

ATKINS

# Aberystwyth Strategic Flood Consequence Assessment

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# Glossary of Terms

Term	Meaning / Definition
DAMs	Development Advice Maps (published by Welsh Assembly Government within TAN15)
DEFRA	Department for Environment, Food and Rural Affairs (UK Government)
EAW	Environment Agency Wales
EWL	Extreme Water Level (tide level)
FCA	Flood Consequence Assessment
FEH	Flood Estimation Handbook method (for hydrological assessment)
HEC-RAS	Hydrologic Engineering Centers River Analysis System (modelling software developed by US Army Corps of Engineers)
LDP	Local Development Plan
Lidar	Light Detection and Ranging data (ground level information)
LPA	Local Planning Authority
mAOD	Metres Above Ordnance Datum
NGR	National Grid Reference
PPW	Planning Policy Wales (Welsh Assembly Government's Planning Policy)
QMED	Median Annual Maximum Flood
STAM	Solutions for Total Asset Management database (Dwr Cymru Welsh Water records of reported sewer flood incidents)
SuDs	Sustainable Drainage Systems
TAN	Technical Advice Note
TAN15	PPW Technical Advice Note 15: Development and Flood Risk
Zones A, B & C	Flood Zones defined on Welsh Assembly Government DAMs

# Executive Summary

Atkins was appointed by Ceredigion County Council to assist in the development of the Aberystwyth Local Development Plan (LDP) by undertaking a Strategic Flood Consequence Assessment (SFCA) for the town. The goals of the SFCA are to assess the flood risk at candidate sites being considered for development within the LDP and provide advice regarding management of the risk in order to meet requirements set forth by the Welsh Assembly Government, particularly those in Technical Advice Note 15 (TAN15).

The SFCA was undertaken in two phases. Phase 1 defined the areas that needed to be considered in the assessment, assigning preliminary risk levels to the 90 initially identified sites in five areas, and the extent and nature of the work required to complete an assessment at each site. An additional 46 sites were added after the completion of Phase 1. This report comprises Phase 2 of the work, which details the results of the qualitative and quantitative assessments carried out at each site and the conclusions with regard to the potential for development and management of identified flood risks.

In general, the main flood risks at Aberystwyth are tidal flooding and fluvial flooding from the Afon Rheidol and the Afon Ystwyth. Other potential risks include coastal flooding from wave overtopping and flooding from ordinary watercourses, culverted watercourses, sewers and surface water runoff. The risks posed by each of these potential sources were analysed for the sites in the five areas: North Aberystwyth, Coastal & Town Centre Areas, Llanbadarn, Glanyrafon Industrial Estate and Rhydyfelin & Penparcau. The results of the analyses were used to draw conclusions about development potential, and constraints and requirements under TAN15.

In the North Aberystwyth area, 10 of the 11 candidate sites were judged to have minimal flood risk. At the remaining site, a potential for flooding as a result of surface water runoff was identified; however, the risk is considered manageable. No problems are anticipated with developing the area providing that development proposals give careful consideration to surface water drainage requirements. Capacities of existing sewers should be confirmed and, as a general TAN15 requirement for all development, sustainable drainage systems (SuDs) should be implemented wherever possible.

Of the 51 sites in the Coastal & Town Centre Areas, only six are considered at limited risk of flooding with no anticipated difficulties for development. Elsewhere the main flood risk was identified as tidal inundation and/or wave overtopping at 35 sites, fluvial flooding and overland fluvial flow from the Afon Rheidol at six sites, and surface water runoff at four sites.

Significant problems with development are anticipated at 25 sites. At the remaining 20 sites identified with flood risks, some development is considered possible; however, proposals will be subject to constraints regarding development type. Detailed site-specific FCAs will be required at most of these sites.

Twenty-two of the 33 sites in the Llanbadarn area are considered to have minimal flood risk and no anticipated problems for development. Surface water runoff was identified as the main flood risk at eight sites, but development is considered possible with adequate management of the risk. At the three remaining sites, fluvial flooding from ordinary watercourses presents some issue for development; however, development of parts of two of the sites is considered possible with the provision of flood-free access/ egress routes. The third site will require a detailed FCA to confirm the possibility of partial development.

In the Glanyrafon Industrial Estate area, fluvial flooding from the Afon Rheidol causes significant problems for development at 11 of the 17 sites. Detailed site-specific FCAs will be required to determine whether TAN15 acceptability criteria can be met if portions of the sites are developed. Development is considered impossible at two sites that are known to provide compensatory flood storage for a sewage works. A risk of flooding from an ordinary watercourse was identified at the four remaining sites, and development of the sites will require confirmation of flood-free access/ egress routes.

Four of the 24 sites in the Rhydyfelin & Penparcau area are considered to have minimal flood risk and no anticipated problems for development. Surface water runoff was identified as the main flood risk at 15 sites, but the risk is low and development is considered possible with implementation of measures to manage the risk. Fluvial flooding from the Nant Paith was identified as the main flood risk at the remaining five sites. At



two of the sites, development is considered possible with the provision of flood-free access/ egress routes. The potential for partial development of two of the other sites will need to be confirmed by detailed site-specific FCAs. The risk associated with development at the final site subject to fluvial flooding is considered unacceptable, and justification will be difficult under TAN15 guidelines.

# 1. Introduction

## 1.1 Background

The Welsh Assembly Government's Planning Policy Wales (PPW) provides the planning policy framework under which the Local Planning Authorities (LPAs) must prepare their Local Development Plans (LDPs). PPW highlights the need to reduce flood risk by avoidance of development within high risk areas, as opposed to the previous approach of flood defence and mitigation of the consequences of flooding. The guidance requires LPAs to consider the catchment as a whole and take a strategic approach to flood risk.

PPW is supplemented by a number of Technical Advice Notes (TANs). Of key interest is TAN15<sup>1</sup>: Development and Flood Risk, which provides guidance to LPAs regarding the assessment of flood risk when they are preparing their LDPs. The advice note seeks to guide planning decisions so that new development is directed away from areas that are considered to be at high risk of flooding. Where development has to be considered within a high risk area, TAN15 outlines justification tests in order to guide decisions regarding whether a specific development may proceed.

In January 2009 Atkins was appointed by Ceredigion County Council (Ceredigion CC) to assist in the development of the Aberystwyth LDP by undertaking a Strategic Flood Consequence Assessment (SFCA) for the town.

## 1.2 Purpose of the SFCA

The SFCA provides an assessment of the flood risk for the proposed development sites (known as candidate sites) that are being considered within the LDP and provides guidance regarding the management of this risk. It encompasses a broad level assessment and does not remove the requirement for more detailed site-specific assessments which will follow the adoption of the LDP. Site-specific FCAs will need to be undertaken by developers at the planning application stage as required under TAN15.

The overarching aim of the SFCA is to provide sufficient data and information to enable the LPA to apply a sequential approach to the allocating of sites, promoting flood Zones A and B before Zone C as defined by the Welsh Assembly Government's Development Advice Maps (DAMs).

The SFCA will assist Ceredigion CC to:

- Prepare appropriate policies for the management of flood risk within the LDP;
- Inform the Sustainability Appraisal so that flood risk is taken into account when considering options and in preparation of strategic land-use policies;
- Identify the level of detail required for site-specific FCAs in particular locations and enable the Council to determine the acceptability of flood risk in relation to emergency planning capability;
- Identify potential for producing local standing advice; and
- Identify issues relating to managing surface water and use for sustainable drainage.

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<sup>1</sup> Planning Policy Wales: Technical Advice Note: 15 Development and Flood Risk: Welsh Assembly Government July 2004

## 1.3 Approach to the SFCA

The SFCA for Aberystwyth considers both fluvial and tidal influences on flood risk within the town. Consideration is also given to other sources of flood risk; there are a number of ordinary watercourses in the vicinity as well as public sewer networks.

Since the suitability of available information to inform the SFCA was not fully known at the start, the SFCA has been undertaken in two phases.

### 1.3.1 Phase 1

The first phase of this project involved scoping out the requirements to be considered within the SFCA of the area. This included defining the areas within Aberystwyth where the flood consequences needed to be determined and the extent and nature of the analytical assessments required to define the risks.

It was felt that the recommendations indicated in the Environment Agency Wales' guidance note to local authorities for SFCAs were too detailed for such a broad scale assessment, and that assessing all the sites in detail against the TAN15 guidance would be prohibitively expensive. A meeting was held with Ceredigion CC and the Environment Agency Development Control to agree an acceptable approach to the SFCA as well as the scope of activities to be undertaken within Phase 2.

Activities undertaken within Phase 1 and the agreed approach to Phase 2 are documented within the Phase 1 Report.

### 1.3.2 Phase 2

This report documents works undertaken within Phase 2 of the SFCA in accordance with the agreed approach.

Candidate sites were categorised as High, Medium or Low flood risk and divided into five areas for assessment. For areas containing mainly Low Risk sites where minimal flooding is expected, it was agreed that only a qualitative assessment of the perceived risks would be undertaken.

Where Medium Risk sites are present a strategic level assessment was undertaken in order to better understanding of the level of risk. This included simple steady-state modelling of watercourses and a review of the flood extents, assessment of potential overland flow paths, and identification of any possible culvert or sewer issues in the area.

A more detailed assessment of flooding was necessary for High Risk areas identified within the town centre area; therefore, two-dimensional modelling was undertaken to understand the flood flow paths, depths and velocities.

## 2. The Study Area

### 2.1 Development Sites

A review of the various sites identified for development on Ceredigion CC Candidate Sites Map was undertaken within Phase 1. The initial risk categorisation of the sites within the defined SFCA study area is shown on Drawing Number 5037097.760/RCF/002 in Appendix A. The risk was not categorised for sites added since the completion of Phase 1.

For the purposes of detailed analysis, the sites were divided into five areas (see drawing):

- North Aberystwyth;
- Coastal & Town Centre Areas;
- Llanbadarn;
- Glanyrafon Industrial Estate; and
- Rhydyfelin & Penparcau.

A detailed description of each area is included in the area-specific sections within this report.

### 2.2 Climate and Hydrology

The coastal town of Aberystwyth, Mid Wales is situated at the confluence of the Afon Rheidol and Afon Ystwyth on Cardigan Bay. Its oceanic climate is responsible for mild temperatures and consistent rainfall with monthly averages ranging from 60mm in the spring to 120mm in the autumn.

The drainage area of the Afon Rheidol at Llanbadarn Fawr is approximately 180km<sup>2</sup>. Land use in the basin is generally agricultural in upland areas with approximately 20% forest cover. Soils are permeable, and runoff is influenced by groundwater extraction and drainage from old mines. Flows in the Rheidol are regulated by a series of hydroelectric dams, the first of which is approximately 13km upstream of the mouth of the river.

The drainage area of the Afon Ystwyth at Pont Llolwyn is approximately 170km<sup>2</sup>. Land use in the basin is similar to that in the Rheidol basin with farming in upland areas and approximately 18% forest cover. Soils in the east are peaty and seasonally wet, and soils in the west are generally permeable. Runoff and flows are largely the products of land use and natural basin characteristics.

### 2.3 Sources of Flooding

The main risks of flooding to Aberystwyth are from the tide and the two main rivers, the Afon Rheidol and the Afon Ystwyth, which flow west and north to join with each other and the sea at the centre of the town. Risks for these sources have been considered in some detail within this SFCA.

Other flood risks identified include:

- Ordinary watercourses;
- Culverted watercourses;
- Sewers;
- Wave overtopping; and
- Surface water runoff.

The risks associated with each possible source of flooding are discussed on an area-specific basis.

## 2.4 Development Design Life and the Impacts of Climate Change

Flood risk must be considered over the anticipated lifetime of each development. Until recently, Environment Agency Wales (EAW) policy has been to accept a development lifetime of 50 years. For residential developments, however, the EAW consider this to be too short a period and as best practice they now advise consideration of up to 100 years development life for residential developments. For other developments, a 70 year scheme life has been deemed appropriate. These longer design life periods have been considered for the developments in this SFCA to provide a conservative approach to guiding decisions regarding the LDP.

The design lifetimes of proposed developments are particularly important in light of the fact that TAN15 recommends consideration of the potential impacts of climate change when assessing the consequences of flooding. The latest DEFRA guidance for fluvial flooding is to apply a 20% increase to peak river flows in order to evaluate the influence of climate change. In this SFCA, the 1% (1 in 100) annual chance event peaks in all watercourses have been increased by 20%. No allowance for climate change was applied to the 0.1% (1 in 1000) annual chance event because of the high uncertainty already involved in estimating the peaks for this event.

Climate change was also taken into account in the case of tidal flooding by applying an allowance for the net rise in sea level. Detailed discussion regarding the allowance made is included in Section 4.3.1 of this report.

## 2.5 TAN15 Development Advice Maps

The Welsh Assembly Government's Development Advice Maps (DAMs) contained within TAN15 define flood areas as Zones A, B, C1 or C2. The assessment of flood risk and evidence required to justify development varies from zone to zone. Zone A is considered at low risk of flooding and the advice note seeks to encourage development within such areas rather than in higher risk areas. Land within Zone C is considered at high risk of flooding; Zone C1 is specified as areas that benefit from some level of flood defence, whilst Zone C2 is completely undefended.

The DAMs are regularly revised with reference to new data. Towards the end of the preparation of this SFCA report, in September 2009, a revised DAM was released to Ceredigion CC. Atkins have not had sight of the revised map but understand that there have been no changes to the DAM Zones defined for Aberystwyth. Therefore, this report remains based on the older maps.

## 3. North Aberystwyth

### 3.1 Site Description

#### 3.1.1 General Site Description

The North Aberystwyth area is a mixed rural and developed area located to the northeast of Aberystwyth at National Grid Reference (NGR) SN600825. The area is segmented by the northwest-southeast trending B4572 and the A487. North of the A487, the area is primarily rural with the exception of a small caravan park located along the B4572 and a residential area associated with the Aberystwyth University campus. The main university campus is located south of the A487 to the west of the residential area of Waun Fawr.

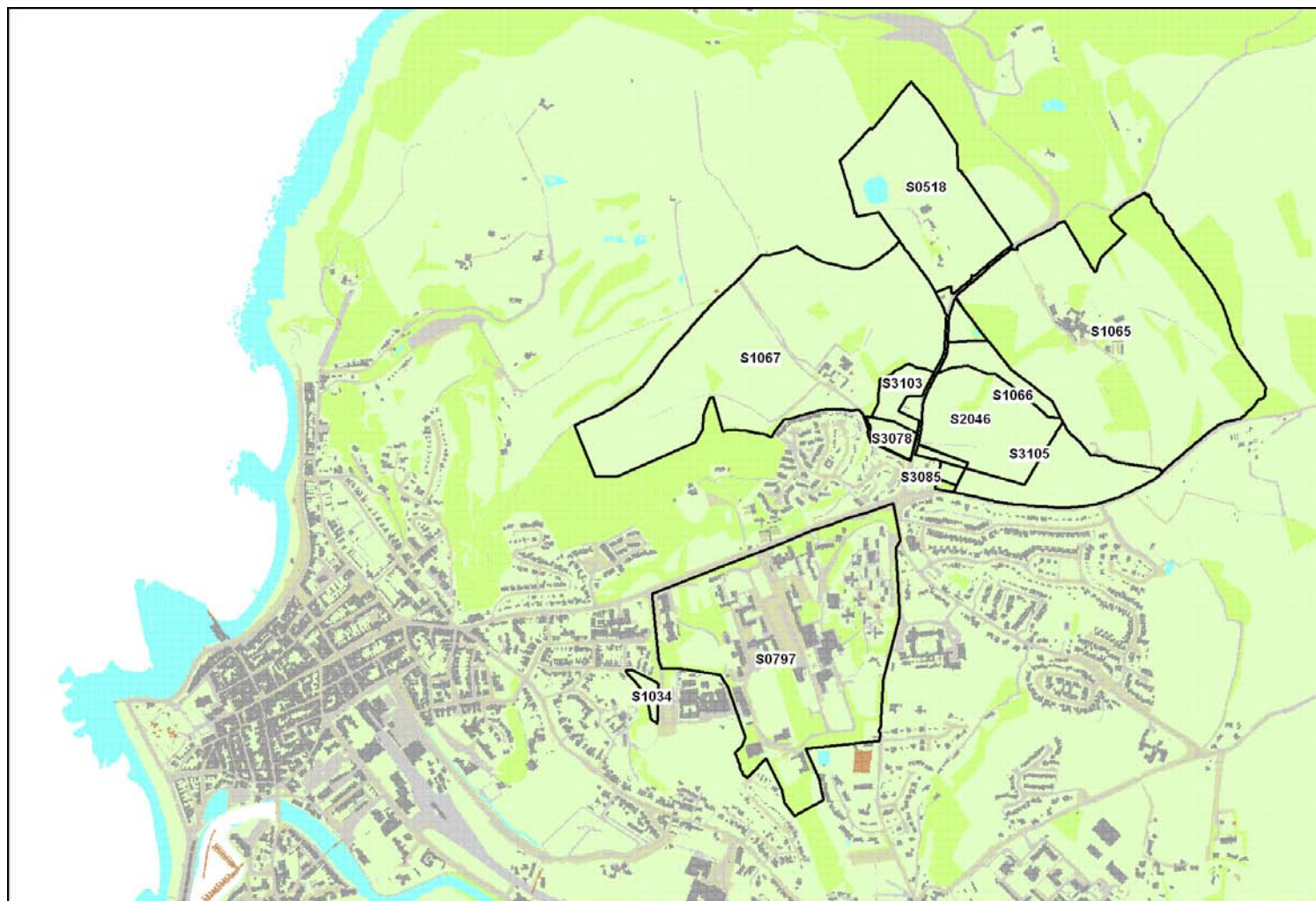
The area north of the A487 is situated on a hilltop and drained by minor watercourses that flow to the north and south, passing through multiple culverts. The watercourses flowing south run along the north side of the A487, opposite the main university campus. No watercourses are marked on the area to the south of the A487.

#### 3.1.2 Proposed Development

The 11 candidate sites identified in the area can be divided into two groups. Nine of the sites are located north of the A487; one has been specified for housing development and the majority of the rest are mixed use including some residential development.

One of the two sites south of the A487 is currently occupied by Aberystwyth University. The other site is a small site on the hillside below the campus that is currently unoccupied. The sites are shown on Figure 3.1 and summarised in Table 3.1 below.

Figure 3.1 - Candidate Site Locations



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Table 3.1 - Candidate Sites Summary

Site ID	Name	NGR	Development Type	Design Life
S0518	Caravan Park	SN600829	Housing	100
S1065	Frongoch Farm, Clarach Rd, Aberystwyth	SN606826	Other – Education and research; Livery/ stables	70
S1066	Penglais Farm (East) and Cefn Hendre Land, Clarach	SN603823	Other – Park and walk/ ride; Education development	70
S2046	Field in the north east quadrant of Waunfawr	SN603823	Other – Park and ride	70
S3085	Plashendre Field	SN601822	Mixed	100
S3105	Penglais Farm (East) and Cefn Hendre Land, Clarach	SN603823	Mixed	100
S1067	Penglais Farm (West), Clarach Rd, Aberystwyth	SN596825	Other – Student housing; Sport and recreation; Education and research	100
S3078	Field near Mature Student Village	SN599823	Mixed	100
S3103	East Penglais Farm	SN600824	Unsure	100
S0797	Penglais Campus	SN596817	Other – Education/ academic	70
S1034	Land to the south of Bronglais General Hospital, Aberystwyth	SN593816	Other – Car parking for Bronglais Hospital	70

### 3.1.3 Hydrological Situation

The sites to the north of the A487 are located on a hilltop. The ground slopes gently in all directions. Two watercourses that originate in the area drain to the north; one passes through a culvert immediately outside the S0518 site boundary. The other watercourse originates at two ditches draining fields and then flows north, forming the eastern boundary of site S1065. Two watercourses originate within site S1067 and drain the area to the south. One begins near Penglais Farm, entering a culvert beneath a carriageway at the southern boundary of the site. The second is located to the west and flows for a short distance before passing through a culvert and into a canyon to the south of the site. The two watercourses join outside the boundary of the site and flow west along the north side of the A487. The drainage areas of all four watercourses are poorly defined within the boundaries of the candidate sites, becoming better defined further downstream.

The two candidate sites south of the A487 [S0797 (the main university campus) and S1034] have no defined watercourses. The land generally slopes to the west.

## 3.2 Data Review and Analysis

### 3.2.1 Information Available

A review of the available data has included the following:

- TAN15 Development Advice Map;



- Environment Agency Extreme Flood Outline Map;
- STAM Database; and
- Light Detection and Ranging (Lidar) data.

### 3.2.2 Analysis Approach

The candidate sites included in Phase 1 have been categorised as Low Risk. A detailed assessment is therefore considered unnecessary, and a strategic assessment is considered sufficient to understand the risks associated with development in this area and to provide initial guidance for the management of the identified risks.

Assessment of this area has included:

- Review of likely overland flow paths using Lidar data;
- Review of minor watercourses within the area; and
- Check for recorded sewer flooding.

## 3.3 Flood Risk from Main Rivers and Ordinary Watercourses

### 3.3.1 Flood Risk from Minor Watercourses

Four minor watercourses in the area were identified from digital Ordnance Survey data and are described above. These are both natural and manmade drainage paths channelling water from higher ground down toward the Afon Clarach in the north and channels and culverts to the Afon Rheidol in the south.

None of the drainages are considered to pose a risk of flooding to the candidate sites; it could be argued that they actively contribute to the reduction in flood risk by carrying surface water away from the high ground.

## 3.4 Flood Risk from Sewers, Culverted Watercourses and Groundwater

### 3.4.1 Flood Risk from Sewers

No sewer flooding incidents were identified in the area.

### 3.4.2 Flood Risk from Culverted Watercourses

Lidar data were examined to determine potential flood risk posed by blockage of any of the culverts identified along the watercourses. In general, the culverts are located near the boundaries of the candidate sites. The ground elevation data suggest that water overtopping at the culverts would flow out of and away from the sites.

### 3.4.3 Flood Risk from Groundwater

Susceptibility to groundwater flooding was not included as a part of this assessment. Risk associated with groundwater should be investigated as part of any proposed development.

## 3.5 Flood Risk from Surface Water Runoff

Lidar data was analysed to determine the likely direction of flows from the hilltop on which the candidate sites north of the A487 are located. Surface water runoff generated within the candidate sites would flow overland along poorly defined flow paths until reaching the boundaries of the sites or one of the minor watercourses described above. Catchment areas are small and therefore limited runoff flow rates are anticipated. These factors combined indicate low risk of flooding from surface water runoff.

The Lidar data indicate that surface water runoff generated at site S0797 would run west over the site. Areas to the north and east of the site are not anticipated to contribute overland flow to the site. The northern boundary of the site is formed by the A487, which blocks overland flow from the

north. Along the eastern site boundary, the land slopes off to the east rather than towards the candidate site. These observations indicate that the catchment area is small; therefore, limited runoff rates are anticipated except where surfaces are paved. It is considered that flows generated from impermeable surfaces could be managed to reduce the risk of flooding from these sources. No watercourses are available to collect surface water flow and divert it away from the site; surface water drainage is currently provided by the existing sewer system.

Surface water runoff generated at site S1034 would flow to the west toward an existing residential area.

### 3.6 TAN15 Constraints

The candidate sites fall within TAN15 Zone A. Fluvial and tidal flood risk is low and few constraints are given within TAN15 for development within this zone. It is important, however, that development proposals give careful consideration to overland flow paths and the management of surface water runoff. TAN15 notes that any development will result in changes to the natural hydrology of a catchment due to an increase in runoff from impermeable ground and built-up areas. Developers should consider surface water drainage requirements, and adequate capacity of existing sewers must be confirmed to ensure proposed developments do not result in flooding elsewhere.

### 3.7 Summary of Flood Risk and Management

#### 3.7.1 Candidate Sites S0518, S1065, S1066, S2046, S3085, S3105, S1067, S3078 and S3103

These sites fall within TAN15 Zone A and are located on high ground. Minor watercourses divert waters to the north and south of the sites; any overtopping at the culverts on the watercourses is anticipated to flow toward the site boundaries and away from the proposed development areas. Minimal flood risk has been identified, and no difficulties are anticipated in the development of these sites providing adequate consideration is given to the management of surface water runoff.

#### 3.7.2 Candidate Sites S0797 and S1034

These sites also fall within TAN15 Zone A. Although situated at lower elevations than the other four sites in the area, these sites have no watercourses. Neither site appears to be vulnerable to surface water flooding from off site, providing adequate sewer capacities at the existing development to the east of site S1034.

No evidence of sewer flooding has been identified at site S0797; therefore, it is considered that the existing sewer system is sufficient to convey the surface water runoff generated at the site under current development conditions. The current flood risk is thus considered minimal, and no problems with developing the site are anticipated providing developers adequately investigate the capacity of the existing sewer system to handle any changes in surface water runoff. Additional runoff could be managed through the implementation of sustainable drainage systems (SuDs) as required by TAN15.

The flood risk at site S1034 is also considered minimal.

## 4. Coastal & Town Centre Areas

### 4.1 Site Description

#### 4.1.1 General Site Description

Aberystwyth is located at NGR SN583817. It is a coastal town that has seen significant development over the centuries. The ruins of its Norman Castle look south over the once busy harbour that lies at the confluence of the Afon Rheidol and Afon Ystwyth, and north to four-storey Victorian/ Edwardian sea-front terraces. Away from the coast, the narrow streets of the thriving town are crowded with old buildings and new developments.

Town centre expansion has primarily occurred north of the Afon Rheidol, along the river valley to the east.

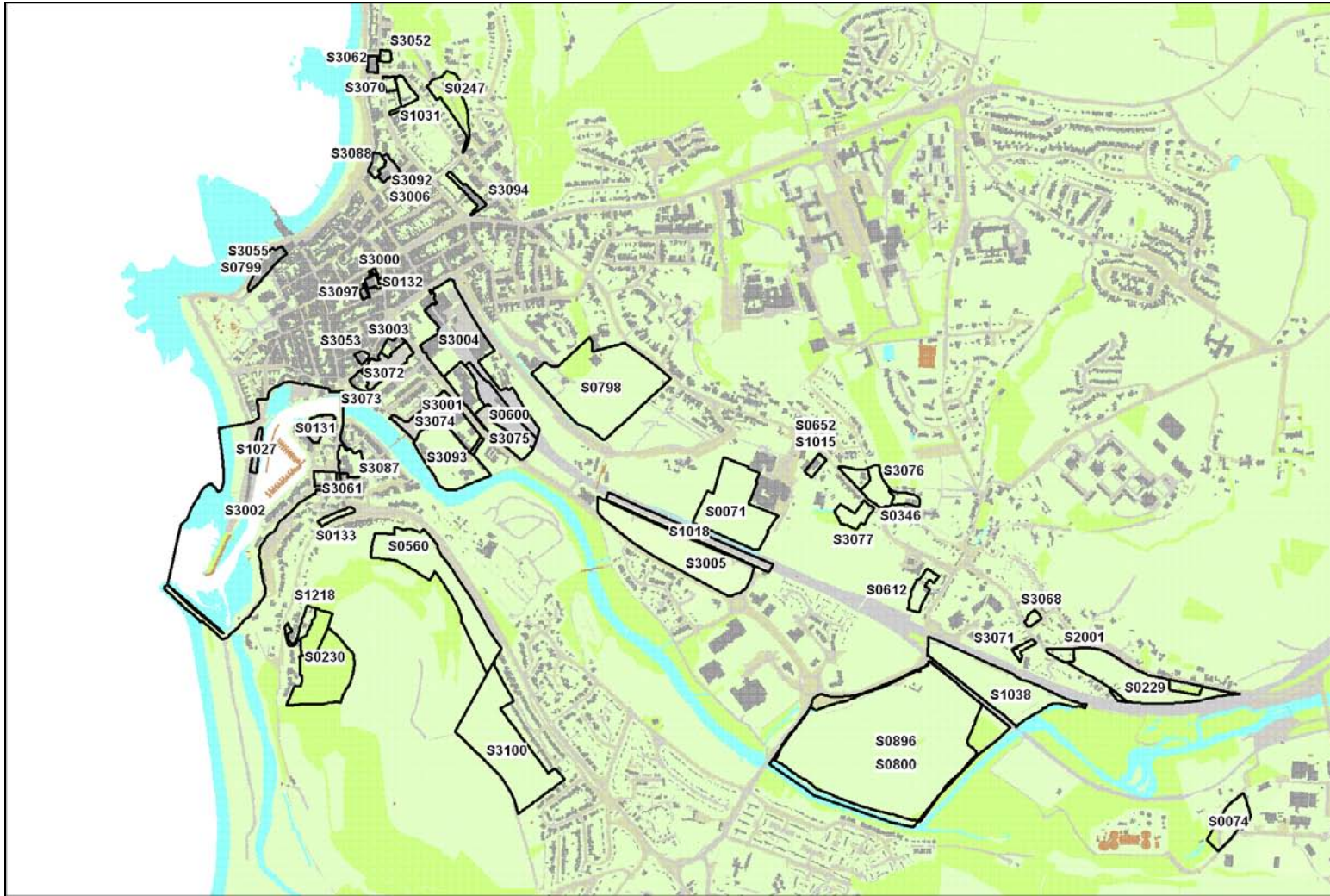
#### 4.1.2 Proposed Development

A number of significant sites have been identified within the LDP for potential development. The proposed developments vary from housing to employment to retail and mixed use. These may be summarised geographically as follows:

- 10 sites at the harbour/ south of the Afon Rheidol – employment and housing;
- 14 sites within the town centre (elevated ground) – housing, retail and mixed use;
- 11 sites adjacent to the Vale of Rheidol Railway station (low-lying land) – mixed developments;
- 8 sites within the Parc y Llyn and Plascrug development areas – mixed developments;
- 3 sites on the Blaendolau Playing fields – mixed developments; and
- 5 sites immediately north of the railway line – housing.

The 51 candidate sites are shown on Figure 4.1 and summarised in Table 4.1 below.

Figure 4.1 - Candidate Site Locations



This map is reproduced from the OS map by the Ceredigion County Council with permission of the controller of HM Stationery Office, © Crown Copyright (Licence No. 100024419).

Table 4.1 - Candidate Sites Summary

Site ID	Name	NGR	Development Type	Design Life
S1027	Aberystwyth Harbour Garages	SN580811	Employment	70
S0131	Land at Y Lanfa, Aberystwyth	SN582812	Mixed	100
S3002	Aberystwyth Harbour (including fire station)	SN580811	Mixed	100
S3061	Fire Station Aberystwyth	SN582 11	Mixed	100
S3087	Old Brewery opp. Fire Station	SN582811	Mixed	100
S0133	Land at the Boat Park, Aberystwyth	SN582810	Housing	100
S1218	Land adj. Hamden	SN581809	Housing	100
S0230	Land adj. Ewyn Y Don, Felin Y Mor Road, Aberystwyth	SN582805	Housing	100
S0560	Penparcau Road	SN585808	Housing	100
S3100	Field behind West Maelor	SN578 03	Unsure	100
S0799	Old College	SN580817	Unsure	100
S3055	Aberystwyth, Old College	SN580817	Mixed	100
S3052	Vacant Boars's Head Pub, Queens Road	SN584822	Mixed	100
S3062	Old Council Offices (Court, Forest Commission Office)	SN583822	Mixed	100
S3070	Adj. North Road Health Clinic	SN584822	Mixed	100
S1031	North Road Clinic, Aberystwyth	SN584821	Housing	100
S0247	Troed-yr-Aur, Aberystwyth	SN585821	Housing	100
S3094	Cambrian Tyres, Corner of Queens Road and Vaynor St	SN586818	Mixed	100
S3006	Cinema, Bath St	SN584819	Mixed	100
S3092	Cinema, Bath St	SN584819	Mixed	100
S3088	Bay Hotel and Adj. Properties	SN583819	Housing	100
S0132	Aberystwyth Post Office, Great Darkgate Street	SN583816	Mixed	100
S3000	Old Post Office	SN583816	Retail	100
S3097	PO site, Aberystwyth	SN583816	Mixed	100
S3053	Tabernacle Church, Mill Street	SN583814	Housing	100
S3003	Mill St Car Park	SN584814	Mixed	100
S3072	Mill St Car Park	SN584814	Mixed	100
S3073	Sea Cadet HQ	SN583813	Housing	100
S3001	Park Avenue South Site	SN585812	Mixed	100
S3074	Park Avenue South Site	SN585812	Mixed	100



Site ID	Name	NGR	Development Type	Design Life
S3093	Football Grounds, Park Avenue	SN585811	Mixed	100
S0600	Vale of Rheidol Railway land, Aberystwyth	SN587812	Mixed	100
S3004	Parc Avenue North (Station and retail parks)	SN585814	Mixed	100
S3075	Parc Avenue Car Park	SN586 12	Mixed	100
S0798	Vicarage Fields	SN589813	Other – Retain as open space/ recreation	70
S0071	Plascrug Leisure Centre, Aberystwyth	SN593810	Other – Athletic track; Open space/ recreation	70
S1018	Parc y Llyn Ditch	SN591809	Mixed	100
S3005	WAG and CCC Offices	SN591809	Employment	100
S1015	Aberystwyth Ambulance Station, Llanbadarn Rd	SN596812	Mixed	100
S0652	Aberystwyth Ambulance Station, Llanbadarn Rd	SN596812	Mixed	100
S3077	Land behind Ty Clyd, nr Jnct of Sulien Rd and Quebec Rd	SN596810	Housing	100
S0346	Plas Mansion, Llanbadarn Fawr	SN597810	Housing	100
S3076	Vicarage Gardens, Quebec Road	SN597810	Housing	100
S0896	Blaendolau Playing Field	SN597804	Other – Retain as open space/ recreation	70
S0800	Blaendolau Playing Fields	SN598803	Unsure	100
S1038	Land adj. to Blaendolau Fields, Aberystwyth	SN600805	Mixed	100
S0612	Paddocks and Yard in Llanbadarn Fawr	SN598808	Housing	100
S3071	Land between Blaendolau Farm and Llety Gwyn	SN601806	Housing	100
S2001	Land at Parc yr Onnen, Llanbadarn Fawr, Aberystwyth	SN604805	Housing	100
S0229	Land at Pwllhobi, Llanbadarn Fawr, Aberystwyth	SN604805	Housing	100
S3068	Pwllhobi Terrace, Vacant plot nr. Bryn Rheidol	SN601807	Housing	100

#### 4.1.3 Hydrological Situation

The historic Aberystwyth town centre is located on elevated ground. On the lower ground to the north, Victorian/ Edwardian developments extend along the coastline and are subject to tidal attack. The prevailing wind/ wave climate is from the southwest, and some protection is afforded

by the Old Stone Pier and natural outcrop at Castle Hill; however, wave over topping of the sea front at Marine and Victoria Terraces does occur.

To the east, more recent development areas lie within the wide floodplain of the Afon Rheidol. The tidal influence extends upstream to approximately Pont Pen-y-bont and overtopping of banks from both tidal and fluvial flows can occur.

Historic flooding from the Afon Rheidol has been addressed by various means; the most recent being the construction of flood defences along the north bank of the river in 2000. The defences extend from Pont Aberystwyth at the harbour upstream to Pont Pen-y-bont. Downstream, where buildings lie immediately adjacent to the river banks, a variety of reinforced concrete and brick walls form a hard defence line. Further upstream the defence changes to a softer earth embankment.

A second flood defence embankment is located immediately upstream of the Vale of Rheidol Railway bridge. This was constructed to protect land adjacent to the Blaendolau Playing Fields from fluvial flooding from the Afon Rheidol.

A number of other significant watercourses lie into the area. Many of the natural streams flowing from upland areas to the north have been diverted into man-made drainage ditches and culverted sections on route to discharge in the Afon Rheidol.

## 4.2 Data Review and Analysis

### 4.2.1 Information Available

A review of the available data has included the following:

- TAN15 Development Advice Map;
- Environment Agency Extreme Flood Outline Map;
- STAM Database;
- HEC-RAS hydraulic model of the Afon Rheidol (2007 model supplied by the Environment Agency);
- Revised Rheidol flow data (agreed with the Environment Agency in May 2009);
- Extreme Water Levels for Aberdovey and Cardigan (2000 levels supplied by the Environment Agency);
- Site-specific FCAs undertaken by Atkins for Ceredigion CC and private developers at:
  - Parc y Llyn Office Development (June 2005);
  - Renewable Energy (Biomass) Plant, Plascrug (April 2007);
  - Plascrug Primary School (September 2007);
  - New Court Building, Parc y Llyn (December 2007); and
  - Park Lodge Hotel, Parc y Llyn (March 2008).
- Aberystwyth Coastal Defences – Condition Survey Report, and Project Appraisal and Priority Action Plan (undertaken by Atkins in 2008);
- Jacobs Report on Aberystwyth Coastal Defence Strategy (June 2006);
- Topographic Survey of flood defences (undertaken by Infomap Chartered Surveyors May 2009); and
- Light Detection and Ranging (Lidar) data.

## 4.2.2 Analysis Approach

The majority of the town centre sites fall within the Environment Agency extreme flood outline. Many of these sites fall within TAN15 Zone C2; they are undefended and are at high risk of flooding.

Other sites, particularly those located on the low-lying land adjacent to Vale of Rheidol Railway station, are shown to benefit from flood defences and are within TAN15 Zone C1. Although the sites have the benefit of flood defences, they are classed as High Risk due to the likelihood of defences being overtopped by sea level rises in the future.

To fully understand the risk from tidal flooding, over the development design life, a detailed assessment including two-dimensional modelling of the area is required.

Other flood risks, including the assessment of fluvial flooding from the Afon Rheidol and other watercourses, are likely to be of secondary importance. At this strategic assessment level, analysis of existing analyses and simple one-dimensional modelling was considered sufficient to determine the overall flood risk issues to the town centre sites and provide guidance on further study at a later date. Should the tidal risks be effectively managed then detailed assessment of the other risks identified would be required within the site-specific FCAs.

Analysis undertaken at this stage has included:

- Analysis of predicted Extreme Water Levels (EWLs) and calculation of anticipated sea level rises over the development design life;
- Development of a two-dimensional tidal inundation model using TuFlow;
- Update of Environment Agency Afon Rheidol hydraulic model with new hydrological flow data;
- Comparison of topographic survey, Lidar and hydraulic model data;
- Review of the various site-specific FCAs undertaken by Atkins (2005 -2008);
- Hydraulic modelling of the Plascrug Ditches, including hydrological assessment of the catchment;
- Assessment of overland flow paths from overtopped watercourses and surface water runoff; and
- Check for any recorded sewer flooding in area and review of culverts.

## 4.3 Flood Risk from Tidal Sources

### 4.3.1 Flood Risk from Tidal Inundation

The significant flood risk to the town centre area is from tidal overtopping of the flood defences on the north bank of the Afon Rheidol. The defences were designed to a level of 4.61mAOD to provide protection up to the 0.5% (1 in 200) annual chance tidal level for the 50 year scheme life<sup>2</sup>.

Since the construction of the defences, there have been changes in the approved guidance regarding the calculation of anticipated sea level rises. The 2007 report on climate change published by the IPCC emphasises the certainty of accelerated climate change. Until recently the accepted guidance for sea-level rise in Wales has been 5mm/year. This has now been revised, and current DEFRA guidance<sup>3</sup> states that anticipated sea level rises are 3.5mm/year until 2025, 8.0mm/year between 2025 and 2055, 11.5mm/year between 2055 and 2085, and 14.5mm/year beyond 2085.

<sup>2</sup> 4.36mAOD sea level (based in Atkins 1998 analysis) + 250mm sea rise over 50 years

<sup>3</sup> Flood and Coastal Defence Appraisal, FCDPAG3 Economic Appraisal, Supplementary Note to Operating Authorities – Climate Change Impacts, October 2006.



In addition, the predicted Extreme Water Level (EWL) for Aberystwyth has been reviewed as part of this SFCA. No record of EWLs is available for Aberystwyth. The Jacobs report on the Aberystwyth Coastal Defence Strategy makes reference to a number of different analyses; however, the EWLs quoted are not in line with recent guidance. Regardless, the report provides insight into the issues associated with sea level rises and coastal flooding. The Environment Agency was consulted, and a calculation of levels at Aberystwyth from recorded data at Aberdovey and Cardigan was considered to give the best estimate of EWLs. Data was provided as 0.4% (1 in 250) and 0.1% (1 in 1000) annual chance tidal event levels for the year 2000 at Aberdovey and Cardigan. Aberystwyth levels were pro-rated based on distance around coast, sea level rises were applied to give 2009 levels, and the 0.5% (1 in 200) annual chance tidal event level interpolated from available data.

Table 4.2 below summarises the estimated tidal levels, for various scheme lives. Levels are given in metres above Ordnance Datum for easy comparison with site ground levels.

**Table 4.2 – Extreme water levels for Aberystwyth**

	<b>0.5% (1 in 200) annual chance tidal level (mAOD)</b>	<b>0.1% (1 in 1000) annual chance tidal level (mAOD)</b>
Current (2009) EWL prediction	4.36	4.59
2059 EWL	4.70	4.94
2079 EWL	4.93	5.17
2109 EWL	5.35	5.58

Tidal curves were generated with reference to the above EWLs for use within a two-dimensional model of the town centre. Modelling work was carried out using the TuFlow modelling software package. The recent topographic survey was used to define Rheidol defence levels, and Lidar data was used to define the coastal boundary and town centre topography. Ordnance Survey MasterMap data was referenced to define buildings, hard surfaces and other features.

The tidal inundation model produced provides a full understanding of the flood depths and velocities likely to be encountered and enables full assessment of the candidate sites in line with TAN15 guidelines.

Drawing Numbers 5037097.760/RCF/110 to 117 and 120 to 127 contained within Appendix B show, respectively, the maximum flood depths and velocities predicted by the model for the 0.5% (1 in 200) and 0.1% (1 in 1000) annual chance tidal events for the current day and future (50 year, 70 year and 100 year) design life periods. The position and value of the maximum flood depth encountered for each event is shown on the relevant drawing. The maximum predicted flood depth in the vicinity of the Mill Street Car Park and Park Avenue is also shown. Maximum depths encountered within each identified candidate site are given in the table in Appendix C. Where depths do appear to be acceptable, further checks will also be required to confirm other TAN 15 requirements can be met (see Section 4.7).

Time lapse model results were reviewed to give an indication of the spread of flood waters as the defences are overtopped. It was seen that overtopping of the defences first occurs in the vicinity of Pont Aberystwyth, and initial flow routes are west along Rheidol Place towards the high-tide harbour. Steeply rising ground in this direction soon contains flows, and as waters start to overtop the defence walls that run past the football ground, flooding spreads northeast along Maesyrafon.

Once the car park, football ground and residential streets in between are inundated, tidal waters start to overtop the earth embankments along Boulevard St Briec. The Ystwyth Retail Park and Park & Ride are inundated before the railway lines are overtopped and water spreads west into the town centre and east towards the Parc y Llyn and Plascrug areas.

In the town centre, water first spreads along Terrace Road before spilling northeast along Cambrian Street, North Parade and parallel roads. The northeastern boundary of floodwaters in the worst-case scenario modelled [the 0.1% (1 in 1000) annual chance tidal event expected in

2109] lies along Queen's Road. Water reaches Bath Road but is not shown to spill over Marine Terrace.

Flow east is concentrated along the railway line and the Plascrug Ditches/ Plascrug Avenue. The Plascrug playing fields are inundated at tides over approximately 4.9m AOD. Around the 5.1m AOD tide, floodwaters start to spill back over the railway line into the western end of the Parc y Llyn development by the footbridge crossing the lines and into the eastern end across the playing fields to the east of the residential development. As waters rise, they remain confined in the east to the currently undeveloped playfields next to the Lletty Parc Hotel by the defence embankment that exceeds 6m AOD. However, water continues to flow from east to west flooding much of the Parc y Llyn Retail Park. To the north, waters eventually spread to cover the entire area south of Quebec Road.

It is clear from the maps that the predicted flooding affects many of the sites currently highlighted for development. Further discussion at a candidate site level is included below.

#### 4.3.2 Flood Risk from Wave Overtopping

The two-dimensional modelling undertaken is based on still water levels and does not allow for wave overtopping. Review of the topographic information available confirms that Marine Terrace and Victoria Terrace are elevated above all the still water levels considered and tidal inundation will not occur from this direction.

Anecdotal evidence, however, suggests that wave overtopping could be a significant issue for the sea-front areas, as the photo below shows.

**Figure 4.2 - Wave Overtopping at Victoria Terrace (January 2005)**



Although specific data regarding predicted wave heights was not available and detailed analysis of overtopping volumes could not be undertaken, conclusions regarding the risk of flooding from wave overtopping have been drawn from a review of the Jacobs Coastal Defence Strategy Report and other available information. Wave overtopping is an issue when the wind direction is from the west or southwest. As previously noted, a degree of protection is provided to the harbour by the Old Stone Pier and to New Promenade by the natural outcrop at Castle Hill; however, Marine Terrace and Victoria Terrace remain unprotected.

Along Victoria Terrace and the northern end of Marine Terrace, the terraced properties are likely to provide protection to the properties behind. To the south, a low point on the road is found adjacent to the bandstand; here levels rise to approximately 6.2m AOD before dropping to the east. It is anticipated that water will overtop here and follow a flow path down Terrace Road into the low-lying town centre area. The extent of flooding is unlikely to exceed that already identified as at risk from tidal inundation by the overtopping of the Rheidol defences because the probability is low that a 0.1% (1 in 1000) annual chance tidal event would coincide with a significant wave

event. No candidate sites, other than those already identified as at risk, are considered to be at risk of flooding from wave overtopping.

## 4.4 Flood Risk from Main Rivers and Ordinary Watercourses

### 4.4.1 Flood Risk from Afon Rheidol

A number of site-specific FCAs have been undertaken for sites in the Parc y Llyn area, and flooding from the Afon Rheidol has been identified as a risk. An update of previous work was considered necessary for this SFCA to reflect recent changes in hydrological methods.

Recent guidelines issued<sup>4</sup> suggest that the previous FEH method used to estimate flows is only appropriate up to the 1% (1 in 100) annual chance event. For flows above this, estimates should be based on the new hybrid method. The Environment Agency was consulted, and it was agreed that the flows in the Rheidol should be 253m<sup>3</sup>/s for the 1% (1 in 100) annual chance event and 439m<sup>3</sup>/s for the 0.1% (1 in 1000) annual chance event. In addition, the Environment Agency advises modelling a third scenario of the 1% (1 in 100) annual chance event with a 20% increase to reflect climate change. These flows were routed through the reach using the most recent Environment Agency Afon Rheidol HEC-RAS model to provide an estimate of anticipated levels within the main river.

The defence immediately upstream of the Vale of Rheidol Railway Bridge was surveyed and found to vary in level from 7.81 to 8.25mAOD, although the majority of the bund is situated at a level of approximately 7.9mAOD. The revised Afon Rheidol hydraulic model suggests that water levels during the 1% (1 in 100) annual chance event with climate change and the 0.1% (1 in 1000) annual chance event would be around 6.58 and 7.35mAOD respectively. If these levels are correct, it could be concluded that the defence is sufficient to withstand even the extreme flood event; however, the model does not include the railway bridge. Previous modelling work undertaken for an FCA for Park Lodge Hotel<sup>5</sup> indicates that a significant amount of flow energy is lost at the bridge structure and this, together with the sharp bend in the watercourse, results in increased levels upstream, particularly for the extreme flood event. Using results from this model, the 0.1% (1 in 1000) annual chance event water level immediately upstream of the bridge is estimated to be nearer 8.27mAOD. Hence, overtopping of the defence by around 370mm is expected during extreme flood events. The Park Lodge model confirmed that the defence is of a sufficient height to withstand the 1% (1 in 100) annual chance event with climate change.

Once the defence upstream of the bridge is overtopped, flood water will flow into a wedge shaped parcel of land that forms a broad channel between the two railway embankments. Flows will then gravitate west to a point where the Vale of Rheidol Railway crosses the A4120. From this point, overland flows are likely to be established once the level of flood water reaches the level of the railway line and the A4120 highway at approximately 6.4mAOD. Ground levels indicate that flood water can potentially flow simultaneously in three directions: south over the railway line, north into Llanbadarn Industrial Estate, and west along the railway corridor.

It is estimated that around 80% of the flow will weir over the railway embankment to the south and inundate the Blaendolau Playing Fields. The defence along the A4120 should protect the Parc y Llyn Retail Park until water levels in the field exceed approximately 6.3mAOD (a depth of approximately 1.5m). Water is most likely to return to the Afon Rheidol upstream of Pont Pen-y-bont prior to this point.

To the north, water may flow along the A4120 road into Llanbadarn and inundate the lower lying areas south of the A44. The land rises steeply to the north, and flood risk to the majority of sites in Llanbadarn does not originate from the Rheidol but from the culverted ordinary watercourses

<sup>4</sup> Environment Agency Flood Estimation Guidelines version2 Doc.No.197\_08 (2008); Environment Agency/DEFRA Science Report SC050050 – Improving the FEH Statistical Procedures for Flood Frequency Estimation (2008)

<sup>5</sup> Park Lodge Hotel Extension Flood Consequence Assessment, Atkins Report Number 5061096-DG-FCA2-D2, January 2009.

identified in Section 5. The one exception to this is the site identified as “Paddocks and Yard in Llanbadarn Fawr” (S0612) which is located just off the A4120.

Overland flows into Llanbadarn may propagate to the east and fill the low-lying area between the A44 and the main railway line identified by candidate sites S2001 and S0229. In addition to the overland flow route, there is also a risk to these sites of direct flooding from the Afon Rheidol due to the presence of flow routes through the main railway embankment. A two underpasses exist through the main railway line linking the riverside cycle path to the minor residential road of Parc yr Onnen (see Figure 4.3 below) and to the A44. Once water overtops the defence on the bend upstream of the Vale of Rheidol Railway Bridge, the pedestrian underpasses could allow flood waters to inundate the low-lying area to the north of the railway. Existing and proposed residential developments are at risk from flooding via this mechanism.

A culvert to the east of the pedestrian underpasses also exists and is known to have been the source of flooding in the past; it is unclear whether this risk has since been eliminated by provision of flap valve or similar.

**Figure 4.3 – One of Underpasses through Railway Embankment**



Previous studies have identified that the main overland flow path, once water overtops the defences, follows the railway corridor. The Vale of Rheidol Railway runs northwest towards Aberystwyth town centre. Ground levels of the Maes Mawr housing development in the Parc y Llyn area are elevated, and along the northern boundary gabion baskets have been used to retain the raised fill, creating a low-lying area between the raised ground and the mainline railway embankment. In the event of an extreme flood on the Afon Rheidol, this feature will act as a wide open channel for the conveyance of flood waters to the northwest. Overland flows will generally gravitate along this channel towards Aberystwyth; however, at the northwestern boundary of the Parc y Llyn site, raised ground associated with a former level crossing of the railways and an adjacent development interrupts the overland flow path. The raised ground restricts overland flows from continuing further west towards the town centre, and the impoundment of flow in the channel will cause water levels to rise until they exceed the level of the railway embankment.

We anticipate that water will weir into the Plascrug playing fields adjacent to the school and will also begin to flow along the railway corridor towards Aberystwyth. As flooding continues, inundation of the playing fields will occur. The level to which water would rise within the playing fields will be controlled by overland flow paths along Plascrug Avenue and along the railway corridor towards Aberystwyth.

In order to provide an estimate of the flood depths and extents, we have conceptualised a channel along Plascrug Avenue and have considered the headwater depth required to generate various flows. Flow from the floodplain back into the main river channel was conceptualised as being directed over the existing flood defence walls on the right bank of the Afon Rheidol. Generated



depths of flooding are below those expected by the tidal inundation of this area from overtopping of the same defence.

The extent of flooding from the Afon Rheidol predicted by work undertaken within this study matches closely with that shown on the Environment Agency Extreme Flood Outline Map. Hence the flood extent plans included within Appendix D of this report, Drawing Numbers 5037097.760/RCF/130 and 131 are based on the Environment Agency 1% (1 in 100) and 0.1% (1 in 1000) annual chance event outlines, respectively.

#### 4.4.2 Flood Risk from Plascrug Ditches

Historically, the Plascrug Ditches have been a source of flooding in the area. Small open channels feed into the main channel adjacent to the Plascrug Leisure Centre before entering a twin arch culvert within the playfield area. The exact route of the culvert is unknown, although it eventually proceeds to a surface water storage area under the Mill Street Car Park prior to discharging into the Afon Rheidol. The ditches are tidally influenced but no current tidal flooding problem has been reported.

The main risk of flooding from the ditches results from the anticipated insufficient capacity of the culverts and risk of blockage to these old structures. Overtopping of the channel in the vicinity of the Plascrug playing fields is likely during large storm events. The flow of water will follow similar paths to along Plascrug Avenue as previously identified.

## 4.5 Flood Risk from Sewers, Culverted Watercourses and Groundwater

### 4.5.1 Flood Risk from Sewers

A number of sewer flooding incidents are known to have occurred in the area over the years. These are mostly concentrated in the low-lying areas along Mill Street, Alexandra Road and Park Avenue, and adjacent to the high-tide harbour. Detailed investigation regarding the exact locations and cause of flooding will need to be undertaken as part of any site-specific FCA. At this strategic level, sewer problems are considered minor compared with the tidal flooding problem.

### 4.5.2 Flood Risk from Culverted Watercourses

In addition to the culverted sections of the Plascrug Ditches already mentioned, there are a number of other watercourses in the area that enter short sections of culverts.

The watercourses in Llanbadarn (see Section 5) enter a long culvert at the A44 (NGR SN600809) that runs under the A4120 before returning to an open watercourse just north of the railway lines. The watercourse remains mostly in an open channel adjacent to the road before reaching its discharge point just downstream of Pont Pen-y-bont. However, short sections of culvert exist to convey the watercourse under the railways lines and the road and these are unlikely to be of a sufficient size to convey extreme flood event flows. Waters overtopping the channel at the culvert entrances will flow towards the Llanbadarn Industrial Estate and across the Blaendolau Playing Fields. These areas have already been identified as at risk, and the extent of flooding from this source is considered insignificant compared to flooding from the Rheidol; however, the frequency of flooding from the ordinary watercourses identified is likely to be significantly greater. Anecdotal evidence suggests the occurrence of flooding as frequently as once in every five years (20% annual probability).

To the north of the town, the Penglais watercourse enters a culvert adjacent to Dan y Coed at NGR SN592819 and flows beneath the town along Penglais and North Roads before discharging onto the beach at the northern end of Marine Terrace. The capacity of the culvert is considered to be insufficient to carry flood event flows, and overtopping is probable. The frequency of overtopping has not been analysed, but possible flow paths have been determined from available Lidar data. We would expect flows to follow a route west down Penglais Road before turning southwest into the low-lying areas along Cambrian Street and Alexandra Road approaching the railway station. Flood waters would pond in the areas already identified as at risk from tidal

inundation. No additional candidate sites would be affected from the flow of water into the town centre area.

It should be noted that even where the anticipated flood risk from existing culverts is low, the Environment Agency generally advises against development over the top of existing culverts because inaccessibility can exacerbate problems should they develop in the future. With respect to Main Rivers, the Environment Agency has direct consenting powers; however, with respect to the culverted ordinary watercourses within Aberystwyth the EA can only provide advice to the planning authority and development could potentially proceed where benefits outweigh risks. Consideration of the Environment Agency's advice is particularly applicable to the new developments proposed in the Mill Street Car Park area (sites S3003 and S3072).

#### 4.5.3 Flood Risk from Groundwater

Susceptibility to groundwater flooding was not included as a part of this assessment. Risks associated with groundwater should be investigated as part of any proposed development.

## 4.6 Flood Risk from Surface Water Runoff

Surface water runoff is not considered to be a significant risk factor for the town centre sites. Land slopes toward the floodplain area in which much of the current development lies. Existing natural watercourses have been supplemented by man-made drainage channels, and much of the expected surface runoff is collected by these channels and routed through the area in culverts to discharge into the Afon Rheidol and the sea. Proposals for any development should include assessment of current surface runoff routes and channel/ culvert capacities and give due consideration to the use of SuDs as required by TAN15.

For the sites identified to the south of the Rheidol a review of Lidar data was undertaken to assess possible flow routes from the high ground identified at Pendinas. The hill area was once a fort and is now traversed by several public footpaths leading to the Wellington Monument at the peak. There are no defined watercourses, and due to the limited catchment area and natural ground surface, limited runoff is expected. The risk to the three sites located at the north and west of the hill is considered to be low.

## 4.7 TAN15 Constraints

As previously mentioned, the majority of the town centre sites fall within the Environment Agency extreme flood outline. Some sites are considered to benefit from the flood defences located along the Afon Rheidol and hence are classified as TAN15 Zone C1. The undefended areas have a higher risk of flooding and fall within TAN15 Zone C2. To the south of the river, a few of the candidate sites fall within TAN15 Zone A.

TAN15 has different requirements for sites depending on the type of development proposed and the zones into which they fall.

Section 6 of TAN15 states that new development should be directed away from Zone C and towards suitable land in Zone A. Where development is proposed within Zone C it must meet the justification tests outlined within the section. Where consideration of a development site can be justified, the development must then meet the acceptability criteria detailed in TAN15 Section 7 and Appendix 1.

Development within Zone C1 or C2 must be flood free in the 1% (1 in 100) annual chance event with climate change, have acceptable consequences of flooding in the extreme [0.1% (1 in 1000) annual chance] event as defined by TAN15 A1.15, and must not cause flooding elsewhere. Table A1.15 requires consideration of the maximum flood depth within the site (as summarised in the table in Appendix C), the maximum rate of rise of floodwater, maximum speed of inundation, and maximum velocity within the site (as shown on Drawing Numbers 5037097.760/RCF/120 to 127). In addition, flood defences must be shown to be structurally adequate under extreme overtopping conditions, and an emergency flood plan, including flood warning system and identified evacuation routes, must be in place.

Emergency services and highly vulnerable development (as defined by TAN15 Section 5 and including residential development) should not be permitted within Zone C2.

All development, including that within Zone A (which has few constraints to development), must give due consideration to the management of surface water; guidance is provided in TAN15 Section 8. Any development will result in changes to the natural hydrology of the catchment as a result of increased runoff from impermeable ground and built-up areas. TAN15 states that SuDs should be employed to manage surface water runoff wherever possible, and if the use of conventional drainage systems is proposed, improvements to the status quo must be made and developers must give good reasons why SuDs cannot be implemented.

## 4.8 Summary of Flood Risk and Management

### 4.8.1 Candidate Sites S1027, S0131, S3002, S3061 and S3087

Development of the harbour sites will require careful consideration within site-specific FCAs. The sites fall within TAN15 Zone C2 and are at significant risk of tidal flooding.

Aberystwyth Harbour Garages (site S1027) are located on the narrow strip of land overlooking the harbour. Lidar data suggest that the majority of the site lies at a level of approximately 5mAOD, and tidal flooding may occur in the future [at the 0.1% (1 in 1000) annual chance event in 2079 (5.17mAOD) and the 0.5% (1 in 200) annual chance event in 2109 (5.35mAOD)]. Flooding could be addressed at a site-specific level by construction of a tidal defence wall in the locality or by raising ground levels given that modelling shows direct flooding at tide peaks and, due to the limited catchment area and site location, no risk of surface water runoff into the site has been identified.

Land at Y Lanfa (site S0131) lies between the 5 and 6mAOD elevation contours. Flooding near the end of the development design life is anticipated unless work to raise ground levels is undertaken. The land dips in the vicinity of the existing fire station and flooding to sites S3061 and S3087 would be anticipated prior to flooding of the Land at Y Lanfa unless site levels are raised. Ground raising works could be completed without impacts on flooding elsewhere given that the risk identified is tidal and water storage issues associated with fluvial flooding do not apply in this case.

Inclusion of housing has been proposed as part of mixed development at some of these sites. We conclude, however, that residential development cannot be permitted at these sites under TAN15 guidelines, but some development may be allowed. Consideration of the site access/ egress routes would be required as well as ensuring that the development sites themselves are flood free during the 1% (1 in 100) annual chance event with climate change.

### 4.8.2 Candidate Sites S0133, S1218, S0230, S0560 and S3100

The candidate sites to the south of the Afon Rheidol are proposed for residential development. The sites fall within TAN15 Zone A, and analysis of Lidar data confirms that they are all located above 10mAOD and are at no risk from tidal or fluvial flooding.

No problems with developing these sites are anticipated, providing adequate consideration is given to the management of surface water runoff.

### 4.8.3 Candidate Sites S0799 and S3055

The Old College is located on the coast just north of the Castle. The sites lie at a level of around 8.5mAOD and are not considered to be at risk from tidal still water levels; however, detailed consideration of the risk from wave action should be made as part of site-specific FCAs prior to any development proceeding. A degree of protection from wave overtopping may be afforded by the rock outcrop in the area, but modelling of the wind and wave climate will be required to confirm this.

Other than the risk from wave action, no other flood risks have been identified for the sites.

#### 4.8.4 Candidate Sites S3052, S3062 and S3070

These candidate sites have been specified for mixed use. They lie at a level of approximately 6mAOD and hence are not considered to be at significant risk from tidal still water levels. However, their location close to the sea front suggests that the risk of flooding from wave overtopping could be high, particularly at site S3062.

A site-specific FCA will be required to investigate this risk further and determine whether management or mitigation of the flood risk is possible.

#### 4.8.5 Candidate Sites S1031 and S0247

Two candidate sites at the northern edge of Aberystwyth are allocated for housing. Both sites are situated above the 8mAOD contour, and modelling confirms that they are not at risk of flooding from tidal inundation. Risks associated with wave overtopping are also considered to be negligible due to their location away from the immediate sea front; the terraced properties along Marine Terrace will provide protection to properties behind, and sites S0131 and S0247 will not be flooded from wave overtopping.

No significant problems are anticipated in the development of these sites, providing developers consider the management of surface water runoff from the steeply sloping land to the northeast.

#### 4.8.6 Candidate Site S3094

Candidate site S3094 lies just outside TAN15 Zone C1 at a level of between 5 and 6mAOD. Modelling work suggests that this site will be partially inundated with tidal flooding at the 0.1% (1 in 1000) annual chance event in 2059 and the 0.5% (1 in 200) annual chance event in 2079. However, due to the sloping nature of the site, inundation remains partial even at the most extreme event [0.1% (1 in 1000) annual chance event in 2109], and access/ egress routes onto Loveden Road and Vaynor Street will remain flood free.

Partial development of the site should be permissible, and depending on the layout and use of the proposed development, even full development of the site may be possible whilst still meeting TAN15 requirements.

#### 4.8.7 Candidate Sites S3006 and S3092

The Cinema in Bath Street is considered a high risk location. The sites lie at a level of approximately 5mAOD and are expected to be flooded from tidal inundation during the 0.1% (1 in 1000) annual chance event in 2079 and the 0.5% (1 in 200) annual chance event in 2109.

There is also a significant risk that wave overtopping along the coast will flow down Terrace Road and Bath Street flooding the cinema sites at an event sooner than 2079. A greater frequency of flooding is also anticipated from wave overtopping events.

Despite the above risks, the sites fall within TAN15 Zone B and justification of the development of the sites may be possible under TAN15 guidelines. The proposed development type is unclear, but for the worse case of a 0.1% (1 in 1000) annual chance event over a 100 year design life, the maximum depth of flooding expected to occur does not exceed 600mm, and velocities do not exceed 0.15m/s. With reference to the indicative guidelines in TAN15 A1.15, it may be possible that development of the sites could proceed.

Detailed FCAs will be required and consideration of the risk from wave action over the anticipated development design life will be necessary to determine whether the flood risk associated with development of the sites is considered acceptable or not.

#### 4.8.8 Candidate Site S3088

The Bay Hotel has been proposed for redevelopment as housing. Once tidal waters flood the Cinema in Bath Street they are expected to pool in this area, and modelling indicates the depths of flooding may exceed 1m during the 0.1% (1 in 1000) annual chance event in 2109.



In addition, the risk of flooding from wave overtopping in this area has been identified as high. The likelihood of being able to justify this site for a highly vulnerable development such as residential use is low, and under TAN15 guidelines development of this site should be discouraged.

#### 4.8.9 Candidate Sites S0132, S3000 and S3097

Three developments are proposed for the Old Post Office area in Great Darkgate Street. The sites lie just outside of TAN15 Zone C1 at elevations between 6 and 7mAOD. They are not shown to be effected by tidal inundation, and the town centre location ensures that wave overtopping will not be a problem either.

Development of the sites is considered possible although a number of issues will need to be considered as part of site-specific FCAs. Site-specific reports must confirm that acceptable access/ egress routes are available for emergency services during flood events given that the tidal inundation modelling indicates that this area of the town maybe cut off during extreme flood events in the future.

Existing site drainage services should be accessed and detailed investigations into the locations and causes of sewer flood incidents in the locality should be undertaken to give a full understanding of possible problems. TAN15 requires that use of SuDs be considered for the site, but given the location and nature of redevelopment it is expected that a developer would propose use of existing drainage systems; confirmation of their suitability is vital to ensure problems in other locations do not result from development at these sites.

#### 4.8.10 Candidate Site S3053

The site of the now burnt down Tabernacle Church on Mill Street is proposed for residential development. Located between 7 and 8mAOD the site is expected to remain flood free during extreme tidal flood events.

As with the Old Post Office site, development of this site is anticipated to be possible under TAN15 providing a site-specific FCA is produced that addresses the issue of access/ egress routes.

#### 4.8.11 Candidate Sites S3003, S3072, S3073, S3001, S3074, S3093, S0600, S3004, and S3075

Development of the Mill Street Car Park along Park Avenue and of the Vale of Rheidol Railway land highlighted will be difficult to justify under TAN15 guidelines. Although the sites fall within TAN15 Zone C1 and theoretically benefit from flood protection, modelling work has demonstrated that tidal overtopping is likely to occur even under current conditions and that these sites will be the first to be flooded. Flood depths and velocities encountered in the future will be unacceptable, and management of the risks will be problematic.

The sites are also at risk from flooding from other sources; overland flow routes from fluvial flooding of the Afon Rheidol upstream have been identified, and there is a risk of flooding from the Plascrug Ditches. Sewer flooding in the area has also been reported.

As mentioned in Section 4.5.2, in addition to TAN15 imposed restrictions, development at the Mill Street Car Park site (S3003 and S3072) would be discouraged by the Environment Agency since it would involve construction over an existing culvert.

Development of any of these sites will require careful consideration.

#### 4.8.12 Candidate Site S0798

The Vicarage Fields site slopes from less than 2mAOD at the southwest end adjacent to the Plascrug Ditch up to approximately 7mAOD at the northeastern end. The site falls partially with TAN15 Zone C1 and partially within Zone A.

Tidal inundation modelling indicates that about half of the site will flood during a 0.1% (1 in 1000) annual chance event in 2109. Flooding from other identified risks, including overland flow routes from fluvial flooding of the Afon Rheidol and flooding from the Plascrug Ditches, is not anticipated to exceed this risk.

Development of the flood-free part of the site should not be a problem. A site-specific FCA will need to confirm that emergency access/ egress routes are available; Llanbardarn Road joining to the A487 to the north is likely to be considered an acceptable route.

Development of more than 50% of the site may be considered, but the management of flood risk within the portion subject to tidal flooding may prove difficult.

#### 4.8.13 Candidate Sites S0071, S1018, S3005, S1015, S0652 and S3077

As mentioned in Section 4.3.1, the Parc y Llyn and Plascrug areas are flooded from tidal inundation as waters spread along the railway line from the west. Modelling shows that the Parc y Llyn Ditch will be inundated during a 0.5% (1 in 200) annual chance event in 2079 or a 0.1% (1 in 1000) annual chance event in 2059. The Plascrug Leisure Centre (site S0071) will also be flooded during these events. As tide levels rise above 5mAOD, the ambulance station (sites S1015/ S0652), Land behind Ty Clyd (S3077) and then the WAG and Ceredigion CC offices (site S3005) become inundated. During the 0.1% (1 in 1000) annual chance event in 2079, a tide level of 5.17mAOD, only part of site S3005 is flooded, and depths are generally less than 600mm. However, when tide levels rise to 5.35mAOD [the 0.5% (1 in 200) annual chance event in 2109] the site is shown to be completely covered, and at a tide level of 5.58mAOD [the 0.1% (1 in 1000) annual chance event in 2109] depths across the majority of the site exceed 600mm. Velocities remain below 0.15m/s at all six sites for all the modelled flood events.

Because the sites are located within TAN15 Zone C2 only less vulnerable development, if any, may be considered. The threshold frequency for tidal events for both commercial/ retail and industrial properties is the 0.5% (1 in 200) annual chance event<sup>6</sup>. Assuming a 100 year design life, this means that the sites must be shown to remain flood free during the 0.5% (1 in 200) annual chance event in 2109. Review of the modelled event indicates that none of the site areas remain flood free and hence development cannot comply with the indicative acceptance criteria within TAN15.

Modelling does show, however, that parts of sites S3005, S0071 and S3077 are likely to have flood depths of less than 600mm; and therefore, site re-profiling may enable the development of some of the site areas providing other flood risks can be addressed. The Plascrug Ditch runs through the centre of site S0071, and flooding in the vicinity of the ditch due to limited culvert capacity is anticipated. In addition, overland flow paths from fluvial flooding of the Afon Rheidol may affect the sites.

Development of any of these sites will require careful consideration. Development may be impossible to justify for the Parc y Llyn Ditch (site S1018) or the ambulance station (sites S1015/ S0652). Development of the Plascrug Leisure Centre (site S0071) and Land behind Ty Clyd (S3077) will require extensive site-specific FCAs to assess potential measures for the management of flood risks. Site-specific FCAs have already been completed for the WAG and Ceredigion CC offices (site S3005), which are currently under construction.

#### 4.8.14 Candidate Sites S0346 and S3076

Land at Plas Mansion/ Vicarage Gardens slopes steeply from a level of approximately 6mAOD along Quebec Road to almost 30mAOD at the northern edge of the site. Modelling work suggests that the road forms the northern boundary to any expected tidal inundation of the area and the sites will remain flood free.

The majority of the runoff from the area north of the sites is anticipated to flow southeast toward the watercourses in Llanbadarn, and the catchment area draining directly to the sites in question is considered insignificant.

No notable flood risks have been identified for these sites, and because they lie within TAN15 Zone A, no problems with developing the sites are anticipated.

<sup>6</sup> TAN15 section A1.14

#### 4.8.15 Candidate Sites S0896, S0800 and S1038

The Blaendolau Playing Fields and adjacent land are at risk of flooding from the Afon Rheidol. As discussed in Section 4.4.1, previous studies indicate that the defence immediately upstream of the Vale of Rheidol Railway Bridge is overtopped by approximately 370mm during extreme [0.1% (1 in 1000) annual chance] flood events. Flooding to site S1038 is certain. As flood waters rise, around 80% of overland flow is expected to weir over the railway embankment to the south and inundate the Blaendolau Playing Fields prior to discharging back into the Afon Rheidol immediately upstream of Pont Pen-y-bont.

Modelling of the overland flows has not been undertaken as part of this study; therefore, it is impossible to determine the flow velocities likely to be encountered across the fields, but we anticipate them to be significant. In order to determine compliance with TAN15 acceptability criteria, two-dimensional modelling of the overtopping of the flood defences and subsequent overland flows will be required as part of any site-specific FCA.

In addition to the fluvial flood risk from the Afon Rheidol, risks of tidal inundation and flooding via overland flow paths from the Llanbadarn watercourses to the north also exist.

The sites are located within TAN15 Zone C2, and we anticipate significant difficulties in justifying any development at these sites. Development should therefore be discouraged.

#### 4.8.16 Candidate Site S0612

Tidal inundation modelling indicates that the Paddocks and Yard in Llanbadarn Fawr are on the edge of the flood risk area. The site will remain flood free until 2079, at which point a 0.1% (1 in 1000) annual chance event will result in flooding of a small area of site to the southeast; flood depths will be less than 600mm and localised raising of the site could ensure that no flooding occurs. However, the site is proposed for residential development and a design life of 100 years must be considered. TAN15 A1.14 specifies the threshold frequency for tidal flooding of a residential development as the 0.5% (1 in 200) annual chance event; in 2109 over half of the site will be flooded if a 0.5% (1 in 200) event occurs, suggesting that development of much of the site cannot be justified under TAN15 guidelines. Re-profiling of the site may be possible, but it is likely that such works would exacerbate flooding on adjacent land and hence would not be allowable under TAN15.

In addition to the tidal risk, there are risks from overland flow paths from fluvial flooding. Overtopping of both the Afon Rheidol and the ordinary watercourses to the north of the site could result in further flooding to the Paddocks and Yard. These risks are reflected in the fact that the site is located within TAN15 Zone C2.

Considering the various flood risks associated with the site, we anticipate significant difficulties in justifying the proposed housing development under TAN15 guidelines.

#### 4.8.17 Candidate Sites S3071, S2001 and S0229

These three candidate sites are situated in the low-lying area north of the main the railway embankment. The area is defined as TAN15 Zone C2 and is known to be at risk of flooding from the Afon Rheidol. As mentioned in Section 4.4.1, once the river defences are overtopped, a direct flood route exists through the pedestrian underpass in the vicinity; in addition, a culvert to the east has previously been known to allow waters through the railway, although this may now be blocked by flap valve or similar. Once north the railway, waters are anticipated to spread out in the area south of the A44, which is elevated above the floodplain at this point.

The sites are also considered to be at risk from overland flow paths generated from the overtopping of watercourses in Llanbadarn. Potential flow paths exist down the A44, past the Llandabarn Industrial Estate and into the low-lying area.

Development of these sites should be discouraged. The flood risk associated with development is considered to be unacceptable, and justification will be difficult under TAN15 guidelines.

#### 4.8.18 Candidate Site S3068

To the north of the A44 road the land slopes steeply and the vacant plot near Bryn Rheidol, Pwllhobi Terrace, is believed to be a minimal risk of flooding. The site lies outside of TAN15 Zone C2 and no flooding directly from the Afon Rheidol or from overland flow routes associated with this source is anticipated. Road drainage for the residential terraces immediately to the north of the site will collect any rainfall runoff from the hillside. Possible flood water routes from overtopping of watercourses in Llanbadarn are also expected to bypass the site; therefore, no problems with developing this site are anticipated.

# 5. Llanbadarn

## 5.1 Site Description

### 5.1.1 General Site Description

Llanbadarn Fawr is a village located east of Aberystwyth at NGR SN605805. Existing housing is located off of the A44 which runs west to meet the A487. The A487 forms the southern boundary of the area. Central to the area is the Llanbadarn campus of Aberystwyth University. Over much of the remaining development area, current land use is predominately agricultural.

The Waun Fawr and Llanbadarn Fawr watercourses flow generally north to south-southwest through the area, joining and entering a culvert beneath the A44.

The area is separated from the flood zone along the Afon Rheidol by the Vale of Rheidol Railway lines and the A44.

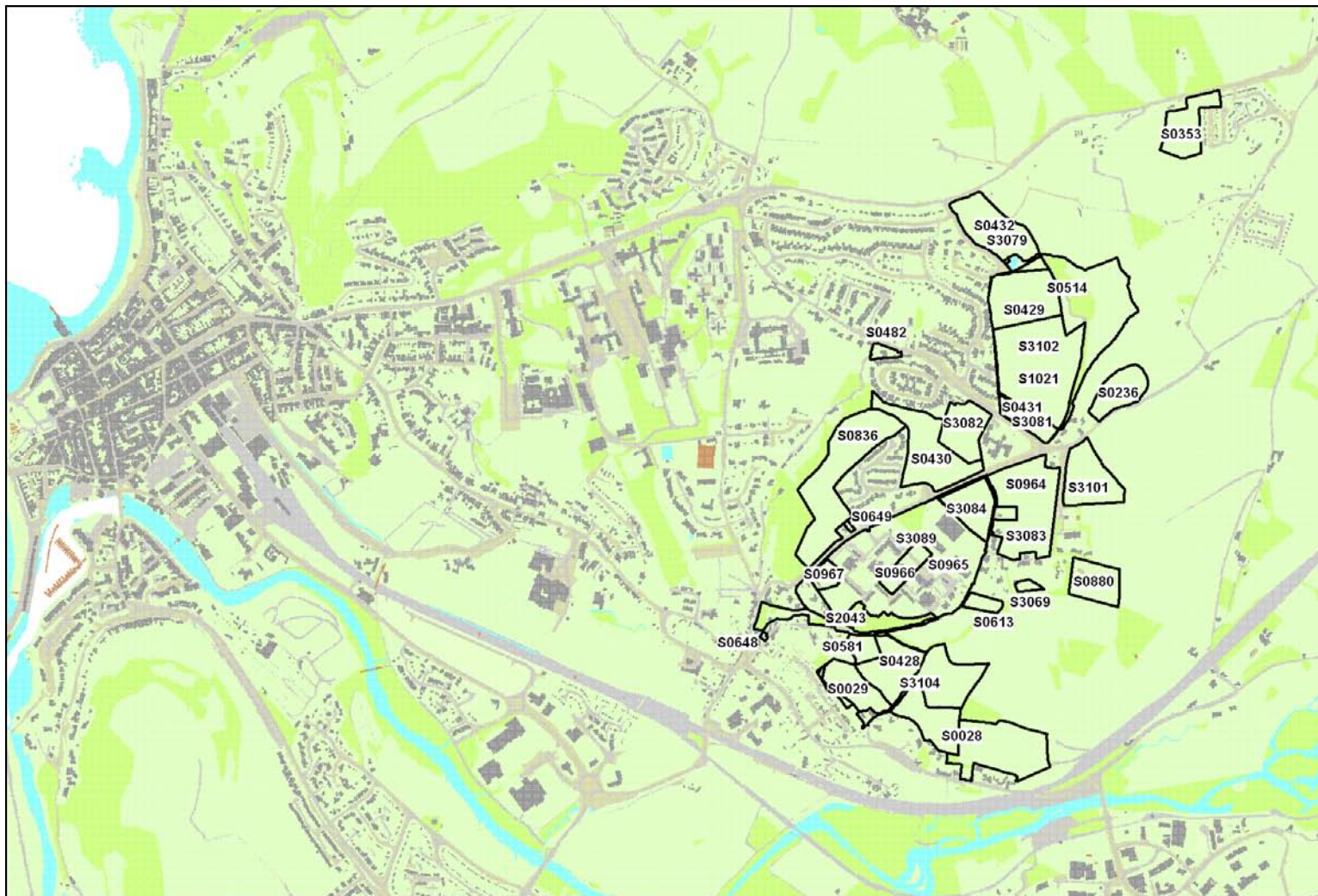
### 5.1.2 Proposed Development

Fourteen of the 33 proposed development sites are located adjacent to either the Waun Fawr or Llanbadarn Fawr watercourses. Eight of the remaining sites are situated on the hillside above where the drainages begin. The other sites are set back from the channel boundaries. The majority of the candidate sites are currently under agricultural use, although also included are four sites that cover the Llanbadarn campus of Aberystwyth University. Development of the Llanbadarn area will expand the residential extent of Aberystwyth further to the east.

The candidate sites are shown on Figure 5.1 and summarised in Table 5.1 below.



Figure 5.1 - Candidate Site Locations



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Table 5.1 - Candidate Sites Summary

Site ID	Name	NGR	Development Type	Design Life
S0432	Land at Lon Llewelyn	SN606820	Housing	100
S3079	Land at Lon Llewelyn	SN606820	Mixed	100
S0429	Land behind Maesceinion	SN607817	Housing	100
S0514 <sup>7</sup>	Cefn Hendre	SN608818	Housing	100
S0353	Land at Clawdd Helyg, Commins Coch	SN612823	Housing	100
S1021	Waunfawr Field, Waunfawr, Aberystwyth	SN608816	Other – Retain as agricultural/ no development	70
S3102	Disused Quarry	SN607818	Housing	100
S3081	JHLA Quarry		Housing	100
S0431	Land opposite Hafod y Waun nursing home	SN607815	Housing	100
S0236	Land adj. Llys Dewi, Waun Fawr, Aberystwyth	SN610816	Housing	100
S0482	Masawelon, Waunfawr	SN603817	Housing	100
S0430	Land adj. to Hafod y Waun nursing home	SN605814	Housing	100
S3082	Erw Goch Field	SN606815	Mixed	100
S0836	Land at Primrose Hill Llanbadarn Fawr	SN602814	Housing	100
S0649	Brynteg, Primrose Hill	SN603812	Housing	100
S3101	North Depot, Field near Hafod Y Waun Nursing Home	SN609814	Housing	100
S0964	Land rear of Ty Gwyn	SN608813	Unsure	100
S3083	Land rear of Ty Gwyn	SN608813	Mixed	100
S3084	Livery. Primrose Hill near College	SN606813	Mixed	100
S3089	Llanbadarn Fawr Campus	SN604811	Unsure	100
S0965	Llanbadarn Fawr Campus	SN604811	Housing	100
S0966	Llanbadarn Fawr Campus (middle)	SN604811	Housing	100
S0967	Llanbadarn Fawr Campus	SN602811	Housing	100
S2043	Primrose Hill	SN604809	Other – Retain as cycle/ walk way; Open space/ recreation	70
S0613	Field in Llanbadarn Fawr	SN606810	Housing	100

<sup>7</sup> Site mislabelled as S0353 in Phase 1 report. Correction has been made for this report and site S0353 added to area.

Site ID	Name	NGR	Development Type	Design Life
S3069	Land behind Plas Lluest	SN607811	Housing	100
S0880	Plas Lluest Plant Nursery site	SN609811	Housing	100
S0581	Field near Llanbadarn Fawr	SN603809	Housing	100
S0428	Field at Ffynon Dderw, Llanbadarn Fawr	SN603808	Housing	100
S0028	Land at Pendre, Llanbadarn Fawr	SN606806	Housing	100
S0029	Land at Ffynon Dderw, Llanbadarn Fawr	SN603807	Housing	100
S3104	Llanbadarn Farm	SN604808	Housing	100
S0648	Glenalmond, Llanbadarn Fawr, Aberystwyth	SN604805	Housing	100

### 5.1.3 Hydrological Situation

The candidate sites to the north are located on high ground east of existing residential development. The catchment areas are small and therefore no defined drainage features are present.

The Waun Fawr watercourse flows through a steep-sided canyon that forms the western boundary of the area. Three of the candidate sites are located adjacent to the canyon to the east. The Llanbadarn Fawr drainage near the eastern boundary of the area follows a slightly less confined route, passing adjacent to eight of the candidate sites. Additional sites are situated south of the Llanbadarn Fawr watercourse on hillsides above existing residential development along the A44; no defined channels are present. The land generally slopes to the south toward the residences and the A44.

Between the Waun Fawr and Llanbadarn Fawr watercourses lies the Llanbadarn campus. The ground surface across the campus generally slopes to the southwest, and a small drainage ditch at the southern end of the campus empties into the Llanbadarn Fawr channel.

The Waun Fawr and Llanbadarn Fawr watercourses join near the downstream extent of the area and enter a culvert at the A44. Two candidate sites are located adjacent to the confluence of the two watercourses. The culvert runs under the A4120 before returning to an open watercourse just north of the Vale of Rheidol Railway.

## 5.2 Data Review and Analysis

### 5.2.1 Information Available

A review of the available data has included the following:

- TAN15 Development Advice Map;
- Environment Agency Extreme Flood Outline Map;
- STAM Database; and
- Light Detection and Ranging (Lidar) data.

### 5.2.2 Analysis Approach

In general, the candidate sites identified on the higher ground to the north of the watercourses were categorised as Low Risk during Phase 1, and sites that border the watercourses were considered Medium Risk. A site investigation was conducted since the Phase 1 assessment was completed in order to more accurately delineate the courses of the Waun Fawr and Llanbadarn



Fawr channels. As a result, three sites that were previously considered Medium Risk (S0649, S0028 and S0029) have been changed to Low Risk as they are set back from the confirmed drainage courses. Two sites that were previously considered Low Risk (S0965 and S0581) have been changed to Medium Risk because they were found to be adjacent to the watercourse. These changes are not reflected on Drawing Number 5037097.760/RCF/002 in Appendix A, which shows the initial Phase 1 categorisation.

All of the sites in the area fall within TAN15 Zone A and are outside the Environment Agency extreme flood outline; therefore, a detailed assessment is considered unnecessary at this stage, and a strategic assessment is considered sufficient to understand the risks associated with development in this area and provide initial guidance for the management of the identified risks.

Although the sites are outside the Environment Agency flood zone for the Afon Rheidol, the flood boundary is shown to extend as far north as the A44. Because of the close proximity to the southern sites in the area, the potential for flooding from the Afon Rheidol was considered.

Assessment of this area has included:

- Hydrological assessment of the Waun Fawr and Llanbadarn Fawr watercourses and construction of a HEC-RAS steady-state hydraulic model;
- Review of likely overland flow paths using Lidar data;
- Consideration of sources of flooding from the Afon Rheidol (e.g. via underpasses beneath the Vale of Rheidol Railway); and
- Check for recorded sewer flooding.

## 5.3 Flood Risk from Main Rivers and Ordinary Watercourses

### 5.3.1 Flood Risk from Waun Fawr and Llanbadarn Fawr Ordinary Watercourses

The aim of undertaking the construction of a hydraulic model of the Waun Fawr and Llanbadarn Fawr watercourses was to assess the flood risk to the candidate sites that border the channels.

The modelling extent was defined from the headwaters of the watercourses downstream to the entrance to the culvert at the A44 as shown on Drawing Numbers 5037097.760/RCF/140 and 141. A walkover inspection of the study area was undertaken in June 2009 which focused on confirming the drainage paths, estimating the hydraulic roughness of the channels, visually assessing the steepness and appearance of the watercourses, and documenting any existing structures. The model cross sections were generated from Lidar data (see drawing for locations); a full topographic survey was not considered an appropriate use of resources for this level of assessment.

An initial inspection of the model suggested that the Lidar may not accurately capture the full depth of the channels. At first, it was thought that it would be better to assume that the channel containing flows less than QMED was not represented in the model and that the model should be used only to route flows exceeding QMED. After further consideration, however, it was decided to omit a QMED reduction and route the full range of flows using the model in order to give a conservative estimate of the flood risk. More detailed modelling of the watercourses will be required at site-specific FCA stage to confirm the exact flood extents.

Final 1% (1 in 100) annual chance event with climate change and 0.1% (1 in 1000) annual chance event flows were estimated to be 4.1 and 7.1m<sup>3</sup>/s in the Waun Fawr watercourse and 1.9 and 3.4m<sup>3</sup>/s in the Llanbadarn Fawr watercourse.

The predicted flood extents for the 1% (1 in 100) annual chance event with climate change and 0.1% (1 in 1000) annual chance events are shown on Drawing Numbers 5037097.760/RCF/140 and 141. The outlines are nearly identical at the scale of the drawings because of the small difference between the predicted water-surface elevations combined with the steepness of the topography along the watercourses.

### Waun Fawr Watercourse

A small portion of candidate site S0482 that sits at a relatively low elevation adjacent to the channel is predicted to be at risk of flooding during both the 1% (1 in 100) annual chance event with climate change and the 0.1% (1 in 1000) annual chance event. The site is located at the upstream extent of the model, however, and these results should be considered indicative. Downstream, modelling indicates that flows during both events are completely contained within the canyon, presenting no flood risk to the adjacent sites S0430 and S0836. The predicted water levels during the two events differ by 0.08 to 0.19m, too narrow a margin to appear as separate outlines on the drawings.

At Primrose Hill, the channel enters a culvert beneath the road; the culvert was not explicitly modelled for this assessment because it was not considered cost effective to obtain survey data for the structure at this stage. Instead, Lidar data were examined to determine the likely overland flow paths should the culvert become blocked or its capacity exceeded. The data suggest that water that overtops the culvert would flow overland toward the south, entering the road and either crossing it and re-entering the channel downstream or continuing along the road. The potential at-risk area is shown on the drawings.

### Llanbadarn Fawr Watercourse

Upstream of the confluence with the Waun Fawr, modelling indicates that flow in the Llanbadarn Fawr watercourse is contained within a defined channel during both the 1% (1 in 100) annual chance event with climate change and the 0.1% (1 in 1000) annual chance event. The predicted water surface elevations during the two events differ by 0.05 to 0.17m; as in the case of the Waun Fawr, this is too narrow a margin to appear as separate outlines on the drawings. The modelled flood outlines indicate no flood risk to the majority of the sites adjacent to the watercourse (sites S3069, S0613, S0428, S0965, S3089, S3104 and S0581). Site S2043 encompasses the channel itself; therefore, flood risk exists in the portions of the site that include the channel adjacent slopes.

During the June 2009 site investigation it was discovered that the Llanbadarn Fawr watercourse has multiple culverted sections where it flows adjacent to sites S0428, S0965, S3089, S3104 and S0581 and through site S2043. These sections were not explicitly modelled; however, Lidar data were examined to determine potential overland flow paths should the culvert become blocked or overtopped. The data show that all three sites slope down relatively steeply toward the watercourse; therefore, it is anticipated that water that overtops the culverts would be contained within the defined valley as indicated on the drawings.

At and downstream of the confluence of the Waun Fawr and Llabadarn Fawr watercourses, the topography is relatively flat, resulting in a slightly greater extent of flooding during the 0.1% (1 in 1000) annual chance event than during the 1% (1 in 100) annual chance event with climate change. A risk of flooding is anticipated during both events at candidate sites S0648 and S2043. Inundation of approximately 30% of site S0648 is predicted for the 0.1% (1 in 1000) annual chance event. The model extent ends a short distance downstream of the site where the channel enters a culvert at the A44.

Potential flooding caused by overtopping at the culvert entrance is discussed below.

#### 5.3.2 Flood Risk from Afon Rheidol

Section 4: Coastal & Town Centre Areas of this report includes a discussion of the potential flood risk caused by overtopping of an existing defence located along the right bank of the Afon Rheidol between the railway lines south of the A44 and the Llanbadarn area. The assessment concludes that overtopping of the defence is likely during the 0.1% (1 in 1000) annual chance event. Once the defence is overtopped, flood water is expected to flow west to where the Vale of Rheidol Railway crosses the A4120 and then potentially north along the A4120 into the Llanbadarn area. Overland flows into Llanbadarn may propagate to the east, inundating lower lying areas south of the A44.

Lidar data show that land rises steeply to the north of the A44; therefore, no risk of flooding is anticipated at the Llanbadarn sites considered in this section. Access to the sites from the A4120 and A44 may be affected, however.

## 5.4 Flood Risk from Sewers, Culverted Watercourses and Groundwater

### 5.4.1 Flood Risk from Sewers

A single sewer flooding incident was reported on 5<sup>th</sup> October 2008 on Primrose Hill. Sewage was described coming from the manhole in the middle of the road during heavy rain. Anecdotal evidence received from Ceredigion CC indicates that the Llanbadarn Fawr culvert beneath the A44 and A4120 blocks during events as low as the 20% (1 in 5) annual chance event, causing water to back up and flood out of the manholes in the area. Such an occurrence may explain the October 2008 incident.

Given the relatively high annual probability of culvert blockage, the risk of sewer flooding in the vicinity of the culvert is considered high. The area north of the A44 at risk of flooding from this source was estimated recurring flooding at the location of the October 2008 incident. Flood waters are anticipated to flow down Primrose Hill, potentially continuing to the west along Heol-y-Llan or to the east toward the A44; the estimated at-risk area is shown on the drawings.

### 5.4.2 Flood Risk from Culverted Watercourses

Culverted sections are present on both the Waun Fawr and Llanbadarn Fawr watercourses. On the Waun Fawr, a short culvert is located just downstream of site S0482. Water that overtops the culvert would likely flow across the road and back into the open watercourse downstream as indicated on the drawings. Downstream on the Waun Fawr, overtopping of the culvert beneath Primrose Hill poses no flood risk to the candidate sites although other properties may be affected as shown. Flood water may cross the road and re-enter the open watercourse or continue downhill along Primrose Hill. Site-specific FCAs for development adjacent to the Waun Fawr should consider possible adverse effects on Waun Fawr flows and the potential for flooding at Primrose Hill.

As discussed above, water that overtops the culverts on the Llanbadarn Fawr is anticipated to remain within the well-defined valley, affecting only site S2043. The flood risk to other sites adjacent to the watercourse is considered low. This should be confirmed by site-specific FCAs.

Downstream of the confluence with the Waun Fawr, the Llanbadarn Fawr enters a long culverted section that begins at the A44. Anecdotal evidence received from Ceredigion CC indicates potential blockage and associated flooding once every 5 years (20% annual probability). As described in the previous section, culvert blockage is likely to cause sewer flooding upstream as well as flooding from overtopping of the culvert entrance itself. The risk of flooding from these sources is considered high based on the expected annual probability of occurrence. Lidar data were used to estimate the at-risk areas of both sources of flooding, which are shown on the drawings.

As indicated on the drawings, the A44 and adjacent properties would be directly affected by flooding associated with culvert blockage at the A44. No flood risk to candidate sites is anticipated, although site-specific FCAs should consider the effects of development on flows in the Waun Fawr and Llanbadarn Fawr which could influence the frequency of culvert blockage.

### 5.4.3 Flood Risk from Groundwater

Susceptibility to groundwater flooding was not included as a part of this assessment. Risks associated with groundwater should be investigated as part of any proposed development.

## 5.5 Flood Risk from Surface Water Runoff

Lidar data were analysed to determine likely overland flow directions resulting from surface water runoff in the area. Sites S3102, S0429, S0514, S1021, S3081 and S0431 are located in the north

of the area on a hilltop. The sites have minimal catchment areas but some steep slopes; therefore, some surface water runoff is anticipated. Sites S0353, S0432 and S3079 are also located on high ground but may experience surface water runoff from off site as indicated on the drawings. The catchment area above the sites is small, however, and thus the contribution is likely to be minimal. A similar situation is expected for sites S0236, S3101 and S0880. Runoff generated from these sites as a result of development will need to be managed to avoid adverse impacts to existing and proposed development located down slope.

Sites S0482, S0430, S3082, S0836, S0964, S3083, S3069 and S0649 are located on hillsides below existing development. It is assumed that surface drainage facilities in existing upslope developed areas are of sufficient capacity; therefore, the risk of surface water flooding from off site is considered low.

The Llanbadarn campus sites (S0965, S3084, S3089, S0966 and S0967) are situated on a relatively steep hillside and could have surface water runoff flowing through them; however, it is anticipated that the flows could be managed to reduce the risk of flooding. Runoff leaving the sites is directed toward the Llanbadarn Fawr watercourse.

Minimal risk of flooding from surface water runoff is anticipated at sites S2043, S0613, S0581, S0428 and S0648 where catchment areas are limited and runoff would drain directly to the Llanbadarn Fawr channel.

Sites S3104, S0029 and S0028 also have relatively limited and undeveloped catchment areas; however, the ground surfaces at the sites are steep and surface water runoff through the sites is expected. Runoff from upslope areas may also pose a risk to the sites as indicated on the drawings. The local influence of hedgerows on potential surface water drainage patterns has not been investigated. Runoff generated at the sites themselves would likely affect existing residential development to the south.

## 5.6 TAN15 Constraints

All of the sites in the Llanbadarn area fall with TAN15 Zone A. Fluvial and tidal flood risks are low and few constraints are given within TAN15 for development within this zone. It is important, however, that development proposals consider overland flow paths, the management of surface water runoff and risk from culverted sections of the watercourses. TAN15 notes that any development will result in changes to the natural hydrology of the catchment as a result of increased runoff from impermeable ground and built-up areas. Developers should ensure consideration of surface water requirements; Section 8 of TAN15 requires the use of SuDs wherever possible to manage surface water runoff. Where the use of conventional drainage systems is proposed, developers must give good reason why SuDs cannot be employed, and improvements should be made to ensure there is adequate capacity within existing sewers and culverts so that the proposed developments do not result in flooding elsewhere.

## 5.7 Summary of Flood Risk and Management

### 5.7.1 Candidate Sites S0353, S0432, S3079, S3102, S0429, S0514, S1021, S3081, S0431, S0236, S3101 and S0880

These sites are located on high ground away from the ordinary watercourses identified in the area. Catchment areas are limited; therefore, flood risk associated with surface water runoff is also considered minimal. No difficulties with developing these sites are anticipated; however, developers should address surface water requirements, particularly on steep slopes, and prevent adverse effects to off-site areas.

### 5.7.2 Candidate Site S0482

This site is located adjacent to the Waun Fawr ordinary watercourse, and a risk of flooding from the watercourse is anticipated for the low-lying portions of the site. As such, development of the site should be confined to the upslope portion, providing that flood-free access/ egress is ensured. Detailed modelling of the watercourse using topographic survey of the watercourse channel will be required as part of the FCA to confirm exact flood extents.

5.7.3 Candidate Sites S0430, S3082, S3083, S0964, S0836 and S0649

No risk of flooding from the watercourses in the area is anticipated at these sites. Assuming adequate capacity of existing sewers, no flood risk from off-site surface water drainage is anticipated.

5.7.4 Candidate Sites S0965, S3084, S3089, S0966 and S0967

The southern boundaries of sites S0965 and S3089 are adjacent to the Llanbadarn Fawr watercourse; however, the risk of flooding from this source is low. Although surface water runoff poses some risk of flooding at the sites, the risk is considered manageable. Developers should analyse existing sewer capacities and consider the surface water requirements of any new development.

5.7.5 Candidate Site S2043

This site is located along the Llanbadarn Fawr watercourse and includes the slopes adjacent to the channel. Information received from Ceredigion CC indicates that the preservation rather than development has been requested at this site, as it encompasses a historic garden and various Tree Preservation Orders.

If development was to be considered, it would only be possible on certain portions of the site. Although located within TAN15 Zone A, the low-lying areas of the site are at risk of fluvial flooding. The land rises away from the channel; therefore, development of the flood-free parts of the site should be possible if flood-free access/ egress can be provided.

5.7.6 Candidate Sites S3069, S0613, S0428 and S0581

These sites are located along the Llanbadarn Fawr watercourse. However, no risk of flooding at these sites is anticipated due to the steep nature of the hillsides adjacent to the channel. Drainage areas are generally small, and the risk of surface water flooding is considered minimal. Development of the sites may take place without issue.

5.7.7 Candidate Sites S3104, S0029 and S0028

These sites could be at risk of flooding from surface water runoff. Upslope areas are currently undeveloped. However, catchment areas are relatively limited; therefore, it is anticipated that the risk can be managed.

Surface water runoff generated at the sites could be managed through the implementation of SuDs. Proposed discharge into existing sewer/ highway surface water drainage networks will need to be agreed with the local drainage and highway authorities.

5.7.8 Candidate Site S0648

Although this site falls within TAN15 Zone A, flood risk posed by the Llanbadarn Fawr ordinary watercourse has been identified. Model predictions suggest that the lowest lying one-third of the site will flood during the 0.1% (1 in 1000) annual chance event. Further modelling of the watercourse using surveyed channel sections will be required as part of the FCA to confirm the exact extent of flooding anticipated.

The land rises away from the watercourse; therefore, development of the flood-free part of the site is possible providing that provision of flood-free access/ egress is confirmed in a site-specific FCA.

## 6. Glanyrafon Industrial Estate

### 6.1 Site Description

#### 6.1.1 General Site Description

The Glanyrafon Industrial Estate is located to the east of Aberystwyth, off the A44 at NGR SN610804. The site is located immediately south of the Vale of Rheidol Railway line; the railway line forms the northern border of the estate. To the south and east of the estate the land rises steeply. A number of minor watercourses on the hillside drain towards the estate and collect within the ordinary watercourse which runs along the southern boundary of the site.

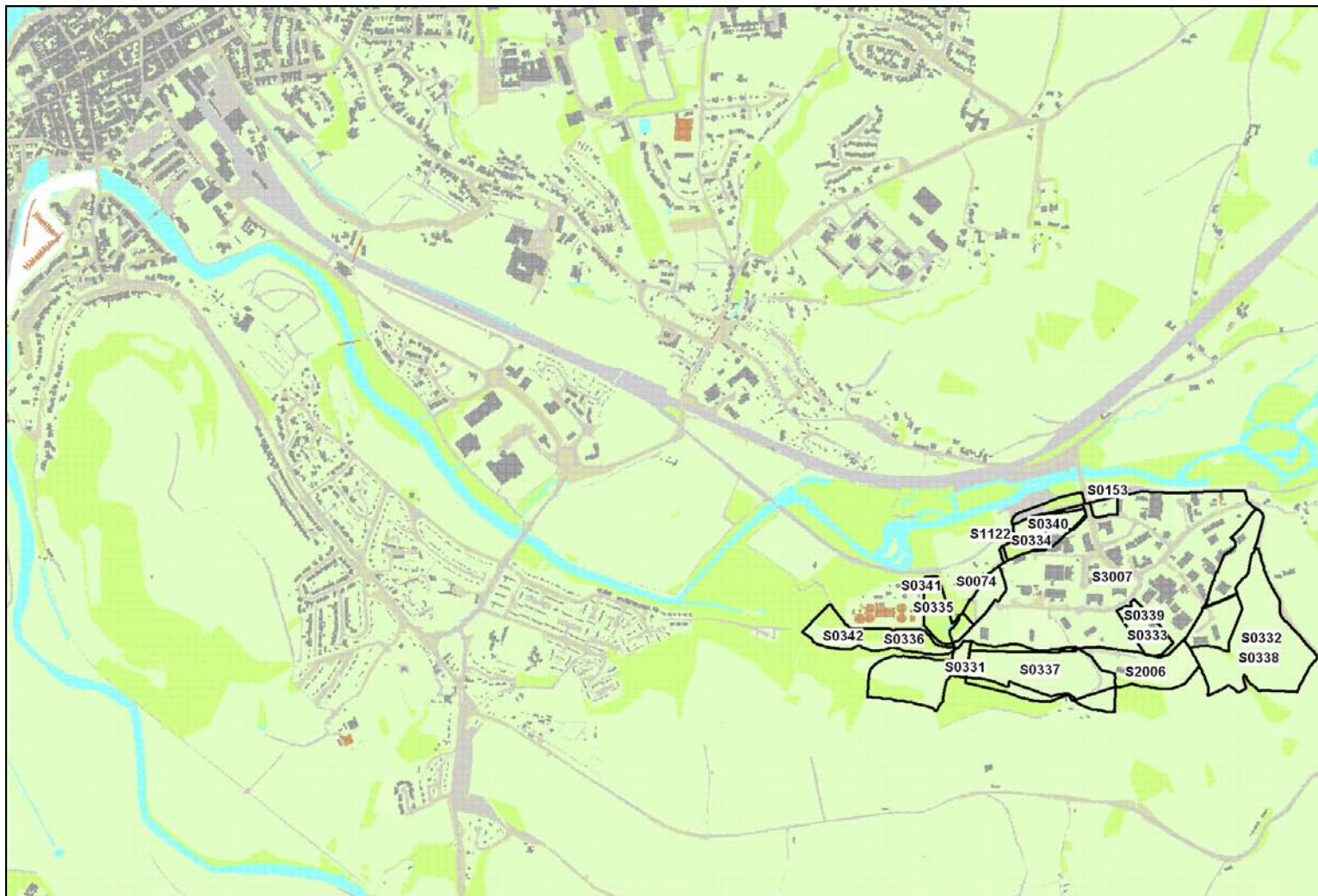
The industrial estate has been developed over the past 30 years or so; the initial highway and drainage infrastructure was constructed in the early 1970s and the first commercial buildings were constructed in 1976. The site is now a thriving employment site hosting a range of industrial and commercial businesses.

#### 6.1.2 Proposed Development

The majority of the site area has been identified on the LDP Candidate Sites Map for potential development. Because limited area is available for new development, many of the identified sites are redevelopments aiming to bring new businesses into the estate. The 17 candidate sites are shown on Figure 6.1 and summarised in Table 6.1 below.



Figure 6.1 - Candidate Site Locations



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Table 6.1 - Candidate Sites Summary

Site ID	Name	NGR	Development Type	Design Life
S0153	Land at the Gas Yard, Glanyrafon Estate, Aberystwyth	SN610804	Retail	70
S2006	Glanyrafon Industrial Estate	SN611801	Other – Car park	70
S0331	Land at Glanyrafon Estate	SN608799	Mixed	70
S0332	Land at Glanyrafon Estate	SN615800	Mixed	70
S0333	Land at Glanyrafon Estate	SN611800	Mixed	70
S0334	Land at Glanyrafon Estate	SN608803	Mixed	70
S0335	Land at Glanyrafon Estate	SN606800	Mixed	70
S0336	Land at Glanyrafon Estate	SN604800	Mixed	70
S0337	Land at Glanyrafon Estate	SN608799	Mixed	70
S0338	Land at Glanyrafon Estate	SN615800	Mixed	70
S0339	Land at Glanyrafon Estate	SN611800	Mixed	70
S0340	Land at Glanyrafon Estate	SN608803	Mixed	70
S0341	Land at Glanyrafon Estate	SN606800	Mixed	70
S0342	Land at Glanyrafon Estate	SN604800	Mixed	70
S1122	Glanyrafon Enterprise Park, Aberystwyth	SN609803	Employment	70
S3007	Glanyrafon Industrial Estate	SN610802	Employment	70
S0074	Field Opposite Ty Clyd	SN607801	Employment	70

### 6.1.3 Hydrological Situation

Glanyrafon Industrial Estate lies within the floodplain of the Afon Rheidol. In addition, a number of other watercourses flow through the area draining a significant catchment area to the south and east.

The estate has a history of flooding problems dating back to the late 1970s. To address problems of flooding from the Afon Rheidol, flood defences were constructed to the north of the estate circa 2000. The defences comprise raised earth embankments and steel pile flood defence walls.

## 6.2 Data Review and Analysis

### 6.2.1 Information Available

A review of the available data has included the following:

- TAN15 Development Advice Map;
- Environment Agency Extreme Flood Outline Map;
- STAM Database;
- HEC-RAS hydraulic model of the Afon Rheidol (2007 model supplied by the Environment Agency);
- Revised Rheidol flow data (agreed with the Environment Agency May 2009);

- Glanyrafon Industrial Estate Hydrological Assessment by Waterman Quadrant (October 2006);
- Topographic Survey of flood defences (undertaken by Infomap Chartered Surveyors (May 2009); and
- Light Detection and Ranging (Lidar) data.

### 6.2.2 Analysis Approach

The majority of the Glanyrafon Industrial Estate falls within TAN15 Zone C1 and the Environment Agency extreme flood outline. Although the area has the benefit of a flood defence it is classed as High Risk.

The flow regime within the area is complex, with multiple flow paths being generated within the area once the defences are overtopped. In order to provide information on the flood depths and velocities likely to be encountered within the area, two-dimensional modelling will be required. This will be a significant investment for the Council which is not justifiable as part of this strategic assessment. The majority of the potential development sites are being proposed by private developers, and the onus to prove that the flood risk at the sites can be acceptably managed is likely to be passed to them. For this strategic assessment, therefore, an appraisal of existing analyses and simple one-dimensional modelling techniques were considered sufficient to determine the overall flood risk issues at the Glanyrafon Industrial Estate and to provide guidance on further work to be carried out at a later date.

Analysis undertaken in compilation of this report has included:

- Update of the Environment Agency Afon Rheidol hydraulic model with new hydrological flow data;
- Comparison of topographic survey, Lidar and hydraulic model data;
- Review of the hydrological flood assessment of the Glanyrafon Estate undertaken by Waterman Quadrant in 2006;
- Hydraulic modelling of ordinary watercourse to south of site, including hydrological assessment of the catchment; and
- Check for any recorded sewer flooding in area and review of culverts.

## 6.3 Flood Risk from Main Rivers and Ordinary Watercourses

### 6.3.1 Flood Risk from Afon Rheidol

The most significant flood risk to the Glanyrafon Industrial Estate is from the Afon Rheidol.

The assessment made by Waterman Quadrant of flooding to the Glanyrafon Industrial Estate was originally carried out in 1999 and updated in 2006. The 2006 update was required to bring analysis in line with TAN15 requirements to consider the 0.1% (1 in 1000) annual chance event and to reflect the changes in estimated peak flow values with the introduction of FEH methods as the industry standard. The most significant change included in the new analysis was the inclusion of the Glanyrafon defence embankment which was constructed after the original analysis was undertaken.

The Waterman Quadrant report concluded that the defence embankment protected the Glanyrafon Industrial Estate from the 1% (1 in 100) annual chance event and from direct flooding from the Rheidol during the 0.1% (1 in 1000) annual chance event. Hydraulic modelling showed, however, that during the 0.1% (1 in 1000) annual chance event the banks of the Rheidol are overtopped upstream of Glanyrafon Halt and flooding over the Vale of Rheidol Railway line is anticipated. Just upstream of Glanyrafon Halt, the railway passes through a cutting and any floodwaters on the railway are channelled through this cutting and into the estate. Waterman Quadrant estimated that approximately 2.2m<sup>3</sup>/s of flood waters would out-flank the defences and flow through the estate during the 0.1% (1 in 1000) annual chance event.

Waterman Quadrant assessed flooding of the estate by modelling the estate as a series of flood storage cells linked by overflow weirs. A significant proportion of the estate was shown to flood with waters flowing southeast to discharge into the ordinary watercourse to the south of the site, which then flows into the Afon Rheidol. Potential problems with the limited capacity of the culverts associated with the ordinary watercourse were noted, but no modelling of the watercourse was undertaken.

As previously noted in Section 4.4.1, following changes in recent guidelines the peak flows in the Rheidol were agreed to be 253 and 439m<sup>3</sup>/s for the 1% (1 in 100) and 0.1% (1 in 1000) annual chance events respectively. Comparing these with the values used by Waterman Quadrant of 235 and 341m<sup>3</sup>/s, it can be seen that there has been a significant change in the flows anticipated during the 0.1% (1 in 1000) annual chance event. In addition, the Environment Agency advises modelling a third scenario of the 1% (1 in 100) annual chance event with a 20% increase to reflect climate change, and this had not previously been undertaken.

The updated flows were routed through the reach using the most recent Environment Agency Afon Rheidol HEC-RAS model. Predicted water levels were compared with those modelled by Waterman Quadrant and with the surveyed defence levels. Exact comparison with the Waterman Quadrant levels was not possible because a difference in the locations of model cross sections between the two sources was noted; however, the nearest sections were considered to provide a reasonable comparison.

Modelling work confirmed that the defence embankment provides protection from the 1% (1 in 100) annual chance event in the Rheidol including climate change.

In contrast, the 0.1% (1 in 1000) annual chance event peak is expected to overtop the defences upstream of the road bridge by approximately 100mm. There will also be an increased risk from overland flow path which originate upstream of Glanyrafon Halt. There is also a risk that the defence could breach and total inundation of the estate would occur. Drawing Number 5037097.760/RCF/151 shows the extent of flooding if the defence was to breach and floodwaters rose to the same level as those in the Afon Rheidol. This is a conservative estimate and demonstrates that the entire industrial estate is at risk of flooding during extreme events.

More detailed analysis is required within any site-specific FCA to determine the depths and velocities of flooding and to identify whether individual sites meet the indicative acceptance criteria within TAN15.

### 6.3.2 Flood Risk from Ordinary Watercourse

No modelling work has previously been carried out for the ordinary watercourse to the south of Glanyrafon Industrial Estate. Assuming that the risk from the Afon Rhiedol can be mitigated, it is important to confirm that the risk to the estate from this undefended stream is minimal.

The watercourse's catchment area extends to hillsides to the south and east. A hydrological assessment of the area completed for this assessment determined that the anticipated 1% (1 in 100) annual chance event with climate change and 0.1% (1 in 1000) annual chance event peaks in the ordinary watercourse are 2.2 and 3.4m<sup>3</sup>/s respectively.

A simple one-dimensional HEC-RAS hydraulic model was constructed with Lidar sections as shown on the drawings. The use of Lidar rather than surveyed cross sections gives a conservative approach to flood extents. One structure was included in the model: the culvert at NGR SN610800. Downstream of this culvert the watercourse appears to be an open drainage ditch. Upstream, a number of small culverts are known to exist. Modelling showed that there was little difference in the flood levels anticipated for the 1% (1 in 100) annual chance event with climate change and for the 0.1% (1 in 1000) annual chance event; in both cases flows are expected to spill out of the channel, particularly at the culverts and on the approach to the confluence with the Afon Rheidol. The exact extent of flooding cannot easily be determined because the flat ground profile of the site would cause water to spread in all directions. Therefore, the extents of flooding shown on Drawing Numbers 5037097.760/RCF/150 and 151 represent the potential risk areas.

## 6.4 Flood Risk from Sewers, Culverted Watercourses and Groundwater

### 6.4.1 Flood Risk from Sewers

Foul sewer flooding has been observed following breaches at a pumping main from a pumping station located on the estate. Foul water is pumped from the estate to a gravity public sewer just beyond the railway bridge on the A44, then to another pumping station and back to the estate for treatment. Based on information provided by Ceredigion CC, breaches have occurred at least annually at the pipe near the bridge from the estate to the A44. Foul water from a breach at this location typically collects in puddles along the road access to the estate, posing no flood risk to the candidate sites. The primary concern is the impact to water quality in the Afon Rheidol. However, the potential for breaches at other locations along the aging system exists, and if they occur beneath redeveloped sites some flood risk to new infrastructure might be anticipated. Re-routing of the sewer directly to the treatment works would eliminate this risk.

The capacity of the sewer/ drainage infrastructure provided for the estate appears to be sufficient for the current industrial units. If significant development is proposed, a full review of the current provision should be undertaken to confirm this remains the case.

### 6.4.2 Flood Risk from Culverted Watercourses

Previous studies have identified that culverts on the ordinary watercourse through the Glanyrafon Industrial Estate are of insufficient capacity to pass the 0.1% (1 in 1000) annual chance event peak. During flood flows, overtopping of the watercourse is likely, and it is anticipated that flood waters would flow down the roads and inundate significant areas of the estate, although depths of flooding may be small.

Detailed analysis of the culverts will need to be undertaken as part of any site-specific FCA.

### 6.4.3 Flood Risk from Groundwater

Susceptibility to groundwater flooding was not included as a part of this assessment. Risks associated with groundwater should be investigated as part of any proposed development.

## 6.5 Flood Risk from Surface Water Runoff

Runoff from the high land surrounding the Glanyrafon Industrial Estate enters the watercourses that surround the estate. Flooding may result from overtopping of the watercourses and from direct overland flow paths, particularly from land to the south of the estate as shown on Drawing Numbers 5037097.760/RCF/150 and 151.

In addition, surface water run-off from the estate highways and industrial unit yards is dealt with by an Archimedes Screw Pump located within Glanyrafon Industrial Estate. The pumping station, which is maintained by Ceredigion CC, outfalls into the Afon Rheidol. Anecdotal evidence exists which suggests that the failures in the operation of the Archimedes Screw Pump have occurred on occasion resulting in surface water flooding within the estate. The extent and frequency of reported flood events has not been ascertained, hence will require further investigation prior to development within the area.

## 6.6 TAN15 Constraints

As previously mentioned the majority of the area falls within TAN15 Zone C1. New development should thus meet the application of the justification test (Section 6 in TAN15). The sites should also meet the acceptability criteria of being flood free in the 1% (1 in 100) annual chance event with climate change, having acceptable consequences of flooding in the extreme [0.1% (1 in 1000) annual chance] event as defined by TAN15 A1.15, and not causing flooding elsewhere. In addition, flood defences must be shown to be structurally adequate under extreme overtopping conditions, and an emergency flood plan, including flood warning system and identified evacuation routes, must be in place.

Outside of Zone C1, sites within Zone A may be developed without issue providing consideration is given to surface water requirements. Any development will result in changes to the natural hydrology of the catchment due to increases in runoff from impermeable ground and built-up areas. TAN15 states that SuDs should be employed to manage surface water runoff wherever possible, and if the use of conventional drainage systems is proposed, developers must give good reasons why SuDs cannot be implemented.

## 6.7 Summary of Flood Risk and Management

### 6.7.1 Candidate Sites S0153, S0074, S0334, S0335, S0340, S0341, S1122, S2006, S3007, S0333 and S0339

These sites lie mainly within TAN15 Zone C1; however, modelling work has shown that they are at direct risk of flooding from the Afon Rheidol during the 0.1% (1 in 1000) annual chance event.

There is also significant risk of flooding from overland flows arising from the overtopping of the ordinary watercourse to the south and from insufficient capacity of the culverts at the upstream end of the watercourse. Potential flood risks from foul sewers and the failure of the Archimedes Screw Pump that deals with surface water runoff from the estate have also been identified.

Development of any of these sites will require careful consideration.

Works to raise the current defence height would not be entertained by the Environment Agency. However, it may be possible to meet TAN15 acceptability criteria through the completion of site-specific mitigation works by developers. More detailed analyses of potential solutions and their impacts will be required to confirm this.

It is recommended that the site-specific FCAs include two-dimensional modelling of the overtopping of the flood defences and inundation of the Glanyrafon Industrial Estate with both current and proposed layouts to demonstrate compliance with TAN15 acceptability criteria.

### 6.7.2 Candidate Sites S0342 and S0336

These two candidate sites carry the same risks as the other sites within TAN15 Zone C1; however, it is known that the land in this area was lowered to provide compensatory flood storage when the sewage works to the immediate north was constructed. Development of these sites would have significant impact on the sewage works and is not considered possible.

### 6.7.3 Candidate Sites S0331, S0332, S0337 and S0338

These sites lie within TAN15 Zone A. There is a risk of flooding from the ordinary watercourse in low-lying areas; however, development of at least parts of the sites is possible.

Developers must review flood risk issues associated with any culvert issues to ensure that proposed developments do not exacerbate flooding elsewhere on the Glanyrafon Industrial Estate. Confirmation of safe access/ egress routes, and consideration of the management of surface water runoff, including operation of the existing Archimedes Screw Pumping Station, will also be required.

# 7. Rhydyfelin & Penparcau

## 7.1 Site Description

### 7.1.1 General Site Description

Rhydyfelin is a semi-rural community located to the south of Aberystwyth at NGR SN593792. Residential properties are located along the A487(T) which runs north through the area of Penparcau to Aberystwyth town centre. Penparcau is a well developed area constrained by the Afon Rheidol to the north, and its expansion is beginning to encroach on Rhydyfelin.

The Nant Paith watercourse flows under a road bridge at Rhydyfelin on its route west to join with the Afon Ystwyth approximately 200m downstream. The main river forms the western boundary to development, while to the south and east development is sparse and limited to a few residential properties and farmland.

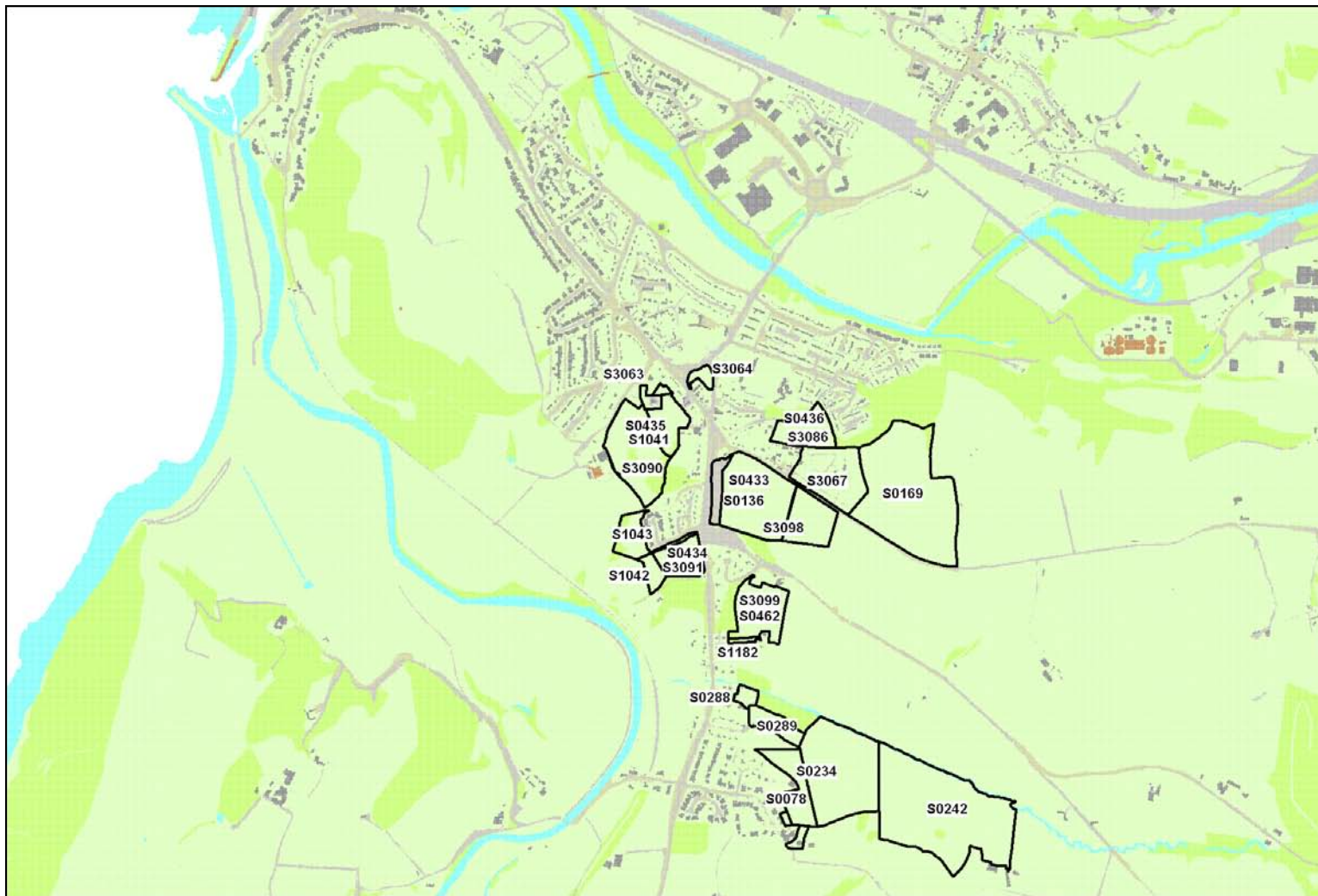
### 7.1.2 Proposed Development

The development sites proposed for Rhydyfelin & Penparcau can be divided into two main areas. Five candidate sites have been identified along the left (southern) bank of the Nant Paith. These are all specified as housing developments. A further 19 candidate sites are proposed to the north. Again these are intended housing developments that will provide in-fill between Rhydyfelin and Penparcau.

The candidate sites are shown on Figure 7.1 and summarised in Table 7.1 below.



Figure 7.1 - Candidate Site Locations



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Table 7.1 - Candidate Sites Summary

Site ID	Name	NGR	Development Type	Design Life
S0169	Land Adj. Southgate, Aberystwyth	SN598796	Housing	100
S3067	Midfield Caravan Park, Penparcau	SN595797	Housing	100
S0436	Land opposite Llwyn yr Eos Infants School, Penparcau	SN595798	Housing	100
S3086	Land opposite Llwyn yr Eos Infants School, Penparcau	SN595798	Housing	100
S3064	Open space opposite round about in Southgate, Penparcau	SN592800	Housing	100
S3063	Welsh Martyr's Catholic Church	SN591797	Housing	100
S0435	Land adj. to St Anne's Church, Penparcau	SN591798	Housing	100
S1041	Land at Penparcau	SN591798	Housing	100
S3090	Land at Piercefield Land	SN590798	Housing	100
S0433	Land at Craig yr Eos, Penparcau	SN593796	Housing	100
S0136	Land at Craig yr Eos, Penparcau	SN593796	Housing	100
S3098	Opposite Midfield Caravan Park	SN594796	Housing	100
S1043	Land to the west of Maescrugau, Penparcau, Aberystwyth	SN590795	Housing	100
S0434	Land opposite Maescrugau, Penparcau	SN592795	Housing	100
S1042	Land to the south of Maescrugau, Penparcau	SN591795	Housing	100
S3091	Land to the south of Maescrugau, Penparcau	SN591795	Housing	100
S0462	Land south of Gwaryfelin	SN594793	Housing	100
S3099	Land south of Gwaryfelin	SN594793	Housing	100
S1182	Land at Talyglog Lane, Rhydyfelin	SN593792	Housing	100
S0288	Land adj. to Bodnantm Rhydyfelin	SN593791	Housing	100
S0289	Land adj. to Paitholwg, Rhydyfelin	SN594790	Housing	100
S0234	Land adj. Bronystwyth, Rhydyfelin	SN596788	Housing	100
S0242	Waun Grug, Rhydyfelin	SN599788	Housing	100
S0078	Bronystwyth Fields, Rhydyfelin, Aberystwyth	SN595788	Housing	100

### 7.1.3 Hydrological Situation

The Nant Paith watercourse lies within a narrow valley and the ground slopes steeply to the north and south. Parts of five sites identified in this area are situated within watercourse's floodplain. Numerous minor watercourses have been identified draining the slopes to the south down into the Nant Paith. The catchment areas of the watercourse are well defined.

The candidate sites to the north are located on the high ground between the Nant Paith and the Afon Rheidol. Less defined drainage paths exist within this area, although there are a number of defined channels joining into the Afon Ystwyth.

## 7.2 Data Review and Analysis

### 7.2.1 Information Available

A review of the available data has included the following:

- TAN15 Development Advice Map;
- Environment Agency Extreme Flood Outline Map;
- STAM Database; and
- Light Detection and Ranging (Lidar) data.

### 7.2.2 Analysis Approach

The candidate sites identified on the higher ground to the north have been categorised as Low Risk in the Phase 1 report. The sites that border the watercourse fall partially within TAN15 Zone C2 and the Environment Agency extreme flood outline, and these are considered Medium Risk.

Since the site area within Zone C2 is typically less than 25%, a detailed assessment is considered unnecessary at this stage and a strategic assessment is considered sufficient to understand the risks associated with development in this area and provide initial guidance for the management of the identified risks.

Assessment of this area has included:

- Hydrological assessment of the Nant Paith catchment and construction of a HEC-RAS steady-state hydraulic model;
- Review of likely overland flow paths using Lidar data;
- Review of minor watercourses within area; and
- Check for recorded sewer flooding

## 7.3 Flood Risk from Main Rivers and Ordinary Watercourses

### 7.3.1 Flood Risk from Nant Paith

The main aim of undertaking construction of a hydraulic model of the Nant Paith was to confirm the flood extents shown on the Environment Agency flood risk maps and to assess the flood risk to the candidate sites that border the river.

Sites to the south of the Rhydyfelin & Penparcau area lie adjacent to the watercourse between the A487(T) and the B4340 road bridge known as Pont Paith. In order to determine the effect of the bridges, the hydraulic model was extended 300m upstream of Pont Paith and downstream was extended beyond the old railway embankment to the river's confluence with the Afon Ystwyth. The hydraulic model extents are presented on Drawing Numbers 5037097.760/RCF/160 and 161.

In order to gain a more complete understanding of the river system, a walkover inspection of the study area was undertaken in June 2009. This assessment concentrated on the estimation of hydraulic roughness of the channel and floodplains and inspection of structures. Model cross sections (located as shown on the drawings) were generated from Lidar data; a full topographic survey was not considered an appropriate use of resources for this level of assessment.

Original modelling methodology suggested that the Lidar may not accurately represent the watercourse profile and it would be better to assume that the watercourse contains flows up to a bankfull flow equivalent to QMED, and only flows exceeding QMED would be routed through the model to determine out-of-bank flood extents. On inspection, however, it was discovered that the Lidar data show a clear channel, and modelling of flood event flows with the QMED reduction was considered inappropriate. Use of Lidar is expected to give a conservative estimate of channel

depths and hence flood extents. Topographic survey of the channel profile and re-modelling of the Nant Paith is recommended as part of a detailed FCA . Final 1% (1 in 100) annual chance event with climate change and 0.1% (1 in 1000) annual chance event peaks in the ordinary watercourse were estimated to be 20.5 and 29.6m<sup>3</sup>/s respectively.

The modelled flood extents for the events are indicated on Drawing Numbers 5037097.760/RCF/160 and 161. It can be seen that these compare reasonably well with the Environment Agency extreme flood outline (also shown).

The candidate sites that border the watercourse, namely S0288, S0234 and S0242, were analysed with respect to the area of flooding anticipated. Results are summarised in Table 7.2 below.

**Table 7.2 – Modelled Flood Areas**

Site ID	Total Site Area (m <sup>3</sup> )	Site Area Inundated during 0.1% event (m <sup>3</sup> )	Percentage Inundated
S0288	2,923	2,609.1	89.3 %
S0234	64,687.7	21,497.7	33.2 %
S0242	84,846.3	16,086.3	19.0 %

### 7.3.2 Flood Risk from Minor Watercourses

A number of minor watercourses in the area were identified on the Ordnance Survey maps and are indicated on the drawings. These are both natural and man-made drainage paths channelling water from the higher ground down toward the Afon Ystwyth. None provides any flood risk to the sites identified, and in fact it could be argued that they actively contribute to the reduction in flood risk by carrying surface water away from the high ground, in particular away from sites S1043, S0434, S1042 and S3091.

## 7.4 Flood Risk from Sewers, Culverted Watercourses and Groundwater

### 7.4.1 Flood Risk from Sewers

Anecdotal evidence suggests that one sewer flooding incident has occurred within the area. This is located just north of candidate sites S0435, S1041, S3063 and S3090 on high ground off Penparcau Road. The risk associated within the incident is considered low; however, confirmation of this will be required within the site-specific FCAs.

### 7.4.2 Flood Risk from Culverted Watercourses

No culverted watercourses were identified in the area.

### 7.4.3 Flood Risk from Groundwater

Susceptibility to groundwater flooding was not included as a part of this assessment. Risks associated with groundwater should be investigated as part of any proposed development.

## 7.5 Flood Risk from Surface Water Runoff

Drainage channels to the south of the Nant Paith should channel water from the hillside on defined paths directly into the watercourse; hence, minimal risk from overland flow is anticipated for the sites within the valley floor.

Lidar data were analysed to determine the likely direction of surface water runoff from the hills on which the majority of the other sites within the area are located. Anticipated flow directions are indicated with arrows on the drawings. Many sites are located at hill peaks; they have minimal catchment areas and limited runoff flows are anticipated. In addition, it can be seen that flow tends to be diverted away from the area; therefore, it has been concluded that the risk to these areas from overland flow is low.

Two groups of sites have been identified as having potential problems: S3067 and S0436/ S3086, and S3063/ S0435/ S1041/ S3090. These sites are steeply sloping and potentially could have surface water runoff flowing through them originating from the directions shown on Drawing Numbers 5037097.760/RCF/160 and 161. However, the catchment areas are not considered to be significant, and thus it is anticipated that the flows could easily be managed to reduce the residual risk.

## 7.6 TAN15 Constraints

The candidate sites to the north of the Nant Paith fall with TAN15 Zone A. Fluvial and tidal flood risk is low and few constraints are given within TAN15 for development within this zone. However, it is important that developers give careful consideration to overland flow paths and the management of surface water runoff. TAN15 Section 8 notes that any development will result in changes to the natural hydrology of the catchment due to increases in runoff from impermeable ground and built-up areas. Guidance states that SuDs should be employed to manage surface water runoff wherever possible, and if the use of conventional drainage systems is proposed, good reasons must be given as to why SuDs cannot be implemented. Developers are required to confirm the make improves to the status quo in order that capacity of existing sewers is adequate to ensure proposed developments do not result in flooding elsewhere.

To the south of the watercourse, sites within TAN15 Zone C2 have been identified for potential residential development. TAN15 categorises all residential premises as “highly vulnerable development” and, for TAN15 Zone C2, states that “the flooding consequences associated with Emergency Services and highly vulnerable development are not considered to be acceptable. Plan allocations should not be made for such development and planning applications not proposed.”

Other less vulnerable development, including commercial and retail development and car parking areas, may be permitted within this zone providing they meet the justification tests. Developments must be flood free in the 1% (1 in 100) annual chance event with climate change, have acceptable consequences of flooding in the extreme 0.1% (1 in 1000) annual chance event as defined by TAN15 A1.15, and not cause flooding elsewhere.

## 7.7 Summary of Flood Risk and Management

### 7.7.1 Candidate Site S0288

This site falls almost entirely within TAN15 Zone C2 and the Environment Agency extreme flood outline associated with the Nant Paith. Analysis has confirmed that the majority of this site is at risk of flooding from both the 1% (1 in 100) and the 0.1% (1 in 1000) annual chance events.

Development of this site should be discouraged. The flood risk associated with development is considered to be unacceptable, and justification will be difficult under TAN15 guidelines.

### 7.7.2 Candidate Sites S0234 and S0242

Flooding of part of sites S0234 and S0242 is anticipated from the Nant Paith; however, the land rises away from the watercourse and development of parts of the sites is certainly possible. Analysis suggests that approximately 33% of S0234 and 19% of S0242 will flood during the 0.1% (1 in 1000) annual chance event.

Detailed FCAs will be required for development of these sites; this should include detailed modelling of the watercourse using surveyed channel sections to confirm flood extents. Development may take place within the flood-free parts of the sites without issue. For the site areas within the flood boundary, residential development is not permitted under TAN15 guidelines.

Developers should also ensure consideration of surface water requirements and analysis of the capacity of existing sewers is made.



### 7.7.3 Candidate Site S0078 and S0289

These sites fall within TAN15 Zone A and outside of both the Environment Agency defined and recently modelled extreme flood extents. There is minimal flood risk and no difficulties are anticipated in the development of these sites providing flood-free access/ egress routes can be provided.

### 7.7.4 Candidate Sites S0169, S3064, S0433, S0136, S3098, S0462, S3099 and S1182

These sites fall within TAN15 Zone A and are located on high ground. There is no risk of flooding from any watercourses within the area, and minimal risk from sewer flooding has been identified.

No problems with developing these sites are anticipated.

### 7.7.5 Candidate Sites S1043, S0434, S1042 and S3091

A minor watercourse shown on the drawings helps to contain runoff from these sites and divert water along the site borders and south towards the main river. The sites are considered to be at minimal risk of flooding, and development should be possible.

### 7.7.6 Candidate Sites S3067, S0436, S3086, S3063, S0435, S1041 and S3090

These sites may be at risk of flooding from surface water runoff; however, the risk is considered low. The catchment areas are not considered significant, and it is anticipated that the flows could easily be managed by the provision of drainage ditches at the tops of the sites and agreed discharge into existing watercourses or the current sewer/ highway surface water drainage network. The Environment Agency and Local Drainage and Highway Authorities will need to be consulted on this matter.

The sites are within TAN15 Zone A, and management of the flood risk is considered possible.



# 8. Conclusions

## 8.1 Site Summaries

The five study areas identified have been assessed in detail and conclusions drawn in the area-specific sections regarding the flood risks associated with each candidate site and the potential for justification of the proposed development under TAN15.

Tables 8.1 to 8.5 below summarise the conclusions drawn.

**Table 8.1 – Summary of North Aberystwyth Development Sites**

Site ID	Name	Main Flood Risk	Potential for Development
S0518	Caravan Park	Limited risk	No problems anticipated
S1065	Frongoch Farm, Clarach Rd, Aberystwyth		
S1066	Penglais Farm (East) and Cefn Hendre Land, Clarach		
S2046	Field in the north east quadrant of Waunfawr		
S3085	Plashendre Field		
S3105	Penglais Farm (East) and Cefn Hendre Land, Clarach		
S1067	Penglais Farm (West), Clarach Rd, Aberystwyth		
S3078	Field near Mature Student Village		
S3103	East Penglais Farm		
S0797	Penglais Campus	Surface water runoff	No problems anticipated
S1034	Land to the south of Bronglais General Hospital, Aberystwyth	Limited risk	No problems anticipated

Table 8.2 - Summary of Coastal and Town Centre Development Sites

Site ID	Name	Main Flood Risk	Potential for Development
S1027	Aberystwyth Harbour Garages	Tidal inundation	Some possible, but not residential
S0131	Land at Y Lanfa, Aberystwyth		
S3002	Aberystwyth Harbour (including fire station)		
S3061	Fire Station Aberystwyth		
S3087	Old Brewery opp. Fire Station		
S0133	Land at the Boat Park, Aberystwyth	Limited risk	No problems anticipated
S1218	Land adj. Hamden		
S0230	Land adj. Ewyn Y Don, Felin Y Mor Road, Aberystwyth		
S0560	Penparcau Road		
S3100	Field behind West Maelor		
S0799	Old College	Wave overtopping	No problems anticipated
S3055	Aberystwyth, Old College		
S3052	Vacant Boars's Head Pub, Queens Road	Wave overtopping	Significant problems anticipated
S3062	Old Council Offices (Court, Forest Commission Office)		
S3070	Adj. North Road Health Clinic		
S1031	North Road Clinic, Aberystwyth	Surface water runoff	No problems anticipated
S0247	Troed-yr-Aur, Aberystwyth		
S3094	Cambrian Tyres, Corner of Queens Road and Vaynor St	Tidal inundation	Partial development of area possible
S3006	Cinema, Bath St	Tidal inundation & wave overtopping	Detailed FCA required to confirm possibility of development
S3092	Cinema, Bath St		
S3088	Bay Hotel and Adj. Properties	Tidal inundation & wave overtopping	Significant problems anticipated
S0132	Aberystwyth Post Office, Great Darkgate Street	Tidal inundation	Development possible, but need access/ egress check
S3000	Old Post Office		
S3097	PO site, Aberystwyth		
S3053	Tabernacle Church, Mill Street	Tidal inundation	Development possible, but need access/ egress check
S3003	Mill St Car Park	Tidal inundation	Significant problems anticipated
S3072	Mill St Car Park		

Site ID	Name	Main Flood Risk	Potential for Development
S3073	Sea Cadet HQ	Tidal inundation	Significant problems anticipated
S3001	Park Avenue South Site		
S3074	Park Avenue South Site		
S3093	Football Grounds, Park Avenue		
S0600	Vale of Rheidol Railway land, Aberystwyth		
S3004	Parc Avenue North (Station and retail Parks)		
S3075	Parc Avenue Car Park		
S0798	Vicarage Fields	Tidal inundation	Partial development of area possible
S0071	Plascrug Leisure Centre, Aberystwyth	Tidal inundation	Significant problems anticipated Detailed FCA required to confirm possibility of partial development of area
S1018	Parc y Llyn Ditch		
S3005	WAG and CCC Offices		
S1015	Aberystwyth Ambulance Station, Llanbadarn Rd		
S0652	Aberystwyth Ambulance Station, Llanbadarn Rd		
S3077	Land behind Ty Clyd, nr Jnct of Sulien Rd and Quebec Rd	Surface water runoff	No problems anticipated
S0346	Plas Mansion, Llanbadarn Fawr		
S3076	Vicarage Gardens, Quebec Road		
S0896	Blaendolau Playing Field	Overland fluvial flow from Afon Rheidol	Significant problems anticipated
S0800	Blaendolau Playing Fields		
S1038	Land adj. to Blaendolau Fields, Aberystwyth		
S0612	Paddocks and Yard in Llanbadarn Fawr	Tidal inundation	No problems anticipated
S3071	Land between Blaendolau Farm and Llety Gwyn	Fluvial flooding from Afon Rheidol	Significant problems anticipated
S2001	Land at Parc yr Onnen, Llanbadarn Fawr, Aberystwyth		
S0229	Land at Pwllhobi, Llanbadarn Fawr, Aberystwyth		
S3068	Pwllhobi Terrace, Vacant plot nr. Bryn Rheidol	Limited risk	No problems anticipated

Table 8.3 - Summary of Llanbadarn Development Sites

Site ID	Name	Main Flood Risk	Potential for Development
S0432	Land at Lon Llewelyn	Limited risk	No problems anticipated
S3079	Land at Lon Llewelyn		
S0429	Land behind Maesceinion		
S0514	Cefn Hendre		
S0353	Land at Clawdd Helyg, Commins Coch		
S1021	Waunfawr Field, Waunfawr, Aberystwyth		
S3102	Disused Quarry		
S3081	JHLA Quarry		
S0431	Land opposite Hafod y Waun nursing home		
S0236	Land adj. Llys Dewi, Waun Fawr, Aberystwyth		
S0482	Masawelon, Waunfawr	Fluvial flooding from ordinary watercourse	Development possible, but need access/ egress check
S0430	Land adj. to Hafod y Waun nursing home	Limited risk	No problems anticipated
S3082	Erw Goch Field		
S0836	Land at Primrose Hill Llanbadarn Fawr		
S0649	Brynteg, Primrose Hill		
S3101	North Depot, Field nr. Hafod Y Waun Nursing Home		
S0964	Land rear of Ty Gwyn		
S3083	Land rear of Ty Gwyn	Surface water runoff	No problems anticipated
S3084	Livery. Primrose Hill nr. College		
S3089	Llanbadarn Fawr Campus		
S0965	Llanbadarn Fawr Campus		
S0966	Llanbadarn Fawr Campus (middle)		
S0967	Llanbadarn Fawr Campus	Fluvial flooding from ordinary watercourse	Detailed FCA required to confirm possibility of partial development of area
S2043	Primrose Hill		
S0613	Field in Llanbadarn Fawr	Limited risk	No problems anticipated
S3069	Land behind Plas Lluest		

Site ID	Name	Main Flood Risk	Potential for Development
S0880	Plas Lluest Plant Nursery site	Limited risk	No problems anticipated
S0581	Field near Llanbadarn Fawr		
S0428	Field at Ffynon Dderw, Llanbadarn Fawr		
S0028	Land at Pendre, Llanbadarn Fawr	Surface water runoff	Development possible with management of surface water runoff
S0029	Land at Ffynon Dderw, Llanbadarn Fawr		
S3104	Llanbadarn Farm		
S0648	Glenalmond, Llanbadarn Fawr, Aberystwyth	Fluvial flooding from ordinary watercourse	Development possible, but need access/ egress check

Table 8.4 - Summary of Glanyrafon Development Sites

Site ID	Name	Main Flood Risk	Potential for Development
S0153	Land at the Gas Yard, Glanyrafon Estate, Aberystwyth	Fluvial flooding from Afon Rheidol	Significant problems anticipated
S2006	Glanyrafon Industrial Estate		Detailed FCA required to confirm possibility of partial development of area
S0331	Land at Glanyrafon Estate	Fluvial flooding from ordinary watercourse	Development possible, but need access/ egress check
S0332	Land at Glanyrafon Estate		
S0333	Land at Glanyrafon Estate	Fluvial flooding from Afon Rheidol	Significant problems anticipated
S0334	Land at Glanyrafon Estate		Detailed FCA required to confirm possibility of partial development of area
S0335	Land at Glanyrafon Estate		
S0336	Land at Glanyrafon Estate	Dedicated overland route	Not possible
S0337	Land at Glanyrafon Estate	Fluvial flooding from ordinary watercourse	Development possible, but need access/ egress check
S0338	Land at Glanyrafon Estate		
S0339	Land at Glanyrafon Estate	Fluvial flooding from Afon Rheidol	Significant problems anticipated
S0340	Land at Glanyrafon Estate		Detailed FCA required to confirm possibility of partial development of area
S0341	Land at Glanyrafon Estate		
S0342	Land at Glanyrafon Estate	Dedicated overland route	Not possible
S1122	Glanyrafon Enterprise Park, Aberystwyth	Fluvial flooding from Afon Rheidol	Significant problems anticipated
S3007	Glanyrafon Industrial Estate		Detailed FCA required to confirm possibility of partial development of area
S0074	Field Opposite Ty Clyd		



Table 8.5 - Summary of Rhydyfelin & Penparcau Development Sites

Site ID	Name	Main Flood Risk	Potential for Development
S0169	Land Adj. Southgate, Aberystwyth	Surface water runoff	No problems anticipated
S3067	Midfield Caravan Park, Penparcau	Surface water runoff	Development possible with management of surface water runoff
S0436	Land opposite Llwyn yr Eos Infants School, Penparcau		
S3086	Land opposite Llwyn yr Eos Infants School, Penparcau		
S3064	Open space opposite round about in Southgate, Penparcau	Surface water runoff	No problems anticipated
S3063	Welsh Martyr's Catholic Church	Surface water runoff	Development possible with management of surface water runoff
S0435	Land adj. to St Anne's Church, Penparcau		
S1041	Land at Penparcau		
S3090	Land at Piercefield Land		
S0433	Land at Craig yr Eos, Penparcau	Surface water runoff	No problems anticipated
S0136	Land at Craig yr Eos, Penparcau		
S3098	Opposite Midfield Caravan Park		
S1043	Land to the west of Maescrugau, Penparcau, Aberystwyth	Limited risk	No problems anticipated
S0434	Land opposite Maescrugau, Penparcau		
S1042	Land to the south of Maescrugau, Penparcau		
S3091	Land to the south of Maescrugau, Penparcau		
S0462	Land south of Gwaryfelin	Surface water runoff	No problems anticipated
S3099	Land south of Gwaryfelin		
S1182	Land at Talyglog Lane, Rhydyfelin		
S0288	Land adj. to Bodnantm Rhydyfelin	Fluvial flooding from Nant Paith	Significant problems anticipated
S0289	Land adj. to Paitholwg, Rhydyfelin	Fluvial flooding from Nant Paith	Development possible, but need access/ egress check
S0234	Land adj. Bronystwyth, Rhydyfelin	Fluvial flooding from Nant Paith	Detailed FCA required to confirm possibility of partial development of area
S0242	Waun Grug, Rhydyfelin		
S0078	Bronystwyth Fields, Rhydyfelin, Aberystwyth	Fluvial flooding from Nant Paith	Development possible, but need access/ egress check

# Appendix A - SFCA Study Area Map



# Appendix B – Town Centre Depth and Velocity Maps

5037097.760/RCF/110 – 2009 Predicted Maximum Flood Depths 0.5% Annual Chance Tidal Event  
5037097.760/RCF/111 – 2059 Predicted Maximum Flood Depths 0.5% Annual Chance Tidal Event  
5037097.760/RCF/112 – 2079 Predicted Maximum Flood Depths 0.5% Annual Chance Tidal Event  
5037097.760/RCF/113 – 2109 Predicted Maximum Flood Depths 0.5% Annual Chance Tidal Event  
5037097.760/RCF/114 – 2009 Predicted Maximum Flood Depths 0.1% Annual Chance Tidal Event  
5037097.760/RCF/115 – 2059 Predicted Maximum Flood Depths 0.1% Annual Chance Tidal Event  
5037097.760/RCF/116 – 2079 Predicted Maximum Flood Depths 0.1% Annual Chance Tidal Event  
5037097.760/RCF/117 – 2109 Predicted Maximum Flood Depths 0.1% Annual Chance Tidal Event  
5037097.760/RCF/120 – 2009 Predicted Maximum Flood Velocity 0.5% Annual Chance Tidal Event  
5037097.760/RCF/121 – 2059 Predicted Maximum Flood Velocity 0.5% Annual Chance Tidal Event  
5037097.760/RCF/122 – 2079 Predicted Maximum Flood Velocity 0.5% Annual Chance Tidal Event  
5037097.760/RCF/123 – 2109 Predicted Maximum Flood Velocity 0.5% Annual Chance Tidal Event  
5037097.760/RCF/124 – 2009 Predicted Maximum Flood Velocity 0.1% Annual Chance Tidal Event  
5037097.760/RCF/125 – 2059 Predicted Maximum Flood Velocity 0.1% Annual Chance Tidal Event  
5037097.760/RCF/126 – 2079 Predicted Maximum Flood Velocity 0.1% Annual Chance Tidal Event  
5037097.760/RCF/127 – 2109 Predicted Maximum Flood Velocity 0.1% Annual Chance Tidal Event

# Appendix C - Maximum Flood Depths for Town Centre Sites



Site ID	Name	Predicted Maximum Flood Depth (m) 0.5% (1 in 200) Annual Chance Event				Predicted Maximum Flood Depth (m) 0.1% (1 in 1000) Annual Chance Event			
		2009	2059	2079	2109	2009	2059	2079	2109
S1027	Aberystwyth Harbour Garages	0.94	1.26	1.45	1.87	0.98	1.46	1.69	2.10
S0131	Land at Y Lanfa, Aberystwyth	Outside model extent							
S3002	Aberystwyth Harbour (including fire station)	6.42	6.76	6.99	7.41	6.65	7.00	7.23	7.64
S3061	Fire Station Aberystwyth	Outside model extent							
S3087	Old Brewery opp. Fire Station	Outside model extent							
S0133	Land at the Boat Park, Aberystwyth	Outside model extent							
S1218	Land adj. Hamden	Outside model extent							
S0230	Land adj. Ewyn Y Don, Felin Y Mor Road, Aberystwyth	Outside model extent							
S0560	Penparcau Road	Outside model extent							
S3100	Field behind West Maelor	Outside model extent							
S0799	Old College	0	0	0	0	0	0	0	0
S3055	Aberystwyth, Old College	0	0	0	0	0	0	0	0
S3052	Vacant Boars's Head Pub, Queens Road	0	0	0	0	0	0	0	0
S3062	Old Council Offices (Court, Forest Commission Office)	0	0	0	0	0	0	0	0
S3070	Adj. North Road Health Clinic	0	0	0	0	0	0	0	0
S1031	North Road Clinic, Aberystwyth	0	0	0	0	0	0	0	0
S0247	Troed-yr-Aur, Aberystwyth	0	0	0	0	0	0	0	0

Site ID	Name	Predicted Maximum Flood Depth (m) 0.5% (1 in 200) Annual Chance Event				Predicted Maximum Flood Depth (m) 0.1% (1 in 1000) Annual Chance Event			
		2009	2059	2079	2109	2009	2059	2079	2109
S3094	Cambrian Tires, Corner of Queens Road and Vaynor St	0	0	0.79	1.25	0	0.80	1.07	1.49
S3006	Cinema, Bath St	0	0	0	0.28	0	0	0.05	0.59
S3092	Cinema, Bath St	0	0	0	0.28	0	0	0.05	0.59
S3088	Bay Hotel and Adj. Properties	0	0	0	0.20	0	0	0	1.62
S0132	Aberystwyth Post office, Great Darkgate Street	0	0	0	1.29	0	0	1.11	1.52
S3000	Old Post Office	0	0	0	1.29	0	0	1.11	1.52
S3097	PO site, Aberystwyth	0	0	0	0.03	0	0	0	0.46
S3053	Tabernacle Church, Mill Street	0	0	0	0	0	0	0	0
S3003	Mill St Car Park	0	1.43	2.13	2.60	0.74	2.14	2.42	2.83
S3072	Mill St Car Park	0	1.43	2.13	2.60	0.74	2.14	2.42	2.83
S3073	Sea Cadet HQ	0.66	1.27	1.54	1.98	0.98	1.55	1.80	2.21
S3001	Park Avenue South Site	0.19	1.51	2.21	2.75	0.84	2.22	2.52	2.93
S3074	Park Avenue South Site	0	1.50	2.21	2.75	0.84	2.22	2.52	2.93
S3093	Football Grounds, Park Avenue	0.19	1.00	1.70	2.18	0.46	1.71	1.97	2.38
S0600	Vale of Rheidol Railway land, Aberystwyth	0	0.95	1.67	2.13	0.28	1.67	1.95	2.37
S3004	Parc Avenue North (Station and retail parks)	0	1.31	2.02	2.48	0.63	2.03	2.30	2.71
S3075	Parc Avenue Car Park	0	1.24	1.95	2.41	0.56	1.95	2.23	2.64

Site ID	Name	Predicted Maximum Flood Depth (m) 0.5% (1 in 200) Annual Chance Event				Predicted Maximum Flood Depth (m) 0.1% (1 in 1000) Annual Chance Event			
		2009	2059	2079	2109	2009	2059	2079	2109
S0798	Vicarage Fields	0	1.64	2.62	3.08	0	2.62	2.90	3.32
S0071	Plascrug Leisure Centre, Aberystwyth	0	0	1.75	2.45	0	1.76	2.17	2.71
S1018	Parc y Llyn Ditch	0	0	1.45	2.71	0	1.54	2.43	2.96
S3005	WAG and CCC Offices	0	0	1.34	2.60	0	1.43	2.32	2.86
S1015	Aberystwyth Ambulance Station, Llanbadarn Rd	0	0	0	1.47	0	0	1.19	1.73
S0652	Aberystwyth Ambulance Station, Llanbadarn Rd	0	0	0	1.47	0	0	1.19	1.73
S3077	Land behind Ty Clyd, nr Jnct of Sulien Rd and Quebec Rd	0	0	0.33	1.62	0	0.36	1.34	1.88
S0346	Plas Mansion, Llanbadarn Fawr	0	0	0	0.33	0	0	0.15	0.55
S3076	Vicarage Gardens, Quebec Rd	0	0	0	0	0	0	0	0
S0896	Blaendolau Playing Field	Outside model extent							
S0800	Blaendolau Playing Fields	Outside model extent							
S1038	Land adj. to Blaendolau Fields, Aberystwyth	Outside model extent							
S0612	Paddocks and Yard in Llanbadarn Fawr	0	0	0	0.63	0	0	0.19	0.93
S3071	Land between Blaendolau Farm and Llety Gwyn	Outside model extent							
S2001	Land at Parc yr Onnen, Llanbadarn	Outside model extent							

Site ID	Name	Predicted Maximum Flood Depth (m) 0.5% (1 in 200) Annual Chance Event				Predicted Maximum Flood Depth (m) 0.1% (1 in 1000) Annual Chance Event			
		2009	2059	2079	2109	2009	2059	2079	2109
	Fawr, Aberystwyth								
S0229	Land at Pwllhobi, Llanbadarn Fawr, Aberystwyth	Outside model extent							
S3068	Pwllhobi Terrace, Vacant plot nr. Bryn Rheidol	Outside model extent							

# Appendix D – Area Specific Maps

5037097.760/RCF/130 – Coastal & Town Centre Areas Predicted Flood Extents 1% Annual Chance Event + Climate Change

5037097.760/RCF/131 – Coastal & Town Centre Areas Predicted Flood Extents 0.1% Annual Chance Event

5037097.760/RCF/140 – Llanbadarn Predicted Flood Extents 1% Annual Chance Event + Climate Change

5037097.760/RCF/141 – Llanbadarn Predicted Flood Extents 0.1% Annual Chance Event

5037097.760/RCF/150 – Glanyrafon Industrial Estate Predicted Flood Extents 1% Annual Chance Event + Climate Change

5037097.760/RCF/151 – Glanyrafon Industrial Estate Predicted Flood Extents 0.1% Annual Chance Event

5037097.760/RCF/160 – Rhydyfelin & Penparcau Predicted Flood Extents 1% Annual Chance Event + Climate Change

5037097.760/RCF/161 – Rhydyfelin & Penparcau Predicted Flood Extents 0.1% Annual Chance Event



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