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Date: 21 March 2018

FAO: Vale of Glamorgan Council (Planning Authority) / Natural Resources Wales

Dear Sir or Madam,

PROPOSED ANAEROBIC DIGESTION PLANT, COG MOORS WASTEWATER TREATMENT WORKS CARDIFF ROAD, DINAS POWYS, CF64 4TR

Arcadis Consulting UK Limited (Arcadis) has produced the following Flood Consequences Assessment (FCA) Statement in support of the planning application being submitted for development at the Dwr Cymru Welsh Water (DCWW) Cog Moors Waste Water Treatment Works (WwTW) located near Dinas Powys, Vale of Glamorgan (VOG).

Proposed Works

The proposed development comprises a number of new process and storage tanks and buildings, together with the demolition of and modification to existing items of plant and equipment.

Temporary construction compounds would be sited on an area of mown grassland immediately adjacent to the existing final settlements tanks, and on an area of grassland to the east and south of the proposed Advanced Anaerobic Digestion (AAD) plant.

Vehicle access to the proposed development would continue to be gained from the A4055 via Green Lane.

Detailed drawings have been provided as part of the wider planning application pack. It is noted that the assessment of flood risk within this FCA has been made for the redline boundary illustrated on the NRW flood product data (see Appendix B), which incorporates the proposed works as detailed above. The redline boundary, submitted as part of the wider planning application pack (as provided in Appendix A1), includes revision to the redline boundary utilised

within the flood product data to incorporate ecological mitigation measures (as illustrated in Appendix A2), with no material changes to proposed development having been made. An assessment of any impacts associated with the proposed ecological mitigation measures has been included within the FCA.

Site Description

The site is located on land east of the A4055 Cardiff Road on the existing Cog Moors WwTW (National Grid Reference (NGR) 316015,169540), approximately 2km east of Barry and 1km south of Dinas Powys.

The site is located within a low-lying landscape, characterised by flat fields bounded by drainage ditches. The land rises steeply to the north of the WwTW site (Pop Hill) and is intermittently wooded.

The nearest residential properties to the WwTW are located at Downs Farm, approximately 230m to the south; along Cross Common Road to the north east and along Sully Road and Cog Road to the east and south, respectively.

Technical Advice Note 15 (TAN15): Development and Flood Risk

In accordance with the Welsh Government Development Advice Maps (DAMs), the majority of the WwTW site is situated in Zone C2, which is described as areas of the floodplain without significant flood defence infrastructure. This zone is based upon the predicted extent of inundation during a flood with 0.1% chance of happening in any year. However, a small portion of the site to the east is located within Zone B. This, lower risk zone, is described as areas of land known to have been flooded in the past, evidenced by sedimentary deposits.

Section 5 of TAN15 provides guidance on the types of development appropriate for each of the DAM zones, by categorising development according to vulnerability of flooding.

TAN15 does not explicitly define the flood risk vulnerability of the nature of the works proposed at the site. It is considered that the proposed development would be classified as ‘Less Vulnerable’, in line with other ‘utilities infrastructure’.

Section 5.3 of the guidance outlines that less vulnerable development should be subject to both the Justification Test, detailed in Section 6 of TAN15, and the acceptability of consequences as part of the test outlined in Section 7 and the requirements of Appendix 1.

In line with TAN15 guidance, a significant proportion of new development has been directed towards the lower risk Zone B.

In terms of justification, the proposed AAD plant would operate in association with and is therefore located adjacent to the existing sludge treatment facilities at Cog Moors WwTW that are to be retained. The proposed AAD plant development will provide an enhanced level of treatment for sewage sludges generated by the wastewater treatment process at Cog Moors and by other WwTWs in South Wales, in accordance with DCWW’s Sludge Strategy. Liquors

produced by the AAD process would be returned to the inlet works of the Cog Moors WwTW, for treatment.

It is considered that the proposed development would satisfy the Justification Test, given its location in Zone C would improve the performance of an existing WwTW and it concurs with the aims of Planning Policy Wales (PPW), meeting the definition of previously developed land. The proposed development would also comply with relevant policies set out in the VOG Council's Local Development Plan 2011 to 2026, in particular the following:

Policy MD1: Location of New Development

'To ensure that new development on unallocated sites assists in delivering the strategy, development will be favoured where it:

- *Will benefit from existing infrastructure provision or where new infrastructure can be provided without any unacceptable effect on the natural or built environment; and*
- *Promotes sustainable construction and makes beneficial use of previously developed land and buildings'.*

As outlined in Section 11 of TAN15 for development proposed in Zone C, an assessment in accordance with Appendix 1 should be submitted with the planning application. The following therefore provides an assessment of the risk of flooding from a variety of sources to the proposed development, as well as any impacts from the development on third parties, where applicable.

Statement of Flood Risk from All Sources

Fluvial Flood Risk

Proposed Development

The Natural Resources Wales (NRW) Flood Map indicates that the majority of the site is located in Flood Zone 2 (flooding from rivers or sea with up to a 0.1% (1 in 1000) chance of happening in any given year). However, there are areas of the site in the east and the north west that are located in Flood Zone 3 (flooding from rivers with a 1% (1 in 100) chance or greater of happening in any given year). These flood zones indicate the site is considered to be at medium to high risk of flooding, respectively.

The site is located approximately 300 metres (m) from the Sully Brook to the south, which is an NRW designated Main River. The Cadoxton River, also an NRW designated Main River, is situated approximately 700m from the western boundary of the site. The site is located approximately 5km north of the coastline.

Consultation has been carried out with NRW to identify the scope of the Flood Consequences Assessment (FCA) required and to obtain up to date flood product data. The flood product data provided was taken from two hydraulic models developed as part of the Cadoxton Strategic Flood Risk Assessment (SFRA) (see Appendix B: Flood Product Data). This data has been used to further assess the risk of fluvial and tidal flooding to the proposed development site.

With regard to fluvial flooding, risk to the development during the 1 in 100-year (1%) plus 20% climate change (CC) defended event has been assessed, in accordance with TAN15 requirements. The maximum flood elevation for this scenario is 6.84m Above Ordnance Datum (AOD) and the maximum depth of flooding on site would be 0.95m. These flood depths would be limited to the western fringe of the site and the area of proposed new development would not be affected (see Appendix B: Flood Product Data). In addition, examination of the 1 in 1000 year (0.1%) fluvial defended event indicates that whilst there would be a marginally higher maximum depth of flooding (1.21m) on the site, this is also limited to the western fringes of the site where no new development is proposed.

There is an FE Feed Pumping Station which largely comprises underground chambers and three concrete slabs above the existing ground level proposed to be located as part of the permanent works in the temporary construction compound and in the 1 in 1,000-year flood extent. It is considered that the area of the FE Feed Pumping Station could experience flood depths up to 300mm in the 1 in 1000-year flood event. However, in reality given that the concrete slabs would be raised between 55mm and 150mm the depth of flooding in the 1 in 1000-year event would be less. It is considered that any vulnerable above ground infrastructure, such as vales and pipework would be further elevated above the concrete slab to not be at risk of flooding.

The volume of flood storage loss in the 1 in 1000-year flood extent resulting from the construction of the concrete slabs has been estimated. Full details of the calculations have been provided in Appendix D to this report. It is estimated that 3.7m^3 of floodwater would be displaced which would result in a corresponding very small floodwater depth increase of 0.01mm across the 1 in 1,000-year floodplain. It is therefore considered that the construction of the proposed FE Feed Pumping Station would have a negligible impact on flood risk to third parties.

Based on assessment of NRW flood levels and site topography, the proposed development is considered to be at negligible risk of flooding from fluvial sources. NRW have confirmed that land re-profiling or raising is acceptable within the confines of the planning application boundary, (see Appendix C: Correspondence) as this would have no impacts on third party flood risk.

No consideration of the flooding consequences of defence failure, breach or overtopping has been made given that the relative difference between the defended and undefended 1 in 100-year maximum fluvial flood levels is negligible, (at 6.65m AOD and 6.64m AOD respectively).

Inspection of Ordnance Survey (OS) mapping has highlighted that there are a series of drains located within the site. It is considered that where development has the potential to impact on these drains, an ordinary watercourse consent (OWC) would be required and the risk of flooding associated with any modifications to these drains would be managed appropriately as part of a detailed drainage strategy (see below) and in consultation with Vale of Glamorgan Council as the Lead Local Flood Authority (LLFA).

It is therefore considered that the risk of flooding from ordinary watercourses would be negligible.

Access Track

The flood product data indicates that whilst the majority of the existing access road to the WwTW (Green Lane) would be flood free during the 1 in 100 year (+20% CC) fluvial event, a small portion near NGR 315727, 169646 is at risk, with a maximum flood elevation of 6.84m AOD and a maximum flood depth of 0.63m.

Historical flooding information for the track has been obtained from DCWW and it is noted that the track itself has not experienced flooding in the past, however the fields either side of the track are known to flood.

Topographic survey data has been utilised to further examine the risk of fluvial flooding to the track. The lowest ground elevation along the track is 6.63m AOD, which when compared to the maximum flood elevation for the 1 in 100 year (+20%CC) fluvial event (6.84m AOD) would correspond to a depth of 210mm of flooding in a very localised area of the access track (at the location of the NGR noted above). It is considered that emergency vehicles would be able to access the site using Green Lane in this event, as such vehicles can safely travel through floodwaters up to 300mm.

No works are proposed that impact or alter the existing track and therefore no associated impacts on flood risk to third parties are anticipated.

It is considered that the risk of fluvial flooding to the access track is therefore negligible.

Temporary Construction Compounds

The flood product data maps (as provided in Appendix B) indicate that the temporary contractors compound to the west of the site is partially located in an area at risk of fluvial flooding during the 1 in 100-year with 20% climate change (+CC) event (defended).

In particular, the temporary site cabins within the compound are considered to be partially at risk of fluvial flooding up to depths of 0.3m in the 1 in 100-year (+CC) event. Whilst the temporary car park in the compound would largely be flood free during this event, a very small area, along its western fringe, may be located within the fluvial flood extents for the 1 in 100-year (+CC) event and may therefore also experience flood depths up to 0.3m.

In line with TAN15 and in correspondence with NRW (Appendix C), it is considered acceptable that the temporary car park may experience flooding up to a depth of 0.3m, in the 1 in 100-year (+CC) event, given its low vulnerability to shallow flooding.

The temporary site cabins would be raised by a minimum of 0.3m (above the flood level of 6.84 m AOD) and therefore the risk of flooding to these cabins in the 1 in 100-year (+CC) event would be negligible during the 18-month construction period. It is anticipated that the temporary site cabins would be raised on a series of ‘feet’ which would allow floodwaters to be conveyed

beneath them. This arrangement would help to minimise the volume of floodplain storage loss and the potential for impacts on third parties.

The volume of floodplain storage loss resulting from raising the temporary site cabins has been estimated, as a precautionary approach assuming they are raised on a solid infilled base, rather than the intended feet. Full details of the calculations have been provided in Appendix D to this report.

During the 1 in 100-year (+CC) event it is estimated that 88.8m^3 of floodwater would be displaced which would result in a corresponding very small floodwater depth increase on the floodplain of 0.247mm. Given that the feet by which the cabins are intended to be raised would have a significantly smaller footprint than that which has been assessed in this calculation, it is concluded that the raising of the temporary site cabins would have a negligible impact on flood risk to third parties.

Further assessment of flood conditions has been undertaken to determine the risk of the raised cabins being 'floated' during the 1 in 100-year (+CC) event. The velocity of floodwaters in the area of the temporary site cabins has been taken from the flood product data provided by NRW and this data, together with the floodwater depth (0.3m) and consideration of a debris factor, has been used to determine a Flood Hazard Rating (HR)[1]. Further details of the calculations have been provided in Appendix D to this report.

The maximum velocity for floodwaters in the 1 in 100-year (+CC) fluvial extent, within the planning application boundary as a whole is 0.36m/s. It is noted that the velocity of floodwaters experienced in the area of the temporary site cabins, situated on the fringes of the flood extent, is likely to be less than this value, given that the flood product data indicates a mean velocity on the site of 0.04m/s.

The HR value of 0.76 that has been calculated using this conservative velocity value indicates a 'Moderate' flood hazard. However, as conservative data has informed the calculation, the degree of hazard is likely to be Low. Given that the ratings are indicative of hazards to people i.e. the indicative of the likelihood of a person not being able to stand up in floodwater, it is considered that the risk of the site cabins floating due to them being raised on feet, is negligible.

In the 0.1% AEP or 1 in 1000-year (defended) event, the temporary site cabins and temporary car park are considered to be at risk of fluvial flooding up to depths of 0.6m. Consultation with NRW has determined that this is acceptable, in line with TAN15 guidelines (see Appendix C).

The probability of a 1 in 1000-year or 0.1% AEP event occurring during the 18-month construction period is very low (0.2% chance of a 1 in 1000-year event occurring in a 2-year period).

[1] DEFRA/Environment Agency, 2006. Flood and Coastal Defence R&D Programme. Flood Risk to People. Phase 2 FD2313/TR2 Guidance Document. Supplemented in 2008 by 'Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purpose – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2312/TR1'.

However, it is recommended that the site contractors sign up to the NRW Flood Warnings service and prepare a Flood Management Plan to facilitate safe access and egress from the temporary construction compound in the event of flooding.

The temporary contractor compounds to the east and south of the proposed AAD plant are not located within the 1 in 100-year or 1 in 1000-year fluvial flood extents. There is therefore a negligible risk of flooding associated with these temporary contractor compounds.

Proposed Ecological Mitigation Measures

The ecological mitigation measures proposed across the site are illustrated in Appendix A2. The proposed measures are limited to the following: a SINC grassland management area, amenity grassland, species rich grassland, woodland belt planting, individual tree planting, an area to be managed for wildlife and the management for biodiversity of an area of existing land (tree planted) on site.

The majority of the proposed ecological mitigation measures are situated to the east of the site and are not located within the 1 in 100-year (+CC) fluvial flood extent. There is a small section of existing land (tree planted) to the south east of the site that is proposed to be managed for biodiversity which is located within the 1 in 100-year (+CC) fluvial flood extent and would therefore be considered to be at risk of fluvial flooding, up to depths of 0.6m. However, given that this measure does not require the raising of land or changes to the existing flood conveyance routes or flood levels within the floodplain, it is considered that there would be negligible impacts on fluvial flood risk on site or to third parties associated with this mitigation measure.

To the west of the site, along the southernmost boundary, there are 9 individual trees proposed to be planted as part of the ecological mitigation measures for the site. These trees would be located within the 1 in 100-year (+CC) extent, with depths of flooding up to 1m. Given the small footprint of the trees in the floodplain, it is considered that the impact of planting on fluvial flood risk to the site and third parties would be negligible. There is an area of woodland planting proposed to the north of Green Lane. This would have negligible impact on flood risk given its location outside of the 1 in 100-year (+CC) extent.

Tidal Flood Risk

The 1 in 200 year defended tidal event, including upper confidence interval climate change allowance, has been used to inform the assessment of flood risk and design thresholds for the proposed development site. The flood product data indicates that the site, access track and temporary construction compounds would be flood free in this scenario, and no tidal flooding is predicted over the development lifetime (25 years) taking climate change impacts into consideration.

It is therefore considered that the risk of tidal flooding to the site is negligible and there would be no impacts to third parties.

The majority of the proposed ecological measures are not located within the 1 in 200 year defended tidal extent, with the exception of 9 individual trees which are

proposed to be planted in the south west corner of the site. It is considered, however, that the associated impact on tidal flood risk to the site and third parties would be negligible.

Artificial Sources

There are no artificial waterbodies raised above natural ground level, for example reservoirs or canals, in the vicinity of the site and the site is not located within NRW's maximum extent of flooding from reservoirs.

It is therefore considered that the risk of flooding from artificial sources is negligible.

Surface Water

Data on existing surface water flood risk has been gathered from NRW published datasets. Much of the site falls within the 'very low' category of risk, which is indicative of a chance of surface water flooding each year of less than 0.1% (1 in 1000). Areas of the site to the north and east, in the location of the existing digester tanks, are considered to be at medium (chance of flooding between 1% (1 in 100) and 3.3% (1 in 30)) to high (chance of flooding of greater than 3.3% (1 in 30)) risk of surface water flooding. However, there are no records of surface water flooding affecting the site.

Current flood risk and development planning policy specifies that surface water arising from a developed site should, as far as practicable, be managed in a sustainable manner to mimic the surface water flows arising from the site prior to the proposed development. The developer should seek opportunities to reduce the overall level of flood risk through appropriate application of Sustainable Drainage Systems (SuDS). This has been considered as part of the overall drainage strategy prepared for the proposed development, which is summarised below.

Drainage Strategy

Surface waters arising from the proposed development would be managed sustainably on site, draining into the existing mains and existing inlet works to the WwTW for use as process water. The risk of flooding associated with any modifications to land drains across the site would also be managed appropriately.

A drainage design has been prepared and has been submitted as part of the planning application pack.

Summary

The majority of the Cog Moors WwTW site is located in Zone C2. However, a large portion of new development has been situated within the lower risk Zone B.

The assessment indicates that the risk of flooding to the proposed development, including the existing access track and temporary construction compounds, from

fluvial and tidal sources is negligible and this has been confirmed in correspondence with NRW.

There is medium to high risk of surface water flooding in some parts of the proposed development site. However, a drainage strategy has been developed to demonstrate the appropriate and sustainable management of surface waters arising from the development.

It is considered that there would be negligible impacts on flood risk to third parties associated with the proposed development and the proposed ecological mitigation measures that also form part of the scheme.

Therefore, the proposed development is considered to meet the requirements of TAN15.

Kind Regards,

Emma Coward
Graduate Hydrologist

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Direct line: 02920926726

List of Appendices

Appendix A: Drawings
(A1): 4798-S-202-HYD-XX-XX-DR-XX-06120
(A2): 4798-S-202-HYD-XX-XX-DR-NX-06127

Appendix B: Flood Product Data

Appendix C: Correspondence

Appendix D: Calculations

Appendix A: Drawings

(A1): 4798-S-202-HYD-XX-XX-DR-XX-06120

A1

N

CARDIFF ROAD
(A4055)

CROSS COMMON ROAD

GREEN LANE
(SITE ACCESS ROAD)

SITE ENTRANCE

SULLY ROAD

PROPOSED SITE DEVELOPMENT
SCALE 1:2500

NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETERS UNLESS OTHERWISE STATED.
2. ALL LEVELS ARE IN METERS ABOVE GROUND LEVEL.
3. DO NOT SCALE FROM THIS DRAWING.

LEGEND:
- PLANNING APPLICATION BOUNDARY
- EXISTING
- PROPOSED
- TEMPORARY CONTRACTORS COMPOUND
- PROPOSED SECURITY FENCE TO TIE INTO EXISTING FENCE LINE

1:2500 | 25m | 50m | 75m | 100m | 125m | 150m | 175m | 200m | 225m | 250m

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
P03	14/03/18	DM	UPDATED BOUNDARY	LW	MN	14/03/18
P02	17/10/17	DP	FOR INFORMATION	YF	MN	17/10/17
P01	21/08/17	DP	FOR INFORMATION	YF	MN	21/08/17

Capital Delivery Alliance
Cynghrair Cyflawni Cyfalaf
Ty Awen, Spooner Close, Coed Kernew, Newport, NP10 8FZ

Project Name: COG MOORS WwTW AAD

Drawing Title: PROPOSED SITE DEVELOPMENT

Suitability.	Suitability Code.
ISSUED FOR INFORMATION	S2

Originator.	Designer.	Date.
DP	RN	17/10/17

Internal Project Number.	Scale.	Rev.
UA007902	1:2500	P03

Drawing Number: 4798-S-202-HYD-XX-XX-DR-XX-06120

(A2): 4798-S-202-HYD-XX-XX-DR-NX-06127

A1

Minimum 1.5m clearance to be maintained between the edge of proposed woodland planting and existing field boundary hedgerow to allow access along existing public footpath.

Trees along north eastern boundary are covered by Tree Preservation Orders

Trees along north eastern boundary are covered by Tree Preservation Orders

LEGEND:

- Planning Application Boundary
- DCWW Land Ownership Boundary
- Public Rights of Way
- Site of Importance for Nature Conservation (SINC)
- Existing Amenity Grass
- Existing Tree and shrub planting
- Existing Tree planting to be managed for biodiversity
- Existing Grassland to be managed as Species Rich Grassland
- SINC Grassland Management Area
- Proposed Amenity Grassland
- Proposed Species Rich Grassland
- Proposed Woodland Belt Planting
- Tall Ruderal
- Dense Scrub
- Proposed Individual Tree Planting
- Area to be Managed for Wildlife
- Bird Nest Box
- Bat Box
- Hibernaculum to be created
- Dormouse Nest Boxes
- Existing Ephemeral Ditch
- Existing Dry Ditch
- Proposed Drainage Ditch

Latin Name	Common Name	Outline Specification	% in Mix
Proposed Woodland Belt Forestry Transplant Mix			
Corylus avellana	Hazel	1+1 Forestry transplant; Bare root; 1.5m spacing.	24%
Quercus robur	Pedunculate Oak	As above.	24%
Carpinus betulus	Hornbeam	As above.	6%
Crataegus monogyna	Hawthorn	As above.	6%
Prunus avium	Wild Cherry	As above.	5%
Ligustrum vulgare	Wild Privet	As above.	4%
Acer campestre	Field Maple	As above.	4%
Viburnum lantana	Wayfaring-Tree	As above.	4%
Sorbus aucuparia	Rowan	As above.	3%
Cornus sanguinea	Dogwood	As above.	3%
Lonicera periclymenum	Honeysuckle	2L Pot; 1.5m spacing.	2%
Frangula alnus	Alder Buckthorn	1+1 Forestry transplant; Bare root; 1.5m spacing.	2%
Rhamnus cathartica	Buckthorn	As above.	2%
Euonymus europaea	Spindle	As above.	2%
Prunus padus	Bird Cherry	As above.	2%
Sambucus nigra	Elder	As above.	2%
Ilex aquifolium	Holly	2L Pot; 1.5m spacing	1%
Hedera helix	Ivy	2L Pot; 1.5m spacing.	1%
Individual Trees			
Quercus robur	Pedunculate Oak	2x, 3 Breaks,Fthd, BR, 1.5-1.75m. 10m spacing	40%
Alnus glutinosa	Alder	As above.	30%
Prunus avium	Wild Cherry	2x, 5 Breaks,Fthd, BR, 1.5-1.75m. 10m spacing	30%

Rev.	Date.	Drawn.	Description.	Chkd.	Appd.	Date.
P06	13.03.18	DM	UPDATED BOUNDARY	LF	LW	13.03.18
P05	12.02.18	DM	SOLAR PANELS MOVED	LF	LW	12.02.18
P04	31.01.11	DM	THIRD ISSUE	LF	LW	31.01.11
P03	19.12.17	RG	SECOND ISSUE	SF	LW	19.12.17
P02	25.10.17	RG	SECOND ISSUE	SF	LW	25.10.17
P01	27.07.17	RG	FIRST ISSUE	SF	LW	21.06.17

Capital Delivery Alliance
Cynghrair Cyflawni Cyfalaf
Ty Awen, Spooner Close, Coed Kernew, Newport, NP10 8FZ

Project Name.
COG MOORS WwTW AAD

Drawing Title.
FIGURE 10
LANDSCAPE MITIGATION PLAN

Suitability.	Suitability Code.
INFORMATION	S2

Originator.	Designer.	Date.
R.G.	S.F.	21.06.17
Internal Project Number.	**Scale.**	**Rev.**
UA007902	1:1250@A1	P06

Drawing Number.
4798-S-202-HYD-XX-XX-DR-NX-06127

Dwr Cymru Cyf gives this information as to the position of its underground apparatus by way of general guidance only on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon in the event of excavations or other works made in the vicinity of the company's apparatus and any onus of locating the apparatus before carrying out any excavations rests entirely on you. It must be understood that the furnishing of the information is entirely without prejudice to the provision of the New Roads and Streetworks Act 1991 and of the Company's right to be compensated for any damage to its apparatus.

Dwr Cymru Cyf has no duty to identify private apparatus and the information as to the position of the private apparatus is given by way of general guidance only on the strict understanding that it is based on the best information available and no warranty as to its correctness is relied upon. Not all private apparatus is identified but their presence should be anticipated.

Appendix B: Flood Product Data

ATI-12429a – Cogs Moor, Green Lane

E:315950 N: 169507

1. Current Flood Map

Figure 1 shows the current Flood Map (version 201701) at this location. The Flood Map represents a combination of the undefended fluvial and tidal flood extents derived from detailed local models and national generalised model data. Undefended scenarios are provided as being a possible worst case scenario in the event of defence failure.

Please note that the current tidal flood outlines shown on the Flood Map in **Figure 1** are based on an NRW Tidal Projection Mapping study (2013) that uses sea level nodes within the Severn Estuary. Each node represents a set of extreme sea levels which were generated by the Environment Agency in 2011[1] for current day (in the studies case, 2008). These levels were projected in-land over a digital terrain model to produce depth and elevation grids as well as tidal mapped outlines for both the 0.5% (1 in 200) AEP (annual exceedance probability) and the 0.1% (1 in 1000) AEP; including climate change and upper confidence intervals (+/-95%).

These outlines offer a more precautionary picture of tidal flood risk and therefore supersede the localised hydraulic modelled outlines described in **Section 2** below.

More information on the Flood Map can be obtained from the Natural Resources Wales website http://www.naturalresources.wales/floodriskmap

2. Local Flood Risk Mapping Study

Model Summary

The results summarised in the tables below are taken from two hydraulic models developed as part of the 'Cadoxton Strategic Flood Risk Assessment'. These are:

a. A multi-domain 1D-2D ESTRY/TUFLOW model assessing fluvial and tidal flood risk from the River Cadoxton and its tributaries – the East Brook, Sully Brook and Cold Brook – from just upstream of Dinas Powys to the Cadoxton sea outfall[2]. The fluvial outputs below are provided from this model.

b. A Tidal Inundation model extending the coastal boundary to include Barry Docks[3]. The above fluvial/tidal model was adopted and modified to allow broad-scale tidal flooding within the lower Cadoxton River catchment. This model is subject to substantially more tidal inundation flooding and as such has been used to provide tidal outputs below.

Results – Site of Interest

The polygon shown in the figures represents the site in question and has been used to query the height, depth, velocity & hazard grids to provide the results in Tables 1-6 below. NULL values indicate that the site is flood free during a particular scenario.

The elevation results have been interpolated to include the climate change increment from the DEFRA guidance on extreme sea level data to show current day scenarios (see Tables **4 & 6** below).

95% confidence bounds for these values were also derived using the confidence intervals for the Newport Extreme Sea Level node.

Example depth grids for the defended fluvial 1 in 100+CC and 1 in 1000, and the defended tidal 1 in 200 (2114) including confidence intervals are reproduced in **Figures 2, 3 and 5** below.

Example hazard grids for the defended fluvial 1 in 1000, and the defended tidal 1 in 200 year (2089) including Confidence Interval, are represented in **Figures 4 & 6**. The hazard rating below relates to the Hazard to People Classification using the hazard matrix[4].

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification
Less than 0.75		Very low hazard – Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

Table 1: Defended Fluvial Level Data

	1 in 2	1 in 5	1 in 10	1 in 30	1 in 50	1 in 75	1 in 100	1 in 200	1 in 100CC	1 in 1000
Model Grid Size (m)	1	1	1	1	1	1	1	1	1	1
Wet Cells	1	119	251	320	320	345	404	676	791	2377
Depth, mean (m)	0.00	0.05	0.19	0.26	0.29	0.33	0.33	0.27	0.30	0.27
Depth, max (m)	0.00	0.20	0.48	0.59	0.63	0.70	0.76	0.87	0.95	1.21
Elevation, mean (mAOD)	6.06	6.16	6.37	6.48	6.52	6.59	6.65	6.76	6.84	7.13
Elevation, max (mAOD)	6.06	6.23	6.37	6.48	6.52	6.59	6.65	6.76	6.84	7.45
Velocity, mean (m/s)	0.00	0.01	0.02	0.04	0.05	0.05	0.04	0.03	0.04	0.04
Velocity, max (m/s)	0.00	0.04	0.15	0.26	0.33	0.36	0.35	0.37	0.36	0.65
Hazard, mean	0.50	0.52	0.76	0.94	0.98	1.01	0.96	0.81	0.83	0.83
Hazard, max	0.50	0.60	1.19	1.28	1.32	1.35	1.38	1.44	1.48	1.61

Table 2: Undefended Fluvial Level Data

	1 in 100	1 in 1000
Model Grid Size (m)	1	1
Wet Cells	404	2327
Depth, mean (m)	0.32	0.27
Depth, max (m)	0.75	1.21
Elevation, mean (mAOD)	6.64	7.13
Elevation, max (mAOD)	6.64	7.45
Velocity, mean (m/s)	0.04	0.04
Velocity, max (m/s)	0.37	0.65
Hazard, mean	0.96	0.83
Hazard, max	1.38	1.61

Table 3: Defended Tidal Level Data with Climate Change (excluding upper confidence Intervals)

	1 in 200			1 in 1000		
	2014	2089	2114	2014	2089	2114
Model Grid Size (m)	2.5	2.5	2.5	2.5	2.5	2.5
Wet Cells	0	0	0	0	0	46
Depth, mean (m)	NULL	NULL	NULL	NULL	NULL	0.23
Depth, max (m)	NULL	NULL	NULL	NULL	NULL	0.50
Elevation, mean (mAOD)	NULL	NULL	NULL	NULL	NULL	6.40
Elevation, max (mAOD)	NULL	NULL	NULL	NULL	NULL	6.40
Velocity, mean (m/s)	NULL	NULL	NULL	NULL	NULL	0.07
Velocity, max (m/s)	NULL	NULL	NULL	NULL	NULL	0.39
Hazard, mean	NULL	NULL	NULL	NULL	NULL	0.79
Hazard, max	NULL	NULL	NULL	NULL	NULL	1.24

Table 4: Interpolated Tidal Results (2016)

	1 in 200			1 in 1000		
	2016	2091	2116	2016	2091	2116
Elevation, max (mAOD)	NULL	NULL	NULL	NULL	NULL	6.43

Table 5: Defended Tidal Level Data with Climate Change (including upper confidence Intervals)

	1 in 200			1 in 1000		
	2014	2089	2114	2014	2089	2114
Model Grid Size (m)	2.5	2.5	2.5	2.5	2.5	2.5
Wet Cells	0	0	46	0	234	3185
Depth, mean (m)	NULL	NULL	0.23	NULL	0.28	0.50
Depth, max (m)	NULL	NULL	0.50	NULL	1.06	2.99
Elevation, mean (mAOD)	NULL	NULL	6.40	NULL	6.97	7.69
Elevation, max (mAOD)	NULL	NULL	6.40	NULL	6.97	7.69
Velocity, mean (m/s)	NULL	NULL	0.07	NULL	0.06	0.26
Velocity, max (m/s)	NULL	NULL	0.39	NULL	0.58	1.54
Hazard, mean	NULL	NULL	0.79	NULL	0.82	1.16
Hazard, max	NULL	NULL	1.24	NULL	1.53	2.57

Table 6: Interpolated Tidal Results (2016)

	1 in 200			1 in 1000		
	2016	2091	2116	2016	2091	2116
Elevation, max (mAOD)	NULL	NULL	6.43	NULL	7.00	7.72

Results – Emergency Access to Site

The access route provided was used to query the height, depth, velocity and hazard grids to provide the results in **Tables 7-12**. NULL values indicate the site is flood free during this scenario.

Table 7: Defended Fluvial Level Data

	1 in 2	1 in 5	1 in 10	1 in 30	1 in 50	1 in 75	1 in 100	1 in 200	1 in 100CC	1 in 1000
Model Grid Size (m)	1	1	1	1	1	1	1	1	1	1
Wet Cells	0	28	70	173	190	250	332	569	714	1226
Depth, mean (m)	NULL	0.02	0.05	0.08	0.09	0.12	0.15	0.16	0.21	0.35
Depth, max (m)	NULL	0.05	0.16	0.28	0.31	0.39	0.45	0.56	0.63	0.90
Elevation, mean (mAOD)	NULL	6.23	6.37	6.48	6.52	6.59	6.65	6.76	6.84	7.10
Elevation, max (mAOD)	NULL	6.23	6.37	6.48	6.52	6.59	6.65	6.77	6.84	7.10
Velocity, mean (m/s)	NULL	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.04
Velocity, max (m/s)	NULL	0.00	0.01	0.01	0.01	0.01	0.01	0.24	0.20	0.22
Hazard, mean	NULL	0.51	0.55	0.62	0.66	0.71	0.73	0.69	0.74	0.98
Hazard, max	NULL	0.53	0.80	1.01	1.02	1.19	1.22	1.28	1.32	1.45

Table 8: Undefended Fluvial Level Data

	1 in 100	1 in 1000
Model Grid Size (m)	1	1
Wet Cells	290	1226
Depth, mean (m)	0.14	0.35
Depth, max (m)	0.44	0.90
Elevation, mean (mAOD)	6.64	7.10
Elevation, max (mAOD)	6.64	7.10
Velocity, mean (m/s)	0.00	0.03
Velocity, max (m/s)	0.01	0.21
Hazard, mean	0.73	0.98
Hazard, max	1.22	1.45

Table 9: Defended Tidal Level Data with Climate Change (excluding upper confidence Intervals)

	1 in 200			1 in 1000		
	2014	2089	2114	2014	2089	2114
Model Grid Size (m)	2.5	2.5	2.5	2.5	2.5	2.5
Wet Cells	0	0	0	0	0	29
Depth, mean (m)	NULL	NULL	NULL	NULL	NULL	0.08
Depth, max (m)	NULL	NULL	NULL	NULL	NULL	0.25
Elevation, mean (mAOD)	NULL	NULL	NULL	NULL	NULL	6.40
Elevation, max (mAOD)	NULL	NULL	NULL	NULL	NULL	6.40
Velocity, mean (m/s)	NULL	NULL	NULL	NULL	NULL	0.01
Velocity, max (m/s)	NULL	NULL	NULL	NULL	NULL	0.02
Hazard, mean	NULL	NULL	NULL	NULL	NULL	0.60
Hazard, max	NULL	NULL	NULL	NULL	NULL	0.97

Table 10: Interpolated Tidal Results (2016)

	1 in 200			1 in 1000		
	2016	2091	2116	2016	2091	2116
Elevation, max (mAOD)	NULL	NULL	NULL	NULL	NULL	6.43

Table 11: Defended Tidal Level Data with Climate Change (including upper confidence Intervals)

	1 in 200			1 in 1000		
	2014	2089	2114	2014	2089	2114
Model Grid Size (m)	2.5	2.5	2.5	2.5	2.5	2.5
Wet Cells	0	0	29	0	193	561
Depth, mean (m)	NULL	NULL	0.08	NULL	0.31	0.58
Depth, max (m)	NULL	NULL	0.25	NULL	0.82	1.53
Elevation, mean (mAOD)	NULL	NULL	6.40	NULL	6.97	7.68
Elevation, max (mAOD)	NULL	NULL	6.40	NULL	6.97	7.69
Velocity, mean (m/s)	NULL	NULL	0.01	NULL	0.03	0.06
Velocity, max (m/s)	NULL	NULL	0.02	NULL	0.16	0.31
Hazard, mean	NULL	NULL	0.60	NULL	0.92	1.16
Hazard, max	NULL	NULL	0.97	NULL	1.41	1.78

Table 12: Interpolated Tidal Results (2016)

	1 in 200			1 in 1000		
	2016	2091	2116	2016	2091	2116
Elevation, max (mAOD)	NULL	NULL	6.43	NULL	7.00	7.71

Table 13: Sea level rise, mm per year

Assumed vertical land movement	1990-2025	2025-2055	2055-2085	2085-2115
-0.5	3.5	8.0	11.5	14.5

3. Additional Information

We do not hold any historic flooding information for the area of interest.

The local authority may be able to provide information on issues such as localised flooding from sewers, drains and culverts.

4. References

[1] Environment Agency (2011) 'Coastal flood boundary conditions for UK mainland and islands – SC060064'

[2] JBA Consulting (2015) 'Cadoxton Flood Risk Study Hydraulic Model User Report'

[3] JBA Consulting (2015) 'Cadoxton Flood Risk Study Tidal Inundation Model – Model User Report and Results Discussion Final'

[4] Supplementary note on flood hazard ratings and thresholds for development planning and control purpose (May 2008)

[5] Flood and Coastal Defence Appraisal Guidance: FCDPAG3 Economic Appraisal. Supplementary Note to Operating Authorities – Climate Change Impacts; October 2006; Department for Environment, Food and Rural Affairs.

5. Notes

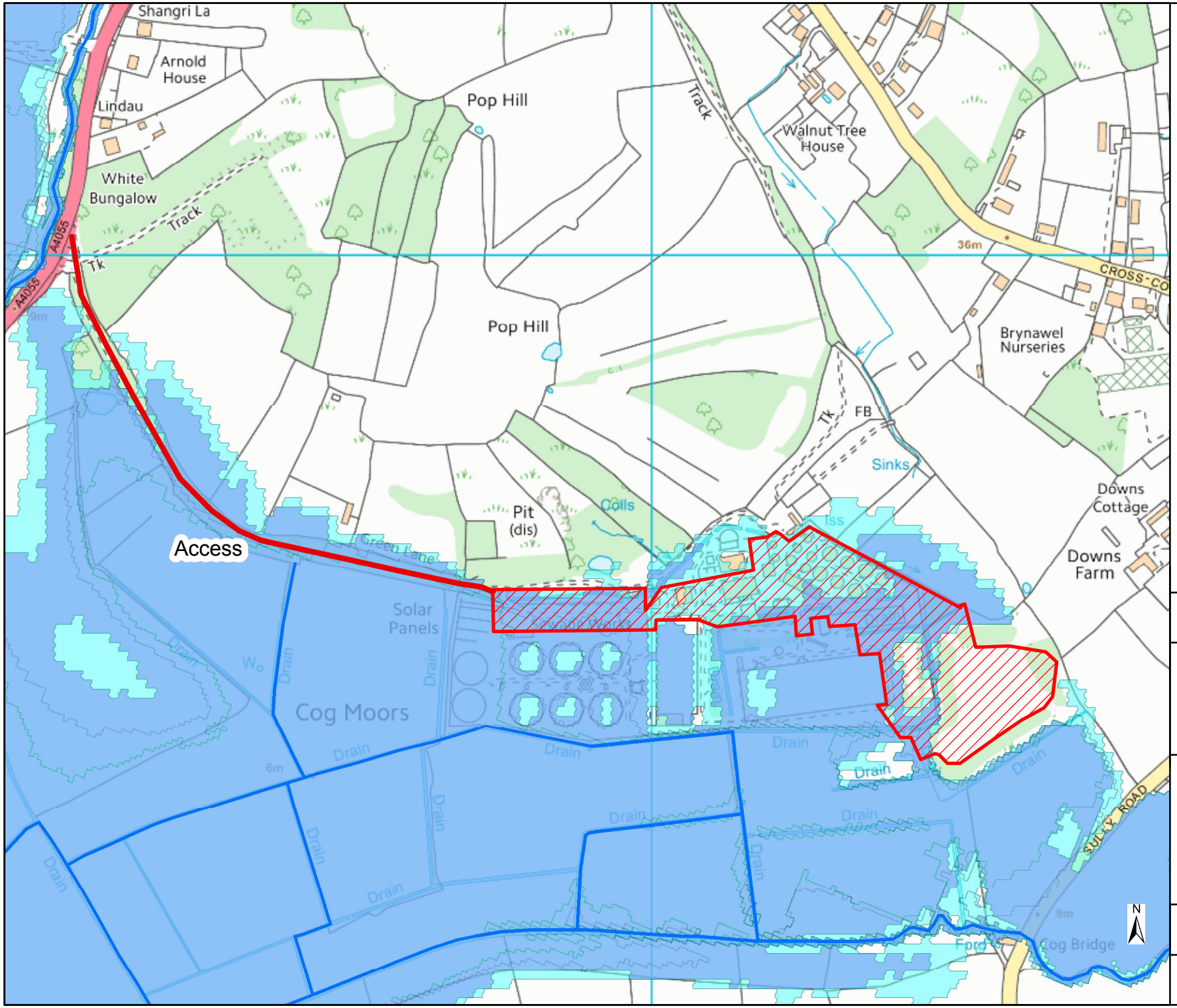
The scope of the model is the mapping of flood risk, it is not intended for detailed design. The model should be considered as the starting point for more detailed modelling, commensurate with the consequences of flooding at the site of interest.

NRW models are available under licence agreement for the purpose of further development. Contact Natural Resources Wales Data Distribution team for details of terms, conditions and pricing.

If the data is used in support of an FCA, please include the reference number.

Please refer to NRW standard terms and conditions.

Flood Risk Analysis
17/03/2017



Legend

- Site Location
- Flood Zone 3 (1 in 100 year undefended fluvial and 1 in 200 year undefended tidal extents)
- Flood Zone 2 (1 in 1000 year undefended fluvial and tidal extents)
- Areas benefiting from defences
- Defences
- Flood Storage Area
- Main Rivers

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

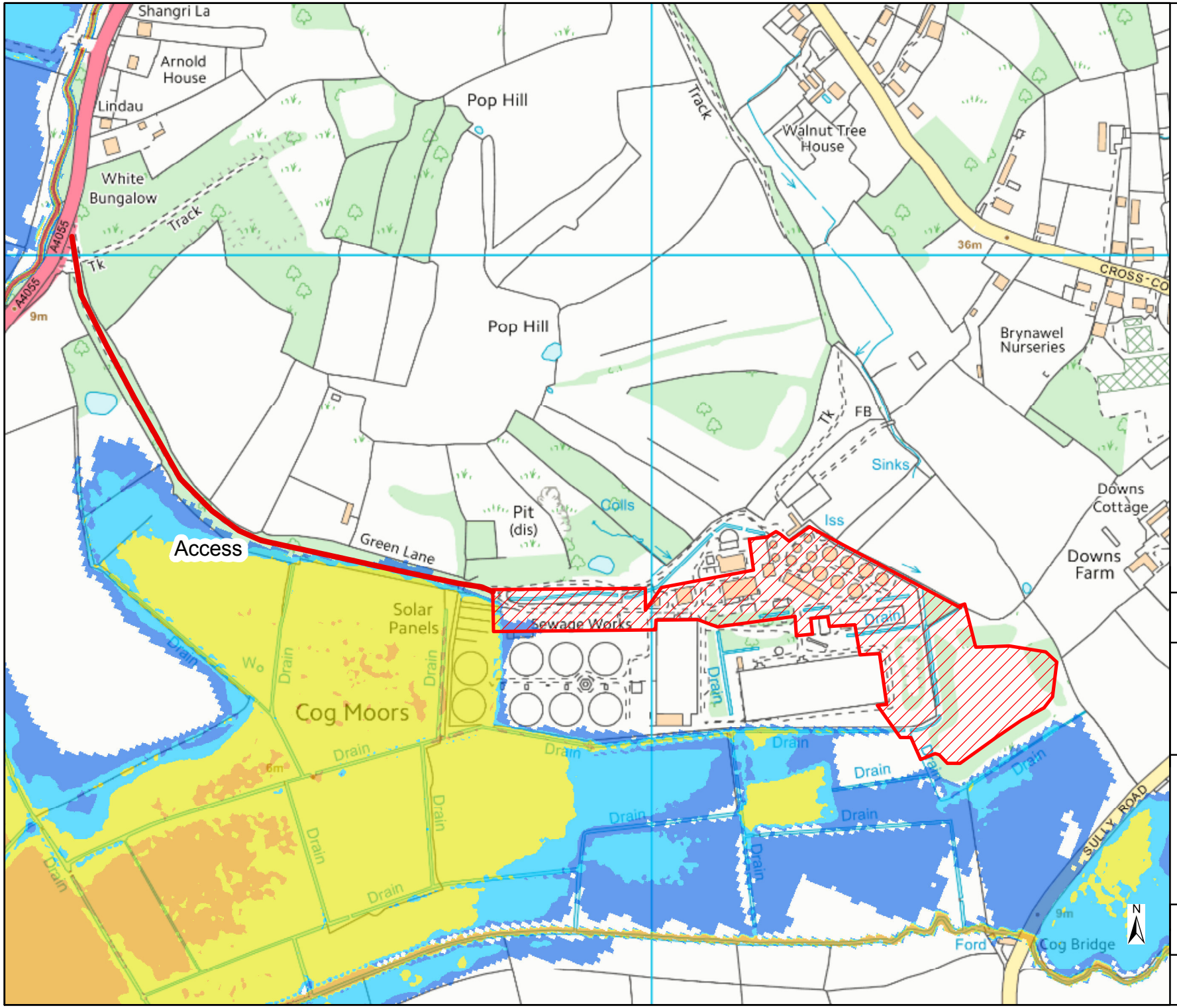
Drawing

Figure 1:
Current Floodmap
[v201701]

Date

17th March 2017

Scale 1:5,500



Legend

Site Location

Flood Depth (m)

- 0.0 - 0.3
- >0.3
- >0.6
- >1.0
- >2.0

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Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

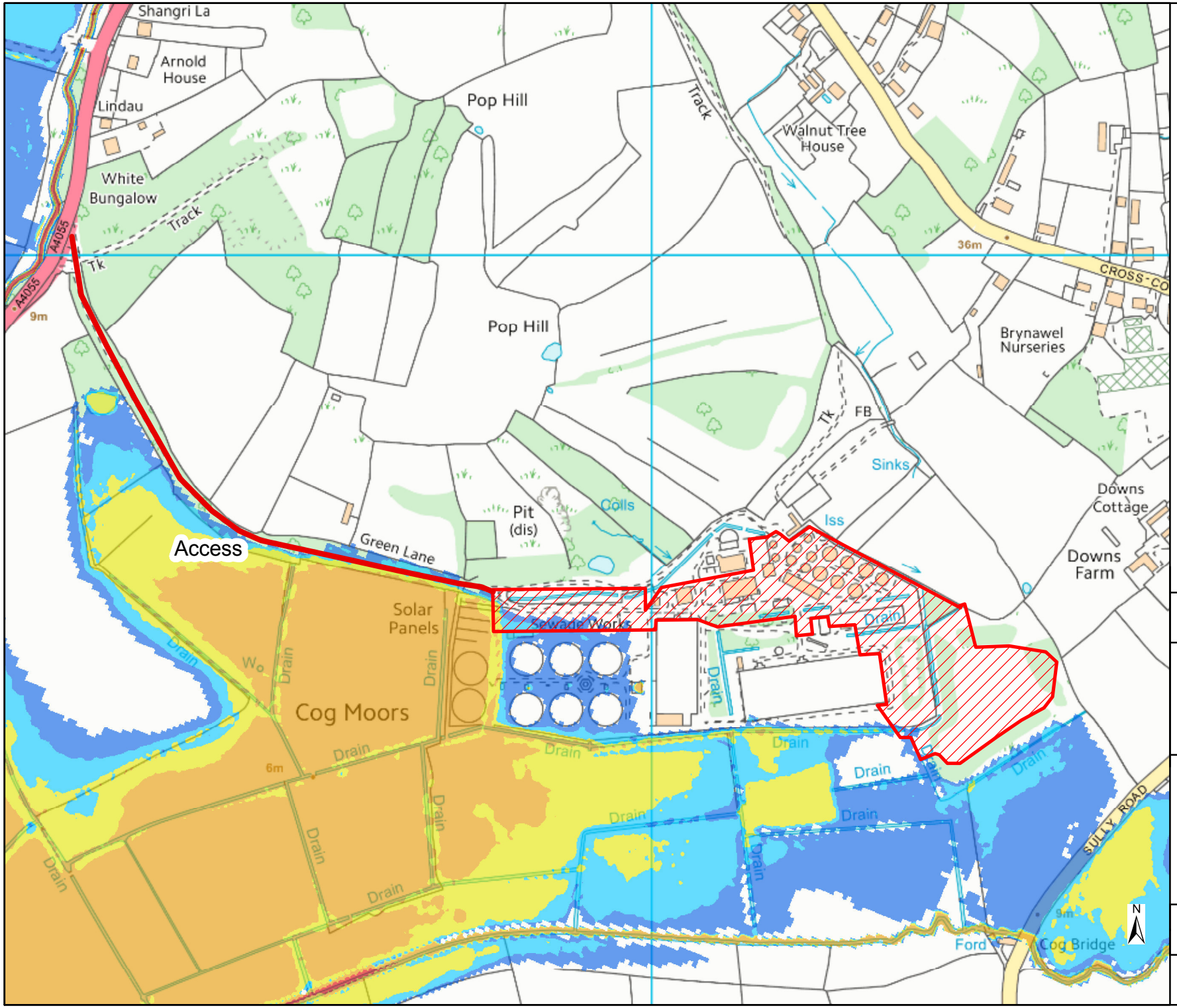
Drawing

Figure 2:
Fluvial Depth Grid
for 1% AEP with climate change
(1 in 100+20%)
year event with Defences

Date

17th March 2017

Scale 1:5,500



Legend

Site Location

Flood Depth (m)

- 0.0 - 0.3
- >0.3
- >0.6
- >1.0
- >2.0

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

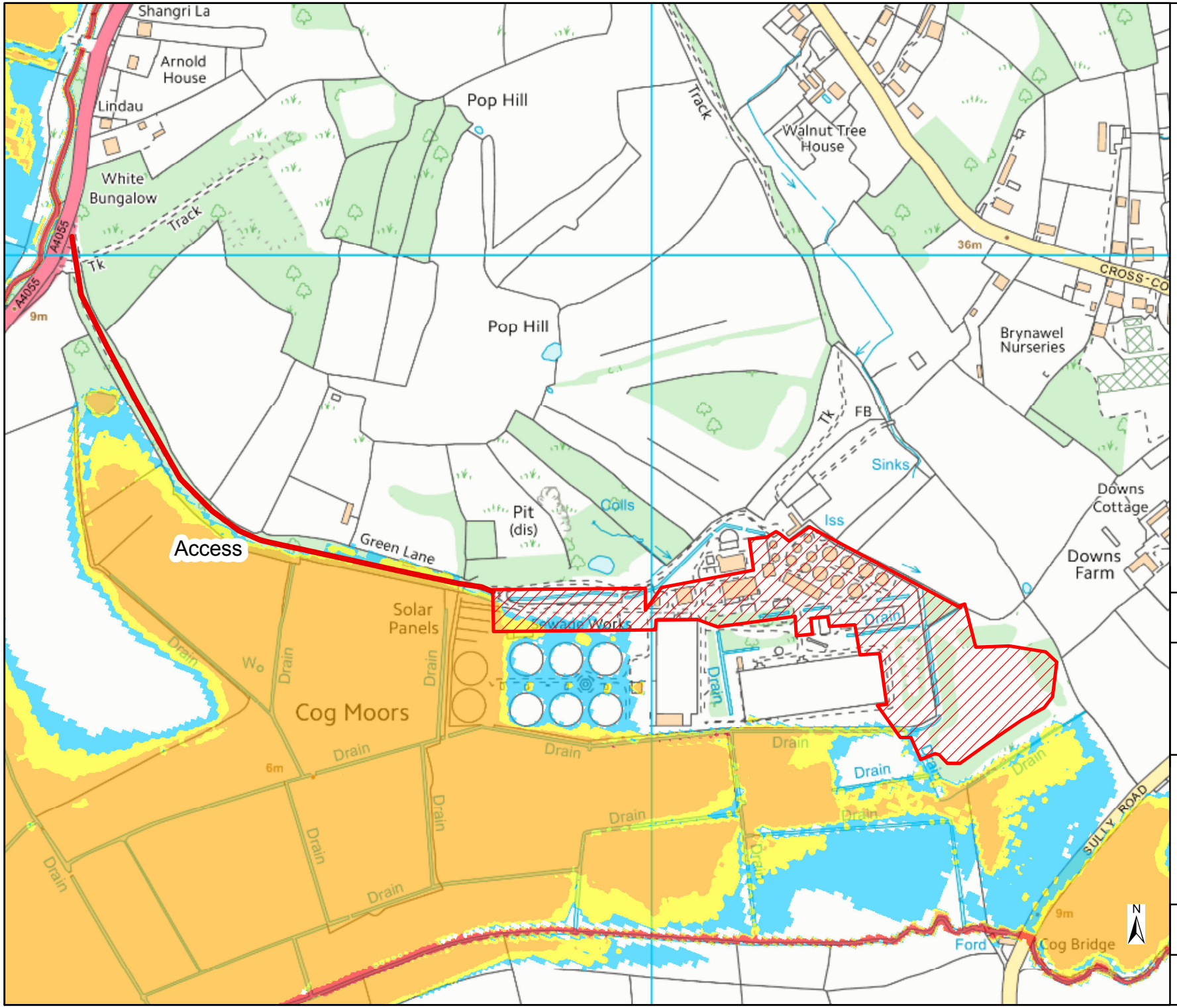
Drawing

Figure 3:
Fluvial Depth Grid
for 0.1% AEP (1 in 1000)
year event with Defences

Date

17th March 2017

Scale 1:5,500



Legend

Site Location

Flood Hazard

- < 0.75
- 0.75 - 1.25
- 1.25 - 2.00
- > 2.0

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

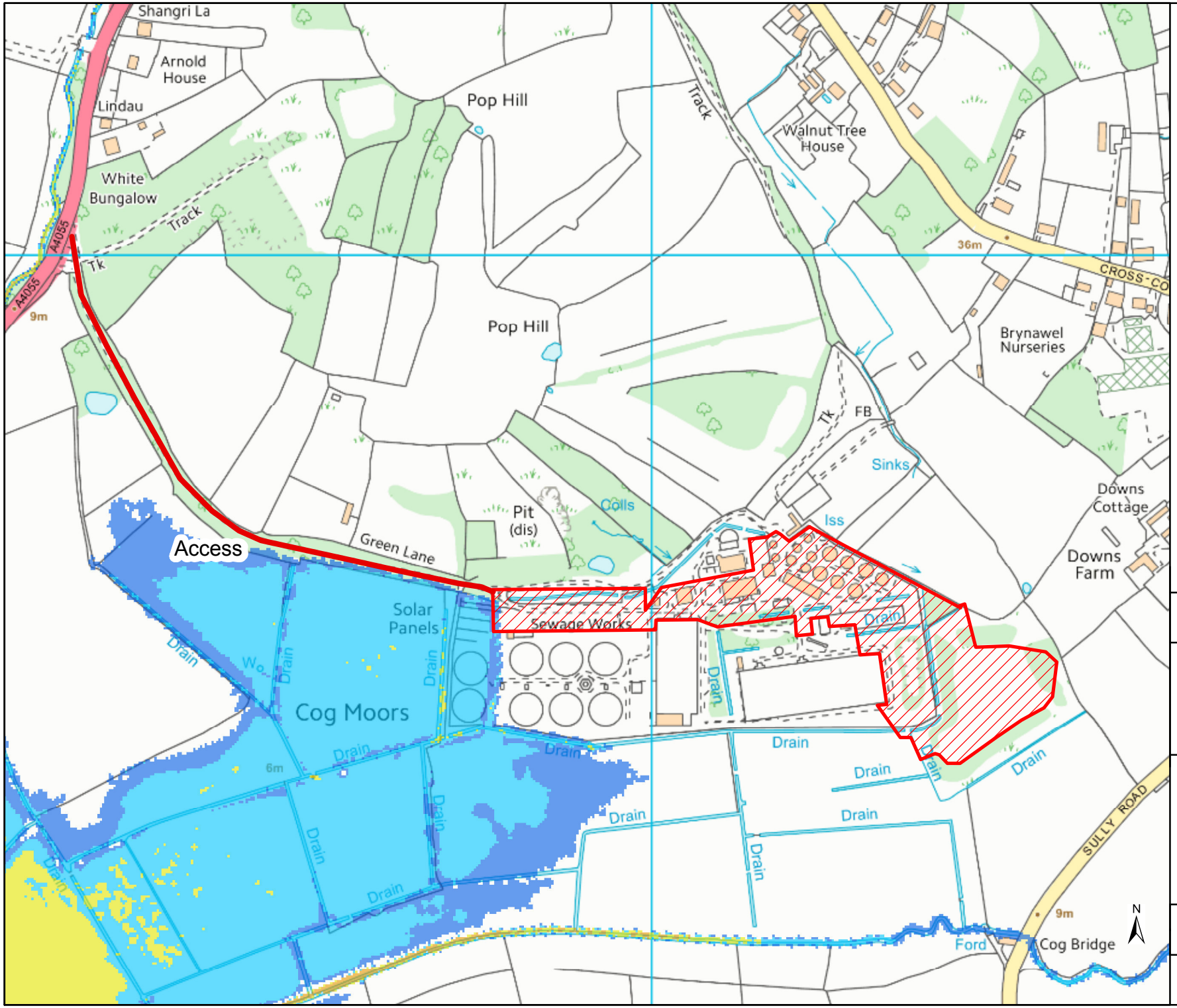
Drawing

Figure 4:
Fluvial Hazard Grid
for 0.1% AEP (1 in 1000)
year event with Defences

Date

17th March 2017

Scale 1:5,500



Legend

Site Location

Flood Depth (m)

- 0.0 - 0.3
- >0.3
- >0.6
- >1.0
- >2.0

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

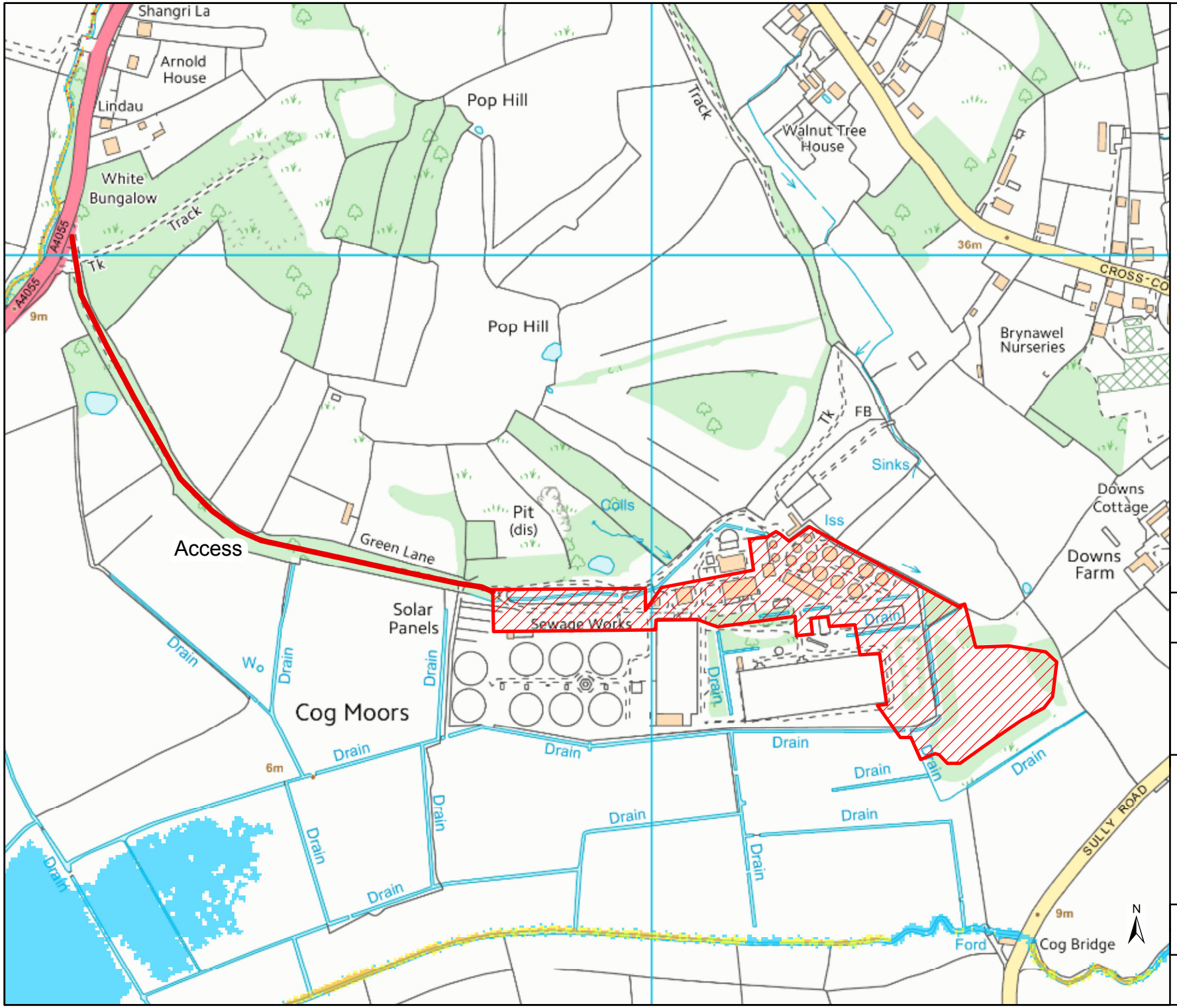
Drawing

Figure 5:
Tidal Depth Grid for 0.5% AEP (1 in 200) year event - defended including upper confidence intervals (2114)

Date

17th March 2017

Scale 1:5,500



Legend

Site Location

Flood Hazard

- < 0.75
- 0.75 - 1.25
- 1.25 - 2.00
- > 2.0

Cyfoeth Naturiol Cymru
Natural Resources Wales

Project

Cogs Moor, Green Lane
[Ref:ATI-12429a]

Drawing

Figure 6:
Tidal Hazard Grid for 0.5% AEP (1 in 200) year event - defended including upper confidence intervals (2089)

Date

17th March 2017

Scale 1:5,500

Appendix C: Correspondence

Matt Jeffes

From: Llewellyn, Carl <Carl.Llewellyn@cyfoethnaturiolcymru.gov.uk>
Sent: 23 August 2017 11:02
To: Emma Coward
Cc: Matt Jeffes; Lisa Driscoll
Subject: RE: Cog Moor FCA

Thanks for letting me know

Regards

Eich Enw/ Carl Llewellyn
Teitl swydd/ Dadansoddiad Risg Llifogydd / Flood Risk Analysis
Cyfoeth Naturiol Cymru / Natural Resources Wales
Ffôn/Tel: 03000 653092
E-bost/E-mail:
Carl.Llewellyn@naturalresourceswales.gov.uk

On **23rd August 2016** the Welsh Government published a Policy Clarification Letter regarding climate change allowances for planning purposes, supplemented by a guidance note and map. The letter and supporting documents supplement the policy advice provided in Technical Advice Note (TAN) 15: Development and Flood Risk. Local planning authorities, applicants and their consultants are expected to use these climate projections from **1st December 2016**.

The documents are available via the following link:
http://gov.wales/topics/planning/policy/policyclarificationletters/2016/cl-03-16-climate-change-allowances-for-planning-purposes/?lang=en

---

From: Emma Coward [mailto:Emma.Coward@arcadis.com]
Sent: 23 August 2017 11:00
To: Llewellyn, Carl <Carl.Llewellyn@cyfoethnaturiolcymru.gov.uk>
Cc: Matt Jeffes <Matt.Jeffes@arcadis.com>; Lisa Driscoll <Lisa.Driscoll@arcadis.com>
Subject: Cog Moor FCA

Hi Carl,

I have made a note of the key points we have discussed on the telephone over the last few weeks in relation to the Cog Moors Scheme FCA below:

We discussed that NRW would find it acceptable that the temporary car park may experience flooding up to a depth of 0.3m, in the 1 in 100-year (+CC) event, given its low vulnerability to shallow flooding.

We discussed that NRW would find it acceptable that in the 0.1% AEP or 1 in 1000-year (defended) event, the temporary site cabins and temporary car park are considered to be at risk of fluvial flooding up to depths of 0.6m.

The assessment of flood risk within the FCA has been made for the redline boundary illustrated on the Flood Product data which incorporates all of the proposed development. However, the redline boundary submitted as part of the wider planning application pack for the scheme includes revision to the redline boundary utilised within the flood product data to incorporate ecological mitigation measures, with no material changes to the proposed development having been made. An assessment of any impacts associated with the proposed ecological mitigation measures has been incorporated into the FCA as per your recommendation.

Thanks,
Emma

Emma Coward | Graduate Engineer - Water Management and Resilience |
Emma.Coward@arcadis.com
Arcadis Consulting (UK) Ltd | Arcadis Cymru House, St Mellons Business Park, Fortran Rd, Cardiff | CF3 0EY | UK

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Matt Jeffes

From: Llewellyn, Carl <Carl.Llewellyn@cyfoethnaturiolcymru.gov.uk>
Sent: 25 April 2017 10:45
To: Emma Coward
Cc: Lisa Driscoll
Subject: RE: Cogs Moor Scheme

Morning Emma thank you for the information and you are correct in your assumption providing that any land raising/re profiling is confined to the red hash boundary as shown on the product four then no compensation would be required.

I would still recommend that an FCA is undertaken, but this can be minimal in nature just confirming new levels for the site showing this is not with in the 100cc or 1000 year outlines. You can also comment on access and egress as this could be effected to a minimal level, but at least you can recognise this and recommend management, maybe in the form of a second route out of the site.

Please include the product 4 in any FCA you produce

Happy to discuss

Regards

Eich Enw/ Carl Llewellyn
Teitl swydd/ Dadansoddiad Risg Llifogydd / Flood Risk Analysis
Cyfoeth Naturiol Cymru / Natural Resources Wales
Ffôn/Tel: 03000 653092
E-bost/E-mail:
Carl.Llewellyn@naturalresourceswales.gov.uk

On **23rd August 2016** the Welsh Government published a Policy Clarification Letter regarding climate change allowances for planning purposes, supplemented by a guidance note and map. The letter and supporting documents supplement the policy advice provided in Technical Advice Note (TAN) 15: Development and Flood Risk. Local planning authorities, applicants and their consultants are expected to use these climate projections from **1st December 2016**.

The documents are available via the following link:
http://gov.wales/topics/planning/policy/policyclarificationletters/2016/cl-03-16-climate-change-allowances-for-planning-purposes/?lang=en

---

From: Emma Coward [mailto:Emma.Coward@arcadis.com]
Sent: 18 April 2017 15:02
To: Llewellyn, Carl <Carl.Llewellyn@cyfoethnaturiolcymru.gov.uk>
Cc: Lisa Driscoll <Lisa.Driscoll@arcadis.com>
Subject: Cogs Moor Scheme

Hi Carl,

As discussed, please find attached the Product 4 Data sent through to us from your Customer Services Team.

I look forward to talking to you next week.

Kind Regards,

Emma

Emma Coward | Graduate Engineer - Water Management and Resilience |
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Appendix D: Calculations

Where HR = D x (V + N) + DF

Factor	Description	Value
D	Depth of Flooding (m)	0.3
V	Velocity of floodwaters (m/sec)	0.36
N	Constant 0.5	0.5
DF	Debris Factor (0.5)	0.5
HR	Hazard Rating	0.76

Where V = ((HR – DF) / D) - N

Factor	Description	Value
D	Depth of Flooding (m)	0.3
V	Velocity of floodwaters (m/sec)	0.33
N	Constant 0.5	0.5
DF	Debris Factor (0.5)	0.5
HR	Hazard Rating	0.75

SUPPLEMENTARY NOTE ON FLOOD HAZARD RATINGS AND THRESHOLDS FOR DEVELOPMENT PLANNING AND CONTROL PURPOSE – Clarification of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1.

Suresh Surendran and Geoff Gibbs (Environment Agency),
Steven Wade and Helen Udale-Clarke (HR Wallingford)
May 2008

Introduction

This document is a supplementary note to reconcile information provided in the 'Flood Risks to People Methodology' (FD2321/TR1[1]) and the 'Framework and Guidance for Assessing and Managing Flood Risk for New Development' (FD2320/TR2[2]) reports about the Flood Hazard Rating. It has been produced because both PPS25 in England and TAN15 in Wales require that people should be appropriately safe around new development. The document emphasises that for FRAs and FCAs at all levels to inform development allocations and proposals the simplified approach of FD2320 with regard to flood hazard rating should be used rather than the approach in FD2321. Although the final version of FD2321/TR1 post-dates FD2320/TR2, the work presented actually pre-dates the guidance in FD2320/TR2. This supplementary guidance is issued for those involved in development planning and control and to clarify the detail or difference of the Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1.

FD2321/TR1 was a research project based on the detailed literature review and analysis of empirical evidence related to flood hazard, derived mainly from theoretical assumptions and some basic laboratory experiments. Factors that affected flood hazard and vulnerability were combined in a form of multi-criteria analysis that was be used to identify the hot-spots and broadly estimate the probability of people seriously harmed and fatalities during the event of a flood. The multi-criteria method was calibrated to actual events, validated using data from seven flood events and shown to work well. The FD2321 (Risk to people) methodology illustrates the fundamental concepts and demonstrate how the approach could be used for different applications - it did not set a policy for flood hazard thresholds.

(Nevertheless there are a number of assumptions used in the FD2321 methodology, particularly with respect to the impact of debris and people's behaviour during flood events. There is a requirement for further research to collate more evidence on flood hazard, particularly the impacts of debris, and vulnerability in order to refine assumptions made in the flood hazard calculations, flood hazard thresholds and risks to people guidance. The study recommend more laboratory and field based tests on the impact of physical water quality aspect such as debris, mudflow; chemical and biological water quality that cause seriously harm or fatalities to people.)

---

[1] Defra and Agency (2006) *The Flood Risks to People Methodology*, Flood Risks to People Phase 2, FD2321 Technical Report 1, HR Wallingford et al. did the report for Defra/EA Flood and Coastal Defence R&D Programme, March 2006.
(http://sciencesearch.defra.gov.uk/Document.aspx?Document=FD2321_3436_TRP.pdf)

[2] Defra and Agency (2005) *Framework and Guidance for Assessing and Managing Flood Risk for New Development*, Flood Risk Assessment Guidance for New Development, FD2320 Technical Report 2, HR Wallingford et al. did the report for Defra/EA Flood and Coastal Defence R&D Programme, October 2005.
(http://sciencesearch.defra.gov.uk/Document.aspx?Document=FD2320_3364_TRP.pdf)

FD2320/TR2 (FRA guidance for new development) provides guidance that is a specific interpretation of the methodology developed under FD2321, within the context of development planning and control. Based on FD2320 consultation workshops, the project board (key users and experts) advised the project team to provide a simple methodology. Due uncertainties and limitations related to estimating risks to people, FD2320 adopted a precautionary approach, particularly with respect to the selection of debris factors and flood hazard thresholds

Risk to People (Ninj)

Ninj = **Nz** x **Flood Hazard Rating** x **Area Vulnerability** x **People Vulnerability**

where,

Ninj (Risk to People)	= number of injuries within a particular hazard 'zone';
Nz	= number of people within the hazard zone (at ground/basement level);
Flood Hazard Rating	= HR = function of flood depth/velocity (within the hazard zone being considered) and debris factor;
Area Vulnerability	= function of effectiveness of flood warning, speed of onset of flooding and nature of area (including types of buildings); and
People Vulnerability	= function of presence of people who are very old and/or infirm/disabled/long-term sick

Flood Hazard Rating (HR) and thresholds

The revised 'hazard rating' expression based primarily, on consideration to the direct risks of people exposed to floodwaters.

HR = **d** x (**v** + **n**) + **DF**

where, HR = (flood) hazard rating;
d = depth of flooding (m);
v = velocity of floodwaters (m/sec); and
DF = debris factor (0, 0.5, 1 depending on probability that debris will lead to a hazard)
n = a constant of 0.5

This final revised Flood Hazard Rating formula from the Flood Risks to People project is presented on page 10 (section 3.5) of FD2321/TR1. The formula is identical in both FD2320 and FD2321 reports.

Based on Table 3.2 of FD2321, the Figure 3.2 of FD2321 illustrates the "Hazard to People Classifications" as a function of depth, velocity and debris factor. Such categorisation and the look-up table with flood hazard threshold could be useful for a range of application as an initial indication of Risks to People.

In this case (Figure 3.2 of FD2321) the calculation takes a debris factor as zero (**HR** = **d** x (**v** + **0.5**) + **0**).

However FD2321 strongly recommends the use of the debris factor and the formulas described in the Guidance Document for further calculation. The Table 3.1 of FD2321/TR1 (Table 1 of this note) suggests appropriate debris factors for different depths, velocities and the dominant land use.

Table 1: Guidance on debris factors for different flood depths, velocities and dominant land uses. (Source FD2321 Table 3.1):

Depths (d)	**Pasture/Arable**	**Woodland**	**Urban**
0 to 0.25 m	0	0	0
0.25 to 0.75 m	0	0.5	1
d>0.75 m and\or v>2	0.5	1	1

The way that Flood Hazard Rating and thresholds have been presented in Table 13.1 in FD2320/TR2 compared to Figure 3.2 of FD2321/TR1

A concern was raised in the FD2320 consultation workshops and by the FD2320 Project Board during discussions on FD2321, that the methodology was complex and the results presented in the Figure 3.2 of FD2321 were not reflecting the potential risk to people (as this table was of hazard rating for different depths and velocity without debris). There was a need for further work to include debris, area vulnerability and people vulnerability aspects. They requested a simpler single table to represent the risk to people.

For example Figure 3.2 of FD2321 did not reflect the fact that there is a risk from drowning even at low depths and velocities. In reality FD2321/TR1 recognises this but only in the subsequent "people vulnerability" calculation (risk to children, old, sick and disable). For still water up to 1.25m depth, the Figure 3.2 of FD2321/TR1 assumes that there is low hazard, if there are no debris or vulnerable group. However to avoid further calculation, but include the vulnerability aspect the Table 13.1 of FD2320 for still water with the depths between 0.25–1.25m were reclassified as "danger to some", which was felt to be more appropriate for development planning and control, where users may make use of flood hazard without completing he more complex full calculations including people and area vulnerability.

Similarly Figure 3.2 of FD2321/TR1 shows that at the depth of 0.25m, if there is no debris then up to the flow velocity of 2.0 m/sec there would be low hazard. However FD2321/TR1 suggests the usage of an appropriate debris factor dependent on depth, velocity and the dominant land use. To make the process simpler (whatever the land use), FD2320/TR2 includes a default debris factor. In the Table 13.1 of FD2320/TR2 a debris factor of 0.5 has been applied for depths less than and equal to 0.25m and a debris factor of 1.0 has been used for depths greater than 0.25m. Therefore, in the Table 13.1 of FD2320/TR2 at the depth of 0.25m, up to the flow velocity of 0.30 m/sec is treated as low hazard.

Table 3.2 of FD2321/TR1 (Table 2 of this note) provides thresholds for classifying the hazard to people. In the FD2321/TR1 report the threshold between "danger for most" and "danger for all" is 2.5 and it was used as an initial indication of Risk to People (further calculation is recommended using the formulas). However as there is no further analysis in FD2320 but the Project Board decided that the threshold between "danger for most" and "danger for all" should be more precautionary and a Flood Hazard Rating of 2.0 is selected as a key threshold. i.e. In FD2321 the threshold for "danger for all" is 2.5 and it lowered to 2.0 in FD2320. Therefore, the Flood Hazard Rating between 2.0 to 2.5 in FD2320 is not classified as it is in FD2321.

Table 2: Hazard to People (Source Table 3.2 in FD2321/TR1)

Thresholds for Flood Hazard Rating H = d x (v + 0.5) + DF		**Degree of Flood Hazard**	**Description**
FD2321	**FD2320**		
<0.75	<0.75	Low	**Caution -** "Flood zone with shallow flowing water or deep standing water"
0.75 - 1.25	0.75 - 1.25	Moderate	**Dangerous for some (i.e. children) -** "Danger: Flood zone with deep or fast flowing water"
1.25 - 2.5	1.25 - 2.0	Significant	**Dangerous for most people -** "Danger: flood zone with deep fast flowing water"
>2.5	>2.0	Extreme	**Dangerous for all -** "Extreme danger: flood zone with deep fast flowing water"

The final difference between Table 13.1 in FD2320/TR2 and Figure 3.2 of FD2321/TR1 is the use of smaller increments of depth, so that lower depths are presented more fully in FD2320/TR2. This was felt to be more helpful for identifying what might be judged as acceptable depending on site specific circumstances.

Conclusions

Table 13.1 of FD2320 and Figure 3.2 of FD2321 look very similar but there are significant differences (see Table 3 of this paper). Either Table/Figure can be used as the basis for assessing the risks to people associated with different flood depths velocities and debris factors.

Table 3: comparison of Table 13.1 of FD2320/TR2 and Figure 3.2 of FD2321/TR1

	In Table 13.1 of FD2320/TR2	**In Figure 3.2 of FD2321/TR1**
The depths above 0.25m	Danger for some, most or all	For still water, up to 1.25m the hazard is low (In addition to hazard rating further calculation to include vulnerability aspect is recommended)
Debris factor	Debris factor of 0.5 has been applied for depths $\leq$0.25m and a debris factor of 1.0 has been used for depths $\geq$ 0.25m.	In this case a Debris factor of zero applied (in addition to this further calculation is recommended using debris factor and the formulas)
HR Thresholds for "Dangerous for all" hazard classification	>2.0 (precautionary due to uncertainties and to avoid further calculation as FD2321)	>2.5
Increments of depth	Small increments at lower depths	Every 0.25 m

Table 13.1 of FD2320/TR2 is a simple method applies the precautionary principle and uses suitable assumptions (so that there is no need for further calculations) for application in the development planning and control context (see Table 4 of this paper - an extended version of table 13.1).

This table is recommended for development planning and control use.

Table 4 – Hazard to People Classification using Hazard Rating *(HR= d x (v + 0.5) + DF)* for (Source Table 13.1 of FD2320/TR2 - Extended version)

HR	Depth of flooding - d (m)												
	DF = 0.5				DF = 1								
Velocity - v (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.0	0.03 + 0.5 = 0.53	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.13 + 0.5 = 0.63	0.15 + 1.0 = 1.15	0.20 + 1.0 = 1.20	0.25 + 1.0 = 1.25	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25
0.1	0.03 + 0.5 = 0.53	0.06 + 0.5 = 0.56	0.12 + 0.5 = 0.62	0.15 + 0.5 = 0.65	0.18 + 1.0 = 1.18	0.24 + 1.0 = 1.24	0.30 + 1.0 = 1.30	0.36 + 1.0 = 1.36	0.48 + 1.0 = 1.48	0.60 + 1.0 = 1.60	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50
0.3	0.04 + 0.5 = 0.54	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.19 + 0.5 = 0.69	0.23 + 1.0 = 1.23	0.30 + 1.0 = 1.30	0.38 + 1.0 = 1.38	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	1.13 + 1.0 = 2.13	1.50 + 1.0 = 2.50	1.88 + 1.0 = 2.88
0.5	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.25 + 0.5 = 0.75	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	2.50 + 1.0 = 3.50
1.0	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.38 + 0.5 = 0.88	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	2.25 + 1.0 = 3.25	3.00 + 1.0 = 4.00	3.75 + 1.0 = 4.75
1.5	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.50 + 0.5 = 1.00	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	2.00 + 1.0 = 3.00	3.00 + 1.0 = 4.00	4.00 + 1.0 = 5.00	5.00 + 1.0 = 6.00
2.0	0.13 + 0.5 = 0.63	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	0.63 + 0.5 = 1.13	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.75	6.00	7.25
2.5	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.60 + 0.5 = 1.10	0.75 + 0.5 = 1.25	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	1.80 + 1.0 = 2.80	3.40	4.00	5.50	7.00	8.50
3.0	0.18 + 0.5 = 0.68	0.35 + 0.5 = 0.85	0.70 + 0.5 = 1.20	0.88 + 0.5 = 1.38	1.05 + 1.0 = 2.05	1.40 + 1.0 = 2.40	1.75 + 1.0 = 2.75	3.10	3.80	4.50	6.25	8.00	9.75
3.5	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.80 + 0.5 = 1.30	1.00 + 0.5 = 1.50	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	3.00	3.40	4.20	5.00	7.00	9.00	11.00
4.0	0.23 + 0.5 = 0.73	0.45 + 0.5 = 0.95	0.90 + 0.5 = 1.40	1.13 + 0.5 = 1.63	1.35 + 1.0 = 2.35	1.80 + 1.0 = 2.80	3.25	3.70	4.60	5.50	7.75	10.00	12.25
4.5	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	1.00 + 0.5 = 1.50	1.25 + 0.5 = 1.75	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.00	5.00	6.00	8.50	11.00	13.50
5.0	0.28 + 0.5 = 0.78	0.60 + 0.5 = 1.10	1.10 + 0.5 = 1.60	1.38 + 0.5 = 1.88	1.65 + 1.0 = 2.65	3.20	3.75	4.30	5.40	6.50	9.25	12.00	14.75

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification
Less than 0.75		Very low hazard - Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

Size of Cabins	No. of Cabins	Total Area (m2)	Raised Cabin Level (m)	Floodplain Storage Loss (m3)	Area of Flood Cell (m2)	Increment (m)	Increment (mm)
9.7x3.5m (LXW)	10	295.85	0.3	88.8	358700	0.0002474	0.247

Proposed Development	Total Area (m2)	Raised Above Ground Level (m)	Floodplain Storage Loss (m3)	Area of Flood Cell (m2)	Increment (m)	Increment (mm)
FE Pump Slab 1	28.28	0.055	1.56			
Slab 2	5.28	0.15	0.79			
Slab 3	8.75	0.15	1.31	385000	0.000010	0.01
		Total Floodplain Storage Loss (m3):	3.7			