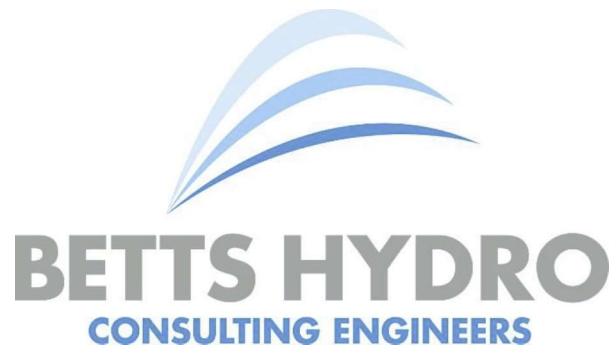


APPENDIX I: HYDRAULIC MODELLING ASSESSMENT

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LAND OFF ROSSETT ROAD ROSSETT

RIVER ALYN AT ROSSETT HYDRAULIC ASSESSMENT



For
Castle Green
Unit 20
St Asaph Business Park
St Asaph
Denbighshire
LL17 0LJ

The Castle Green logo consists of the words 'Castle' and 'Green' in a white serif font, separated by four vertical bars of varying heights, all contained within a dark green rectangular box.

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AUGUST 2021

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RIVER ALYN AT ROSSETT HYDRAULIC ASSESSMENT

Document Tracking Sheet

Document Reference: HYD554_ROSSETT.ROAD_HA
Revision: 2.0
Date of Issue: 19.08.21
Report Status: FINAL

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Revision History:

Rev.:	Date:	Status:	Prepared by:	Checked by:	Issued by:
2.0	19.08.2021	FINAL	PT	DK	PT
1.0	18.06.2021	FINAL	PT/DK	DK	DK
0.0	23.04.2020	DRAFT	DK	RN	DK



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Specialist Software

-  Flood Modeller 4.6
-  TUFLOW Build 2018-03-AE
-  QGIS 3.16.6

Abbreviations & Acronyms

AEP	Annual Exceedance Probability	mAOD	Metres Above Ordnance Datum
FZ	Flood Zone	NGR	National Grid Reference
CC	Climate Change	NPPF	National Planning Policy Framework
EA	Environment Agency	OS	Ordnance Survey
FEH	Flood Estimation Handbook	TWL	Top Water Level
FRA	Flood Risk Assessment	LLFA	Lead Local Flood Authority

1.0 INTRODUCTION

1.1 Commission

- 1.1.1 This Hydraulic Assessment was commissioned by Castle Green to undertake a Hydraulic Assessment understand the fluvial flood risk posed by the River Alyn in relation to a proposed development on Land at Rossett Road, Rossett.
- 1.1.3 This report is to support the Flood Consequence Assessment and Drainage Management Strategy as part of a planning application.

1.2 Outline of Assessment

- 1.2.1 Betts Hydro obtained Natural Resources Wales's (NRW) hydraulic model of the River Alyn in Rossett.
- 1.2.2 Modifications were made to the NRW model to improve the accuracy of the outputs and make them more relevant to the development site.
- 1.2.3 The model was run for the fluvial events from the 1 in 2 year to the 1 in 1000 year, including climate change and blockage analyses in the existing scenario. The key flood events were then simulated in the proposed scenario.
- 1.2.4 The results of the study provided flood depth, level, modelled events, and a comparison of flood depth difference in the existing and proposed scenarios was undertaken.

2.0 EXISTING SITE

2.1 Location

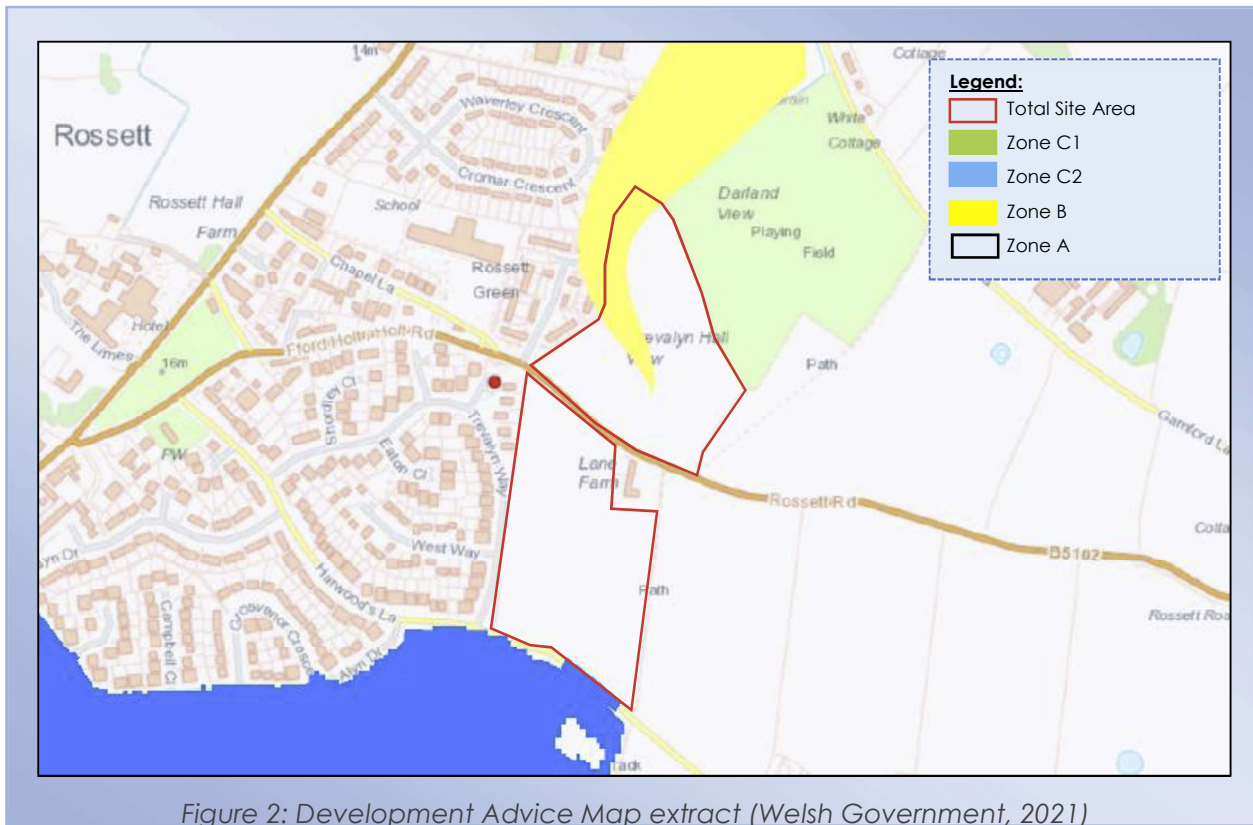
- 2.1.1 The site is accessed off Rossett Road in Rossett. The Ordnance Survey National Grid Reference (OS NGR) for the site is E: 337284, N: 357242 and the nearest postcode is LL12 0DZ. The total site covers 6.27ha and is divided into two separate parcels by Rossett Road. The Northern Development Parcel covers 2.83ha and the Southern Development Parcel covers 3.44ha. The parcels are edged in red in **Figure 1**. The site is bounded to the north, east and south by undeveloped agricultural land. To the west of site however is the main village of Rossett with both residential and commercial development.



Figure 1: Aerial Photograph of site (Bing Maps, 2021)

2.2 Natural Resources Wales Development Advice Map (DAM)

2.2.1 The Natural Resources Wales' (NRW) Development Advice Map (DAM) indicates that the site is located within Zone A and is within an area of low fluvial flood risk. The nearest Main River is the River Alyn located less than 180m to the south. There are flood defences upstream of the site on the northern bank of the River Alyn. The DAM is shown in **Figure 2**.



2.2.2 The Flood Zones are defined as follows:

- Flood Zone A: Areas considered to be at little or no risk of fluvial/tidal flooding.
- Flood Zone B: Areas known to have historically flooded based on sedimentary evidence deposits.
- Flood Zone C: Areas considered to be located on floodplain based on EA extreme flood outline data (equal to or greater than 0.1% fluvial/tidal flooding). This zone is subdivided into:
 - Zone C1 - Areas considered to be developed and served by significant infrastructure (flood defences).
 - Zone C2 - Areas considered to be located within natural floodplain without significant flood defences.

3.0 HYDRAULIC MODELLING

3.1 River Alyn Model

- 3.1.1 Natural Resources Wales has provided the River Alyn hydraulic model. Betts Hydro has reviewed NRW's River Alyn model, the extent of which is shown in **Figure 3**. The model includes the River Alyn from Croeshowell Hill west of the A483 to Rossett Road bridge. The NRW model includes data for simulating events from the 1 in 2 year to the 1 in 1000 year and includes the 20% and 30% allowance for climate change on the 1 in 100 year event.

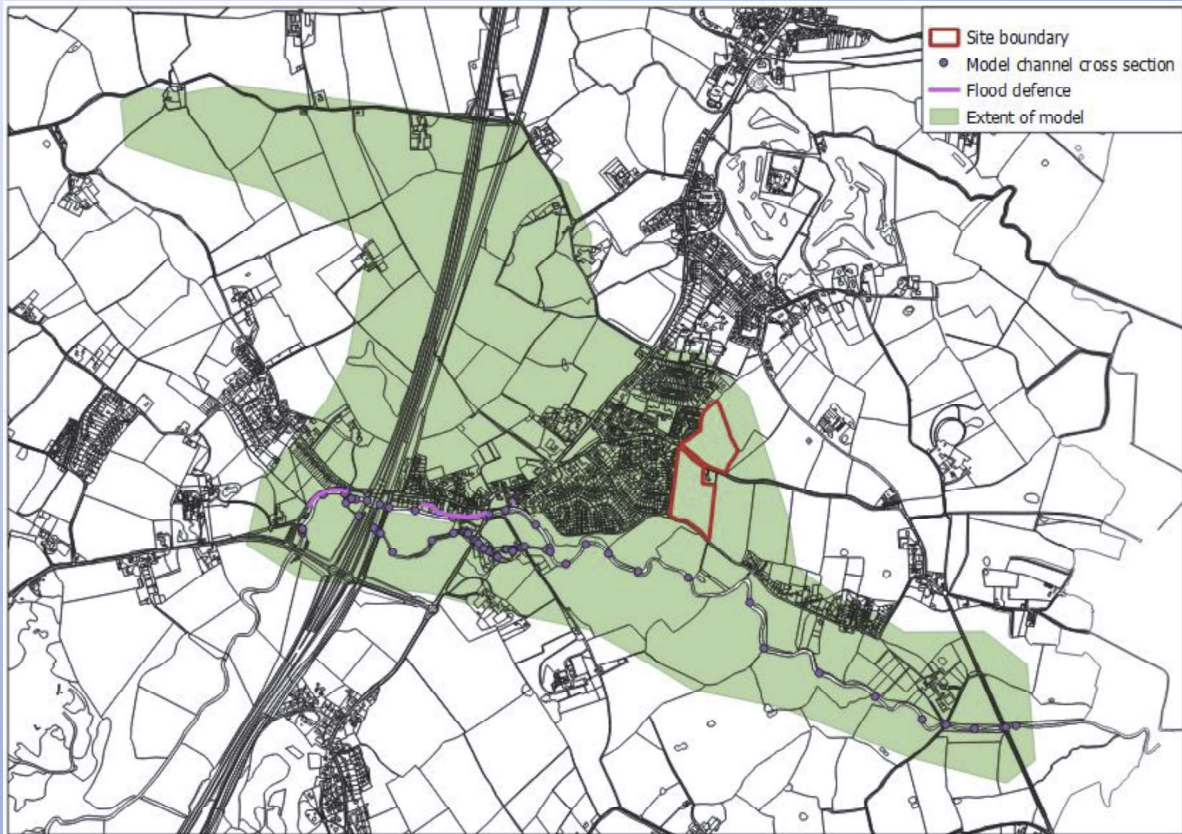


Figure 3: NRW model extent

- 3.1.2 The current guidelines for climate change on the River Dee catchment (in which the River Alyn falls under) is for an allowance of 20% for the Central estimate and 45% for the Upper estimate on top of the 1 in 100 year flow event.
- 3.1.3 The resolution of the flood outputs is a 3m grid, which was deemed adequate for the present study.

3.2 Existing Scenario Model Modifications

3.2.1 The NRW model was modified to provide better accuracy and the update the climate change allowance to the current standard. The following modifications were made to create the present study existing scenario model:

- Model 2D domain extended;
- New HQ boundaries added at 2D model extent;
- Site specific topographical survey added;
- Climate change allowance updated to current standard of 25% and 45%.

3.2.2 The existing site topographical survey is shown on the MB Surveying Ltd drawing no. **MBS825** in **Appendix A**. The full model schematic is provided on drawing no. **HYD554/001/A** in **Appendix B**.

3.3 Proposed Scenario Model Modifications

3.3.1 Proposed site ground and finished floor levels were added to the model to create a proposed scenario. The proposed site levels are shown on Drawing nos. **HYD554/0101/G** and **HYD554/0104/G** in **Appendix C**.

3.3.2 The design allows flood flow to pass through the site in extreme events while maintaining the proposed dwellings free from flooding without detriment to nearby properties.

4.0 MODEL RESULTS

4.1 Introduction

- 4.1.1 For the present study, the Natural Resources Wales River Alyn model was used, with some modifications, to better understand the fluvial flood risks to the site. The following modelling scenarios were undertaken:

-  Existing scenario
-  Proposed scenario

- 4.1.2 The results of these modelling scenarios were presented as flood extent, depth and level maps focusing on the proposed development area.

4.2 Existing Scenario

- 4.2.1 Betts Hydro has updated the NRW with the site topographical survey and the climate change allowances to meet the current standard of 25% and 45% increases over the next 100 years.

- 4.2.2 To give a full picture of flood risk to the site of a wide range of annual exceedance probabilities (AEP) and scenarios have been assessed. In all simulations, the defended scenario has been used to provide the real flood risk. The following simulations have been undertaken:

-  50% AEP (1 in 2 year)
-  10% AEP (1 in 10 year)
-  5% AEP (1 in 20 year)
-  3.3% AEP (1 in 30 year)
-  2% AEP (1 in 50 year)
-  1% AEP (1 in 100 year)
-  0.1% AEP (1 in 1000 year)
-  1% AEP plus 20% climate change
-  1% AEP plus 45% climate change
-  1% AEP plus 20% climate change with 25% blockage at Chester Road bridge
-  0.1% AEP with 25%th blockage at Chester Road bridge

- 4.2.3 The results have been presented as the enclosed peak flood depth and flood level plans.

Existing Scenario Results

- 4.2.4 Flow remains mostly within the River Alyn channel banks in the 50% AEP (1 in 2 year) event, as shown on **Drawing nos. HYD554/101/A and HYD554/102/A in Appendix D**. There is no flooding on the north side of the River Alyn and no flood risk to the proposed development site.
- 4.2.5 In the 10% AEP (1 in 10 year) event, flooding on land between the River Alyn and Harwood's Lane occurs, as shown on **Drawing no. HYD554/103/A in Appendix D**. Peak depth of flooding is between 0.41m and 0.60m. **Drawing no. HYD554/104/A in Appendix D** shows the peak level which is between 12.81mAOD and 13.00mAOD near to Harwood's Lane. The lowest ground level on the southern parcel of the proposed is approximately 13.50mAOD, hence no risk of flooding to site is posed in this event.
- 4.2.6 Flood extent and depth increased in the 5% AEP (1 in 20 year) when compared to the 10% AEP event, as can be seen on **Drawing nos. HYD554/105/A and HYD554/106/A in Appendix D**, although the flood still does not extend to Harwood's Lane. The peak flood depth is approximately 0.61m and the peak flood level is between 12.81mAOD and 13.00mAOD closest to Harwood's Lane.
- 4.2.7 **Drawing no. HYD554/107/A in Appendix D** shows the peak flood depth in the 3.3% AEP (1 in 30 year) event which is between 0.61m and 0.80m just south of Harwood's Lane. The peak flood level, shown on **Drawing no. HYD554/108/A in Appendix D**, is between 13.01mAOD and 13.20mAOD on the southern side of Harwood's Lane.
- 4.2.8 The flood extent has increased in the 2% AEP (1 in 50 year) event when compared to the 3.3% AEP event as expected. The flooding is still confined south of Harwood's Lane. The peak flood depth is approximately 0.81m just south of Harwood's Lane, as shown on **Drawing no. HYD554/109/A in Appendix D**. The peak flood level, shown on drawing no. **HYD554/110/A in Appendix D**, is between 13.01mAOD and 13.20mAOD.
- 4.2.9 **Drawing nos. HYD554/111/A and HYD554/112/A in Appendix D** show the peak flood depth and flood level in the 1.3% AEP (1 in 75 year) event, respectively. The peak flood depth is between 0.81m and 1.00m just south of Harwood's Lane and the peak level is between 13.21mAOD and 13.40mAOD.
- 4.2.10 The peak flood depth in the 1% AEP (1 in 100 year) event is shown on **Drawing no. HYD554/113/A in Appendix D** and is between 0.81m and 1.00m. The flood still does not extend beyond Harwood's Lane the site is not affected. **Drawing no. HYD554/114/A in Appendix D** shows the peak flood level in the 1% AEP event to be between 13.21mAOD and 13.40mAOD which below the lowest site ground level.
- 4.2.11 The 0.1% AEP (1 in 1000 year) event flood depth and level plans are shown on **Drawing nos. HYD554/115/A and HYD554/116/A in Appendix D**, respectively. The peak flood depth is approximately 1.21mAOD and the peak flood level is approximately 13.60mAOD on the southern side of Harwood's Lane close to the south west corner of the site.

Climate Change

4.2.12 The 1% AEP (1 in 100 year) event was simulated with the latest climate change allowances of 20% and 45% increases in flow. The 1% AEP event plus 20% climate change flood depth and level plans are shown on **Drawing nos. HYD554/117/B and HYD554/118/B** in **Appendix D**, respectively. The flood extent still remains south of Harwood's Lane and the peak depth is between 1.01m and 1.20m. The peak flood level is between 13.41mAOD and 13.60mAOD.

Blockage Analysis

4.2.13 A blockage analysis was performed by simulating an 25% reduction in the area of the opening at the arch bridge at Chester Road. The flow AEP events simulated were the 1% AEP event plus 20% climate change which is determined to be design event in which site mitigation measures such as raising the finished floor level are based on, in accordance with TAN15 A1.14. The 0.1% AEP event with blockage was also run to evidence dwellings remain safe in extreme flood events and flood risk is not increased elsewhere in accordance with TAN15 A1.15.

4.2.14 The flood depth in the 1% AEP plus 20% climate change with 25% blockage existing scenario is shown on **Drawing no. HYD554/131/A** in **Appendix D**. Peak flood level is shown on **Drawing no. HYD554/132/B** in **Appendix D**. The site is shown to remain flood free in this event with the nearest flooding located adjacent to Harwood Lane to the south of the site. There is not predicted to be overland flow routes from the area of the blockage through Rossett in this event.

4.2.15 The 0.1% AEP (1 in 1000 year) with 25% blockage at Chester Road has been run to assess the site during extreme events. The flood depth in the 0.1% AEP with 25% blockage existing scenario is shown on **Drawing no. HYD554/133/A** in **Appendix D**. The site is predicted to be inundated during this event. The peak depth in the southern portion of the site is approximately 0.13m and north of Rossett Road it is 0.32m. Peak flood level is shown on **Drawing no. HYD554/134/A** in **Appendix D**. The peak flood level is 12.85mAOD on the site south of Rossett Road and 12.33mAOD on the northern side of Rosset Road.

Conclusions

4.2.16 The site remains flood free in events up to the 0.1% AEP (1 in 1000 year) event. Flooding does occur on the site in the extreme 0.1% AEP event with blockage at Chester Road Bridge. The site is shown to flood to a maximum depth of 0.32m in this residual risk event.

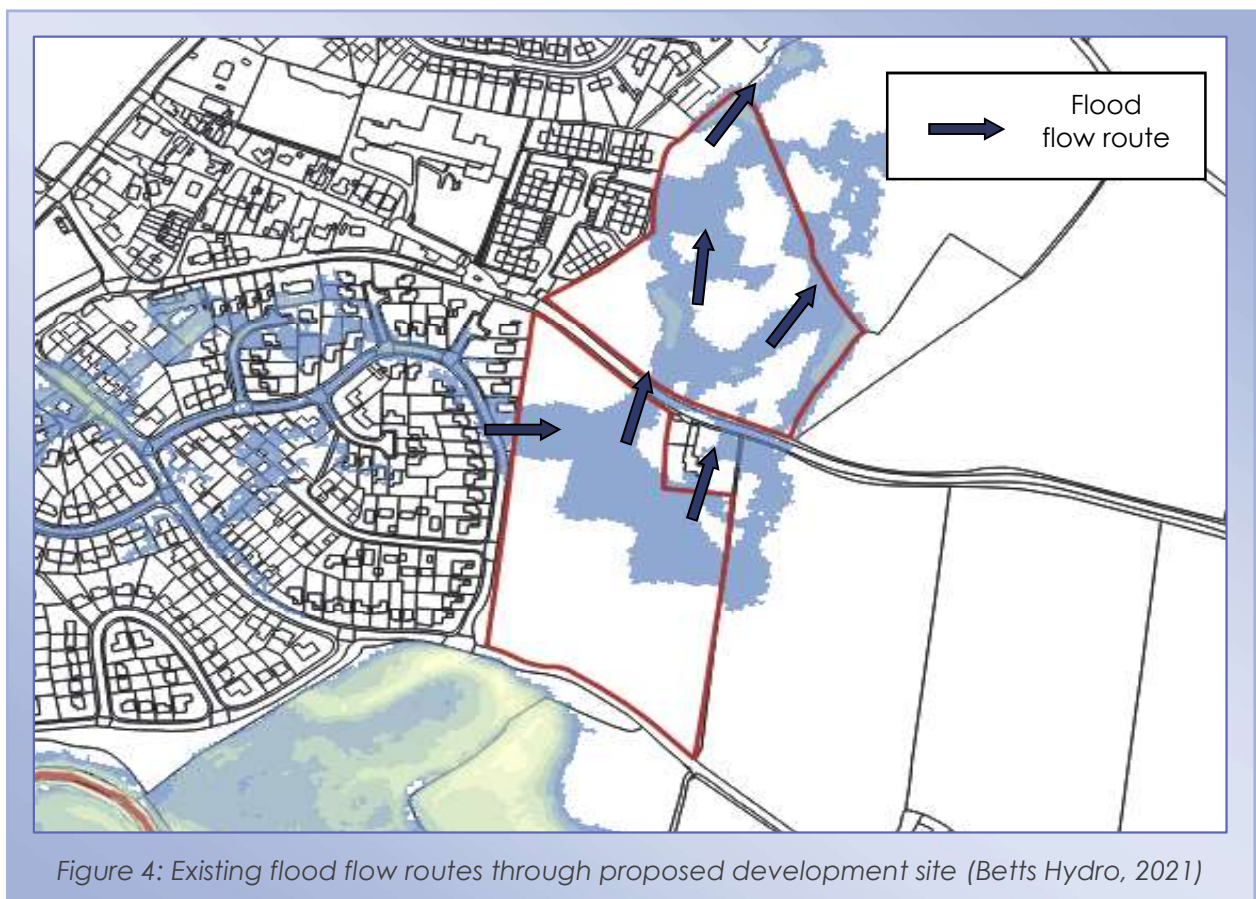
4.3 Proposed Scenario

4.3.1 The Stage 1 hydraulic modelling assessment has addressed the existing site scenario and identified the events that posed a flood risk to the site. Stage 2 has addressed the post development scenario in those events. The events identified that pose a flood risk to the site were:

- 0.1% AEP with 25% blockage at Chester Road bridge

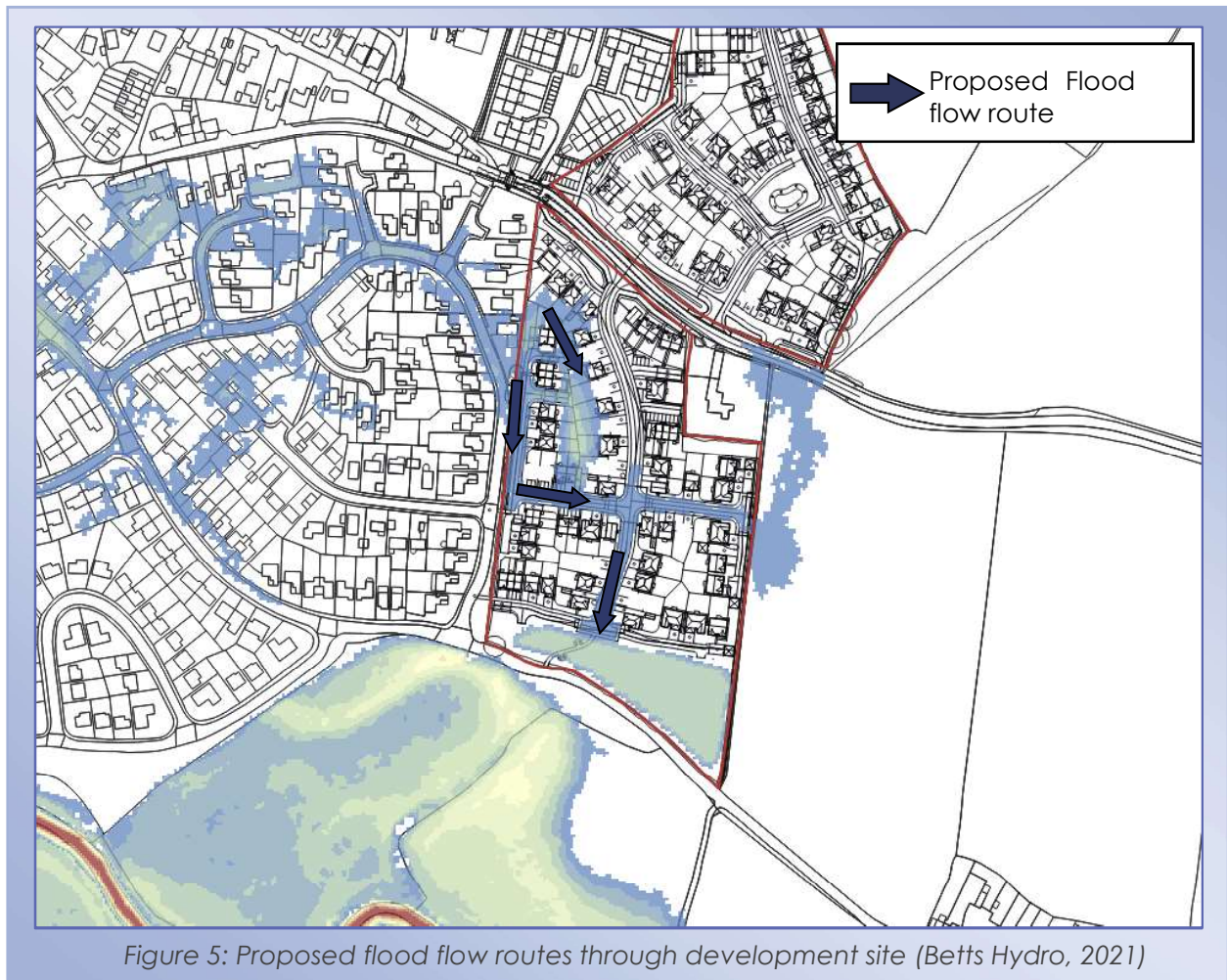
Post Development Scenario

4.3.2 **Figure 4** shows the proposed development layout with the 0.1% AEP (1 in 1000 year) with blockage flood extent and depth and the basic direction of flood flow through the development site. Flood flow enters the western boundary via a flood path through the village. Flow from the southern parcel, crosses Rossett Road and flows north to the northern parcel.



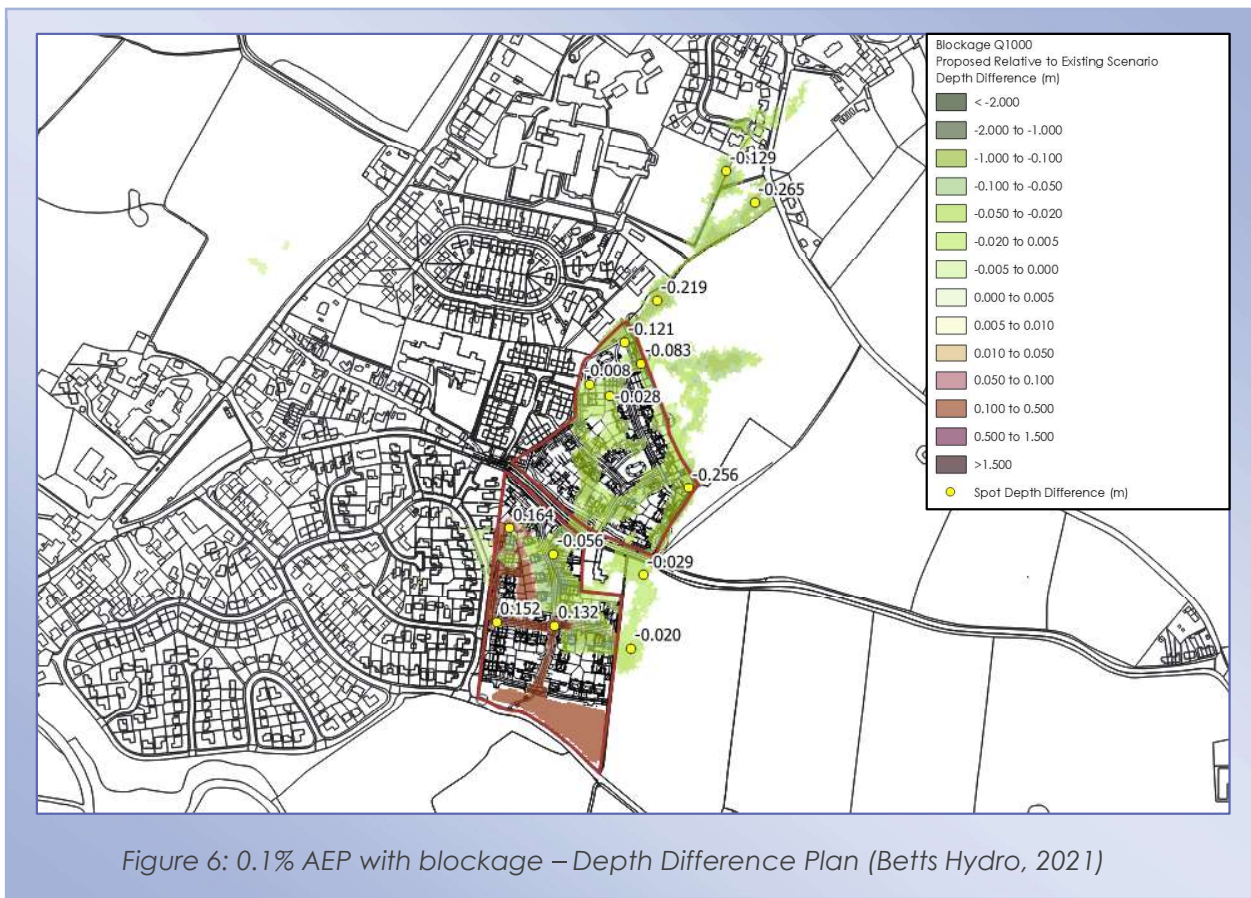
4.3.3 Levels in the proposed development have been designed to facilitate flood flow through the site in the 0.1% AEP (1 in 1000 year) flood with blockage. The proposed flood flow routes through the development in the 0.1% AEP (1 in 1000 year) with blockage are shown in **Figure 5**. The site design directs flow water to the south of the site via lowered roads and garden areas to a basin feature within the POS area of the site, containing flood water in this event

- 4.3.4 As in the existing scenario, the proposed scenario was tested with a blockage of 25% at Chester Road bridge. Drawing no. **HYD554/137/B** in **Appendix E** shows the proposed flood depth plan in the 0.1% AEP blockage scenario. As shown in the existing scenario flood flow enters the southern parcel of the development site via the western boundary and flows north, in the proposed scenario flooding is directed to south and there is reduced flood risk to the northern site area as well as additional areas to the north of the site (including school playing fields). The peak depth in the southern portion of the site is approximately 0.55m in rear gardens. The basin feature within the POS is predicted to flood to a depth of 0.4m. No properties are predicted to flood by more than 600mm with the majority of properties remaining flood free in accordance with TAN 15. A1.15. The peak flood level is shown on **Drawing no. HYD554/138/B** in **Appendix E**. The peak flood level is 13.45mAOD within the southern parcel near to Rossett Road. Predicted flood velocities are shown in **Drawing no. HYD554/139/B** in **Appendix E**. Predicted peak flood velocities for the southern parcel are 0.16m/s with the majority of predicted velocities below 0.1m/s. Predicted flood velocities onsite are less than 0.3m/s and therefore compliant with TAN 15 A1.15.



Depth Difference

- 4.3.5 A comparison of flood depth between the existing and proposed scenarios has been undertaken in the 0.1% AEP (1 in 1000 year) flood event with 25% blockage at Chester Road bridge.
- 4.3.6 The depth difference in the 0.1% AEP plus 25% climate change is shown on **Drawing no. HYD554/405/B** in **Appendix F** and **Figure 6**. As the design of the site prevents flood flow to the north of Rossett Road, it is predicted that dwellings located off Broadoaks and land to the north of the site, including the school field will no longer be at flood risk in this event. Flood risk is also shown to be removed from the farm building located adjacent to the southern parcel. These areas previously flooded to depths of 0.03m and 0.02m respectively in the 1 in 1000 year plus 25% blockage event, this event is classed as a residual risk event.



Sensitivity Analysis

- 4.3.20 A sensitivity analysis was undertaken on the following key parameters in the model:

 1% AEP plus 25% Climate Change with 80% blockage of Chester Road bridge

- 4.3.21 The design event has been reviewed with an associated sensitivity test. The 20% increase in flow has been increased to 25% and the area blocked increased from 25% to 80% as requested by NRW. In this sensitivity event the predicted flood depths are shown in **Drawing no. HYD554/127/B** within **Appendix G**. The site is shown to be inundated in the southern parcel with minor flooding also predicted within the northern

parcel. Flows are predicted to enter the site from the western boundary within the southern portion, similar to the 1 in 1000 year event with 25% blockage. The onsite storage basin is not shown to overtop in this event. The peak predicted flood depth in the southern parcel is 0.78m and 0.45m in the northern parcel. Predicted flood levels are shown in **Drawing no. HYD554/128/B** within **Appendix G**. The predicted flood level in the southern parcel is 13.53mAOD and 12.65mAODm in the northern parcel.

- 4.3.22 In terms of predicted flood depths and velocities the proposed development is compliant with TAN 15 A1.15.

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

- 5.1.1 The existing site remains flood free in events up to the 0.1% AEP (1 in 1000 year) event, including the 1% AEP plus 20% climate change with 25% blockage (the design event). The development is therefore compliant with TAN15 A1.14 with the site flood free in the design event.
- 5.1.2 Flooding onsite occurs in the extreme 0.1% AEP with 25% blockage. This is an extreme event and are beyond that which would normally be considered a design event. The predicted flood depths and velocities are within the thresholds detailed within TAN15 A1.15 with predicted flood depths less than 600mm for the properties that are inundated and predicted flood velocities onsite are less than 0.3m/s.
- 5.1.3 Proposed road and dwelling levels have been set channel flood flow through the site in the extreme event to a basin within the POS area to the south of the site. This approach contains flood flow in extreme events within the site.
- 5.1.4 The hydraulic modelling of the proposed scenario has also demonstrated that there is positive change in flood risk elsewhere with a reduction in the number of dwellings at risk in the residual 1 in 1000 year plus 25% blockage event as a result of flood flow being contained onsite.
- 5.1.5 A sensitivity analysis has shown that variation in the model key parameter does not affect the predicted flood levels to such an extent that the proposed dwellings would be at risk of flooding above prescribed thresholds.

5.2 Recommendation

- 5.2.1 The separate Flood Consequence Assessment should be reviewed in addition to this Hydraulic Modelling Assessment.

BIBLIOGRAPHY & REFERENCES

Bibliography

National Planning Policy Framework, CLG (2019).
Planning Practice Guidance, CLG (2014)
Flood Estimation Handbook (FEH)
Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management
Authorities. Environment Agency (2016)

Web-based References

Bingmaps – <http://www.bing.com/Maps/>
Environment Agency – www.environment-agency.gov.uk/
EA Flood Map for Planning - <https://flood-map-for-planning.service.gov.uk/>
Flood Modeller - <https://www.floodmodeller.com/>