ARUP

Natural Resources Wales

Ynysybwl Strategic Outline Case

Shortlist hydraulic modelling report

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Ove Arup & Partners Limited
4 Pierhead Street
Capital Waterside
Cardiff
CF10 4QP
United Kingdom
arup.com

ARUP

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1. Introduction

Ove Arup and Partners Limited (Arup) has been appointed by Natural Resources Wales (NRW) to undertake a Strategic Outline Case for the proposed Ynysybwl Flood Risk Management scheme centred on the Nant Clydach.

As part of the Strategic Outline Case (SOC), hydraulic modelling is required to identify and assess potential flood alleviation options. The potential options are required to reduce the risk of flooding to the 16 properties at Clydach Terrace. These properties experienced significant internal flooding during the Storm Dennis flood event in February 2020.

A long listing exercise has been undertaken previously to identify and assess potential flood alleviation schemes at Clydach Terrace, the details of which are provided in document 290076-ARP-00-XX-RP-CX-1010.

Based on the outputs of the longlisting exercise, a shortlist of potential options has been developed. A further modelling assessment has been undertaken to refine the modelled representation of the options and produce flood outputs for input to the economic appraisal. This report details the modelling that has been undertaken, the outcomes of the study, and the conclusions of the modelling exercise.

1.1 Background and location

The site is located in Ynysybwl, Rhondda Cynon Taf (nearest post code: CF37 3LT, central grid reference: ST 06008 94561).

The Clydach is a small tributary of the River Taff which enters the Taff on its western bank midway between the confluences of the Rhondda and Cynon. The watercourse is short and steep in a confined upland valley where the course of the stream is flanked by residential properties.

Historically the river has been diverted. Clydach Terrace lies on the natural floodplain in a very constrained section of the Clydach valley upstream of a large culvert. The Terrace has historically suffered from severe flooding from records dating back to 1955. Notably during Storm Dennis in February 2020, flood waters from the Nant Clydach overtopped the highway wall which runs along the length of the Terrace, internally flooding 16 properties. Flooding experienced was significant, with rapid onset and the internal depth of flooding to the lowest lying houses was reportedly up to 1.8m.

No formal flood defences are currently present at Ynysybwl although the highway wall acts as a de-facto defence. The river is prone to shoaling. NRW and its predecessor bodies have undertaken channel maintenance to remove shoal material from the river channel adjacent to Clydach Terrace.

1.2 Previous work

The shortlist option modelling has been undertaken using the NRW approved model of the Nant Clydach which was developed by Arup in 2022. The model comprises a linked 1D-2D ESTRY-TUFLOW model, with the channel and structures represented in 1D and the floodplain and upper catchment represented in 2D. Further information regarding the construction of the model, verification against storm events and hydrological analysis are presented in document, 290003-ARP-YX-RP-00-00-W0-0002, the Project Report for the previous phase of work commissioned by NRW. The model technical report is included as Appendix A of the Project Report.

A direct rainfall approach has been utilised due to concerns regarding hydrological routing accuracy in the upper catchment, the need to represent the contribution of surface water flood risk, the small size of the catchment and the likelihood of future model uses including the assessment of Natural Flood Management (NFM) in the upper catchment.

This model was used previously to assess the longlist of potential FRMS options.

2. Baseline Options

Welsh Business Justification Case Guidance[1] recommends the development of a Business as Usual (BAU) and Walkaway (WAW) scenario to provide a baseline for comparison with any intervention to determine whether it represents value for money.

The BAU option typically represents the continuation of the existing Flood and Coastal Erosion Risk Management (FCERM) regime as existing, and can include routine maintenance, inspection and repair of existing assets. Alternately, the WAW option is the cessation of all current activities.

The assumptions used to represent the BAU and WAW scenarios in the modelling have been informed by discussion with NRW and the assumptions previously made in the Initial Assessment stage of the project.

2.1 Walkaway

The following assumptions have been made for the WAW scenario model:

- 67% blockage of the Ynysybwl tunnel;
- An increase in shoal depth of 0.5m; and
- No vegetation clearance.

The assumptions made reflect the predicted outcome of cessation of current maintenance activities based on previous amounts of shoaled material removed by NRW and the current maintenance regime. The culvert blockage percentage has been informed by NRW Guidance Note 43[2], Modelling Blockage and Breach Scenarios. The Medium blockage proportion of 67% has been chosen as a high level assumption for this appraisal. It is acknowledged that this is a basic approach, and in reality it is unlikely that such a significant blockage would occur across the full width of the culvert structure. However, this assumption is considered appropriate at this stage of assessment.

The Ynysybwl culvert structure is represented in the model using a series of irregular culvert units. The blockage proportion factor is not available for this type of structure, and therefore to represent the blockage of the culvert the width of the upstream culvert section has been reduced by the required blockage proportion. This effectively represents a vertical blockage within the culvert. The 67% reduction in culvert width is shown in Figure 1.

[1] Welsh Government, 2019 "Flood and Coastal Erosion Risk Management, Business Case Guidance", (flood-and-coastal-erosion-risk-management-fcerm-business-case-guidance_0.pdf (gov.wales) Accessed 23/01/2024)

[2] Natural Resources Wales, 2021 "Flood Risk Management: Modelling blockage and breach scenarios", (https://cdn.cyfoethnaturiol.cymru/media/692247/gn43-modelling-for-breach-and-blockage-scenarios-accessible.pdf, accessed February 2024)

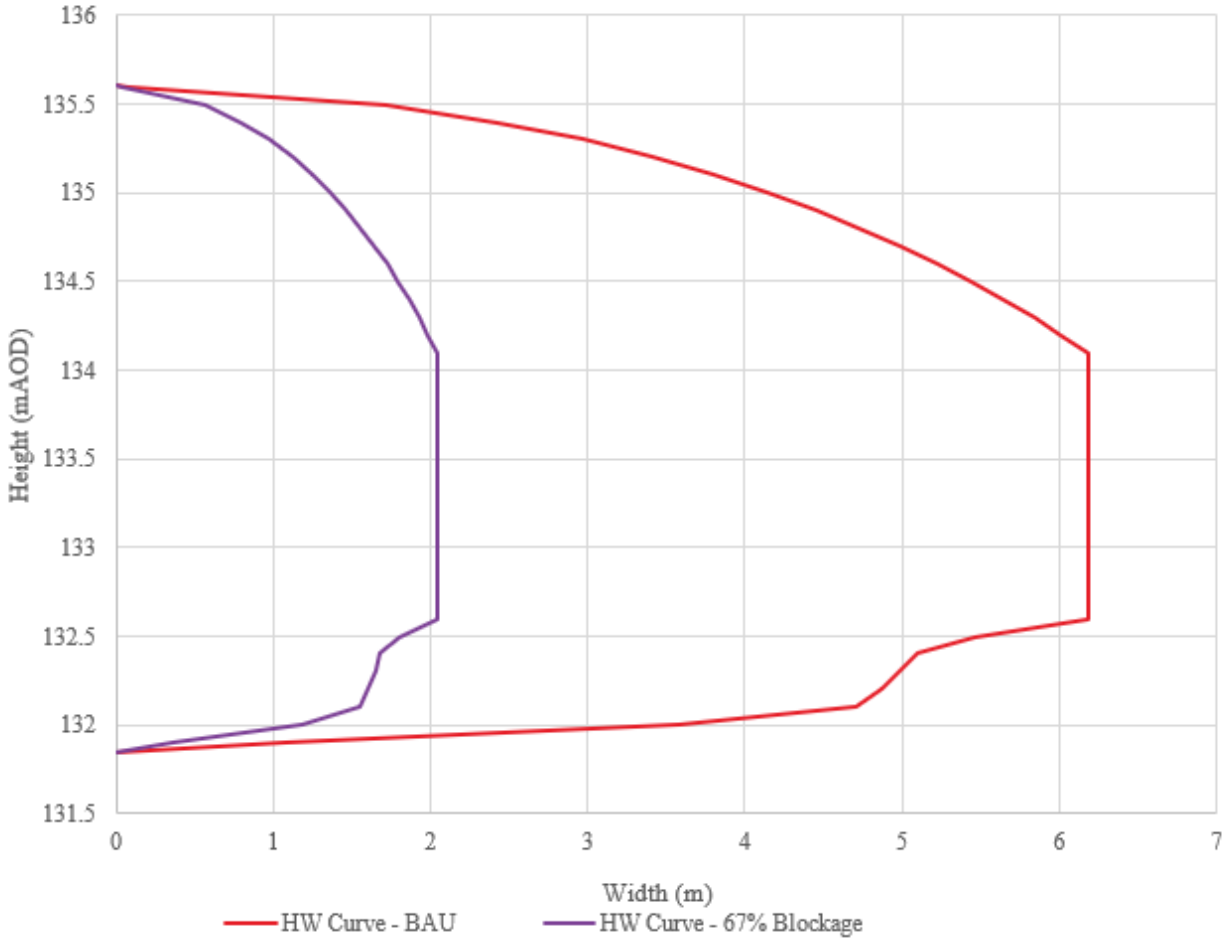

Figure 1 Comparison of HW tables used to inform the geometry of the Ynysybwl tunnel in the BAU and WAW scenarios

It is understood that NRW have historically completed annual channel maintenance in a short (approximately 100-150m long) region adjacent to Clydach Terrace. Typically, between 50-150 tonnes of river shoal has been removed. Based on the range of weight of soil removed, an estimation of the material density (1-2 tonnes/m^3) and the channel widths in the area (typically between 4-12m) a range of estimates of depth of shoaling between 0.05m and 0.50m can be reached.

A worst case scenario has been represented in the WAW model, wherein the bed level of the channel reach adjacent to Clydach Terrace has been increased by 0.50m. A comparison of the previous bed level and the bed level in the WAW scenario is provided in Figure 2.

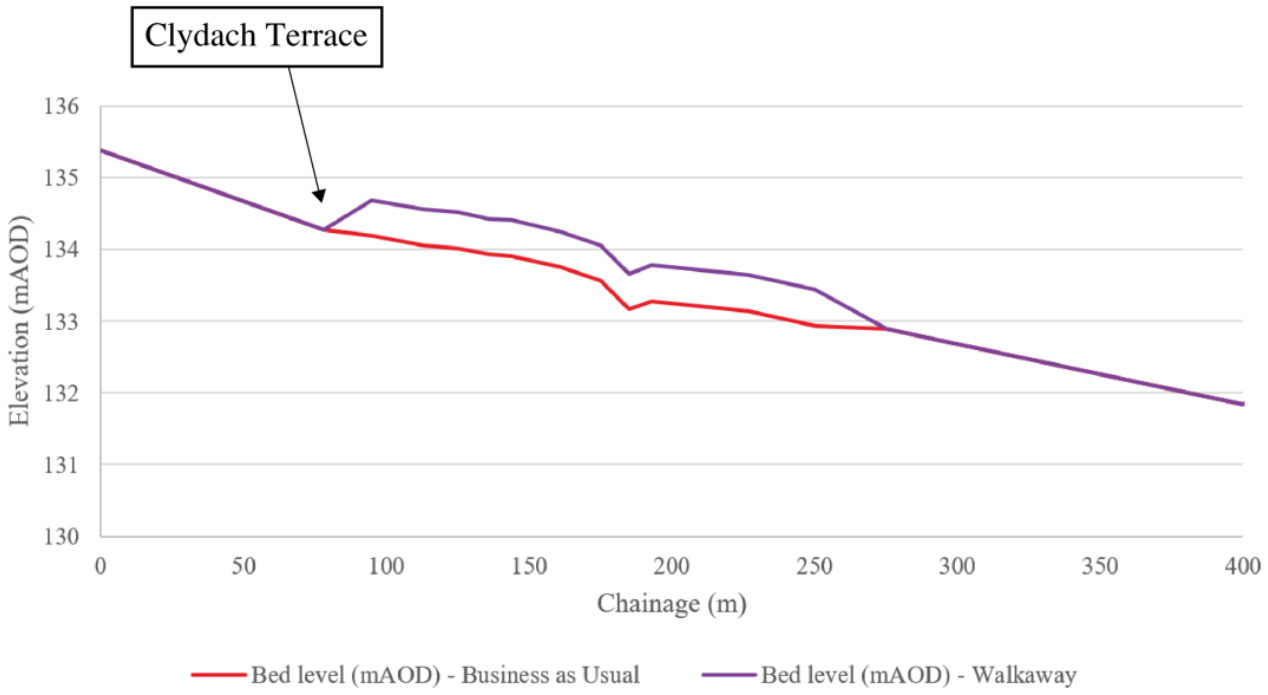

Figure 2 Long section of the Nant Clydach bed elevation adjacent to Clydach Terrace in the BAU and WAW scenarios

The Mannings roughness values in the 1D channel have been increased by 30% to represent the likely impacts of a cessation of in-channel maintenance. This represents the increase in roughness that could occur due to an increase in vegetation, shoaling and accumulation of debris in the channel if regular maintenance were not undertaken. Table 1 summarises the typical roughness values applied in the 1D channel in the BAU and WAW scenarios.

Table 1 Summary of in-channel roughness values used in the BAU and WAW scenarios

Part of section where roughness has been applied	BAU roughness value	WAW roughness value
Cobble bed	0.055	0.072
Stone bed	0.035	0.046
Trees and bush	0.06	0.078
Grass	0.032	0.042
Asphalt/concrete	0.013	0.017

2.2 Business as Usual

The following assumptions have been made for the BAU scenario model:

- No blockage;
- No increase in shoal depth; and
- Vegetation clearance on going.

In this scenario, the model run and geometry files remain the same as in the previous baseline model. The Ynysybwl tunnel has been represented with the surveyed geometry, with no reduction in flow area. The in-channel survey was undertaken for Ynysybwl shortly after Storm Dennis and therefore is assumed to represent the channel without significant shoaling. The roughness values have similarly been left unchanged from the previously used baseline values.

3. Shortlist modelling

3.1 Shortlist Option 1

Shortlist Option 1 comprises the following:

- Raising the level of the Clydach Terrace wall to provide a 2% AEP SoP in the assumed construction period of 2025-2029.
- Extending the Clydach Terrace wall downstream by approximately 6m to prevent out-flanking.
- Continuation of the existing maintenance regime, therefore assumptions regarding channel roughness, blockage and shoaling remain the same as in the BAU scenario.

In the BAU and WAW scenarios, the de-facto defence wall is represented in the model using two z-shapes that have been informed by survey data collected in 2021. The first z-shape represents the base of the wall, and the second represents the crest. Shortlist Option 1 comprises raising the height of this wall to provide a 2% AEP SoP in the assumed construction period of 2025-2029.

It was identified during the longlist modelling exercise that there is a low spot on the right bank immediately downstream of the existing wall extent. In larger flood events, the existing wall is outflanked to the south. Water subsequently overtops at this point before flowing north along Clydach Terrace to flood the properties on this street. Consequently, the option includes extending the wall downstream by approximately 6m to prevent this flood mechanism.

The extent and alignment of the original and extended wall is shown in Figure 3. The height of the wall has been set based on the maximum water level in the 2% AEP flood event with a 5% allowance for climate change. The 5% climate change uplift to rainfall accounts for the presumed impacts of climate change between the present day and the assumed time of construction. No freeboard allowance has been accounted for.

The wall height in this scenario is approximately 0.45m higher at the lowest point of the existing wall in the BAU scenario. This results in a maximum wall height of approximately 1.7m, without a freeboard allowance.

Further information regarding the application of climate change is provided in Section 3.3.1.

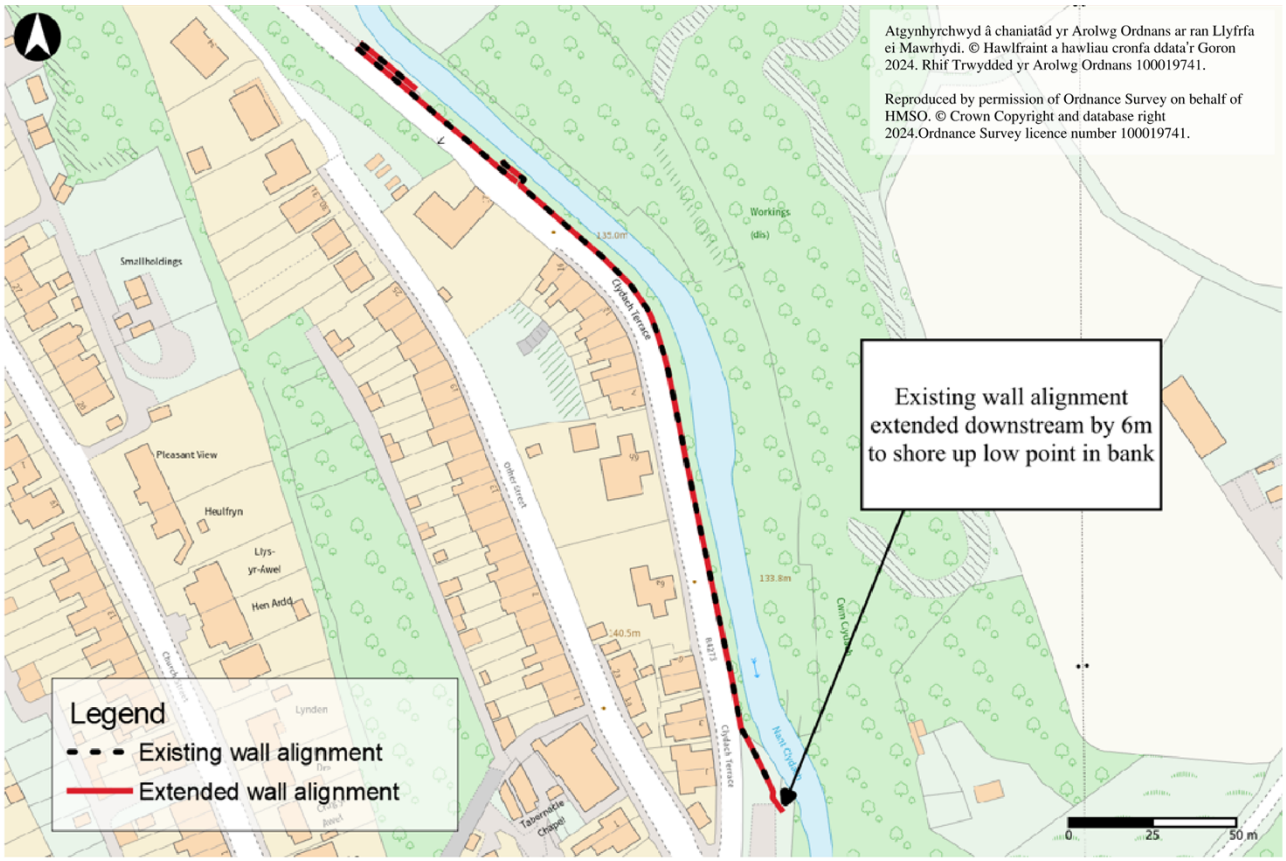

Figure 3 Extent of existing and wall proposed as part of Shortlist Options 1 and 2, which has been extended by approximately 6m downstream

3.2 Shortlist Option 2

Shortlist Option 2 includes the following:

- Raising the level of the Clydach Terrace wall to provide a 1% AEP SoP in the assumed construction period of 2025-2029.
- Extending the Clydach Terrace wall downstream by approximately 6m to prevent out-flanking.
- Continuation of the existing maintenance regime.

The schematisation of the wall extent is the same as in the Shortlist Option 1 model scenario. However, the wall height has been raised to the maximum water level in the 1% AEP event with a 5% allowance for climate change. The 5% climate change uplift to rainfall accounts for the presumed impacts of climate change between the present day and the assumed time of construction. No freeboard allowance has been accounted for.

The wall height in this scenario is approximately 0.65m higher at the lowest point of the existing wall in the BAU scenario. This would result in a maximum wall height of approximately 1.9m, without a freeboard allowance.

3.3 Model Scenarios

3.3.1 Application of climate change

The available Welsh Government guidance[3] indicates that an uplift should be applied to design rainfall derived for the present day to account for the future impacts of climate change.

Table 2 below reproduces the uplift values provided in the guidance for use in smaller catchments, designated as <5km2.

Table 2 Summary of climate change allowances

Applies across all of Wales	Total potential change anticipated for 2020s (2015-2039)	Total potential change anticipated for 2050s (2040-2069)	Total potential change anticipated for 2080s (2070-2115)
Upper Estimate	10%	20%	40%
Central Estimate	5%	10%	20%

The Central Estimate values have been used in this study. The 2020s allowance of 5% has been applied to inform the rainfall and design event flooding in 2025 – 2029, which is the assumed construction period for a potential FRMS at Ynysybwl. It is unlikely that all of the potential change for the 2015-2039 epoch will be realised by the construction date, however the approach used is conservative as the full uplift amount is applied to the inflows used in the modelling of the 2020s epoch.

To assess the impact of climate change further into the future, a 20% allowance has been applied, which corresponds to the uplift value predicted for the 2080s epoch. It assumed that the design life of the option would be 75-100 years, and therefore this value has been used in order to appraise the option performance during this period, toward the end of the design life of the scheme.

3.3.2 Model runs

Table 3 summarises the modelled flood event runs that have been undertaken for the BAU, WAW and Shortlist Options.

Table 3 Summary of modelled return periods and scenarios

	Flood return period (AEP %)													
	5% climate change							20% climate change						
	50	20	10	2	1.33	1	0.1	50	20	10	2	1.33	1	0.1
BAU	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
WAW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Shortlist Option 1				✓	✓	✓	✓				✓	✓	✓	✓
Shortlist Option 2				✓	✓	✓	✓				✓	✓	✓	✓

For the Shortlist Option models, the smallest flood return periods (50% to 10% AEP) have not been run. Although the shortlisted options provide the designated SoP in terms of flooding from the Nant Clydach, the options do not reduce the residual risk from surface water flooding in the smallest flood return periods.

This is a limitation of the appraisal as it oversimplifies, and potentially underestimates, the residual damages that may occur from surface water flooding with the scheme options in place. Further work at a later stage of assessment should consider this residual risk.

[3] Welsh Government, August 2022 *"Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales"* Accessed 22/01/2024 (Adapting to Climate Change: Guidance for Flood and Coastal Erosion Risk Management Authorities in Wales (gov.wales))

4. Results

The results for each of the shortlist options are presented below. A selection of flood return periods are presented to illustrate the onset of flooding to the properties to Clydach Terrace in each of the scenarios.

The primary focus of the SOC is understanding and mitigating the flood risk to the 16 properties on Clydach Terrace that flooded during Storm Dennis. However, the risk to other properties and receptors is considered as part of this modelling assessment.

Figure 4 shows the building footprints on Clydach Terrace and off Windsor Place to the south that are shown to be at risk of flooding from both fluvial and surface water sources and are therefore part of the study area examined in the modelling study. Other receptors in the area are not considered to be at risk and are therefore not considered further.

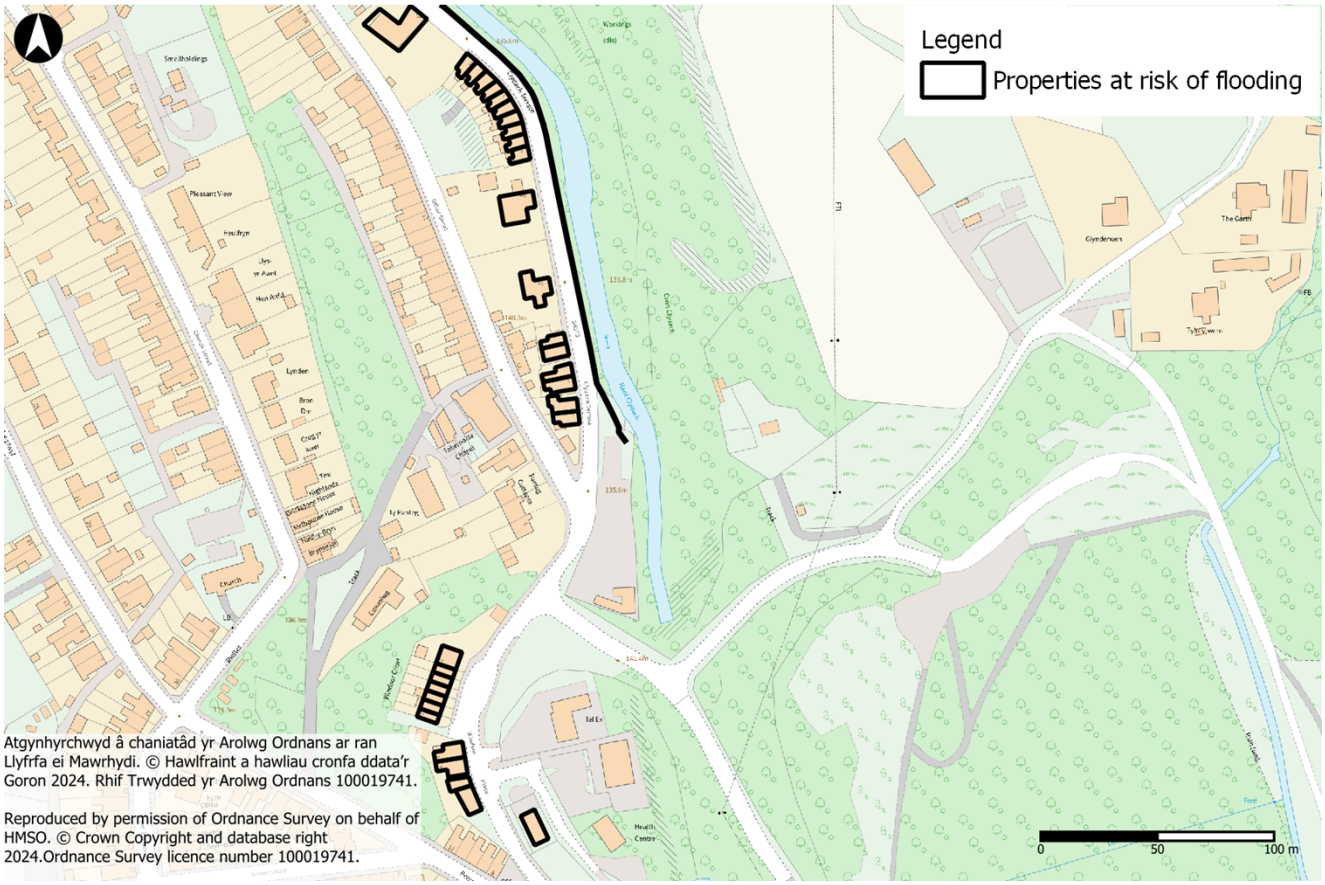

Figure 4 Receptors considered at risk in the study area

4.1 Baseline results

The direct rainfall modelling approach used in the Ynysybwl model means that the entire model is "wet". A map cut-off depth of 0.01m has been applied in the model input files. This essentially filters the model outputs so that results are shown only in locations where the flood depth exceeds 0.01m.

4.1.1 Business as Usual

The model outputs indicate that the existing defence wall is not overtopped in the 10% AEP event including a 5% allowance for climate change. Up to this flood return period, no overtopping of the de-facto defence wall is observed, as shown in Figure 5. There is some residual surface water flooding on Clydach Terrace and Windsor Place that is not related to out of bank flooding from the Nant Clydach.

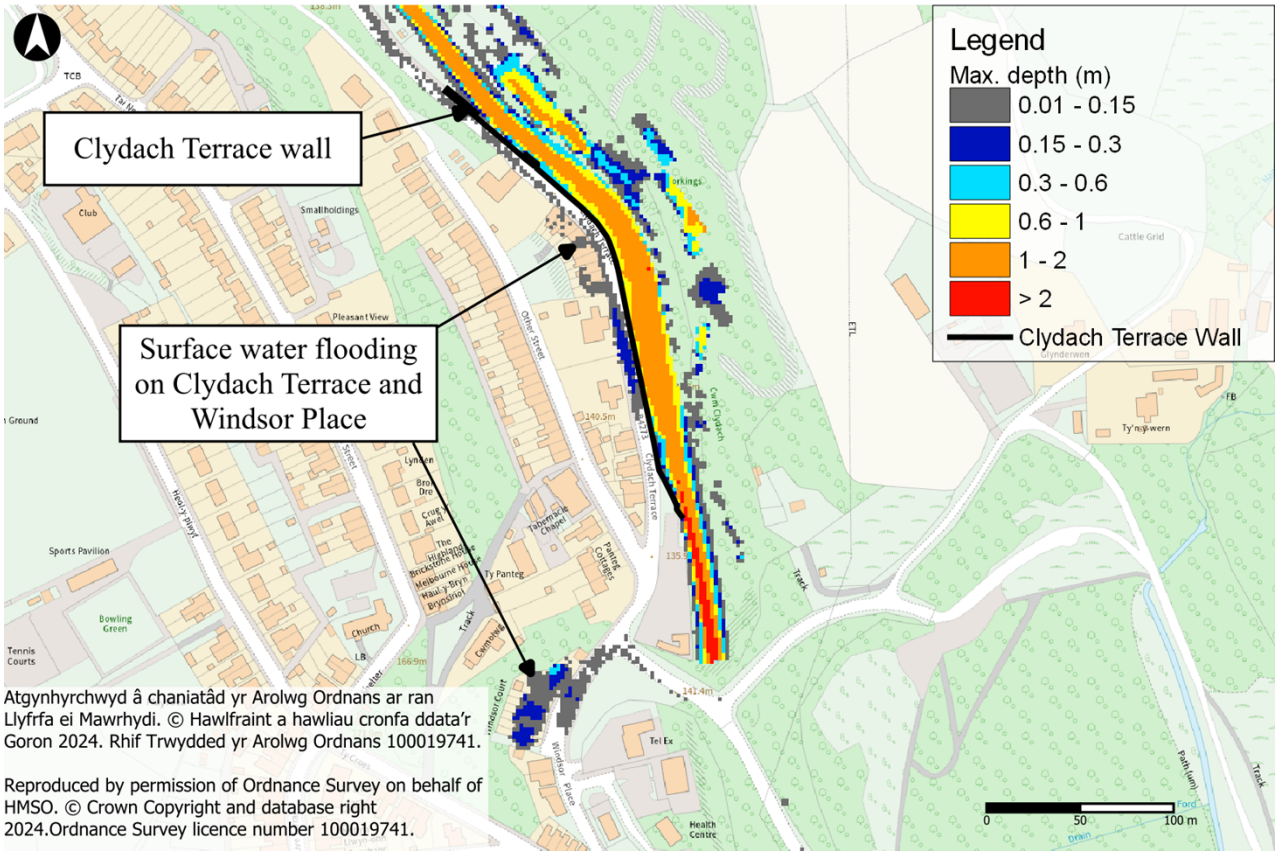

Figure 5 Maximum flood depths on Clydach Terrace and Windsor Place in the BAU scenario for the 10% AEP flood event with a 5% climate change allowance

In the 2% AEP event in the 2020s epoch, the wall is overtopped, and water subsequently inundates a number of properties on Clydach Terrace. The flood extent is generally isolated to the Clydach Terrace properties, as shown in Figure 6, though there is surface water flooding to 7 properties off Windsor Terrace to the south.

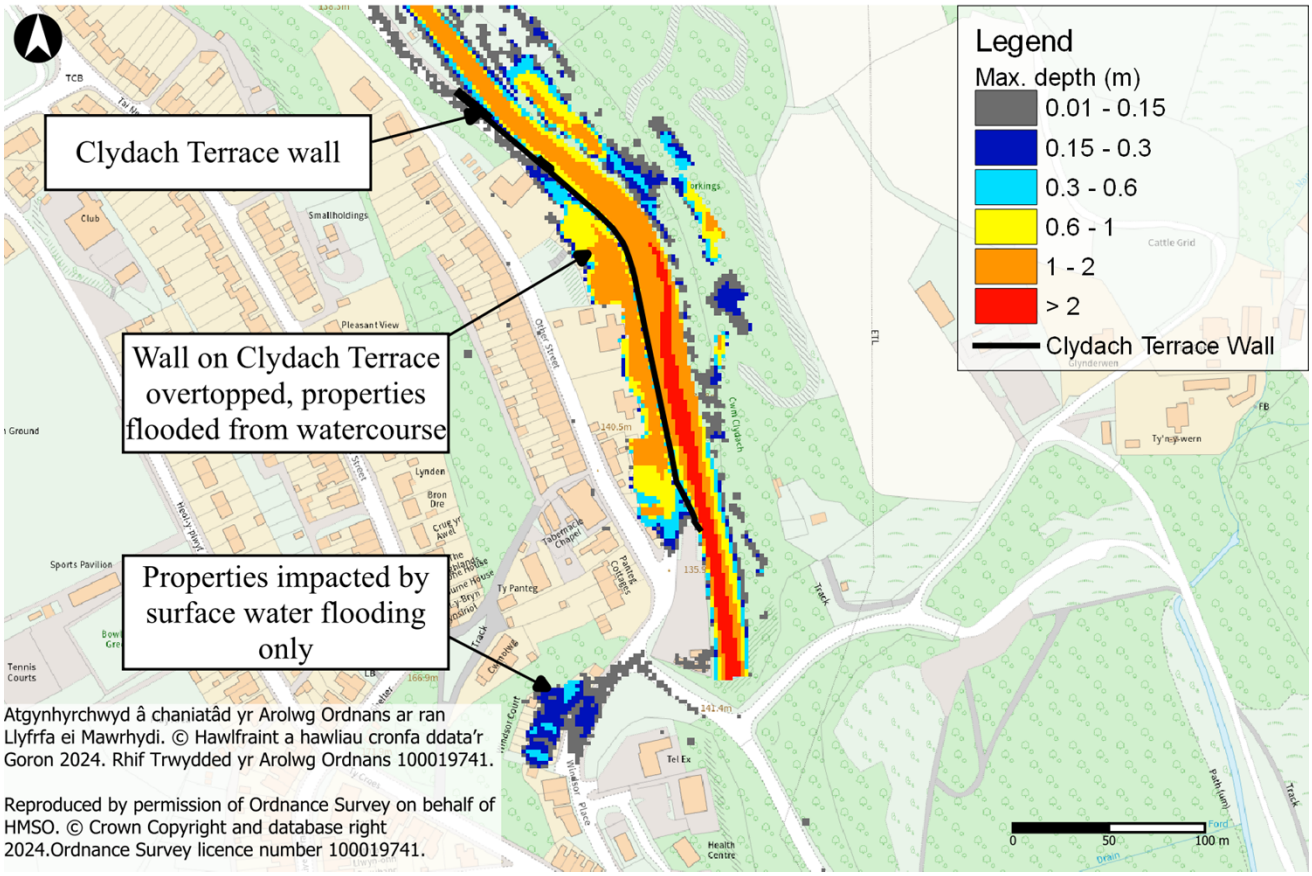

Figure 6 Maximum flood depths on Clydach Terrace and Windsor Place in the BAU scenario for the 2% AEP flood event with a 5% climate change allowance

In the 0.1% AEP event in the 2020s epoch, significant flooding is observed to both the properties on Clydach Terrace and to a number of additional properties further to the south, on Windsor Place road. The low point to the south of the existing wall length results in water overtopping at this location, as well as over the wall directly, and contributing to the flooding observed, as shown in Figure 7.

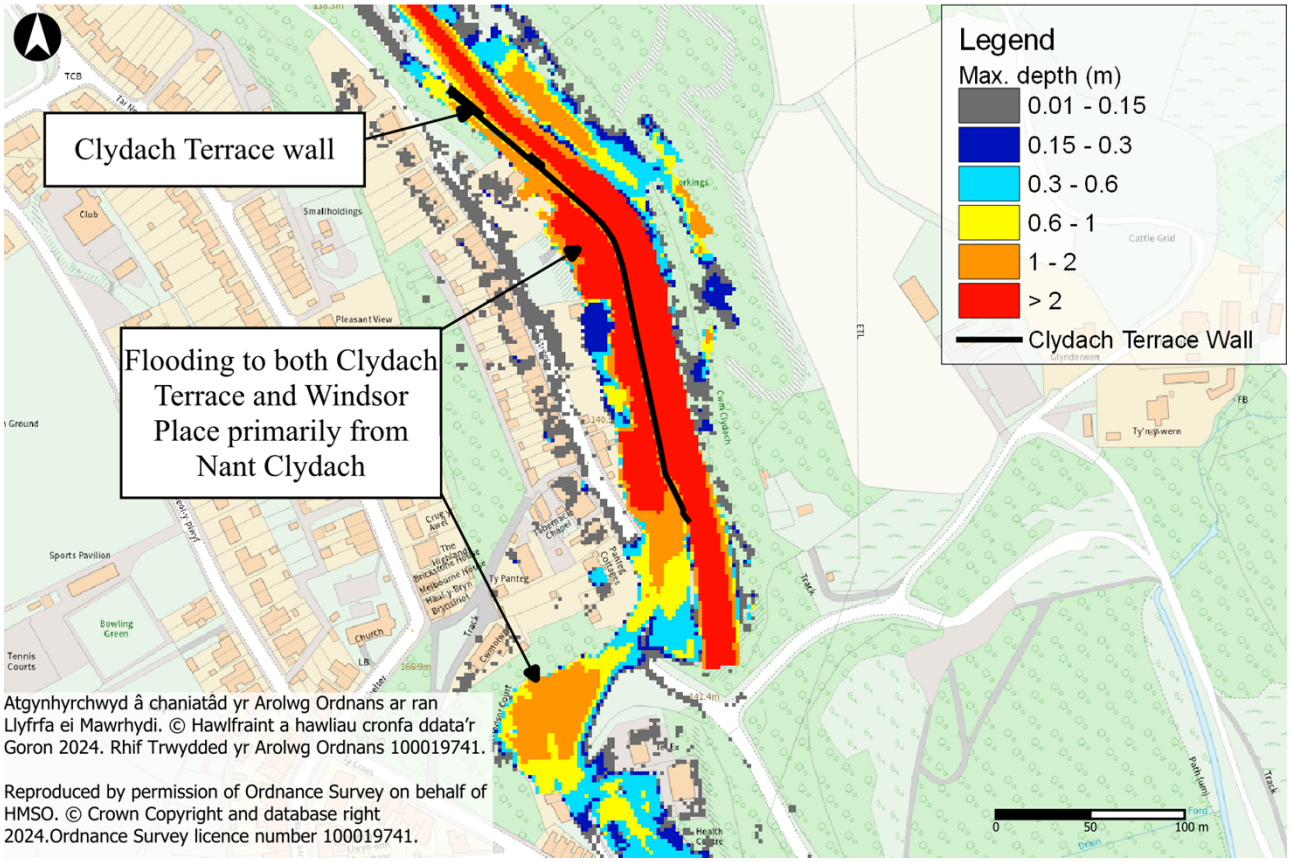

Figure 7 Maximum flood depths on Clydach Terrace and Windsor Place in the BAU scenario for the 0.1% AEP flood event with a 5% climate change allowance

4.1.2 Walkaway

In the WAW scenario, the onset of flooding occurs at an increased flood frequency. Figure 8 shows the flooding in the 50% AEP event with 5% climate change allowance. In this event, the wall is overtopped and flooding to the properties on Clydach Terrace is observed. Surface water flooding is observed to the properties on Windsor Terrace, however flooding from the Nant Clydach impacts Clydach Terrace properties only.

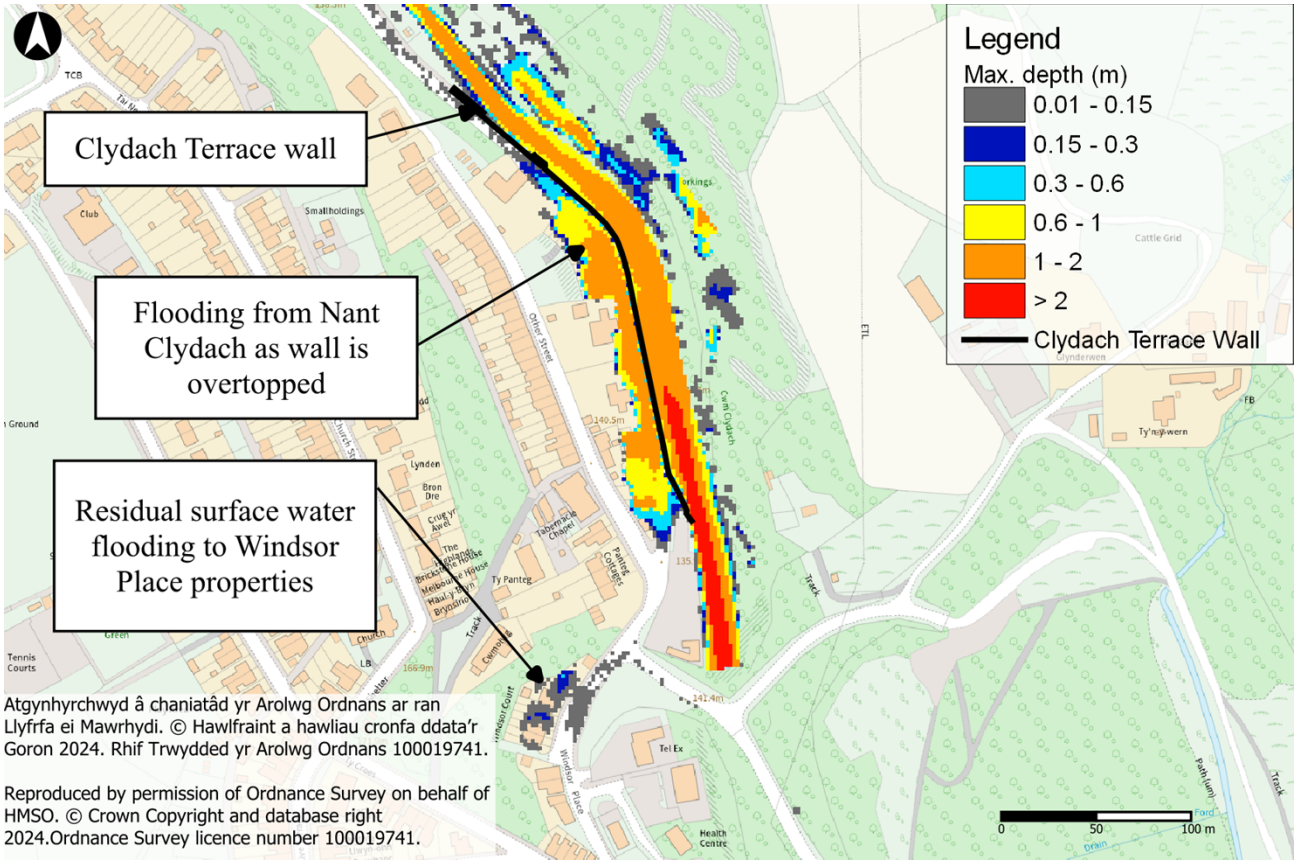

Figure 8 Maximum flood depths on Clydach Terrace and Windsor Place in the WAW scenario for the 50% AEP flood event with a 5% climate change allowance

In the 20% AEP event with 5% climate change allowance, overtopping occurs at the low spot downstream of the existing de-facto defence wall. Water flows downstream along Windsor Terrace, flooding 9 properties off Windsor Place in addition to the Clydach Terrace properties, as shown in Figure 9.

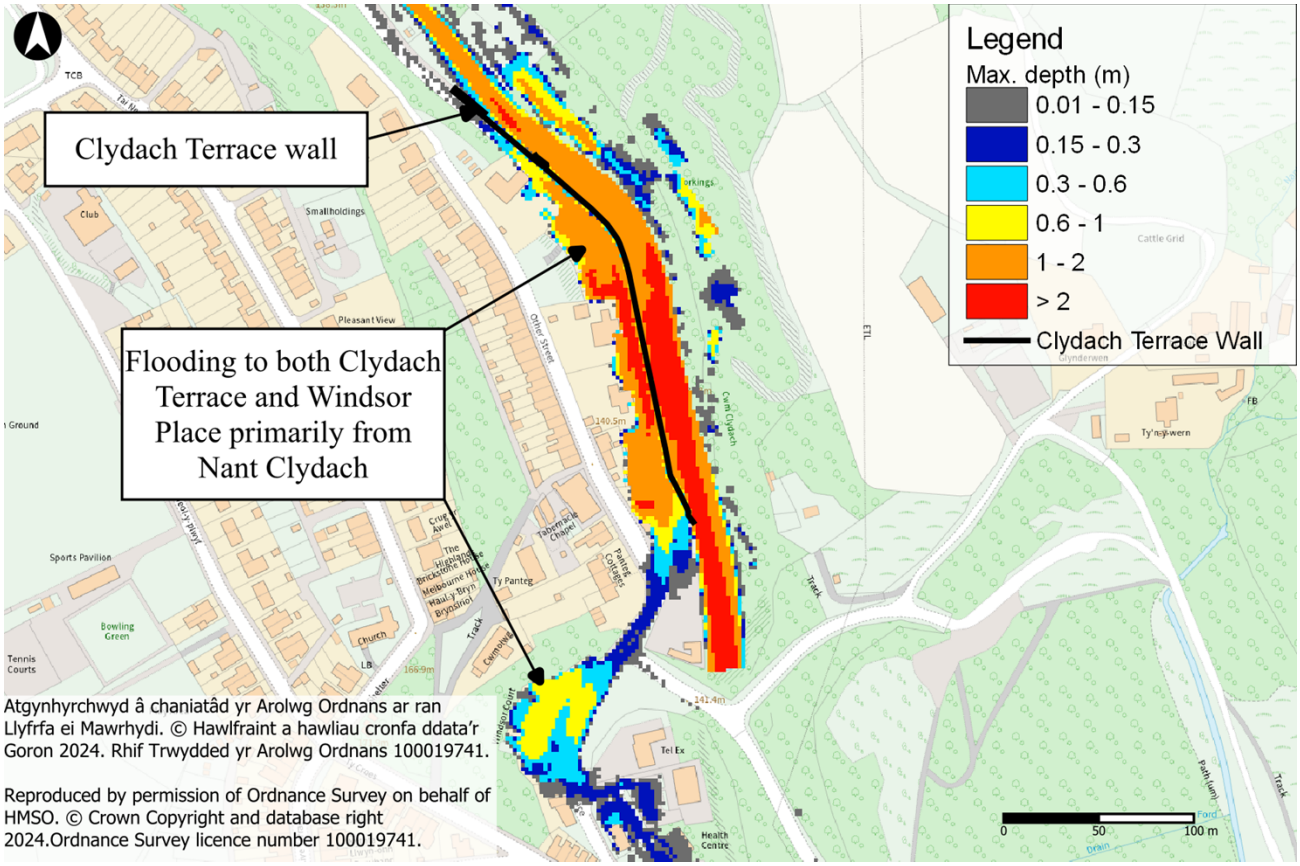

Figure 9 Maximum flood depths on Clydach Terrace and Windsor Place in the WAW scenario for the 20% AEP flood event with a 5% climate change allowance

With the combined addition of 0.5m of shoaling, 67% blockage of the Ynysybwl tunnel and increased roughness values, water levels in the channel are substantially elevated in comparison to the baseline scenario and therefore flooding occurs at significantly lower return periods.

4.2 Shortlist results

4.2.1 Shortlist Option 1

The model results indicate that Shortlist Option 1 provides the required SoP of a 2% AEP flood event, with a 5% allowance for climate change. A depth difference map comparing the flood depth results in the 2% AEP event to the baseline outputs is shown in Figure 10. Although flooding from the Nant Clydach is prevented in this flood event, there is some residual surface water flooding on the terrace.

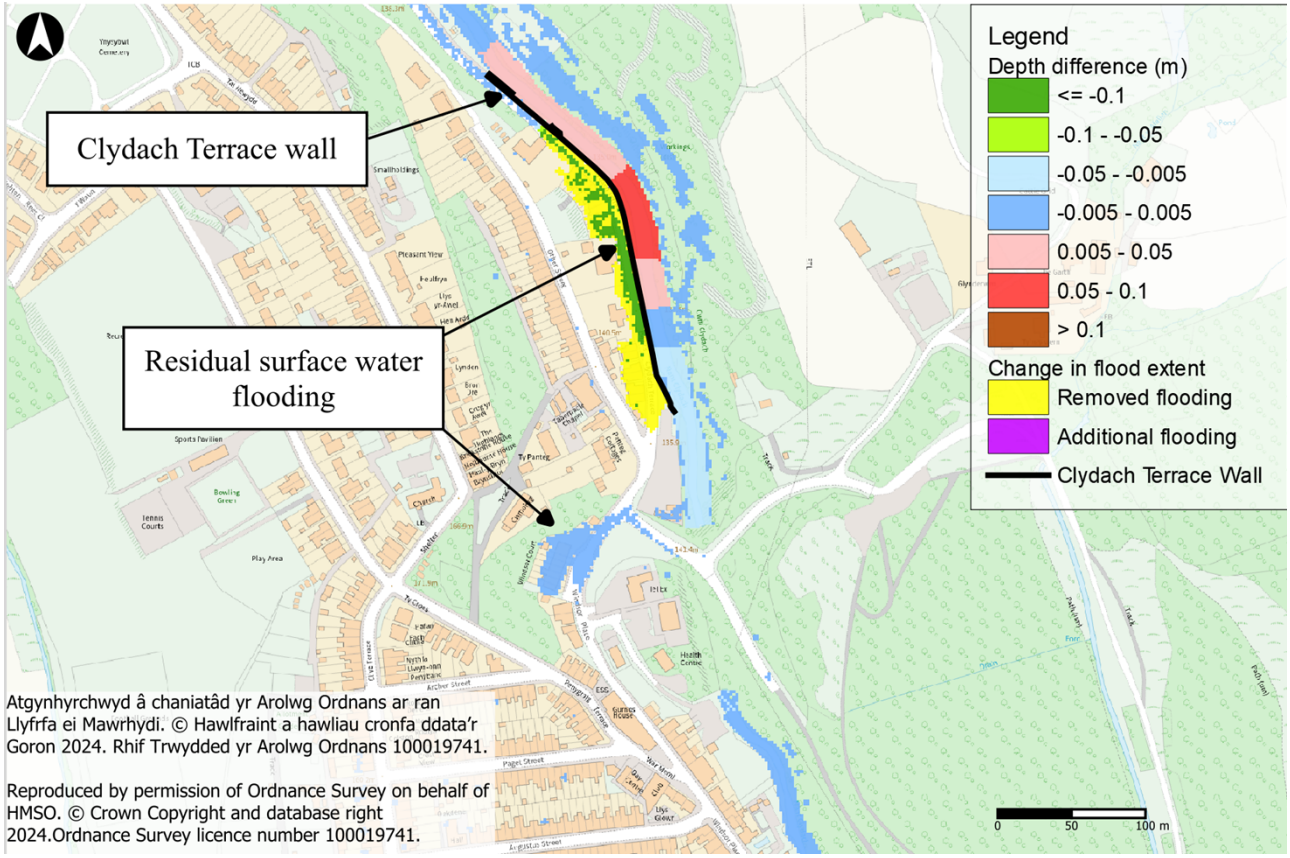

Figure 10 Depth difference map comparing maximum depths in the Shortlist Option 1 scenario to the BAU scenario in the 2% AEP event with a 5% allowance for climate change

In the next largest modelled flood event, the 1.33% AEP event, the proposed flood defence is overtopped and there is flooding to the properties on Clydach Terrace as shown in Figure 11. When overtopping occurs, the flood depths along Clydach Terrace are between 1-2m in the 1.33% AEP event.

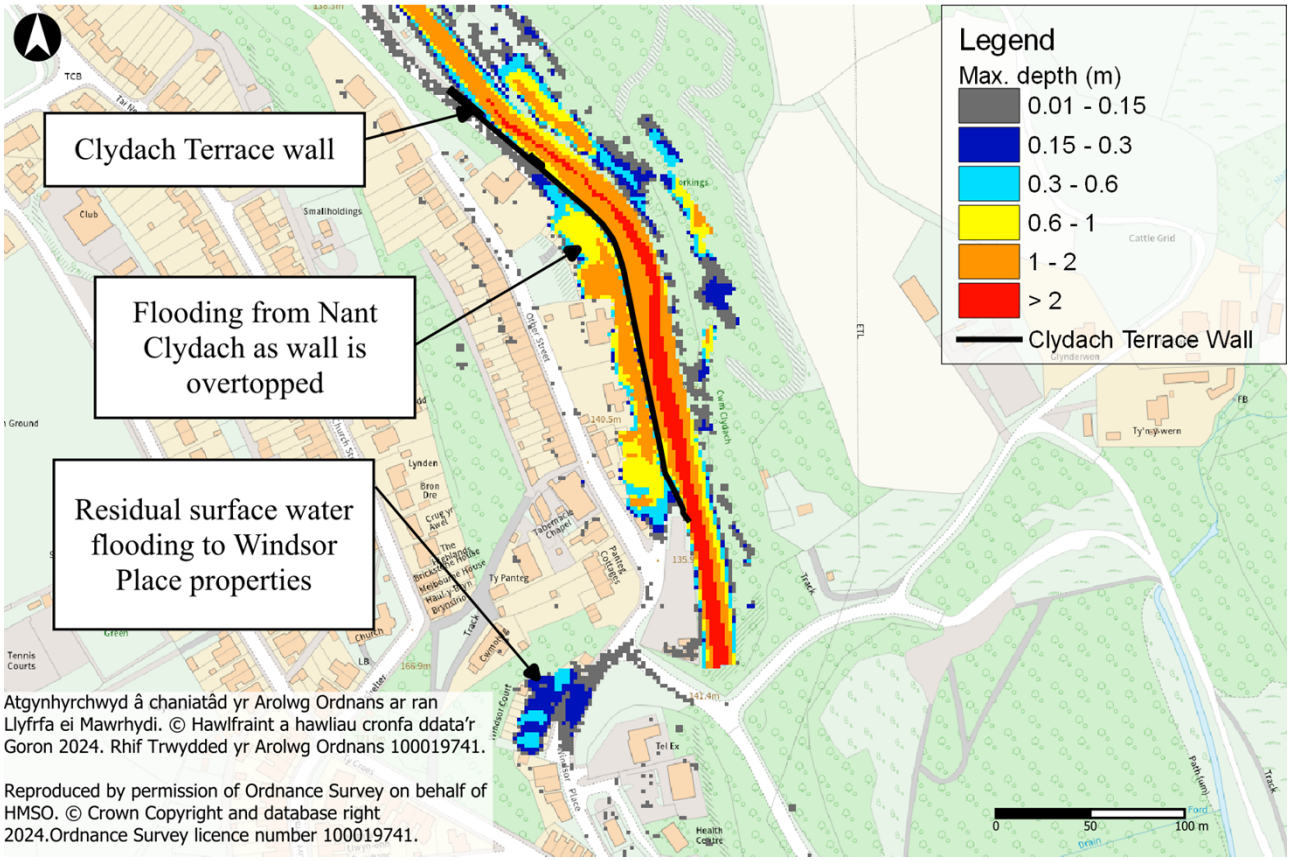

Figure 11 Maximum flood depths on Clydach Terrace and Windsor Place in the Shortlist Option 1 scenario for the 1.33% AEP flood event with a 5% climate change allowance

A depth difference map showing the difference between the Shortlist Option 1 results and the BAU results in the 1.33% AEP event with a 5% climate change allowance is shown in Figure 12. The depth difference map shows that the wall is overtopped in this event, and there is flooding to the properties on Clydach Terrace. The flood depths are reduced by approximately 0.2-0.3m as the higher wall, when compared to the existing wall height, reduces the amount of water that overtops from the channel.

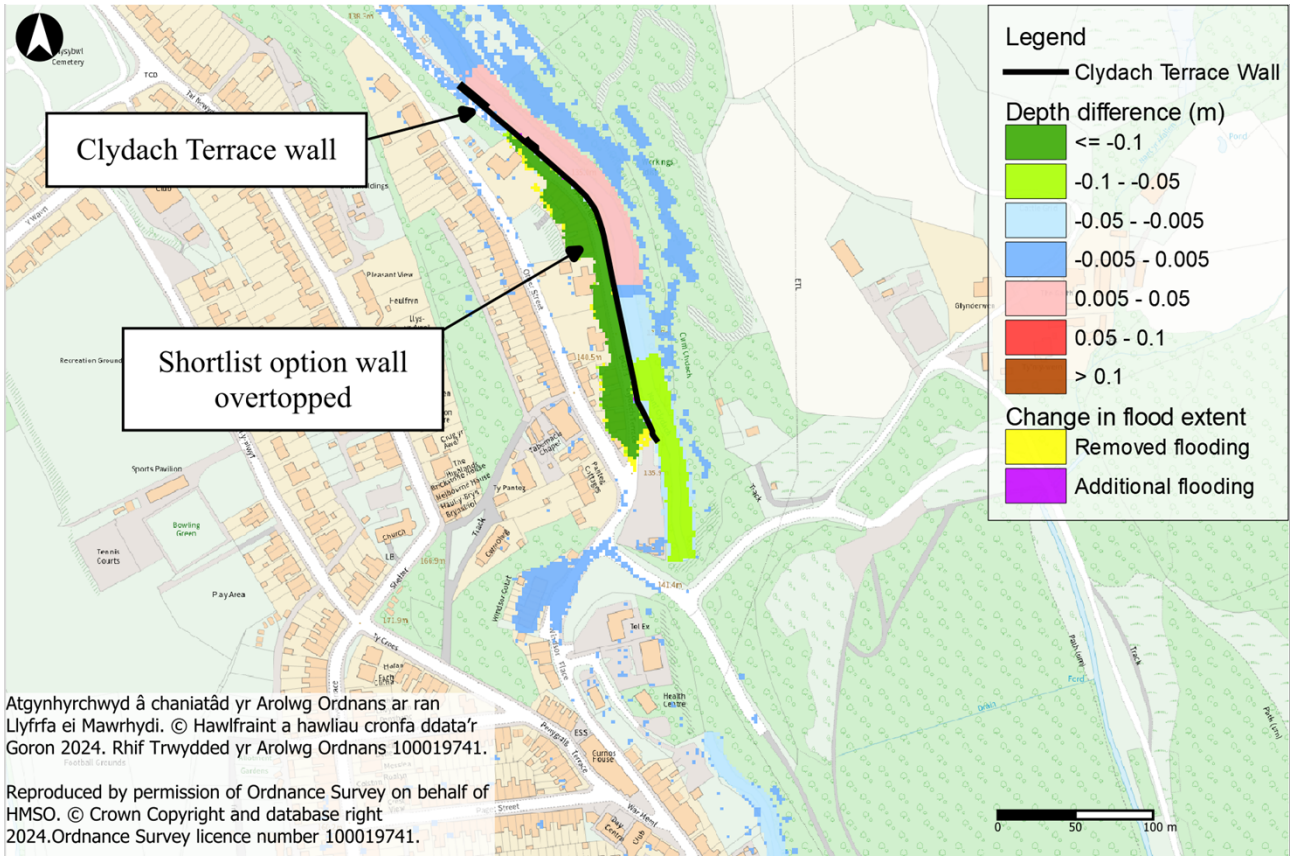

Figure 12 Depth difference map showing the difference in maximum flood depths between Shortlist Option 1 and the BAU scenario in the 1.33% AEP event with a 5% climate change allowance

4.2.2 Shortlist Option 2

The model results indicate that Shortlist Option 2 can similarly provide the required SoP of a 1% AEP flood event, with a 5% allowance for climate change. A depth difference map comparing the flood depth results in the 1% AEP event to the baseline outputs is shown in Figure 13. As in the baseline scenario, there is some residual surface water flooding on the terrace.

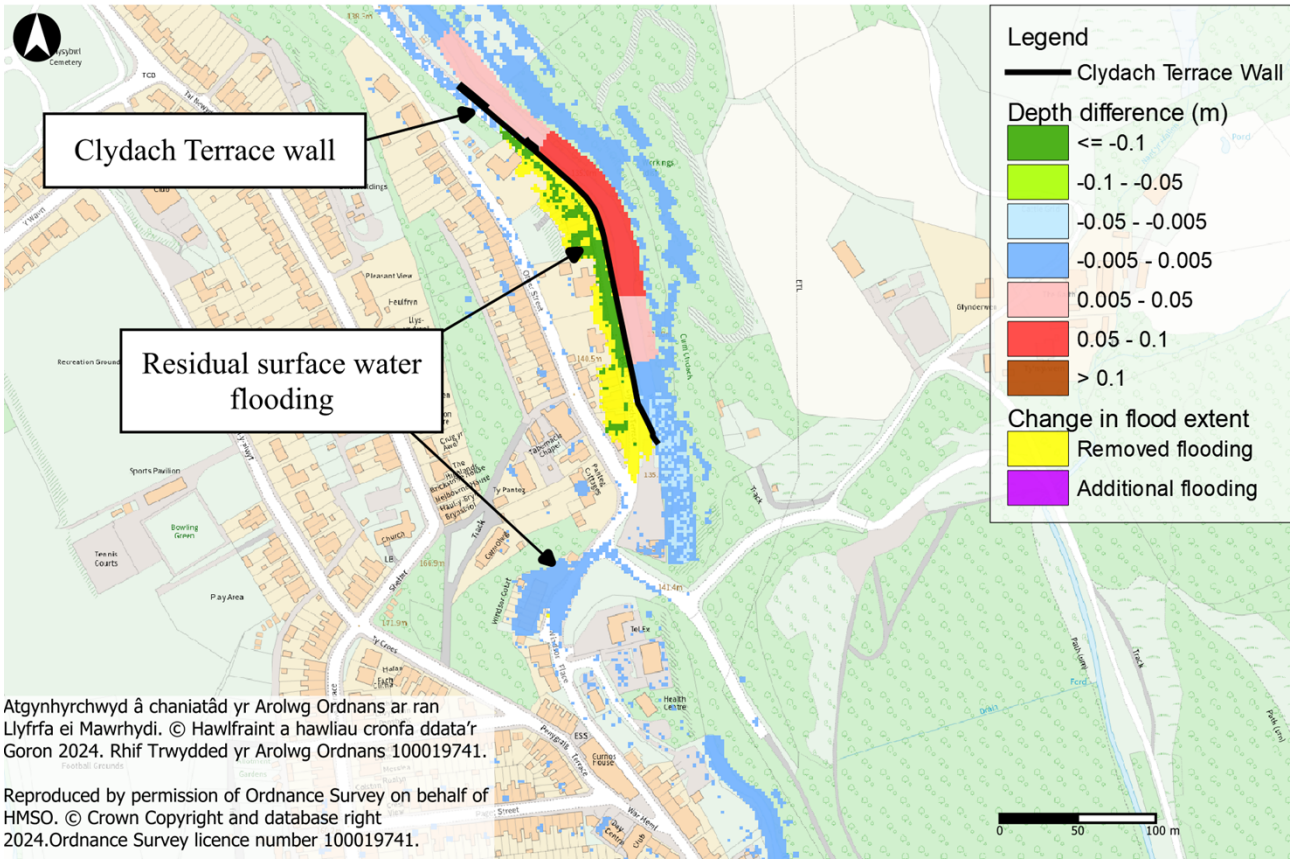

Figure 13 Depth difference map comparing maximum depths in the Shortlist Option 2 scenario to the Baseline scenario in the 1% AEP event with a 5% allowance for climate change

In the next largest modelled flood event, the 0.1% AEP event, the proposed flood defence is overtopped and there is flooding to the properties on Clydach Terrace as shown in Figure 14.

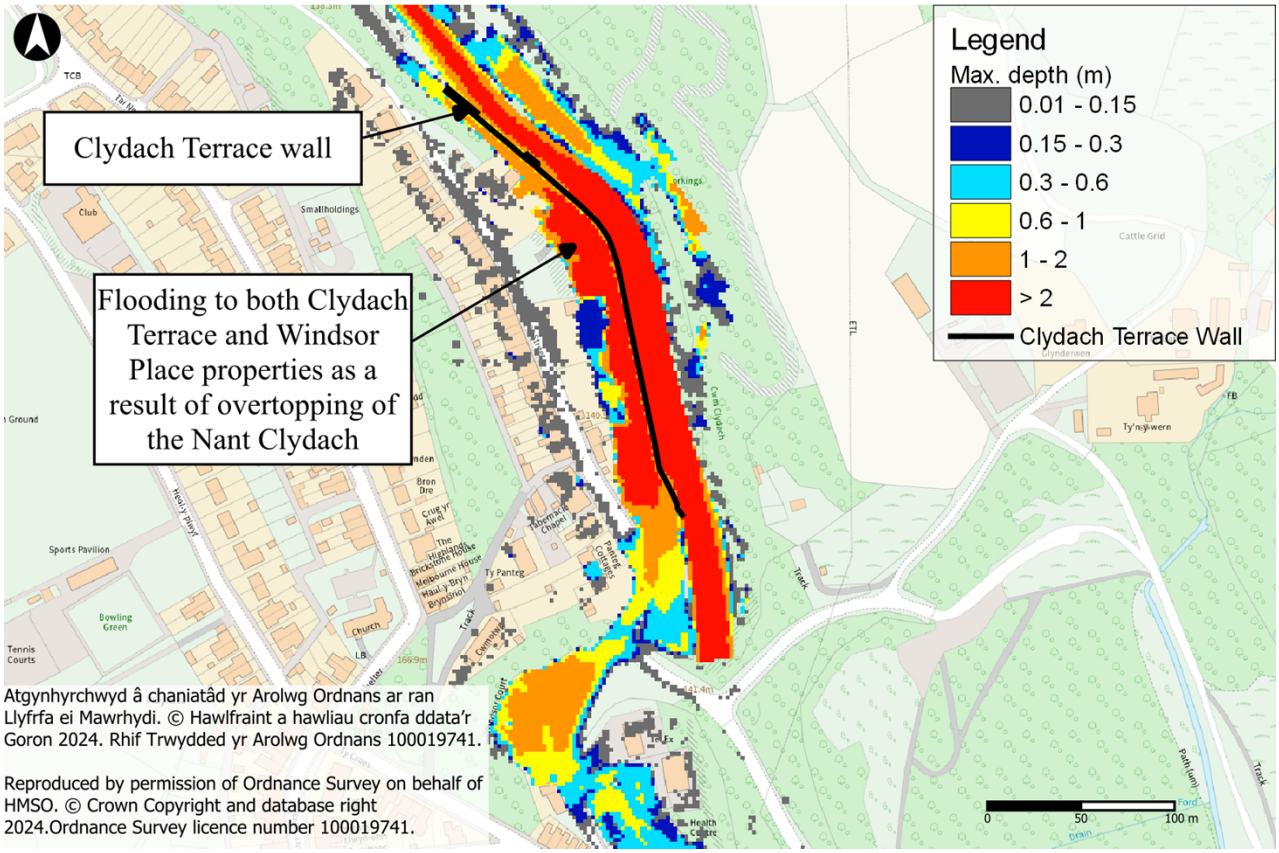

Figure 14 Maximum flood depths on Clydach Terrace and Windsor Place in the Shortlist Option 2 scenario for the 0.1% AEP flood event with a 5% climate change allowance

A depth difference map showing the difference in maximum depths between the Shortlist Option 2 results and the BAU results in the 0.1% AEP event with a 5% climate change allowance is shown in Figure 15. In this scenario, there is an increase in flood depths in parts of Clydach Terrace. The increase is typically 0.03-0.05m. This increase is likely associated with the new wall alignment retaining some water in the channel, which then overtops the wall further upstream. The overall flood extent is not increased, and therefore flooding to properties or receptors that are currently not flooded in the BAU scenario is not anticipated.

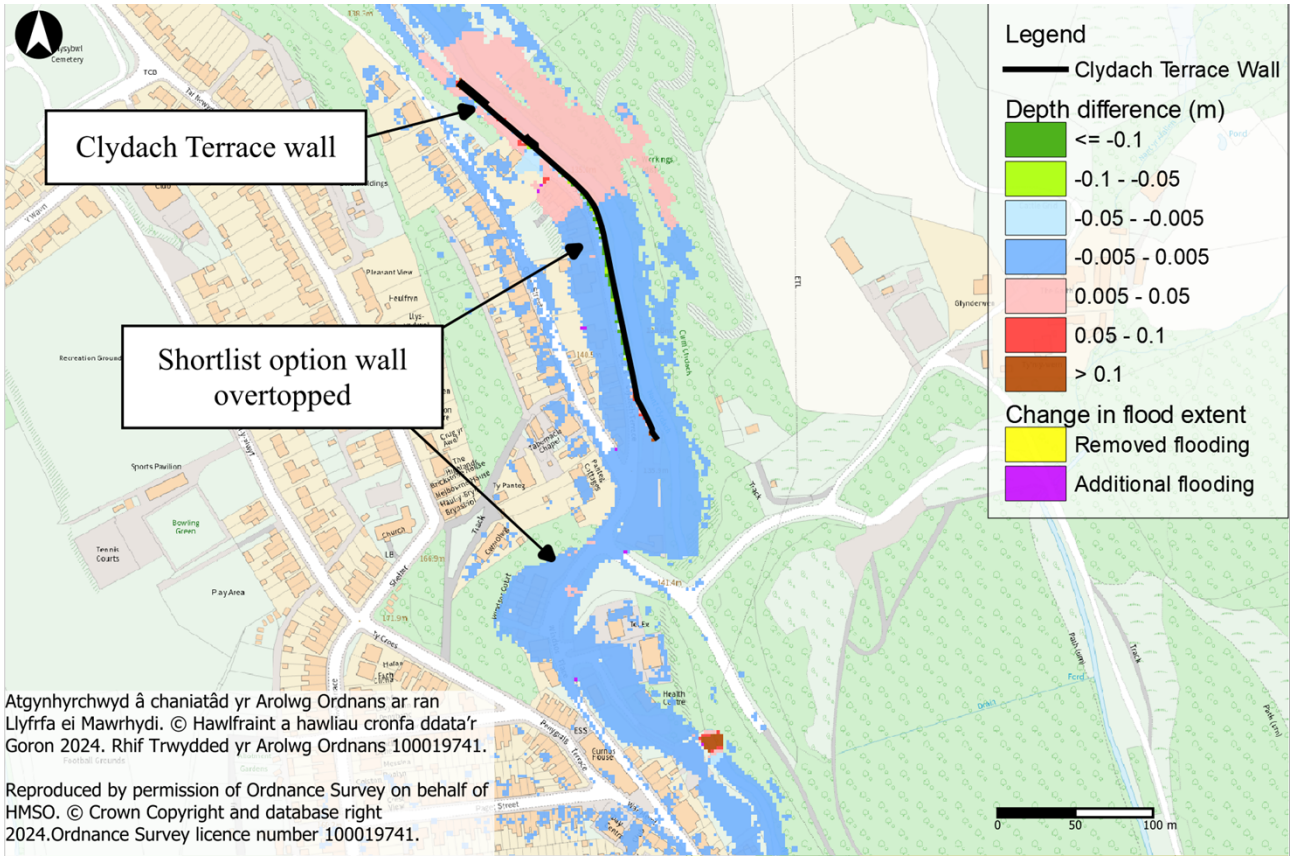

Figure 15 Depth difference map showing the difference in maximum flood depths between Shortlist Option 2 and the BAU scenario in the 0.1% AEP event with a 5% climate change allowance

4.3 Flooded property count

Buildings have been represented in the model using flow constrictions. Where available, the surveyed threshold height has been applied as the invert level in the flow constriction, which effectively sets the footprint of the building to the surveyed level. An additional blockage and flow constriction shape is applied above the property threshold to represent the impact of the building structure on flow. A Manning's roughness value of 0.015 is applied in addition to the flow constriction.

Figure 16 shows the properties on and around Clydach Terrace that have a surveyed threshold. In the absence of survey data, an assumed threshold level has been applied in the model based on LiDAR or National Receptor Dataset information.

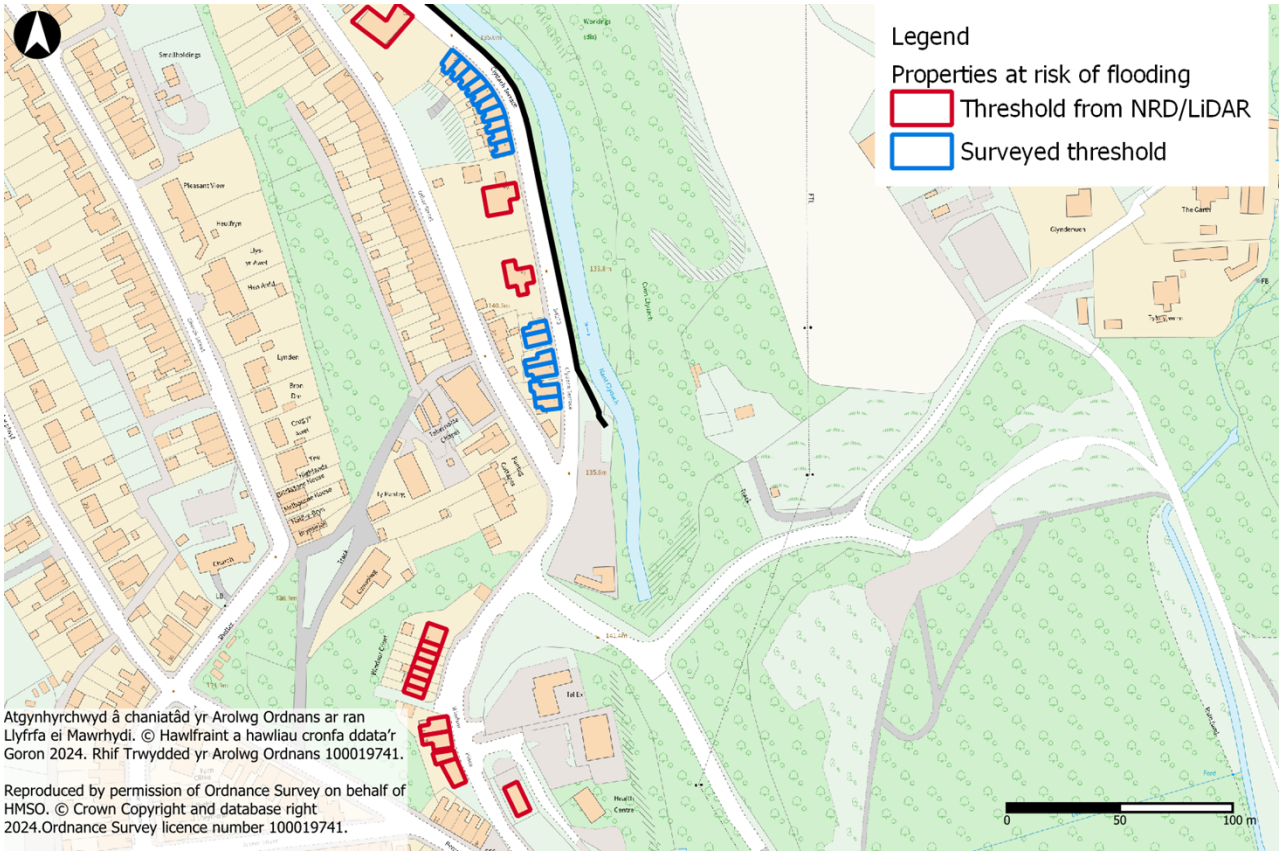

Figure 16 Summary of threshold data source for receptors

Table 4 shows a summary of the number of the number of properties considered to experience internal flooding in each of the modelled return periods and scenarios. The property count includes properties that are considered to flood from surface water sources, in addition to those properties which are primarily flooded from the Nant Clydach.

As the model used for this assessment is a direct rainfall model, rainfall is applied over the entire catchment area, including the building footprints. As a result, shallow water depths are seen across the entire model extent, including within the building outlines. However, this does not always indicate that flooding above property threshold would occur due to an accumulation of surface water flooding. As such, where these observed surface water depths are less than the threshold height of the building (based on the difference between the threshold level of the building and the underlying ground level taken from LiDAR), the property has been excluded from the flooded property count.

Fluvial flooding from the Nant Clydach occurs once the wall is overtopped. For the properties that have flooded previously in Storm Dennis the surveyed threshold heights have been represented explicitly using flow constriction shapes within the modelling. For these properties it is therefore assumed that if there is water inside the building footprint due to overtopping of the Nant Clydach that internal flooding of the property would occur, and the property has been included in the flooded property count. For the other properties that have been included in the study, which don't have surveyed threshold levels, a threshold level has been estimated using google street view imagery. This assumed threshold level has taken off the observed flood depth in order to determine if the property is internally flooded.

Table 4 Count of flooded properties

	Flood return period (AEP %)													
	5% climate change							20% climate change						
	50	20	10	2	1.33	1	0.1	50	20	10	2	1.33	1	0.1
BAU	5	8	11	23	23	23	26	16	22	23	23	23	24	26

	Flood return period (AEP %)													
	5% climate change							20% climate change						
	50	20	10	2	1.33	1	0.1	50	20	10	2	1.33	1	0.1
WAW	18	26	26	26	26	26	27	21	26	26	26	26	26	28
Shortlist Option 1	0	0	0	11	23	23	26	0	0	0	23	23	25	26
Shortlist Option 2	0	0	0	11	11	13	26	0	0	0	17	23	24	26

In the WAW scenario, a significant number of properties are shown to flood at low return periods, including the 50% AEP event, primarily due to overtopping of the Nant Clydach wall. Figure 17 summarises the properties that are considered to flood internally in this event. A total of 2 properties are considered to flood from surface water sources, and a further 16 flood due to the Nant Clydach.

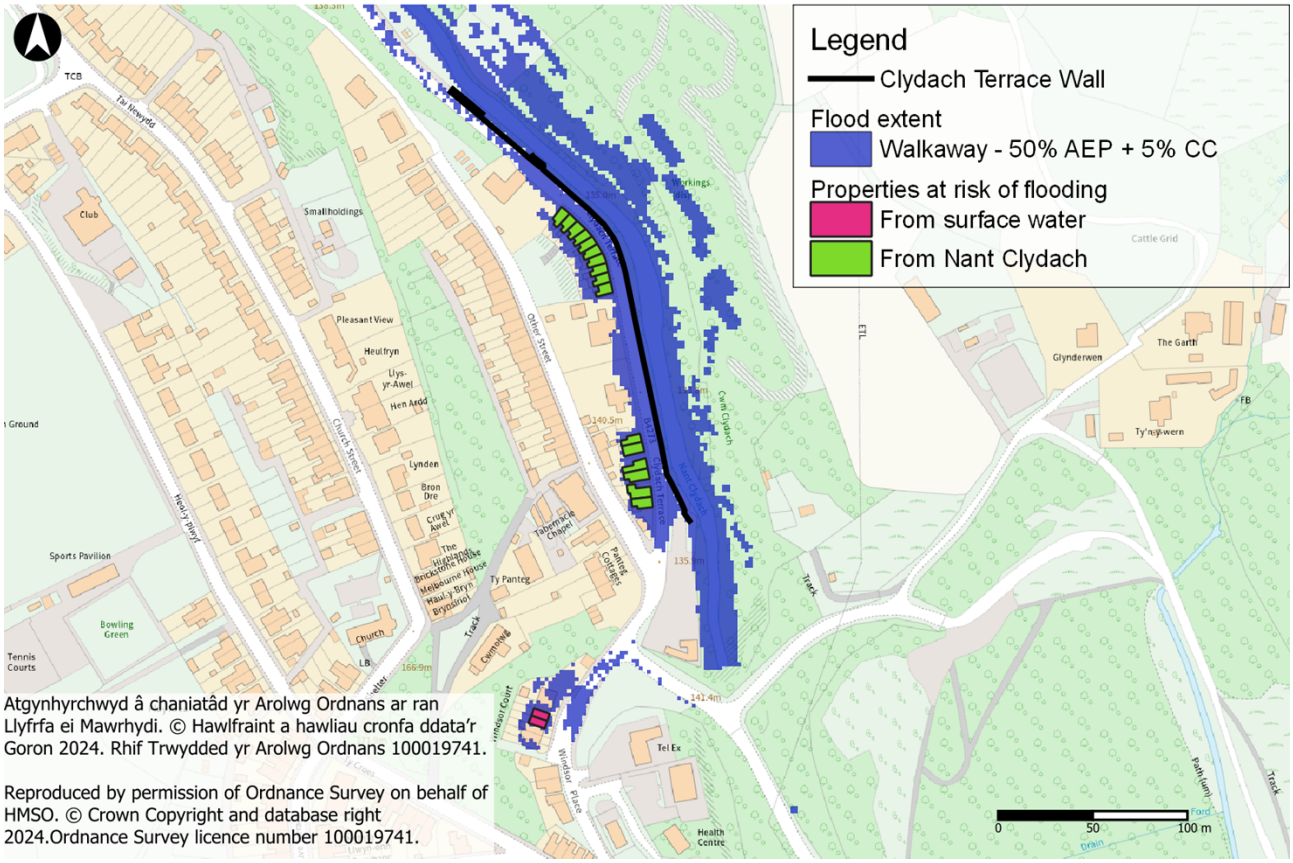

Figure 17 Summary of flooded properties in the Walkaway scenario for the 50% AEP event with a 5% climate change allowance

The presence of the de-facto defence in the BAU scenario protects a number of properties from fluvial flooding in the 2020s epoch. However, with the impact of climate change into the future the SoP offered by the existing wall is significantly reduced.

Figure 18 summarises the properties that are considered to flood internally in the BAU scenario for the 2% AEP event, with a 5% climate change allowance. A total of 11 properties are considered to flood from surface water sources, and a further 12 are flooded from the Nant Clydach, due to overtopping of the adjacent wall.

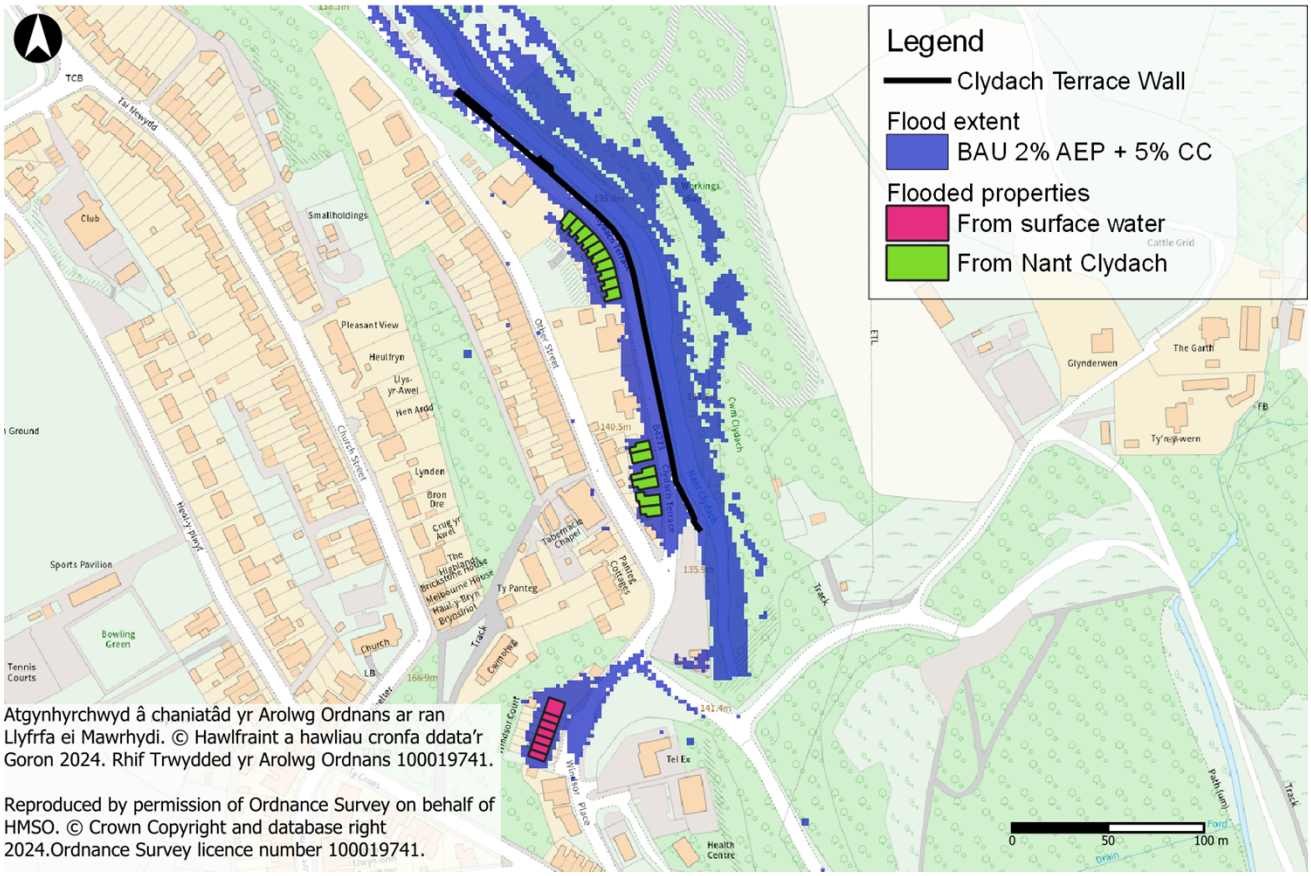

Figure 18 Summary of flooded properties in the BAU scenario for the 2% AEP event with a 5% climate change allowance

Similarly, Figure 19 summarises the properties that are considered to flood internally in the BAU scenario for the 1% AEP event, with a 5% climate change allowance. As in the 2% AEP event, a total of 23 properties are considered to flood internally, 11 from surface water sources and 12 from the Nant Clydach.

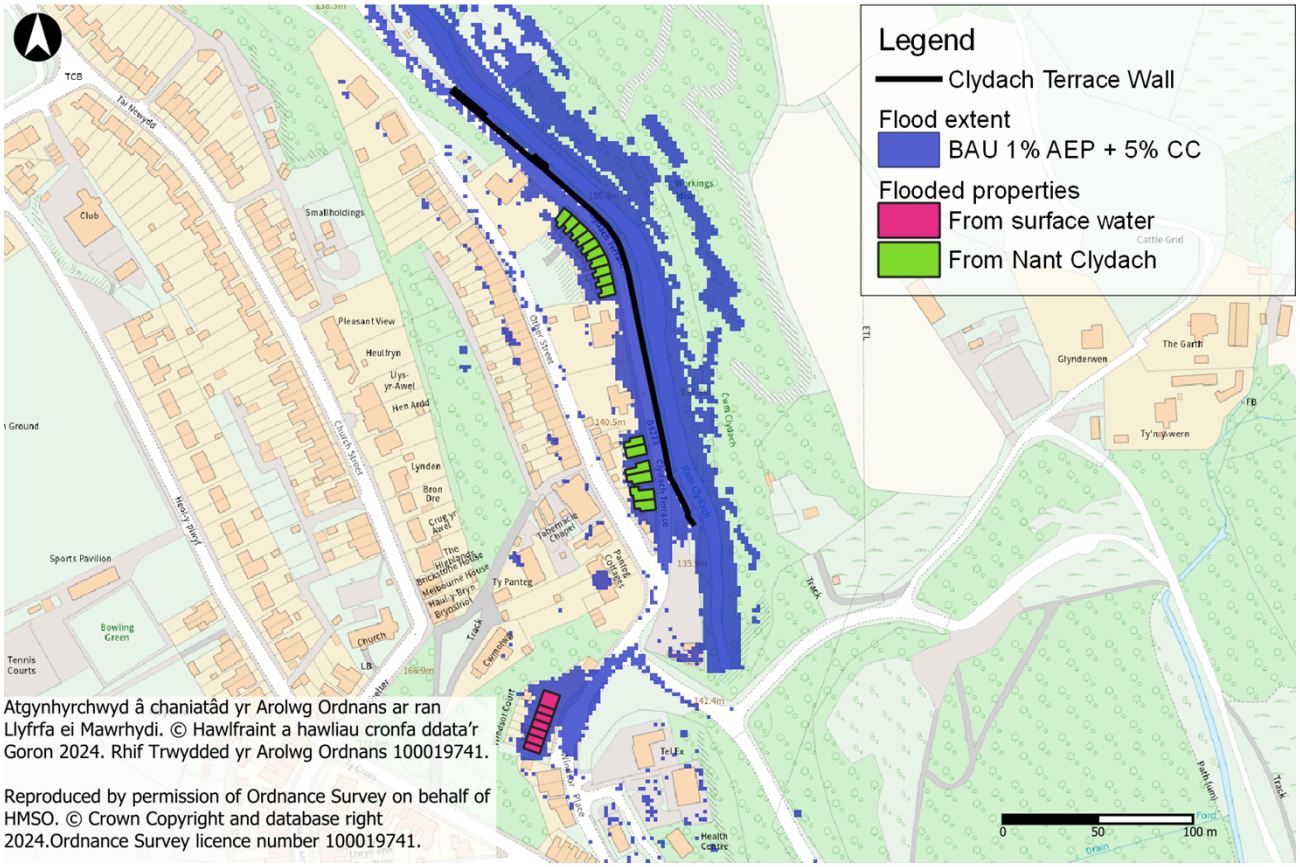

Figure 19 Summary of flooded properties in the BAU scenario for the 1% AEP event with a 5% climate change allowance

The modelled options are able to provide a reduction in flood risk from the Nant Clydach to a number of properties in flood events up to the design SoP. However, the modelling study has shown that there remains a residual risk of flooding from surface water flooding. For the 2% AEP event with 5% climate change event in Shortlist Option 1, the 11 flooded properties are flooded from surface water sources only. Figure 20 summarises the properties which are protected from flooding by the scheme, and the properties that are considered to still be at residual risk of flooding from surface water sources.

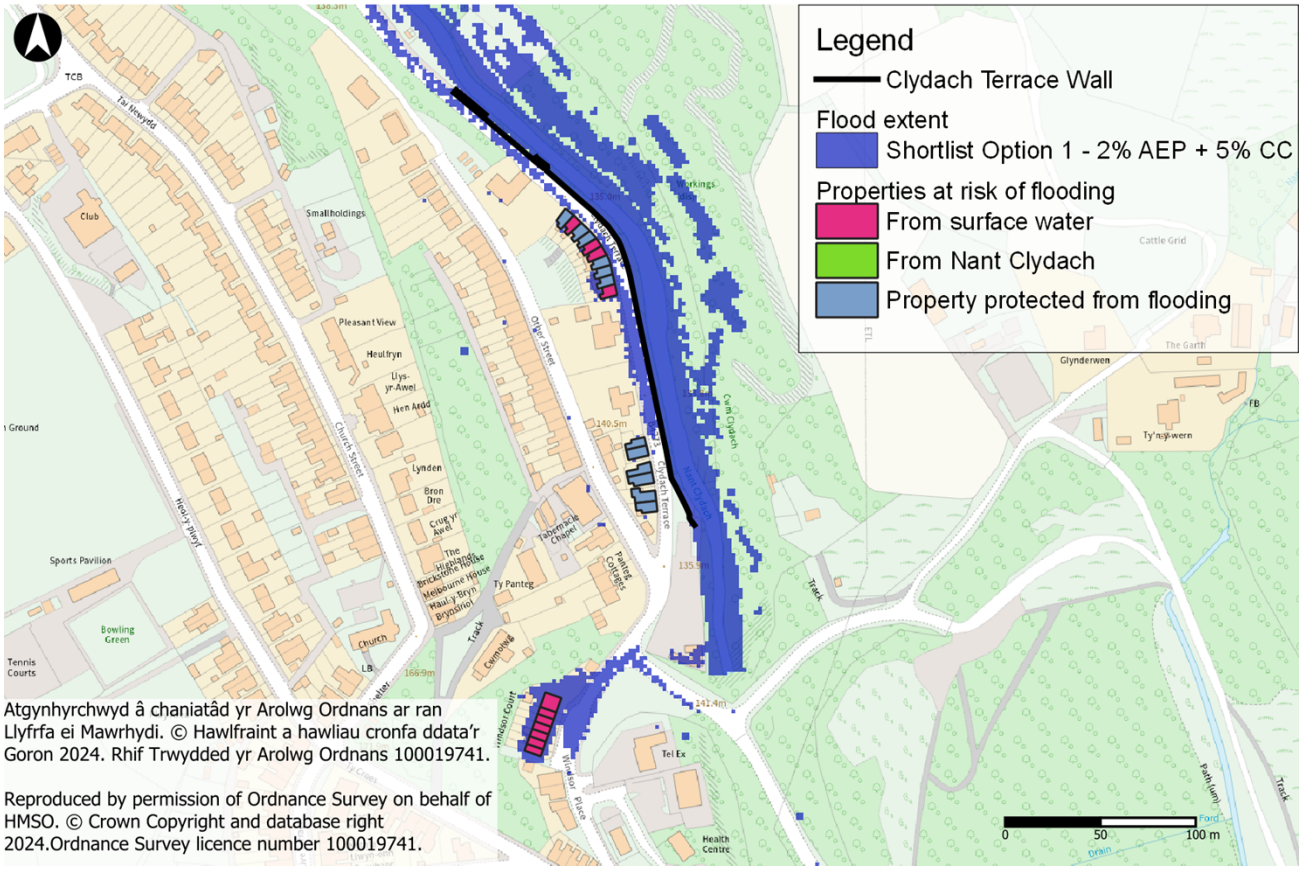

Figure 20 Summary of flooded properties in the Shortlist Option 1 scenario for the 2% AEP event with a 5% climate change allowance

Similarly, for Shortlist Option 2 in the 1% AEP event with 5% climate change, the 13 properties are flooded via surface water flooding only, as shown in Figure 21.

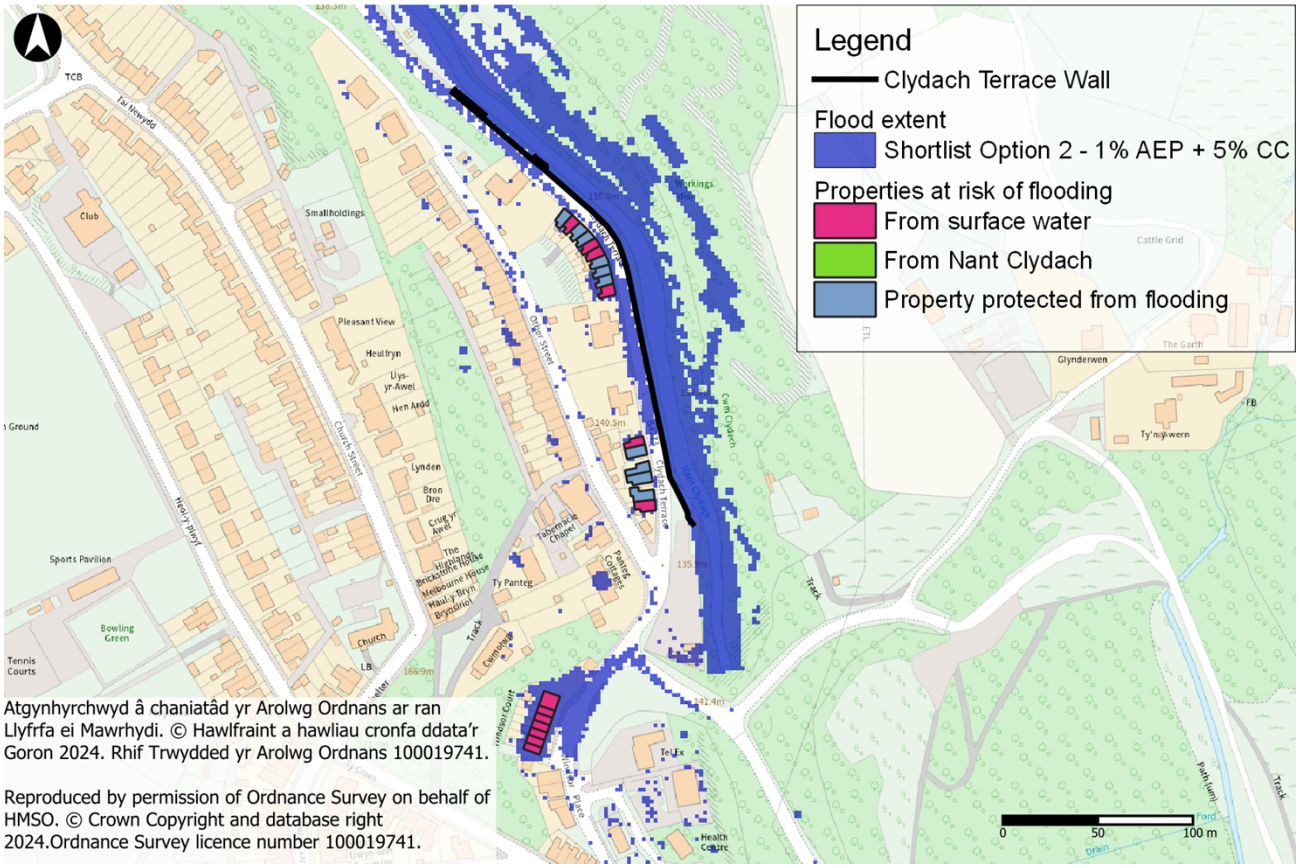

Figure 21 Summary of flooded properties in the Shortlist Option 2 scenario for the 1% AEP event with a 5% climate change allowance

It is also noted that the proposed Shortlist Options provide a reduction in flood risk to the properties on Clydach Terrace only. The properties on Windsor Place are considered to be at risk of surface water flooding only in events up to the 1% AEP event with 5% climate change. In the 0.1% AEP event overtopping occurs at the downstream extent of the proposed wall on Clydach Terrace. This occurs in both the BAU scenarios and in the Shortlist Option models. Water subsequently flows to the south and to the properties on Windsor Place, and therefore in this event the properties to the south are impacted by flooding to the Nant Clydach as shown in Figure 22.

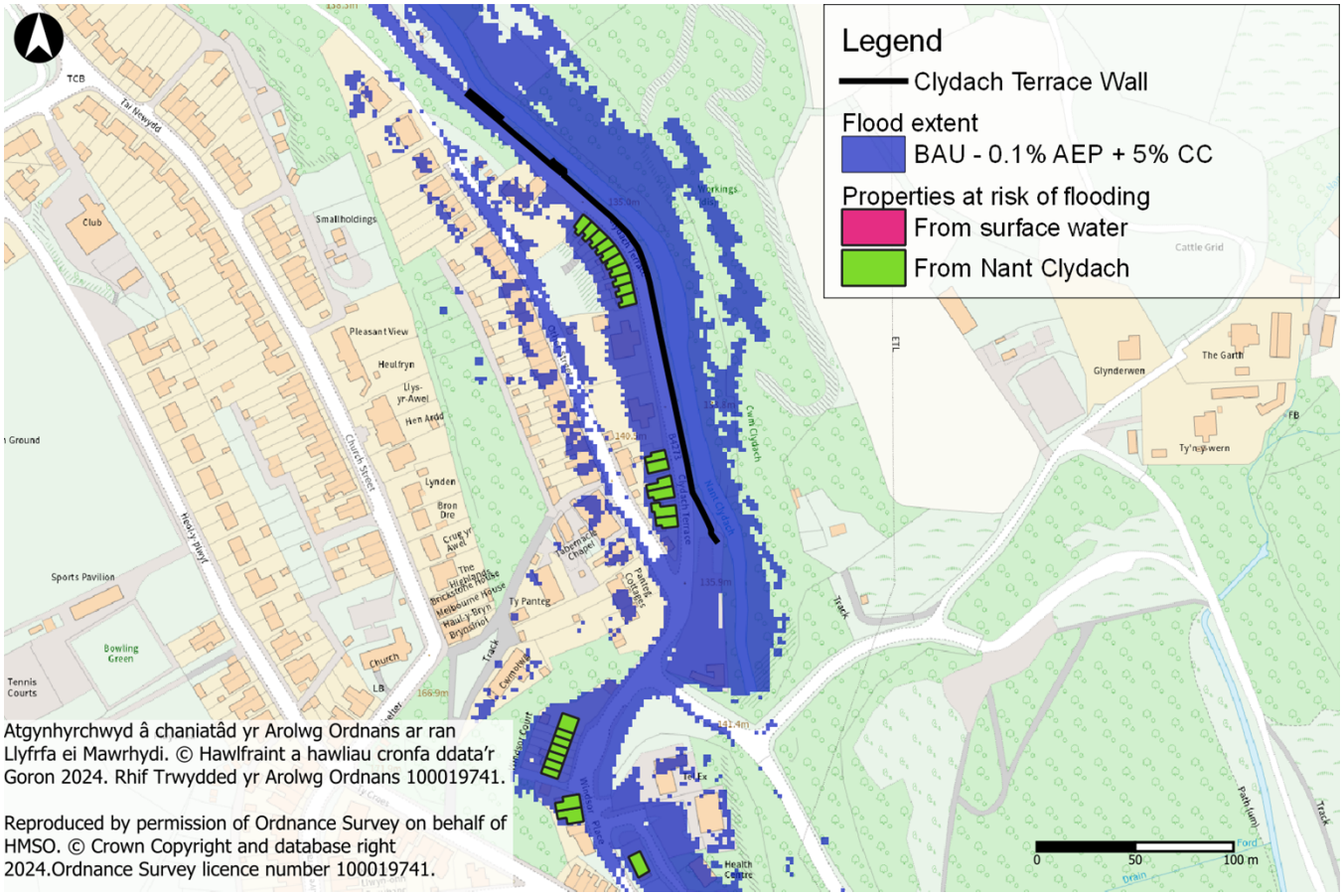

Figure 22 Summary of flooded properties in the BAU scenario for the 0.1% AEP event with a 5% climate change allowance

5. Summary and Conclusion

A hydraulic modelling study has been undertaken to establish the Business and Usual and Walkaway flood risk and then assess the flood risk benefit of two short listed options at Clydach Terrace, Ynysybwl. The modelling assessment has been undertaken using a 1D-2D ESTRY-TUFLOW model of the Nant Clydach and upper catchment produced by Arup, and subsequently accepted by NRW, in 2022.

A series of assumptions have been made to inform the Business as Usual and Walkaway baseline scenarios. These assumptions have been determined through discussion with NRW. They relate to the assumed impact on the Nant Clydach watercourse if the existing maintenance regime were to be completely stopped. The model has subsequently been modified to represent the impacts of shoal deposition, blockage of the Ynysybwl tunnel and increased vegetation and debris in the channel.

The two shortlisted options comprise raising the existing level of the de-facto flood defence on Clydach Terrace so that it provides a 2% AEP and 1% AEP Standard of Protection in the assumed construction period of 2025-2029 for each option respectively.

The model outputs have shown that in the Business as Usual scenario, the existing de-facto defence provides a flood risk benefit to the properties on Clydach Terrace for flood events <2% AEP event. However, during larger flood events, or in the future when the impact of climate change is likely to be more significant, the existing wall is shown to be increasingly likely to overtop. The model outputs also highlight the importance of the existing maintenance regime. With the Walkaway assumptions in place, flooding to Clydach Terrace is considered to occur during more frequent flood events due to raised water levels in the channel due to the cessation of maintenance.

The assessment indicates that the proposed scheme options are able to provide the required Standard of Protection to a number of properties on Clydach Terrace. However, the model outputs further indicate that residual surface water flooding occurs to properties on Clydach Terrace with the raised wall in place, and also to properties further downstream on Windsor Place.

This study further recommends that:

- An assessment of freeboard is made to inform the required design levels for the proposed flood defences in Shortlisted Option 1 and 2; and
- As part of the economics appraisal, consideration is given to the feasibility of using Property Level Flood Resilience measures to address the residual risk arising from surface water flooding.