Natural Resources Wales

Ammanford Flood Risk Management Scheme

Design Philosophy Statement

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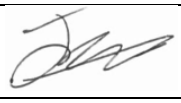
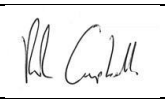
		Signature	p.p. 		
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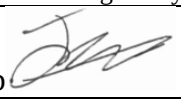
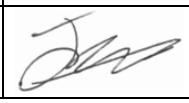
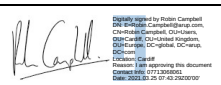
		Signature	p.p 		
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1 Introduction

1.1 Project overview

Ove Arup and Partners Limited (Arup) has been commissioned by Natural Resources Wales (NRW) to undertake a range of engineering and environmental services in relation to the design development, consenting and detailed design for a flood risk management scheme for Ammanford, Carmarthenshire.

The study area is within the town of Ammanford in Carmarthenshire, approximately 12 miles north of Swansea. The location is shown in Figure 1 (produced by JBA Consulting in April 2018 for the Outline Business Case).

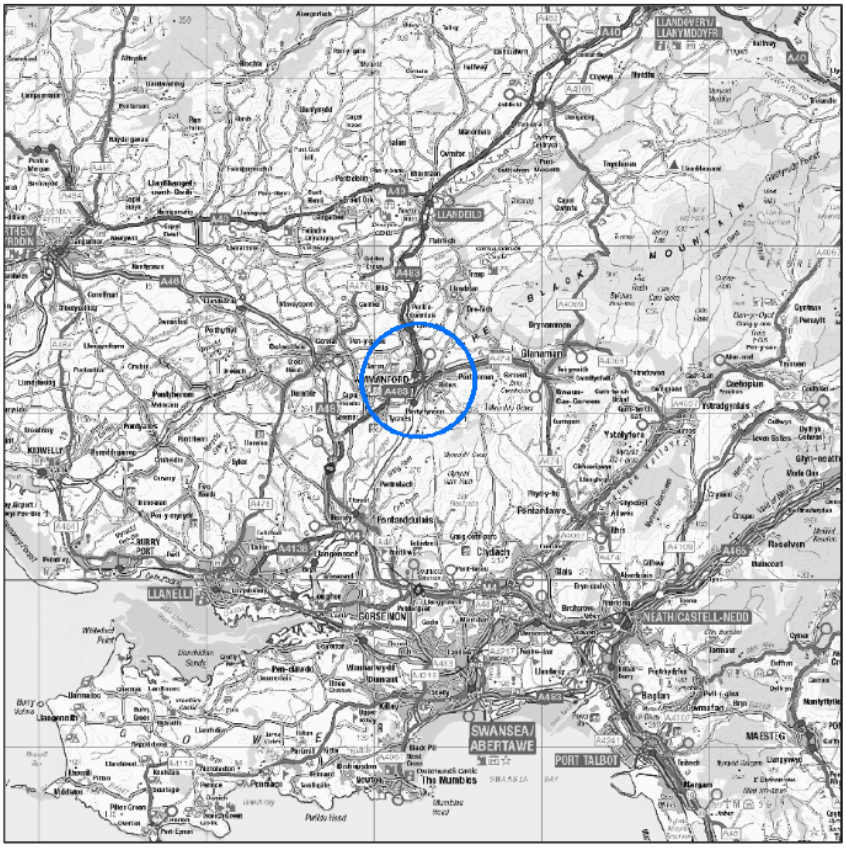

Figure 1: Study area Location (JBA Consulting, 2016)

Ammanford has a history of flooding. This is caused by heavy rainfall occurring in the contributing catchments, rapid response of the rivers to rainfall events, and the limited capacity of the river channel to convey the peak flows. Much of Ammanford is built on low-lying land adjacent to the river. The interaction of three contributing watercourses – the Rivers Loughor, Lash and Marlas - leads to multiple locations where the river exceeds capacity and spills into the adjacent land, causing flooding to properties and roads. Several significant historical flood events have occurred in Ammanford between 1979 and 2009. These events led to the flooding of properties in Tir-y-Dail, Station Road, Aberlash Road, the Heart of Wales railway line and the Coleg Sir Gâr campus.

For the Ammanford study area (which encompasses areas where raised Bunds have been proposed in Figure 2 below), there are no formal flood defence structures in place. If nothing is done to reduce flood risk within the study area, modelling shows that 198 homes and 25 business will remain at risk of flooding from the 1% Annual Exceedance Probability (AEP) event at the present day, increasing to 314 homes and 26 businesses by 2119. This results in present value damages of £7.9 million and considerable disruption and uncertainty for the local community.

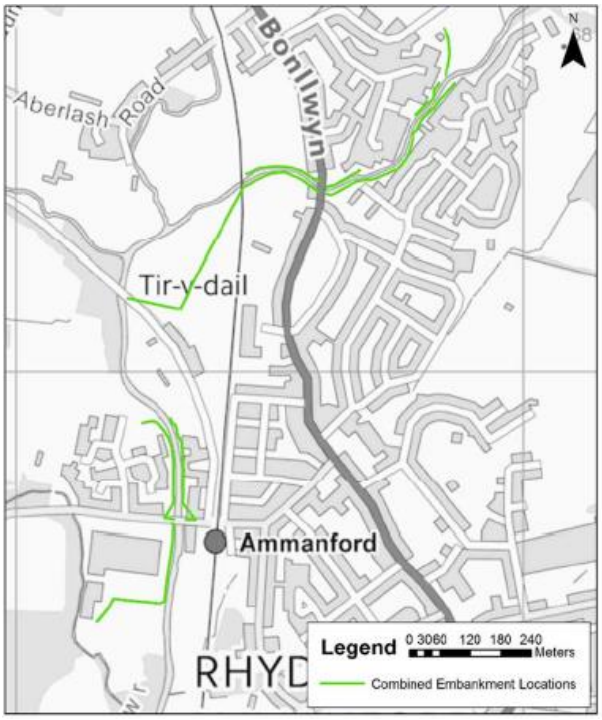

Figure 2: Proposed locations of raised Bunds (JBA Consulting, 2016)

The Ammanford study area is listed as one of the top communities at risk of flooding from main rivers within the Western Wales Flooding Risk Management Plan (FRMP) area. It is also highlighted as one of the top five communities with the greatest modelled increase in future flood risk as a result of climate change. NRW's position regarding Ammanford is that 'there is still more to be done to manage and reduce the risk of flooding' and a 'High' priority measure has been given to assessment and feasibility work to reduce flood risk in Ammanford.

The project objectives are to:

- Reduce the risk of flooding to the town and community of Ammanford from the River Loughor, River Lash, and River Marlas, considering predicted climate change.
- Provide enhancements that benefit the natural environment and the well-being of the community, helping to achieve Welsh Government Well-Being Goals, NRW Well-Being Objectives and Carmarthenshire Well-Being Objectives.
- Improve fish passage over the existing weir on the River Loughor which currently obstructs migratory species.

NRW completed a 5-Case Model Outline Business Case (OBC) for a Flood Risk Management (FRM) project in Ammanford to meet the above project objectives. This business case has been approved by NRW's FRM Business Board.

The OBC preferred option comprises a combination of flood risk management measures including earth bunds, walls, ground raising, Property Flood Resilience (PFR) and environmental enhancements. An outline design was included in the OBC appendices.

Arup's commission is to develop the outline design into a detailed design including environmental enhancements, specification and works information for NEC3 ECC, for the construction of the preferred option.

1.2 Purpose

This Design Philosophy Statement is a live document that will be used by the project team as a reference throughout the detailed design phase of the project.

This Design Philosophy Statement will outline the project scope, key design considerations and requirements. It also includes references to documents and design standards that are to be used for specific areas of the design.

The project design decision register is also included in Appendix B.

1.3 Proposed works

Following detail design development, a summary of the proposed works is shown on Figure 3 and summarised in Table 1 below.

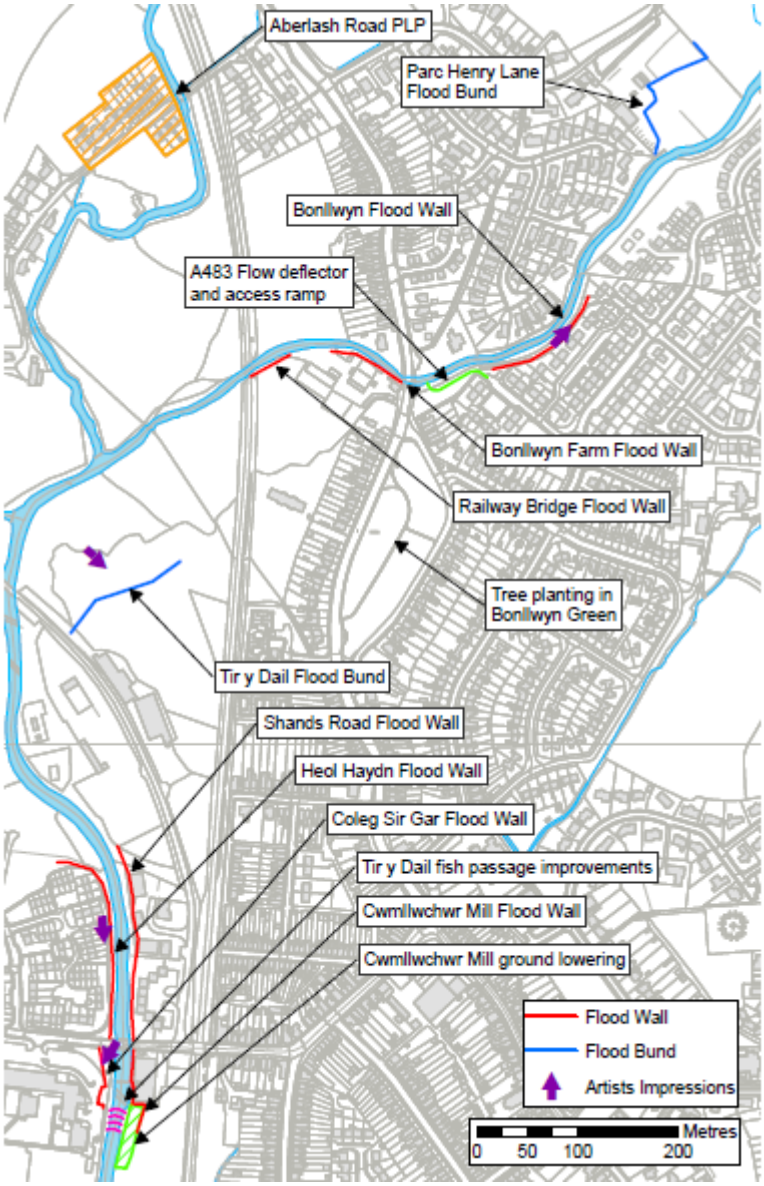

Figure 3 – Scheme overview figure

Note the Aberlash Road PLP is to be delivered separately by NRW and therefore does not form part of this Design Philosophy Statement

Table 1 - Summary of scheme proposals

Defence	Location	Works Proposed	Length (m)	Typical defence height (m)	Typical width (m)
Parc Henry Lane Flood Bund	Northern bank of the River Loughor wrapped around	Proposed grass flood bund to tie-into existing riverbank north of the River	172m	0.3 - 0.7m	Northern section 2m

Defence	Location	Works Proposed	Length (m)	Typical defence height (m)	Typical width (m)
	the existing and proposed properties at Parc Henry Lane.	Loughor. The works would include areas of minor ground raising a bund with a typical 2m crest width, 1:3 slopes and cellular paving with grass infill at the terminus.			(including 1m crest). Southern section 6.6m (including 2m crest).
Bonllwyn Flood Wall	Southern bank of the River Loughor to the rear of properties fronting Ffordd-Yr-Afon.	Construction of reinforced concrete flood wall with dry side brick cladding and concrete copings. The proposed development would include 12no. replacement trees upon the riverbank and 2no. large bulb planting areas with a the adjacent existing footpath reinstated along its existing alignment	105m	1.0m	0.4m (excluding buried wall foundation)
A483 Flow Deflector and Access Ramp	Southern riverbank of the River Loughor, immediately adjacent (east) of the A483 road bridge, with the access track connecting to the dead end of Heol Llwyd.	Installation of a timber flow deflector and scour protection within the watercourse, vehicle access ramp constructed of reinforced concrete and cellular paving with grass infill. The side slopes to the vehicular ramp would be lined with blockstones. Works would include a gated access, vehicle bollards and reinstated pedestrian path.	67m	N/A	4m
Bonllwyn Farm Flood Wall	Bonllwyn Farm on the southern bank of the River Loughor.	Construction of a mass concrete flood wall.	80m	0.8m	0.7m
Bonllwyn Farm Landscape Planting	Southern bank of the River Loughor between the proposed	Mitigation planting of 13no. trees and wet woodland mix to mitigate	N/A	N/A	N/A

Defence	Location	Works Proposed	Length (m)	Typical defence height (m)	Typical width (m)
	Bonllwyn Farm and Railway Bridge flood walls.	riparian vegetation loss upon the River Loughor.			
Railway Bridge Flood Wall	Immediately east of railway bridge on the southern bank of the River Loughor.	Construction of reinforced concrete flood wall.	45m	1.2m	0.3m (excluding buried wall foundation)
Bonllwyn Green Landscape Planting	South of the River Loughor, adjacent to Llandybie Road to the west.	Tree mitigation planting and public realm enhancements including 57no. trees, 4no. timber benches and wildflower meadow planting.	N/A	N/A	N/A
Tir-y-Dail Flood Bund	Agricultural land situated between Shands Road and Heart of Wales Railway Line.	Proposed flood bund with a typical 2m crest width and associated landscaping. Each bund terminus would be installed with cellular with grass infill.	137m	2m	20m
Shands Road Flood Walls	Land situated between light industrial units at Shands Road on eastern bank of the River Loughor.	Construction of 4no. flood walls to tie-into existing industrial units to create continuous flood wall. Waterproofing will be applied to the external river side walls of the industrial units where they form part of the defence line. Mitigation planting, comprising 27no. trees and wet woodland mix to trunk areas.	200m	1.5m	0.4m (excluding buried wall foundation)
Heol Haydn Flood Wall	Land situated on western riverbank of the River Loughor adjacent	Construction of reinforced concrete flood wall with brick cladding on the dry side and concrete copings and reinstated pathway. The proposals would include	210m	1m	0.4m (excluding buried wall foundation)

Defence	Location	Works Proposed	Length (m)	Typical defence height (m)	Typical width (m)
	to Gwyn Fryn Estate properties.	mitigation planting of 39no. trees and 9no. areas of spring flower planting and public realm improvements.			
Coleg Sir Gâr Flood Wall	Western riverbank of the River Loughor south of Dyffryn Bridge, adjacent to Coleg Sir Gâr Ammanford Campus.	Construction of a flood wall with brickwork cladding and concrete copings. The works would include replanting of 11no. trees, 2no. bulb planting areas, and public realm improvements.	80m	1.2m	0.4m (excluding buried wall foundation)
Tir-y-Dail Weir and Fish Passage Improvements	Within the River Loughor watercourse south of Dyffryn Bridge.	Installation of 5no. pre-barrage notches, reinforcements to the existing Tir-y-Dail weir and installation of rip rap protection.	50m	N/A	N/A
Cwmllwchwr Mill	Commercial units situated to the immediate south of Dyffryn Bridge upon the eastern riverbank.	Construction of a flood wall adjacent to commercial units, rip rap covering, ground lowering, cellular paving with grass infill, reinstated path and mitigation planting comprising 59no. trees and wet wootland mix planting.	90m wall length plus area of ground lowering	0.6-1.4m	0.3m for wall upstand (excluding buried wall foundation and area of ground lowering)

2 Design Requirements

2.1 Standard of protection

The design flood event is a flood with a 1 in 100 chance of occurrence in any given year with an allowance for climate change to 2119. The standard of protection was determined as part of the Outline Business Case (NRW, 2019).

2.2 Design life and maintenance

The proposed design life and maintenance requires are summarised in the table below.

Table 2 - Summary of proposed design life and maintenance of assets

Asset	Proposed design life	Maintenance by NRW
All Bunds	100 years	Inspected and grass cutting twice a year
All flood walls	Walls and bases 100 years Joint sealants manufacturer's guarantee for at least 10 years	Inspected yearly Periodic replacement of sealant
Shands Road tanking	Manufacturer's guarantee for at least 10 years	Inspected yearly
A483 Bridge Flow Deflectors	Designed to remain stable to given return period event (to be agreed with NRW)	Inspected following high flow events (trigger event tbc)
Landscaping and enhancements	Will vary for different products and materials, but will aim for robust materials to maximise design life and maintenance requirements	To be determined as part of landscaping specification
Fish passage	30 years	Regular visits from NRW fisheries officers to monitor performance of fish pass and remove debris as necessary. Pass has been designed to minimise risk of blockage. Some maintenance is anticipated in early years of pass operation to improve passage and maintain rock armour.

Note further details of the inspections and maintenance of assets will be presented in the Operation Manual.

2.2.1 Bund maintenance

The following points outline the agreed geometry of bund for grass cutting, maintenance and inspection.

- Only 'light' vehicles will drive over the bunds such as maintenance trucks and mowing equipment up to an equivalent uniformly distributed load of 5kPa.
- For safe maintenance, slopes will be a maximum of 1V:3H. For context, general guidance is provided below from the Fluvial Design Guide.
  Normally the Bund side slopes are between 1:2 (vertical to horizontal) and 1:3. Steeper slopes are very difficult to maintain (grass cutting), while flatter slopes tend to add unnecessarily to the footprint of the Bund and the quantity of fill material required.[1]
- Where standard maintenance vehicles are required to access the crest of the bunds, the crest width will be a minimum of 4m. Where not required and the bund will only accessed by pedestrians or a tracked remote controlled mower, the crest width will be a minimum of 2m. For context, general guidance is provided below from the Fluvial Design Guide.
  The width of the crest is normally determined by asset management requirements, with widths of 2m to 5m being the normal range. In the absence of more specific guidance, designers are advised to adopt a crest width which is two metres wider than the maximum width of plant that will be used on the crest (allowing one metre safety margin on each side). [2]
- NRW have indicated that a tracked remote controlled mower will be used to cut the bunds (such as a 'Robocut' machine) which will work transversely across the profile of the mound. As such the bottom and top of the slopes should be 'rounded' to allow the mover to pass smoothly over the top. The radius on the corners of the mound will be dependant on the slope angle.
- NRW have indicated any fencing at the toe of the mound should be located at least 0.5m away
- NRW have indicated that a 6m diameter turning area should be allowed for at the end of the bunds for the robotic mower. The turning area should be lined with plastic cellular paving to prevent cutting up of the grass.

2.3 Interfaces

The interfaces with the proposed works which have been identified are summarised in the table below.

Table 3 - Summary of interfaces with proposed flood defence works

Defence	Interfaces
Coleg Sir Gar Bund	Landowner: Coleg Sir Gar Other: Upstream end tie-in to road bridge
Shands Road Wall (and property tanking)	Landowner: CCBC, Teen Challenge UK Other: Interfaces with 3no. commercial units and road bridge at downstream end

[1] http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter9.aspx?pagenum=8
[2] http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide/Chapter9.aspx?pagenum=8

Heol Haydn Wall	Landowner: CCBC, Family Housing Association (Wales) Limited Other: Downstream end tie-in to road bridge
Tir-Y-Dail Bund	Landowner: Brynmarlais Estate (V. Herbert and H. Davies), N. Lewis, Mr and Mrs P Jones, Mr and Mrs Richards, Bryn Bach Coal Ltd. Other: Downstream end tie-in to road embankment, field is used for grazing animals
Railway Bridge Bund	Landowner: Anthony Paul Jones and Nicola Jayne Jones of Bonllwyn Farm Other: Downstream end tie-in to Network Rail bridge or embankment
Bonllwyn Farm Wall	Landowner: Anthony Paul Jones and Nicola Jayne Jones of Bonllwyn Farm Other: Upstream end tie-in to road bridge
Bonllwyn	Landowner: CCBC (works immediately adjacent to front gardens) Other: None
Parc Henry Lane Bund	Landowner: Tablic Limited Other: Within / adjacent to new housing development
Tir-y-Dail Weir and Fish Passage Improvements	Landowner: Unidentified Other: DCWW weir
Cwmllwchwr Mill	Landowner: Robert Stuart Thomas Other: NRW Hydrometry and Telemetry Team
Bonllwyn Green	Landowner: CCBC Other: Two bus stops on western side, benches, signposts, bins, lamposts

Reference should be made to the note in Appendix A for interfaces with utilities.

2.4 Access requirements

The existing access requirements in the vicinity of the proposed works which have been identified are summarised in the table below.

Table 4 - Summary on existing access routes in vicinity of proposed works

Defence	Permanent Works Access
Coleg Sir Gar Wall	Access required to existing sewer pump chamber. Agreed with landowner this would be provided via downstream end of wall. Student access to be discouraged through gated fence at end of wall and planting behind the wall.
Shands Road Wall (and property tanking)	NRW have requested maintenance steps over the wall which will also provide access to an existing surface water manhole on the river side of the flood wall. Existing council access corridor down norther side of units to be maintained open and free from landscape planting.
Heol Haydn Wall	Works adjacent to existing footpath along top of riverbank
Tiy-Y-Dail Bund	Existing public right of way and also various informal footpaths used by public. One of the informal footpaths to be severed by bund alignment.

Railway Bridge Wall	None
Bonllwyn Farm Wall	None
Bonllwyn Wall	Existing footpath, to be reinstated alongside wall
Parc Henry Lane Bund	None
Fish passage	None
Cwmllwchwr Mill	Existing access along river side of building to be maintained.
Bonllwyn Green	Existing footpath around perimeter of park (absent on eastern perimeter) and simple network of paths through interior of parkk

2.5 Key risks

There is a live project risk register for the scheme which is shared with NRW and Arup on SharePoint.

https://arup-my.sharepoint.com/:f:/p/jamie_lancaster/EjTd1kZ0LRdBrAh6jE2Zxr0BPQM25tYy6vmmlETUqt4f-A

3 References

A list of applicable design standards is provided in the table below. Eurocodes will be used in conjunction with the accompanying UK national annex as they are written at 24/04/2020.

Code/Guide Ref.	Title
BS EN 1990	Eurocode 0: Basis of structural design.
BS EN 1991	Eurocode 1: Actions on structures.
BS EN 1992	Eurocode 2: Design of concrete structures.
BS EN 1996	Eurocode 6: Design of masonry structures
BS EN 1997	Eurocode 7: Geotechnical design.
BS EN 206	Concrete. Specification, performance, production and conformity.
BS 8500:2015 Part 1 & 2	Concrete. Complementary British Standard to BS EN 206.
Natural Resources Wales Standards	Well-being Statement 2017/18
BS 13383-1:2002	Armourstone – Part 1: Specification
BS 8545: 2014	Trees: from nursery to independence in the landscape
BS 3882: 2015	Specification for Topsoil
BS 5837: 2012	Trees in relation to design, demolition and construction – Recommendations
BS 3998: 2010	Tree work – Recommendations
TAN 12	Technical Advice Note 12: Design (Welsh Government)
JNCC	UK Biodiversity Action Plan
BS 8300-1: 2018	Design of buildings and their approaches to meet the needs of disabled people. Code of practice
Doc No 110_07	Environment Agency, Technical design details – Bunds, Issued 01/05/07
DMRB	Design Manual for Roads and Bridges suite of documents.
Welsh Government Statutory Standards for Sustainable Drainage	Welsh Government Statutory Standards for Sustainable Drainage
SFA 7th Edition	Sewers for Adoption 7th Edition.
CIRIA C683	The Rock Manual- The use of rock in hydraulic engineering
CIRIA C742	Manual on scour at bridges and other hydraulic structures, second edition.

4 Baseline information

4.1 Coordinate System

The following coordinate system will be adopted unless specified otherwise on drawings:

- All levels to be specified in metres above Ordnance Datum Newlyn.
- Site grid X/Y - true OS (OSGB36)

Construction datums will be specified in due course.

4.2 Survey Information

The following survey information will be used as baseline information:

- Topographic survey, Infomap, November 2018
- Topographic survey, Usk Land Survey, March, August, November and December 2020
- Ground Investigation Factual Report, WYG, April 2020 and January 2021
- River Loughor Sediment Study, Arup, June 2020
- Preliminary Ecological Appraisal, JBA (2018) and Arup (2020).
- Landscape and Visual Appraisal, Arup, January 2021
- GPR Utilities Trace, Midlands Survey Ltd, March and December 2020
- Statutory Utilities Search, Linesearch, January 2020
- Tree Survey and Arboricultural Impact Assessment, Mackley Davies Associates Ltd, October 2020
- Land Ownership, provided by Natural Resources Wales, January 2020

4.3 Flood defence levels

The defence level of each constituent part of the scheme will be calculated based on the hydraulic model for the design flood event, which is the 1% AEP with an allowance of 30% for climate change, using the central allowance for West Wales up to 2119. This is determined using the Welsh Government 2017 guidance on adapting to climate change for Risk Management Authorities[3].

[3] https://gov.wales/sites/default/files/publications/2019-06/adapting-to-climate-change-guidance-for-flood-and-coastal-erosion-risk-management-authorities-in-wales.pdf

An allowance will be applied above the protected peak water level (freeboard) to allow for residual uncertainty in accordance with Section 3.10 of the Welsh Government FCERM Business Case Guidance[4] as summarised in the table below.

Table 5 - Summary of residual uncertainty analysis (freeboard)

Location	Change in flood level for a given change in variable ($\partial R_x, \partial R_y, \partial R_z$) (m)				Residual Uncertainty (m)	Amendments
	1D Zone	2D Zone	Flows	Embankment permeability		
Parc Henry Lane	0.15	0	0.216	0	**0.29**	NRW requested amended to 0 as only minor ground raising.
Bonllwyn	0.16	0	0.32	0	**0.17**	-
Bonllwyn Farm and Railway Wall	0.15	0	0.74	0	**0.18**	Currently pending decision following Railway Wall options study.
Tir-y-Dail	0.14	0.01	0.49	0	**0.16**	-
Shands Road, Heol Haydn, Cole Sir Gar and Cwmllwchwr Mill	0.2	0.09	0.55	0	**0.22**	-

In addition, flood defence levels will be such that detriment is managed in accordance with the agreed detriment criteria as outlined below:

Detriment Criteria

The detriment criteria proposed is as follows:

- Detriment should be based on flood depth and frequency of flooding
- An increase in flood depth of less than 5mm is within standard modelling tolerance and will not constitute detriment
- The assessment will be based on the 2119 climate change allowances
- The assessment will be done for the following return periods with 2119 climate change allowances:
    - 1 in 30 (3.33%) with climate change
    - 1 in 100 (1%) with and without climate change
    - 1 in 1000 (0.1%) without climate change, with climate change (if agreed)
- The bands for flood frequency assessment will be as follows:
    - Very Low < 1:1000 (0.1%)
    - 1:1000 (0.1%) ≤ Low < 1:100 (1%)
    - 1:100 (1%) ≤ Medium < 1:30 (3.33%)
    - 1:30 (3.33%) ≤ High

[4] https://gov.wales/sites/default/files/publications/2019-06/flood-and-coastal-erosion-risk-management-fcerm-business-case-guidance_0.pdf

A detriment is assumed to occur where flood depth increases by greater than 5mm as a result of the scheme design, or where the flood frequency increases. Additionally properties that flood in the scheme in any of the above events, that are not observed to flood in existing conditions would be considered detriment, regardless of depth.

Success Criteria

At least one of the following conditions must be satisfied for each property:

- No detriment; or
- detriment but 'likelihood of flooding with detriment' is low or very low. In this case communication to property owners will be undertaken; or
- detriment and 'likelihood of flooding with detriment' is medium or high. In this case mitigation will be proposed which will change the 'likelihood of flooding with detriment' to low or very low.

4.4 Environment and ecology

A Phase 1 Habitat survey was undertaken by Arup on 21st January 2020 and the results are presented in the Preliminary Ecological Appraisal report (Arup, February 2020). The PEA was updated in July 2020 to incorporate the fish passage works. The following was identified:

- Various habitats throughout the site including broadleaved parkland/scattered trees, scattered scrub, mixed parkland/scattered trees, dense/continuous scrub, amenity grassland, buildings and bare ground.
- The site has the potential to support roosting and foraging bats, otters, white-clawed crayfish, badgers, dormice, fish, reptiles, nesting birds and Section 7 invertebrates and mammals.
- Several invasive species were found within the site.

Further ecological surveys were undertaken including bats, badgers, otters and water voles. An otter license for disturbance is required for the scheme which is currently under preparation.

Note no internationally, nationally/locally designated sites are present within 2 km of the site.

Sensitive receptors will be considered as part of the detailed design to minimise potential impact during the construction, operation and maintenance of the assets.

An Environmental Action Plan has been prepared to manage environmental and ecological risks during construction.

5 Design of flood defences

The proposed design approach for the various forms of proposed flood defences is summarised in the following sections.

5.1 Bunds

5.1.1 Input Information

- Topographic survey, Infomap, November 2018
- Topographic survey, Usk Land Survey, March, August, November and December 2020
- Ground Investigation Factual Report, WYG, April 2020 and January 2021
- Landscape and Visual Appraisal, Arup, January 2021
- Statutory Utilities Search, Linesearch, January 2020
- Tree Survey and Arboricultural Impact Assessment, Mackley Davies Associates Ltd, October 2020

5.1.2 Relevant standards and guidance

- BS EN 1997-1 Eurocode 7: Geotechnical design. Part 1: General rules
- NA+A1:2014 to BS EN 1997-1:2004+A1:2013 UK National Annex to Eurocode 7
- CIRIA C749 Application of Eurocode 7 to the design of flood Bunds
- Environment Agency, Technical design details – Bunds, Issued 01/05/07

5.1.3 Loading

- Water pressures applied up to the crest level of the bund on the river side
- A maintenance load of 5kPa

5.1.4 Methodology

Scenarios

For the design of the flood Bund, the following scenarios will be considered:

- Normal condition under maintenance loading
- Flood condition with flood water at crest level
- Rapid drawdown scenario post flood event, with residual pore water pressures in the soil

Slope Stability Analysis

The stability of the Bund slopes will be analysed using Oasys Slope using Bishop's methodology with variably inclined interslice forces. The analysis was undertaken in accordance with BS EN 1997-1:2004 with partial factors applied as defined for Design Approach 1 Combination 1 and Combination 2.

Geotechnical parameters will be derived based on the findings of the ground investigation and presented in the Geotechnical Investigation Report (GIR).

5.1.5 Design assumptions

- Based visual inspections, the existing riverbanks are stable and do not show any signs of distress or movement. NRW or other stakeholders have not provided any information or records suggesting historic bank stability issues. As such, the design will consider the local stability of the bund and assume that the riverbanks are stable in their current existing form.
- The geometry requirements for maintenance as outline in Section 2.2.1 will be applied.

5.2 Concrete Walls

5.2.1 Input Information

- Topographic survey, Infomap, November 2018
- Topographic survey, Usk Land Survey, March, August, November and December 2020
- Ground Investigation Factual Report, WYG, April 2020 and January 2021
- Landscape and Visual Appraisal, Arup, January 2021
- GPR Utilities Trace, Midlands Survey Ltd, March and December 2020
- Statutory Utilities Search, Linesearch, January 2020
- Tree Survey and Arboricultural Impact Assessment, Mackley Davies Associates Ltd, October 2020

5.2.2 Relevant standards and guidance

- BS EN 1990:2002+A1:2005: Eurocode - Basis of structural design
- BS EN 1991-1-1:2002: Eurocode 1 - Actions on structures
- BS EN 1991-1-7:2006+A1:2014: General actions – Accidental actions
- BS EN 1992-1-1:2004: Eurocode 2 - Design of concrete structures- Part 1: general rules and rules for buildings
- BS EN 1992-3:2006: Eurocode 2 - Design of concrete structures- Part 3: Liquid retaining and containment structures
- BS EN 1996-1-1:2005+A1:2012 – Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures.

- BS EN 1996-1:2006 - Design of masonry structures – Part 2: Design considerations, selection of materials and execution of masonry.
- BS EN 1997-1 Eurocode 7: Geotechnical design. Part 1: General rules. The relevant UK annex associated with each of the above will also be used.
- DMRB Volume 1 Section 3 CD356 Highway structures and bridges. Design of highway structures for hydraulic action

5.2.3 Loading

- Water pressures applied up to the top of the wall on the river side
- Impact from floating debris calculated in accordance with CD356. The load will be calculated for:
    - a log/tree weighing 3000 kg where there is nothing in the river channel to prevent a large tree floating down the river and striking the wall
    - a telegraph pole or similar weighing 500 kg where there is something in front of the wall (e.g. a fence) or a short distance upstream (e.g. a bridge) that would prevent large debris reaching the wall but would allow smaller things to pass
    - no impact load at all where there is something in front of the wall (e.g. an area of dense vegetation) or a short distance upstream (e.g. a bridge) that would prevent floating debris from striking the wall

  In all these cases the debris will be assumed to be travelling at the velocity of the water in a flood and striking the wall at any angle between 0 and 20 degrees.

5.2.4 Methodology

Structural

Stem, base and shear key will be checked for adequate resistance against failure in bending or shear, and to ensure crack width is not excessive.

Design will assume that a small amount of leakage is acceptable in a flood and the tightness class will be class 0 in accordance with section 7 of BS EN 1992-3:2006.

Stability

The overall stability of the wall will be accessed against both sliding and overturning failure mechanisms. The stability assessment will be undertaken in accordance with BS EN 1997-1:2004. Geotechnical parameters will be derived based on the findings of the ground investigation and presented in the Geotechnical Investigation Report (GIR).

Foundation

The bearing capacity of the wall foundation will be assessed under loading from flood water. The stability assessment will be undertaken in accordance with Annex D of BS EN 1997-1:2004. Geotechnical parameters will be derived based

on the findings of the ground investigation and presented in the Geotechnical Investigation Report (GIR).

5.2.5 Design assumptions

- Based visual inspections, the existing riverbanks are stable and do not show any signs of distress. As such, the design will consider the local stability of the wall and not the stability of the riverbanks.
- As the walls are not located adjacent to highways, no vehicle impact loading will be allowed for.

	Finishes description	**Standard/specification**
Formed	Rough finish buried concrete and concrete behind cladding.	As CESWI 7th edition, 4.22
Unformed	Screeded finish buried surfaces of bases Brushed finish for concrete on access ramps	As CESWI 7th edition, 4.21

5.2.6 Aesthetic requirements

The aesthetics requirements have been determined as part of the LVIA and as agreed with NRW, further details are as follows:

- Brick cladding to look aged coal tone and retain the natural variation in the surface. Brick units to be washed with black mineral to achieve desired look (or equivalent product).
- Coping stone finish to be textured imitation concrete to match nearby bridge parapet coping stone.
- Pillars to be cladded on all faces with materials matching the wall cladding and pillar cap to match wall coping in shape and materials.
- The finish to concrete structures shall be in accordance to CESWI 7th Edition rough sawn timber finish.

5.3 Shands Road Property Tanking

At Shands Road there are three commercial units at the proposed location of the flood defence in close proximity to the top of the riverbank. At the upstream end, downstream end and two gaps between the commercial units, flood walls are proposed, the design of which is covered by the above. These walls will connect in to the commercial units and the exterior river side wall of the commercial units will be waterproofed through tanking.

The global stability of the existing buildings will as a starting point be verified by checking that the moments and shears during a flood will not exceed what the buildings should have been designed for.

Individual components will be checked by either:

- Verifying that the moments and shears acting on the element during a flood will not exceed what the element should have been designed for, or
- Showing that the element is compliant with industry standards for the loading imposed on it duringA a flood.

Where neither of these is possible, strengthening works will be designed.

The calculation assessments concluded that the additional loading the building is experienced due to the water is not greater than the capacity of the design. However, we do not know if it was designed correctly or if there any material defects so we cannot prove this beyond doubt. We also must caveat the assumptions around the base plate connection and foundation raft design. If this is incorrect then we cannot guarantee the building will be able to withstand the additional loading. This residual risk will be communicated to the contractor and site verification completed.

5.4 Cwmllwchwr Mill Units

At Cwmllwchwr Mill units, the new defences need to be built in a way that maintains access to the gauging station and the river.

The access and maintenance requirements for the gauging hut include:

- The formal access route from the north needs to be accessible in a flood event using only steps to go up/down (no ladders) and this route needs to get from the car park to the station using steps only.
- The existing steps adjacent to the station need to remain accessible
- The stilling well needs to continue functioning, but it would be acceptable to reduce its size and raise it to 0.2m above the defence level
- The cables, ducts, etc. that currently go from the river to the station need to continue going from the river to the station. The existing gully pots are used to draw cables through and need to be maintained.
- Access to the river channel is very occasional and does not involve carrying large or heavy equipment. It is preferred to maintain stepped access as much as possible but due to space constraints, access via ladders could be used as long as there is a safe platform at the bottom of that ladder.

It is proposed that the line of defence is provided by a mass concrete infill doubling as a pedestrian walkway around the gauging station with a handrail on the river edge. This will tie-in to new walls on the north and south.

A new mass concrete block may be required to secure the backstay cable which is to be confirmed through the design process.

The existing gauging station stanchion is to be repaired and re-commissioned. New rings are proposed to make the stilling well smaller with remainder of well to be infilled. New ducts are proposed to tie the existing ducts to the new smaller well.

To maintain access to the river, a floodgate between the new line of defence and the existing steps is proposed. A new mass concrete platform adjacent to the steps is proposed.

5.5 Seepage

As part of the detailed design, a Seepage Assessment has been undertaken for the scheme (Arup, 1st October 2020). This seepage assessment has demonstrated that for the majority of the scheme the risk of excessive seepage is considered to be low. In summary this is primarily based on the low permeability Alluvium being present throughout the majority of the scheme and the relatively short duration of the flood event for which the defences are required to retain water. As such, no additional measures are recommended to reduce or control seepages.

In a small number of localised areas there is a higher risk of seepage. Generally it is envisaged that this risk can be mitigated through construction (such as the inspection of formations). However, for the Bonllwyn Farm Wall it is anticipated that there could be higher seepage at this location due to the absence of Alluvium. The purpose of this defence is to prevent homes located over 500m away and as such a significant volume of seepage would need to occur to cause flooding of these homes. In addition, there are significant challenges associated with the installation of a sheet pile cut off at this location. As such, it was agreed with NRW that the potential for higher seepages at this location is accepted and no further additional measures are undertaken. If in future flood events higher than acceptable groundwater seepages do occur which result in flooding, drainage and attenuation could be installed to better control such seepages.

6 Flow deflector and access ramp

6.1.1 Input Information

- Flood model data including cross sections, water levels and cross-sectional velocity.
- JBA Geomorphology Study.
- River Loughor Sediment Study, Arup, June 2020
- Ground Investigation Factual Report, WYG, April 2020 and January 2021
- Statutory Utilities Search, Linesearch, January 2020
- Tree Survey and Arboricultural Impact Assessment, Mackley Davies Associates Ltd, October 2020

6.1.2 Relevant standards and guidance

- CIRIA C683 The Rock Manual;
- CIRIA C742 Manual on scour at bridges and other hydraulic structures;
- River Restoration Centre: Practical Use of Deflectors in River Restoration Science Digest (https://www.therrc.co.uk/sites/default/files/files/Science_Digest/deflectors_v4.pdf)
- Environment Agency Fluvial Design Guide.

6.1.3 Methodology

The form of the flow deflector(s) will be determined by calculations of shear stress and sediment transport capacity, which are informed by flow velocities derived from hydraulic modelling. The most appropriate scale and alignment of the structure(s) will be determined based on literature review evidence of the performance of similar structures.

The structure will be conservatively represented in the hydraulic model to consider its effect upon flood risk.

An access ramp is required to provide plant access for the maintenance of the flow deflectors. See section 6.1.5

6.1.4 Design assumptions

The sediment size and degree of armouring of the accumulated sediment (and wider riverbed) will be estimated from description and photographs in JBA's geomorphology walkover information and from the River Loughor Sediment Study (Arup, 2020).

Cross sectional average velocities derived from hydraulic modelling are suitable for use in calculating the shear stress required to induce sediment transport.

Suitable information (e.g. foundation depth and composition) is available to assess the scour risk to the A483 road bridge, and that the asset owner is consulted during the design.

The flow deflector will be formed of timber hardwood (agreed with NRW by email - 2nd Sept 2020). This will provide a degree of flexibility in its form so that it can be modified to improve performance or easily repaired as required.

6.1.5 Access requirements

Access to the flow deflectors is to be provided by an access track and ramp to the river bed. The track is to be accessed by 3m wide and 20 tonnes vehicles and so NRW have advised a minimum width of 4m. The track is to be constructed with recycled plastic cellular paving and grass infill.

The access ramp to the riverbed is to be constructed of brushed concrete and should have a maximum gradient of 1V:5H. No turning head is required as vehicles will reverse back up the track.

The use of the access track and ramp will be infrequent due to it only being used for maintenance of the deflectors. Tree loss should be minimised and designs reviewed by an arboriculturist.

7 Landscaping and enhancements

7.1 Input information

- Topographic survey, Infomap, November 2018
- Topographic survey, Usk Land Survey, March, August, November and December 2020
- Landscape and Visual Appraisal, Arup, January 2021
- GPR Utilities Trace, Midlands Survey Ltd, March and December 2020
- Statutory Utilities Search, Linesearch, January 2020
- Tree Survey and Arboricultural Impact Assessment, Mackley Davies Associates Ltd, October 2020

7.2 Relevant standard and guidance

- National Plant Specification;
- BS 4428: 1989 Code of practise for general landscape operations (excluding hard surfaces;
- BS 3936: 1992 Recommendations for cultivation and planting in the Advance Nursery Stock category;
- BS 8545: 2014 Trees: from nursery to independence in the landscape;
- BS 3882:2015 Specification for topsoil;
- BS 8601: 2013 Specification for subsoil and requirements for use;
- DEFRA Construction Code of Practice for the Sustainable Use of Soils on Construction Sites

7.3 Methodology

A mix of native species will be used for planting areas along the wet side of the wall and close to the river corridor. Species have been chosen which are water tolerant and can withstand storm and flood conditions.

For areas within the dry side of the wall and within the residential setting a mix of native and ornamental species have been chosen to provide visual amenity and ecological benefit to help improve the residential setting.

A shade tolerant amenity grass mix is proposed in the residential settings and at Coleg Sir Gar where grass will be shaded by close tree canopy and/or nearby buildings and is likely to receive heavy foot traffic. Bulb planting in these areas will increase the ecological value and provide visual amenity.

A species rich grassland mix has been selected for the flood bunds at Parc Henry Lane and Tir-Y-Dail that reflects the existing open grassland with the addition of wildflowers in the mix which will increase ecological value and visual amenity.

A Grassland seed mix at Mill units has been selected which is tolerant of seasonal flooding and which also include wildflowers which will increase ecological value.

7.4 Design assumptions

- The ground conditions and riverbanks are stable to allow for vegetation clearance and planting.
- Topsoils have sufficient nutrients. Prior to planting percolation tests should be carried out to ensure that soils are suitable for planting.
- Tree planting within tree protection areas has been minimised but in areas where this cannot be avoided, planting will be hand dig only.
- Construction of the flood bunds and walls will be finished in time to allow for planting during the appropriate planting period.

8 Tir-y-Dail fish passage

The current weir is a crude crump-profile weir which appears to be constructed from mass concrete and blockstone. The weir serves both as a long-term flow gauging site for Natural Resources Wales and as protection for a sewer which crosses the river at this location.

The weir is in poor condition, being undercut and scoured in multiple places as shown in Figure 1. There is currently no provision of fish passage.

Figure 1- Existing Weir

8.1.1 Input information

- Ammanford Topographical Weir Survey (Rev C 15/11/2020);
- Technical Note: Current weir condition assessment (09/07/2020);
- Preliminary Ecological Appraisal (10/03/2020);
- Hydraulic Model (09/01/2020); and
- Fishtek Fish Passage Assessment and Design (17/06/2020) and Fishtek Revised Design (09/11/2020).

8.1.2 Relevant standards and guidance

- CIRIA C683 The Rock Manual;

- CIRIA C742 Manual on scour at bridges and other hydraulic structures;
- CIRIA C763 River weirs – Design, maintenance, modification and removal.

8.1.3 Loading

- Water pressures and flows caused by river flows, including the effects of scour
- The majority of debris is likely to clear over the pre-barrages in floods and therefore debris loading is not to be considered.

8.1.4 Methodology

Arup commissioned Fishtek Consulting to assess the current potential for upstream and downstream fish passage and develop the preferred option for the site to the outline design stage.

It is proposed that a series of five blockstone pre-barrages will provide fish easement by stepping the upstream water levels. The pre-barrages will each have a notch with an adherent nappe profile. There will be no change to the impounded area – all flows will be contained within the river channel. The outline design for the pre-barrages can be found in drawings 100-02815-02 to 102-02815-02.

- Individual blocks will be tested for stability according to flows from design life. Flows will be derived from hydraulic modelling results.
- Scour protection designed in line with scour and / or rock manual.

8.1.5 Design assumptions

- Whether the fish pass is to be constructed in ‘wet’ or ‘dry’ conditions will be discussed with the ECI contractor but is assumed to be from the East bank.
- Hydraulic modelling results are sufficient for determining flows and velocities.
- The blockstones will allow some leakage through them and so are thought to act individually.

9 Material Selection

The following materials will be used for the proposed works. All materials are to be designed and specified in accordance with the relevant design code of practices.

9.1 Structural Concrete

Concrete for structural elements will have a suitable strength grade and shall be detailed to ensure adequate performance for the duration of the design life.

Structural elements and joints spacing shall be designed to prevent excessive cracking.

Surface finishes will be as defined in section 5.2.6 unless otherwise specified by considering the exposure of the element in question and the desired aesthetic.

Unless otherwise specified nominal cover to reinforcement will be 55mm.

9.2 Earth Bunds

Earth Bunds will be constructed from imported low permeability fill as specified in the project Earthworks Specification. Potential for onsite reuse of surplus soils in the earth Bunds will be considered based on the results of the ground investigation.

Bunds will be covered with topsoil and grass cover. Site won topsoil will be used where possible, with any shortfall made up of imported topsoil meeting the requirements of BS 3882:2015.

In regard to the grass cover, this will be established by an appropriate seed mix or turf. Depending on the season the grass is planted, biodegradable scour protection matting may be required to protect the bund fill and assist the grass in establishing.

9.3 Backfill

Where backfilling is required, this will be done using site won material where suitable as per the geotechnical engineer's recommendations and specified in the project Earthworks Specification. Alternatively, imported fill be used if necessary.

9.4 Reinstatement

Where the ground is disturbed, this will be reinstated back to its current condition or better.

9.5 Rock armour and blockstone

Rock armour and blockstone elements will be specified in line with CIRIA C683: The Rock Manual.

Appendix A

Interfaces with utilities

Appendix B

Design Decision Register