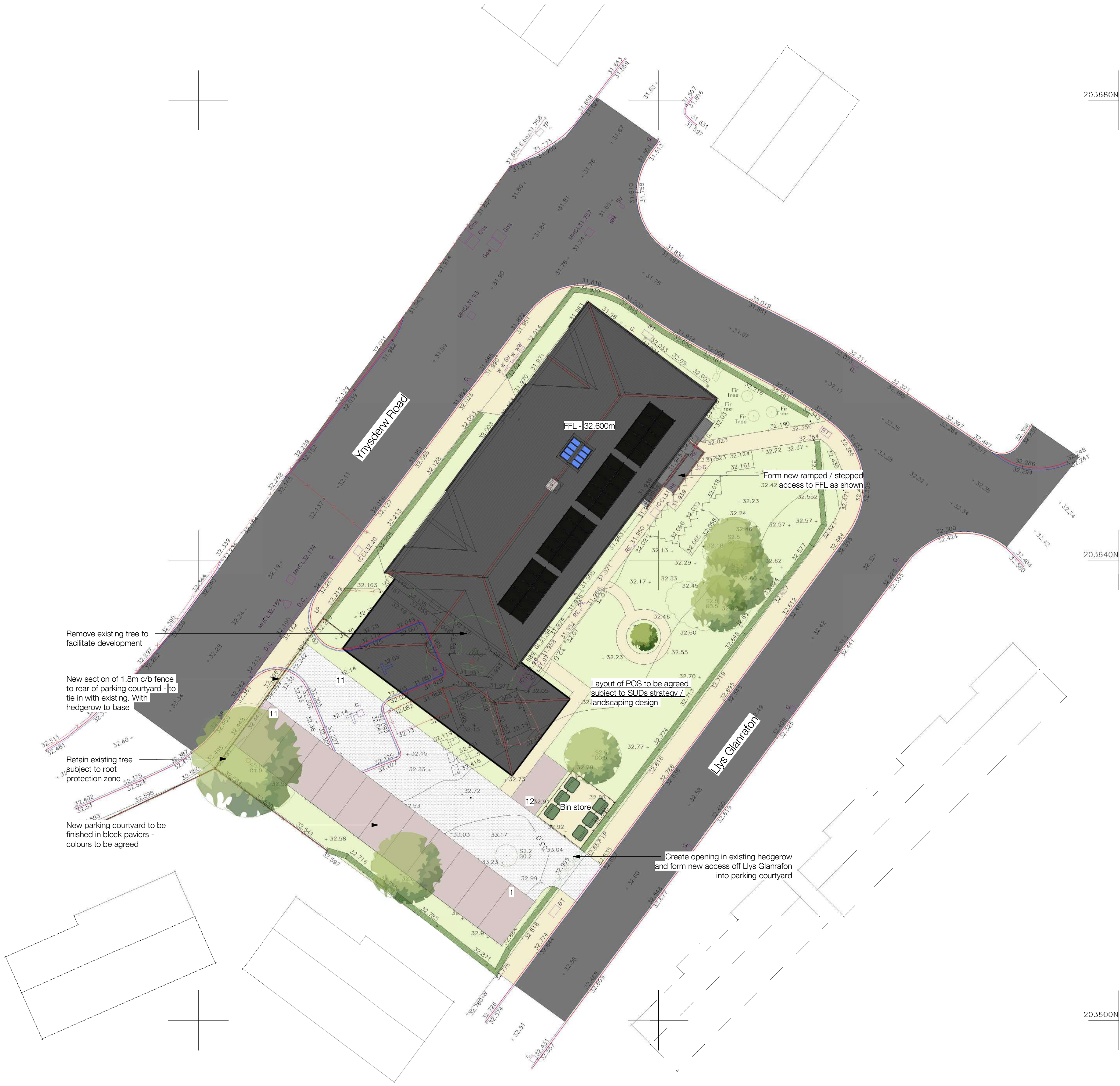
7 Conclusions

- JBA Consulting were commissioned by Pobl Group to prepare a Flood Consequence Assessment (FCA) to support a planning application for the re-development of the existing building and an extension to the rear elevation of Ty Mawr on Ynysdwerw Road.
- The site is 0.15 hectares in size and is comprised of a disused residential building and associated gardens and car parking. The site was used as a former sheltered housing scheme and was classified as C3b under the Wales planning classifications. The previous site was considered highly vulnerable development by TAN-15.
- The proposed development consists of the re-development of the existing building into residential flats, incorporate an extension to the southern extent of the existing building. The development will also include an extension to the existing car parking area. The development is classed as highly vulnerable development by TAN-15. However, the change in planning classification from C3b to C3a could see a reduction in the vulnerability of the occupants and therefore a lowering in risk.
- The site is located within Zone C1, as categorised by NRW's Development Advice Maps. Zone C1 refers to areas of the floodplain served by significant infrastructure, including flood defences. New residential development in C1 must satisfy the Justification Tests of TAN15. Although it is not clear whether the Justification Tests apply to the re-development of an existing residential block, notwithstanding this point this assessment has applied the Justifications Tests in full.
- The NRW flood maps show the majority of the site has a very low risk of flooding from surface water and small watercourses, meaning that most of the site has less than a 1 in 1,000 (0.1% AEP) chance of flooding from this source. A small area of the site along the edge of the existing building has a 1 in 1,000-year (0.1% AEP) chance of flooding.
- The site is not at risk of tidal, groundwater, sewer, or reservoir flooding.
- Detailed flood modelling has been completed in 2021 to provide an improved understanding of flood risk to the site. This has informed the building finished floor levels being set to 32.6mAOD so that the development will be flood free in the 1% AEP plus climate change event and flood to a maximum depth of 0.58m in the 0.1% AEP event.
- In the 1% AEP plus climate change event the proposals are modelled to have no effect on flood risk elsewhere. In the 0.1% AEP event, the model predicts some variation of flood levels around the building. Widespread benefit is predicted to the east and west of the site, and some localised increase in levels to immediate south of the site. The use of a 4m grid resolution limits the level of detail to accurately represent the true elevations of the streetscape and the buildings in the area. Given the extreme nature of the flood risk and widespread flooding of area already predicted, it is concluded that these affects, if real, will have negligible impact on the risk and consequences of flooding in the area.
- An assessment of the Justification Test and Acceptability Criteria has been undertaken, with all aspects found to be satisfied for the site.
- It is concluded that on the grounds of flood risk, the proposed development site is compliant with the aims and objectives of Planning Policy Wales and TAN-15.

Appendices

A Proposed site plans

Revisions		
A	10.10.21	Layouts updated for planning submission
B	29.05.22	Updated following design review



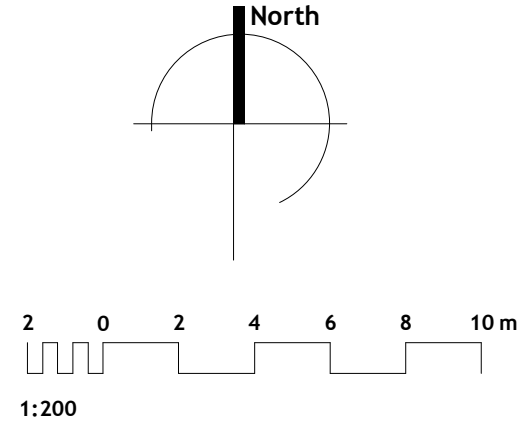
Proposed site plan
1 : 200

Schedule of accommodation

6no. 2b3p Apartments (60 - 74m²)
6no. 1b2p Apartments (47-52m²)

Total 12 homes

12 Parking spaces
Bin store
Amenity space
1no. Communal lounge per floor



Notes

Do not scale from this drawing. Use figured dimensions only, which are displayed in millimeters unless stated otherwise. The contractor is requested to check all dimensions before work is put in hand. Any discrepancies within the drawing should be reported prior to commencement of works.

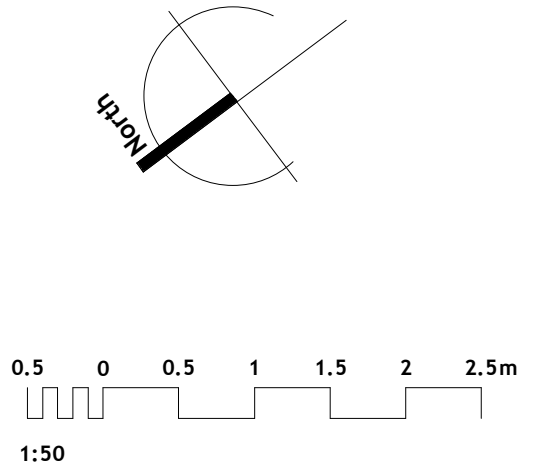
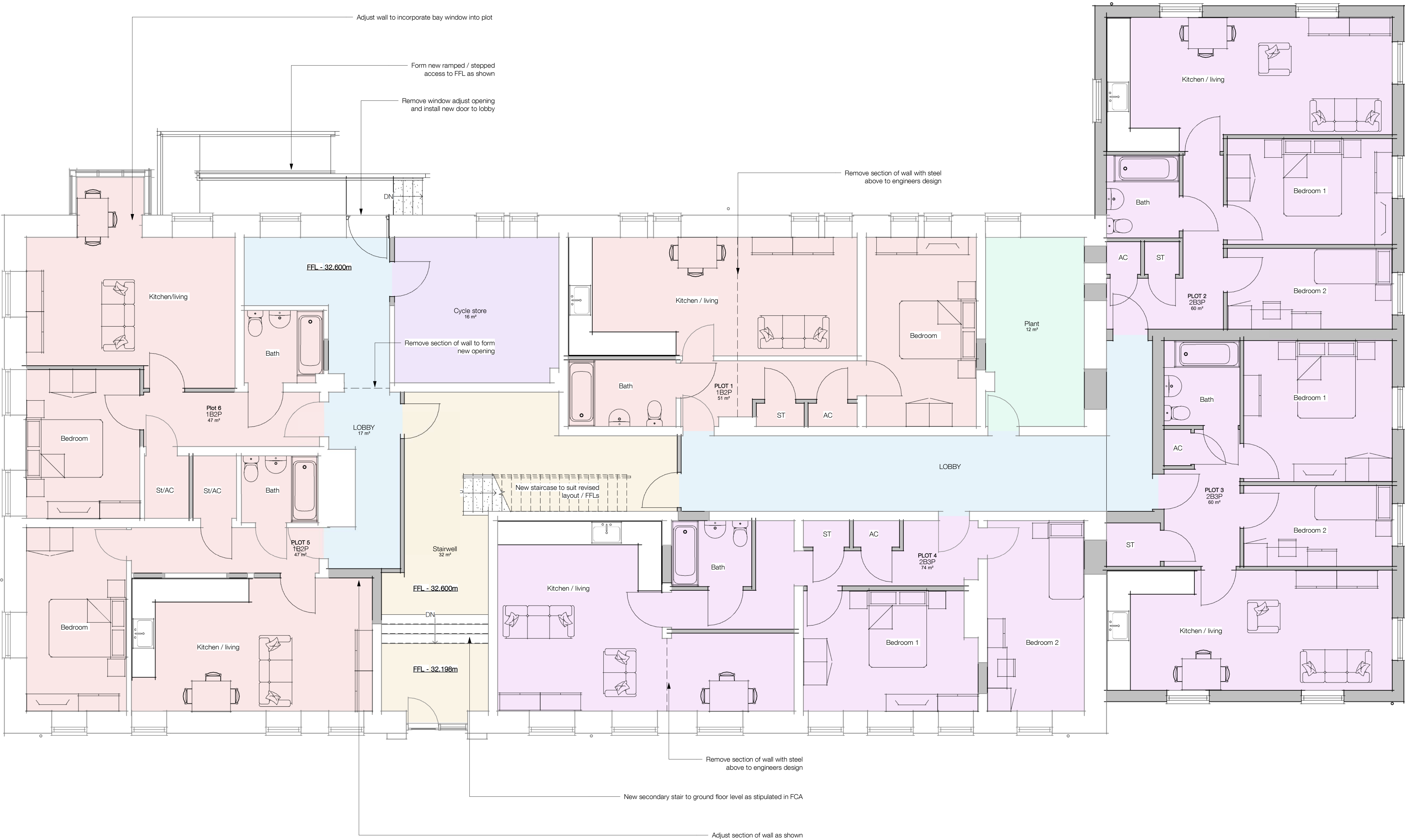
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Project	TY MAWR, PONTARDAWE
Project number	N331
Client	POBL GROUP LTD
Title	Proposed site plan
Drawing number	A005
Scale	1 : 200 at A1
Revision	B
Status	PLANNING
Drawn	PC
Date	20.09.2021

Revisions		
A	10.10.21	Layouts updated for planning submission
B	29.05.22	Updated following design review



Notes

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Project	TY MAWR, PONTARDAWE
Project number	N331
Client	POBL GROUP LTD
Title	Proposed ground floor layout
Drawing number	A006
Scale	1 : 50 at A1
Revision	B
Status	PLANNING
Drawn	PC
Date	20.09.2021

Proposed ground floor plan

1 : 50

B FEH Calculation Record

Flood estimation report: Tŷ Mawr FCA Advice

Introduction

This report template is based on a supporting document to the Environment Agency's flood estimation guidelines. It provides a record of the hydrological context, the method statement, the calculations and decisions made during flood estimation and the results.

Contents

1	Method statement	3
2	Locations where flood estimates required	11
3	Statistical method	13
4	Revitalised flood hydrograph 2 (ReFH2) method	16
5	Discussion and summary of results	18
6	Annex	22

Approval

	Name and qualifications	Date
Method statement prepared by:	Gwyn Jones MSc MESCI	27/10/2021
Method statement reviewed by:	Jenni Essex BSc MSc PhD CEnv MCIWEM C.WEM	27/10/2021
Calculations prepared by:	Gwyn Jones MSc MESCI	27/10/2021
Calculations reviewed by:	Jenni Essex BSc MSc PhD CEnv MCIWEM C.WEM	27/10/2021

Revision History

Revision reference	Date issued	Amendments	Issued to
REVA	Dec 2021	REVA	POBL / NRW

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
CPRE.....	Council for the Protection of Rural England
FARL.....	FEH index of flood attenuation due to reservoirs and lakes
FCA	flood consequence assessment
FEH	Flood Estimation Handbook
GEV	Generalised Extreme Value
GL	Generalised Logistic
HOST	Hydrology of Soil Types
KAP3.....	Kappa 3
NRFA	National River Flow Archive
NRW	Natural Resources Wales
POT	Peaks Over a Threshold
QMED.....	Median Annual Flood (with return period 2 years)
ReFH.....	Revitalised Flood Hydrograph method
SAAR	Standard Average Annual Rainfall (mm)
Tp	Time to peak of the instantaneous unit hydrograph
URBEXT2000.....	Revised index of urban extent, measured differently from URBEXT1990
WINFAP-FEH	Windows Frequency Analysis Package – used for FEH statistical method

Note on flood probability

This document quotes the probability of a flood magnitude in terms of a return period based on analysis of annual maximum (AMAX) floods. The return period of a flood on the AMAX scale is the average interval between AMAX floods of that magnitude or greater. The inverse of the AMAX return period is the annual exceedance probability (AEP).

Return periods are output by the Flood Estimation Handbook (FEH) software and can be expressed more succinctly than AEP. AEP can be helpful when presenting results to non-specialists who may associate the concept of return period with a regular rather than an average interval.

Return period can also be measured on the peaks-over-threshold (POT) scale as the average interval between floods of that magnitude or greater. The difference between AMAX and POT return periods is only important for short return periods (under 10 years).

The table below is provided to enable quick conversion between these different measures.

AMAX return period (years)	n/a	2	5	10	20	30	50	75	100	200	1,000
AEP (%)	n/a	50	20	10	5	3.33	2	1.33	1	0.5	0.1

POT return period (years)	1	1.5	4.5	9.5	20	30	50	75	100	200	1,000
---------------------------	---	-----	-----	-----	----	----	----	----	-----	-----	-------

1 Method statement

1.1 Requirements for flood estimates

Overview	The purpose of the study is to review and update an existing 1D-2D hydraulic model of the Afon/River Tawe at Pontardawe, South Wales, to support a flood consequence assessment (FCA) for a development site at Ty Mawr in Pontardawe. The study requires a new hydrological assessment to be undertaken, to update the existing (2018) model hydrology¹ using the latest methods, software, and data. The analysis was undertaken in accordance with the Natural Resources Wales (NRW) latest flood estimation technical guidance (GN008)². This report documents the hydrological assessment. Inflows representing the Tawe, along with the Upper Clydach and Cwm Du tributaries, are included within the hydraulic model. Design peak flow estimates and hydrographs were derived for a range of annual exceedance probability (AEP) events in the 2018 hydrology assessment. For the current study, peak flow estimates and hydrographs were generated for the following AEP events: 50%, 20%, 10%, 3.33%, 2%, 1% and 0.1%. The effects of climate change will be accounted for using the latest guidance³. An uplift of 30% (change factor / central estimate) will be made to the 1% AEP flow estimates, based on the location of the catchment within the wider West Wales River Basin District.
----------	---

1 JBA Consulting (2018). 2018s1312 – Hydrology_report v2.0

2 Natural Resources Wales (2017). Flood Estimation: Technical Guidance (GN008) version 1.0. Available at:

<https://www.naturalresourceswales.gov.uk/media/684119/gn008-flood-estimation-technical-guidance.pdf>

3 Welsh Government (September 2021). Climate change allowances and flood consequence assessment. Available at: Climate change allowances and flood consequence assessments | GOV.WALES

1.2 The catchment

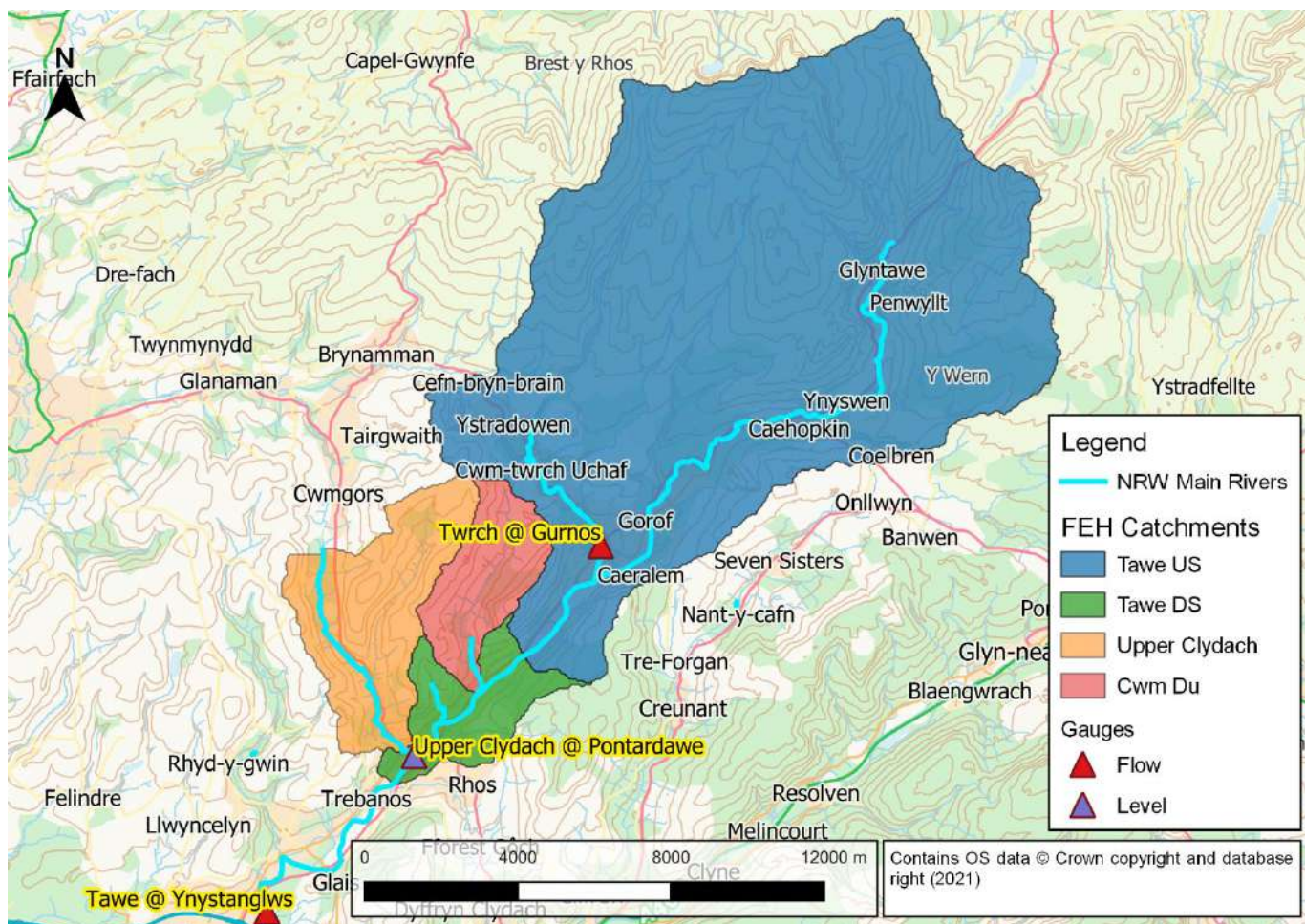


Figure 1-1 - Overview of FEH catchments and gauges

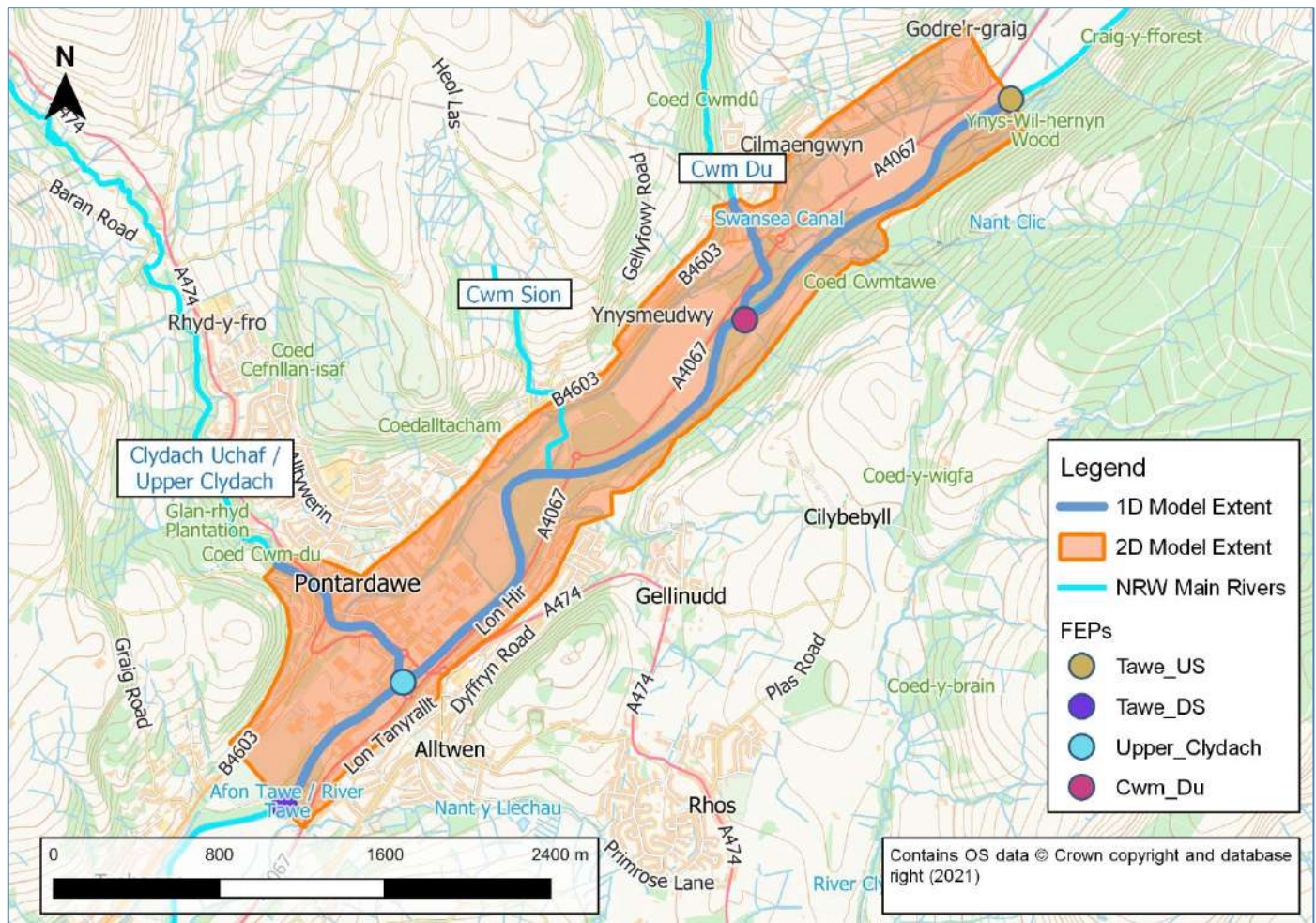


Figure 1-2 - Model extent and FEP locations

Description	The Afon Tawe rises in the mountains of Fforest Fawr in the west of the Brecon Beacons National Park. A third of the catchment lies within the Brecon Beacons National Park boundary. It flows in a south westerly direction through the Swansea Valley to Ystradgynlais and Pontardawe and onwards to Swansea where it discharges into Swansea Bay. At the downstream extent of the model reach the Tawe catchment is approximately 189km². Along the study reach several tributary branches join the Tawe, most notably (for the purpose of this study), from upstream to downstream: • Cwm Du, a right-bank tributary, which drains an area of approximately 10km² and joins the River Tawe upstream of the Pontardawe. • Cwm Sion, a right-bank tributary, which drains an area of approximately 1.2km² and joins the River Tawe between Cwm Du and Pontardawe. • Upper Clydach, a right-bank tributary, draining an area of approximately 19km² which enters the Tawe in the settlement of Pontardawe. Swansea Canal is located parallel to and above the right bank of the River Tawe. The canal extends from approximately 4km upstream of Pontardawe and terminates adjacent to the Upper Clydach. Catchment topography is steep with limited floodplain extent. A small tarn (Llyn y Fan Fawr) feeds the Nant y Llyn, a headwater tributary of the River Tawe; there are no other significant lakes or reservoirs within the catchment. The catchment is essentially rural and livestock farming is the predominant land use. There is substantial forestry and areas of upland heath. The main urban
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areas are Ystalyfera, Ystradgynlais and Pontardawe, with other smaller settlement areas such as Ynyswen further up the catchment. There is historical mining and quarrying within the catchment, with evidence of disused mines in the landscape.

Underlying geology comprises sedimentary bedrock of mixed permeability. Impermeable strata are found in the catchment headwaters while mixed to moderate permeability bedrock is found in the mid and lower catchment, respectively, predominantly Coal Measures.

Soils were assessed using the Soilscape website⁴. Slowly permeable, wet soils are typically found in upland areas and valley slopes with more freely draining soils found in the lower catchment and valley bottom. Isolated extents of restored soils, mostly from quarry and opencast spoil, are predominantly located in upland areas.

The catchment response to rainfall is likely to be rapid due to the steep topography and generally impermeable geology and soils. The more permeable soils located in the middle and lower catchment may act to provide a small amount of storage and hence moderate runoff in more frequent events.

The tarn located in the headwaters is likely to have a minimal impact on runoff response due to its size and location (i.e., in the upper catchment).

The historical mining and quarrying operations may have changed the natural runoff response in some areas of the uplands. It is difficult to determine or quantify the consequences of this, however the areas covered are relatively small compared to the overall catchment size.

1.3 Source of flood peak data

Source	NRFA peak flows dataset, Version 10, released August 2021. This contains data up to water year 2019-20.
--------	---

1.4 Gauging stations (flow or level)

Watercourse	Station name	Gauging authority number	NRFA number	Catchment area (km ²)	Type	Start of record and end if station closed
Tawe	Ynystanglws	059001	59001	228km ²	Velocity Area	10/1956 - Present
Upper Clydach	Pontardawe	NRW 4119	-	18.8km ²	Level	04/2002 to present
Twrch	Gurnos	060017	060017	49.9km ²	Velocity area	01/1995 - present

1.5 Data available at each flow gauging station in Table 1.4

Station name	Start and end of NRFA flood peak record	Update for this study?	OK for QMED ?	OK for pooling ?	Data quality check needed?	Other comments on station and flow data quality
Ynystanglws	1956-2019	N/A	Yes	Yes	No. NRFA gauge	Gravel bed provides unstable control. Early record has

⁴ <http://www.landis.org.uk/soilscape/index.cfm>
2020s1518 - FEH calculation record_v1.0 (Dec 21)

Station name	Start and end of NRFA flood peak record	Update for this study?	OK for QMED ?	OK for pooling ?	Data quality check needed?	Other comments on station and flow data quality
						bypassing >2.75m stage, which is not accounted for in the rating. Embankments and a lower side weir were constructed in 1973 to control flow to floodplain storage; the side weir was raised by ~1m in April 1998 to match the embankment height. The rating was amended in November 1973 and May 1998, presumably to account for the bank changes. Amended ratings were also derived in 1981 and 1985. The later ratings have been verified by hydraulic modelling. The shape of the latest rating looks a little unusual above the bankfull level; the 1973, 1981 and 1985 ratings look a little unusual above the QMED level. Data between water years 1956 and 1972 are rejected in the NRFA, presumably due to bypassing not being accounted for in the rating.
Gurnos	1994 - 2019	N/A	Yes	No	No. NFRA gauge	Flow is contained by the road embankments meaning there is no bypassing/out of bank flow. The rating is calculated by hydraulic modelling. The modelled rating is generally insensitive to parameter change, suggesting reasonably high confidence in the rating despite the absence of high flow gaugings. Despite no bypassing/out of bank flow, there is little variation in the AMAX values. AMAX1 is only 1.5 times larger than QMED and only 1.16 times larger than AMAX2. However, a similar (visual) trend is seen in the Ynystanglws AMAX data over the same period of record.
Tabulate any updated or revised flood peak series in the Annex. Give link/reference to any further data quality checks carried out.					The Ynystanglws AMAX series was updated to include the latest water year, as several significant storm events occurred during that period. The peak flow data for the 2020-21 water year was obtained from the NRW website⁵ and was used to update the	

Station name	Start and end of NRFA flood peak record	Update for this study?	OK for QMED ?	OK for pooling ?	Data quality check needed?	Other comments on station and flow data quality
					QMED estimate. This resulted in the QMED estimate for the gauge increasing from 255m ³ /s (as detailed in the NRFA) to 257m ³ /s. The updated series can be found in the Annex (Section 6.2)	

1.6 Rating equations

Station name	Type of rating	Rating review needed?	Comments and link to any rating reviews
Ynystanglws	Empirical – velocity-area station	No	Rating review is not within scope of the study and the gauge is not within the model reach.
Gurnos	Empirical – velocity-area station	No	

1.7 Other data available and how it has been obtained

Type of data	Data relevant to this study?	Data available ?	Source of data	Details
Check flow gaugings	No	No	N/A	N/A
Historical flood data	Yes	No	Internet	An internet search and review of news articles suggests that Pontardawe has experienced flooding in recent years. Most of these references refer to local impacts from blockage of the Cwm Du, Cwm Sion and Clydach tributaries and were not located at the development site. No evidence was found of flooding from the River Tawe at Pontardawe. Evidence was found for flooding of Pontardawe as a result of the Swansea Canal breach on Friday 23rd October 1998⁶. This resulted from blockage of the Nant Cwm Sion grill inlet and instability of the culvert system under the canal causing significant flows to be passed directly into the canal. The Swansea Canal overtopping flooded a considerable part of the town including Lower Herbert Street, Tawe Terrace, parts of Ynysderw Road and Holly Street and the Alloy Industrial Estate were subject to water depths of up to 6 feet.. Several remediation and flood prevention measures were carried out to the culvert and canal. No information could be found which relates specifically to flooding of the development site.

⁶ Exert of Swansea Canal Breach at Pontardawe on Friday 23rd October 1998: Summary Report British Waterways. Available at:
[https://www.npt.gov.uk/ldpexamination/AP10.3b%20Supporting%20Papers%20re%20British%20Waterways%20Report%20on%20Swansea%20Canal%20\(1999\).pdf](https://www.npt.gov.uk/ldpexamination/AP10.3b%20Supporting%20Papers%20re%20British%20Waterways%20Report%20on%20Swansea%20Canal%20(1999).pdf)

Flow or river level data for events	N/A	N/A	N/A	Flood event analysis is not within the scope of this study.
Rainfall data for events	N/A	N/A	N/A	
Potential evaporation data	N/A	N/A	N/A	
Results from previous studies	Yes	Yes	NRW/ JBA	Information is available for a previous Pontardawe modelling study undertaken by JBA on behalf of NRW ⁷ in 2014. In 2016, further modelling was carried out to support FCA's. Hydrology inflows were generated for the small tributary Cwm Sion as it was considered relevant to those sites, the other hydrology inflows were based on the 2014 NRW hydrology. JBA conducted a further hydrological study in 2018 ¹ in support of a FCA, deriving new flow estimates. NRW considers these values unsuitable for current modelling due to updates in guidance and catchment descriptors.
Other data or information	N/A	N/A	N/A	N/A

1.8 Hydrological understanding of catchment

Conceptual model	The main site of interest is the proposed development site located in the valley bottom and within the natural floodplain environment. Flooding is likely to result from peak flows and volumes exceeding channel capacity in the River Tawe and from peak flows in the Tawe coinciding with peak flows in tributary branches, particularly the Upper Clydach. Surface water may also contribute to flooding in the vicinity of the study site. However, surface water flooding is not within the scope of this hydrology assessment. The model includes fluvial sources of flooding only.
Unusual catchment features	There are no unusual features that would challenge the adequacy of standard FEH methodologies. However, there may be some interaction between the canal and the watercourses (particularly the upstream tributaries).

1.9 Initial choice of approach

Is FEH appropriate?	Yes
Initial choice of method(s) and reasons	Both the FEH Statistical and ReFH2 methods are suitable for peak flow estimation. The study catchments are <1000km², not highly permeable or heavily urbanised. Hydrograph shapes will be derived using the ReFH2 model and scaled to the FEH Statistical method flows if this is the preferred approach for deriving the peak flows. Lateral inflow hydrographs, to be applied to the model downstream of point inflows, will be derived for the intervening catchment area using ReFH2. Modelled flows will be checked at the downstream lumped catchment flow estimation point (detailed in Section 2.1) to ensure that they approximate the preferred peak flow estimates. If necessary, the intervening area hydrographs will be adjusted

⁷ 2016s4324_Phase3_Summary_0.1
2020s1518 - FEH calculation record_v1.0 (Dec 21)

	following this check.
Software to be used	FEH Web Service ⁸ / WINFAP v5 ⁹ / ReFH2.3

⁸ CEH 2015. The Flood Estimation Handbook (FEH) Online Service, Centre for Ecology & Hydrology, Wallingford, Oxon, UK.

⁹ WINFAP-FEH v5 © Wallingford HydroSolutions Limited 2021.
2020s1518 - FEH calculation record_v1.0 (Dec 21)

2 Locations where flood estimates required

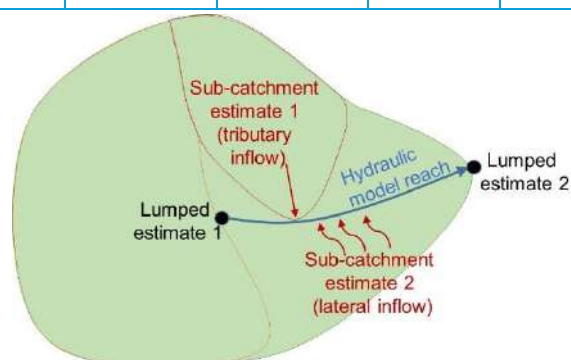
A flow estimation point has been generated for the upstream model extent, the two primary tributaries being modelled (Cwm Du and Upper Clydach) and the downstream extent of the model (as a check flow point). A separate flow estimation point has not been selected for the Cwm Sion tributary in this study; the catchment is small (1.4km²) and the Cwm Sion inflows are not considered a critical mechanism for flooding at the site. The Cwm Sion flows have therefore been included via the intervening area inflow to the model.

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

2.1 Summary of subject sites

Site code	Type of estimate	Watercourse	Name or description of site	Easting	Northing	AREA on FEH Web Service (km ²)	Revised AREA if altered (km ²)
Tawe_US	L	River Tawe	Upstream model extent	275300	206450	151	N/A
Tawe_DS	L	River Tawe	Downstream model extent	271850	203100	189	N/A
Tawe_DS_IA	S	River Tawe	Intervening area between Tawe_DS, Tawe_US, Cwm_Du and Upper_Clydach	N/A	N/A	N/A	9.4
Upper_Clydach	L	Upper Clydach	Tributary inflow, confluence with River Tawe	272350	203700	18.8	N/A
Cwm_Du	L	Cwm Du	Tributary inflow, confluence with River Tawe	274000	205500	9.8	N/A

Note: Lumped catchments (L) are complete catchments draining to points at which design flows are required. Sub-catchments (S) are catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system. There is no need to report any design flows for sub-catchments, as they are not relevant: the relevant result is the hydrograph that the sub-catchment is expected to contribute to a design flood event at a point further downstream in the river system. This will be recorded within the hydraulic model output files. However, catchment descriptors and ReFH model parameters should be recorded for sub-catchments so that the results can be reproduced. The schematic diagram illustrates the distinction between lumped and sub-catchment estimates.



2.2 Important catchment descriptors at each subject site

Site code	FARL	PROPWET	BFIHOST 19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000	FPEXT
Tawe_US	0.994	0.62	0.353	15.0	142	2024	0.018	0.042
Tawe_DS	0.995	0.62	0.366	17.5	144	1953	0.019	0.045

Site code	FARL	PROPWET	BFIHOST 19	DPLBAR (km)	DPSBAR (m/km)	SAAR (mm)	URBEXT 2000	FPEXT
Tawe_DS_IA	N/A	0.62	0.472	3.43	149	1595	0.054	N/A
Upper_Clydach	0.997	0.62	0.408	5.67	156	1690	0.017	0.023
Cwm_Du	1.000	0.62	0.383	4.28	144	1713	0.004	0.038

2.3 Checking catchment descriptors

Catchment boundary checks	OS mapping and LIDAR were used to check the catchment boundaries. The FEH catchment boundary shapefile for each catchment has been overlain within a GIS application and the boundary checked against the surface water network as depicted on OS mapping. The FEH catchment boundary matched reasonably well to OS mapping and LIDAR, with only a few minor errors noted which would make minimal / no difference to the results. Therefore, no adjustments to the catchment boundaries were undertaken.
Other catchment descriptors checks	BFIHOST19 values were checked against the Cranfield University Soilsmap map and found to be sensible for the soil types shown i.e., mixed and moderately permeable. URBEXT and FARL values were checked against OS mapping and found to be sensible. No adjustments were undertaken.
Version of URBEXT	URBEXT2000
Method for updating of URBEXT	CPRE formula from 2006 CEH report on URBEXT2000
Source of BFIHOST	BFIHOST19 was used in the ReFH2 calculations, since the current release (ReFH2.3) was calibrated using BFIHOST19, and also in the FEH Statistical method, since this has been found to improve the results ¹⁰ .

¹⁰ Griffin, A., Young, A. and Stewart, E. (2019). Revising the BFIHOST catchment descriptor to improve UK flood frequency estimates. Hydrology Research. 2020s1518 - FEH calculation record_v1.0 (Dec 21)

3 Statistical method

3.1 Overview of estimation of QMED at each subject site

Site code	Initial QMED rural (m ³ /s)	Final method	Data transfer			Urban adjustment factor (UAF)	Final QMED estimate (m ³ /s)
			NRFA numbers for donor sites used (see 3.3)	Distance between centroids d _{ij} (km)	Adjustment factor (A/B)		
Tawe_US	157	DT	59001	4.592	1.284	1.016	205
Tawe_DS	179	DT	59001	2.267	1.284	1.018	234
Upper_Clydach	19.7	DT	59001	7.677	1.284	1.017	25.8
Cwm_Du	12.4	DT	59001	5.001	1.284	1.003	16.0
Are the values of QMED spatially consistent?					Yes, QMED increases downstream		
Method used for urban adjustment for subject and donor sites					WINFAP v4 ¹¹		
Parameters used for WINFAP v4 urban adjustment if applicable							
Impervious fraction for built-up areas, IF			Percentage runoff for impervious surfaces, PR _{imp}		Method for calculating fractional urban cover, URBAN		
0.3			70%		From updated URBEXT2000		
Notes Methods: DT – Data transfer (with urban adjustment) 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 x QMED _{initial} x UAF Important note on urban adjustment The method used to adjust QMED for urbanisation published in Kjeldsen (2010) ¹² in which PRUAF is calculated from BFIHOST is not correctly applied in WINFAP-FEH v3.0.003. Significant differences occur only on urban catchments that are highly permeable.							

3.2 Search for donor sites for QMED

Nearby gauged catchments were assessed to identify if any were suitable as donors for data transfer.

Recommendations from current research¹³ (and new research¹⁴ to be published soon) indicate that the geographically closest station to the study site tends to produce the best results.

The latest research highlights that descriptors, such as AREA, are included in the regression equation for QMED, so the donor adjustment process accounts for the differences in values between the donor and subject catchments. It also explains that the overarching pattern of QMED model residuals across the UK follows a smooth spatial pattern, hence the recommendation to choose donors by proximity.

There are three potential nearby donors – 59001 (Tawe @ Ynystanglws), 58008 (Dulais @ Cilfrew), and 60017 (Twrch @ Gurnos). 59001 is located downstream of the study site on the

¹¹ Wallingford HydroSolutions (2016). WINFAP 4 Urban adjustment procedures.

¹² Kjeldsen, T. R. (2010). Modelling the impact of urbanization on flood frequency relationships in the UK. Hydrol. Res. **41**. 391-405.

¹³ Kjeldsen, T.R., Jones, D.A. and Bayliss, A.C. 2008. Improving the FEH statistical procedures for flood frequency estimation. Science Report SC050050, Environment Agency.

¹⁴ Stewart, Lisa, Duncan Faulkner, Giuseppe Formetta, Adam Griffin, Tracey Haxton, Ilaria Prosdoci, Gianni Vesuviano and Andy Young (TBC). Estimating flood peaks and hydrographs for small catchments (Phase 2). Report – SC090031/R0, Environment Agency.

same watercourse as the Tawe flow estimation points. 58008 is located to the east on a tributary of the Afon Nedd/River Neath. 60017 is located upstream of the study site on a tributary of the Tawe. All stations show that QMED from catchment descriptors is lower than QMED from flow data. 59001 (Tawe @ Ynystanglws) has been selected as the donor for all flow estimation points. It is the closest station to Tawe_DS, Upper_Clydach and Cwm_Du, based on catchment centroids. The catchment centroid of 60017 is slightly closer to Tawe_US, however, as 59001 is on the same watercourse as Tawe_US, it was decided that 59001 would also be used as the donor for this flow estimation point.

When reviewing the previous study hydrology, NRW stated that 59001 and 60017 show a significant QMED donor adjustment factor, and that use of the moderation term would incorrectly reduce this adjustment factor. It is believed that this refers to the potential for the moderation term to generate spatial inconsistencies between QMED at the flow estimation points on the Tawe and 59001 downstream. This advice was accepted, and the moderation term was not applied for any of the flow estimation points.

As a significant storm occurred in January 2021, the AMAX series for station 59001 was updated to include the 2020 water year and used in the donor adjustment. It should be noted that the additional AMAX value was not used within the pooling analysis. It was thought to be less important in the pooled analysis due to the 'averaging out' of data for specific stations.

3.3 Donor sites chosen and QMED adjustment factors

NRFA no.	Reasons for choosing	Method (AM or POT)	Adjustment for climatic variation?	QMED from flow data (A)	QMED from catchment descriptors (B)	Adjustment ratio (A/B)
59001	See Section 3.2	AM	No	257 (251)*	196	1.28

* The figure in brackets is the QMED value after dividing by the urban adjustment factor, to give the 'as-rural' gauge QMED flow. This is the value that was used to derive the adjustment ratio.

3.4 Derivation of pooling groups

One pooling group was used to represent both Tawe flow estimation points. The pooling group was derived for Tawe_DS as this is closest to the site of interest. Pooling groups for the tributaries are substantially different to the Tawe pooling group and are sufficiently different to each other to warrant using separate groups for Upper Clydach and Cwm Du.

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged?	Changes made to default pooling group, with reasons	Weighted average L-moments
Tawe DS	Tawe_DS	No	Gauge 73012 (Kent @ Victoria Bridge) removed because station 73005 (Kent @ Sedgwick) is on the same watercourse, with the latter retained due to the longer length of record and greater reliability.	L-CV:0.170 L-skew:0.178
Clydach	Upper_Clydach	No	None	L-CV:0.207 L-skew:0.243
Cwm Du	Cwm_Du	No	None	L-CV:0.202 L-skew:0.223

Name of group	Site code from whose descriptors group was derived	Subject site treated as gauged?	Changes made to default pooling group, with reasons	Weighted average L-moments
Note: Pooling groups were derived using the procedures from Science Report SC050050 (2008). 'Urban' pooling groups were used whereby stations with URBEXT2000 < 0.30 are included, rather than only those with URBEXT2000 < 0.03. The L-moments values are the 'deurbanised' values, which is the default setting in WINFAP v5. For Upper Clydach and Cwm Du, the 'small catchments' recommendations available for use within WINFAP v5 were applied. Final pooling groups are detailed in Section 6.1.				

3.5 Derivation of flood growth curves at subject sites

Site code	Method	Name of pooling group	Distribution used and reason for choice	Note any urban adjustment or permeable adjustment	Parameters of distribution	Growth factor for 1% AEP event
Tawe_US	P	Tawe_DS	Generalised Logistic (GL) - GL and Kappa 3 (KAP3) gave an acceptable fit to the data; KAP3 z-value was closest to zero but little different to the GL value, GL selected for consistency with other groups.	Urban adjustment applied. No permeable adjustment required as most / all stations in the pooling groups have SPRHOST >20%.	Location:1.000 Scale:0.168 Shape:-0.181	2.20
Tawe_DS	P	Tawe_DS			Location:1.000 Scale:0.167 Shape:-0.181	2.20
Upper_Clydach	P	Clydach			Location:1.000 Scale:0.201 Shape:-0.246	2.72
Cwm_Du	P	Cwm Du			Location:1.000 Scale:0.200 Shape:-0.224	2.60
Notes Methods: P – Pooled A pooling group (or ESS analysis) derived at one gauge can be applied to estimate growth curves at a number of ungauged sites. Each site may have a different urban adjustment, and therefore different growth curve parameters. Urban adjustments are all carried out using the method of Kjeldsen (2010). Growth curves were derived using the procedures from Science Report SC050050 (2008).						

3.6 Flood estimates from the statistical method

Site code	Flood peak (m ³ /s) for the following AEP (%) events						
	50	20	10	3.33	2	1	0.1
Tawe_US	205	259	297	364	399	451	677
Tawe_DS	234	296	340	416	456	516	775
Clydach	25.8	34.4	40.9	53.0	59.6	70.0	120
Cwm_Du	16.0	21.2	25.0	32.0	35.8	41.6	68.6

4 Revitalised flood hydrograph 2 (ReFH2) method

4.1 Parameters for ReFH2 model

In accordance with research findings, all catchments with URBEXT2000 up to 0.30 were modelled as if they were rural. Research on flood estimation in small catchments¹⁵ found that flood frequency estimates on such catchments were more accurate if the catchment was treated as rural. This reflects the difficulty of generalising the complex and locally-specific effects that urban development has on flood flows.

All catchments				
Site code	Method	C _{max} (mm)	T _{p_{rural}} (hours)	BL (hours)
Tawe_US	CD	3.23	245.65	37.11
Tawe_DS	CD	3.51	254.09	39.20
Upper_Clydach	CD	1.80	283.38	32.77
Cwm_Du	CD	1.57	265.56	29.66
Link to details of any lag or flood event analysis		N/A		
Version of the ReFH2 model applied		ReFH2.3 using the water balance option. This treats BR (baseflow recharge) as a state variable rather than a parameter, setting it automatically in order to conserve volume. The values of BR vary with return period and so are not reported here.		
Parameters for urban runoff model		Impervious fraction of urban areas (IF): default of 0.4 retained. Impervious runoff factor (IRF): default of 0.7 retained. Depression storage: default of 0.5mm retained. Tp for runoff from areas modelled as positively drained was calculated as 0.75 times T _{p_{rural}} .		
Methods: CD: Catchment descriptors				

4.2 Design events for ReFH2 method: Lumped catchments

Site code	Urban or rural	Season of design event (summer or winter)	Storm duration (hours)
Tawe_US	Rural	Winter	9.50
Upper_Clydach	Rural	Winter	4.75
Cwm_Du	Rural	Winter	4.25
Tawe_DS	Rural	Winter	10.50

4.3 Design events for ReFH2 method: Sub-catchments and intervening areas

¹⁵ Stewart, Lisa, Duncan Faulkner, Giuseppe Formetta, Adam Griffin, Tracey Haxton, Ilaria Prosdoci, Gianni Vesuviano and Andy Young (2021). Estimating flood peaks and hydrographs for small catchments (Phase 2). Report – SC090031/R0, Environment Agency.
2020s1518 - FEH calculation record_v1.0 (Dec 21)

Site code	Season of design event	Storm duration (hours)	Storm area for ARF (if not catchment area)(km ²)
All	Winter	10.5	189
Are the storm durations likely to be changed in the next stage of the study		Yes. The individual storm durations above have been used to generate peak flow estimates for comparison with the FEH Statistical method estimates. For application to the hydraulic model a uniform storm duration and areal reduction factor (ARF) will be used. This will be based on the Tawe_DS flow estimation point; a 10.5hr storm duration and ARF set to the value of Tawe_DS will be applied for all inflow hydrographs.	

4.4 Flood estimates from the ReFH2 method

Note: This table is for recording results for lumped catchments. There is no need to record peak flows from sub-catchments or intervening areas that are being used as inputs to a semi-distributed model of the river system.

Site code	Flood peak (m ³ /s) for the following AEP (%) events						
	50	20	10	3.33	2	1	0.1
Tawe_US	151	193	221	267	290	325	506
Tawe_DS	169	213	243	292	317	354	555
Upper_Clydach	16.1	20.7	24.0	29.4	32.1	36.2	60.7
Cwm_Du	9.7	12.7	14.8	18.2	19.9	22.4	37.4

5 Discussion and summary of results

5.1 Comparison of results from different methods

This table compares peak flows from various methods with those from the FEH Statistical method for two key AEP events.

Site code	Ratio of peak flow to FEH Statistical peak					
	50% AEP			1% AEP		
	ReFH2	FEH	Ratio	ReFH2	FEH	Ratio
Tawe_US	151	205	0.74	325	451	0.72
Upper_Clydach	16.1	25.8	0.62	36.2	70.0	0.52
Cwm_Du	9.7	16.0	0.60	22.4	41.6	0.54
Tawe_DS	169	234	0.72	354	516	0.69

5.2 Final choice of method

Choice of method and reasons	The FEH Statistical method is considered to be most appropriate for determining flow frequency at the flow estimation points. Data transfer from a donor station was used to improve the QMED estimate. This donor is on the same watercourse as the Tawe flow estimation points and should be very representative The ReFH2 method flows presented here are based solely on catchment descriptors. For this reason, there can be expected to be lower confidence in the flow estimates derived from the ReFH2 model. The ReFH2 flows are smaller than those generated via the Statistical method. This is likely to be predominantly due to the data transfer procedure increasing the QMED value derived from catchment descriptors for the Statistical method. Although the Statistical method is preferred, there are significant uncertainties associated with applying it to events beyond the 0.5% AEP event, due to the typically short length of river gauge records. To reduce these uncertainties, a hybrid approach was taken to derive the 0.1% AEP event flow, as recommended in NRW's (2017) latest guidance on flood estimation. The 1% AEP event peak flows from the Statistical method were adjusted using the ratio of the 0.1% and 1% AEP event flows from the ReFH2 model.
How will the flows be applied to a hydraulic model?	The ReFH2-generated hydrographs have been scaled to fit the peak flow estimates from the Statistical method. The Tawe_US hydrograph will be applied as a point inflow at the upstream extent of the hydraulic model and routed. Point inflows representing the tributary branches Upper_Clydach and Cwm_Du will also be applied. Lateral flows (i.e., the unaccounted flow between Tawe_US and Tawe_DS) will be distributed by area-weighting the intervening area hydrograph based on tributary catchments joining the Tawe within the model reach (i.e. Nant Clic, Nant Gelli-Nedd, and Cwm Sion). The modelled flows at Tawe_DS will be checked to ensure that they approximate the lumped estimates from the hydrological assessment. If necessary, the intervening area hydrographs will be scaled to better approximate the lumped estimate.

5.3 Assumptions, limitations and uncertainty

Assumptions	The main assumptions are: - The pooling groups used to define the growth curve for the FEH Statistical method are representative of the study catchments. This is likely to be the case for the River Tawe but may not be for the smaller
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	tributaries as these catchments are not well represented in the dataset. - It is appropriate, in this case, to directly apply the QMED donor factor and not use the moderation term. Application of the moderation term can lead to spatial inconsistencies between the flow estimates at the sites of interest and the gauge. - The ReFH2 model provides a representative hydrograph shape. - The storm duration selected is representative of the critical conditions for the Afon Tawe, and the Afon Tawe is the main flood risk source for the proposed development site.
Limitations	The main limitations are: - The FEH Statistical method has been applied beyond the AEP event range of the 1%, the reliability of estimates above is reduced above this AEP. This has been moderated by applying the ReFH2 0.1%:1% AEP ratio to the Statistical method 1% AEP event flow. - There are no flow records at the site of interest, or historical flooding information, available for calibration and verification of the hydrological models.
Uncertainty	It is not possible to directly quantify the uncertainty for the ReFH2 method. There is no method provided in the FEH for estimating uncertainty for the common situation of an ungauged catchment, pooled growth curve and QMED estimated from a donor catchment. The uncertainty will depend on many factors, for example, how unusual the study catchment is relative to the pooling group and donor catchment, and the uncertainty in flow measurement at other gauges. A UK average measure of uncertainty is presented in a technical guidance report¹⁶ generated by a R&D project into the FEH, local data and uncertainty (Environment Agency funded consortium of JBA, CEH and others). The report presents results for rural catchments ($URBEXT2000 < 0.03$) and moderately urbanised catchments ($0.03 \leq URBEXT2000 < 0.15$). The 95% confidence limits for a 1% AEP flood estimate for a rural catchment are: • With donor adjustment of QMED (one donor): 0.47 – 2.12 times the best estimate
Suitability of results for future studies	The design peak flow estimates and hydrographs were derived for the purposes of this modelling study. If peak flow estimates and hydrographs are required for a different purpose it is recommended that, at a minimum, a review of the results is carried out
Other comments on the study	To improve confidence in peak flow estimates and hydrograph shape further assessment of the Upper Clydach level gauge could be undertaken. This is not within the scope of this study but could be considered for future studies. The data could be assessed to determine if the gauge could be used to improve the T_p estimate; this would also require suitable event rainfall data. It may also be possible to generate a modelled rating for the gauge. This would need an assessment of whether the gauge is in a suitable location for flow measurement.

5.4 Checks

Are the results consistent, for example at confluences?	Yes.
What do the	There is no flow gauge at the site of interest against which to compare the

¹⁶ Environment Agency. 2017. Using local data to reduce uncertainty in flood frequency estimation. 2020s1518 - FEH calculation record_v1.0 (Dec 21)

results imply regarding the frequency of floods during the period of record?	design flow estimates.																																	
What is the range of 1% AEP event growth factors?	The 1% AEP event growth factor is: - FEH Statistical: 2.20 (Tawe); 2.60-2.71(tributaries). - ReFH2: 2.09-2.15 (Tawe); 2.25-2.31 (tributaries) The normal range of values is 2.1-4.0. The values for the Tawe are therefore at the lower end of the range. These values are realistic for a steep, wet catchment where flows are expected to be high for less frequent events (therefore constraining the flood growth curves). The tributary catchments are slightly more permeable than the wider Tawe catchment and therefore the slightly higher growth factor for these catchments is reasonable.																																	
What is the range of ratios for 0.1% over 1% AEP event flow?	The 0.1%/1% AEP event ratio is: - FEH Statistical: 1.50 (Tawe); 1.65-1.72 (tributaries) - ReFH2: 1.56-1.57 (Tawe); 1.67-1.68 (tributaries)																																	
How do the results compare with those of other studies?	Table 5-1 shows that peak flow estimates for the current study are universally higher than those derived for the 2018 study. There are several factors leading to this increase: - BFIHOST was updated with BFIHOST19 for the current study, which reduced this value and increased catchment descriptor QMED by 5%-10% - The moderation term was removed from the QMED adjustment procedure, with the QMED donor adjustment factor being directly applied. This increased the adjustment from 1.13-1.20 for the 2018 study to 1.28 for all locations for the current study. - The new small catchments recommendations were applied to the tributaries. The results from the current study are preferred as they use the latest datasets, software, and guidance. Table 5-1: Comparison with previous study design peak flow estimates <table><tr><th rowspan="3">Station code</th><th colspan="4">Flood peak for AEP event (m³/s)</th></tr><tr><th colspan="2">50%</th><th colspan="2">1%</th></tr><tr><th>2018</th><th>2021</th><th>2018</th><th>2021</th></tr><tr><td>Tawe_US</td><td>175</td><td>205</td><td>383</td><td>451</td></tr><tr><td>Tawe_DS</td><td>207</td><td>234</td><td>437</td><td>516</td></tr><tr><td>Upper_Clydach</td><td>20.5</td><td>25.8</td><td>50.5</td><td>70.0</td></tr><tr><td>Cwm_Du</td><td>13.7</td><td>16.0</td><td>33.9</td><td>41.6</td></tr></table>	Station code	Flood peak for AEP event (m³/s)				50%		1%		2018	2021	2018	2021	Tawe_US	175	205	383	451	Tawe_DS	207	234	437	516	Upper_Clydach	20.5	25.8	50.5	70.0	Cwm_Du	13.7	16.0	33.9	41.6
Station code	Flood peak for AEP event (m³/s)																																	
	50%		1%																															
	2018	2021	2018	2021																														
Tawe_US	175	205	383	451																														
Tawe_DS	207	234	437	516																														
Upper_Clydach	20.5	25.8	50.5	70.0																														
Cwm_Du	13.7	16.0	33.9	41.6																														
Are the results compatible with the longer-term flood history?	There is no flow gauge data within the study area against which to compare flows. Flood history that has been identified through this assessment is primarily related to tributary flows that have become blocked from debris or other confounding factors rather than high flow events effecting the study area.																																	
Describe any other checks on the results	Modelled flood levels and extents will be sense-checked to ensure that flow inputs result in realistic outputs.																																	

5.5 Final results

These results are derived from the FEH Statistical method up to the 1% AEP event. The 0.1% AEP event estimates are derived using the ReFH2 ratio applied to the 1% AEP event Statistical method peak flow.

Site code	Flood peak (m ³ /s) for the following AEP (%) events						
	50	20	10	3.33	2	1	0.1
Tawe_US	205	259	297	364	399	451	702
Tawe_DS	234	296	340	416	456	516	809
Upper_Clydach	25.8	34.4	40.9	53.0	59.6	70.0	117
Cwm_Du	16.0	21.2	25.0	32.0	35.8	41.6	69.5

If flood hydrographs are needed for the next stage of the study, where are they provided?	Final_Hydrographs.xlsx
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6 Annex

6.1 Final pooling groups

6.1.1 Tawe_US

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
58002 (Neath @ Resolven)	0.082	42	222.5	0.176	0.304	1.173
59001 (Tawe @ Ynystanglws)	0.272	46	255.3	0.133	0.233	1.541
58001 (Ogmore @ Bridgend)	0.323	60	117.3	0.150	0.041	0.967
72005 (Lune @ Killington)	0.366	51	271.3	0.198	0.131	0.662
55026 (Wye @ Ddol Farm)	0.366	51	115.5	0.170	0.113	0.301
56006 (Usk @ Trallong)	0.372	44	163.6	0.200	0.183	0.661
3002 (Carron @ Sgodachail)	0.393	45	177.9	0.147	0.158	0.211
46003 (Dart @ Austins Bridge)	0.445	62	232.8	0.167	0.105	0.452
73005 (Kent @ Sedgwick)	0.447	52	164.9	0.222	0.282	1.758
27096 (Wharfe @ Netherside Hall)	0.456	17	215.0	0.139	0.133	2.274
73012 (Kent @ Victoria Bridge) - Rejected	0.369	42	144.1	0.203	0.258	
Total		470				
Weighted means				0.170	0.178	

6.1.2 Clydach

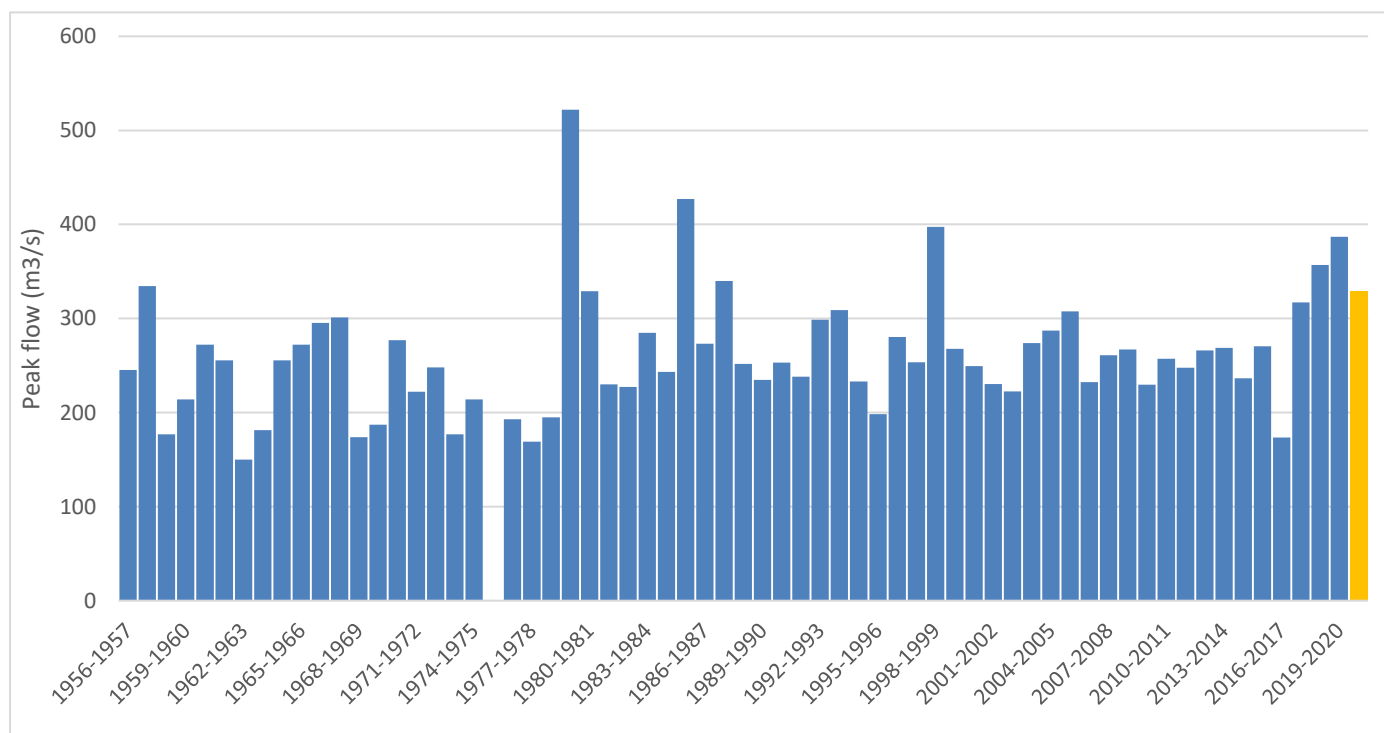
Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
49003 (De Lank @ De Lank)	0.153	54	13.6	0.224	0.217	0.659
206006 (Annalong @ Recorder)	0.211	48	15.3	0.189	0.052	2.664
25012 (Harwood Beck @ Harwood)	0.290	51	33.3	0.186	0.224	0.364
48009 (St Neot @ Craigshill Wood)	0.358	12	8.5	0.245	0.372	0.981
27032 (Hebden Beck @ Hebden)	0.491	54	4.1	0.206	0.232	0.307
48004 (Warleggan @ Trengoffe)	0.506	51	9.9	0.255	0.261	1.125
25011 (Langdon Beck @ Langdon)	0.514	34	15.9	0.228	0.316	0.807
25003 (Trout Beck @ Moor House)	0.525	47	15.2	0.166	0.291	1.830
48001 (Fowey @ Trekeivesteps)	0.536	51	17.3	0.216	0.286	0.070
71003 (Croasdale Beck @ Croasdale Flume)	0.542	37	10.9	0.212	0.323	0.635
21017 (Ettrick Water @ Brockhoperig)	0.574	41	60.4	0.203	0.276	0.191
57010 (Ely @ Lanelay)	0.587	21	39.0	0.162	0.210	2.368
Total		501				
Weighted means				0.207	0.243	

6.1.3

6.1.4 Cwm Du

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
71003 (Croasdale Beck @ Croasdale Flume)	0.278	37	10.9	0.212	0.323	0.422
206006 (Annalong @ Recorder)	0.303	48	15.3	0.189	0.052	2.019
25003 (Trout Beck @ Moor House)	0.326	47	15.2	0.166	0.291	0.744
106002 (Laxdale @ Laxdale)	0.438	12	17.4	0.103	0.132	2.016
25011 (Langdon Beck @ Langdon)	0.497	34	15.9	0.228	0.316	0.789
47022 (Tory Brook @ Newnham Park)	0.623	26	5.9	0.259	0.192	1.802
49003 (De Lank @ De Lank)	0.639	54	13.6	0.224	0.217	0.182
28033 (Dove @ Hollinsclough)	0.712	45	4.2	0.225	0.373	1.264
69047 (Roch @ Littleborough)	0.749	24	9.4	0.241	0.152	0.977
48009 (St Neot @ Craigshill Wood)	0.761	12	8.5	0.245	0.372	0.725
25012 (Harwood Beck @ Harwood)	0.762	51	33.3	0.186	0.224	0.510
27032 (Hebden Beck @ Hebden)	0.823	54	4.1	0.206	0.232	0.295
46005 (East Dart @ Bellever)	0.866	56	39.7	0.155	0.052	1.253
Total		500				
Weighted means				0.202	0.223	

6.2 Ynystanglws - Updated AMAX series



Calculated AMAX for 2020-2021 water year is shown in yellow.

C Topographic Survey



Ty Mawr
Ynysderw Road
Pontardawe

Notes:

Survey Grid
Grid related to O/S Grid at survey point S2
272305.775mE, 203653.272mN, 32.449m

Survey Datum
Related to O/S Grid at Survey Point S2
Value 32.449m

Sheet 1 of 1	Surveyed By: P.M.S.
--------------	---------------------

Datum	Drawn By: P.M.S.
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See Notes Above for Datum	Date of Survey: September 2021
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North Point Approximate	Scale: 1:200
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Client:	Survey Job No.
Pobl Group	SS-1210_2D

Revisions:

A

B

C

Legend:

[illegible]

Survey Station Schedule

Station	Easting	Northing	Level
S1	272282.655	203624.311	32.771
S2	272305.775	203653.272	32.449
S3	272288.166	203650.078	32.149
S4	272279.734	203673.079	31.804
S5	272248.910	203633.970	32.156
S6	272237.539	203621.427	32.530
S7	272267.598	203629.049	31.993



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