

Conwy Deposit Local Development Plan 2007 – 2022 (Revised edition 2011)



REVISED BACKGROUND PAPER 17 – SUBMISSION

Conwy Strategic Flood Consequences Assessment

August 2012

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Conwy Strategic Flood Consequence Assessment

March 2012

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CONWY STRATEGIC FLOOD CONSEQUENCE ASSESSMENT**CONTENTS**

1.	INTRODUCTION	1
1.1	Background Paper 17	1
1.2	Report Structure	1
2.	BACKGROUND INFORMATION	3
2.1	Introduction	3
2.2	Sources of Flood Risk	3
2.3	Policy and Guidance	3
2.4	Conwy Planning Policy	5
2.5	Shoreline Management Plans	6
2.6	Catchment Flood Management Plans	7
2.7	Tidal Clwyd Flood Risk Management Strategy	9
3.	STAGE 1 ASSESSMENTS	10
3.1	Introduction	10
3.2	Data Collection	10
3.3	Stage 1 Assessment Tables	11
3.4	Summary	11
4.	STAGE 2 ASSESSMENTS	25
4.1	Introduction	25
4.2	Abergele (Housing & Mixed-Use)	27
4.3	Llandudno Junction (Housing)	35
4.4	Llandudno (Housing)	37
4.5	Rhos-on-Sea (Housing)	42
4.6	Llanrwst (Housing)	44
4.7	Eglwysbach (Housing)	51
4.8	Llangernyw (Housing)	54
4.9	Cerrigydrudion (Housing & Mixed-Use)	56
4.10	Dolgarrog (Housing)	60
4.11	Llandudno (Employment)	64
4.12	Dolgarrog (Employment)	69
4.13	Llansannan (Employment)	73
4.14	Kinmel Bay (Waste Management Facility)	76
4.15	Llandudno Junction (Waste Management)	81
4.16	Summary	84
5.	CONCLUSION	86

TABLES

Table 2.1 – Development Advice Flood Map Zones (TAN15, 2004)

Table 2.2 – Development Categories (TAN15, 2004)

Table 2.3 – SMP Generic Policies

Table 2.4 – Conwy and Clwyd CFMP Policies

Table 3.1 – Stage 1 Assessment Datasets

Table 3.2 – Stage 1 Assessment: Urban Development Strategy Area (Housing)

Table 3.3 – Stage 1 Assessment: Rural Development Strategy Area (Housing)

Table 3.4 – Stage 1 Assessment: Urban Development Strategy Area (Employment)

Table 3.5 – Stage 1 Assessment: Rural Development Strategy Area (Employment)

Table 3.6 – Stage 1 Assessment: Urban Development Strategy Area (Mixed-Use)

Table 3.7 – Stage 1 Assessment: Waste Management Facility

Table 4.1 – Stage 2 Assessment Datasets

Table 4.2 – Summary of Stage 2 Assessment Outcomes

FIGURES

Figure 4.1 – Flood Zones: Llanfair Road & Siamber-wen, Abergele

Figure 4.2 – Flood Zones: Tandderwen Farm & Rhuddlan Road, Abergele

Figure 4.3 – Afon Gele Model Flood Outlines

Figure 4.4 – Topography: Rhuddlan Road, Abergele

Figure 4.5 – Surface Water Flooding (1 in 200): Rhuddlan Road, Abergele

Figure 4.6 – Flood Zones: Social Club & Youth Club, Llandudno Junction

Figure 4.7 – Flood Zones: Plas yn Dre, Llandudno

Figure 4.8 – Annual Flood Probabilities: Plas yn Dre, Llandudno

Figure 4.9 – Site Levels: Plas yn Dre, Llandudno

Figure 4.10 – Annual Flood Probabilities for Depths >600mm: Plas yn Dre, Llandudno

Figure 4.11 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise:
Plas yn Dre, Llandudno

Figure 4.12 – Flood Zones: Dinerth Hall Farm, Rhos-on-Sea

Figure 4.13 – Flood Zones: Bryn Hyfryd, Llanrwst

Figure 4.14 – Surface Water Flood Mapping: Bryn Hyfryd, Llanrwst

Figure 4.15 – Flood Zones: A470 & North-West, Llanrwst

Figure 4.16 – Photos of Flood Bank and Opening through Wall

Figure 4.17 – Surface Water Flooding (1 in 200): A470 & North-West, Llanrwst

Figure 4.18 – Topography: A470 & North-West, Llanrwst

Figure 4.19 – Flood Zones: Off Heol Martin, Eglwysbach

Figure 4.20 – Surface Water Flooding (1 in 200): Off Heol Martin, Eglwysbach

Figure 4.21 – Afon Hiraethlyn Peak Water Levels

Figure 4.22 – Flood Zones: Coed Digain, Llangernyw

Figure 4.23 – Flood Zones: Fronting B5105, Cerrigydrudion

Figure 4.24 – Cerrigydrudion Topography

Figure 4.25 – Surface Water Flooding (1 in 200): Cerrigydrudion

Figure 4.26 – Flood Zones: Tan Y Ffordd & Gwydr Road, Dolgarrog

Figure 4.27 – Modelled Impact of Climate Change

Figure 4.28 – Reservoir Flooding: Gwydr Road, Dolgarrog

Figure 4.29 – Flood Zones: Former Goods Yard, Llandudno

Figure 4.30 – Annual Flood Probabilities: Former Goods Yard, Llandudno

Figure 4.31 – Ground and Flood Levels: Former Goods Yard, Llandudno

Figure 4.32 – Annual Flood Probabilities for Depths >600mm: Former Goods Yard, Llandudno

Figure 4.33 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise:
Former Goods Yard, Llandudno

Figure 4.34 – Flood Zones: Dolgarrog, Memorial Hall

Figure 4.35 – Reservoir Flooding: Dolgarrog, Memorial Hall

Figure 4.36 – Surface Water Flooding: Dolgarrog, Memorial Hall

Figure 4.37 – Surface Water Flooding: Llansannan

Figure 4.38 – Topography: Llansannan

Figure 4.39 – Flood Zones: Gofer Waste Management Facility, Kinmel Bay

Figure 4.40 – Annual Flood Probabilities: Gofer Waste Management Facility

Figure 4.41 – Topography: Gofer Waste Management Facility

Figure 4.42 – Ground Elevation: Gofer Waste Management Facility

Figure 4.43 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise:
Gofer Waste Management Facility

Figure 4.44 – Flood Zones: Llandudno Junction, Network Rail, Waste Management Facility

Figure 4.45 – Topography around Llandudno Junction, Network Rail, Waste Management Facility

APPENDICES:

Appendix A – Areas at High Risk of Flooding in Conwy

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CONWY STRATEGIC FLOOD CONSEQUENCE ASSESSMENT

1. INTRODUCTION

1.1 Background Paper 17

This report is one of a series of background papers accompanying the Revised Deposit Local Development Plan (LDP) document. When the Council publishes its Revised Deposit LDP, it must explain how the relevant policy has been formulated based on the evidence base available to the Council at the time. This background paper outlines the evidence considered by the Conwy County Borough Council during the preparation of the Local Development Plan (LDP) and the actions proposed by the Council to ensure that the risk to new developments from flooding is minimised. The paper should be read in association with Local Development Plan Background Paper 21 - 'Site Deliverability Assessment' which records in detail the individual assessments undertaken of all the sites considered for allocation in the LDP.

Flooding is a natural occurrence which is often hard to predict. It can pose a direct risk to human life and cause extensive damage to both property and infrastructure. The threat posed by climate change is likely to increase the risk of coastal and fluvial flooding due to a predicted rise in the sea-level and a more intense rainfall. Therefore the risk of flooding is a material consideration which influences both development control decisions and LDP site allocations.

In the first instance the Strategic Flood Consequence Assessment (SFCA) will inform on flood risk to candidate development sites within the LDP. This will enable the Local Planning Authority to adopt the precautionary principle promoted in National Planning Guidance to direct development away from high flood risk areas.

The Council is mindful of the current concerns regarding the risk of flooding and the effects of climate change. The Council does not wish to endanger life and property by proposing inappropriate development in areas at high risk from flooding (Appendix A gives an overview of high flood risk area in the county). However, since 85% of the population of Conwy lives within coastal areas, the Council is also mindful that it has a responsibility to maintain the vitality of its settlements. Therefore the SFCA will, where necessary, demonstrate that the consequences of flooding are sufficiently understood and can be managed in an acceptable and sustainable way to permit development within areas of higher flood risk in order to satisfy identified local needs.

1.2 Report Structure

Following this introduction, the report is structured into three distinct sections and a conclusion. A brief summary of the content of each is given below.

- Background Information – this section brings together general information including sources of flood risk, details on flood risk policies and guidance, management plans and other relevant information to the SFCA.
- Stage 1 Assessment – this is a desk top study carried out using the available GIS datasets to assess flood risk to each of the candidate sites. Those sites where a potentially significant flood risk has been identified were taken forward to Stage

2 Assessments. Otherwise the site is regarded as suitable for allocation in the LDP.

- Stage 2 Assessment – this provides a more detailed discussion of flood risk to the candidate site. More detailed information has been collected and, where required, hydraulic calculations carried out to provide a better understanding of flood risk and flood consequence. Possible flood risk mitigation has been considered where appropriate, as have potential third-party impacts. This process may result in a recommendation that a candidate site is not allocated as part of the LDP.
- Conclusion – provides a summary of work carried out and a summary of the recommendations for allocations.

2. BACKGROUND INFORMATION

2.1 Introduction

The following section describes the background information that it was necessary to consider as part of the SFCA. This information was applied on a case by case basis as appropriate for each candidate site. The section includes an overview of the sources of flood risk considered, a summary of policy and guidance regarding flood risk and flood consequence, and summarises key points from various management plans which help govern long-term planning strategies.

2.2 Sources of Flood Risk

Flooding can occur from a number of sources, each of which has been assessed as part of the SFCA. Sources of flood risk include:

- **Tidal flooding** which can occur during high tides and stormy conditions. A tidal surge can also occur when low atmospheric pressure coincides with a high tide, this can result in serious flooding as a result of waves overtopping defences, or in the worst case a breach of the defences.
- **Fluvial flooding** can happen during heavy rainfall when water drains from the surrounding land into the watercourse which cannot cope with this additional volume of water. Flood defences may provide additional protection from flooding, but these may be overtopped or breached.
- **Surface water flooding** is defined as flooding that takes place as a result of heavy rainfall before it has entered a watercourse, drainage system or public sewer. Surface water flooding may be expected to flow or pond.
- **Sewer flooding** can be caused by intensive rainfall resulting in sewer capacity being exceeded and from which flooding may result via manholes.
- **Groundwater flooding** may occur where prolonged periods of rainfall result in a high water table and the emergence of groundwater. This would normally only be expected to be a significant issue where surface water flooding is also demonstrated to be a problem.

2.3 Policy and Guidance

(a) Planning Policy Wales (PPW)

The LDP has a significant role to play in promoting sustainable development (PPW 4.3). Planning Policy Wales states that Local Planning Authorities must adopt a proactive 'sustainable approach to flooding' by avoiding development within flood risk areas rather than relying on mitigation measures such as flood defences. Local Planning authorities must also ensure that new development does not increase the risk of flooding elsewhere.

(b) Technical Advice Note 15 (TAN15)

Technical Advice Note 15 supplements the policy contained within PPW in relation to development and flood risk. It sets out a precautionary framework which is governed by a development advice map which consists of three zones; A, B and C (subdivided into C1 and C2) as described in Table 2.1. Proposed development within these zones will require the appropriate planning test as outlined in TAN15.

Table 2.1 – Development Advice Flood Map Zones (TAN15, 2004)

Description of Zone	Flood Zone	Use within the precautionary framework
Considered to be at little or no risk of fluvial or tidal/coastal flooding.	A	Used to indicate that justification test is not applicable and no need to consider flood risk further.
Areas known to have been flooded in the past evidenced by sedimentary deposits.	B	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	C	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences.
Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	C1	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
Areas of the floodplain without significant flood defence infrastructure.	C2	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

The type of development proposed is also important when considering flood risk. The three categories of development used in TAN15 are given in Table 2.2.

Table 2.2 – Development Categories (TAN15, 2004)

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

Section 6 of TAN 15 – ‘Justifying the location of development’ - further advises that new development should be directed away from Zone C and that development in Zone C will only be justified if it can be demonstrated that:

- i. Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; (The Deposit LDP is an example of a local authority strategy) **or**,
 - ii. Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;
- and,**
- iii. It concurs with the aims of PPW and meets the definition of previously developed land (PPW fig 2.1); and,
 - iv. The potential consequences of a flooding event for the particular type of development have been considered and found to be acceptable.

For the purpose of this SFCA, where application of the justification test is required, it has been assumed that the criteria **i** or **ii** and **iii** have been met. This SFCA therefore only considers whether a development should proceed based on a strategic scale assessment of the flood consequences. The requirement for assessment of flood consequences are discussed in Section 7 of TAN15 with additional information provided in Appendix 1. Where appropriate, this information is referred to and used in the Stage 2 Assessments.

2.4 Conwy Planning Policy

The following provides a summary of the local policies that are relevant when assessing suitability of candidate sites for the LDP in terms of flood risk.

The Conwy Deposit Local Development Plan (revised edition 2011) **Policy DP/1 ‘Sustainable Development Principles’** states that:

“Development will only be permitted where it is demonstrated that it is consistent with the principles of sustainable development and therefore required to:

- *Accord with the national guidance in line with Policy DP/6 ‘National Planning Policy and Guidance (i.e. PPW & TAN15).*
- *Take account and address the risk of flooding.”*

Furthermore, **Policy DP/4 ‘Development Criteria’** contains the following statement:

“Planning permission will not normally be granted where the proposal would have an unacceptable adverse impact on flooding and flood risk.”

The Conwy LDP also contains important guidelines on drainage systems. **Policy NTE/9** states that

“The use of SUDS will be required wherever reasonably practicable with the preference for on-site disposal. Where this is not proposed a developer will need to justify that discharge is necessary and adequately controlled.”

Also, the Llandudno Conwy District Plan (1982 & 1993) states under **Policy 9B**:

“Within drainage areas subject to flooding there will be a presumption against development which would significantly worsen the situation”

And the Colwyn Borough Local Plan (1999) states under **Policy CG10**:

“Proposals for development on land which is likely to be subject to flooding, which would cause flooding off-site or which would affect flood management of maintenance will not be permitted.”

These policies make it clear that in addition to following the national planning guidelines, the use of sustainable drainage systems must be considered and incorporated wherever possible and that development should not result in increased flood risk to third-parties. It is also worth noting that under the Flood and Water Management Act 2010, “*construction work which has drainage implications may not be commenced unless a drainage system for the work has been approved by the approving body*”.

In 2011 Conwy CBC also released a Coastal Flood Risk Planning Protocol for the area from Pensarn to Kinmel Bay as a source of non-statutory guidance. This was as the result of the Conwy Tidal Flood Risk Assessment (2010) demonstrating a significant level of tidal risk to this area. The outcome is that the protocol recommends for vulnerable and new developments within the tidal zone including climate change area:

- that there will be a presumption against granting permission in respect of highly vulnerable development and;
- proposals for other forms of development will be evaluated against the requirements of TAN15, but that it is highly unlikely that new low vulnerability development will be able to satisfy the requirements of TAN15.

However, there is only one candidate site (Gofer Waste Transfer) that falls within this tidal zone. The site is of low vulnerability and will be assessed accordingly as part of the Stage 2 Assessments.

2.5 Shoreline Management Plans

A Shoreline Management Plan (SMP) provides a large-scale assessment of the risk associated with coastal erosion and flooding and presents policies intended to help manage these risks in a sustainable manner. It does not set policy, but should be considered by local planning authorities when formulating their local development plans.

A second generation of SMPs have recently been produced (SMP2). The coastline on which Conwy CBC sits is split between two SMP2s:

- West of Wales SMP2 – covers the coastline from Llanfairfechan to Great Orme's Head.
- North West and North Wales SMP2 – covers the coastline from Great Orme's Head to the Clwyd Estuary.

The generic shoreline management policies considered are given in Table 2.3.

Table 2.3 – SMP Generic Policies

Policy Option	Description
Hold the Line	By maintaining or changing the current standard of protection. This policy includes those situations where work is carried out in front of the existing defences (such as beach recharge, rebuilding the toe of a structure, building offshore breakwaters and so on) to improve or maintain the standard of protection provided by the existing defence line. It also includes work behind existing defences (such as building secondary flood defences) where this work would form an essential part of maintaining the current coastal defence system.
Advance the Line	By building new defences on the seaward side of the original defences. Use of this policy is limited to those policy units where significant land reclamation is considered.
Managed Realignment	By allowing the shoreline to move backwards or forwards, with management to control or limit movement (such as reducing erosion or building new defences on the landward side of the original defences).
No Active Intervention	Where there is no investment in coastal defences or operations.

The majority of the Conwy CBC shoreline has a policy of 'Hold the Line', with some areas recommending a 'Managed Realignment' in the long-term in order to deal with sea level rise. The exceptions to this are Great Orme and Little Orme where 'No Active Intervention' is recommended; neither of which would impact on any of the candidate sites. There is also a medium-term policy of managed realignment along the Clwyd Estuary; again this would not impact on candidate sites.

2.6 Catchment Flood Management Plans

Similarly to a SMP, a Catchment Flood Management Plan (CFMP) gives an overview of the flood risks and sets out preferred plans for sustainable flood risk management in the long-term. Conwy CBC is covered by the Conwy and Clwyd CFMP. There are six policy options considered:

- **Policy 1** – Areas of little or no flood risk where we will continue to monitor and advise.
- **Policy 2** – Areas of low to moderate flood risk where we can generally reduce existing flood risk management options.
- **Policy 3** – Areas of low to moderate flood risk where we are generally managing flood risk effectively.

- **Policy 4** – Areas of low, moderate or high flood risk where we are already managing the flood risk effectively, but where we may need to take further actions to keep pace with climate change.
- **Policy 5** – Areas of moderate to high flood risk where we can generally take further action to reduce flood risk.
- **Policy 6** – Areas of low to moderate flood risk where we will take action with others to store water or manage run-off in locations that provide overall flood risk reduction or environmental benefits.

The CFMP is divided into 12 sub-areas, of which half are relevant to the Conwy SFCA. Table 2.4 summarises the principle flood risks and the recommended policy for each of the relevant sub-areas. These policies should be taken account of as part of the SFCA and if appropriate will be referred to as part of the assessment; however it is considered unlikely that the policies will have significant implications for the suitability of the candidate sites.

Table 2.4 – Conwy and Clwyd CFMP Policies

Sub-Area	Principle Flood Risks	Policy
Conwy Catchment and Upland Areas (Sub-area 1)	Flooding mainly from Afon Conwy and its tributaries; some localised tidal, surface water and sewer flooding.	Policy 3 – continue to maintain defences, but it may not be justified to replace or increase their height in the future.
Llanrwst and Trefriw (Sub-area 2)	Area suffers from surface run-off, overloaded sewer systems and river flooding from Afon Conwy and tributaries as well as tidally influenced river flooding.	Policy 4 – maintain Conwy Valley flood alleviation scheme into the future. Scheme has been designed to allow additions to existing defences in the future.
Conwy, Llandudno Junction, Mochdre and Ganol Valley (Sub-area 3)	Flooding from the Afon Conwy, Ganol, Wydden and Gyffin. Surface water and sewer flooding can be an issue.	Policy 4 – improved integration of actions by all parties to manage sources of flood risk. Continue to maintain defences, but it may not be justified to replace or increase their height in the future.
Conwy Valley (Sub-area 4)	River and tidally influenced flooding from Afon Conwy, principally to areas of floodplain converted to agricultural use.	Policy 2 – reduce overall level of flood risk management. It may not be justified to continue to maintain defences.
Rhyl & Kinnel Bay (Sub-area 8)	Fluvial and tidal flooding from Clwyd estuary.	Policy 5 – a heavily urbanised area where sea level rise and additional development could significantly increase flood risks. Defences will continue to have a role in reducing flood risk, but a broader range of options also need to be

Sub-Area	Principle Flood Risks	Policy
		considered
Abergele (Sub-area 9)	Flood risk from the Afon Gele and to the extreme east from tidal Afon Clwyd.	Policy 4 – implement new flood risk management works where justified and continue to maintain existing defences.

2.7 Tidal Clwyd Flood Risk Management Strategy

A flood risk management strategy has been produced by the Environment Agency and its partners (including Conwy CBC) to understand how best to manage tidal flooding from the River Clwyd estuary over the next 100 years. The strategy covers the north Wales coastline and inland tidal area between Abergele and Prestatyn.

The overarching recommendation is that all properties in this area should be protected to their current standard or better. In the short-term this will occur by improving existing embankments at low points along the Afon Clwyd. In the medium- to long-term it is recommended that new embankments are built which are set-back from the river.

Although the strategy recommendations can be seen as good news for existing development, Conwy CBC [Coastal Flood Risk Planning Protocol](#), which covers the area to the west of the Afon Clwyd, should be referred to for guidance on new developments (refer to section 2.4).

3. STAGE 1 ASSESSMENTS

3.1 Introduction

A total of 51 candidate sites were considered in this initial assessment. The Stage 1 Assessment is a desktop study using the existing information on flooding to ascertain possible flood risk to each site. Where there is no discernable flood risk, no further assessment is required and the site and its allocation can be incorporated into the LDP. Where there is a demonstrable flood risk to the site, then a more detailed assessment will be required.

3.2 Data Collection

Table 3.1 provides a summary of the datasets that were collected and used as part of the Stage 1 Assessment process.

Table 3.1 – Stage 1 Assessment Datasets

Dataset	Description	Format
Flood Zone 3	1 in 100 annual probability of fluvial flooding or 1 in 200 annual probability of tidal flooding, ignoring the presence of flood defences.	GIS
Flood Zone 2	1 in 1000 annual probability of flooding, ignoring the presence of flood defences.	GIS
Flood Defences	Location of linear defences such as embankments and walls.	GIS
Flood Storage Areas	Land designated and operated to store flood water.	GIS
Areas benefitting from flood defences	Land that may benefit from the presence of major flood defences, which would flood if the defences were not present.	GIS
Development Advice Map	Flood Zone Mapping as defined in TAN15 (refer to Table 2.1).	On-line
Areas Susceptible to Surface Water Flooding	1 st generation modelling showing susceptibility to surface water flooding in three bandings, indicating 'less' to 'more' susceptibility.	GIS
Flood Map for Surface Water 1:30 rainfall	2 nd generation modelling showing areas where surface water would be expected to flow or pond. Indicates 'surface water flooding' as 0.1 - 0.3m depth; and 'deeper surface water flooding' as >0.3m depth.	GIS
Flood Map for Surface Water 1:200 rainfall		GIS
Areas Susceptible to Groundwater Flooding	Shows susceptibility to groundwater flooding on a 1km grid square scale with information on type of susceptibility and the proportion of each grid square susceptible.	GIS
Risk of Flooding from Reservoirs	Shows the largest area that might be flooded if a reservoir were to fail and release the water it holds.	On-line
Historic Flood Maps	Shows the combined extent of known flooding from all sources	GIS
Main Rivers	Watercourses shown on the statutory main river maps held by the Environment Agency.	GIS
Detailed River Network	Centre lines for all watercourses as captured from OS MasterMap.	GIS

3.3 Stage 1 Assessment Tables

Tables 3.2 – 3.7 provide a summary of the Stage 1 Assessments for each candidate site. The assessment of flood risk has been categorised into the following:

- fluvial/tidal/coastal
- surface water
- groundwater

For each category a description of the possible flood risk is given before an overall summary is provided and a recommendation is made as to whether a more detailed Stage 2 Assessment is required. Those sites where a Stage 2 Assessment has been recommended are indicated by the grey shading.

3.4 Summary

As a result of the Stage 1 Assessment process, 31 sites have no discernable flood risk and require no additional assessment. The sites listed below are therefore suitable for development and can be included in the LDP with their current allocation.

Urban Development Strategy Area – Housing

- Penrhyn Bay – Plas Penrhyn
- Llanfairfechan – Glanafon, Penmaen Park, Bryn Y Neuadd,
- Penmaenmawr – Cwm Road
- Rhos-on-Sea – Dinerth Road
- Colwyn Bay – BT Exchange, Lawson Road, Douglas Road, Lansdowne Road
- Old Colwyn – Ysgol y Graig
- Llanrwst – East Llanrwst

Rural Development Strategy Area – Housing

- Glan Conwy – Top Llan Road
- Llanddulas – Pencoed Road, South of the Mill
- Llysfaen – Ty Mawr, Ysgol Cynfran, Adjacent to former Rectory
- Dwygyfylchi – Off Ysguborwen Road, Adjacent to Vadre
- Llanfair Talhaiarn – The Smithy
- Llansannan – East of Aled View
- Betws yn Rhos – Ffordd Llanelwy, Minafon

Urban Development Strategy Area – Employment

- Llandudno Junction North – East of former Goods Yard

Rural Development Strategy Area – Employment

- Dwygyfylchi – Land at Orme View Filling Station
- Llangernyw – Stag Yard
- Llansannan – Land at Scout Hut

Urban Development Strategy Area – Mixed-Use

- Abergele – Business Park
- Conwy – Adjacent to Bodlondeb
- Llandudno – Esgryn

The remaining 20 candidate sites have been taken forward to Stage 2 Assessments to determine whether their allocation in the LDP is appropriate.

Table 3.2 – Stage 1 Assessment: Urban Development Strategy Area (Housing)

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Abergele	Llanfair Road	70 dwellings	Site is at low flood risk, but borders FZ2 & FZ3 (Zone C2) to the east, which forms the floodplain of Afon Gele.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Gele floodplain. Climate change assessment needed to determine whether developable area would alter in the future.	Y
Abergele	Land south of Siamber Wen	120 dwellings	Site is at low flood risk, but borders FZ2 & FZ3 (Zone C2) to the east, which forms the floodplain of Afon Gele.	Shallow flooding indicated across south-eastern corner; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Gele floodplain. Climate change assessment needed to determine whether developable area would alter in the future.	Y
Abergele	Tandderwen Farm	300 dwellings	Majority of site is at low flood risk, but crosses into FZ2 & FZ3 (Zone C2) along the western boundary, which forms the floodplain of Afon Gele.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Gele floodplain. Climate change assessment needed to determine whether developable area would alter in the future.	Y
Llandudno Junction	Social Club/Youth Club	50 dwellings	South-western corner within FZ3 and just under half the site within FZ2 (Zone C1). Site is known to have flooded in the past, as occurred in June 1993 as a result of a blockage in the channel of the Afon Wydden. Flood Alleviation Scheme subsequently built in 1995 and area now benefits from flood defences.	South-western corner shown to be susceptible to deep flooding; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Approximately half the site is at significant flood risk from the Afon Wydden. Further detailed assessment required to address suitability of the site.	Y

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Penrhyn Bay	Plas Penrhyn	30 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Most recent broad-scale modelling shows no indication of susceptibility; although previous modelling does indicate some susceptibility.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llandudno	Plas yn Dre	40 dwellings	Entire site contained within FZ2 & FZ3 and shown to be benefitting from flood defences (Zone C1). Flood risk is from coastal/tidal source.	Much of the site susceptible to shallow flooding.	Groundwater flooding potential issue due to susceptibility to surface water flooding.	Site shown to be at flood risk. Further detailed assessment required to address suitability of the site.	Y
Llanfairfechan	Adjacent to Glanafon	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Shallow flooding indicated at southern corner; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llanfairfechan	West of Penmaen Park	75 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llanfairfechan	Opposite Bryn Y Neuadd	150 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Indication of a flow route across part of the site to a shallow depth, with small strip of deep water collecting by the road embankment at northern boundary. Not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Some susceptibility to surface water flooding due to overland flow route and should be considered at development stage along with appropriate SUDS.	N

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Penmaenmawr	Cwm Road	60 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Most recent broad-scale modelling shows little indication of susceptibility; although previous modelling does indicate approx. half the site to have some susceptibility.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Rhos-on-Sea	Dinerth Road	70 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small area of shallow flooding indicated centrally. Not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Rhos-on-Sea	Dinerth Hall Farm	90 dwellings	Site is at low flood risk, but borders FZ2 & FZ3 (Zone C1) at the western boundary of the site. Flood risk is a combination of fluvial flood risk from the Afon Ganol/Wyddden and coastal/tidal flood risk.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Ganol floodplain. Climate change assessment needed to determine whether developable area would alter in the future.	Y
Colwyn Bay	BT Exchange	70 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Colwyn Bay	Lawson Road	35 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Most recent broad-scale modelling shows no indication of susceptibility; although previous modelling does indicate some susceptibility.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Colwyn Bay	Douglas Road	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small area of deep flooding shown on west side of site; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Colwyn Bay	Lansdowne Road	30 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small area along the northern boundary shown to be susceptible to deep flooding; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Old Colwyn	Ty Mawr	255 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Old Colwyn	Ysgol y Graig	30 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small localised areas of shallow flooding; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llanrwst	Bryn Hyfryd	50 dwellings	Western area of site (just under a third of the area) contained within FZ2 & FZ3 (Zone C2). Flood risk is from unnamed watercourse, approx. 200m to the south and small watercourse flowing around boundary on north-west side.	Susceptibility to surface water flooding shown for same area as fluvial flood risk.	Groundwater flooding potential issue due to susceptibility to surface water flooding.	Just under a third of the site is indicated to be at significant flood risk from various sources of flooding. Further detailed assessment required to address suitability of the site and impact of climate change.	Y

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Llanrwst	North-west Llanrwst	55 dwellings	Site contained within FZ1 (Zone A); however there is an unnamed watercourse running along part of the northern border which should be considered.	Significant areas of the site shown to be susceptible to surface water flooding; more detailed assessment required.	Groundwater flooding potential issue due to susceptibility to surface water flooding.	A significant proportion of the site is shown to be susceptible to surface water flooding. Further detailed assessment required.	Y
Llanrwst	Off the A470	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Majority of the site shown to be susceptible to deep flooding; more detailed assessment required.	Groundwater flooding potential issue due to susceptibility to surface water flooding.	A significant proportion of the site is shown to be susceptible to surface water flooding. Further detailed assessment required.	Y
Llanrwst	East Llanrwst	25 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Table 3.3 – Stage 1 Assessment: Rural Development Strategy Area (Housing)

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Tier 1 Villages							
Glan Conwy	Top Llan Road	80 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small arm of shallow water flooding extending into site which appears to follow small spring. Should be noted at development stage but not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with consideration of small spring on site and SUDS to be considered at development stage.	N
Llanddulas	Pencoed Road	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llanddulas	South of the Mill	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llysfaen	Ysgol Cynfran	40 dwelling	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llysfaen	Adjacent to former Rectory	30 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Dwygyfylchi	Off Ysguborwen Road	15 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Dwygyfylchi	Adjacent to Vadre	20 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Tier 2 Villages							
Llanfair Talhaiarn	The Smithy	15 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Eglwysbach	Off Heol Martin	10 dwellings	Nearly entire site contained within FZ1, but borders onto FZ2 & FZ3 which is the floodplain of the Afon Hiraethlyn. However DAM shows half the site to be within Zone C2.	Significant proportion of the site shown to be susceptible to deep flooding.	Groundwater flooding potential issue due to susceptibility to surface water flooding.	Further detailed assessment required to determine full extent of flood risk from various sources.	Y
Llansannan	East of Aled View	15 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llangernyw	Coed Digain	15 dwellings	Site contained within FZ1 (Zone A) but borders onto FZ3, which is the floodplain of the Afon Elwy.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Climate change assessment needed to determine whether developable area would alter in the future.	Y

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Dolgarrog	Tan Y Ffordd	30 dwellings	Site contained within FZ1 (Zone A) but borders onto FZ2 & FZ3 (Zone C1), which is the floodplain of the Afon Conwy. Reservoir inundation maps shows site borders onto risk area.	Small area of shallow flooding indicated at southern end of site; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Conwy floodplain. Climate change assessment needed to determine whether developable area would alter in the future.	Y
Dolgarrog	Gwydr Road	10 dwellings	Approximately half the site contained within FZ2 & FZ3 (Zone C1). Reservoir inundation maps also show site to be at risk.	Susceptibility to surface water flooding indicated to a shallow depth across a central portion of the site; not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	No development should take place within the Afon Conwy floodplain. Climate change assessment needed to determine whether developable area would alter in the future. Reservoir flood risk needs to be considered.	Y
Betws yn Rhos	Ffordd Llanelwy	5 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Betws yn Rhos	Minafon	5 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Table 3.4 – Stage 1 Assessment: Urban Development Strategy Area (Employment)

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Llandudno Junction	North-east of former Goods Yard	0.4ha of B1 employment	Site contained within FZ1 (Zone A); however DAM map is not the same and shows site bordering Zone C2.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Based on EA flood zone maps, the site is shown to be suitable with appropriate SUDS to be considered at development stage.	N
Llandudno	The former Goods Yard	1.4ha of B1 employment	Site contained within FZ2 & FZ3 (Zone C1) and is protected by flood defences. Historical records show flooding in June 1993 as a result of local drainage/surface water.	Modelling outputs indicate limited susceptibility to surface water flooding; however there is historical flooding recorded from surface water.	Probably not an issue but should be considered because of potential issue with surface water flooding.	Site shown to be at flood risk. Further detailed assessment required to address suitability of the site.	Y

Table 3.5 – Stage 1 Assessment: Rural Development Strategy Area (Employment)

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Dwygyfylchi	Land at Orme View Filling Station	2.7ha of B1/B2/B8 employment	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Most recent broad-scale modelling shows no indication of susceptibility to site; although previous modelling does indicate some susceptibility in northern half.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Dolgarrog	Land at Memorial Hall	0.3ha of B1/B2 employment	The northern third of the site is contained within FZ2 & FZ3 (Zone C1) which forms the floodplain of the Afon Conwy and Afon Porth-Llwyd. Reservoir inundation maps also show site to be at risk from the Dolgarrog reservoir group.	Deep surface water flooding is shown across more than half the site indicating the site to be susceptible.	Groundwater flooding potential issue due to susceptibility to surface water flooding across central portion of the site.	Site shown to be at flood risk. Further detailed assessment required to address suitability of the site.	Y
Llansannan	Land at Llansannan	1.2ha of B1/B2 employment	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Significant areas of deep flooding indicated across the site.	Groundwater flooding potential issue due to susceptibility to surface water flooding across central portion of the site.	Site is shown to be susceptible to surface water flooding. More detailed assessment required to assess site suitability.	Y
Llangernyw	Stag Yard	0.3ha of B1/B2 employment	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llansannan	Land at Scout Hut	0.3ha of B1/B2 employment	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Table 3.6 – Stage 1 Assessment: Urban Development Strategy Area (Mixed-Use)

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Abergele	Abergele Business Park	5ha of B1 employment & 80 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	Small areas of site shown to be susceptible to surface water flooding; however these are mainly around and along existing waterbodies and further assessment not required.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Abergele	South-east Abergele	3.5ha of B1 employment & 150 dwellings	A small area at the northern end of the site contained within FZ2 (Zone C1), but is outside of FZ3. There is a record of historical flooding on this part of the site as a result of flood defences along the Afon Gele being overtopped in Feb 1977.	Susceptibility to deep flooding is indicated around the culvert that passes under the A55.	Probably not an issue but should be considered because of potential issue with surface water flooding.	The majority of the site is not at risk of flooding; however given that a small area of the site is potentially at risk a further assessment is required to assess climate change and drainage.	Y
Conwy	Adjacent to Bodlondeb	0.5ha of B1 employment & 30 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N
Llandudno	Esgyryn	6.2ha of B1 employment & 120 dwellings	Site contained within FZ1 (Zone A) and not considered to be at risk due to climate change.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site suitable with appropriate SUDS to be considered at development stage.	N

Settlement	Site Name	Allocation	Flood Source			Summary	Stage 2
			Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Cerrigy-drudion	Land fronting B4501	1.2ha of B1/B2 employment & 10 dwellings	Site contained within FZ1 (Zone A) although the Nant Hendre-bach flows around the site to the north, for which no flooding is indicated, but should be assessed.	A significant portion of the site to the west is indicated to be susceptible to flooding.	Groundwater flooding potential issue due to susceptibility to surface water flooding in western area of the site.	Further detailed assessment required to determine full extent of flooding from various sources.	Y

Table 3.7 – Stage 1 Assessment: Waste Management Facility

Settlement	Site Name	Flood Source			Summary	Stage 2
		Fluvial/Tidal/Coastal	Surface Water	Groundwater		
Kinmel Bay	Gofer	Site is on high ground and is contained by FZ2 (Zone C1) and surrounded by FZ3. Historical flooding at the site is indicated as a result of tidal flooding caused by a defence breach in Feb 1990.	No indication of susceptibility to surface water flooding.	None anticipated because site is not susceptible to surface water flooding.	Site shown to be at flood risk. Further detailed assessment required to address suitability of the site.	Y
Llandudno Junction	Network Rail	Majority of the site contained within FZ2 & FZ3 (Zone C2 – although flood extents differ between EA flood zones and DAM).	Some small localised areas of site indicated as susceptible to flooding, but not significant enough to require detailed assessment.	None anticipated because site is not susceptible to surface water flooding.	Site shown to be at flood risk. Further detailed assessment required to address suitability of the site.	Y

4. STAGE 2 ASSESSMENTS

4.1 Introduction

Following the initial assessment of flood risk to all 51 candidate sites as part of the Stage 1 Assessment process, 20 of the candidate sites were identified as requiring a more detailed assessment of flood risk to determine whether they are suitable for development.

Additional data has been used for this Stage 2 Assessment, as given in Table 4.1, to further aid the assessment of flood risk and, where appropriate, preliminary calculations have been carried out to supplement this data. However, it should be noted that this assessment is of a strategic scale and future development proposals would likely require additional work and consultation with Environment Agency Wales (EAW) to fully meet the requirements of a FCA.

Table 4.1 – Stage 2 Assessment Datasets

Dataset	Description	Format
Afon Conwy ISIS-TUFLOW	Model built for the Conwy Valley Flood Alleviation Scheme (Halcrow, 2009) and extends from Betws-Y-Coed to just downstream of Dolgarrog.	Model & Model outputs
Afon Hiraethlyn ISIS-TUFLOW	Model developed for Eglwysbach Flood Risk Mapping Study (EAW, 2010). Extends from south to north of Eglwysbach and includes Nant y Rhaglaw at northern edge of the village.	Model & Model outputs
Afon Gele	Model built for the Abergele Flood Alleviation Scheme (Jacobs, 2009). Extends from upstream of Abergele all the way to outfall into the Afon Clwyd.	Model & Model outputs
Conwy Tidal Flood Risk Assessment	Model developed for Conwy CBC to provide flood risk information on tidal/coastal sources to Kinmel Bay and Llandudno areas.	Model outputs only
NFCDD	National Fluvial and Coastal Defence Database. Provides information on flood defences including location, standard of protection and crest levels.	GIS
LiDAR	Light Detection and Ranging. Used to provide topographic information for each site.	GIS
BGS	British Geological Society. Accessed on-line to provide geological information on underlying bedrock geology and superficial deposits.	On-line
NSRI	National Soil Resources Institute. Accessed on-line to provide information on soil types and properties.	On-line
Groundwater	Groundwater. Accessed via the Environment Agency website to provide information on aquifers and vulnerability.	On-line
Flood Warning Areas	Flood Warning. Accessed via EA website to show which candidate sites might benefit from flood warning.	On-line

Housing and Mixed-Use sites have been assessed first because there are some sites which are designated for both uses. Employment and Waste Management sites then follow. Where more than one site is located at a town/village, these have been grouped. The assessment of flood risk is discussed including details of hydrological and hydraulic calculations before bringing the findings of these calculations together when discussing site suitability. For each site, suitability is assessed in terms of the overall flood risk, and where appropriate flood consequences and mitigation are discussed. Finally third-party impacts are reviewed.

The full list of candidate sites and the order in which they have been assessed is as follows:

Housing & Mixed-Use Sites

- Abergele – Llanfair Road, Siamber Wen, Tandderwen Farm, Rhuddlan Road
- Llandudno Junction – Social Club/Youth Club
- Llandudno – Plas yn Dre
- Rhos-on-sea – Dinerth Hall Farm
- Llanrwst – Bryn Hyfryd, North-West & Off the A470
- Eglwysbach – Off Heol Martin
- Llangernyw – Coed Digain
- Cerrigydrudion – Land fronting B5105
- Dolgarrog – Tan Y Ffordd & Gwydr Road

Employment Sites

- Llandudno – Former Goods Yard
- Dolgarrog – Memorial Hall
- Llansannan – Land at Llansannan

Waste Transfer Sites

- Kinmel Bay – Gofer
- Llandudno Junction – Network Rail

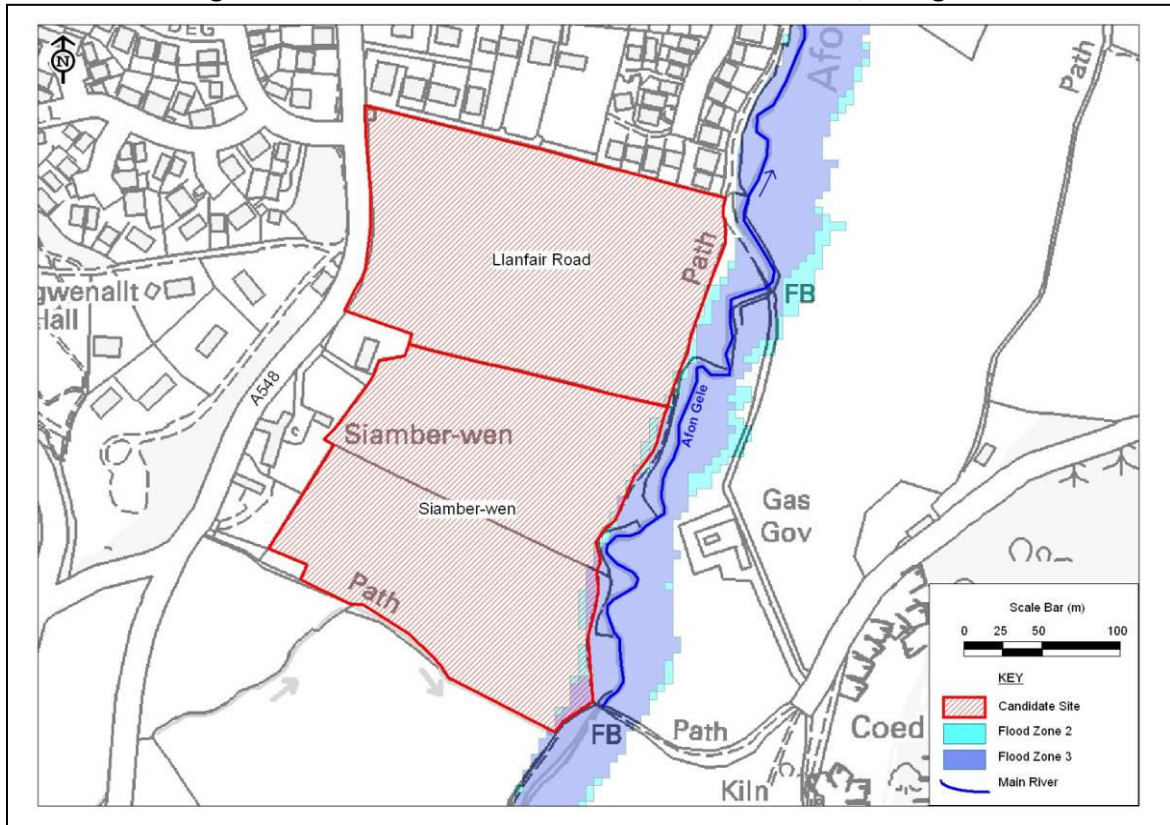
4.2 Abergele (Housing & Mixed-Use)

(a) Llanfair Road & land south of Siamber Wen

These two sites are located next to each other and are a similar size (see Figure 4.1). It was therefore deemed appropriate to assess the flood risk at both sites together. They are greenfield sites at the southern edge of Abergele, with access provided by the A548. The sites are on pasture land and slope steeply down from the A548 to the Afon Gele. The northern of the two sites (Llanfair Road) is allocated for 70 dwellings and the southern site (Siamber Wen) for 120 dwellings.

From Figure 4.1 it can be seen that the eastern boundary of both sites borders on the Afon Gele floodplain and close examination of the flood zone maps shows that small areas of the site cross into these flood zones. Although the proposal to mitigate against this is to set back development from the floodplain, there is a requirement to consider the impact of climate change over the life span of the development, in this case 100 years. This is considered below.

Figure 4.1 – Flood Zones: Llanfair Road & Siamber-Wen, Abergele



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Hydrology

A model of the Afon Gele was obtained from EAW; however the upstream limit of the model is located some 800m downstream of these two candidate sites. A check of the catchment area between the candidate site and where the model starts shows a difference in area of just 4%; it is therefore slightly conservative to use the same peak flow estimates as the model.

A review of the hydrology used in the Afon Gele model was carried out. In the absence of the model report it was necessary to re-calculate flows and compare against the flow

used in the model. This assessment gave a 1 in 100 annual probability flow of $6.6 \text{ m}^3/\text{s}$, around $1.0 \text{ m}^3/\text{s}$ lower than that used in the model ($7.6 \text{ m}^3/\text{s}$). The variance in the estimate could be the result of differences in any number of parameters and are beyond the required level of detail for this strategic assessment. The implication is that the flow used in the Afon Gele model is reasonable (and has been accepted by EAW) and therefore suitable for use in this assessment.

Current guidance on assessing climate change in Wales is that the 1 in 100 annual probability flood peak flow would increase by 20%. The climate change peak flow used in this assessment is therefore $9.1 \text{ m}^3/\text{s}$.

Hydraulics

In the absence of a model to assess the impact of climate change, calculations have been carried out using Manning's equation. This enables the depth of water in a channel to be determined for a given flow. Channel width has been estimated from the site visit as 2.5m and the channel shape assumed to be rectangular given the steep sided banks. The floodplain has been excluded from the calculation. This approach gives a balance of simplifications which will provide a reasonable indication of the flood hydraulics, suitable for this strategic project. A channel gradient of 1 in 50 has been estimated using the 1:25k OS map contours and a Manning's n of 0.045 applied. This gives an indicative increase in water level of 0.19m resulting from climate change, which is likely to be slightly conservative.

The two sites are in an area for which there is no LiDAR coverage. The slope down the field towards the Afon Gele has therefore been calculated using the 1:25k OS map contours. A rise in water level of 0.19m would result in a maximum increase in flood extent of around 2.5m. This estimate is supported by the limited difference in flood extent shown between Flood Zones 2 and 3 in Figure 4.1.

(b) Tandderwen Farm

Tandderwen Farm is a greenfield site at the south-eastern edge of Abergele (refer to Figure 4.2). The main access is from St George's Road, which runs along the eastern boundary; the western boundary borders the Afon Gele. The site is generally pasture land and approximately one third of it drains towards the Afon Gele. The remainder drains towards St Georges Road and into the small watercourse running north through the adjacent Rhuddlan Road site. The Tandderwen Farm site has been allocated for 300 dwellings.

Figure 4.2 shows the western boundary crossing into the Afon Gele floodplain. Although the proposal to mitigate against this is to set back development from the floodplain, there is a requirement to consider the impact of climate change.

Hydrology

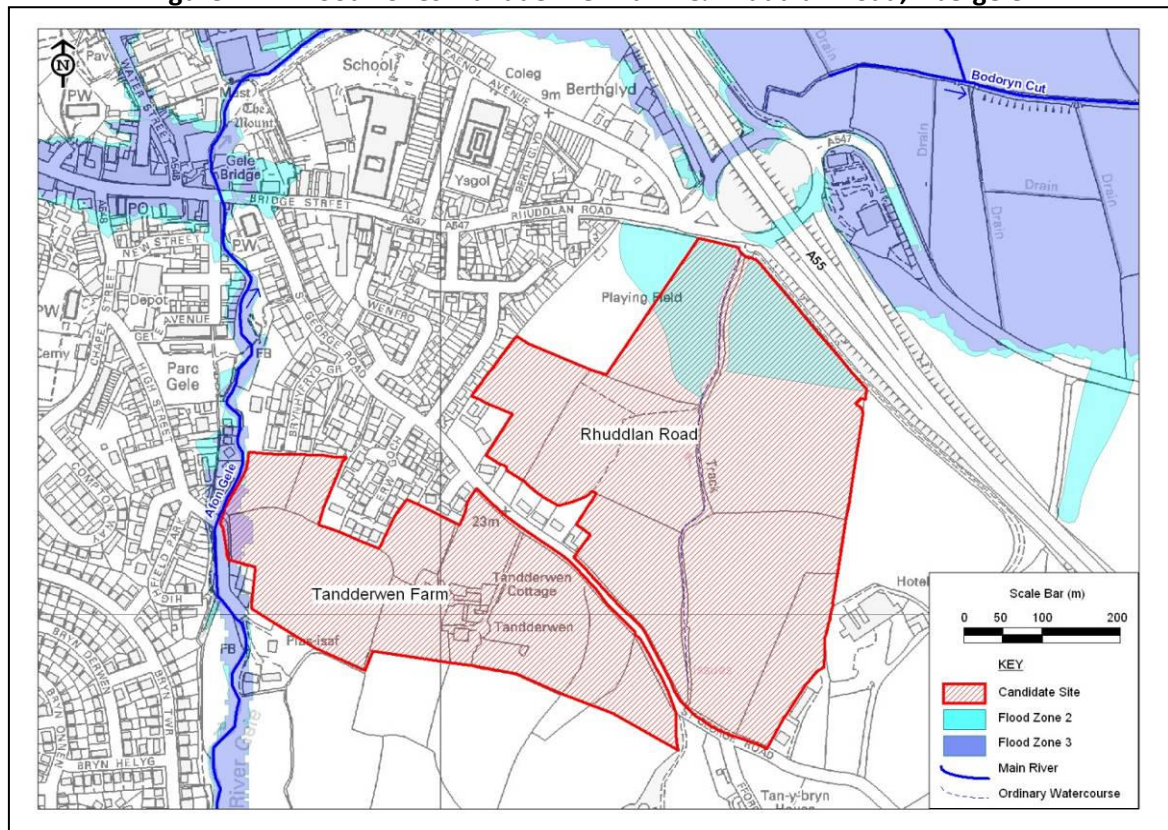
As discussed above, we are able to use the hydrology used in the Afon Gele model supplied by EAW. The model starts around 250m downstream of the Tandderwen Farm site, but the catchment areas are virtually the same. A 1 in 100 annual probability peak flow of $7.6 \text{ m}^3/\text{s}$ has therefore been used, and increased by 20% to $9.1 \text{ m}^3/\text{s}$ to account for climate change.

Hydraulics

Calculations have been carried out using Manning's equation. The channel width has been estimated from the site visit as 3.0m and the channel shape assumed to be rectangular given the steep sided banks. The floodplain has not been included from the calculation. This approach gives a balance of simplifications which will provide a reasonable indication of the flood hydraulics, suitable for this strategic project. A channel gradient of 1 in 60 has been estimated using the 1:25k OS map contours and a Manning's n of 0.045 applied. This gives an indicative increase in water level of 0.16m resulting from climate change, which is likely to be slightly conservative. There are bridges in this reach, but it is anticipated that these would not provide a significant obstruction and they are likely to overtop in large floods.

There is no LiDAR coverage for this site. The slope down the field towards the Afon Gele has therefore been estimated from the 1:25k OS map contours. A rise in water level of 0.16m results in an increase in flood extent of less than 2m at this site.

Figure 4.2 – Flood Zones: Tandderwen Farm & Rhuddlan Road, Abergele



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(c) Rhuddlan Road

The Rhuddlan Road site is located at the south-eastern edge of Abergele, just off the A547 at junction-24 on the A55 (refer to Figure 4.2). The site is greenfield and is made up of pasture land and playing fields and has been allocated for mixed-use development, including 150 dwellings.

There is a small watercourse running through the centre of the site from south to north. This passes under the A55 roundabout through a culvert and enters the Bodoryn Cut, which is pumped into the Afon Gele several kilometres downstream.

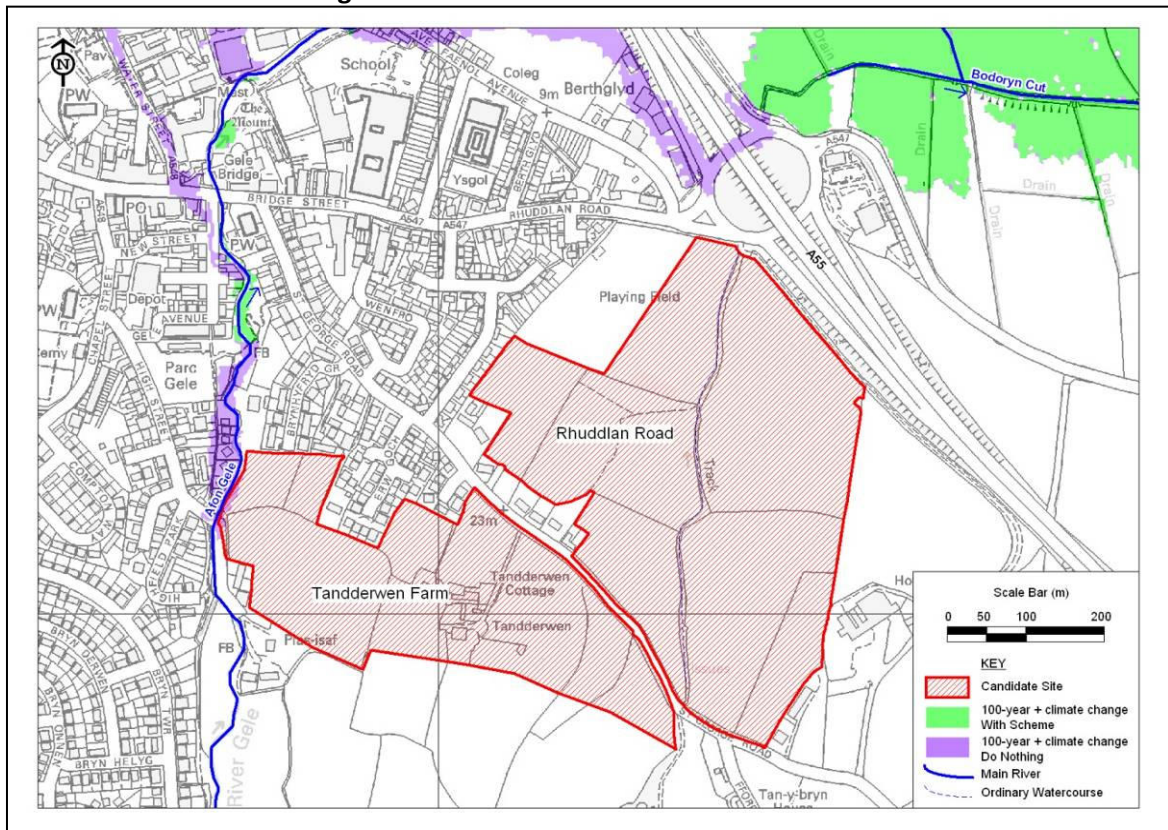
Figure 4.2 shows that the northern end of the site around this culvert is at flood risk and is contained within the Environment Agency's Flood Zone 2 map. This area of flooding is also shown on the Environment Agency historical flood maps (dated February 1977). That flood was caused by overtopping of the Afon Gele defences downstream of Abergele. It should be noted that the A55 layout has changed in the interim as the road has since been duelled east of this junction.

As part of this Stage 2 assessment, the flood risk from the Afon Gele has been assessed using the existing hydraulic model. Additional calculations have been carried out to determine what flood risk is presented by the small watercourse running through the middle of the site. An assessment of the accuracy of the historic flood outline is also provided.

Afon Gele Model

The model of the Afon Gele was built as part of designing the new flood defences in Abergele. The model was built using an ISIS-TUFLOW linked model and extends from 200m upstream of Bridge Street downstream to where the Gele discharges into the Afon Clwyd. The model output from the 1 in 100 annual probability flood with climate change is given in Figure 4.3. This includes one flood outline representing the situation when the flood defences are complete and one for the Do Nothing scenario, in which blockage at key structures and possible breaches in defences are taken into account. This indicates that the Afon Gele does not present a direct flood risk to site for the 1 in 100 annual probability flood with climate change.

Figure 4.3 – Afon Gele Model Flood Outlines



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Small Watercourse – Hydrology

An assessment of peak flows for the 1 in 100 annual probability flood was carried out using statistical, rainfall-runoff and small catchment methods. The outcome of this was that rainfall-runoff gave substantially higher peak flows than the other methods, but that the other methods all closely agree. Since a statistical approach was used for the Afon Gele model, for consistency this method was chosen to assess flood risk at this site and rainfall-runoff discounted. This gave a peak flow estimate of 0.62 m³/s for the 1 in 100 annual probability flood and 0.74 m³/s when climate change is included.

Small Watercourse – Hydraulics

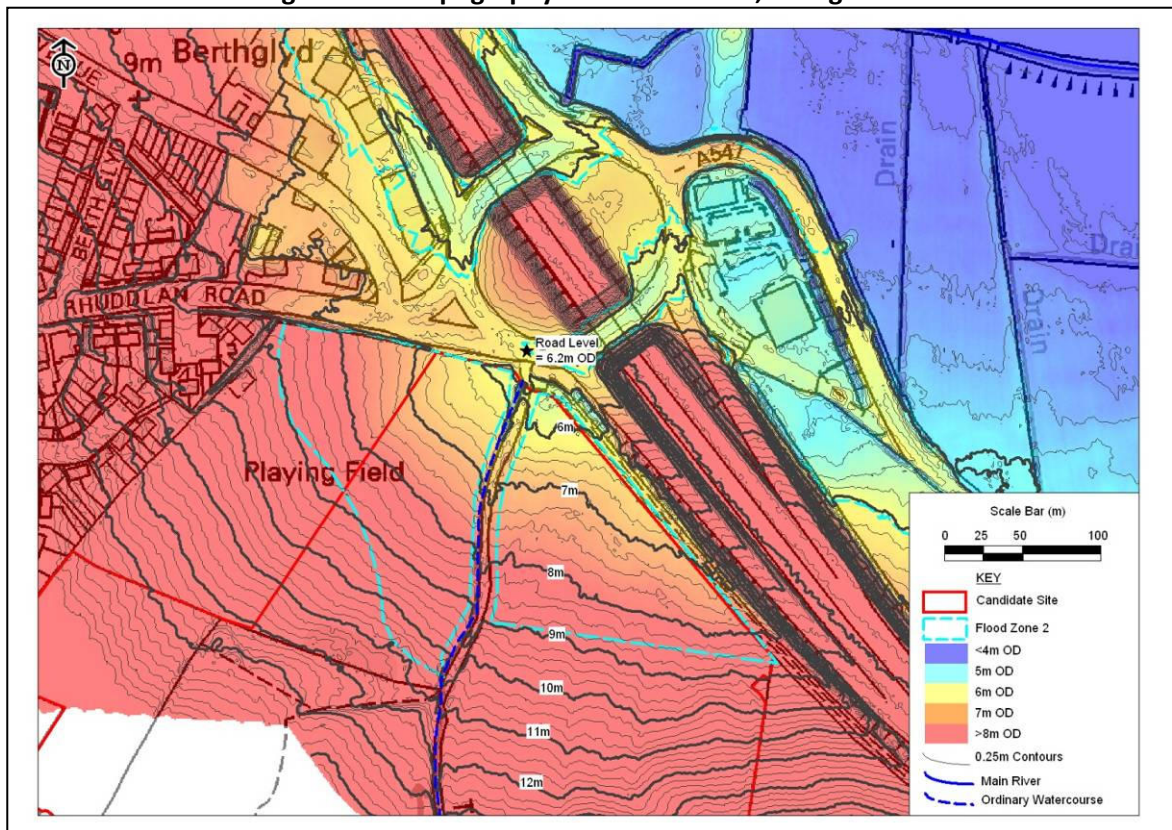
There are two assessments to be made. The first is to consider the channel capacity of the watercourse and to what extent it might cause flooding. The second is the culvert passing under the A55 and whether it has sufficient capacity to pass the 1 in 100-year flow including climate change.

Channel Capacity:

The channel follows a footpath and is heavily overgrown with hedges and trees generally on either side and is only clear at the culvert inlet. A short distance upstream from the inlet the channel is shallow and at the time of the site visit was dry. The channel dimensions have been estimated based on observations rather than LiDAR because the extent of undergrowth would make LiDAR unreliable. It has a base width of around 0.5m and has sloping sides; a high Manning's 'n' of 0.06 has been used, with a channel slope of 1 in 40 based on the field slope from LiDAR.

This indicates that the depth of water at the peak of the flood would be around 0.6-0.7m for both flows. In places the channel is no deeper than 0.50m and therefore flooding from this watercourse is a possibility. The LiDAR shows that the ground falls away from the watercourse to the east and might therefore result in some overland flow, but rises on the other side (refer to Figure 4.4). This is supported by site observations. Out-of-bank flow from the drain will pass down the field to the east to form a pool around the culvert inlet.

Figure 4.4 – Topography: Rhuddlan Road, Abergele



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Culvert Capacity:

The capacity of the culvert has been estimated using Wallingford Hydraulic Tables (6th edition). The culvert is 1m diameter and is concrete lined. LiDAR indicates that the bed of the channel at the culvert is around 5m OD and a 0.6m depth has been assumed from the above calculations. The Afon Gele model gives the water level in the floodplain as being around 5m OD in the climate change simulation. The culvert is 185m long and therefore the hydraulic gradient is around 1 in 300. Assuming a Ks roughness value of 0.60mm, the capacity of culvert is given as 1.5 m³/s. There is a grill at the front of the culvert which would reduce its efficiency and debris is likely to collect in a flood. However, the indication is that there is more than sufficient capacity to pass a 1 in 100-year flow with climate change. Closer inspection and survey would be needed to confirm this.

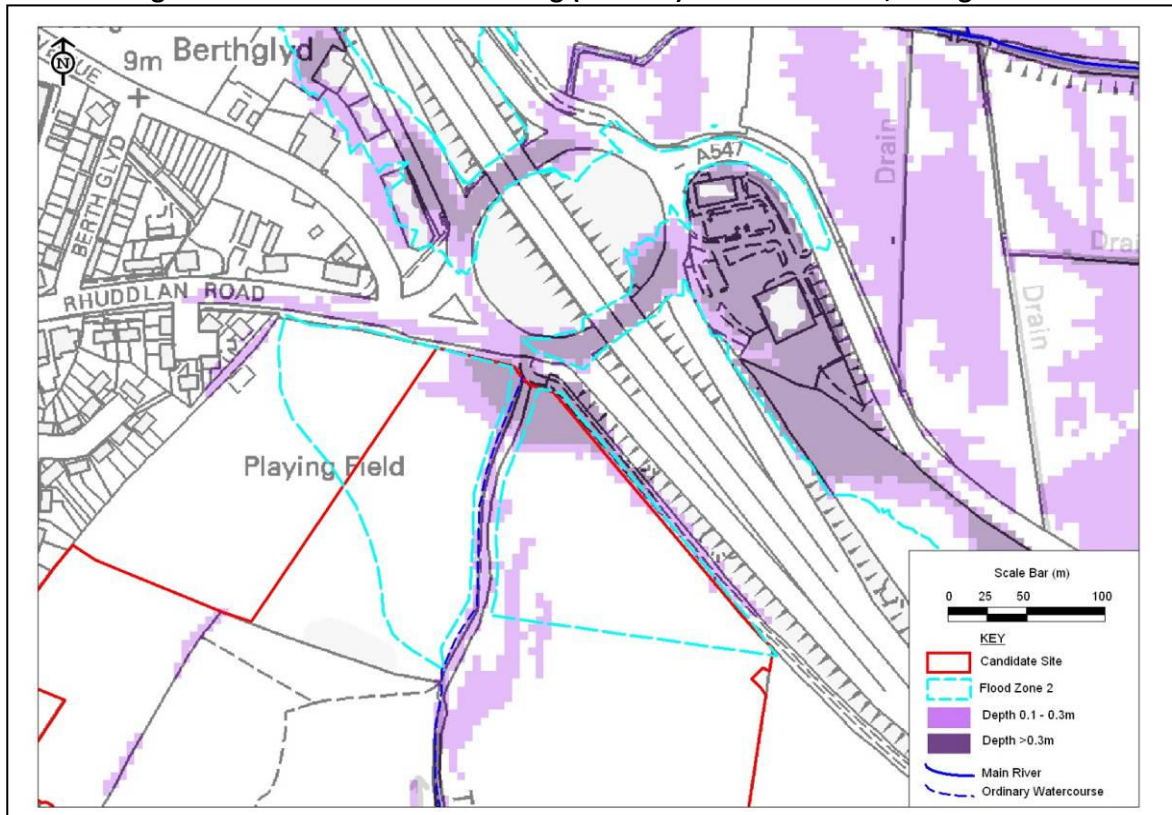
In the event of a blockage at the culvert, it is possible that water levels would rise and overtop onto the road. From LiDAR, the road level at the culvert is around 6.2m OD, water levels would therefore not greatly exceed this as water would spill out across the road and drain away. From Figure 4.4, the approximate extent of flooding can be estimated as being somewhere between the 6.25m and 6.50m contour.

Historic Flooding

The historic outline provided by the Environment Agency matches the demarcation of Flood Zone 2 on the Rhuddlan Road site. Flood Zone 2 has presumably therefore been defined based on the historic flood outline. The accuracy of this flood outline is open to question. Plotting the flood outline against contours generated from LiDAR, as shown in Figure 4.4, indicates flooding up to around the 9m OD contour. If this flooding resulted from the Afon Gele, this would indicate a flood depth across the road of around 3m and a

much wider area of the town should be flooded. It is highly unlikely that this would not also have been recorded.

Figure 4.5 – Surface Water Flooding (1 in 200): Rhuddlan Road, Abergel



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As discussed above, flooding from the small watercourse is possible, but water would accumulate at the bottom of the slope and then overtop the road. However, there may be overland flow which might be better defined as surface water flooding. Figure 4.5 shows susceptibility of the site to surface water flooding in a 1 in 200 annual probability storm. This shows an area of deep flooding to accumulate around the culvert, which matches our assessment of the likely fluvial flood extent. Further upstream some possible shallow surface water flooding on the east side of the watercourse is shown, which again matches our interpretation of fluvial flood risk. This therefore also suggests that the historical flood outline is inaccurate.

(d) Site Suitability

Flood Risk & Mitigation

TAN15 states that highly vulnerable development, which includes residential premises, should not be permitted in Flood Zone C2, which is based on the Environment Agency's Flood Zone 2. At Llanfair Road, Siamber-Wen and Tandderwen Farm this area is clearly defined on Figures 4.1 & 4.2 and site observations confirm this is a realistic outline. The impact of climate change on flood extent has been shown to be limited and the difference from the existing flood zone mapping would be slight.

Llanfair Road, Siamber-Wen and Tandderwen Farm are therefore suitable for residential development, provided a suitable buffer is applied at detail design so that development does not take place in or immediately adjacent to the floodplain.

At the Rhuddlan Road site an area at the northern end of the site is contained within Flood Zone C1, which indicates that development should only take place in this area subject to application of the justification test. However, there is good reason to doubt the accuracy of the flood zone on the Rhuddlan Road site. The extent of flooding from the Afon Gele is likely to be significantly less.

The Rhuddlan Road site also has flood risk from the watercourse running north to south through the middle of the site. Flooding resulting from this watercourse would accumulate around the culvert inlet at the downstream end, but is unlikely to exceed a water level much above 6.2m OD because it would overtop the road. Overland flow or surface water flooding from further upstream is possible, but this flood risk could be suitably managed by clearing the overgrown watercourse and slightly increasing channel capacity. It is estimated that a 1m wide channel with 0.5m depth would be sufficient to retain a 1 in 100 annual probability flood with climate change; a more detailed assessment would be needed at a design stage. There would be a requirement to maintain the watercourse and the culvert under the A55 and a commitment to regularly clear the debris screen.

The majority of the Rhuddlan Road site is therefore suitable for mixed-use development, with the exception of a small area around the culvert inlet. A full FCA would be required with additional topographic survey and modelling to confirm levels and flood extents.

Third-party Impacts

Development should not increase the risk of flooding elsewhere. Since development within the floodplain is not permitted, loss of floodplain is not an issue. However, the increase in runoff from developed sites compared to greenfield sites can be an issue. Although the impacts downstream of individual sites would probably be negligible, the cumulative impact of developments in the area could be significant if runoff is not controlled.

This is a particularly prevalent issue on the Afon Gele, which has flooded the town centre of Abergele in the past; the last major flood was in 1971. EAW have recently constructed a culvert under Ffordd Y Morfa (just north of the area in Figure 4.3) to supplement the capacity of the existing bridge and are currently carrying out localised flood defence works through the town to aid protection.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented. According to the BGS maps, the site is in an area of till deposits underlain by mudstone, siltstone and sandstone. Soil maps from the NSRI indicate slightly acid loams and clay with slightly impeded drainage.

Mapping information on the Environment Agency's website shows the area to be part of a 'principle' bedrock aquifer and of intermediate to high vulnerability – there is however no Groundwater Source Protection Zone (GSPZ) in the area. Infiltration techniques may be possible but feasibility would need to be assessed by site investigation at the design stage; alternatively some form of attenuation would be required and such features would need to be placed outside of the floodplain.

4.3 Llandudno Junction (Housing)

(a) Social Club/Youth Club

This is a brownfield site, currently occupied by a social club and youth club with car parking (refer to Figure 4.6). The access to the site is from Conwy Road (A547), which is the main road passing through Llandudno Junction. The site is located next to the Afon Wydden, although the watercourse is now culverted through this residential area. The Wydden passes south under the railway line and the A55 before discharging into the Conwy estuary. The site has been allocated for 50 dwellings.

Figure 4.6 shows that around half of the site is in Flood Zone 2, which replicates a historical outline from 1993. The site suffered severe flooding in 1993 when a screen across part of the culverted length of the Wydden blocked in combination with an extreme rainfall event (quoted by the Environment Agency as being in excess of 1 in 1000 annual probability) caused properties in Conwy Road and Marl Drive to flood. The railway embankment just downstream of the site acts as a barrier to overland flow toward the Conwy estuary. Subsequently in 1995 a flood defence scheme was built which created a series of flood storage areas upstream, controlled by penstocks and operated by telemetry. Since the completion of the scheme there has been no flooding in the area, but this is dependent of the successful operation of the penstocks. At the time the scheme was designed to give a 1 in 200-year Standard of Protection (SoP), although hydrological methods have changed since then so this SoP would need re-assessing.

There is no model of the Afon Wydden available and given the complexities of the flood defence scheme simplistic calculations will not provide any useful additional information. Based on the historical outline and using the LiDAR, we can determine that the depth of flooding on the site was approaching 2m at the lowest points during the 1993 flood. This is corroborated by anecdotal reports.

(b) Site Suitability

Flood Risk & Mitigation

A significant proportion of the site is contained within Flood Zone C1 (as defined by Flood Zone 2 on Figure 4.6), which indicates that development in this area should only take place subject to application of the justification test. Historically parts of the candidate site have flooded to nearly 2m depth. Although there is now a high standard of protection afforded by the flood defence scheme, it is a complex system and there is a realistic risk of failure. The potential depth of flooding should such a failure occur would present a serious risk to life and therefore the consequences are high. ***We would therefore recommend that development only take place outside of the historical flood outline and the allocation in the LDP be adjusted accordingly.***

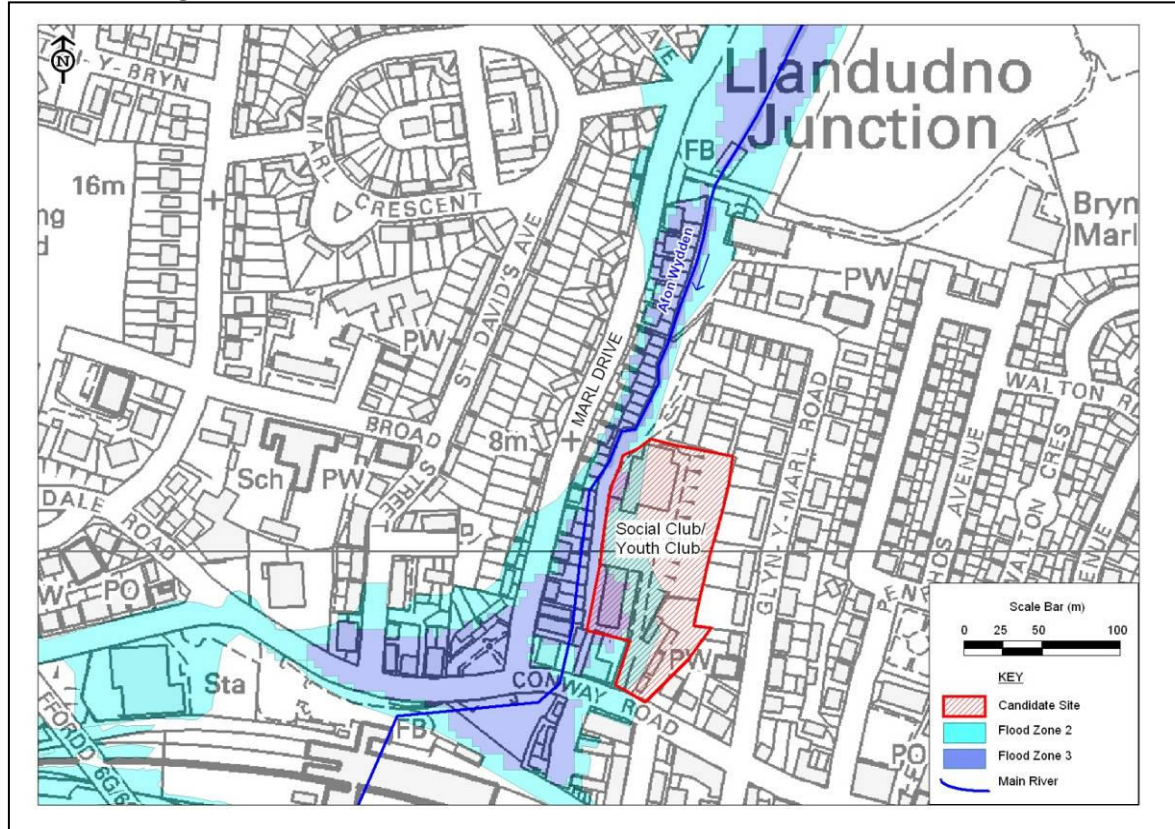
The remainder of the site is suitable, provided that access/egress to the site can be shown to be adequate.

Third-party Impacts

Development should not increase the risk of flooding elsewhere. Although this is a brownfield site, the area has historically flooded and so opportunities to control or reduce runoff should be maximised. This would lessen the burden on the existing flood defence infrastructure. SUDS should be implemented.

According to the BGS maps, the site is in an area of till deposits underlain by mudstone. Soil maps from the NSRI indicate slowly permeable, seasonally wet loamy, clayey soils with impeded drainage. The Environment Agency's groundwater mapping shows the site to be in an area of a "Secondary B" bedrock aquifer and there is no GSPZ in the area. The indication is that infiltration techniques may not be practical at this site, although this should be checked by site investigation at the design stage. As an alternative, some form of attenuation would be required.

Figure 4.6 – Flood Zones: Social Club & Youth Club, Llandudno Junction



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4.4 Llandudno (Housing)

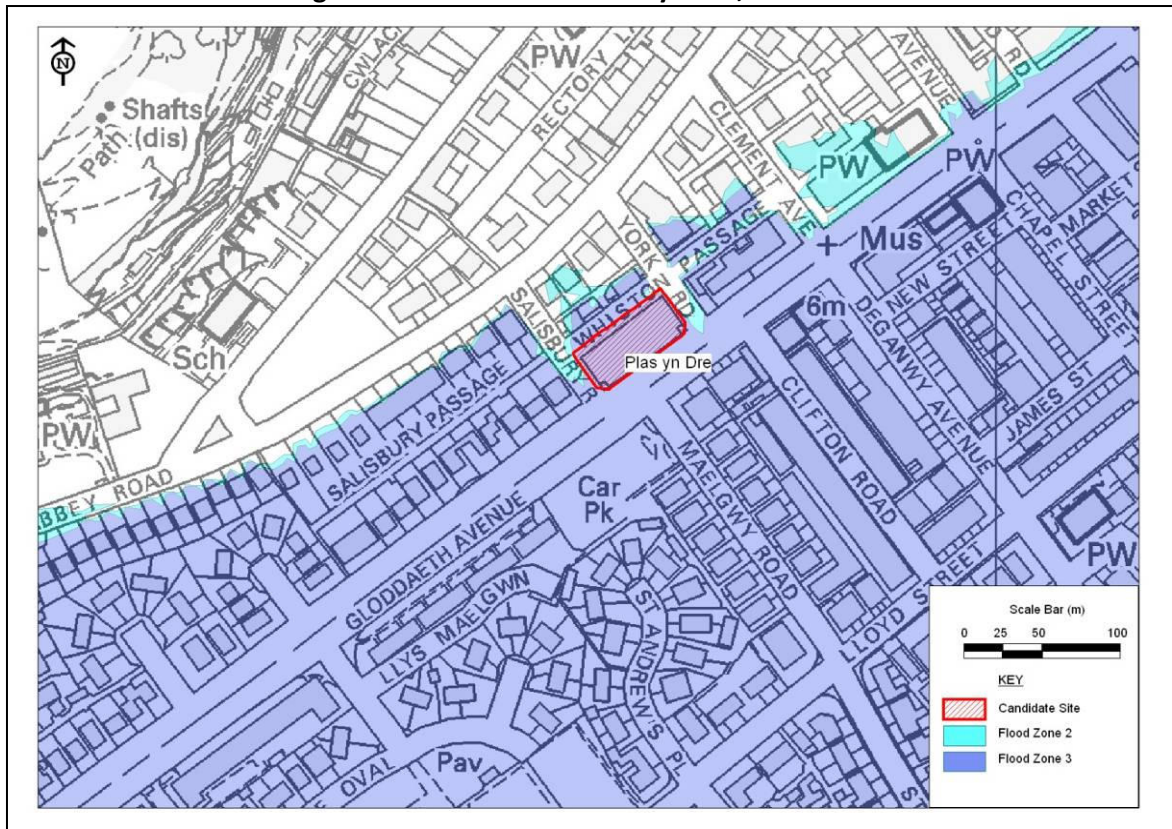
(a) Plas yn Dre

The site is located on the north-western edge of Llandudno adjacent to Gloddaeth Avenue (A546), which links the town's north and west shores. This is a brownfield site which formed a car park to nearby council offices. There is an allocation for 40 dwellings at this site.

The site is completely contained within Flood Zones 2 & 3 (refer to Figure 4.7) because of the potential for tidal flooding. However, the area is protected by the sea defences on both the north and west shores. The site is also at risk of flooding from shallow surface water (<300mm).

The Conwy Tidal Flood Risk Study outputs have been used to assess flood risk to the site. These model outputs have also been used to provide information on the potential impact of climate change. A brief review of the flood risk from surface water flooding is also given.

Figure 4.7 – Flood Zones: Plas yn Dre, Llandudno



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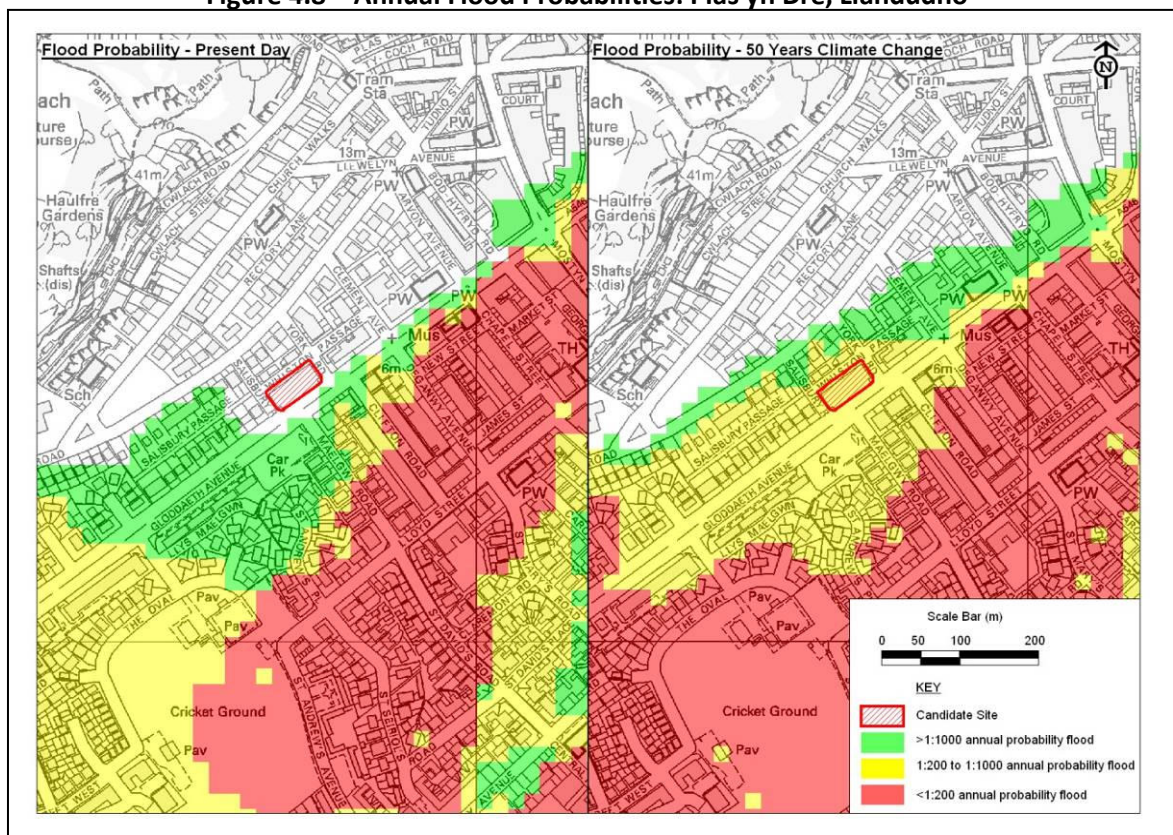
Conwy Tidal Flood Risk Assessment

CCBC commissioned the Conwy Tidal Flood Risk Study to provide a robust and scientific appraisal of the risk of flooding from tidal inundation. This modelled flooding with the existing defences in place, but took account of possible overtopping and breaches. The tidal study's report should be referred to for further information on methodology and scenarios modelled.

Figure 4.8 shows the current probability of the site flooding, compared with the probability of flooding in 50 years time. This shows that currently only a flood greater than the 1 in 1000 annual probability flood would affect the site. When climate change is applied the annual probability changes to between 1 in 200 and 1 in 1000. However, the modelling only included for 50 years of climate change; one hundred years of climate change would normally be used as this is the expected lifespan of a residential development. Based on Defra guidance for Wales the increase in tide level is just over 0.3m for 50 years compared to nearly 1m for 100 years of climate change (relative to 2006 when the modelling was carried out). It is therefore possible that the annual probability of flooding would reduce to 1 in 200 or less.

In order to obtain a better estimate of flooding probability with 100 years of climate change the Conwy Tidal Flood Risk Model would need to be re-run.

Figure 4.8 – Annual Flood Probabilities: Plas yn Dre, Llandudno



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Surface Water Flooding

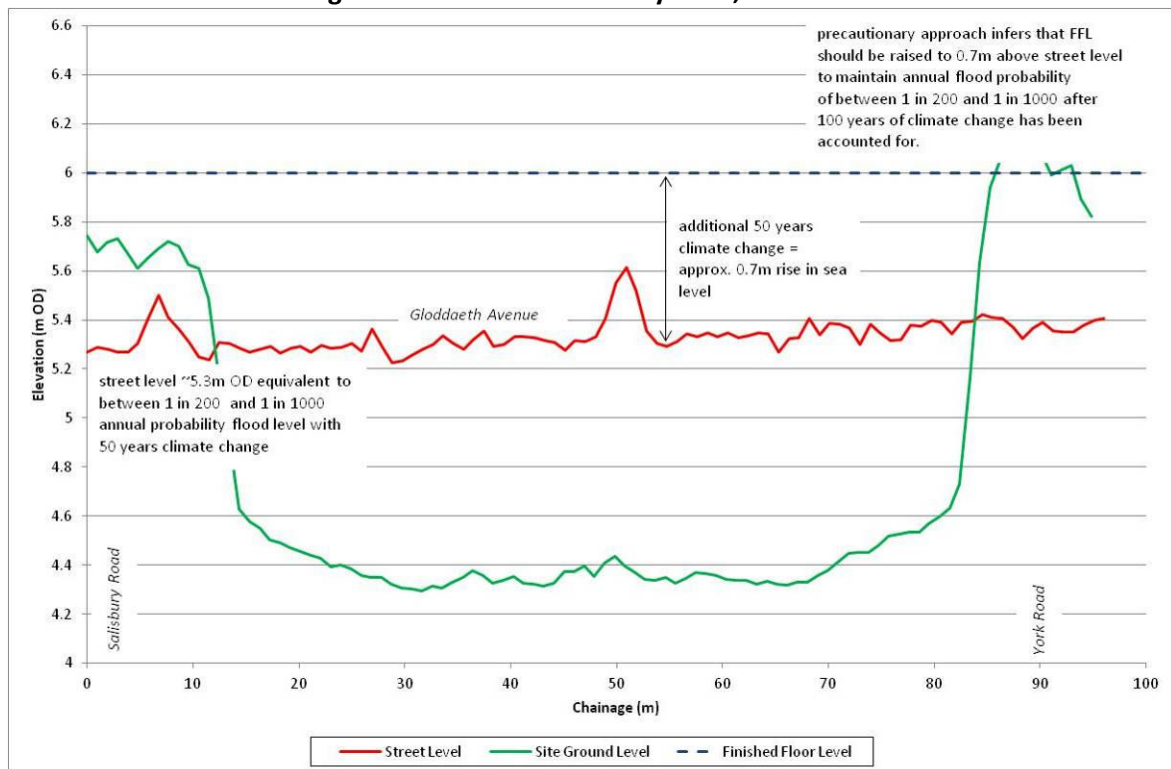
The Environment Agency's surface water maps show the whole area to be inundated by shallow surface water in the 1 in 200 probability rainfall event. From the site visit it was obvious that this car park area is presently low lying compared to Gloddaeth Avenue and with the land rising up onto Great Orme to the north, the site would be prone to collect rain water. The site is liable to flooding to depths greater than 300mm in an extreme and intensive rainfall storm, due to being lower than the surrounding land.

Llandudno has had historical problems with surface water drainage and extensive flooding was caused in 1993 when the drainage system was unable to cope. Although the site is located outside of the area recorded historically as flooding, surface water is a potential issue at this site.

(b) Site Suitability**Flood Risk & Mitigation**

The site is contained within the Environment Agency's Flood Zones 2 & 3 and this is replicated by the DAM, which shows the site to be in Flood Zone C1. The site is currently outside of the 1 in 200 annual probability flood outline, but when taking account of climate change this may not be the case. In the absence of modelling data for the 100 years of climate change scenario, a precautionary approach would need to be taken to make the site agreeable to EAW. From Figure 4.8 it is apparent that the site is outside the 1 in 200 annual probability flood when 50 years of climate change is applied.

To ensure that the site is not flooded when a 100 years of climate change is accounted for the finished floor levels would need to be raised above street level. Figure 4.9 presents a cross-section through the site along with the corresponding street level on Gloddaeth Avenue. From Figure 4.9 we can infer that the street level of around 5.3m OD is somewhere in the 1 in 200 to 1 in 1000 annual probability flood range after 50 years of climate change has been included. A precautionary approach to ensure that the site remains within this band of flood probability when a full 100 years of climate change is applied, would be to ensure finished floor levels are 700mm above street level to account for further sea level rise.

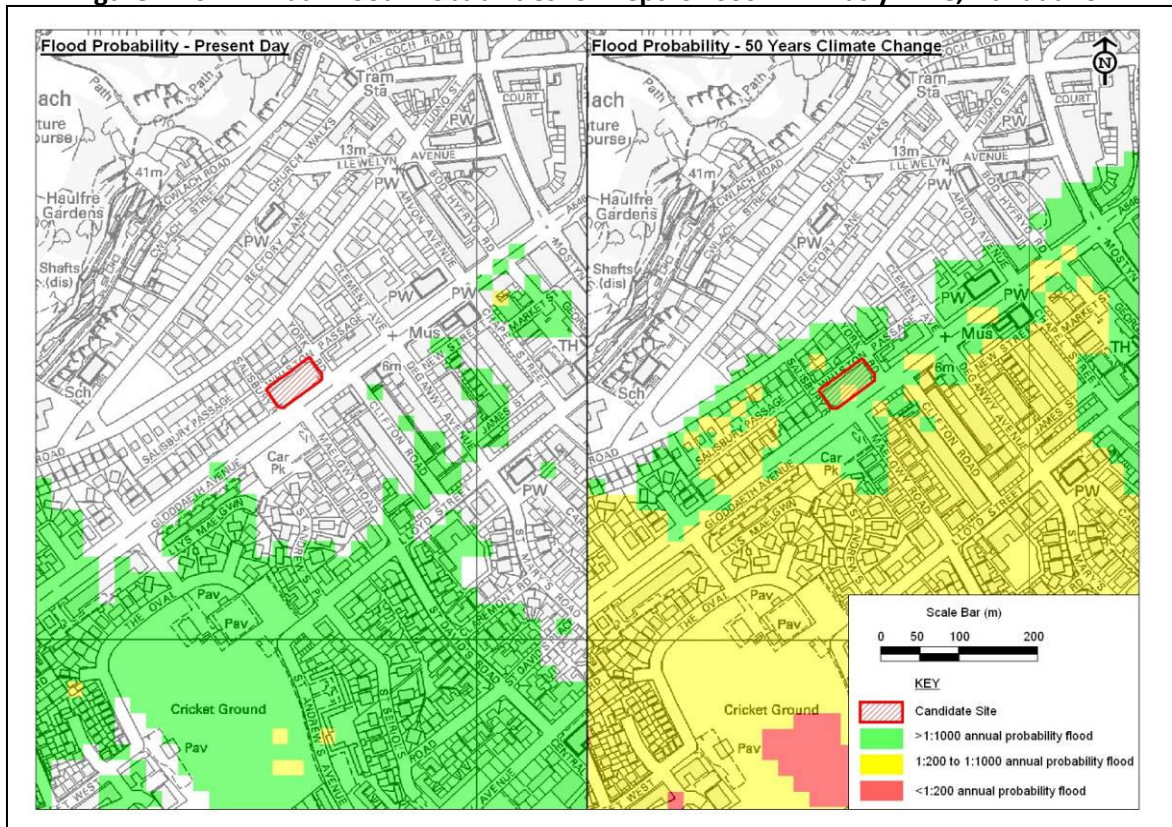
Figure 4.9 – Site Levels: Plas yn Dre, Llandudno

As the site is in Flood Zone C1, the justification test must be applied. For the purpose of the SFCA, a broad assessment of the flood consequences to the site in an extreme flood (1 in 1000 annual probability) has been made. For residential developments the following guidelines are given in TAN15:

- maximum flood depth = 600 mm
- maximum rise of floodwaters = 0.1 m/hr
- maximum speed of inundation = 4 hrs
- maximum velocity = 0.15 m/s

Figure 4.10 presents the event probabilities for flood depths in excess of 600mm, which is the guideline threshold for the maximum depth of flooding of residential property in TAN15. This shows that with 50 years of climate change a 1 in 1000 flood would not result in 600mm depth of flooding around the current site. If the flood levels of the developed site are raised 700mm above street level in line with predicted sea level rise for a further 50 years, then we can infer that flood depths exceeding 600mm would only occur in an event exceeding a 1 in 1000 annual probability.

Figure 4.10 – Annual Flood Probabilities for Depths >600mm: Plas yn Dre, Llandudno



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Figure 4.11 shows the current day flood probabilities relating to rise of floodwater, speed of inundation and velocity of floodwaters (data for the climate change scenario is not available). This shows that around the site the parameters considered are all well within the recommended limits.

Climate change may alter this, but since the site would need to be raised for development to progress, these limits would not be exceeded for a 1 in 1000 annual probability flood. The site is also at the very edge of the flood area and is included within the existing flood warning area. The consequences of flooding in an extreme event are therefore likely to be manageable, but would need more detailed consideration at a design stage. Any proposed development would also need to ensure that there was suitable access and egress in the event of a flood.

It should be noted that the modelling did not account for any future raising of the sea defences. The relevant SMPs for the north shore and west shore defences both have a policy of "hold the line". It is therefore assumed that the defences would be raised and improved in line with sea level rise in the future. The existing defences have a 1 in 200 SoP. As there is a requirement to raise finished floor levels of the site above street level,

surface water flood risk would be mitigated. ***The site is therefore suitable for residential development but would require significant raising of finished floor levels.***

Figure 4.11 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise: Plas yn Dre, Llandudno



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Third-party Impacts

As an existing brownfield site, the potential for increased runoff is low. However, the drainage system in Llandudno is known to be under continual pressure. Every effort should therefore be made to reduce runoff from this site and the applicability of SUDS should be explored at the detailed design stage. If drainage were to be discharged to the sewer network, close consultation with both DCWW and EAW would be required to avoid exacerbating the existing problems.

According to NRSI and BGS maps the site is in an area of freely draining sand dune soils and is underlain by mudstone. The Environment Agency's groundwater mapping shows the site to be outside of any GSPZ. Some form of infiltration may therefore be possible but the feasibility would need to be tested by site investigation at a design stage.

4.5 Rhos-on-Sea (Housing)

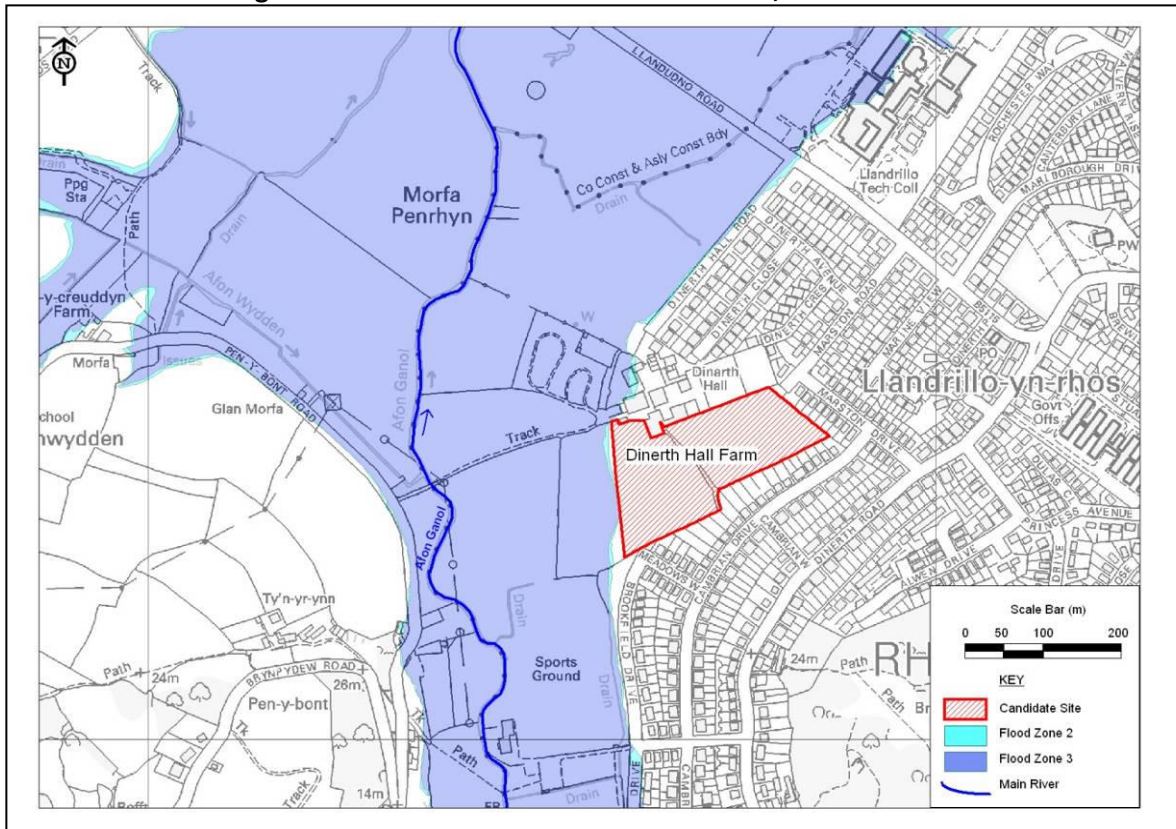
(a) Dinerth Hall Farm

The Dinerth Hall Farm site is located on open pasture and is therefore greenfield (refer to Figure 4.12). The site is on the western side of Rhos-on-Sea and the majority of the site is situated on the high ground, similar to the rest of the town. However, the site slopes and ground levels are lower to the west towards the Afon Ganol and as such this area borders the floodplain. This is the northern section of the Afon Ganol, which drains toward the open sea at Penrhyn Bay (the southern part drains to the Afon Conwy). Access to the site is via existing residential areas including Marston Drive.

Figure 4.12 shows that the site borders onto Flood Zones 2 & 3. Although the mitigation proposal is to set back development from the floodplain, there is a requirement to consider the impact of climate change over the life span of the development, in this case 100 years.

For this site, both fluvial and tidal flood risk must be considered.

Figure 4.12 – Flood Zones: Dinerth Hall Farm, Rhos-on-Sea



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Fluvial

As indicated above the Afon Ganol discharges in two directions; the point of watershed has not been confirmed, but appears to be near Mochdre. The northern part of the Ganol flows past this site and through Rhos-on-Sea Golf Course to discharge through tidal doors into Penrhyn Bay. These allow flow out through the sea wall, but prevent sea water passing up the Ganol at high tide or in storms. The tidal doors have recently been

refurbished and it was noticeable from the site visit that the area is now well drained compared to recent years.

Given that the gradient of the Ganol is very slack through this area, it is likely that a high flow in the river coinciding with a modest high tide will result in water backing up through the system. Estimating the impact of climate change on flood levels without a suitable model is therefore difficult since the calculation becomes one of volume. The floodplain is wide compared to the size of the watercourse and the catchment area, so the increase in peak water level would be slight. The floodplain is also at risk of tidal flooding; as this is likely to have far more of an impact than a fluvial flood, this has been assessed further below.

Tidal

To illustrate that the site is not affected by climate change, an undefended scenario has been used. This implies that during a tidal event there would be no barrier preventing the sea water entering the Afon Ganol floodplain and the peak water level would reach the published extreme tide level. This is a worst case assumption as it ignores the existing sea defences which have a 1 in 200 SoP.

The 1 in 200 probability tide level at Rhos-on-Sea is given as 5.50m OD. Using the Defra guidance on sea level rise over the next 100 years gives a revised level of 6.50m OD. This level closely matches the ground level at the western limit of the site.

(b) Site Suitability

Flood Risk & Mitigation

The site borders onto Flood Zone 2, which equates to Flood Zone C1 under TAN15 because the area is defended. Taking account of climate change gives no significant change in the existing flood zone extents at Dinerth Hall Farm and based on observations on site this seems realistic. ***The site is therefore at low risk and considered suitable for development as it is within Flood Zone A and is not impacted on by climate change. At a detailed design stage it should be ensured that finished flood levels are above 6.50m OD.***

Third-Party Impacts

Development should not increase the risk of flooding elsewhere. A loss of floodplain is not an issue at this site but the increase in runoff from a developed site compared to a greenfield site could be an issue. The surface water drainage in Rhos-on-Sea is controlled by either pumping or discharged to the Afon Ganol. It is known that the existing systems can become overloaded and flood the gardens of properties around Penrhyn Avenue to the north, as well as the golf course.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented so as not to aggravate the situation. According to the BGS maps, the site is in an area of till deposits underlain by limestone. Soil maps from the NSRI indicate slightly acid loams and clay soils with impeded drainage. Mapping information on the Environment Agency's website shows the site to be in the area of a 'principle' bedrock aquifer and of intermediate to high vulnerability – there is however no Groundwater Source Protection Zone (GSPZ) in the area. In light of the drainage issues in the area some form of on-site attenuation would be best utilised, which should be above the floodplain.

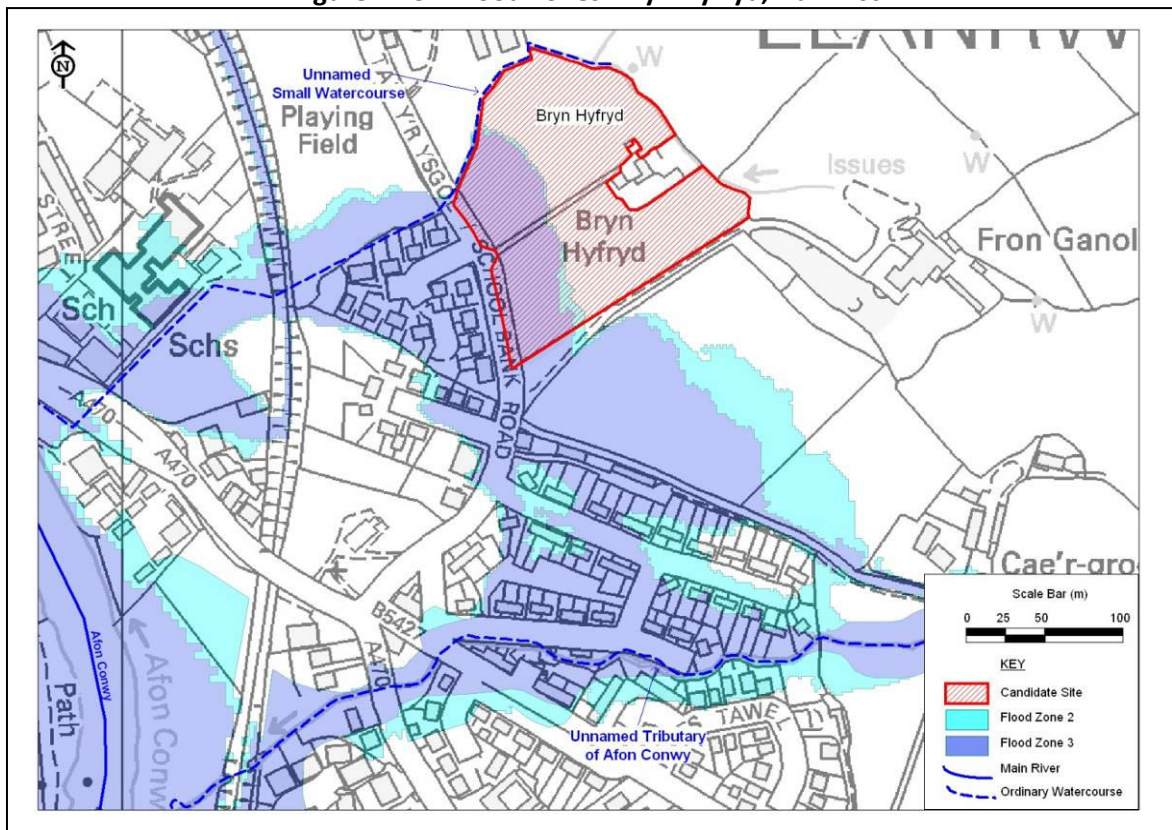
4.6 Llanrwst (Housing)

(a) Bryn Hyfryd

The Bryn Hyfryd site is located on open pasture and is therefore greenfield. The site is found on the eastern side of Llanrwst at the foot of a hill slope. The site itself is sloping, falling around 5m from north-east to south-west. A small watercourse flows around the northern and western boundary before flowing under School Bank Road into a culverted system. This was recently improved and linked into the Afon Bach Flood Alleviation Scheme. The site has been allocated for 50 dwellings.

From Figure 4.13 it can be seen that the lowest third of the site area is contained in both Flood Zones 2 & 3. The site is above the extensive Afon Conwy floodplain and this river does not present a flood risk. However, to the south of the site there is an unnamed tributary of the Afon Conwy. The land falls away from this watercourse towards the Bryn Hyfryd site with a difference in elevation of 2 to 3 metres. There is a need to assess whether this is a viable flood route and if so what the likely impact of climate change would be. The flood risk presented by the smaller watercourse bordering the site also needs to be assessed. The Stage 1 Assessment process also identified from flood maps that surface water flooding is a potential issue at this site.

Figure 4.13 – Flood Zones: Bryn Hyfryd, Llanrwst



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Hydrology

An assessment of peak flows for the 1 in 100 annual probability flood was carried out for the larger watercourse to the south of the site. This was carried out using statistical and rainfall-runoff methods. Both methods gave close agreement and so the slightly higher peak estimate from the rainfall-runoff method was used. This provides a peak flow

estimate of 7.9 m³/s for the 1 in 100 annual probability flood and 9.5 m³/s when climate change is included.

The peak flow for the smaller watercourse adjacent to the site was estimated on a pro rata basis by area, using the peak flow estimates above. This gives a peak flow estimate of 0.55 m³/s for the 1 in 100 annual probability flood and 0.66 m³/s when climate change is included

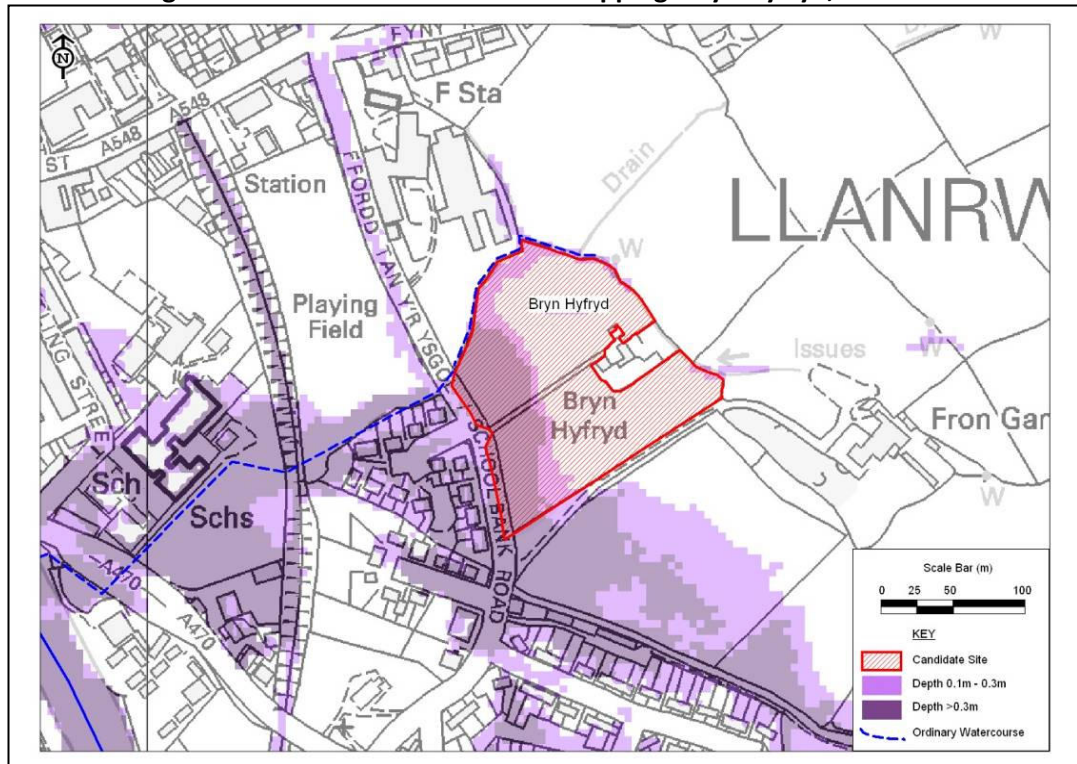
Hydraulics

An assessment of the channel capacity of the larger tributary of the Afon Conwy was carried out using Manning's equation. Channel dimensions and slope were estimated based on site observation and LiDAR. The channel has been canalised in places and there are flood defence walls along its course throughout the residential area. This assessment indicates that there is sufficient capacity in the channel to contain the 1 in 100 annual probability flood including climate change. Flooding may occur where the watercourse passes under the B5427 because of the constriction at the culvert, but this would not present a risk to the Bryn Hyfryd site.

Channel capacity of the smaller watercourse was similarly calculated. A water depth in channel of 0.4m was estimated with little change indicated between the 1 in 100 annual probability flood and climate change scenario. This would indicate that there is potentially sufficient capacity in the channel to contain the flow without spilling out onto the site. However, this watercourse passes through a 600mm diameter culvert under School Bank Road. Although the drainage system has been improved by the Afon Bach Flood Alleviation Scheme this culvert could potentially cause water to back up resulting in overtopping of the bank at the foot of the hill onto the site.

Surface Water

Figure 4.14 shows the surface water flooding predicted by the Environment Agency's broad scale surface water modelling and should only be used as a guideline. The flood outline closely resembles that shown from the fluvial mapping, with deep surface water indicated at the foot of the hill on the Bryn Hyfryd site. It was noticeable during the site visit that the bottom of the field was saturated, with standing pools of water visible.

Figure 4.14 – Surface Water Flood Mapping: Bryn Hyfryd, Llanrwst

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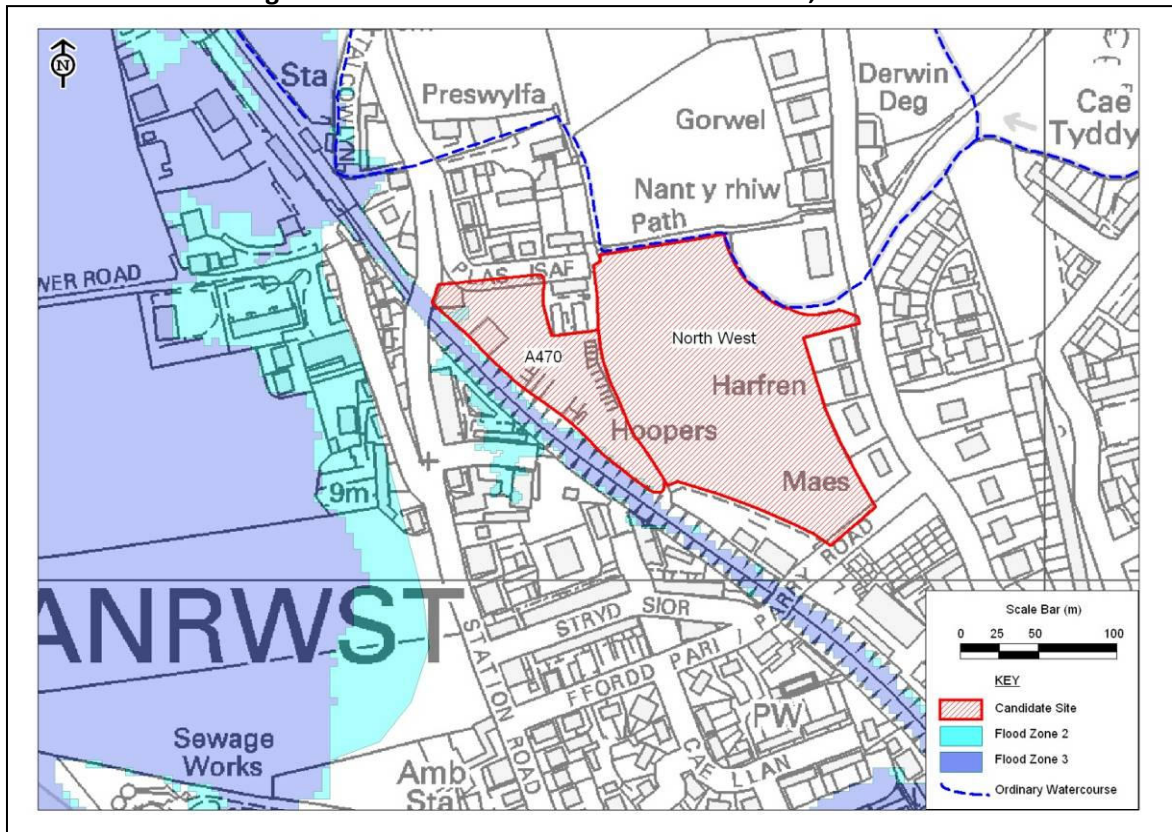
(b) North-West & A470

These two sites have been considered together because they are situated next to each other. The larger, more westerly site (referred to as North-West) is a greenfield site consisting of open pasture. The smaller site adjacent to the A470 is a working yard, and is therefore brownfield. There is a small unnamed watercourse which flows around the northern boundary of the larger site and the edge of the Plas Isaf estate before diverting into a culvert under the A470. The ground levels fall from east to west across the two sites. A railway cutting forms the western boundary of the A470 site. The larger site has been allocated for 55 dwellings and the smaller site for 20 dwellings.

From Figure 4.15 it can be seen that, with the exception of a very small area in the A470 site, both areas are outside Flood Zones 2 & 3. From the site visit a potential flood risk was identified from the small watercourse running around the northern boundary. Figure 4.17 also indicates that the site is potentially susceptible to surface water flooding. A more detailed assessment of flood risk has been conducted as a result.

Hydrology

Rainfall-runoff and statistical methods were applied to obtain peak flow estimates for the 1 in 100 annual probability flood. The statistical method gave a peak flow of 4.2 m³/s compared to 4.9 m³/s for the rainfall-runoff method. The estimates are therefore comparable. For the purpose of the SFCA a precautionary approach has been taken and the slightly higher flow estimate used in the hydraulic calculations, i.e. 4.9 m³/s. This gives a peak flow of 5.9 m³/s when taking climate change into account.

Figure 4.15 – Flood Zones: A470 & North-West, Llanrwst

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Hydraulics

From the site visit it was evident that a flood bank has been constructed alongside the watercourse to prevent flooding of the field and presumably the yard and housing at the southern end of Plas Isaf. It is understood that this was constructed by Conwy CBC, however further information relating to the embankment was unavailable at time of preparing this assessment. Where the watercourse turns sharply from north to west, it passes beneath a wall. Although the opening in the wall is as wide as the channel, the height is potentially very constrictive as shown in Figure 4.16. Using Manning's equation would therefore considered not be appropriate to determine potential depths in channel during flood events.

Figure 4.16 – Photos of Flood Bank and Opening through Wall

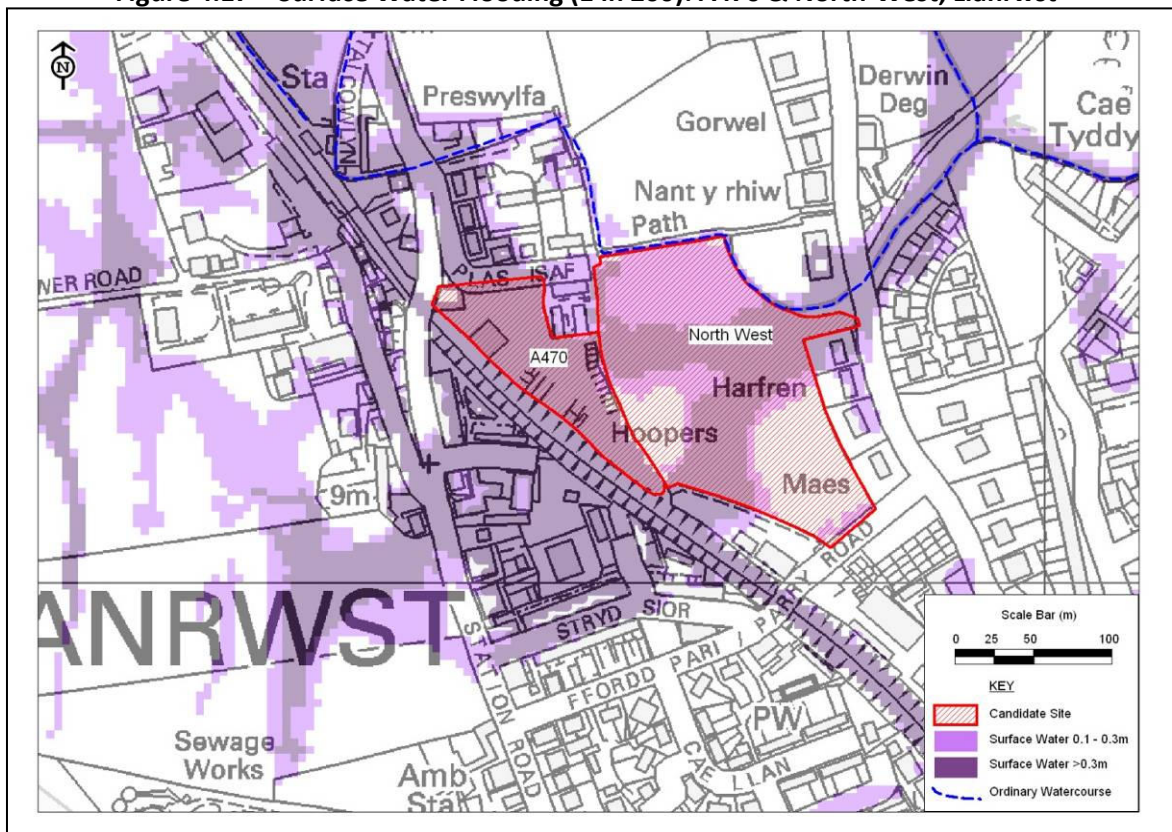
A simple ISIS hydraulic model was constructed from 60m upstream of wall and extending to a point 70m downstream of the constriction. The channel bed was estimated from the site visit to be 1.5m wide with 1 in 3 slopes on the banks. LiDAR was used to estimate the gradient of the bed and the crest level of the embankment. The opening in the wall was modelled as an ORIFICE unit with an estimated bore area of 0.9 m^2 ($1.8\text{m} \times 0.5\text{m}$). A normal critical depth boundary was used at the downstream boundary.

The model was then run unsteady for the 1 in 100 annual probability flood using the ReFH unit. The results showed that the existing flood embankment would be readily overtopped in a large flood event due to the large amount of headloss through the wall opening. The opening would also be liable to block further increasing flood risk.

Surface Water

Figure 4.17 shows both sites to be susceptible to surface water flooding. However, this surface water would be collected upstream of the site by the small watercourse to the north and therefore the fluvial assessment is more appropriate for this site.

Figure 4.17 – Surface Water Flooding (1 in 200): A470 & North-West, Llanrwst



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(c) Site Suitability

Flood Risk & Mitigation

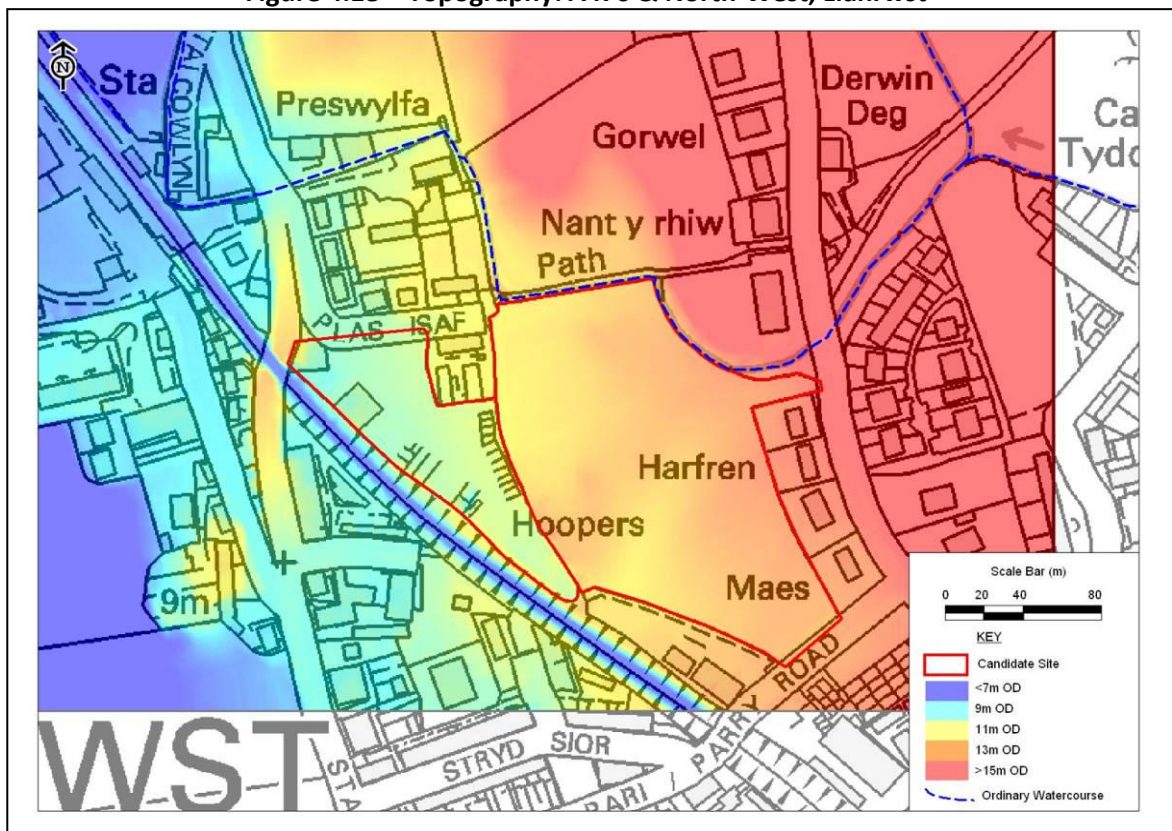
The lower area of the Bryn Hyfryd site is shown as being included in Flood Zones 2 and 3, and as it is not in an area classified as benefitting from defences is classified as Flood Zone C2 under TAN15. As such no residential development should take place in this area and there is not sufficient evidence at this strategic level to suggest the flood zone should be changed, despite the improvements to the drainage resulting from the Afon Bach Flood Alleviation Scheme. The impact of climate change on the 1 in 100 probability flood extent would be negligible.

The area of the Bryn Hyfryd site outside Flood Zone C2 is therefore suitable for residential development.

At the northern end of the village, the two neighbouring sites close to the A470 were initially identified as potentially being susceptible to surface water flooding. However on inspection a fluvial flood risk was found to be of greater concern. Although there is a flood bank protecting the sites from the small watercourse which runs along the northern boundary, the watercourse passes under a wall through a restrictive opening. Hydraulic modelling (which incorporates estimates and assumptions) has been used to assess the impacts of this and it shows that the wall is a significant constriction and the channel has insufficient capacity. A 1 in 100 annual probability flood could result in the flood bank overtopping, with significant consequences for any development at either of these sites. To further advance these two northern sites mitigation options need to be assessed. A discussion of possible options is provided below.

A potential mitigation option may be to include replacing the wall for an alternative boundary feature which would allow flow to pass downstream unrestricted. However, this would increase flow downstream and is likely to increase flood risk to the Plas Isaf housing estate and the railway line. Figure 4.18 presents the topography of the area. This demonstrates that the watercourse does not follow a natural valley; it has been diverted across the hillslope around the estate to the north. The channel capacity here is assessed to be insufficient to contain a 1 in 100 annual probability event and therefore out-of-bank flow would almost certainly flood the housing estate.

Figure 4.18 – Topography: A470 & North-West, Llanrwst



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An alternative option to provide flood storage on part of the site to store water overtopping the embankment has been considered. However, using the ISIS model

indicates the volume of water overtopping the embankment in a 1 in 100 annual probability flood is in the region of 8000m³. This increases to 14,000m³ when climate change is included. This is a substantial volume and considering the combined area of the two sites is just under 28,000 m² suggests that this option is unlikely to be viable.

Off-site mitigation might be considered, for example diverting the watercourse away from the Plas Isaf estate and increasing culvert capacities where necessary, but this is likely to be costly and would mean other landowners being involved.

Both the North-West and A470 sites in Llanrwst are assessed as being at high flood risk with limited means of mitigating that flood risk and therefore are unfavourable for development. It is recommended that Conwy CBC reconsider the allocation of these sites in the LDP.

Third-Party Impacts

Development should also not increase the risk of flooding elsewhere and the increase in runoff from a developed site compared to a greenfield site can be an issue. Llanrwst has a history of flooding problems, some of which have been caused by inadequate drainage systems, so reducing runoff at new developments is critical.

The use of SUDS can perform an important role and should be implemented. According to the BGS maps, Llanrwst is underlain by sandstone and soil maps from the NSRI indicate that this is an area of freely draining loamy soils over rock. Mapping information on the Environment Agency's website shows the area to be part of a minor aquifer with intermediate vulnerability and there is no GSPZ in the area. Infiltration techniques may therefore be appropriate, but feasibility would need to be tested by on site investigation at design stage.

4.7 Eglwysbach (Housing)

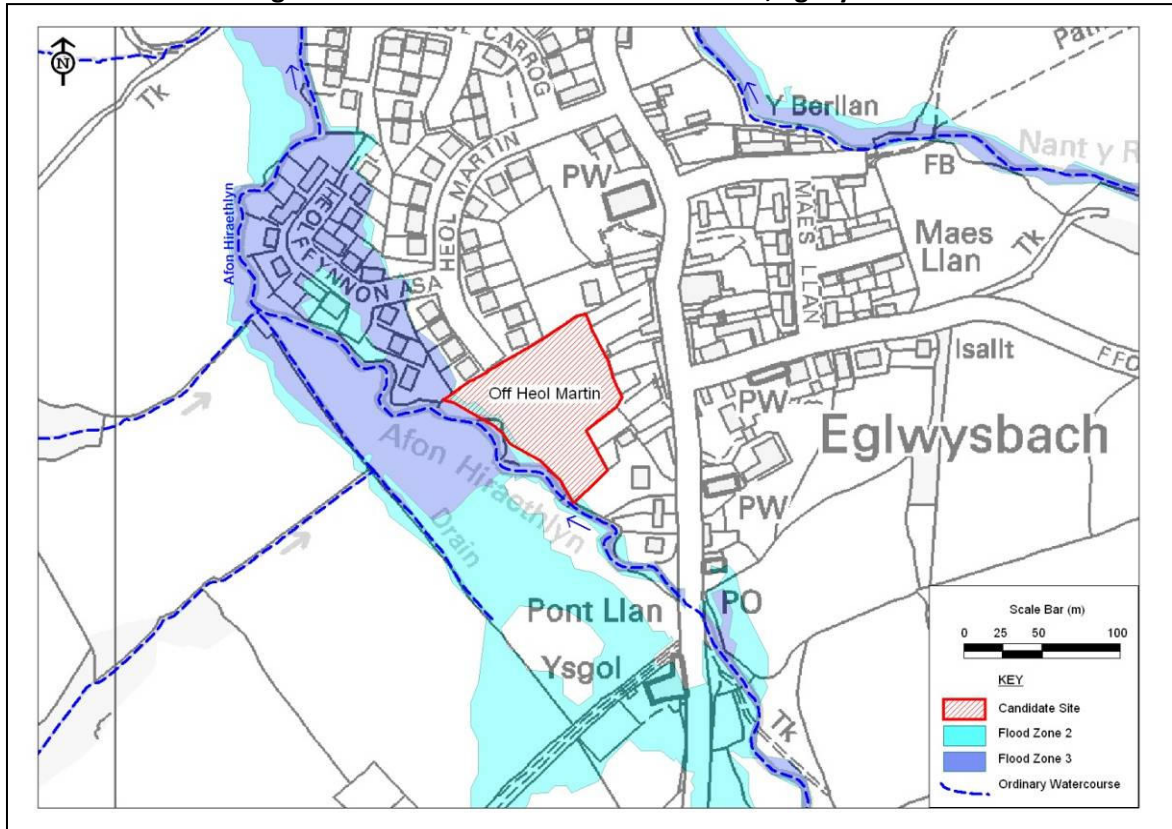
(a) Off Heol Martin

The site in Eglwysbach is located next to the Afon Hiraethlyn, which runs along the western edge of the village. The site is open pasture (greenfield) and surrounded by residential properties; it gently slopes down from the north-east to the south-west. The site is allocated for 10 dwellings.

From Figure 4.19 it can be seen that the south-western boundary of the site extends into Flood Zone 2 and borders Flood Zone 1. Some of the properties in Heol Ffynnon Asa which are shown as being located in the flood zones are known to have flooded in 2004. Figure 4.20 shows the Environment Agency's broad scale surface water flood mapping and indicates approximately half the site to be vulnerable to deep surface water flooding in the 1 in 200 annual probability rain storm.

The impact of climate change on fluvial flood risk and the potential for surface water flooding is assessed below.

Figure 4.19 – Flood Zones: Off Heol Martin, Eglwysbach



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Fluvial

An existing hydraulic model of the Afon Hiraethlyn has been used in the assessment of fluvial flood risk. An ISIS-TUFLOW (1D-2D) linked hydraulic model was developed in 2010 by Environment Agency Wales to enable them to improve the flood zone mapping in Eglwysbach, previously only undertaken using broad scale modelling methods. The model extends from around 200m upstream of the village to the Sewage Treatment Works 350m downstream of the village.

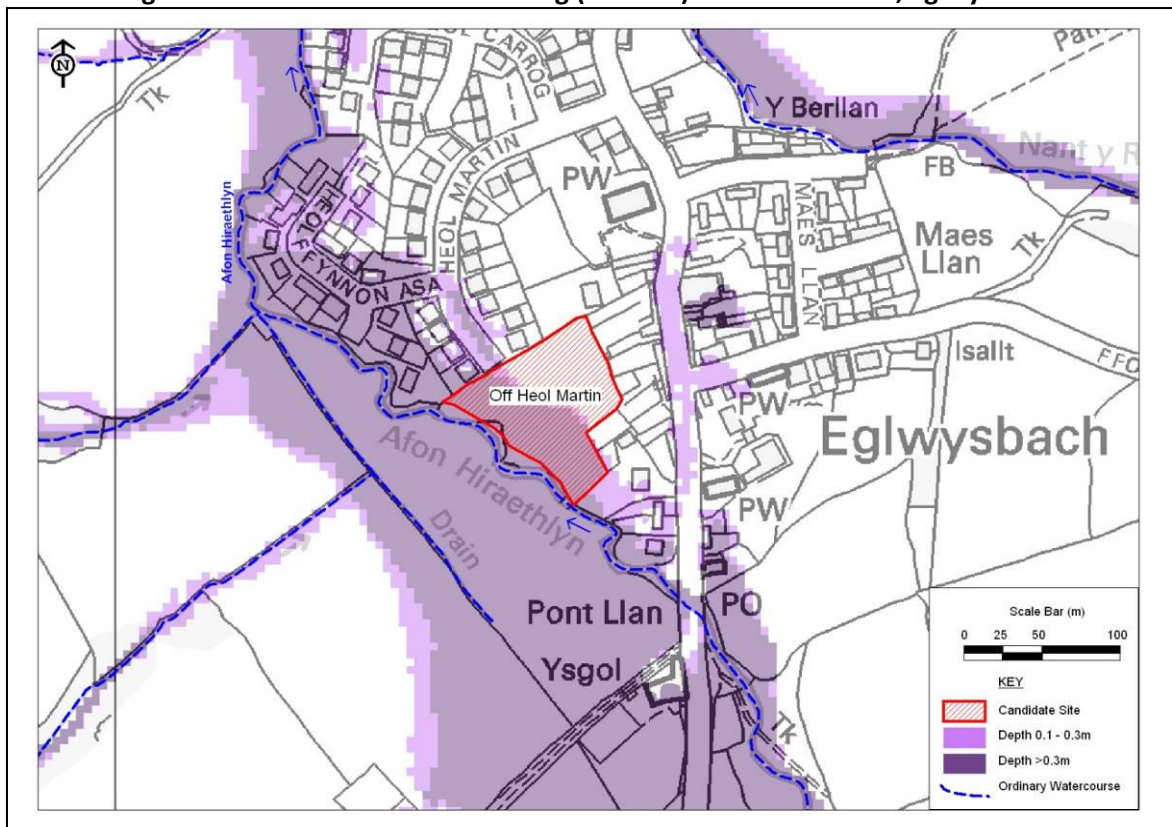
A review of the hydrology and the model has been carried out. The hydrology was carried out using WINFAP-FEH v2, which has now been superseded by v3. The hydrology was therefore reassessed using the latest software and the most up-to-date HiFlows-UK dataset. This gave a 1 in 100 annual probability peak flow of $16.1\text{m}^3/\text{s}$ compared to $14.6\text{m}^3/\text{s}$ used in the model, an increase of around 10%. This would not impact significantly on the demonstrated flood risk to the site. The model is not complex with only one structure within the modelled reach (the road bridge at the upstream end of Eglwysbach). No issues were found with the model and sensitivity analysis on roughness values and boundary conditions indicate that the flood risk shown to the site is robust.

The flood zones have been updated by the Environment Agency (see below) and these are as shown in Figure 4.19. This shows that the site is generally at low flood risk with flooding occurring on the opposite bank and also downstream of the site in Heol Ffynnon Asa because these are lower lying. Given the small difference in extent between the 1 in 100 (Flood Zone 3) and 1 in 1000 (Flood Zone 2) annual probability floods, it would not be expected for climate change to significantly alter the 1 in 100 annual probability flood extent and the model supports this.

Surface Water

The surface water flood maps are generated using broad scale modelling assumptions and should only be used as a guide. The flood outline shown in Figure 4.20 indicate around half the site to be vulnerable to flooding depths in excess of 300mm for the 1 in 200 annual probability rainfall storm. Observations from site and examination of LiDAR indicate a fall across the site towards the Afon Hiraethlyn of around 2m with no areas for water to pond or accumulate to significant depths. The Afon Hiraethlyn would remove surface water runoff from the site and the fluvial flood outline is therefore considered a more realistic output and guide to flood risk.

Figure 4.20 – Surface Water Flooding (1 in 200): Off Heol Martin, Eglwysbach



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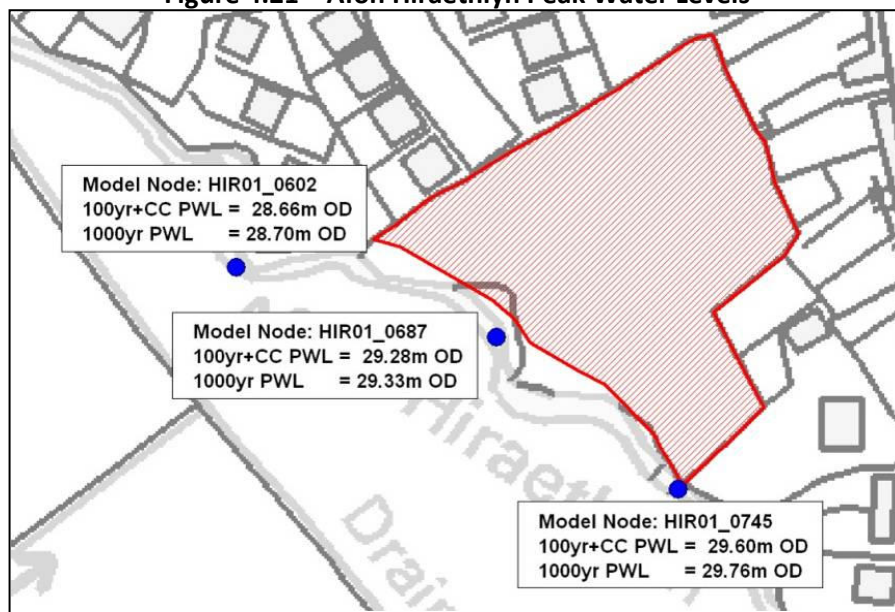
(b) Site Suitability**Flood Risk & Mitigation**

The DAM shows around half the site to be within Flood Zone C2 (extents replicate that shown by surface water flooding in Figure 4.20), and as such development would be prohibited in this area. However, the Environment Agency's flood mapping is more up-to-date than the DAM and this shows the site to border onto Flood Zone 3 with small areas impinging into Flood Zone 2. The surface water mapping is not considered to be realistic here, as there is no evident reason for water to accumulate on the site.

We would therefore recommend that the site is suitable for development provided a suitable buffer is set to locate development away from directly adjacent to the river and a minimum freeboard of 300mm is applied to finished floor levels.

Model output for the 1 in 100 annual probability flood with climate change and 1 in 1000 annual probability flood is given in Figure 4.21.

Figure 4.21 – Afon Hiraethlyn Peak Water Levels



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Third-Party Impacts

Development should also not increase the risk of flooding elsewhere. A loss of floodplain is not an issue at this site but the increase in runoff from a developed site compared to a greenfield site can be an issue. Given that just downstream of this site there is a known flooding problem in Heol Ffynnon Asa, increasing runoff to the Afon Hiraethlyn should be avoided. There are also the catchment wide issues of allowing developments without controlling runoff; as individual sites these may contribute little to flow, but the cumulative impact can be significant.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented at this site. According to the BGS maps, the site is in an area of alluvium and river terrace deposits underlain by mudstones, siltstone and sandstone. Soil maps from the NSRI indicate that Eglwysbach lies in an area of freely draining loamy soils. Mapping information on the Environment Agency's website shows the area to be part of a minor aquifer with intermediate vulnerability, there is however no GSPZ in the area.

Infiltration techniques are likely to be feasible, but this would need to be tested by on site investigation.

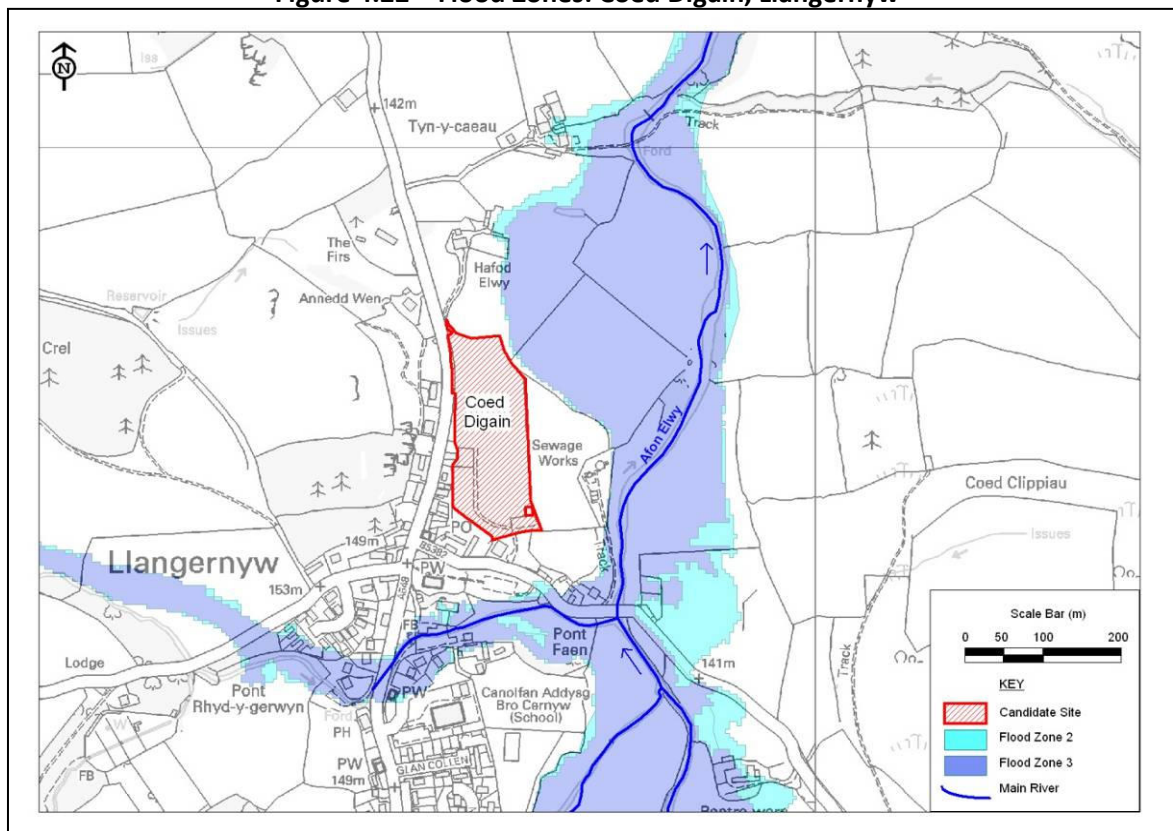
4.8 Llangernyw (Housing)

(a) Coed Digain

Coed Digain is a large site on the northern edge of Llangernyw and is accessed from the A548. The site is open pasture and classified as greenfield. The site has been allocated for 15 dwellings.

From Figure 4.22 it can be seen that the site is outside of both Flood Zones 2 and 3, but it does border these flood zones. In line with other assessments, there is a requirement to confirm whether climate change might have an impact on the site and its flood risk. This has been addressed below.

Figure 4.22 – Flood Zones: Coed Digain, Llangernyw



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Hydrology

In the absence of a river model to assess flood risk, hydrological analysis has been carried out to determine a peak flow for the 1 in 100 annual probability flood. Both statistical and rainfall-runoff methods were used in the assessment. The rainfall runoff method gave a significantly higher flow of 133 m³/s compared to the statistical method with 89 m³/s. For a catchment of this nature, the statistical method would normally be used; however a precautionary approach has been taken here in order to demonstrate that the site has low flood risk. The following flow values have therefore been used to assess the impact of climate change:

- 1 in 100 annual probability = 133 m³/s
- +climate change (+20%) = 160 m³/s

Hydraulics

The impact of climate change has been assessed by determining the approximate increase in water level that result from the increased flows. This has been done using Manning's equation. At the location of the site the Elwy enters a broad floodplain. The calculation has been carried out assuming a rectangular shape with a width of 150m. A high manning's n of 0.06 has been applied to account for attenuation in the floodplain. The gradient of the watercourse was estimated using the 1:25k OS map. This indicates that the depth of water on the floodplain during a 1 in 100 annual probability event would be approximately 1m, with an increase of approximately 0.1m when taking account of climate change. The LiDAR shows that the elevation at the edge of the site is approximately 142m OD compared with the floodplain ground levels of approximately 137m OD, a difference of 5m. We can therefore be confident that the entire site is at low flood risk.

(b) Site Suitability

Flood Risk & Mitigation

The site is shown to be outside of both Flood Zone 2 & 3 and this is replicated by the DAM, which shows the site to be in Flood Zone A. The consideration of climate change has shown there to be no significant change in flood extent and LiDAR indicates that the site is on relatively high ground. ***This site is therefore suitable for residential development and no mitigation against flood risk to the site is required.***

Third-Party Impacts

Development should not increase the risk of flooding elsewhere. A loss of floodplain is not an issue at this site but the increase in runoff from a developed site compared to a greenfield site can be an issue. Although there are no sites immediately downstream that would be affected by increased runoff, the cumulative effect of multiple developments on a catchment wide basis can be significant.

The use of SUDS can therefore perform an important role in managing runoff and should be implemented at this site. According to the BGS maps, the site is in an area of till underlain by mudstone, siltstone and sandstone. Soil maps from the NSRI indicate that the site lies in an area of freely draining loamy soils over rock. Mapping information on the Environment Agency's website shows the site to be an area of a minor aquifer with intermediate vulnerability – there is however no GSPZ in the area. Infiltration techniques are therefore likely to be feasible, but this would need to be tested by site investigation at a design stage.

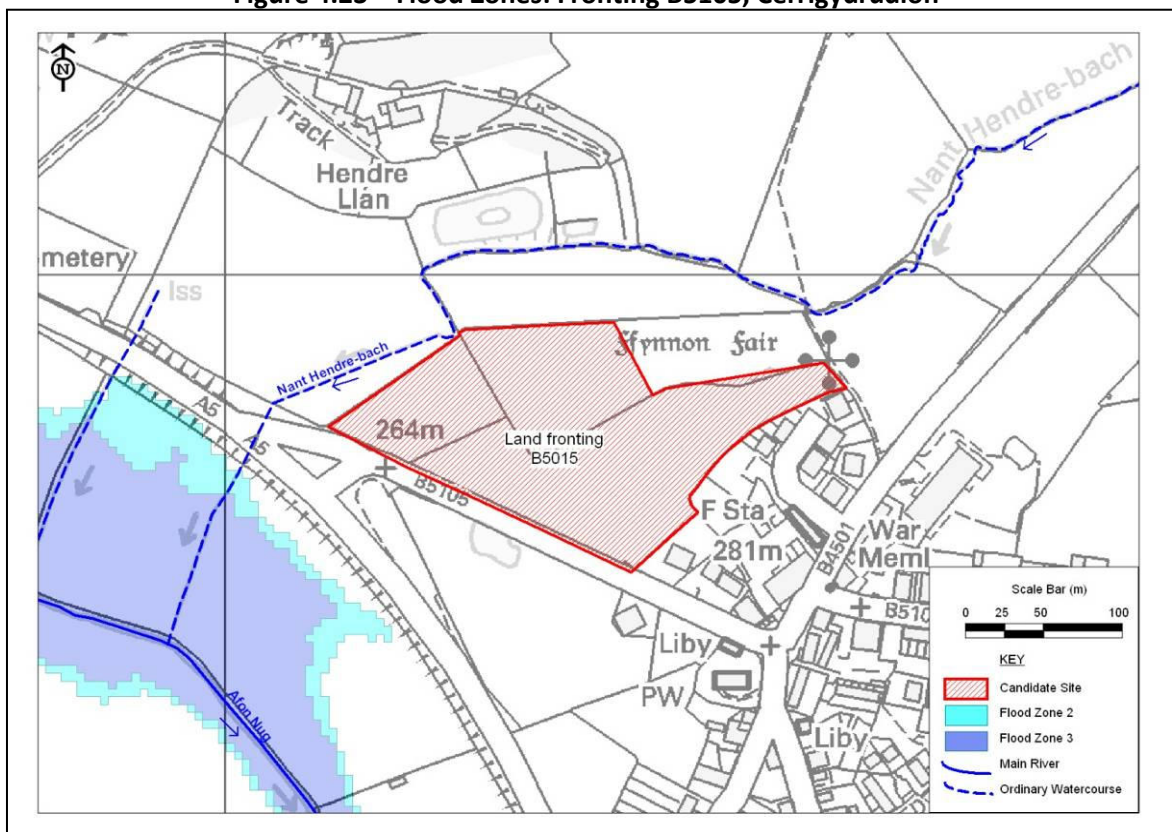
4.9 Cerrigydrudion (Housing & Mixed-Use)

(a) Fronting B5105

The site is located on the north-west side of Cerrigydrudion and is accessed from the B5105. It is open rough grazing and classified as greenfield. The site slopes down from the village towards the small watercourse at the foot of the hill (Nant Hendre-bach). The watercourse is closest to the site where it runs to the A5; it then flows through a road culvert and into the Afon Nug. The site is allocated as mixed development and has an allocation for 10 dwellings.

From Figure 4.23 it can be seen that the site is well outside of both Flood Zone 2 & 3, however there is a potential flood risk from the Nant Hendre-bach which may not have been assessed in the broad scale modelling used to attribute flood risk in this area. Figure 4.25 indicates that the site is potentially also liable to surface water flooding and this is also assessed in more detail below.

Figure 4.23 – Flood Zones: Fronting B5105, Cerrigydrudion



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Hydrology

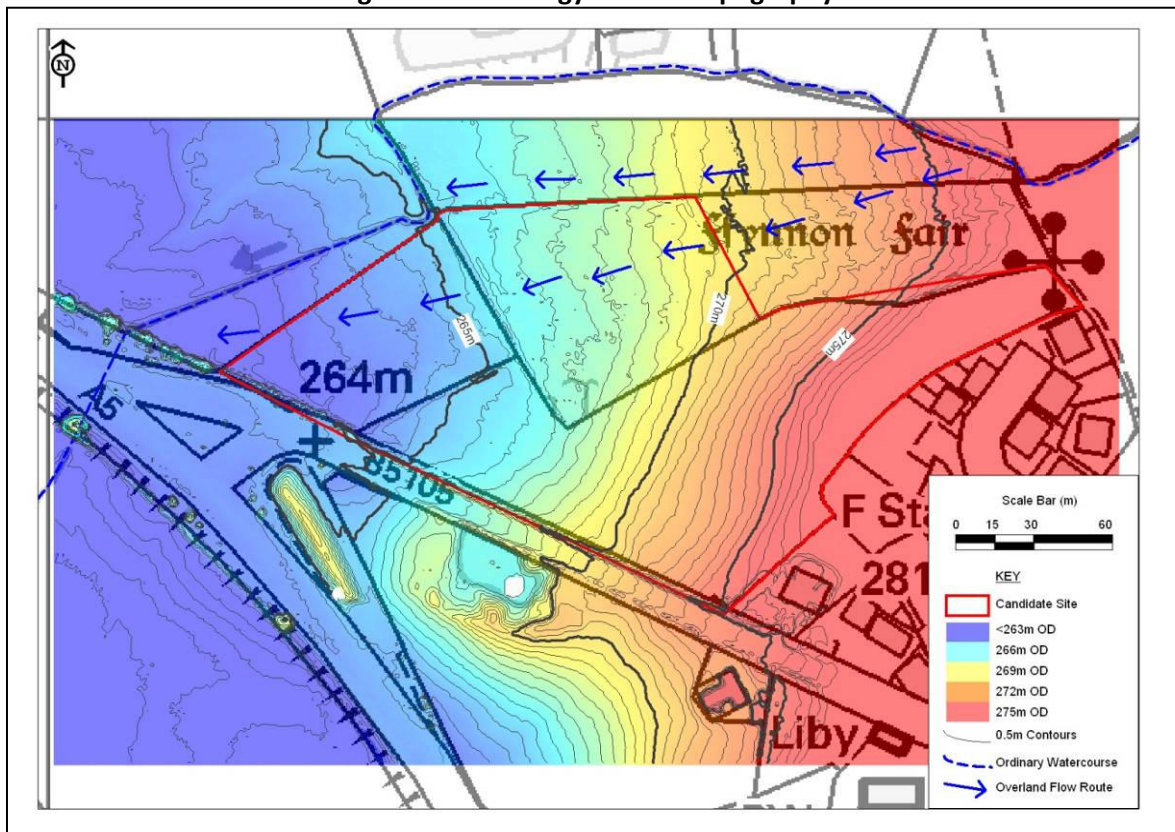
In the absence of any previous modelling a hydrological assessment of the Nant Hendre-bach catchment was carried out. Catchment descriptors were derived from the FEH CD-ROM v3 and the catchment area checked using the 1:25k OS map. Statistical, rainfall-runoff and small catchment methods were used to calculate peak flows for this stream. For the 1 in 100 annual probability flood, the statistical and small catchment methods both estimate a peak flow of $1.7 \text{ m}^3/\text{s}$, in comparison to $2.2 \text{ m}^3/\text{s}$ derived using rainfall-runoff. A precautionary approach has been taken to assessing flood risk and the higher peak flow estimate has been used, i.e. $2.2 \text{ m}^3/\text{s}$. This provides a peak flow of $2.6 \text{ m}^3/\text{s}$ for the climate change scenario.

Hydraulics

Manning's equation was used to give an indication as to the potential flood risk from the Nant Hendre-bach. Channel dimensions were estimated from a combination of site observation and LiDAR. The channel gradient was estimated based on the slope of the field beside the watercourse. A high roughness value was applied because the watercourse has marshy vegetation growing in it. For the 1 in 100 annual probability flood this indicates a water depth in excess of 0.5m, increasing to a little over 0.6m when climate change is applied. The channel is shallow in places and so the channel capacity is potentially exceeded in both instances. However, based on the contours generated from LiDAR, any flooding is likely to flow down to the west and return to the watercourse, although some shallow flooding of the site from overland might occur (refer to Figure 4.24).

Should the culvert under the A5 block, flood water could back-up behind it, increasing the possible flood extent. However, the road level is around 264m OD and flood levels are unlikely to exceed this greatly. A good estimation of flood extent would be between the 264m and 264.5m OD contours.

Figure 4.24 – Cerrigydrudion Topography

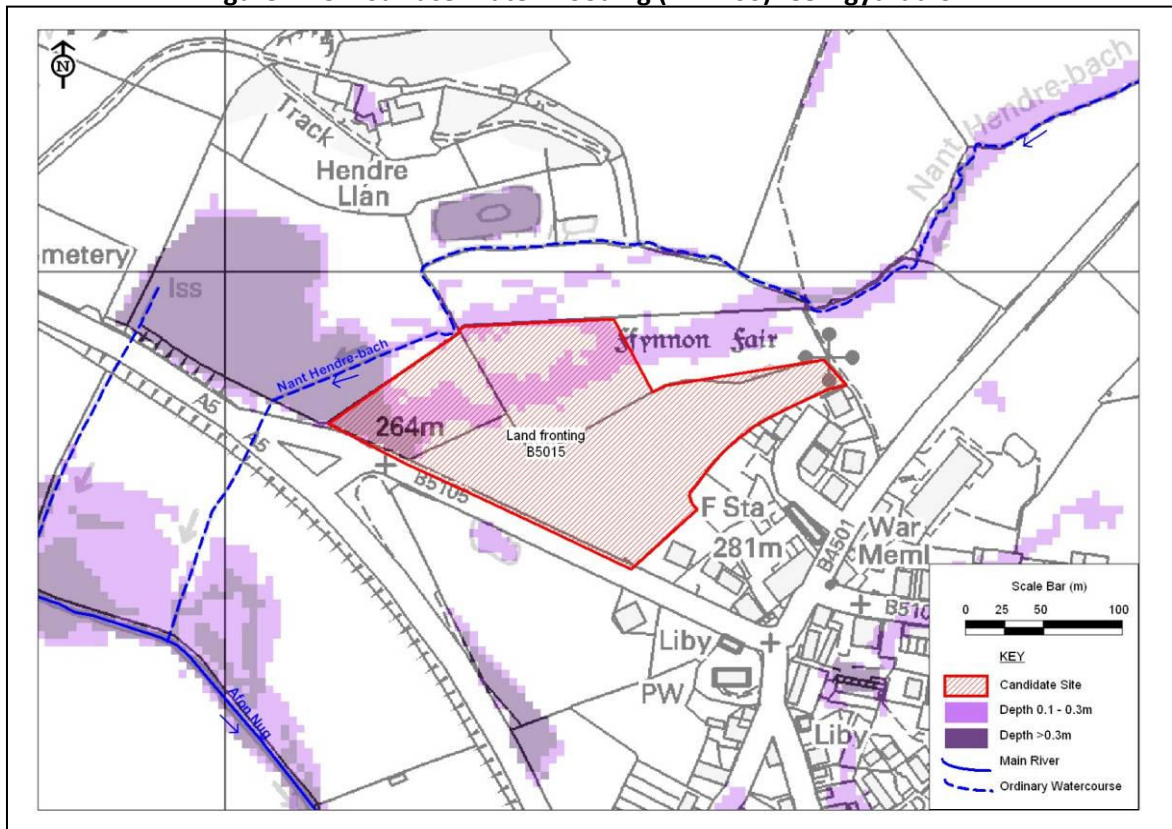


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Surface Water

Surface water was identified as a potential problem at this site based on the Environment Agency's mapping shows an area of deep flooding in the western corner and shallow flooding across part of the north-western half of the site for the 1 in 200 annual probability storm (refer to Figure 4.25). During the site visit it was noted that the area at the foot of the hill where the gradient slackens was wet and boggy. This is potentially the result of both runoff down the hillside and poor land drainage. This boggy area, particularly close to the stream, may not be favourable for development.

Figure 4.25 – Surface Water Flooding (1 in 200): Cerrigydrudion



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(b) Site Suitability

Flood Risk & Mitigation

The site is outside of both Flood Zone 2 & 3 and this is replicated by the DAM, which shows the site to be in Flood Zone A. However a potential flood risk was identified from the Nant Hendre-bach. Initial calculations indicate that there is the potential for the channel capacity to be exceeded which could result in limited flooding on the site. Most floodwater would be expected to accumulate around the culvert under the A5 up to a level of around 264m to 264.5m OD and would make this small area of the site unsuitable for development. There may also be some shallow overland flow, but this could be mitigated for at the design stage. A simple model of the Nant Hendre-bach should be constructed to confirm the flood risk. The resulting flood extents should be used to formally define where development should take place. That detailed assessment should extend to include at least the full extent of Figures 4.23 & 4.25 above.

Surface water mapping shows that the area nearest the stream is vulnerable and the site visit showed this area to be boggy. Figure 4.24 shows how the gradient across the site slackens at the foot of the hill and the area shown in the darker blue may not be

desirable for development because of ground conditions, particularly for housing. However this largely corresponds with the area likely to be at fluvial flood risk.

The majority of the site is therefore suitable for mixed-used development, with the exception of a small area in the western corner. A full FCA would be required with additional topographic survey and modelling to confirm levels and flood extents.

Third-Party Impacts

Development should not increase the risk of flooding elsewhere. The increase in runoff from a developed site compared to a greenfield site can be an issue. Although there are no sites directly downstream that would be affected by increased runoff, the cumulative effect of multiple developments on a catchment wide basis can be significant.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented at this site. According to the BGS maps, the site is in an area of till underlain by mudstone and siltstone. Soil maps from the NSRI indicate that the site lies in an area bordering between freely draining loamy soils over rock and seasonally wet loamy and clayey soils with impeded drainage. The Environment Agency's groundwater mapping shows the site to be in an area of a "Secondary B" bedrock aquifer and of low vulnerability. Infiltration techniques may be feasible on the upper slopes of this site, but would need to be tested by site investigation. However ground conditions are saturated towards the foot of the slope. Attenuation basins should not be placed in areas at risk of flooding, as the volume would not be available for water storage when needed.

4.10 Dolgarrog (Housing)

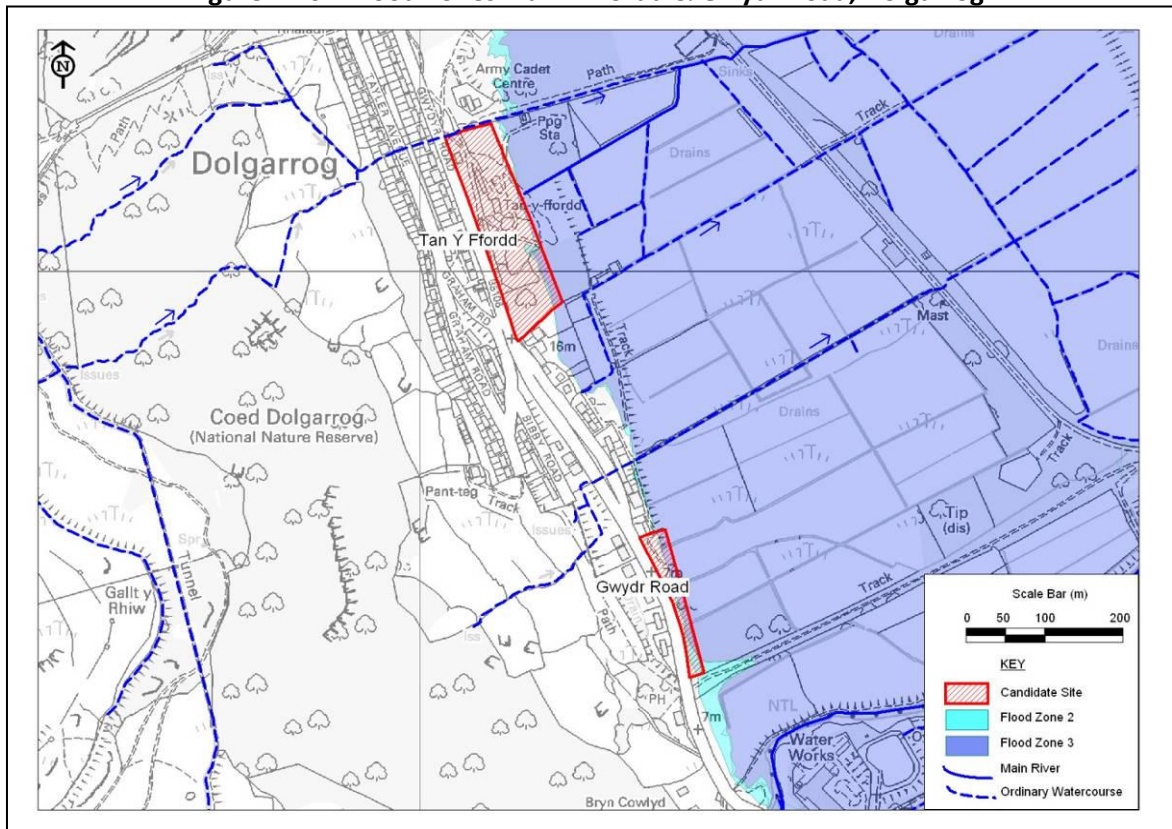
(a) Tan Y Ffordd & Gwydr Road

Both sites are located on the east side of the B5106 on the very edge of the Afon Conwy floodplain; as a result both sites have a steep fall to the east away from the comparatively high elevation of the roadside. The sites are undeveloped and are currently heavily overgrown with brush and woodland and therefore classified as greenfield. The two sites have been considered together because of their close proximity to each other and because their flood risks are from the same sources. The Tan Y Ffordd site has an allocation for 30 dwellings and Gwydr Road for 10 dwellings.

From Figure 4.26 it can be seen that a small area in the south-east corner of the Tan Y Ffordd site is contained within Flood Zones 2 & 3 and that approximately half the Gwydr Road site is contained in the flood zones. In addition, examination of the Environment Agency's "Flood Risk from Reservoirs" map shows the entire Gwydr Road site to be at risk in the event of an extreme failure of the Llyn Cowlyd Reservoir.

To more fully assess the suitability of these sites there is a need to consider the impact of climate change and understand the probability and consequences of a reservoir failure. The Afon Conwy is still tidally influenced at this location, so this has also been taken into account.

Figure 4.26 – Flood Zones: Tan Y Ffordd & Gwydr Road, Dolgarrog

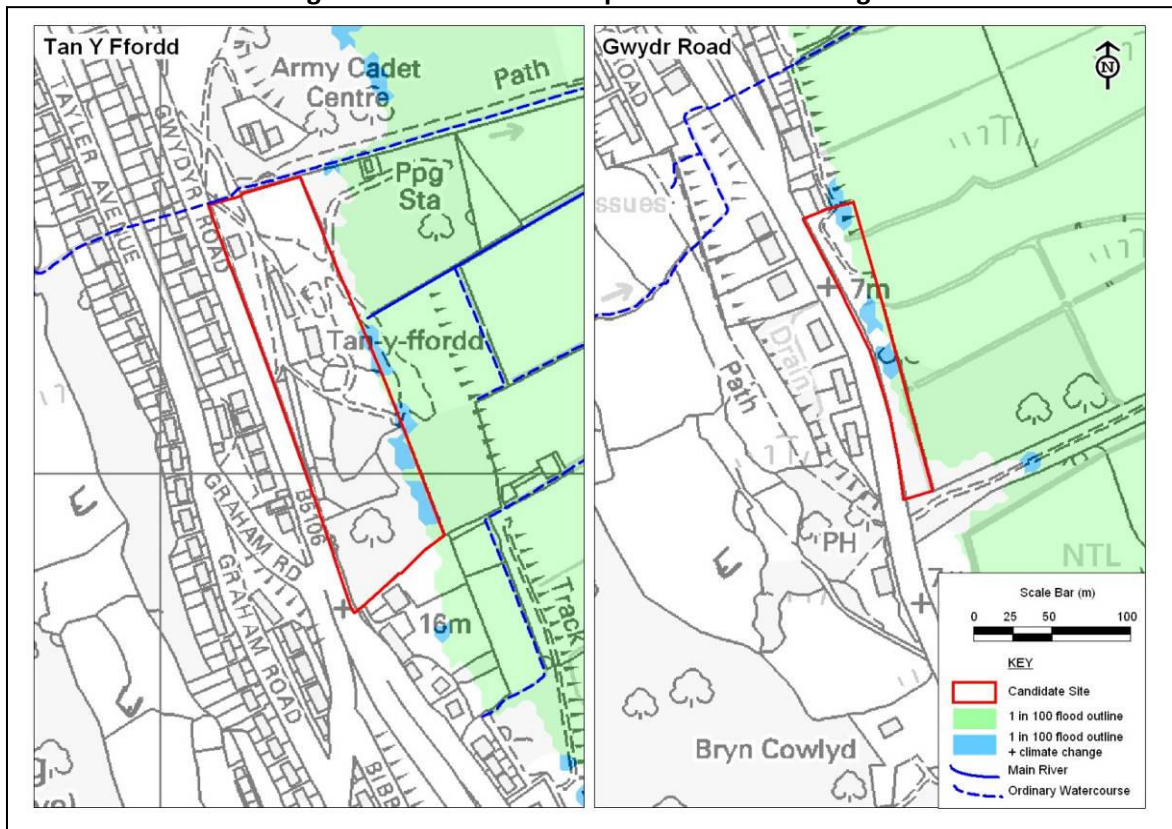


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Fluvial

An existing hydraulic model of the Afon Conwy has been used in the assessment of fluvial flood risk. An ISIS-TUFLOW (1D-2D) linked model was developed as part of the Conwy Valley Flood Alleviation Scheme, completed in 2009. The model extends from just downstream of Betws-y-Coed to Dolgarrog and is therefore applicable to this assessment. Flood outlines generated from the model output for the 1 in 100 annual probability flood, with and without climate change, are shown in Figure 4.27. This shows a slight increase in flood extent for both sites, although the significance as a proportion of the site is greater at Gwydr Road. This slight change in flood area is unsurprising given the sloping topography of the sites. Using level data from LiDAR indicates that from the road to the back of the site there is a fall in elevation of around 10m at Tan Y Ffordd and of between 3-4m at Gwydr Road. The model indicates an increase in flood level from 5.44m OD to 5.68m OD with climate change; an increase of 0.24m. The actual extents of flooding would need confirming against detailed site survey.

Figure 4.27 – Modelled Impact of Climate Change



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Climate change makes relatively little difference to the flood extents, the same can be said when comparing the 1 in 100 annual probability flood to smaller flood events. The Dolgarrog Embankment running along the western bank of the Afon Conwy protects against a 1 in 10 probability flood. Flood events overtopping the defences will fill the floodplain to the fringes of the two sites.

Tidal

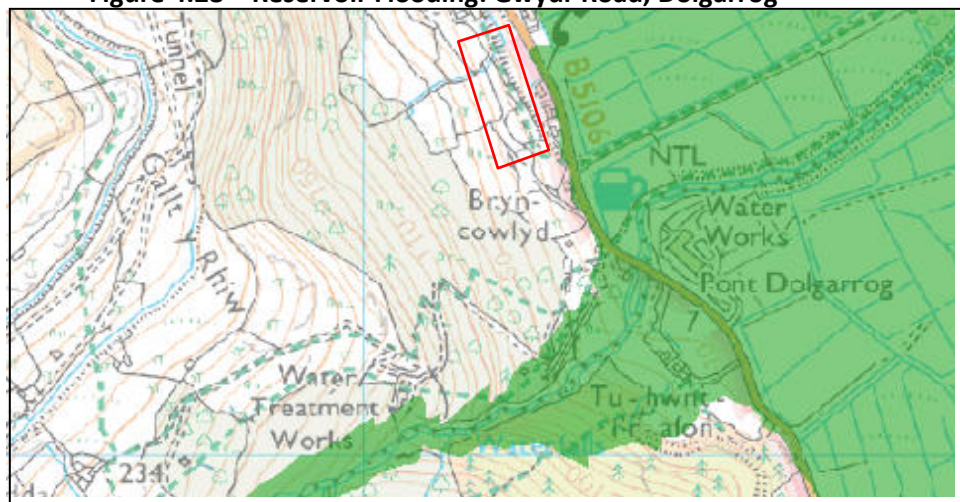
Ideally the Conwy fluvial model would be extended downstream to the Conwy estuary, with a tidal cycle applied to the downstream boundary, and joint probabilities of flooding would be considered. For the scope of the SFCA, this is not appropriate. The peak tide level for the 1 in 200 annual probability event has therefore been used to initially indicate

tidal flood risk. At the Conwy Estuary this is 5.3m OD and increases to around 6.3m OD when climate change over the next 100 years is included. These levels are higher than those stated above from the fluvial modelling and so result in a slight increase in flood extent across the two sites.

Reservoirs

Figure 4.28 is extracted from the Environment Agency's website showing flood risk from reservoirs. This is an extreme outline in the event of a catastrophic failure resulting in the whole reservoir emptying. This shows the Gwydr Road site on the very edge of the flood outline; this potentially reflects the slight fall in the road towards the site. B&V are the Inspecting Engineer for the Dolgarrog Reservoir group and are able to confirm that the owners (RWE) conform to the 1975 Reservoirs Act. The risk of a failure is therefore extremely small.

Figure 4.28 – Reservoir Flooding: Gwydr Road, Dolgarrog



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(b) Site Suitability

Flood Risk & Mitigation

Both sites border on and, to differing degrees, cross into Flood Zone 2. As the area is defended this equates to Flood Zone C1 under TAN15; development could therefore be permitted subject to the discussion below. Development should not take place in the fluvial floodplain, which based on the 1 in 100 annual probability flood with climate change is anything below 5.68m OD. This is a relatively insignificant area for Tan Y Ffordd, but results in the loss of around a third of the Gwydr Road site. Both sites could also be incorporated into the existing flood warning area on the Afon Conwy.

Tidal risk requires the assessment of the 1 in 200 annual probability tide. Applying 100 years of climate change gives a significantly higher peak water level than from fluvial flood risk. Any proposed development would therefore need to have finished floor levels above the predicted peak tide level of 6.3m OD.

Reservoir flooding is shown to be a potential risk, but the probability of a failure is extremely low, although the consequences of such a failure could be severe. We would also point out that both developments are at the foot of a steep sided hill, which could be prone to surface water flowing down the hillside and across the sites during an extreme and intensive storm. Precautions in the development should be taken to manage the

potential source of flood risk, such as ensuring paths and drives slope up from the road into the properties.

Application of the justification test is also required to assess the impact of an extreme event (1 in 1000 annual probability tide). For the purpose of the SFCA, a broad assessment of the flood consequences to the site in an extreme flood (1 in 1000 annual probability) has been made. For residential developments the following guidelines are given in TAN15:

- maximum flood depth = 600 mm
- maximum rise of floodwaters = 0.1 m/hr
- maximum speed of inundation = 4 hrs
- maximum velocity = 0.15 m/s

The 1 in 1000 annual probability tide predicted water level is 0.2m higher than the 1 in 200 annual probability tide. Providing finished flood levels are above the 1 in 200 peak tide level, the 1 in 1000 flood depths would be within acceptable limits. Given the distance of the sites from the coast and their location at the edge of the floodplain, other considerations of rate of rise, speed of inundation and velocity are also likely to be within acceptable limits. This would require confirming at detail design stage.

The Tan Y Ffordd site is suitable for development, although development should not take place within the fluvial floodplain. A reduced area of the Gwydr Road site remains suitable for development, although its allocation for housing in the LDP would need to be reconsidered.

Third-Party Impacts

Development should also not increase the risk of flooding elsewhere. A loss of floodplain is not an issue at these sites but the increase in runoff from a developed site compared to a greenfield site can be an issue. Although the increased runoff to the Afon Conwy from these sites would have negligible impacts, if new development runoff is uncontrolled on a catchment wide basis the cumulative affect can be significant.

The use of SUDS can therefore perform an important role in managing runoff and should be implemented so as not to aggravate the situation. According to the BGS maps, the sites are in an area of till and alluvium deposits underlain by siltstone and mudstone with igneous rock forming the hills above. Soil maps from the NSRI indicate the slopes above the sites to be freely draining soils over rock with the floodplain below being clayey soils with a naturally high groundwater. The sites are in an area of a minor aquifer and there is no GSPZ in the area. Site investigation would be required to determine the viability of infiltration techniques for these sites. Some form of on-site attenuation would be needed, which should be situated outside of the floodplain.

4.11 Llandudno (Employment)

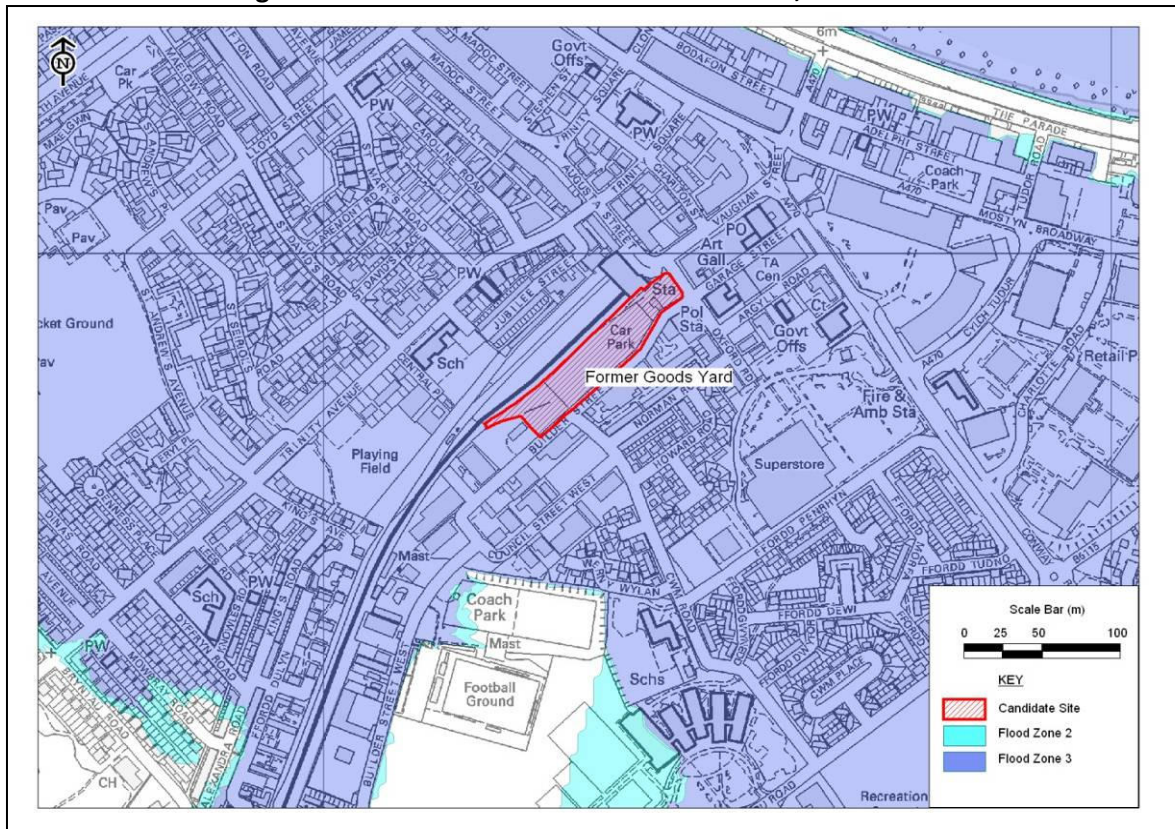
(a) Former Goods Yard

The site is located centrally within Llandudno, just off Builder Street. It is a former goods yard, located next to the railway line and station. This site has been allocated as an employment opportunity.

This brownfield site is completely within Flood Zones 2 & 3 (refer to Figure 4.29) because of the potential for tidal flooding. However the area is protected by the sea defences on the Llandudno's north and west shores. Although the site is not shown to be susceptible to surface water flooding by the Environment Agency mapping, surface water and drainage issues during an intense rain storm in June 1993 resulted in large areas of Llandudno flooding, and the site is within the historical flood outline.

The Conwy Tidal Flood Risk Study outputs have been used to assess flood risk to the site. These model outputs have also been used to provide information on the potential impact of climate change. A review of the flood risk from surface water flooding is also provided.

Figure 4.29 – Flood Zones: Former Goods Yard, Llandudno



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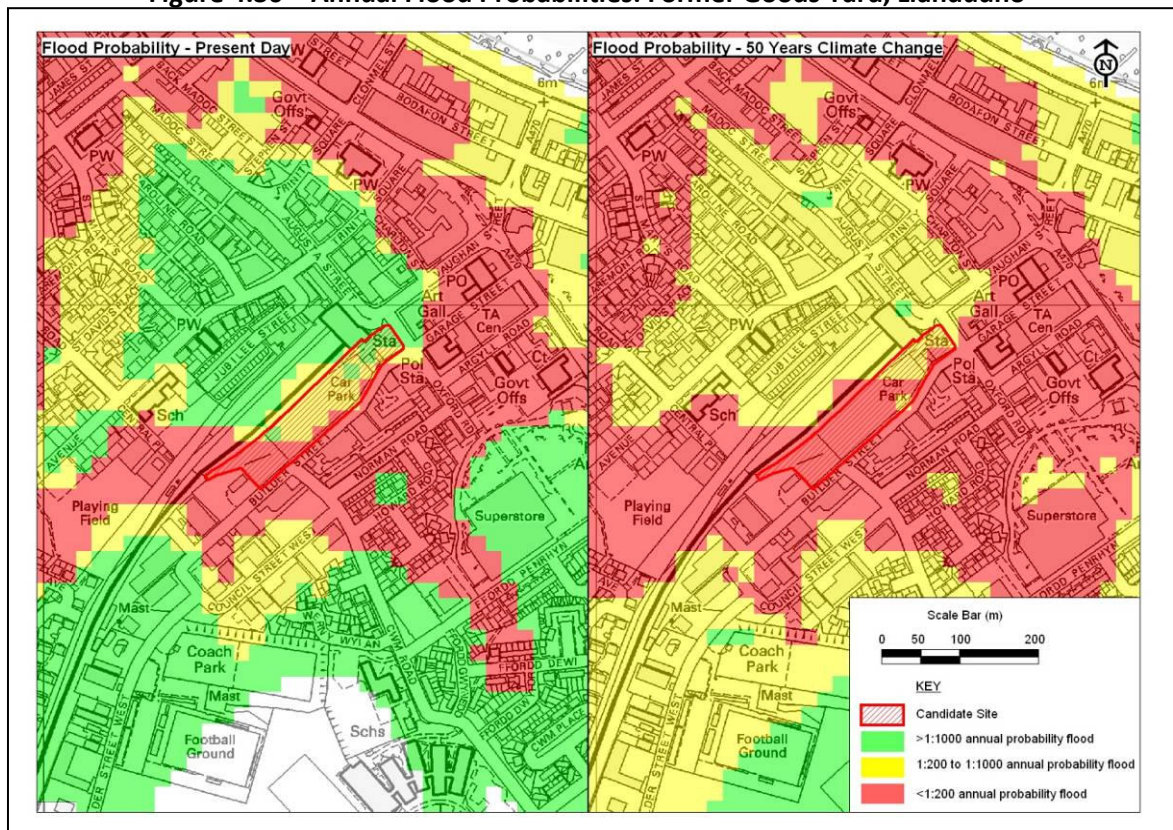
Tidal Flooding

CCBC commissioned the Conwy Tidal Flood Risk Study to provide a robust and scientific appraisal of the risk of flooding from tidal inundation. This modelled flooding with the existing defences in place, but took account of possible overtopping and breaches. The tidal study's report should be referred to for further information on methodology and scenarios modelled.

Figure 4.30 presents the current probability of the site flooding, compared with the probability of flooding in 50 years time. This indicates that, for the majority of the site, only a flood greater than a 1 in 200 annual probability would affect the site under present day conditions. When climate change is applied the annual probability is reduced to below 1 in 200 for the majority of the site. However, the modelling only included for 50 years of climate change, just over 300mm increase in sea level; as an employment site it would be recommended for 75 years of climate change be taken account of. Based on Defra guidance for Wales this is a further increase in sea level of almost 300mm.

It would therefore be reasonable to assume that the entire site is liable to flood in a 1 in 200 annual probability flood when climate change is accounted for.

Figure 4.30 – Annual Flood Probabilities: Former Goods Yard, Llandudno



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Surface Water Flooding

Llandudno has had historical problems with surface water drainage and extensive flooding occurred in 1993 when the drainage system was unable to cope. The site is located at the edge of the recorded flood extent and so surface water flooding can be regarded as a potential issue at this site. However, the site is generally higher than Builder Street and the area to the south, so it is questionable whether the whole site was flooded.

(b) Site Suitability

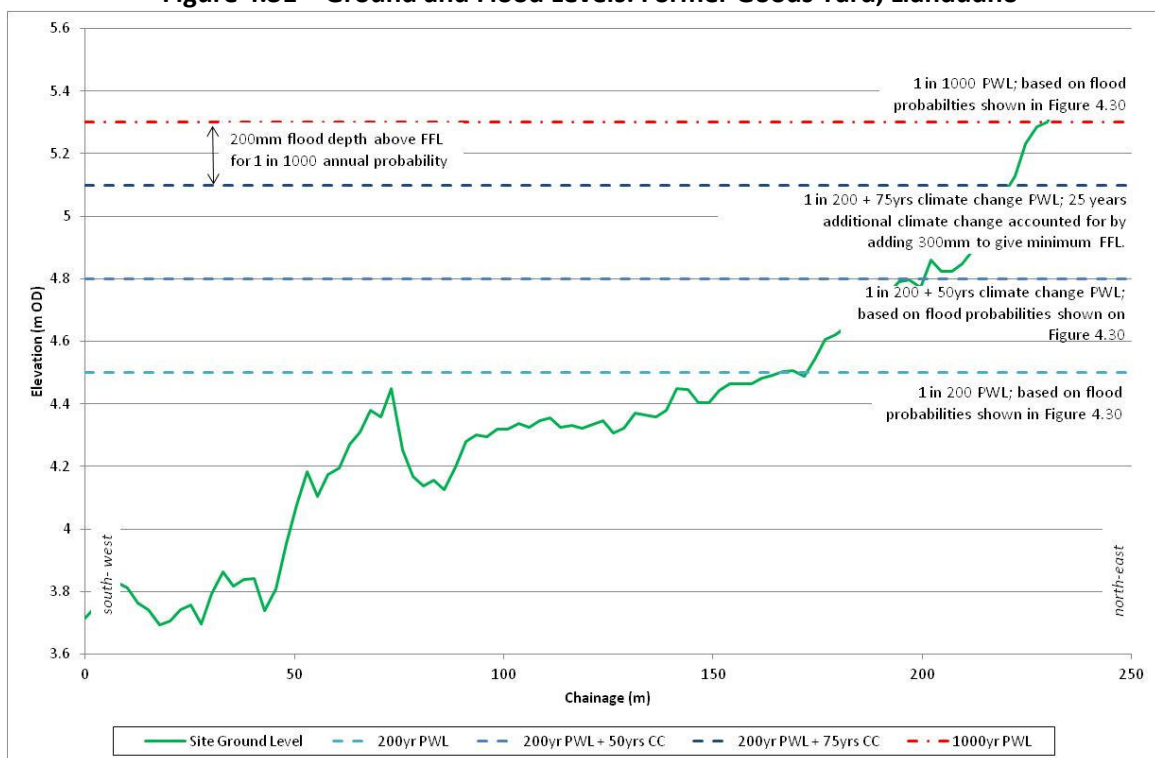
Flood Risk & Mitigation

The site is contained within the Environment Agency's Flood Zones 2 & 3 and this is replicated by the DAM, which shows the site to be in Flood Zone C1. Although this is allocated as an employment site, the developed site should still be outside the 1 in 200 annual probability flood extent. Whilst the Conwy Tidal Flood Risk modelling shows this is

true for the majority of the site in the present day, with climate change the situation is changed.

The site will therefore need to be raised in order to permit development. Figure 4.31 provides a section through the site from south-west to north-east. This shows the site to be highest in the north-east, which corresponds to the flood probabilities shown in Figure 4.30. The 1 in 200 annual probability flood level (4.5m OD) and the level including 50 years of climate change (4.8m OD) have been inferred based on the ground levels where the transition between the mapped flood probability bandings occurs. As discussed above, we need to account for 75 years of climate change. A precautionary approach has been taken by assuming that flood levels will rise by the same amount as is predicted for sea levels i.e. an additional 300mm. This indicates that an initial value for minimum finished floor levels should be 5.1m OD, subject to the justification test described below.

Figure 4.31 – Ground and Flood Levels: Former Goods Yard, Llandudno



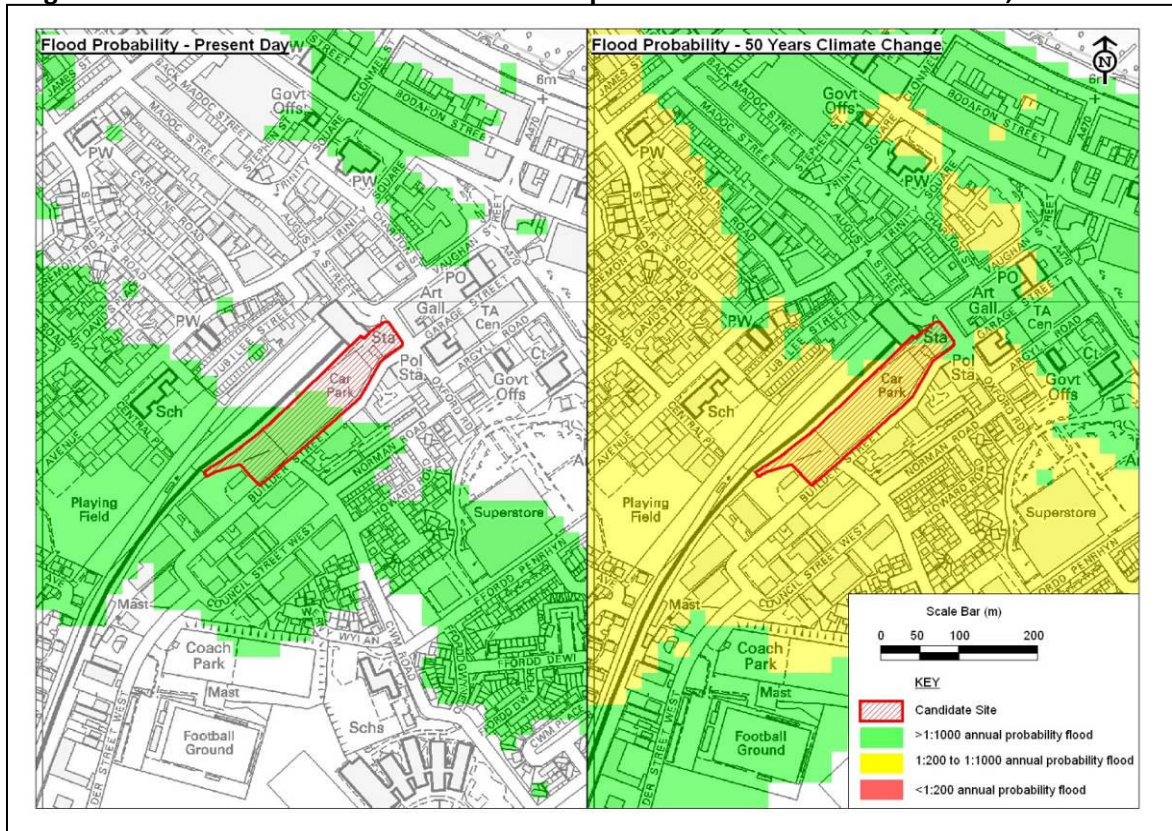
The site is in Flood Zone C1, so the justification test needs to be applied. For the purpose of the SFCA, a broad assessment of the flood consequences to the site in an extreme flood (1 in 1000 annual probability) has been made. For commercial/retail developments the following guidelines are given in TAN15 with variations for industrial units also indicated:

- maximum flood depth = 600 mm (industrial = 1000mm)
- maximum rise of floodwaters = 0.3 m/hr
- maximum speed of inundation = 2 hrs
- maximum velocity = 0.15 m/s (industrial = 0.30 m/s)

Based on the flood probabilities shown in Figure 4.30, the 1 in 1000 annual probability flood is around 5.3m OD. Based on a minimum finished floor level of 5.1m OD, this would only result in 200mm of flood depth and is therefore acceptable. Figure 4.32 shows flood probabilities for flood depths of 600mm or greater. This indicates that in the present day, even with existing ground levels, flood depths in excess of 600mm are highly unlikely. The inclusion of 50 years climate change increases the probability to between a 1 in 200 and 1

in 1000 annual probability. However with ground levels raised across the site the annual probability would be reduced to less than 1 in 1000.

Figure 4.32 – Annual Flood Probabilities for Depths >600mm: Former Goods Yard, Llandudno

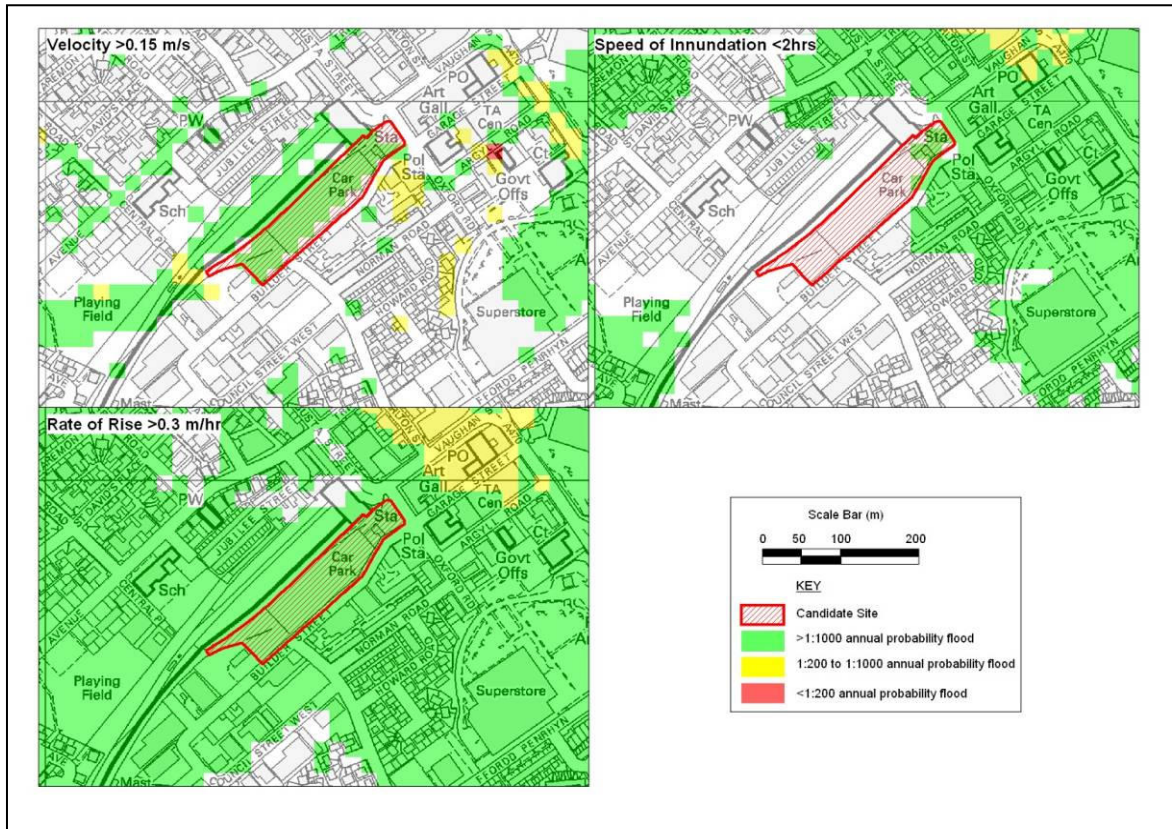


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Figure 4.33 shows probabilities for velocities, speed of inundation and rate of floodwater rise for the current day. This shows that the limits in TAN15 would not be exceeded under current day conditions during an extreme flood. Unfortunately the data for the climate change scenario is not available. However it can be inferred that using the recommended finished floor levels across the site would maintain these parameters within acceptable limits.

It should be noted that the modelling did not account for any future raising of the sea defences. The relevant SMPs for the north shore and west shore defences both have a policy of “hold the line”. It is reasonable to assume that the defences would be maintained and improved in line with sea level rise in the future. The existing defences have a 1 in 200 SoP.

It is questionable if the site itself flooded in 1993. If finished floor levels are raised, then the site should not be at risk of flooding from surface water. There is also a requirement to ensure safe access and egress to the site in the event of a flood. Based on the flood probability modelling for flood depths >600mm, this is most likely to be to the north where street levels are higher. This would require more detailed consideration at a design stage. The site is also in an existing flood warning area. ***The site is therefore suitable for employment use, but would require raising of finished floor levels across the site.***

Figure 4.33 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise: Former Goods Yard, Llandudno

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Third-party Impacts

As an existing brownfield site, the potential for increased runoff is low. However, the drainage system in Llandudno is known to be under continual pressure. Every effort should therefore be made to reduce runoff from this site and the applicability of SUDS should be explored at the detailed design stage. According to NRSI and BGS maps the site is in an area of naturally wet, loamy and clayey soils that may have a naturally high groundwater; infiltration techniques may therefore not be appropriate and some form of attenuation may be more practical. This would need investigation at design stage and given the existing pressures on the drainage system, close consultation with both DCWW and EAW would be required.

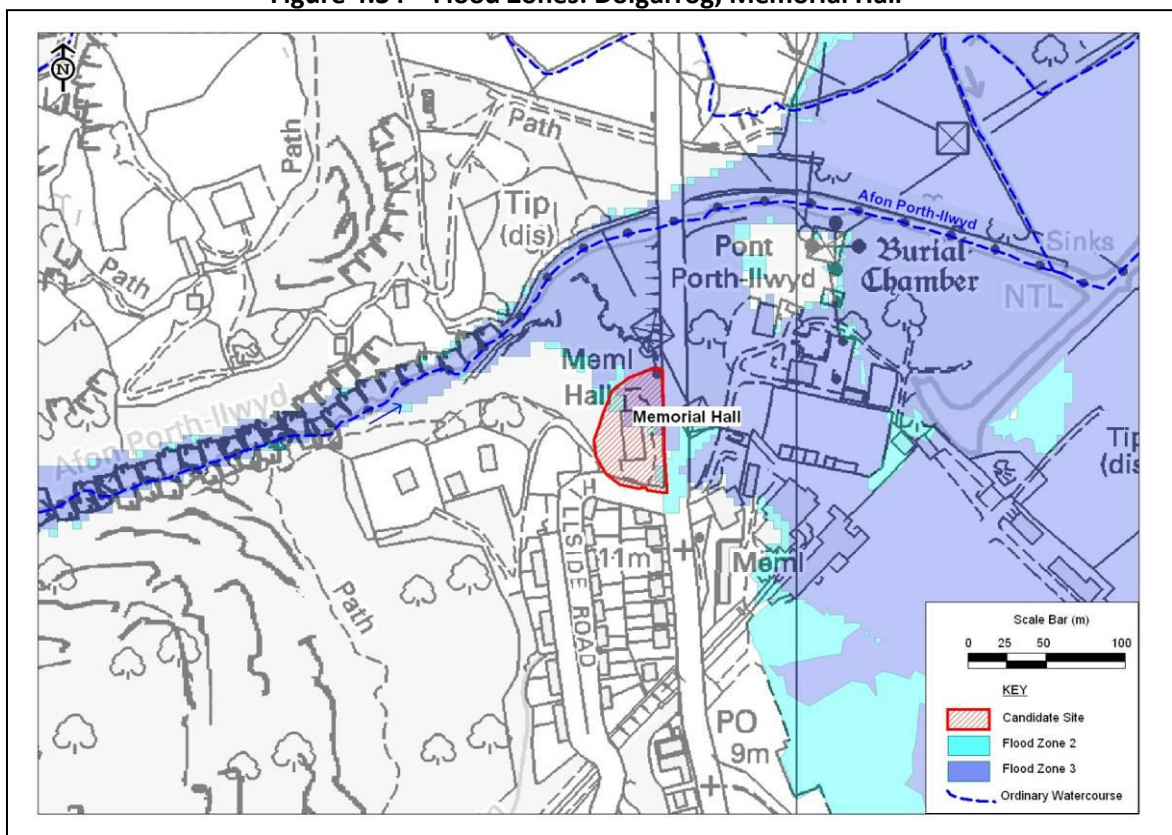
4.12 Dolgarrog (Employment)

(a) Memorial Hall

The site is at the northern end of Dolgarrog. The memorial hall commemorates the last occasion there was loss of life in the UK from reservoir flooding, due to a failure at the Eigiau and Coedty reservoirs. The site is allocated for employment use.

From Figure 4.34 it can be seen that approximately one third of the site is contained in Flood Zones 2 & 3 with the potential flood risk coming from the Afon Porth-Ilwyd. The site is also included within the Environment Agency's reservoir flood maps (refer to Figure 4.35) and is shown as susceptible to surface water flooding (refer to Figure 4.36). These risks have been considered in more detail below.

Figure 4.34 – Flood Zones: Dolgarrog, Memorial Hall



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Fluvial

Figure 4.34 indicates around a third of the Memorial Hall site at flood risk from the Afon Porth-Llwyd. The Afon Porth-Llwyd is contained in a deep gorge which opens out into a slightly shallower river channel around 100m upstream (west) of the B5106. It is at this point that the flood map shows the widening of the flood outline that encroaches onto the site. This flood outline has been produced using broad scale modelling methods, which can be inaccurate.

The flows passing down the Afon Porth-Llwyd are controlled by the Eigiau and Coedty Reservoirs; assessing the peak flows for flood events is therefore difficult without a flood routing model and detailed knowledge of the reservoirs. That is beyond the strategic scope of this study. However an estimate of peak flows has been made using the rainfall-runoff method. This will calculate a peak flow for the naturalised catchment and makes

no account of the reservoir interactions or attenuation; it is therefore likely to be an over estimate. This gave a 1 in 1000 annual probability flow of $193 \text{ m}^3/\text{s}$, used in the first instance to demonstrate adequate channel capacity.

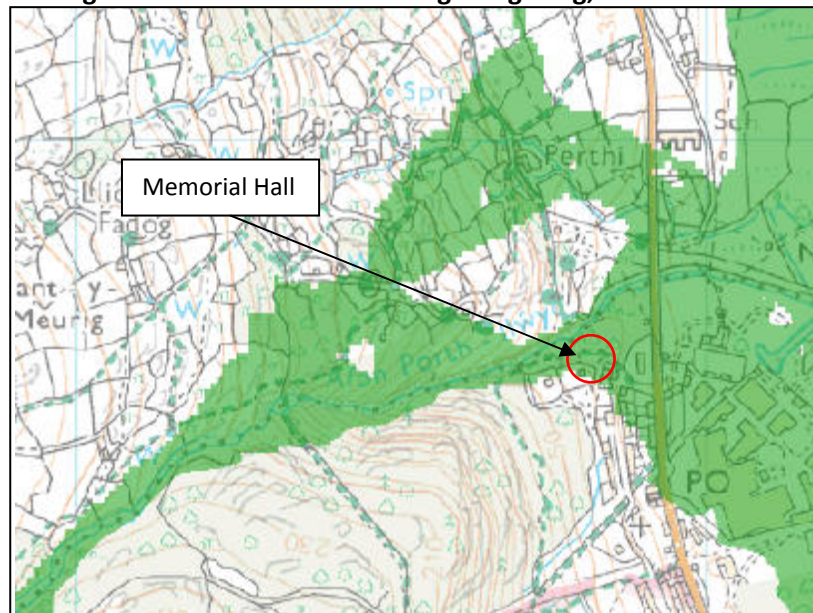
The channel bed is around 10m wide and is generally 4-5m deep as a minimum, upstream of the B5105 road bridge. Given the steep gradient of the channel, it seems unlikely that the Memorial Hall site would flood. Where the bank of the gorge is lower, this has been built up with a substantial wall.

A simple steady-state ISIS hydraulic model was built using cross-sections taken from the LiDAR at 50m intervals. The model extends from 200m upstream of the bridge to 100m downstream. The bridge has not been modelled; it is relatively modern with a large rectangular opening and unlikely to cause a constriction that would result in increased flooding. The model was run using the peak flow from the 1 in 1000 annual probability flood. This showed that even for an extreme flood event there is likely to be sufficient capacity in the channel and the flooding shown would not occur.

Reservoir

From the reservoir flood mapping published on the Environment Agency's website, it is clear that the Memorial Hall site is included within the flood outline (refer Figure 4.35). This outline is a worst case scenario and reservoir flooding is extremely unlikely. B&V are the Inspecting Engineer for the Dolgarrog Reservoir group and are able to confirm that the owners (RWE) conform to the Reservoirs Act 1975. The risk of a failure is therefore extremely small.

Figure 4.35 – Reservoir Flooding: Dolgarrog, Memorial Hall



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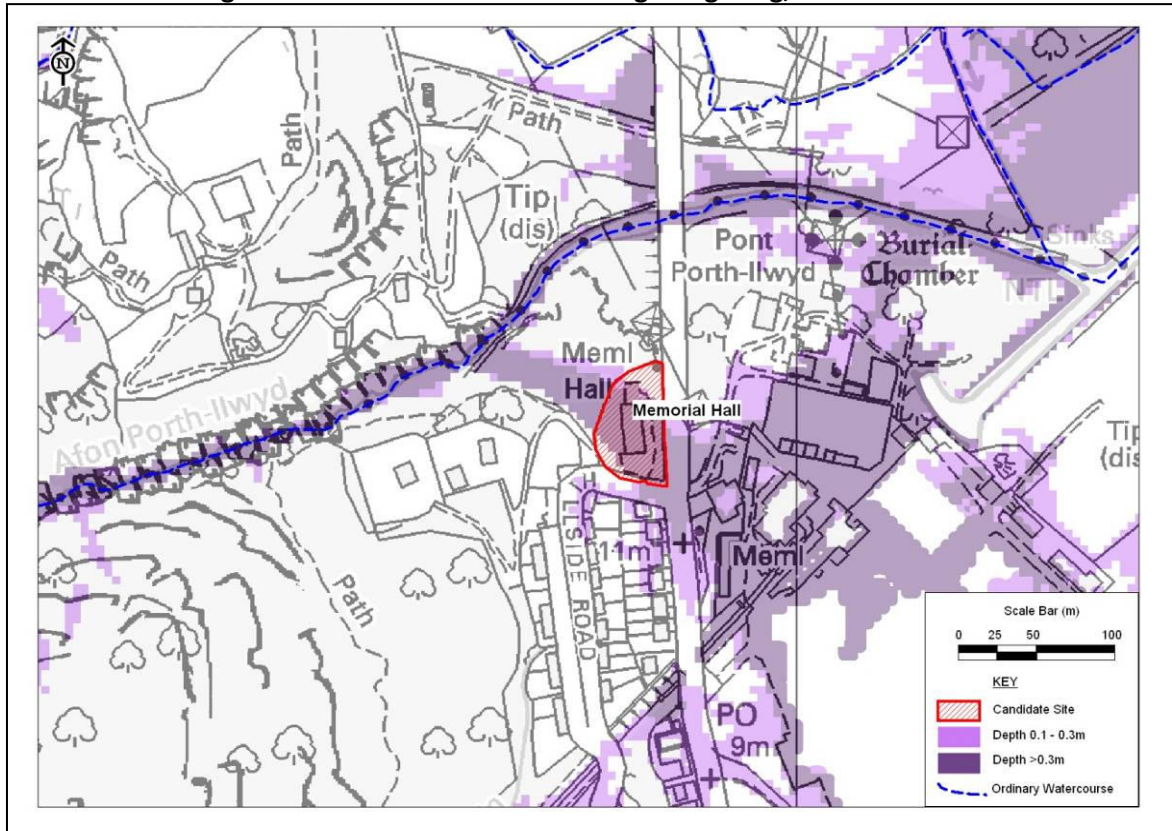
Surface Water

Figure 4.36 indicates that the site is susceptible to surface water flooding. The flood outline across the site follows a steep gully with the Memorial Hall at the bottom of it. The wall mentioned above is at the upper end of this gully. Flow would not pass out of the gorge as shown, so the flow path would be narrower than that on Figure 4.35.

The gully would be effective at collecting surface runoff from the steep hill side above; the water would run down the gully and through the Memorial Hall site. Susceptibility

to surface water flooding is therefore realistic, but potentially less extensive than shown below.

Figure 4.36 – Surface Water Flooding: Dolgarrog, Memorial Hall



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(b) Site Suitability

Flood Risk & Mitigation

Around a third of the site is shown within Flood Zones 2 & 3; this matches the DAM which shows the same area within Flood Zone C2. As this site is proposed for less vulnerable development, this would not prohibit development within this area. Any development should be designed to be flood free in a 1 in 100 annual probability flood and could be mitigated by raising finished floor levels. However, using a simple model with a precautionary peak flow estimate indicates that the site is actually unlikely to flood in a 1 in 1000 annual probability flood. The hydrology and hydraulics of the Afon Porth-Ilwyd would need more detailed calculations, and a survey-based model, to confirm this.

The site is also included within the Reservoir Flood Map; however this is an extreme case scenario. The Eigiau and Coedty Reservoirs are designed to withstand a PMF scale flood and, as Inspecting Engineers, B&V are able to confirm that the reservoirs owned by RWE conform to the Reservoirs Act 1975. This therefore should not prohibit development of the site.

Surface water flooding could be an issue at this site because the Memorial Hall sits in a steep sided gully. However, the actual contributing catchment area is relatively small and this could be mitigated at a detailed design stage with surface runoff being captured and directed away from the site in an appropriate manner, taking full account of its discharge route.

The Memorial Hall site is therefore suitable for development as an employment site. A full FCA would be required with additional topographic survey and modelling to confirm levels and flood extents.

Third-Party Impacts

Development should also not increase the risk of flooding elsewhere. A loss of floodplain is probably not an issue at this site but the increase in runoff from a developed site can be an issue, even at a site which has an existing development on it. Although the increased runoff would have negligible impacts in the Conwy catchment, if new development runoff is uncontrolled on a catchment wide basis the cumulative affect can be significant.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented where possible. According to the BGS maps, the site is in an area of till and soil; maps from the NSRI indicate the slopes above the sites to be freely draining soils over rock. Dolgarrog is in an area of a minor aquifer with intermediate vulnerability; however there is no GSPZ in the area. Infiltration techniques may be possible but feasibility would need to be assessed by site investigation at the design stage.

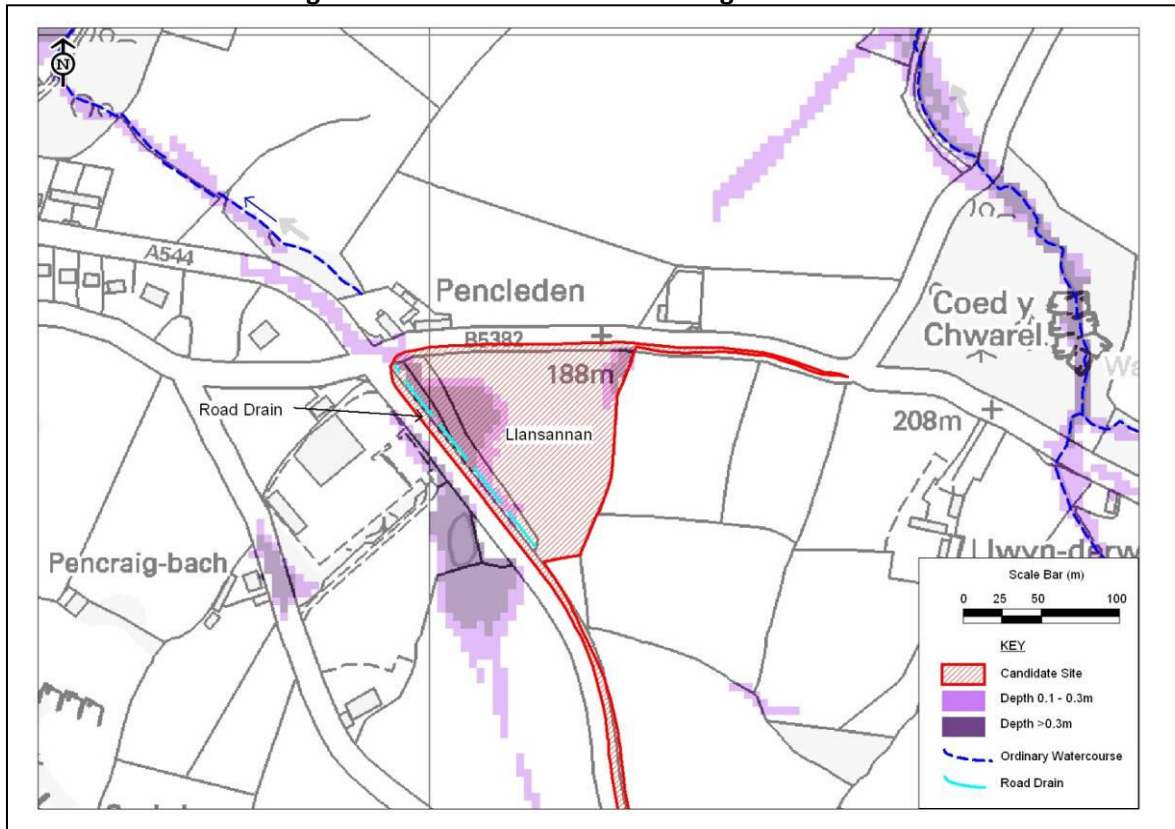
4.13 Llansannan (Employment)

(a) Land at Llansannan

The site is located outside the village of Llansannan to the east and is situated between the B5382 and A544. The site is an open pasture which slopes gently from east to west and is allocated as an employment opportunity.

The site is entirely contained within Flood Zone 1 and there is no flood risk from fluvial sources. However, from Figure 4.37 it can be seen that a significant area of the site is shown as susceptible to deep surface water flooding in the 1 in 200 probability rainfall storm. The flood risk from surface water flooding has been assessed below.

Figure 4.37 – Surface Water Flooding: Llansannan



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Surface Water

Surface water was identified as a potential problem at this site. Figure 4.38 shows the topography of the site. The gradient across the field is slight; there are no significant hollows in which water would be expected to accumulate. In addition there is a drainage ditch that runs alongside the A544 (see Figure 4.37) which would capture any surface water and take it away from the site to the ordinary watercourse shown to the north.

The risk of flooding from the road drain has been preliminarily assessed. The catchment to the road drain is just 0.24km². The peak flow for a 1 in 100 annual probability flood has been estimated using the small catchment method¹, giving a peak flow of 0.3 m³/s. A trapezoidal channel shape has been used to estimate the depth of water in the drain. A

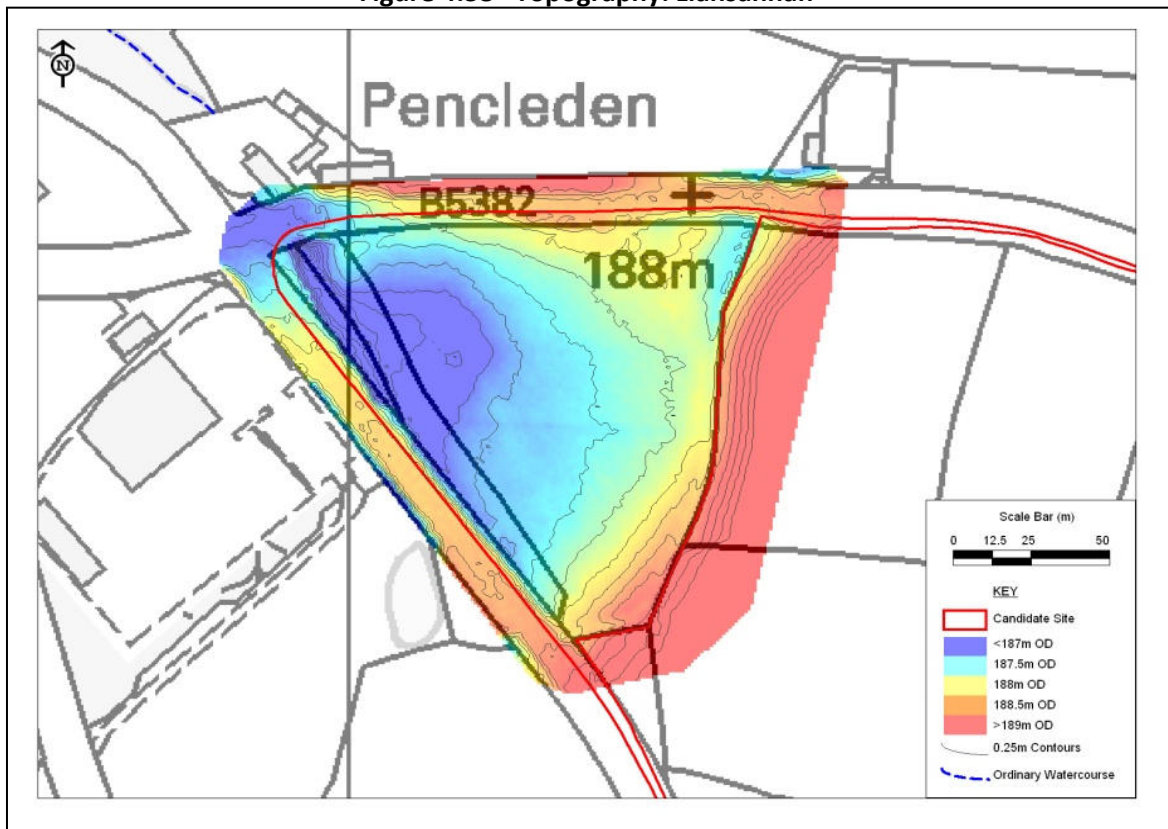
¹ Flood estimation for small catchments, Report No.124, Institute of Hydrology, 1994

1m wide bed and 45 degree slopes have been assumed based on site observation and a gradient of 1 in 200 calculated using LiDAR. A relatively high Manning's 'n' of 0.06 has been applied to account for heavy vegetation. This indicates that the depth of water in the channel would be less than 0.5m for both the 1 in 100 annual probability flood and climate change scenarios. The channel depth is estimated to be in excess of 1m. The drain therefore poses no serious flood risk.

The culvert through which the drain passes under Pencleden is approximately 0.3-0.4m diameter. Given that there is no structure immediately downstream to obstruct flow, it is assumed that the hydraulic gradient across the culvert is the same as the bed gradient, which is approximately 1 in 20. Using Wallingford Hydraulic Tables (6th edition) and assuming a Ks roughness value of 0.60mm gives the full bore capacity of the culvert as between 0.25 - 0.50 m³/s. A slight surcharging of the culvert may occur, particularly with climate change, but it is unlikely to result in flooding of the site. This would need to be more fully assessed as part of a FCA before any proposed development proceeded.

There is a risk that this culvert could become blocked or could fail structurally. It should be inspected as design proceeds and mitigation measures incorporated in the development if appropriate. Should the culvert fail water levels might fill the drain to the road level and then overtop at around 187m OD. This would result in a flood extent closely corresponding to that shown by the surface water flood mapping in Figure 4.37.

Figure 4.38 –Topography: Llansannan



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(b) Site Suitability**Flood Risk & Mitigation**

The site is shown to be in Flood Zone 1 and this agrees with the DAM, which shows the site in Flood Zone A. The site is therefore designated as suitable for development. However, the Environment Agency's surface water flood maps indicated that the site may be susceptible. Close examination of the topography and the observation of a road drain indicate that this is not the case, unless there was a failure or serious blockage of the culvert under the B5382.

Although no specific mitigation is required to reduce flood risk the developer and the council should work together to verify that the road drain is in good condition and has sufficient hydraulic capacity. If this is not the case then mitigation might include improvements to the culvert and/or ensuring finished floor levels are above 187m OD.

This site is therefore suitable for development as an employment site.

Third-Party Impacts

Development should not increase the risk of flooding elsewhere. The increase in runoff from a developed site compared to a greenfield site can be an issue. Although there are no sites directly downstream that would be affected by increased runoff, the cumulative effect of multiple developments on a catchment wide basis can be significant.

The use of SUDS can perform an important role in managing runoff and should therefore be implemented at this site. According to the BGS maps, the site is in an area of till underlain by mudstone and siltstone. Soil maps from the NSRI indicate that the site lies in an area of freely draining loamy soils over rock. Mapping in the Environment Agency's website shows that Llansannan is in a minor aquifer area with intermediate vulnerability – however there is no GSPZ in the area. Infiltration techniques may therefore be appropriate, although feasibility would need to be tested by site investigation at a design stage.

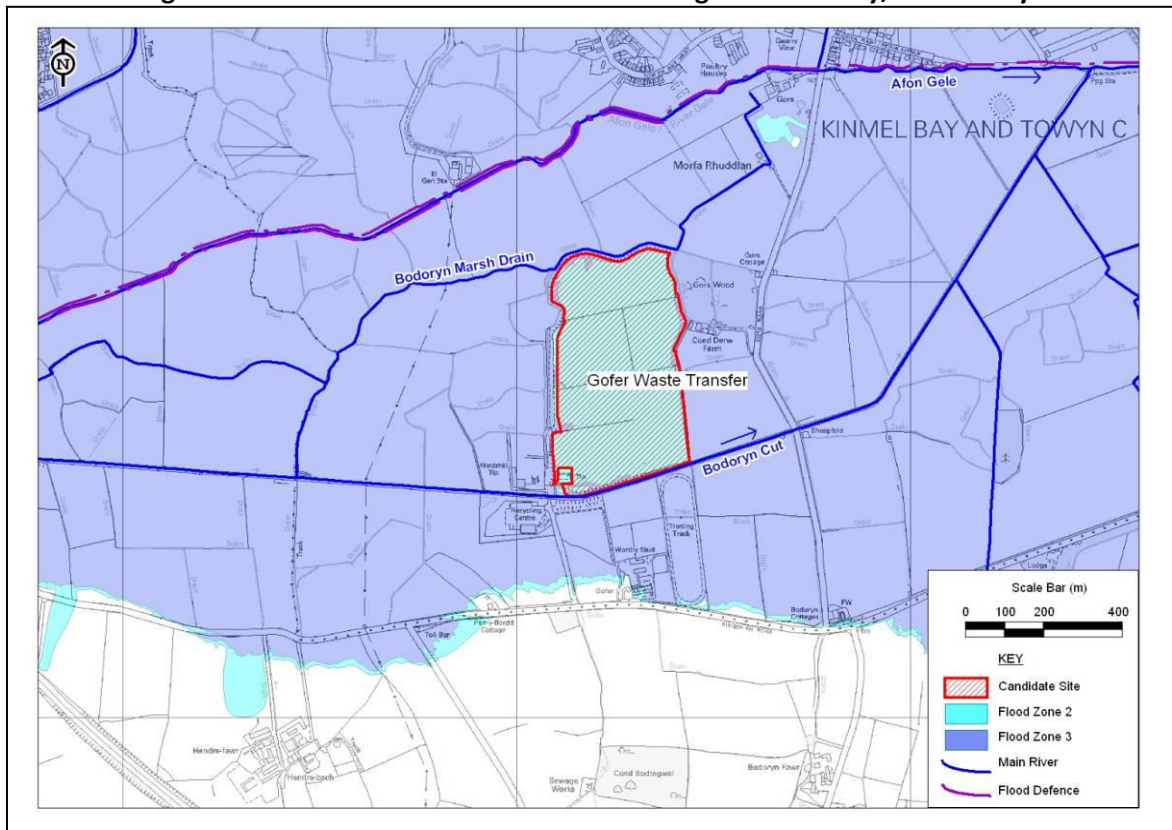
4.14 Kinmel Bay (Waste Management Facility)

(a) Gofer

The Gofer site is located to the south of Towyn and to the east of Abergele. Access to the site is off the A547. The site was previously used for landfill and the majority is currently greenfield. It has been allocated as a waste management facility.

Figure 4.39 shows the site is contained within Flood Zone 2 but is outside of Flood Zone 3. At the northern boundary of the site is the Bodoryn Marsh Drain and at the southern boundary the Bodoryn Cut; further to the north is the Afon Gele. However flood risk from fluvial sources is relatively minor compared to the risk from tidal flooding. The Conwy Tidal Flood Risk Study outputs which are available have therefore been used to assess flood risk to the site.

Figure 4.39 – Flood Zones: Gofer Waste Management Facility, Kinmel Bay



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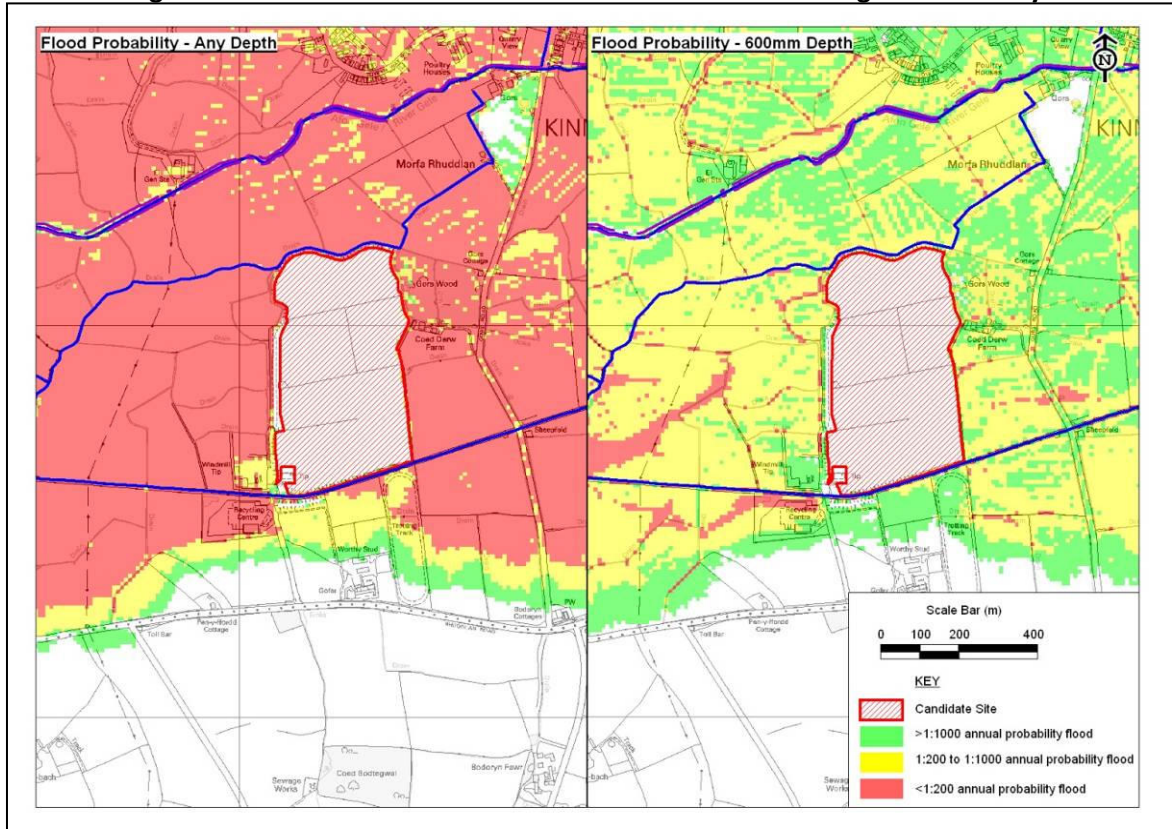
Tidal Flooding

CCBC commissioned the Conwy Tidal Flood Risk Study to provide a robust and scientific appraisal of the risk of flooding from tidal inundation. This modelled flooding with the existing defences in place, but also took account of possible overtopping and breaches. The tidal study's report should be referred to for further information on methodology and scenarios modelled.

Figure 4.40 shows the current probability of the site flooding to any depth and to a flood depth of 600mm or greater. This clearly shows that the site has low flood risk; however we must also consider climate change. The flood depth probabilities taking account of climate change are not currently available. It has therefore been assumed that flood

levels will increase in line with predicted sea level rise. Based on the flood extents shown in Figure 4.40, the peak water level for the 1 in 200 annual probability flood is around 4.2m OD. Over the life-span of the development (75 years), sea level is predicted to rise by between 600-700mm. The peak water level including climate change has therefore been taken as 4.9m OD.

Figure 4.40 – Annual Flood Probabilities: Gofer Waste Management Facility

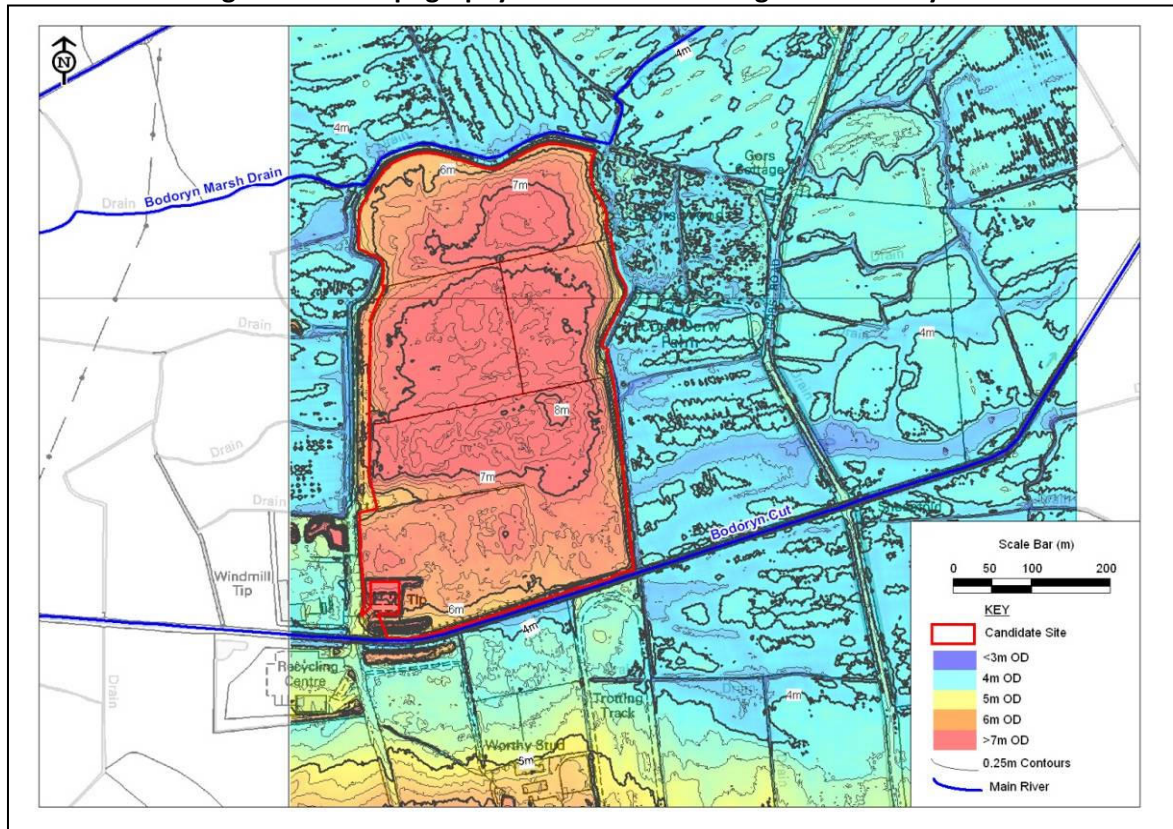


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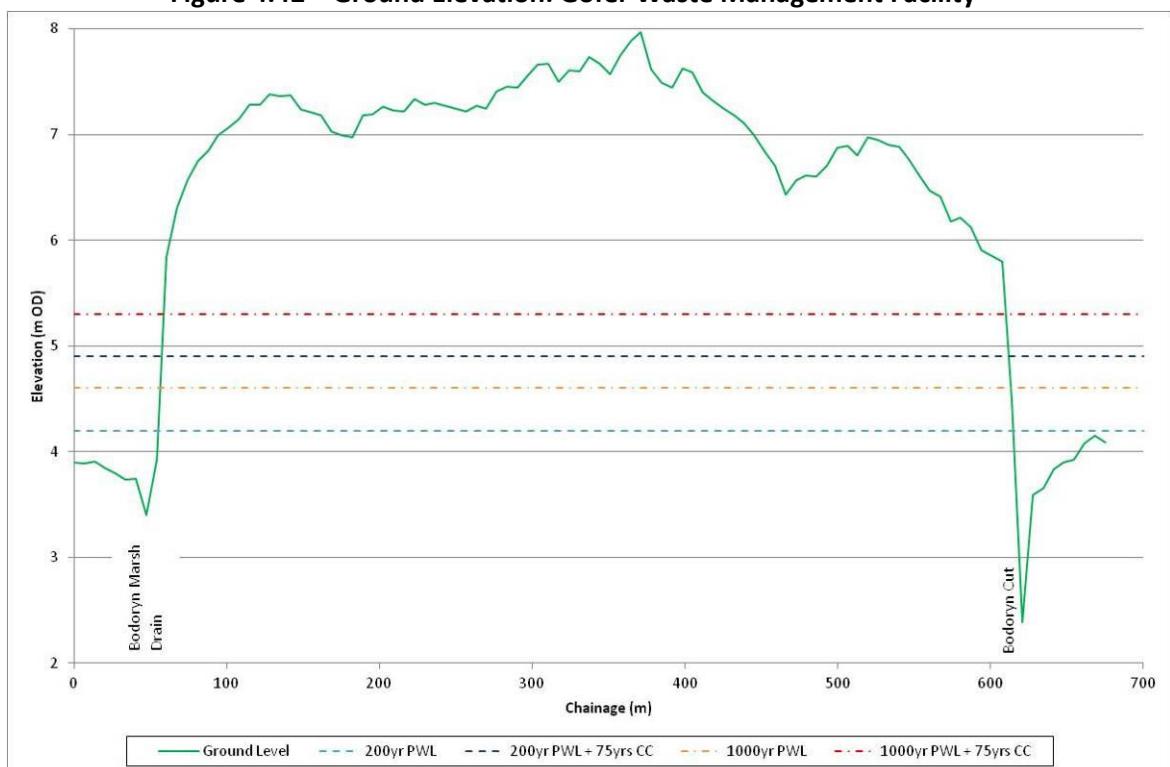
Figure 4.41 shows the topography of the site and Figure 4.42 shows a cross-section through the site from north to south. This shows most of the site has an elevation between 6 - 8m and has steep sides down to the coastal plain at around 4m OD, presumably due to its historic use. The predicted sea-level rise therefore makes no significant impact in terms of flood encroachment onto this site.

Fluvial Flooding

There is flood risk from the Afon Gele, Bodoryn Marsh Drain and Bodoryn Cut. The Afon Gele is the largest of these watercourses; located to the north of the site, it has flood defences running along both banks. The Bodoryn Marsh Drain and Bodoryn Cut run along the northern and southern boundary of the site respectively. These are evident on the LiDAR and are shown in Figure 4.42. Although these watercourses present a flood risk, it can be assumed that flooding from a tidal source presents the higher risk in this case.

Figure 4.41 – Topography: Gofer Waste Management Facility

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Figure 4.42 – Ground Elevation: Gofer Waste Management Facility

(b) Site Suitability*Flood Risk & Mitigation*

The site is contained within the Environment Agency's Flood Zone 2, but outside of Flood Zone 3. The DAM shows the site to be within Flood Zone C1. Although this site is allocated as a waste management facility, the developed site should still be outside of the 1 in 200 annual probability flood extent. The Conwy Tidal Flood Risk modelling shows this to be the case, although the site is shown to be surrounded by flood water on three sides in this scenario. As the ground elevation of the site is up to 4m above the coastal plain and it is steep sided, climate change makes no significant difference.

Because the site is in Flood Zone C1, the application of the justification test is required. As part of the SFCA, a broad assessment of the flood consequences to the site in an extreme flood (1 in 1000 annual probability) has been made. For industrial developments the following guidelines are given in TAN15:

- Maximum flood depth = 1000mm
- maximum rise of floodwaters = 0.3 m/hr
- maximum speed of inundation = 2 hrs
- maximum velocity = 0.30 m/s

The 1 in 1000 annual probability peak water level is around 4.6m OD, based on the flood probabilities shown in Figure 4.40. Taking account of climate change increases this to 5.3m OD. These water levels are shown on Figure 4.42 and show them to still be well below the main area of the site. The site would therefore not flood in a 1 in 1000 annual probability event, even after taking account of 75 years climate change. The other flood parameters are therefore not relevant.

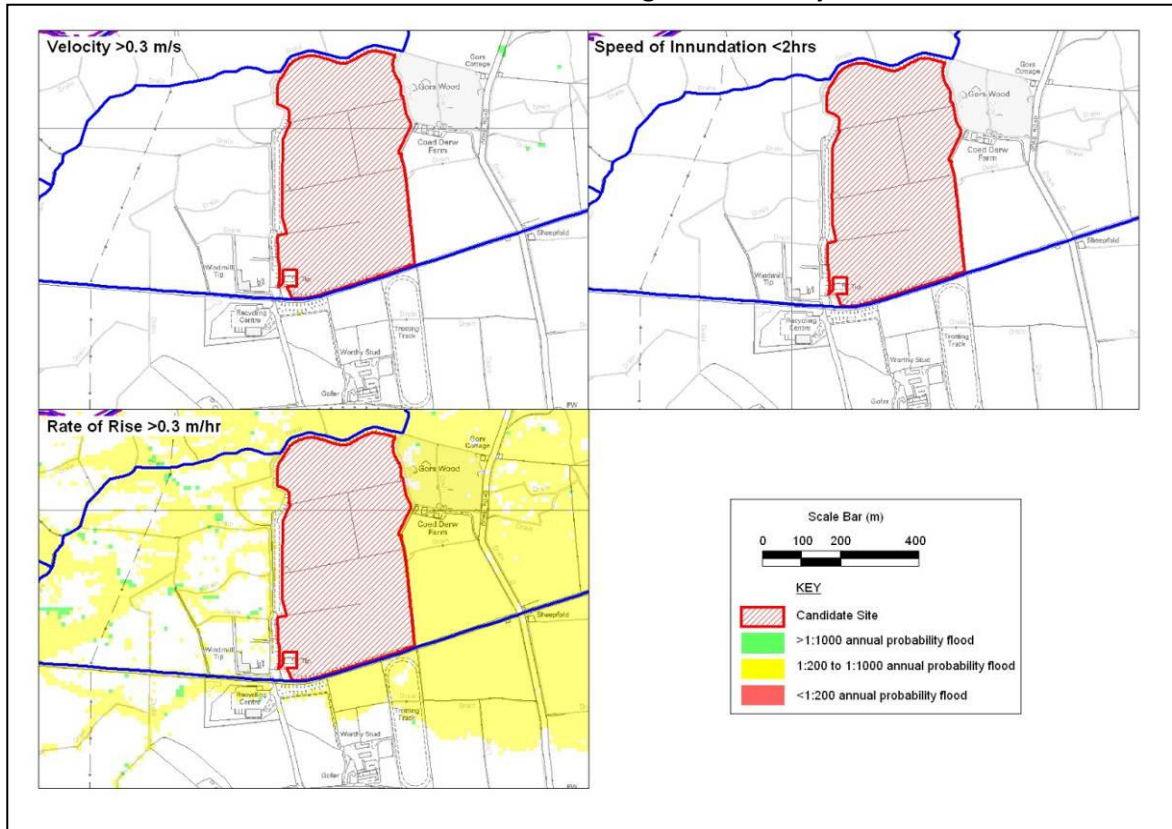
However, there is also a need to consider access and egress to the site. The access road to the site has a low point of around 4.4m OD. The recommended maximum depth of flooding for general infrastructure is 600mm, after taking account of climate change the depth of flooding would be around 900mm. The access road would therefore need to be raised by a minimum of 300mm to give a minimum road level of 4.7m OD.

Figure 4.43 shows the probabilities under present day conditions for the other flood parameters relevant to general infrastructure. This shows that velocity and speed of inundation are unlikely to be exceeded. The rate of rise around the site is above acceptable limits for between a 1 in 200 and 1 in 1000 annual probability, but it is acceptable for the access road. Provided that the road is raised, it can be inferred that this would remain the case after 75 years of climate change is accounted for.

It should be noted that the modelling did not account for any future raising of the sea defences. The relevant SMPs for the north shore and west shore defences both have a policy of "hold the line". It is therefore assumed that the defences would be maintained and improved in line with sea level rise in the future. The existing defences have a 1 in 200 SoP. The site is also in an area benefitting from flood warning.

This site is therefore suitable as a waste management facility subject to safe access and egress being provided.

Figure 4.43 – Annual Flood Probabilities for Flood Velocity, Speed of Inundation and Rate of Rise: Gofer Waste Management Facility



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Third-party Impacts

Development should not increase the risk of flooding elsewhere. Since the proposed development site is currently greenfield there is a risk of increased runoff from the developed site because of hard standing surfaces. Although the impacts downstream of individual sites would probably be negligible, the cumulative impact of developments could be significant if runoff is not controlled. Runoff from the Gofer site would eventually drain into the Afon Gele. Although options may be constrained by the underlying landfill, the use of SUDS can perform an important role in managing runoff and SUDS should therefore be implemented.

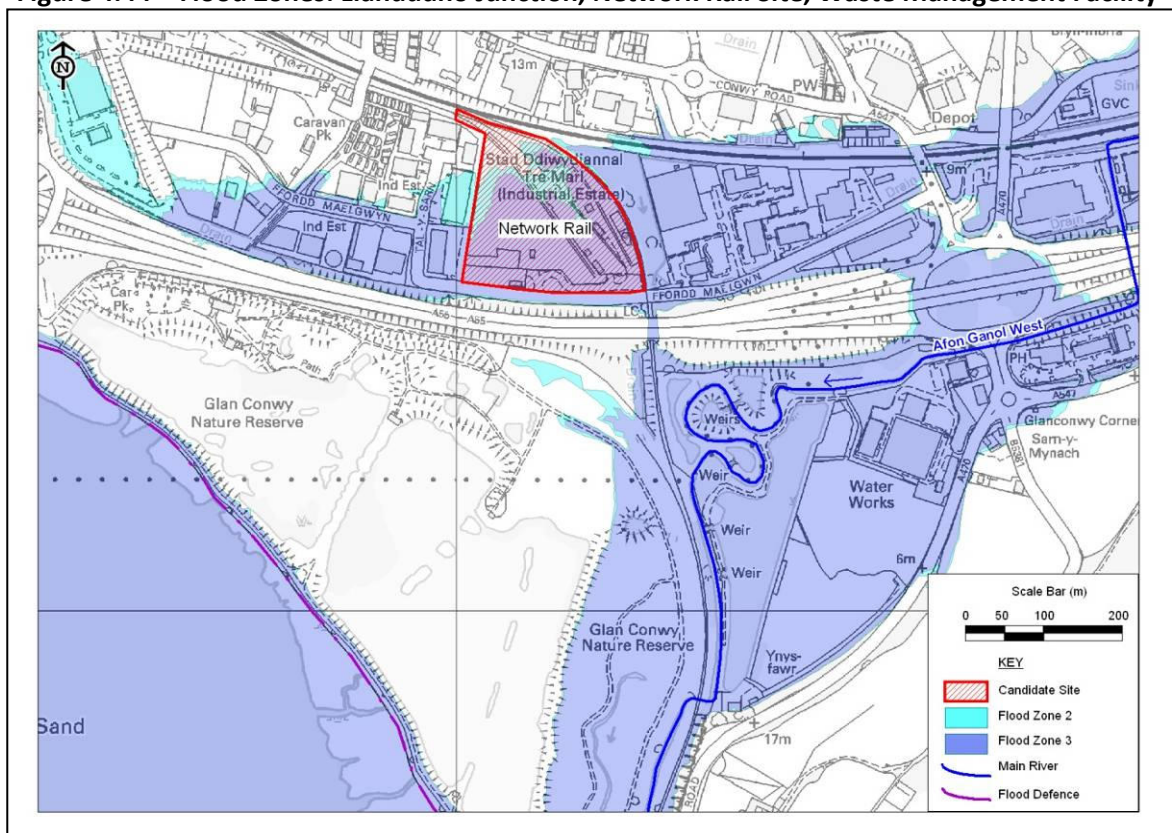
4.15 Llandudno Junction (Waste Management)

(a) Network Rail

This is a brownfield site, accessed off the A547 via Ffordd Maelgwyn and currently occupied by storage units. The A55 runs along the southern boundary and a mainline railway along the northern boundary. To the east and west there are industrial units. The site has been allocated as a waste management facility.

Figure 4.44 shows that the majority of the site is contained within Flood Zones 2 & 3. The flood risk is from tidal flooding along the Afon Ganol valley rather than a fluvial flood risk from the watercourse itself. An assessment of tidal flood risk is given below.

Figure 4.44 – Flood Zones: Llandudno Junction, Network Rail Site, Waste Management Facility



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Tidal Flooding

The Flood Zones shown in Figure 4.44 are based on an undefended scenario. In reality there is a sea defence which runs along the shoreline from Conwy Bridge, past the Glan Conwy Nature Reserve and across the mouth of the Afon Ganol to tie into high ground below Conwy Road. The outfall into the Conwy estuary has a tidal door to prevent tidal flow entering the Afon Ganol.

The land between the nature reserve lagoons and the A55 is high ground. Another possible flood route is from the north, along the Ganol valley from Rhos-on-Sea. However, this is also protected by a sea defence.

All of these defences have a 1 in 200-year SoP, but would probably be overtopped in an extreme tidal event.

(b) Site Suitability

Flood Risk & Mitigation

The site is shown within Flood Zones 2 & 3. This is replicated by the DAM, which shows the site as being in Flood Zone C2. As the proposed development for this site is classified as less vulnerable, this does not prohibit development taking place, subject to the justification test. Any finished development should also be outside the 1 in 200 annual probability tidal flood extent, defined because the site is at tidal flood risk. The sea defences protecting the Llandudno peninsula have a 1 in 200 SoP, the flood risk to the site is therefore low.

Climate change should also be considered, and based on Defra guidance this could result in a sea level rise of more than 0.6m over the next 75 year. However, the SMPs for the coastline around Llandudno have policies for “hold the line”. It is therefore reasonable to assume that these defences will continue to be maintained and improved in line with climate change.

Part of the justification test is to assess the consequences of flooding in an extreme event (1 in 1000 annual probability). Without a detailed model to simulate such a scenario, it is not possible to give definitive answers to the various aspects recommended for consideration. However, the site has a ground level of a between 5 and 5.5m OD, which is higher than the industrial estate to the east (4.5m OD), and higher than the land along the Ganol floodplain to the south of the A55 (<4m OD). The flood routes onto the site, which include the subway under the A55, the A55 roundabout and the railway line, are all on lower ground than the site (refer to Figure 4.45). The site is therefore on the edge of the flooding and would be one of the last areas to flood if at all; flood depths, velocities, rate of rise and speed of inundation would all likely be within acceptable limits for an industrial development.

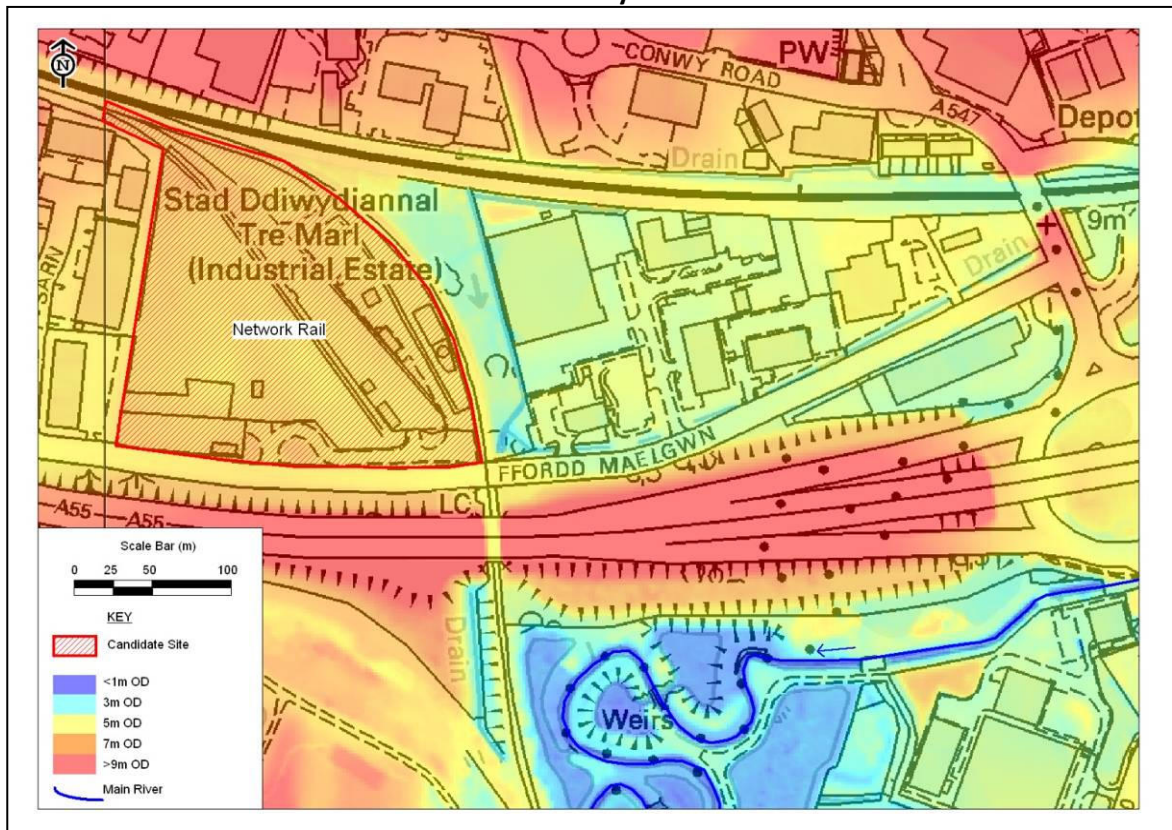
The information available indicates that this site is suitable for development. However, a full FCA would be required including detailed topographic survey and modelling to confirm that flood risk and flood consequences remain acceptable after climate change has been accounted for. The modelling might include an assessment of flood risk should one of the tidal doors on the Afon Ganol fail.

Third-party Impacts

Development should not increase the risk of flooding elsewhere. Although this is a brownfield site, the opportunity should be taken to reduce runoff if possible to alleviate pressure on existing drainage systems.

According to the BGS maps, the site is in an area of till deposits and tidal flat deposits underlain by mudstone, siltstone and sandstone. Soil maps from the NSRI indicate the site to be possibly in an area of loamy and clayey floodplain soils with high groundwater. Infiltration techniques may therefore not be appropriate, but would need to be confirmed by site investigation. Some form of attenuation may be better suited for this site.

Figure 4.45 – Topography around Llandudno Junction, Network Rail, Waste Management Facility



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4.16 Summary

The majority of candidate sites for which a Stage 2 Assessment has been carried out have been shown to be suitable for development. Table 4.2 provides a summary of development suitability for each site.

Table 4.2 – Summary of Stage 2 Assessment Outcomes

Town/Village	Site	Summary
Housing & Mixed-Use		
Abergele	Llanfair Road, Siamber Wen, Tandderwen Farm	All three sites suitable with minor adjustments to site boundaries to ensure development does not take place in the floodplain.
Abergele	Rhuddlan Road	Majority of the site is suitable for development, but further modelling work required at a FCA stage to confirm flood risk from small tributary running through the site and how best to mitigate any flood risk presented.
Llandudno Junction	Social Club/Youth Club	Recommend that development does not take place within the historical flood outline. A significant proportion of this site is therefore not suitable for development.
Llandudno	Plas yn Dre	Site is suitable with significant raising of floor levels. It is understood that an FCA for the site has already been submitted and agreement with the Environment Agency reached.
Rhos-on-Sea	Dinerth Hall Farm	Site suitable with possible minor adjustment to boundary to account for tidal flood risk.
Llanrwst	Bryn Hyfryd	Based on the available information, a significant area of the site is not suitable for development as it has not been shown that it is of low flood risk. As such this area should not be developed.
Llanrwst	North-West, Off the A470	These two sites provide the biggest issue in terms of their suitability. Based on the available information, these two sites are at significant flood risk and it is unlikely that they would be suitable for development.
Eglwysbach	Off Heol Martin	Site suitable with minor adjustments to site boundaries to ensure development does not take place in the floodplain.
Llangernyw	Coed Digain	Site at low flood risk and suitable for development.
Cerrigydrudion	Land fronting B5105	Majority of site suitable for development, but would require additional modelling to confirm flood risk from Nant Hendre-bach.
Dolgarrog	Tan Y Ffordd	Site suitable with minor adjustments to site boundary to ensure development does not take place in the floodplain.
Dolgarrog	Gwydr Road	Significant proportion of an already small site not suitable for development due to climate change and tidal/fluviial flood risk.
Employment		
Llandudno	Former Goods Yard	Site suitable for development with significant floor raising to mitigate tidal flood risk. Would require further consultation with EAW and DCWW at an FCA stage.
Dolgarrog	Memorial Hall	Site suitable but would require additional

Town/Village	Site	Summary
		modelling of at FCA stage to confirm no flood risk from Afon Porth-llwyd.
Llansannan	Land at Llansannan	Site suitable for development. Further assessment of culvert capacity and condition required at FCA stage.
Waste Management Facility		
Kinmel Bay	Gofer	Site on high ground, some mitigation required to make access/egress suitable.
Llandudno Junction	Network Rail	Site likely to be suitable for development with mitigation possibly required. Would require further consultation with EAW and modelling work at FCA stage.

Development should not increase the risk of flooding elsewhere. None of these sites are proposing development in the fluvial floodplain, so in this respect, it is not an issue. However, the increase in runoff from developed sites compared to greenfield sites can be an issue, particularly when considering the cumulative impact of new developments. The use of SUDS can therefore play an important role in managing runoff and should be implemented whether existing greenfield or brownfield site and should be followed as it is also a requirement of both national and local policy.

5. CONCLUSION

This SFCA report forms Background Paper 17, which is one of several to accompany the Revised Deposit Local Development Plan (LDP) document. This SFCA sets out to assess the flood risk and flood consequences to candidate sites determine whether it can be managed in an acceptable and sustainable way to permit development

There are 51 candidate sites for which suitability in terms of flood risk needed to be assessed. An initial Stage 1 Assessment was carried out. This was a desktop study using available datasets and flood maps to demonstrate risk from fluvial, tidal, surface water and groundwater sources. The outcome of this assessment was that 31 of the sites were at low flood risk and no further assessment was required to ascertain their suitability for development.

The remaining 20 candidate sites were taken forward into a Stage 2 Assessment process. Additional data was collected, including available hydraulic models, flood defences data and topographic information. This information was supplemented by hydrological and hydraulic calculations to better determine flood risk to the sites. Where necessary flood consequences were assessed and flood mitigation options considered.

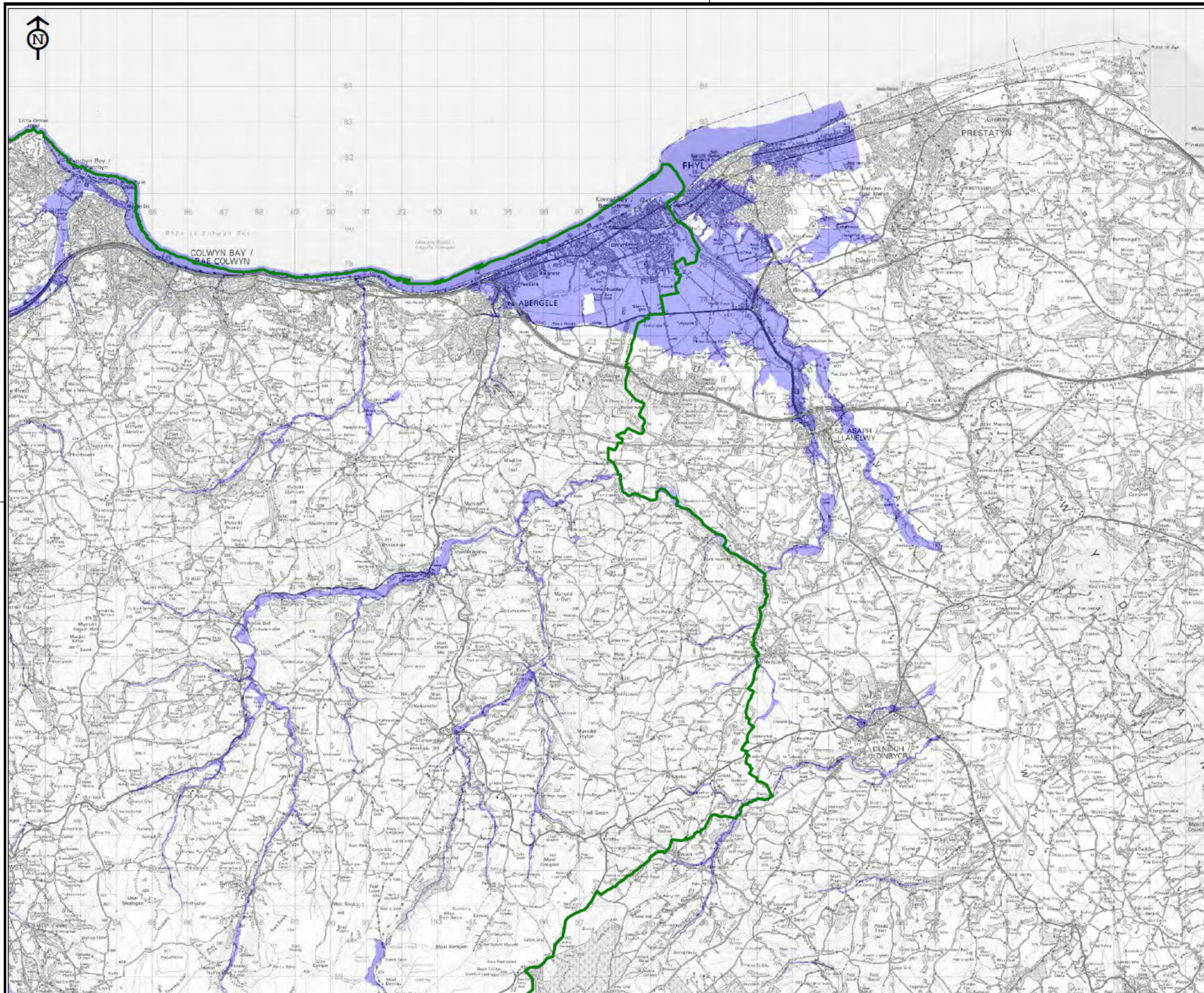
The majority of sites were found to be suitable, subject to minor adjustments to site boundaries to avoid development in the floodplain and/or possible mitigation required to control overland flow. However, the following sites are noteworthy because significant mitigation is required or there is a significant loss of part / all of the site deemed as being suitable for development.

- The housing and employment sites in Llandudno (Plas yn Dre and the Former Goods Yard) are suitable for development, but would require significant raising of floor levels.
- The housing sites at Llandudno Junction (Social Club/Youth Club) and Llanrwst (Bryn Hyfryd) have seen a large area of the site deemed as unsuitable for development.
- There are two sites in Llanrwst (A470 and North-West) for which a significant flood risk has been determined and no adequate on-site mitigation identified. As such, based on the available information, these two sites are unsuitable for development.
- The Gwydr Road site in Dolgarrog loses a significant proportion of the site deemed suitable and given its small size it is questionable as to whether the site remains viable.

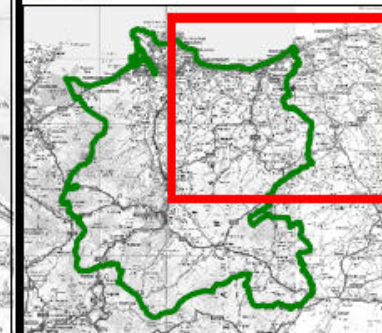
The majority of the candidate sites have been found to be at least partially suitable for development. However this assessment is of a strategic scale and future development proposals would likely require additional work and consultation with Environment Agency Wales (EAW) to fully meet the requirements of a FCA. All sites are also subject to implementing sustainable drainage systems to adequately manage run-off and prevent additional pressures being placed on the drainage network, both man-made and natural.

APPENDIX A:

Areas at High Risk of Flooding in Conwy



KEY PLAN



KEY

 High Flood Risk Area (Flood Zone 3)

 Conwy County Borough Council Boundary



A	TSP	DEB	DEB	RAF	03/12	Final

Rev	Drwn	Chkd	Rvwd	Appr	Date	Description
Designed by: T Paddison						Date: Mar 2012

Client _____



Client Drawing No. _____ Revision _____



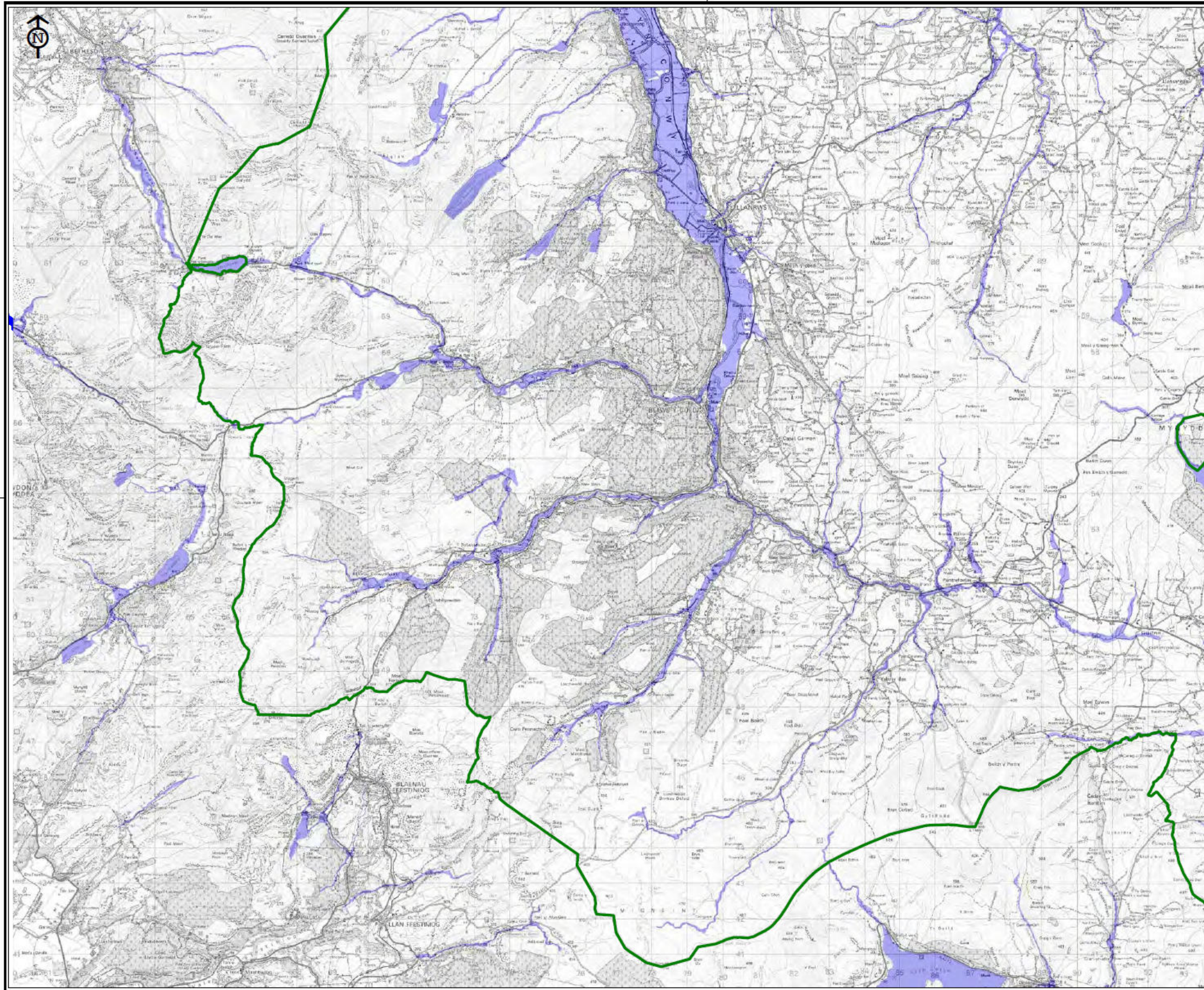
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Conwy Strategic
Flood Consequence Assessment

Drawing title

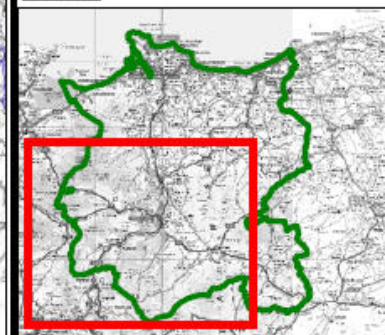
High Flood Risk Areas
(Map 2)

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Drawing no.	A 2	Revision	



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KEY PLAN



KEY

- High Flood Risk Area
(Flood Zone 3)
- Conwy County Borough
Council Boundary

Scale Bar
(km)



A	TSP	DEB	DEB	RAF	03/12	Final
Rev	Drwn	Chkd	Rvwd	Appr	Date	Description
Designed by: T Paddison					Date: Mar 2012	
Client						



Client Drawing No. Revision



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Conwy Strategic Flood Consequence Assessment

Drawing title
**High Flood Risk Areas
(Map 3)**

Drawing scale: 1:100,000 Sheet size: A3

Drawing no. A.3 Revision A

