Carmarthenshire County Council

Machynys Hotel

Flood Consequences Assessment

2020/9590

Rev 1 | 17 December 2020

Job number 278688

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190211 EVY Llanelli Modelling Report v9 Rev E - Drawings

1 Introduction

Carmarthenshire County Council (CCC) has commissioned Ove Arup and Partners Ltd. (Arup) to prepare and submit an outline planning application, with all matters reserved, for a proposed hotel development which forms part of the Llanelli Waterside development. This Flood Consequences Assessment (FCA) has been prepared in support of the planning application and has been undertaken in accordance with Technical Advice Note (TAN) 15 Development and Flood Risk 2004.

2 Existing Site

The site of the proposed hotel development is located near the coast south of the Llanelli town centre. The site is bound to the north by the B4304 Llanelli Coastal Road and to the south by the existing Machynys Peninsula Golf and Country Club. An access road for the golf course runs through the centre of the site in an east west direction. Access to the proposed development is proposed from Nicklaus Avenue, which currently provides access to Machynys Peninsula Golf & Country Club. A second access is available via the B4304 road.

The site comprises open land consisting of rough grass/scrub. A site location plan is included in Appendix A.

The existing site levels generally vary between 5m AOD to 6.8m AOD based on LiDAR data.

2.1 TAN15 Development Advice Map

The TAN15 Development Advice Map (DAM) for the Machynys area is included in Appendix C. A snapshot can be seen in Figure 1. The map indicates that the site is within Zone C1 floodplain.

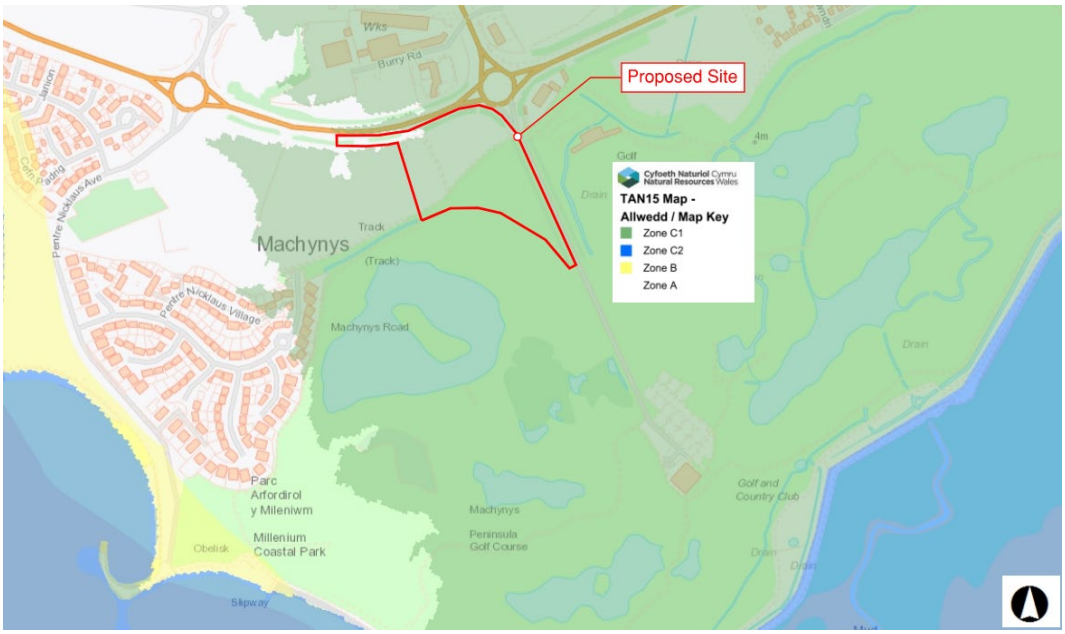

Figure 1 - TAN15 Development Advice Map Snapshot

Definition of the various flood zones as stated in TAN15 Development and Flood Risk are given below.

- Zone A – Defined as an area considered to be at little or no risk of fluvial or tidal/coastal flooding.
- Zone B – Areas known to have been flooded in the past evidenced by sedimentary deposits.
- Zone C1 – Area of floodplain developed and served by significant infrastructure, including flood defences, and liable to flood events with probability of occurrence of 0.1% or greater (i.e. 1 in 1000 year flood event or greater).
- Zone C2 – Area of floodplain without significant flood defence infrastructure, and liable to flood events with probability of occurrence of 0.1% or greater (i.e. 1 in 1000 year flood event or greater).

The main mechanism of flooding at the site is tidal inundation resulting from rising tide level in the Loughor Estuary and a breach of the tidal defences located along the coastline in the vicinity of the site. A fluvial event of the Afon Dafen also needs to be considered

3 Proposed Development

A proposed hotel development is being promoted with the aim of delivering economic, social and environmental benefits to the local area and to Carmarthenshire as a whole. The illustrative site layout is included in Appendix B.

The area surrounding the sites have also been identified for future development including a Health and Wellbeing Village, housing, commercial and leisure development.

3.1 Vulnerability Classification

Flood risk vulnerability classification for various types of development is given in Figure 2, Section 5 of TAN15 Development and Flood Risk. Developments are classified into the following three categories depending upon the ability of the occupants to decide on whether or not they wish to accept the risk to life and property associated with flooding:

- Emergency Services
- Highly Vulnerable Development; and
- Less Vulnerable Development

The proposed hotel development is classified as a **Highly Vulnerable Development**.

TAN15 Development and Flood Risk states that for hotel developments susceptible to tidal flooding, the frequency threshold of flooding (i.e. the threshold

below which the development should not be allowed to flood) is the 1 in 200 year return period tidal event including an allowance for climate change and sea level rise.

3.2 Hydraulic Flood Modelling – Pre-Development

Edenvale Young Associates Ltd. (EVY) have undertaken hydraulic modelling of the area as part of the Health and Wellbeing Village proposed to the north, report reference 190211 EVY0729 Llanelli Modelling Report V9 Rev E. The model has been used to inform the preparation of this FCA. The previous modelling showed that the site is protected by the sea defences and does not flood during all the extreme tidal and fluvial events apart from the 1 in 1000 tidal event, taking into account climate change, modelling result drawings can be found in Appendix E. The previous study identified that during a breach event, the Machynys Central site may flood. Consequently, the breach event was examined further, NRW requested that a 1 in 1000 year breach event was considered. Consequently, additional modelling concentrated on the 1 in 200 and 1 in 1000 return period tidal events, combined with a QMED fluvial event plus climate change, EVY825_Results_Report_v12_Rev_Ac. The pre-development (baseline) and post development scenarios also included a breach in the sea defences. The report and full results can be found in Appendix D.

The following Climate Change (CC) allowances were incorporated in accordance with the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowances* for fluvial flows:

Upper End, Higher Central: 75%

Higher Central, Central: 30%

For the hotel development, 100 year of climate change increases needs to be considered, the extreme tide level was projected to the year 2120 using the following increases in accordance with the Welsh Assembly guidance:

2008-2025: 3.5mm/yr

2025-2055: 8.0mm/yr

2056-2085: 11.5mm/yr

2086-2115: 14.5mm/yr

The previous baseline modelling showed that the site and surrounds do not flood during the extreme fluvial and 1 in 200 +CC year tidal and breach events. However, during the 1 in 1000 year + CC tidal and breach event, the site floods, the worst case scenario is the breach event. The worst case predevelopment maximum water level for the 1 in 1000 year return period tidal breach event was estimated at a maximum of 6.86m AOD for the year 2120.

3.3 Hydraulic Flood Modelling -Post Development

It is proposed that the building, car parks and site roads are raised to a minimum finished level above 6.86m AOD as part of a precautionary approach and to provide development resilience. Post development modelling with a development

level of 6.87m for the whole site and adjacent residential development site to the west was completed by EVY. The results and report can be found in Appendix D.

The results confirmed that the development remained flood free up to and including the 1 in 1000 year return period tidal and breach events for the year 2120 including climate change.

3.4 Access and Egress

Access to the site is provided via the B4304 located to the north of the site. This access road traverses east-west along the northern boundary of the site. To the west, this access and egress route is shown to be largely in Zone A on the TAN15 DAM; with some localised areas along the route shown to be in Zone B. However, to the east, the route is shown to be in Zone C1. Levels along the road in the vicinity of the Machynys roundabout, to the east of the site, are at approximately 5m AOD, rising to over to 8.5m AOD as the road traverses further west. At the location where the proposed access to the residential development and secondary access to the west joins the existing B4304, the existing road level is approximately 6.3m AOD.

Primary access to the development is also proposed from Nicklaus Avenue to the east. The TAN15 DAM shows this to be located in Flood Zone C1. The level of the existing highway at the proposed entrance with Nicklaus Avenue is approximately 5.5m AOD.

The results of the hydraulic model shown on Appendix D indicate that the B4304 at the secondary access road floods by up to 0.56m depth during a 1 in 1000 year return period tidal event, estimated for the year 2120, further west the depth of flooding gradually reduces to zero.

Emergency access to the development is also possible via the proposed residential development to the west and then via the existing development to the south-west. The hydraulic modelling shows that this access route remains flood free up to a 1 in 1000 year return period tidal event plus climate change estimated for the year 2120.

4 Justifying the Location of the Development

TAN15 Development and Flood Risk 2004 states that new development should be directed away from Zone C and towards suitable land in Zone A or B. However, it also recognises the need to be flexible in addressing flood risk whilst considering the negative economic and social consequences if policy were to preclude investment in existing urban areas, and the benefits of reusing previously developed land. It recommends that **Highly Vulnerable Development** and **Emergency Services** should not be permitted in Zone C2. For all other developments in Zone C, the tests outlined in Sections 6 and 7 of TAN15 Development and Flood Risk 2004 should be applied to justify the location of the development and to assess the consequences of flooding.

Section 6 of TAN15 Development and Flood Risk states that development within Zone C will only be justified if it can be demonstrated that:

i. Its location in Zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement; **or**

ii. Its location in Zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;

and,

iii. It concurs with the aims of Planning Policy Wales (PPW) and meets the definition of previously developed land; and,

iv. The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in Sections 5 and 7, and Appendix 1 found to be acceptable.

Criterion (i) or (ii)

The site of the proposed development is part of the South Llanelli and Pembrey Peninsula Development Growth Area (SLAPP), and has been identified as one of the Strategic Regeneration Sites under the Local Development Plan (LDP) of CCC. The site has also been allocated as a Planning and Development Brief Site under Policy GA2/MU3 of the LDP. The site was previously subject of a planning application for hotel use. The proposed development therefore complies with criterion (i).

Criterion (iii)

Previously developed land is defined in PPW as,

"...that which is or was occupied by a permanent structure and associated fixed surface infrastructure."

PPW also includes a preference for the re-use of land. It states, in paragraph 4.8.1, that,

"Previously developed (or brownfield) land should, wherever possible, be used in preference to greenfield sites…"

Paragraph 4.8.2 further states,

"Many previously developed sites in built-up areas may be considered suitable for development because their re-use will promote sustainability objectives. This includes sites:

- *in and around existing settlements where there is vacant or under-used land, commercial property or housing;*
- *which facilitate the regeneration of existing communities."*

Paragraph 9.2.8 of PPW also states that,

"…local planning authorities should follow a search sequence, starting with the re-use of previously developed land and buildings within settlements, then settlement extensions and then new development around settlements with good public transport links."

The Envirocheck reports that have been obtained as part of the geotechnical assessment indicate that the site and its surroundings have a history of industrial and commercial use dating back to 1889. These historical uses included brick works, steel works, tin plate works, engineering works and foundry. The sites therefore conform to the definition of previously developed land as contained within PPW.

Criterion (iv)

The potential consequences of a flooding event have been considered within this FCA and are outlined in the following sections.

5 Assessing Flooding Consequences

The following FCA has been undertaken in accordance with the guidance provided in Section 7 and Appendix 1 of TAN15 Development and Flood Risk, and is referenced against the relevant clauses within those sections.

A1.2 The assessment has been undertaken with the objective of:

1. Developing a full appreciation of the consequences of flooding on the development
2. Developing a full appreciation of the consequences of the development on flood risk elsewhere
3. Establishing whether mitigation measures are required to be incorporated within the design to minimise risk to life and property resulting from flooding

A1.3 A hydraulic modelling exercise has been undertaken by EVY for the pre and post development scenarios. The EVY report can be found in Appendix D.

The identified mechanism of flooding is a tidal and surge event within the Loughor Estuary reach adjacent to the site and a breach of the tidal defences along the coastline in the vicinity of the site. Extreme tide levels, including allowance sea level rise, are given in Section 3.2. The proposed buildings, car parks and site roads will be raised to a minimum of 6.87m AOD as outlined in Section 3.3.

A1.4 Extreme tide levels outlined in Section 3.2 of this report include an allowance for climate change and sea level rise in accordance with the Welsh Assembly guidance.

The hydraulic modelling shows that raising the buildings, car parks and access roads to a minimum level of 6.87m AOD enables the development to be flood free for up to and including the 1 in 1000 year return period tidal event plus climate change up to the year 2120. This demonstrates that a precautionary approach has been adopted in considering the consequences of flooding.

A1.5 The proposed mitigation measure involves raising the development level to a minimum of 6.87m AOD to ensure that a safe and secure environment is provided to those occupying the site.

A1.6 The mechanism of flooding is tidal inundation resulting from the rising tide level in the Loughor Estuary and a breach of the tidal defences located along the coastline in the vicinity of the site. As the mechanism of flooding is tidal, blockages along the flood path, if any, are not likely to increase the tide level. Therefore, such physical changes are not thought to provide an increased risk of flooding.

A1.7 The coastal flood defences in this area provide flood protection to the developments within this region and will therefore be adequately maintained. Even if the flood defences are breached, raising the proposed finished levels to a minimum of 6.87m AOD will enable that the proposed development to remain flood free for up to and including the 1 in 1000

year tidal event for the year 2120. The hydraulic modelling exercise has been undertaken assuming a breach in the flood defences to provide a conservative approach.

A1.8 In the event of an extreme flood, the proposed development will remain flood free for up to and including the estimated 1 in 1000 year return period tidal event for the year 2120 including climate change. As a result, it is assumed that no conditions are required to be attached to the planning permission.

A1.9 The mechanism for flooding for the site is tidal inundation resulting from the rising tide level in the Loughor Estuary and a breach of the tidal defences located along the coastline in the vicinity of the site.

The hydraulic modelling concluded that during the breach event there is no significant change to the flood risk of third parties as a result of raising the development level to a minimum of 6.87m AOD. The post development changes in the flood depth for the worst case breach scenario combined with a fluvial event is less than 10mm in the area around the site. This is considered negligible and that there is no significant change in flood risk to third parties.

The developer will undertake the raising of the site. Flood warning measures, if deemed necessary, will be provided by Natural Resources Wales (NRW) and CCC.

A1.10 The FCA has been undertaken by a suitably qualified professional organisation.

A1.11 It is proposed to raise the minimum development level for buildings, car parks and site roads to 6.87m AOD and therefore the development is shown to be flood free for up to and including the estimated 1 in 1000 year return period tidal event for the year 2120 including climate change.

A1.12 No flood defences are proposed for the scheme. It is assumed that flood warning measures, if deemed necessary, will be provided by Natural Resources Wales (NRW) and CCC.

A1.13 The FCA will be submitted to the NRW for its comments/approval via the planning process.

A1.14 TAN15 Development and Flood Risk 2004 indicates that hotel development should remain flood free under a 1 in 200 year return period tidal event. The proposal will provide adequate protection for the proposed development for up to and including the estimated 1 in 1000 year tidal event for the year 2120 including climate change and is therefore considered adequate.

A1.15 Access to the development from the B4304 to the north is shown to experience flooding during the extreme 1 in 1000 year event plus climate change breach scenario. The depth of flooding anticipated along the site boundary increases from 0.56m at the western boundary, to 1.5m at the eastern roundabout. At the site entrance the existing level is approximately 6.3m AOD. The 1 in 1000 year flood level plus climate change during a breach event is estimated at 6.86mAOD, therefore providing a flood depth of 0.56m at the entrance.

Access to the development from Nicklaus Avenue to the east is shown to experience flooding during the extreme 1 in 1000 year event plus climate change breech scenario. The depth of flooding is anticipated to be approximately 1m at the site entrance increasing to 1.5m at the roundabout junction with the B4304.

Access to the development from the south west via the proposed residential development remains flood free during the 1 in 1000 year event plus climate change breach scenario.

A1.16 With the finished levels of the proposed hotel development raised to a minimum of 6.87m AOD, the proposed development will provide a safe and secure environment for accommodation. Planning conditions relating to flooding are therefore not anticipated to be imposed.

A1.17 The following technical requirements have been met in assessing the flooding consequences.

1. A site location plan showing the Loughor Estuary and the tidal flood defences in the area is included in Appendix A.
2. LiDAR survey showing existing site levels is shown in Appendix A. The minimum proposed development level for the proposed hotel, car parks and site roads is 6.87m AOD.
3. Any flood defences present in this area will be maintained by NRW.
4. Access egress from the site is via the B4304 to the north, whilst an emergency access via the proposed and existing development to the south west is also feasible, as shown on the proposed masterplan in Appendix B. Existing levels are shown on the LiDAR survey in Appendix A.
5. The mechanism of flooding for the site has been described in A1.3
6. The site does not have a history of flooding.
7. The mechanism of flooding is tidal inundation resulting from overtopping or a breach in the existing flood defences in the vicinity of the site. Any blockages along the flow path of the tidal flood should not result in an increased tide level.
8. Extreme tide levels have been derived based on published EA guidance and allowance for climate change has been included based on the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowances.*
9. The proposed minimum development level for the proposed hotel is 6.87m AOD. Existing levels are shown on the LiDAR survey in Appendix A.
10. The TAN15 DAM shows that the majority of the site is within Zone C1. The finished levels of the proposed development will be raised to a minimum of 6.87m AOD. The modelling concluded that with the raised level, the development remains flood free for up to

and including the estimated 1 in 1000 year return period tidal event including climate change for the year 2120.

11. The public sewers within the vicinity of the site are maintained and operated by Dwr Cymru Welsh Water (DCWW). The drainage associated with the proposed hotel development will be designed in accordance with the current statutory guidance. Currently, this includes hydraulic modelling of storm and flood events.

12. The site does not flood during all return periods up to a 1 in 1000 year return period tidal event for the year 2120. Breach analysis (described in Section 3.2) demonstrates that the proposed development will remain flood free in the event of a breach during the estimated 1 in 1000 year return period tidal event for the year 2120.

    The EVY flood modelling concluded that post development changes in the flood depth for the worst case breach scenario combined with a fluvial event is less than 10mm in the area around the site, this is considered negligible and that there is no significant change in flood risk to third parties.

    Surface water runoff likely to be generated from the proposed development will be considered in accordance with the hierarchy of discharge from the Welsh Governments Statutory Standards for Sustainable Drainage. If discharging to a watercourse, the rate of discharge will be restricted to appropriate greenfield runoff rate.

13. As noted in item 12 above, raising the site does not result in any significant displacement of floodwater for events up to and including the worst case breach event for the 1 in 1000 year return period tidal event, including allowance for climate change. Therefore, the proposed development will not have adverse impact on flood risk elsewhere.

14. The proposed developments will have no impact on the coastal morphology and the long term stability and sustainability.

15. Climate change allowance has been included in accordance with the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowances.*

16. There are no proposed flood defences or modification to existing as part of the development.

6 Conclusions

A Flood Consequences Assessment (FCA) has been undertaken for a proposed hotel development on the site located to the north of the Machynys Peninsula Golf and Country Club in Llanelli, Carmarthenshire. The FCA has been undertaken in accordance with the guidelines provided in TAN15 Development and Flood Risk 2004. The TAN15 Development Advice Map (DAM) shows that the majority of the site is within Zone C1 floodplain.

Flood modelling for the pre and post development scenarios has been undertaken by Eden Vale Young (EVY), the report can be found in Appendix D. The site does not flood during all fluvial events and tidal events up to a 1 in 1000 year plus climate change, as the site is protected by sea defences and fluvial flows do not reach the site. However, during a 1 in 1000 year plus climate change event, the sea defences may be overtopped or a breach in the sea defences could develop, resulting in flooding. Following consultation with NRW, a breach analysis has been undertaken, examining breach event up to a 1 in 1000 year tidal event, taking into account climate change. Extreme tide levels for the Loughor Estuary have been derived and factored for climate change in accordance with the Welsh Assembly Guidance: *Flood Consequences Assessments: Climate change allowance.* The results predict the extreme 1 in 1000 year flood level to be 6.86m AOD for the year 2120 at the site.

The flood modelling incorporated a breach analysis of the flood defences with the aim of testing the sensitivity of the development to potential flood risk arising from a breach. It is proposed to raise the site to a minimum development level of 6.87m AOD. The post development results confirm that the site will remain flood free in the event of a potential breach in the existing defences for events up to and including the 1 in 1000 year tide return period including climate change estimated for the year 2120.

Three access points are proposed for the development. The primary access point is from the B4303 to the north, there is also a secondary, emergency access from the proposed and existing development to the south and the third to Nicklaus Avenue to the east. The available topographical information showing existing site levels and an examination of the TAN15 DAM, shows the B4304 to the north west to be outside the extreme flood outline. The B4303 to the north east is shown to be within Zone C1 and hydraulic modelling shows this area to flood during an extreme 1 in 1000 year breach analysis. The resultant depth of flooding at the proposed access to the B4303 is approximately 0.56m. Emergency access from the proposed and existing development to the south is shown as Zone A on the DAM with a small section in Zone C1 however, the hydraulic modelling results show the route to remain flood free for the 1 in 1000 year tidal event including climate change up to the year 2120.

The FCA concludes that the risk of flooding for the proposed development is acceptable in accordance with TAN15 Development and Flood Risk. The hydraulic modelling concluded that there is no significant change to the flood risk of third parties as a result of the development.

Appendix A

Existing Development

Site Location Plan

Existing Ground Levels

A1

Afon Dafen Impounding Structure

Avon Dafen

Afon Lledi

Machynys Roundabout

B4303

Nicklaus Avenue

Proposed Site

Loughor Estuary

Machynys Golf and Country club

Sloping Masonary

Legend

- Site Boundary
- Open Watercourse
- Tidal Flood Defence
- Possible Tidal Flow paths resulting in overtopping or breach of the defences

Notes

1. All dimensions are in metres unless noted otherwise. Do not scale

Issue	Date	By	Chkd	Appd
I1	14/12/20	DO	DO	JS
Issued for Information				

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Client
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Job Title
Machynys Hotel

Drawing Title
Site Location Plan
Appendix A

Scale at A1 1:2500

Discipline Civil

Drawing Status
For Information

Job No	Drawing No	Issue
278688	**Appendix A1**	**I1**

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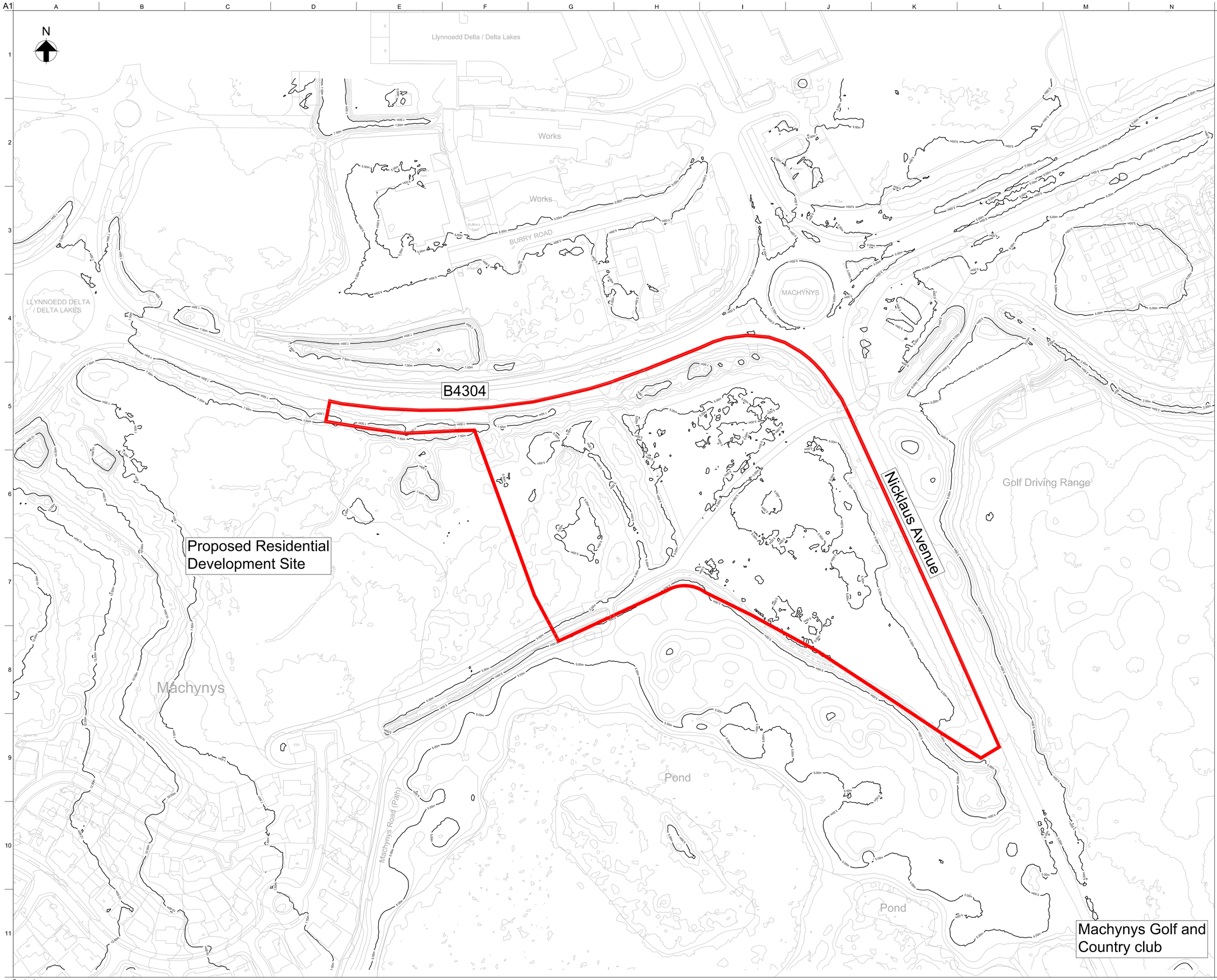

Legend

- Site Boundary
- 5.00m — LiDAR Contours (Existing Levels)

Notes

1. All dimensions are in metres unless noted otherwise. Do not scale.

2. Ground level information based on LiDAR, contours shown at 0.5m intervals.

Issue	Date	By	Chkd	Appd
I1	11/12/20	DO	DO	JS
Issued for Information				

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Client
Carmarthenshire County Council

Job Title
Machynys Hotel

Drawing Title
Existing Ground Levels

Scale at A1 1:1000

Discipline Civil

Drawing Status
For Information

Job No	Drawing No	Issue
278688	**CG1002**	**I1**

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Appendix B

Development Proposals

Proposed Masterplan

A1

Access to B4304

Llanelli Coastal Road

Area of Visitor / Accessible Parking

Pond

New reen and attenuation

Access to Nicklaus Avenue

Hotel (140 bed)

Gardens

Drain

N

Access via proposed and existing residential development to the south west

Existing reen

Pond

New reen and attenuation

Track

0 5 10 20 Metres

Scale 1:500

Key:

- Building Footprint
- Hard Landscaping
- Parking (Indicative)
- Soft Landscaping
- Attenuation
- Site Boundary

Max Parameters :

Overall Site Area	=	37,740m2
Maximum gross development Area	=	10,000m2

Illustrative Site Layout

Notes:

1. Illustrative masterplan layout only to define development quantum.
2. All matters are reserved, final design/layout is subject to design development.
3. Highway access is subject to development and agreement with the Local Authority as a reserved matters application or to be developed by the adjacent housing development.

Issue	Date	By	Chkd	Appd
P01	18/12/20	PB	AP	ME
Issued for Planning Purposes				

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Client: Carmarthenshire County Council

Job Title: Proposed Hotel at Machynys East, Llanelli

Drawing Title: Illustrative Site Layout

Scale at A1: 1:500

Discipline: Architectural

Job No: 278688

Drawing Status: Outline Planning

Drawing No: AL-0-02

Issue: P01

Do not scale

Appendix C

TAN 15 Development Advice Map

Cyfoeth Naturiol Cymru
Natural Resources Wales

TAN15 Map -

Allwedd / Map Key

- Zone C1
- Zone C2
- Zone B
- Zone A

Graddfa / Scale at A3 1: 5,001

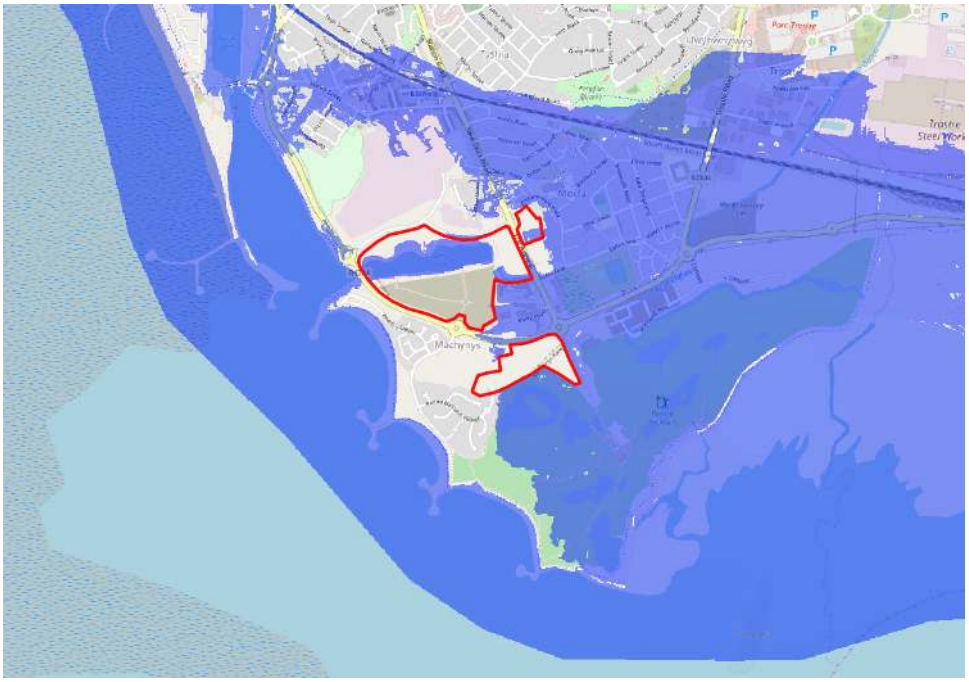
Dyddiad / Date
17/11/2020

0.3 0 0.13 0.3

British_National_Grid Kilometers

Appendix D

EdenvaleYoung Hydraulic Modelling Results



Machynys Housing Development

Hydraulic Modelling Results

Revision A

19 Dec 2019

ARUP

EdenvaleYoung

New Civil Engineer 100 COMPANIES OF THE YEAR 2018

WINNER Design Innovator

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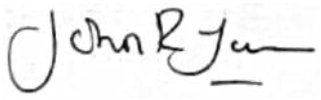
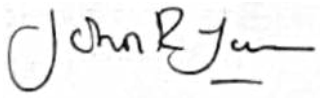
Document Control

Project Name:	Machynys Development	Housing
Project Number:	EVY0782	
Report Revision:	A	
Client:	Arup	

Written by	 Maria Jarquin	19 Dec 2019
Checked by	 John Young	19 Dec 2019
Approved by	 John Young	19 Dec 2019

Revision	Issued to	Date
A	Arup	14/08/2019

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Glossary of Terms

- +CC - Return period inclusive for the predicted effects of Climate Change
- 1D - One-Dimensional
- 2D - Two-Dimensional
- AMAX - A series containing the peak flows recorded at a gauge from each year
- AOD - Above Ordnance Datum (0m sea level, Newlyn, UK)
- Channel Cross Section - profile view of a river channel, normally obtained by surveying a line across the watercourse
- Critical Storm - A storm that produces peak run off in the watershed
- Culvert - A device used to channel water, similar to a pipe though may be larger
- Defended - A scenario in which river defences are used
- FEH - Flood Estimation Handbook
- Fluvial - Referring to the processes associated with rivers and streams
- FRA - Flood Risk Assessment
- GIS - Geographic Information System
- Hydraulic Model - The mathematical process of analysing the interaction of water and the connected environment
- Hydrology - The calculation of catchment based flow rates
- Inflow - Source of water within a modelled domain
- ISIS Software - One-Dimensional hydraulic model – Representation of watercourses
- ISIS-TUFLOW - Hydraulic program that dynamically links ISIS and TUFLOW (1D-2D)
- LiDAR - Light Detection And Ranging, remote sensing technology to measure distance typically used to obtain topographic data over a large area
- Outflow - The method by which water may leave a modelled area
- Overtopping - Where water has passed over a feature that might ordinarily prevent flow
- Q100 - 1% annual probability fluvial event
- Q1000 - 0.1% annual probability fluvial event
- Q100CC - 1% annual probability fluvial event with an allowance for the predicted effects of climate change
- QMED - The median of the set of annual maximum flow data (AMAX)
- TUFLOW Software - Two-Dimensional hydraulic model – Representation of floodplain
- Undefended - A scenario in which river defences are ignored

1 Introduction

1.1 Scope of the Modelling

Edenvale Young Ltd was originally commissioned by Arup to assess flood risk to a development at the Llanelli Welcome and Life Science Village at Delta Lakes in Llanelli. This work was completed in February 2019 following extensive reviews by Natural Resources Wales. Delta Lakes is directly to the north of the Machynys Housing development which is the subject of this report. The modelling used to evaluate the risk of flooding to the Machynys Housing development is based on the hydraulic model developed by Edenvale Young for Delta Lakes. The location of the sites is shown in Figure 1.1.

The scope of the modelling for this assignment includes running the existing hydraulic model to assess flood risk to the Machynys Housing development in the pre and post development condition. Details associated with construction of the hydraulic model, fluvial hydrology, tides / storm surge boundaries and the schematisation of the model are given in Edenvale Young's report. [1].

The modelling programme comprised two stages of work which are:

Stage 1 – Hydraulic modelling to assess baseline flood risk

- Recovering the hydraulic model from archive
- Re-running the model for the 0.5% AEP breach and 0.1% AEP breach with climate change to 2120 and post processing the results for water level, depth, hazard and flood extent

Stage 2 – Hydraulic modelling to assess post development flood risk

- Consultation to ensure that the post development is suitably configured
- The adaptation of the model to include the post development scenario into the model environment and running the model 0.5% AEP breach and 0.1% AEP breach with climate change to 2120 and post processing of the model results to give output for water level, depth and hazard
- Preparation of a modelling report for submission with a Planning Application

[1] Delta Lakes Llanelli, Modelling Report,Trimmed Model, Revision E, February 2019

Figure 1.1: Location Plan

2 Hydrology

2.1 Fluvial Boundary

There are three watercourses in the vicinity of the site of interest; the Afon Dafen, Lleidi, and the Cilli. The Afon Dafen, which flows through the site, originates 7km upstream of the site and flows south before it runs into a reservoir which has a controlled outlet to the estuary. The hydrological analysis used to derive inflows to the model are contained in Section 2.1 of Edenvale Young's report [1].

2.2 Tidal / Surge Boundaries

The site is bounded to the south by the Bristol Channel and requires the application of a tidal / surge boundary to represent inundation from the coast. The primary risk of flooding to the site is considered to be the result of tidal / surge inundation. Details of the application of the tidal / surge boundary are given in Section 2.3 of Edenvale Young's report.

2.3 Breach Locations

The breach location used for this assessment are the same as used for the Delta Lakes project.

2.4 Climate Change

The primary objective of the hydraulic modelling is to asses the impact of flooding on the development in the 0.5% AEP and 0.1% AEP tidal / storm surge events. Whilst flooding at the site is dominated by tidal inundation it is also recognised that the fluvial inflows and the impact of climate change must be incorporated into the modelling. Table 2.1 shows the climate change allowances for fluvial flow which are applicable to the scheme.

Sea Level Rise has been applied in accordance with Welsh Assembly Guidance for climate change (see Table 2.2). The development lifetime is deemed to be 100 years which gives a total sea level rise of 1,123mm. As requested by NRW, tidal boundary water levels have been increased by 0.18m in order to account for the estuary amplification in accordance with the NRW review of the Delta Lakes Model.

[1] Delta Lakes Llanelli, Modelling Report,Trimmed Model, Revision E, February 2019

It should also be noted that the revised coastal flood boundaries for the UK has seen a reduction in maximum still water levels at Llanelli of approximately 0.18m. This has not been applied and the results of the model results are considered to be conservative.

Climate Change Allowance	Percentage
Upper End, Higher Central	70%
Higher Central, Central	30%

Table 2.1: Climate Change Allowances for Flow

Region	2008 – 2025	2026 – 2055	2056 – 2085	2086 – 2115
Wales [mm/ annum]	3.5	8.0	11.5	14.5
Total [mm]	59.3	299.5	644.5	1,079.5

Table 2.2: Climate Change Allowances for Rainfall

3 Hydraulic Modelling

3.1 Model Modifications

No alterations have been made to the ”new” baseline pre-development scenario hydraulic model used for the Delta Lakes Development and as reported in Edenvale Young’s report [1]. The only modification is the incorporation of a shape file to represent the post development platform for the Machynys Housing Development. The z shape and hence the platform elevation has been set at a level above the maximum still water level.

3.2 Scenarios

The model has been run for two scenarios:

- AX - Pre-development Scenario with Breach
- BX - Post-development Scenario with Breach

It should be noted that Scenario AX represents the ”new” baseline pre-development scenario which assumes that the Llanelli Welcome and Life Science Village has been completed. Scenario BX is the post development scenario which assums that both the Llanelli Welcome and Life Science Village and the Machynys Housing development has been constructed.

[1] Delta Lakes Llanelli, Modelling Report, Trimmed Model, Revision E, February 2019

4 Results

4.1 Reference

The result of the hydraulic modelling for maximum level depth and hazard are given in A and are referenced as follows:

Status	Tidal AEP	Fluvial	Breach	Figure No	Result
Pre-Development	0.1% [2120]	QMED 30% CC	Yes	A.1	Level
Pre-Development	0.1% [2120]	QMED 75% CC	Yes	A.2	Level
Pre-Development	0.5% [2020]	QMED 30% CC	Yes	A.3	Level
Post-Development	0.1% [2120]	QMED 30% CC	Yes	A.4	Level
Post-Development	0.1% [2120]	QMED 75% CC	Yes	A.5	Level
Post-Development	0.5% [2020]	QMED 30% CC	Yes	A.6	Level
Pre-Development	0.1% [2120]	QMED 30% CC	Yes	A.7	Depth
Pre-Development	0.1% [2120]	QMED 75% CC	Yes	A.8	Depth
Pre-Development	0.5% [2020]	QMED 30% CC	Yes	A.9	Depth
Post-Development	0.1% [2120]	QMED 30% CC	Yes	A.10	Depth
Post-Development	0.1% [2120]	QMED 75% CC	Yes	A.11	Depth
Post-Development	0.5% [2020]	QMED 30% CC	Yes	A.12	Depth
Pre-Development	0.1% [2120]	QMED 30% CC	Yes	A.13	Hazard
Pre-Development	0.1% [2120]	QMED 75% CC	Yes	A.14	Hazard
Pre-Development	0.5% [2020]	QMED 30% CC	Yes	A.15	Hazard
Post-Development	0.1% [2120]	QMED 30% CC	Yes	A.16	Hazard
Post-Development	0.1% [2120]	QMED 75% CC	Yes	A.17	Hazard
Post-Development	0.5% [2020]	QMED 30% CC	Yes	A.18	Hazard

Table 4.1: Table of Results

4.2 Flood Level

The worst case condition is the 0.1% AEP tidal even in conjunction with a fluvial flow of QMED with an allowance of 75% for climate change. Figure 4.2 and Figure 4.3 shows the results of the modelling for Pre and Post development scenarios respectively. Table 4.2 gives a comparison of peak water levels at five reference points adjacent to the development [see Figure 4.1].

4.3 Flood Depth

Figure 4.4 and Figure 4.5 shows flood depths adjacent to the site for the Pre and Post development respectively.

Reference Point	Pre-Development	Post-Development
RP1	6.86 m AOD	-
RP2	6.86 m AOD	6.87 m AOD
RP3	6.86 m AOD	6.87 m AOD
RP4	6.86 m AOD	6.86 m AOD
RP5	6.86 m AOD	6.86 m AOD

Table 4.2: Pre and Post Development Maximum Water Levels 0.1% AEP tidal even in conjunction with a fluvial flow of QMED with an allowance of 75% for climate change

4.4 Flood Hazard

Danger to people is assessed though the concept of hazard. Hazard combines flow velocity and depth. This approach recognises the fact that both deep-still and shallow-fast flowing flood water can be dangerous. Figure 4.6 and Figure 4.7 shows the results of the hazard modelling for Pre and Post development respectively.

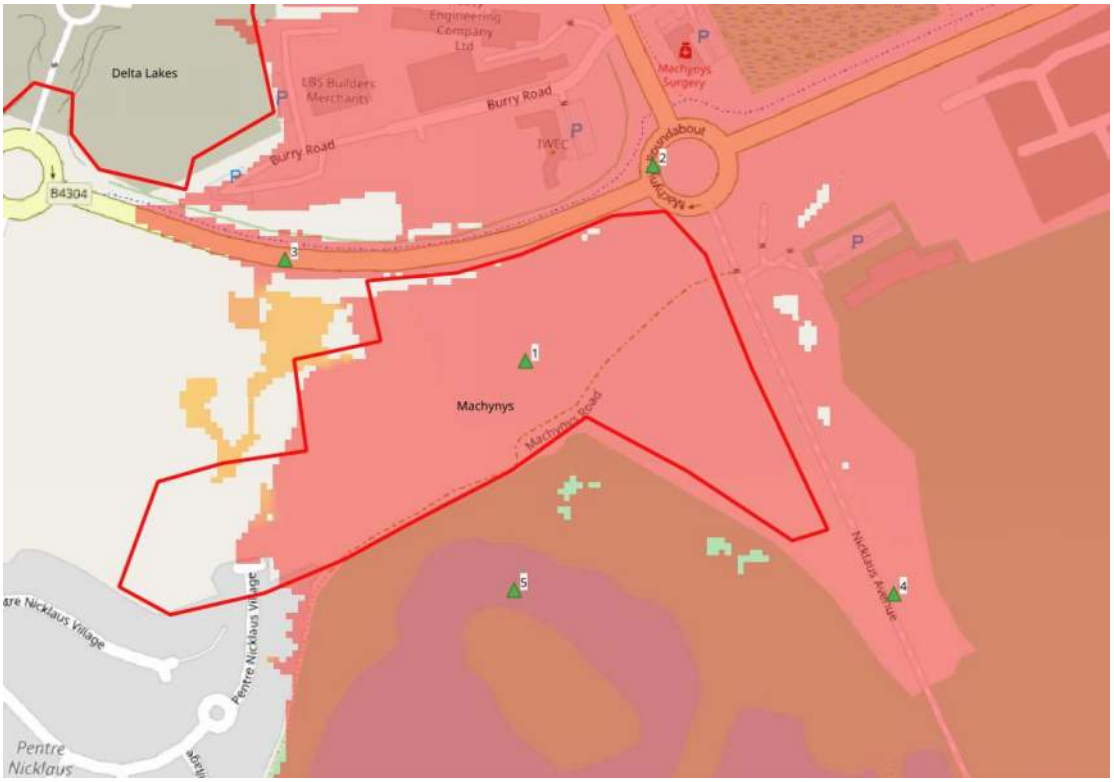


Figure 4.1: Reference Points

Figure 4.2: Pre-development Model Results - Peak Water Level for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

Figure 4.3: Post-development Model Results - Peak Water Level for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

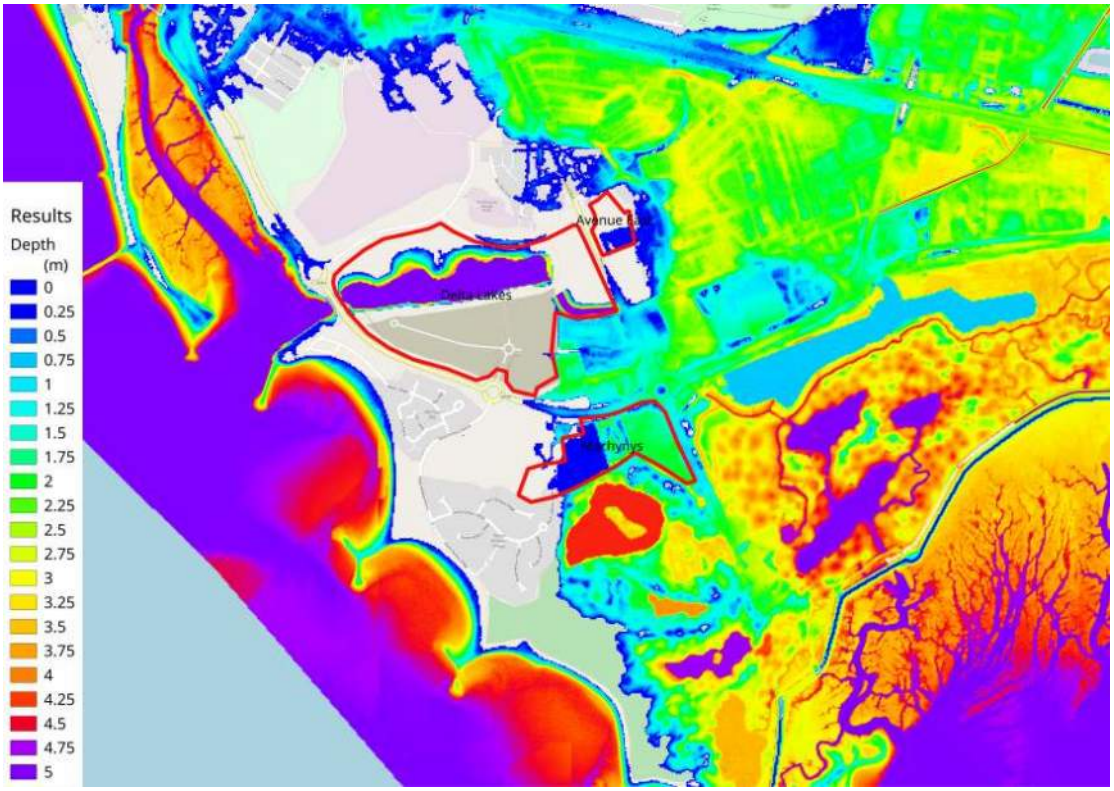


Figure 4.4: Pre-development Model Results - Peak Water Depth for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

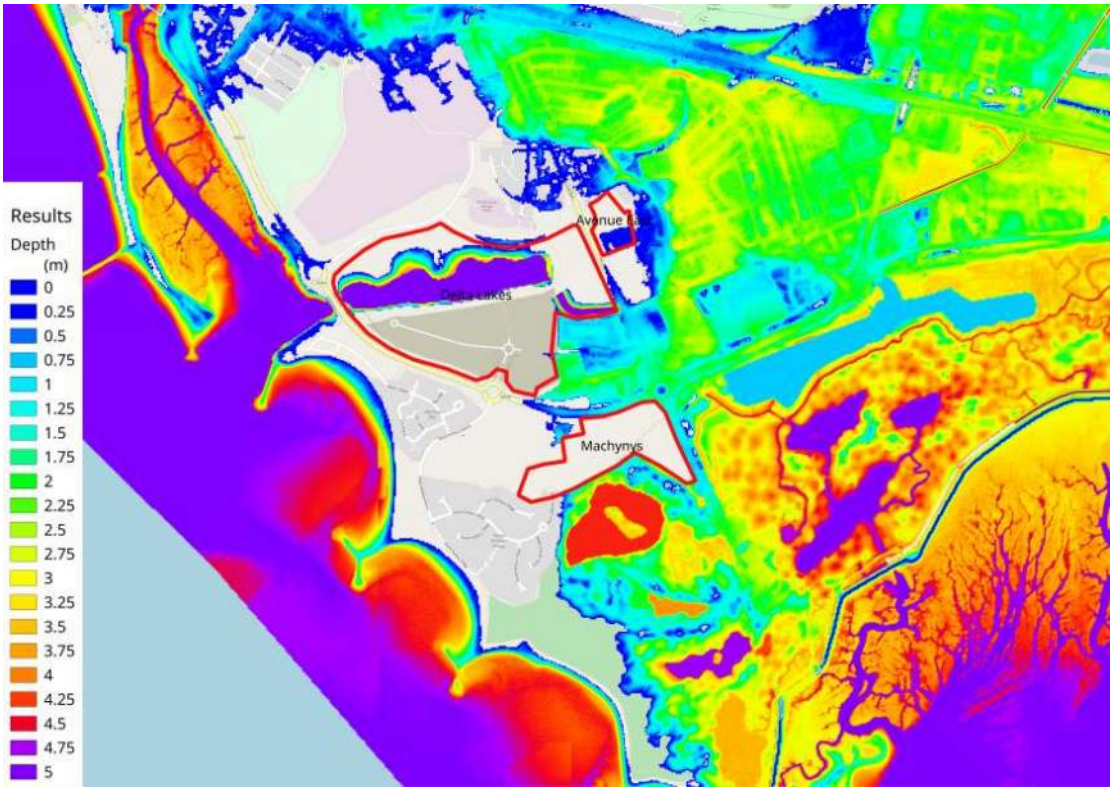


Figure 4.5: Post-development Model Results - Peak Water Depth for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

Figure 4.6: Pre-development Model Results - Peak Hazard for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

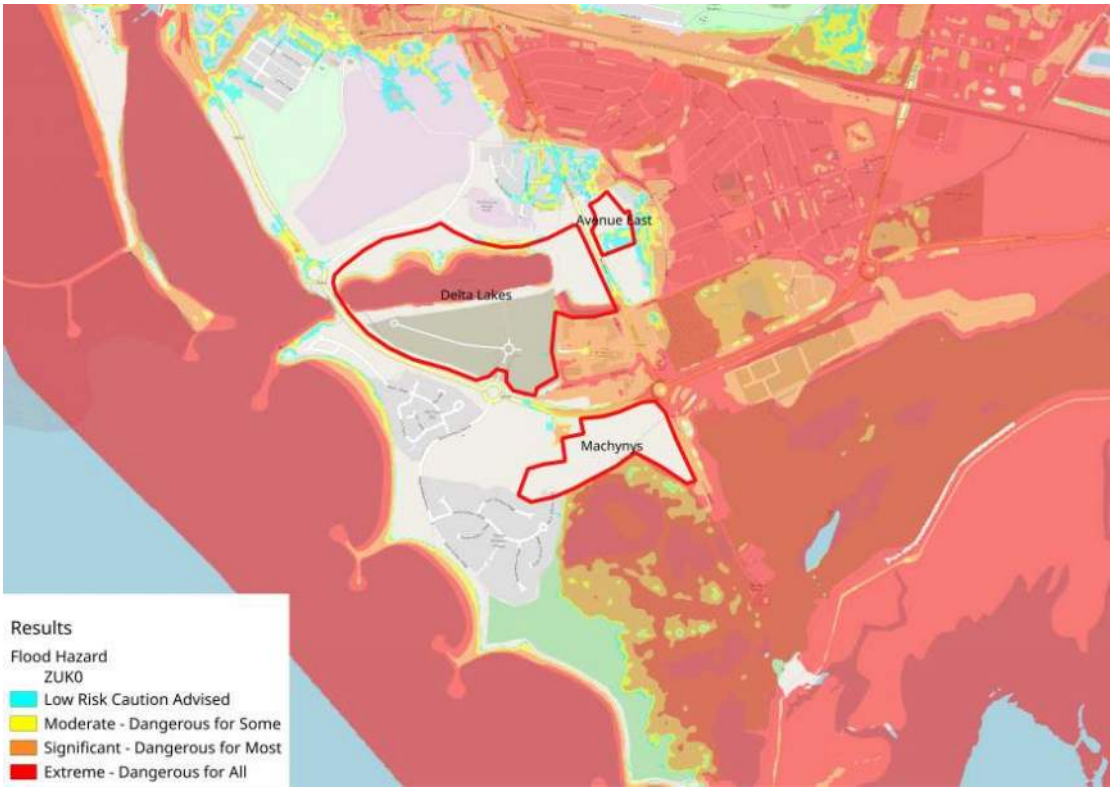


Figure 4.7: Post-development Model Results - Peak Hazard for a 0.1% AEP tidal /surge event in conjunction with a fluvial flow of QMED with 75% Climate Change

5 Conclusions and Recommendations

5.1 Conclusions

EVY were commissioned by Arup to undertake hydraulic modelling the Machynys HousingDevelopment. Based on the analysis contained in this document, the following conclusions have been made:

- Hydraulic modelling has confirmed that the changes in flood depth are negligible and that there is no significant change in flood risk to third parties as a result of the development.
- A building platform with an elevation greater than 6.87m AOD would ensure that the site is flood free.

A Appendix A - Model Results

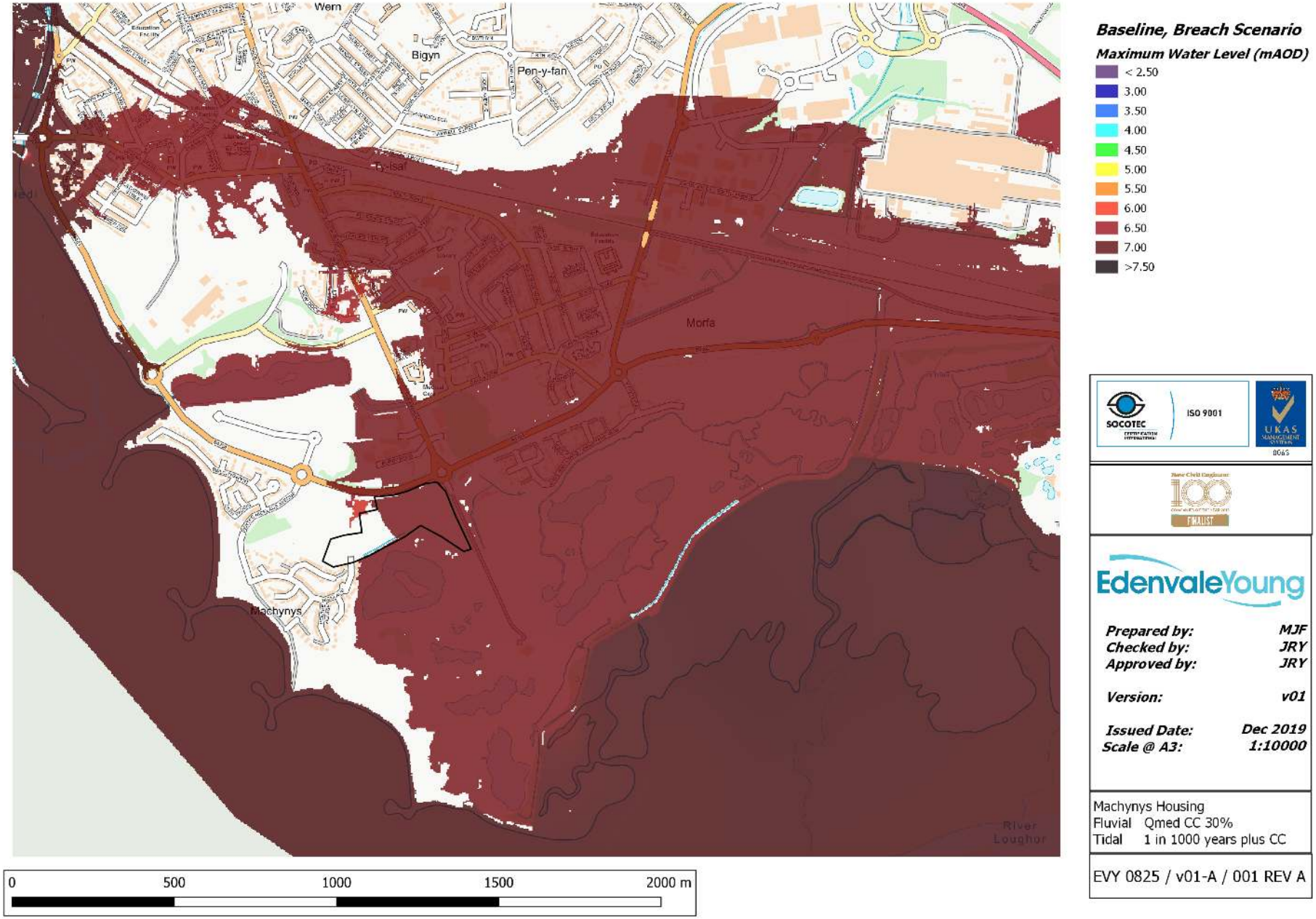


Figure A.1: Pre-Development Model Results - Peak Level - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

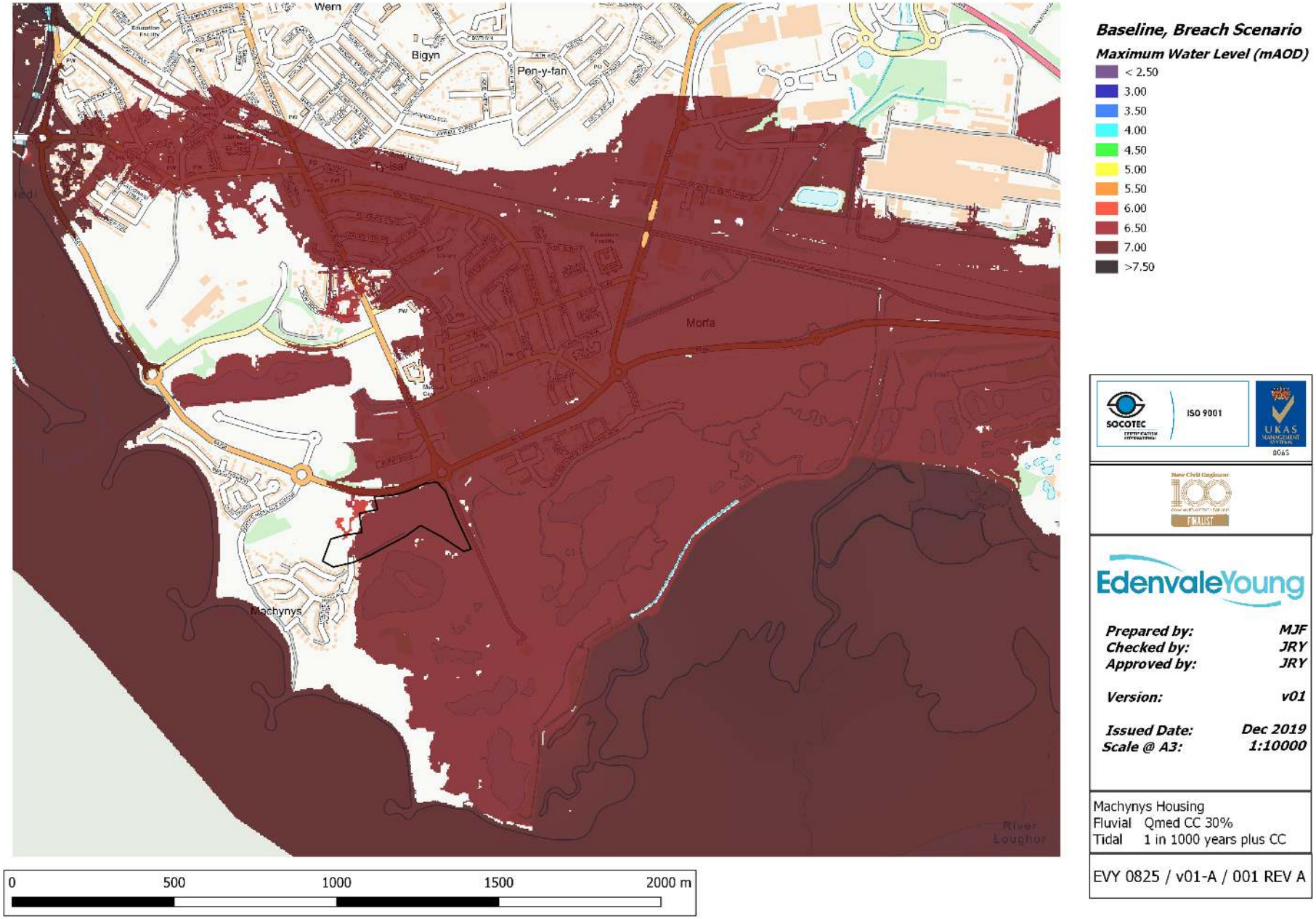


Figure A.2: Pre-Development Model Results - Peak Level - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

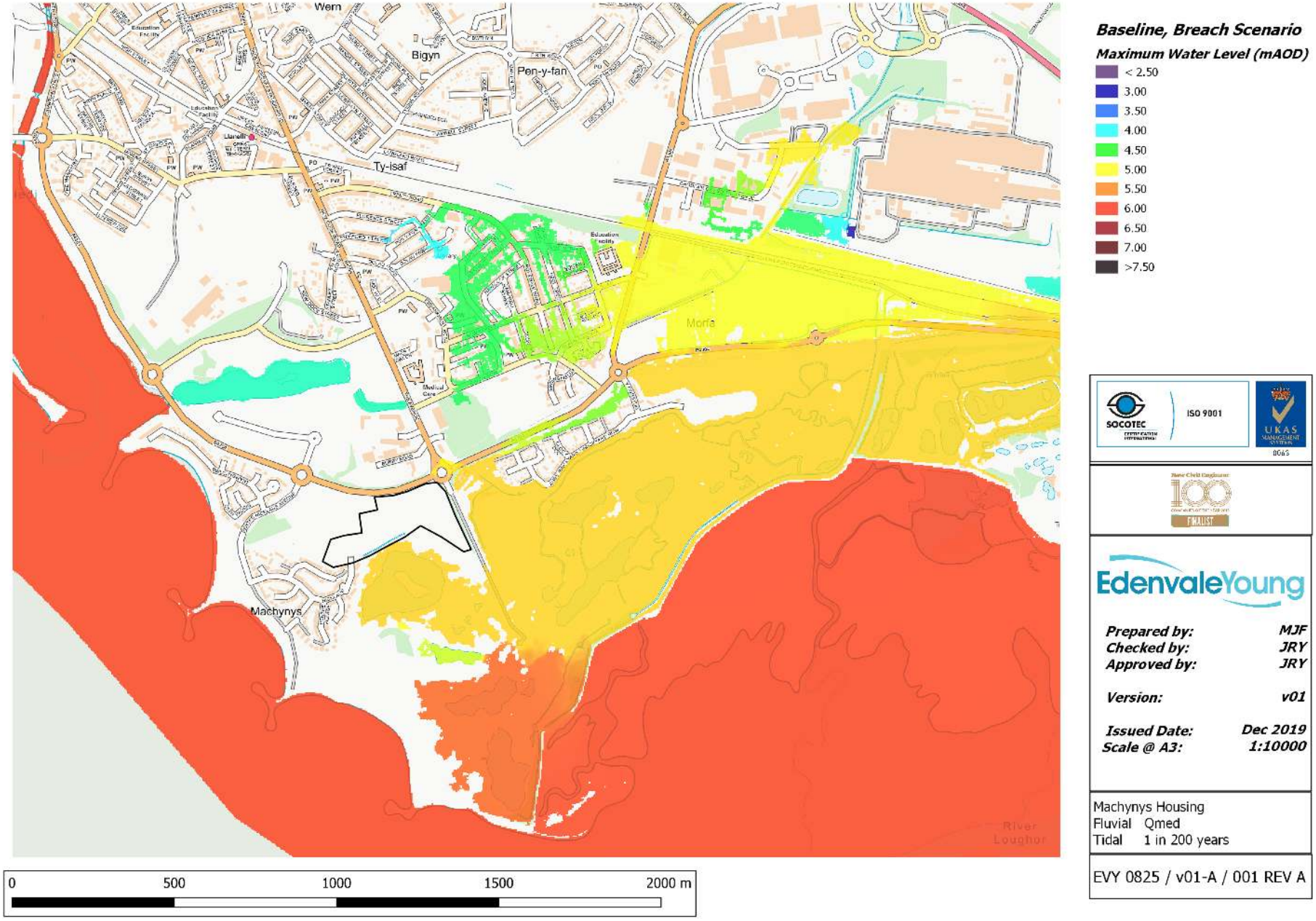


Figure A.3: Pre-Development Model Results - Peak Level - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

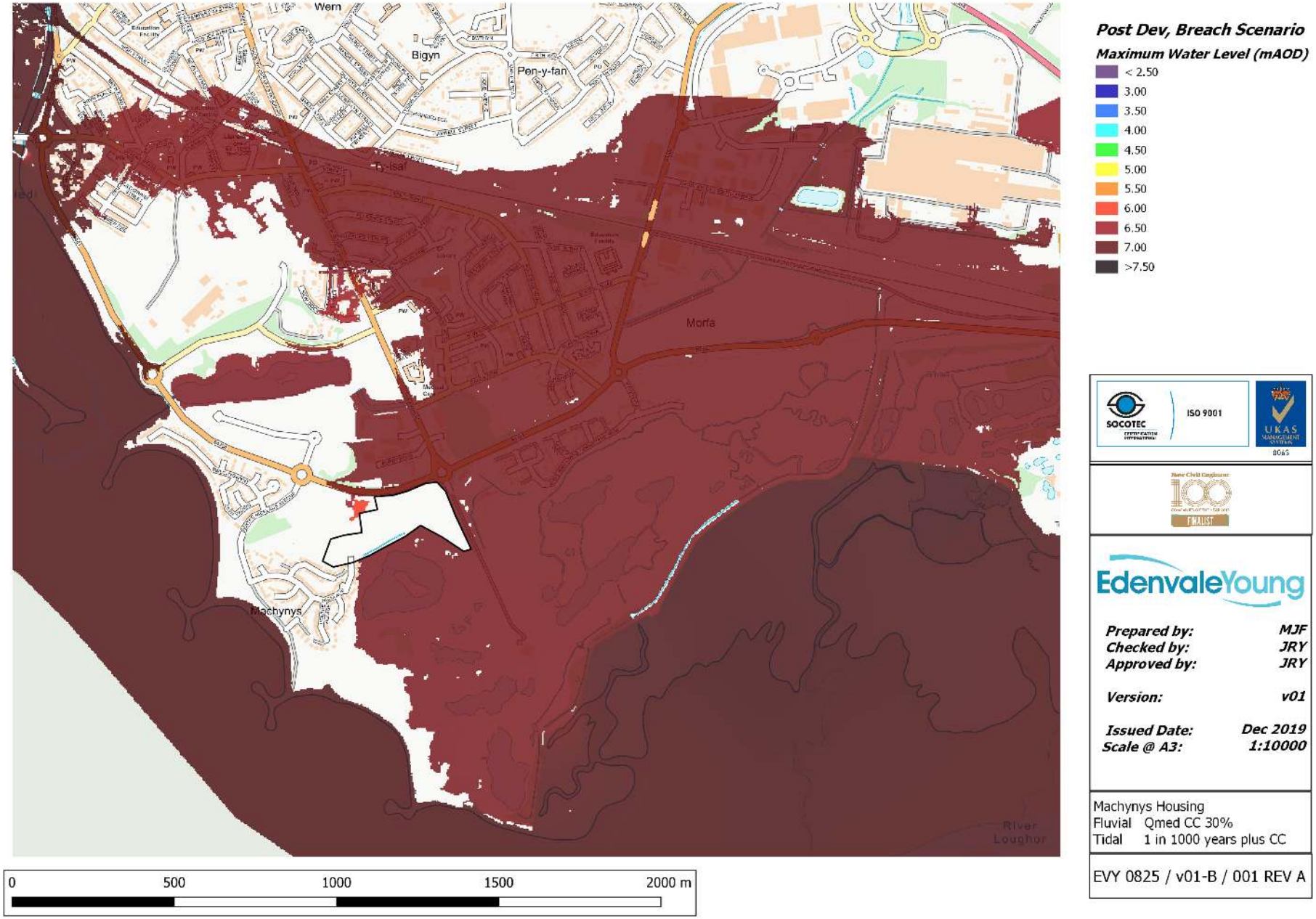


Figure A.4: Post-Development Model Results - Peak Level - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

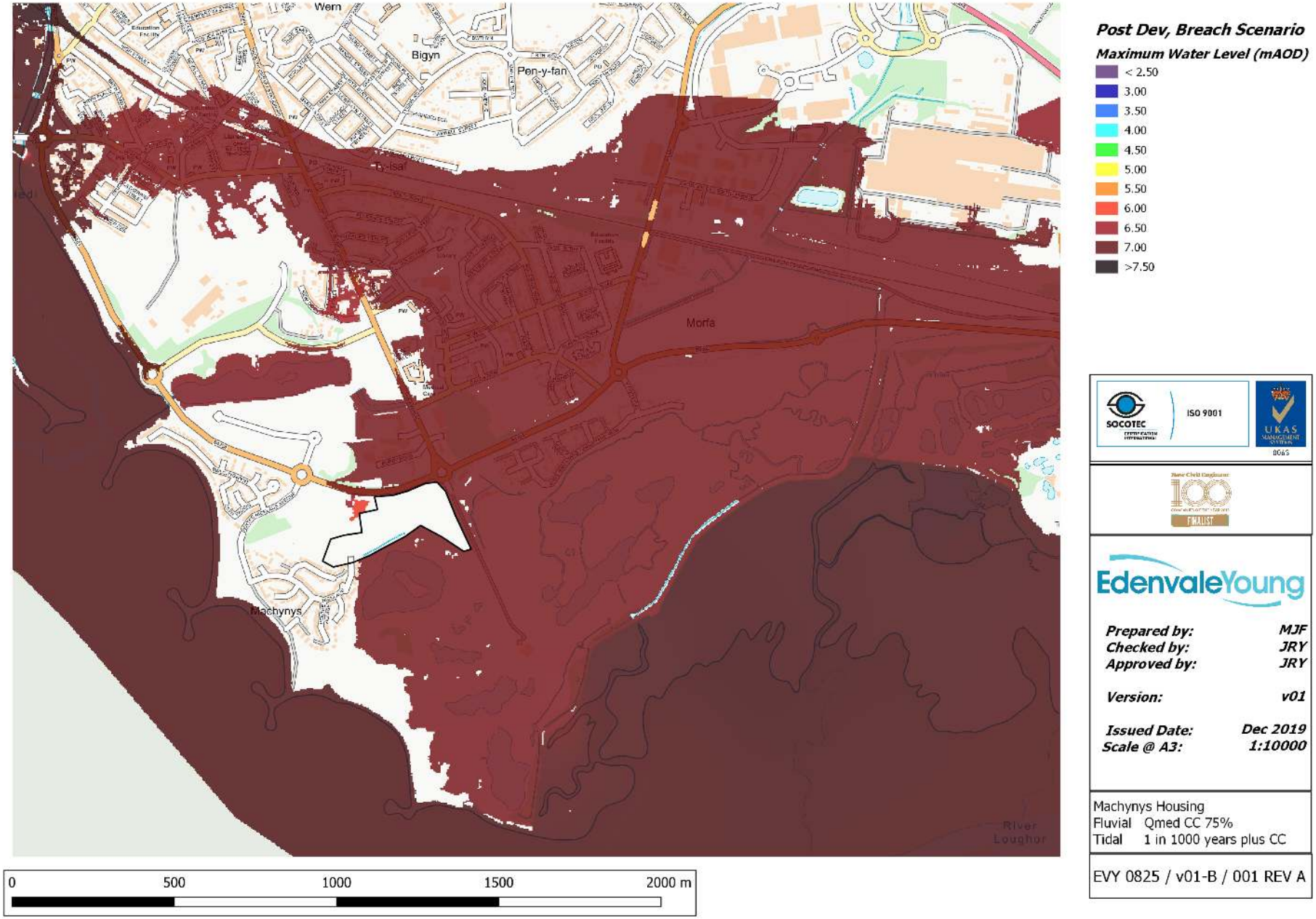


Figure A.5: Post-Development Model Results - Peak Level - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

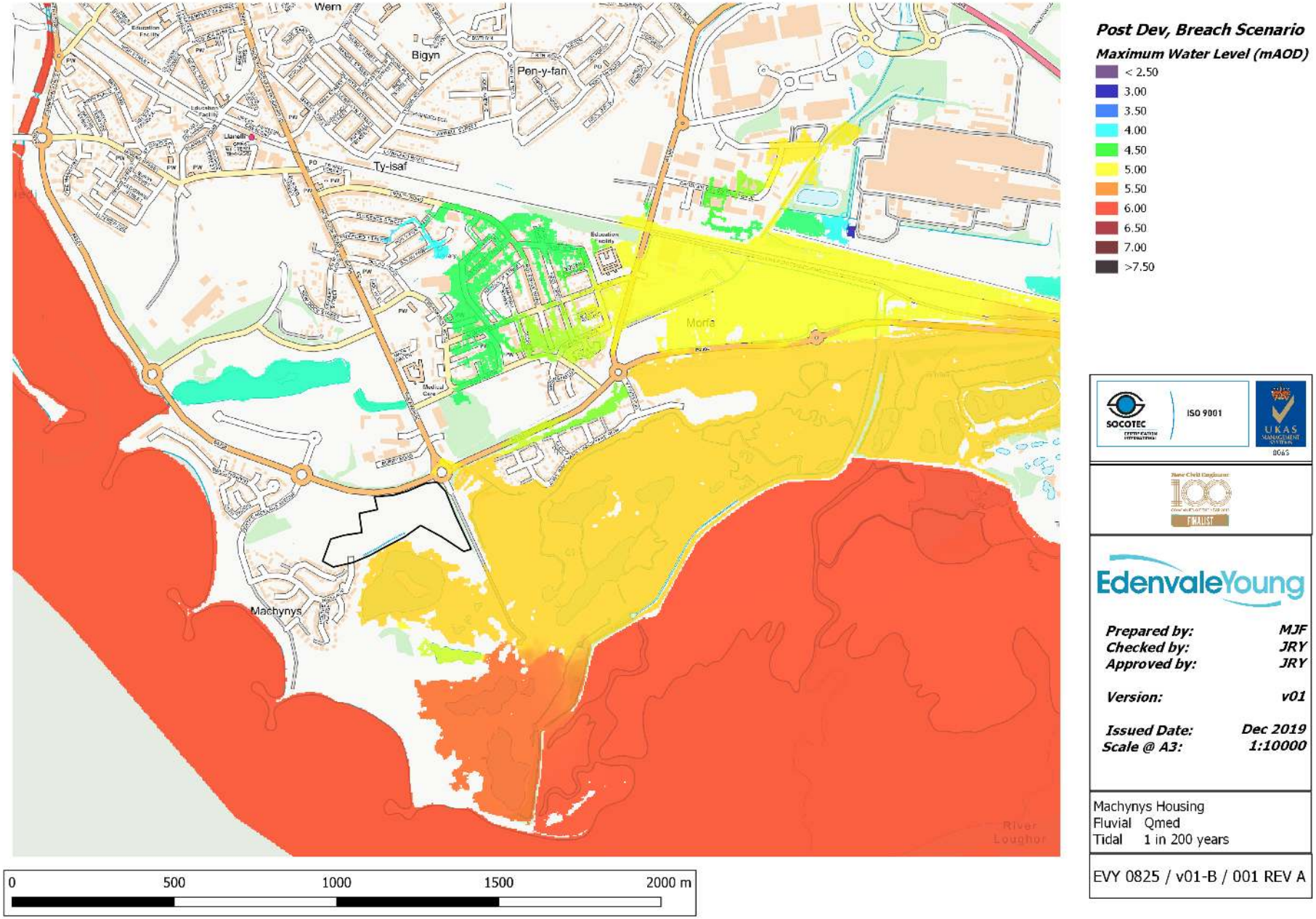


Figure A.6: Post-Development Model Results - Peak Level - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

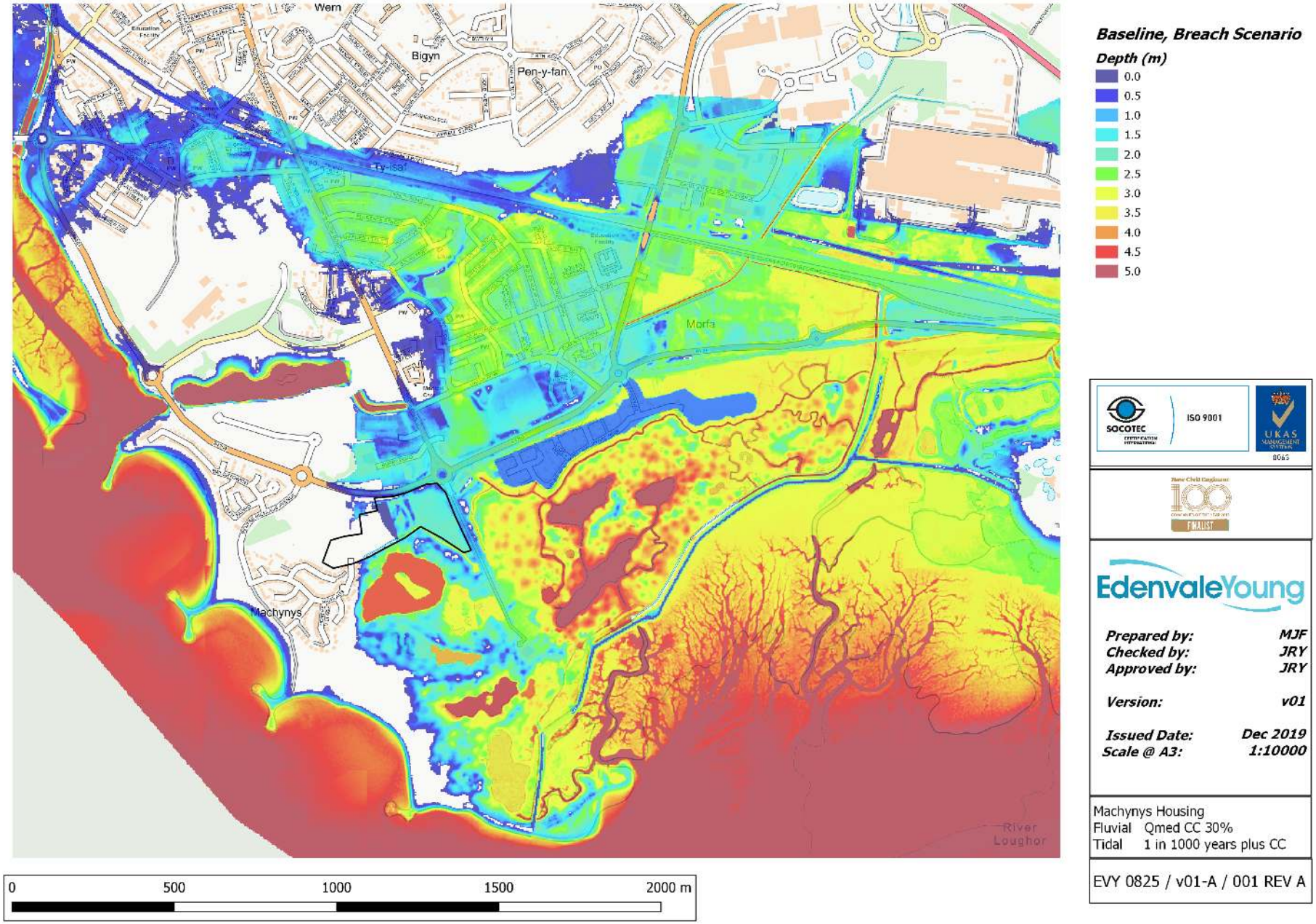


Figure A.7: Pre-Development Model Results - Peak Depth - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

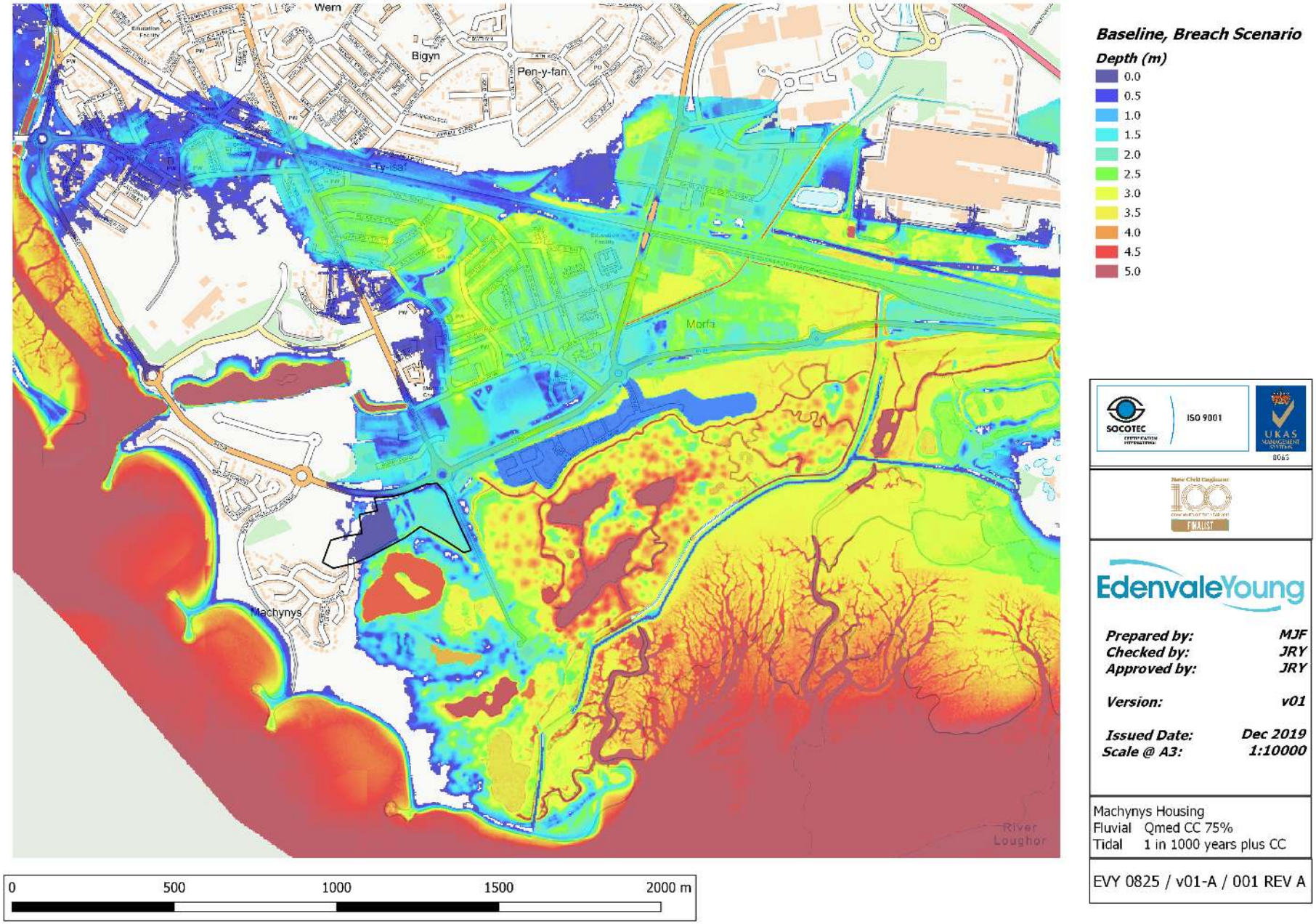


Figure A.8: Pre-Development Model Results - Peak Depth - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

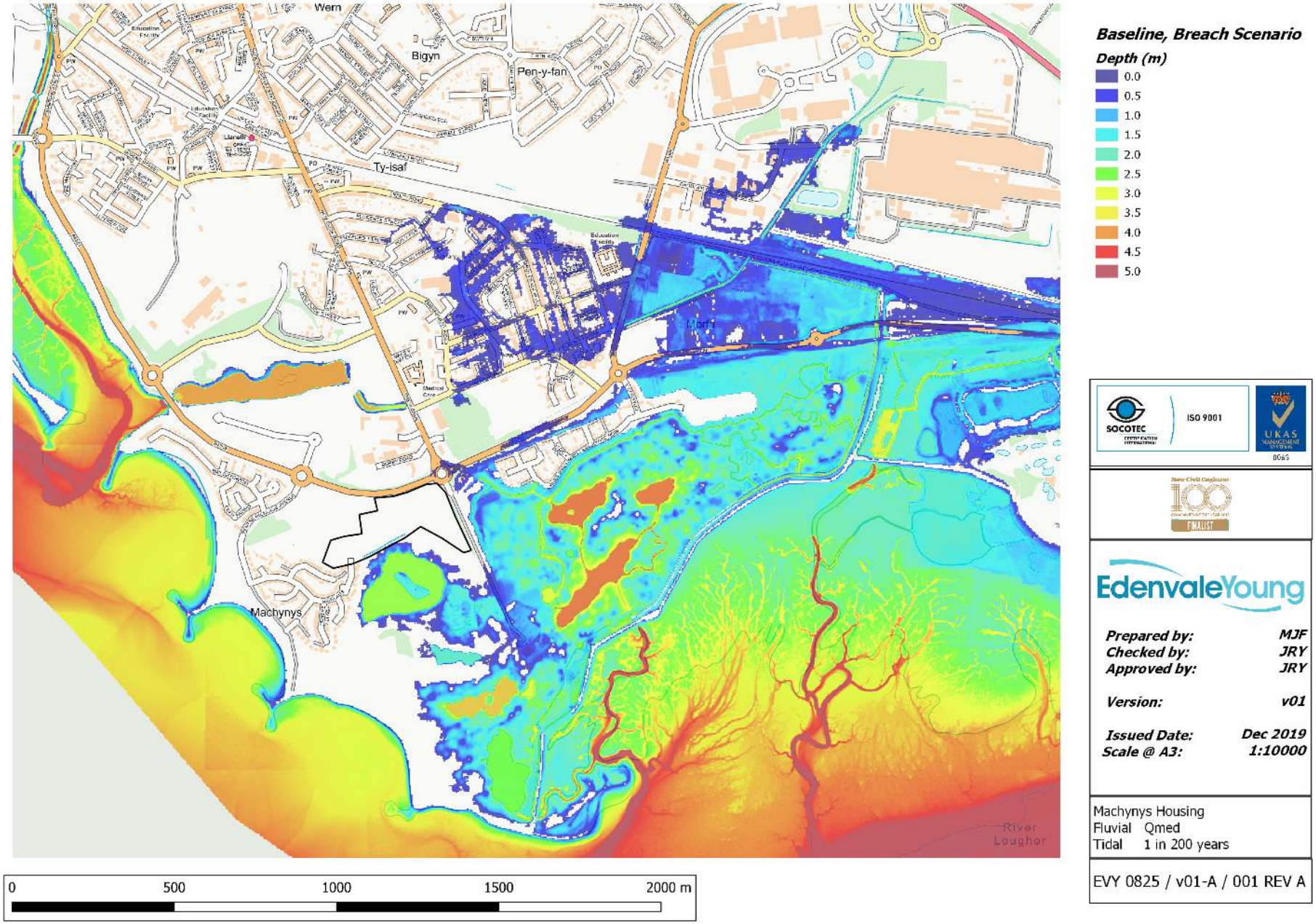


Figure A.9: Pre-Development Model Results - Peak Depth - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

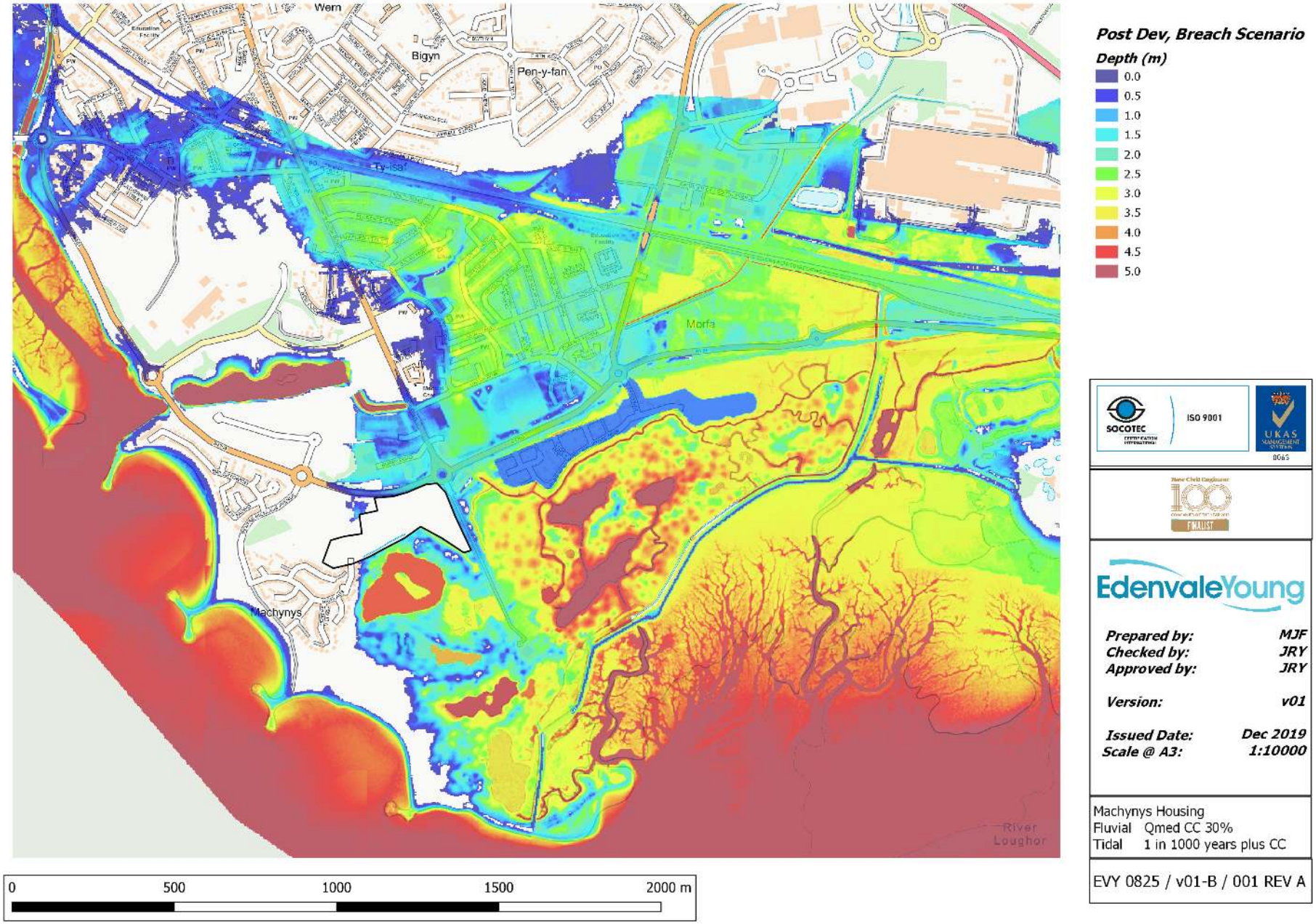


Figure A.10: Post-Development Model Results - Peak Depth - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

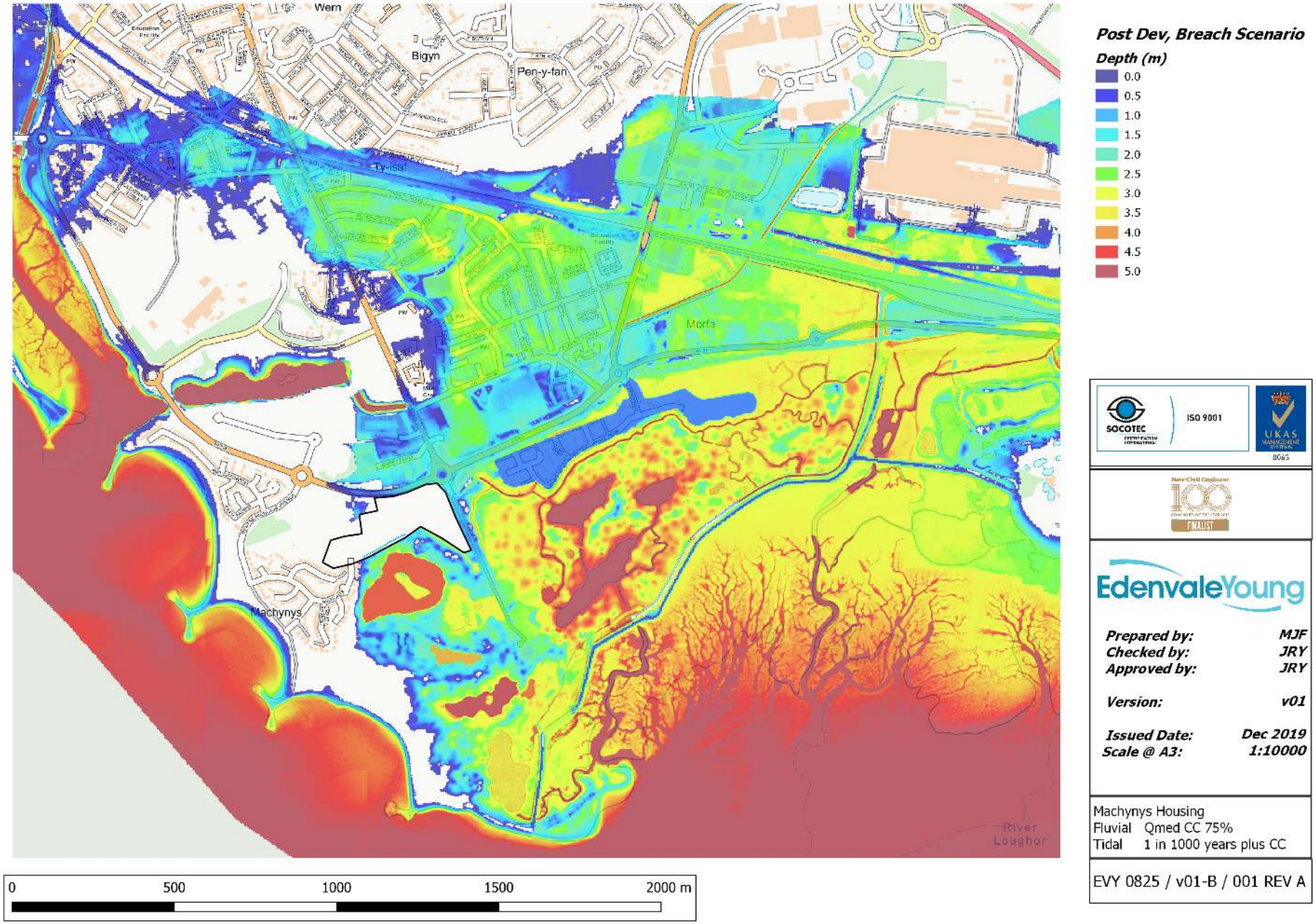


Figure A.11: Post-Development Model Results - Peak Depth - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

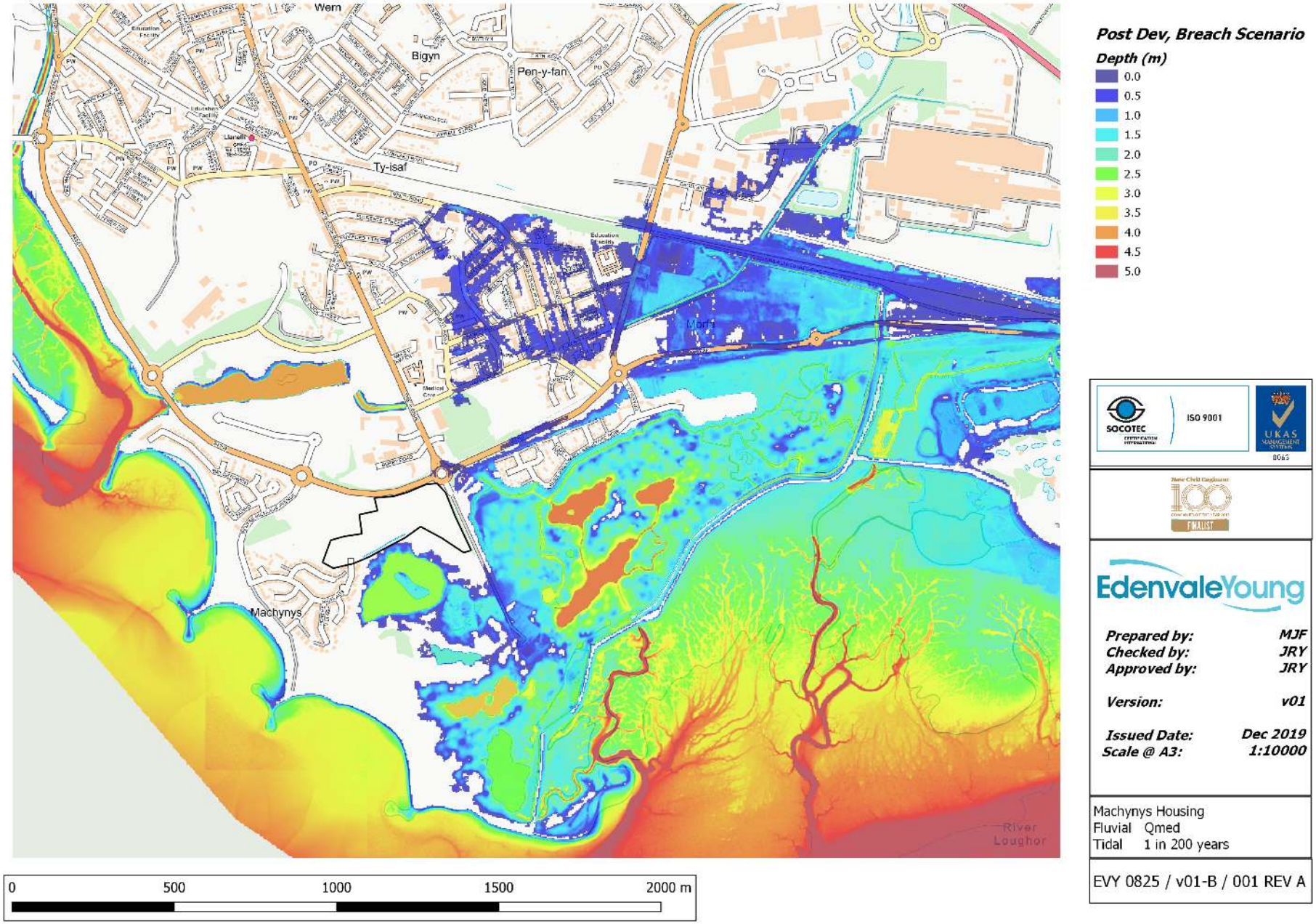


Figure A.12: Post-Development Model Results - Peak Depth - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

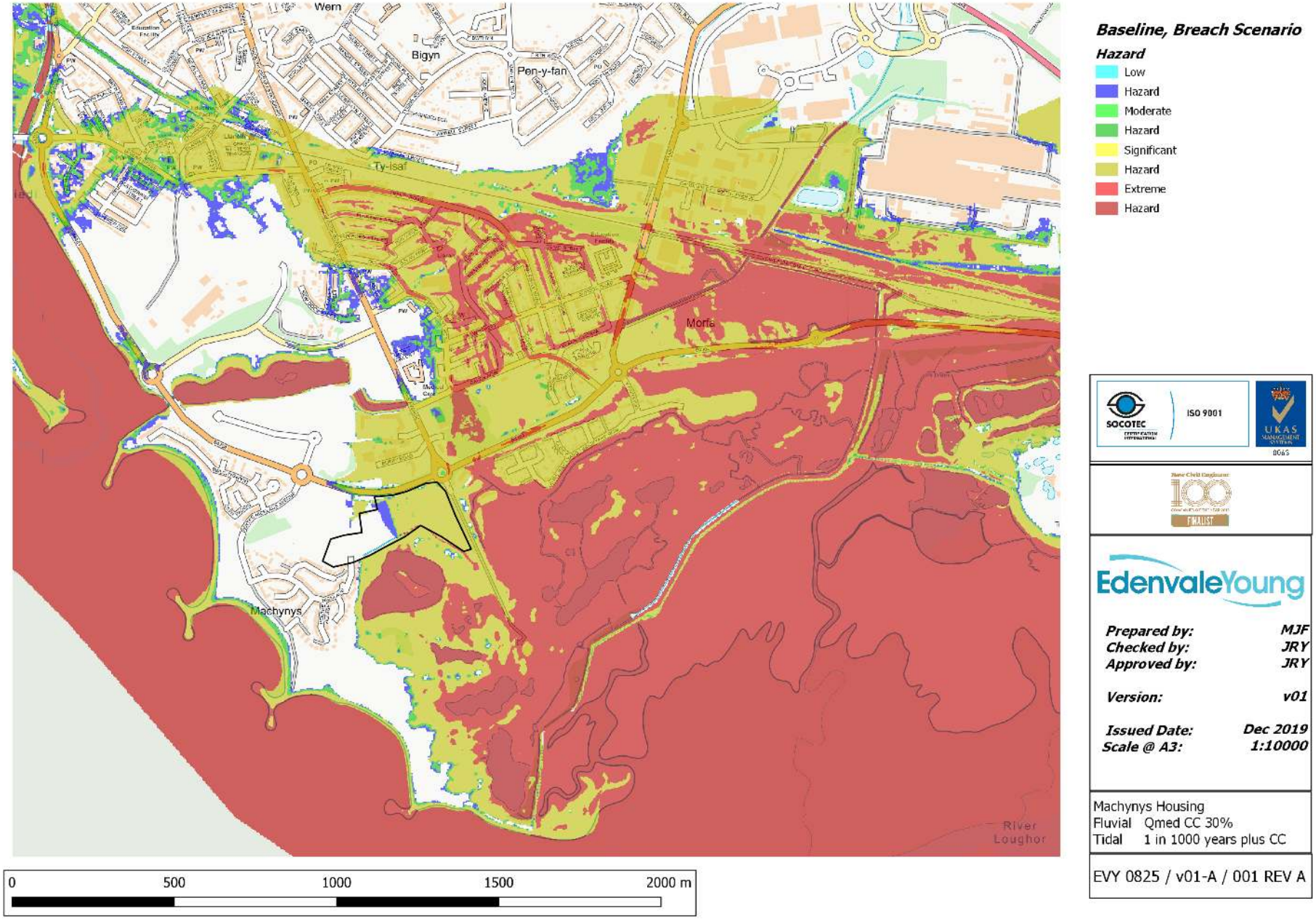


Figure A.13: Pre-Development Model Results - Peak Hazard - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

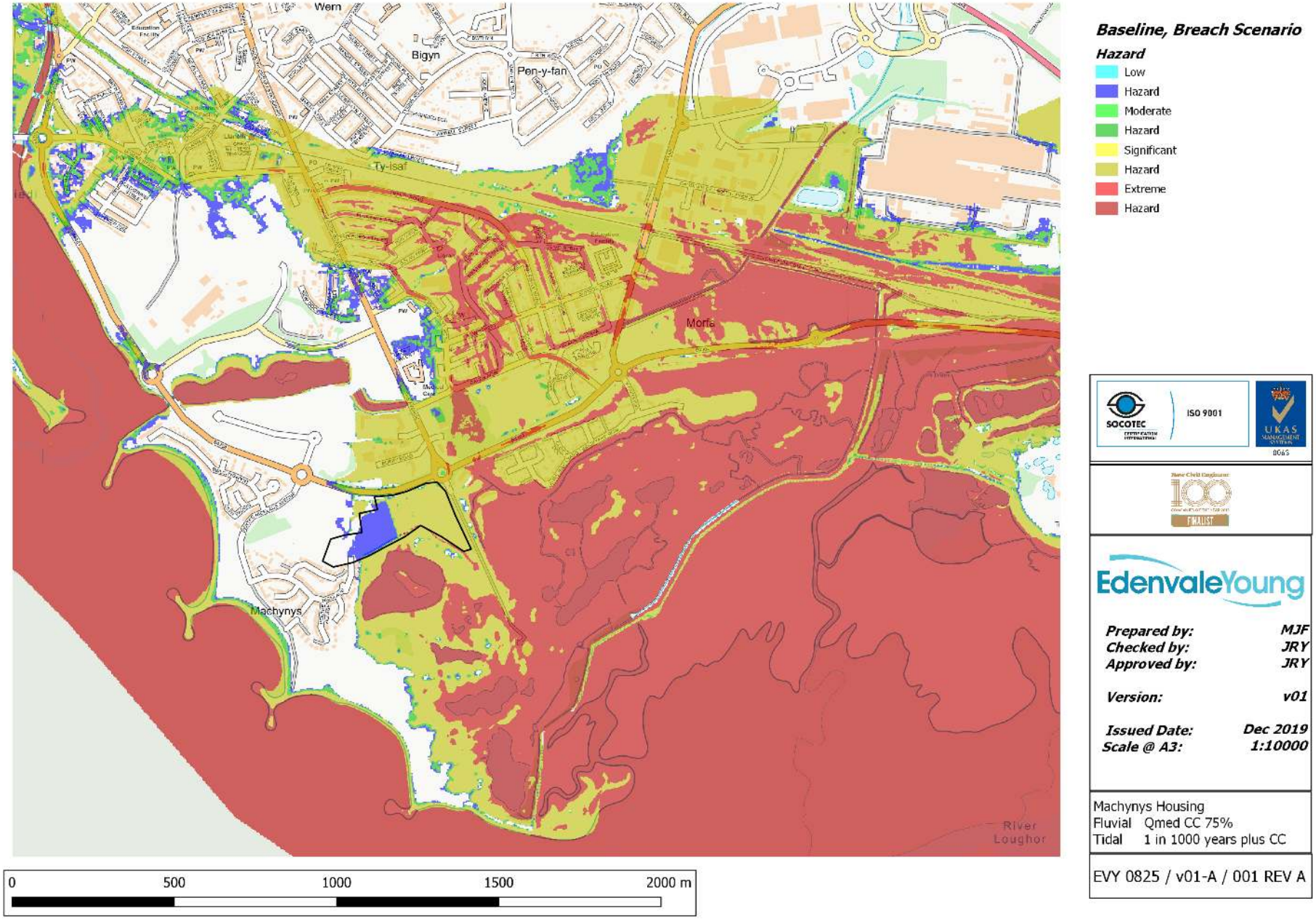


Figure A.14: Pre-Development Model Results - Peak Hazard - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

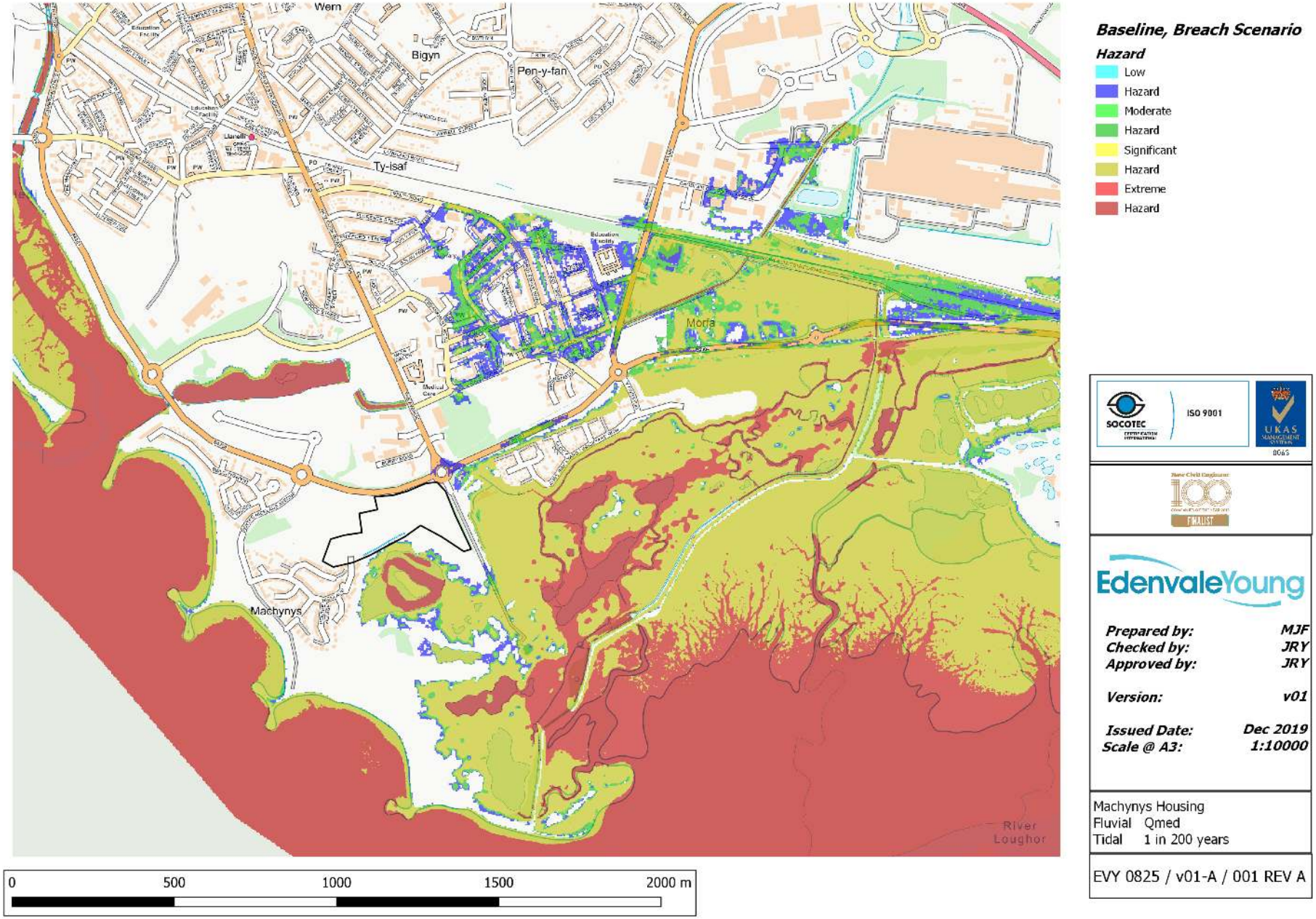


Figure A.15: Pre-Development Model Results - Peak Hazard - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

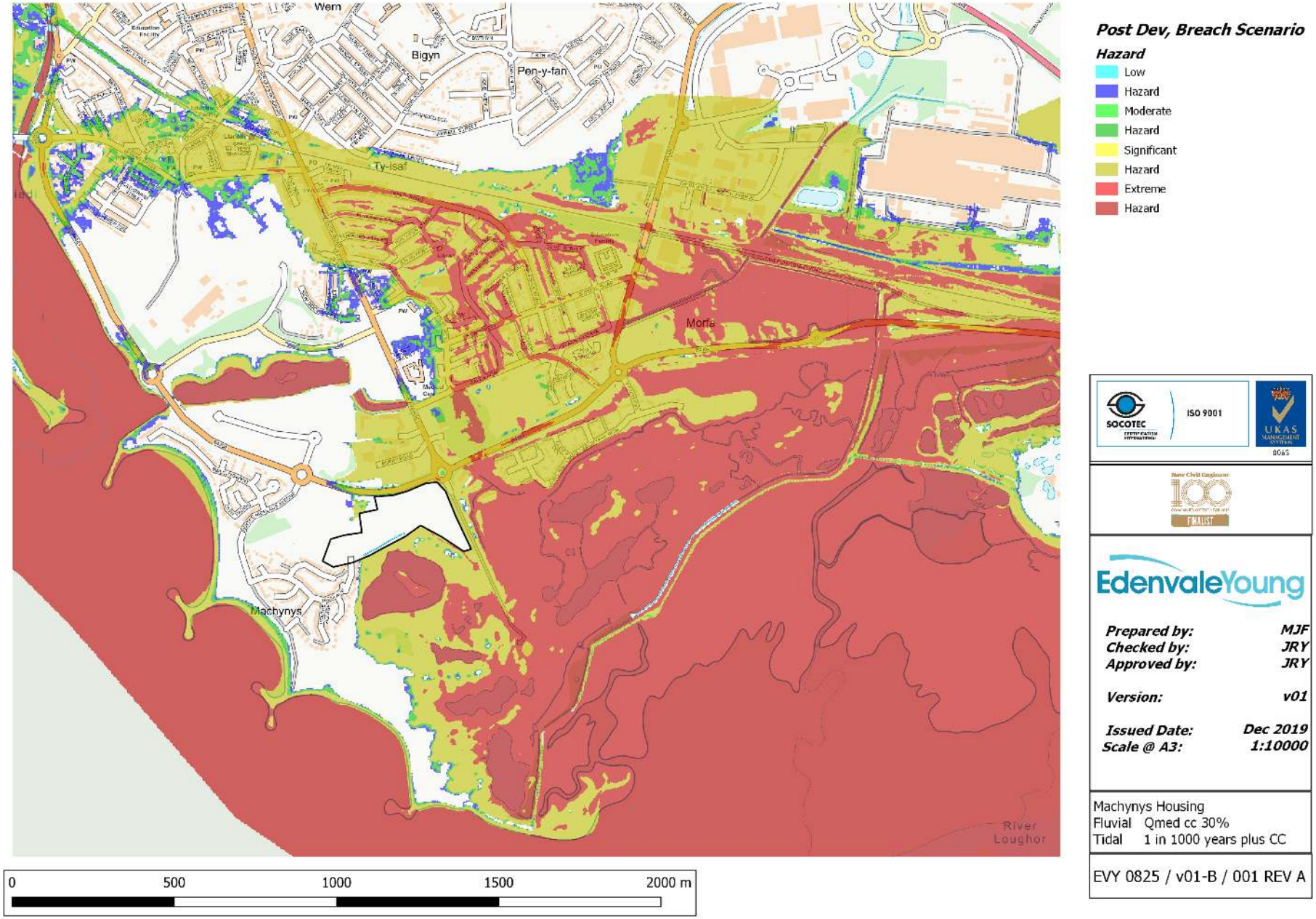


Figure A.16: Post-Development Model Results - Peak Hazard - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 30% CC Breach

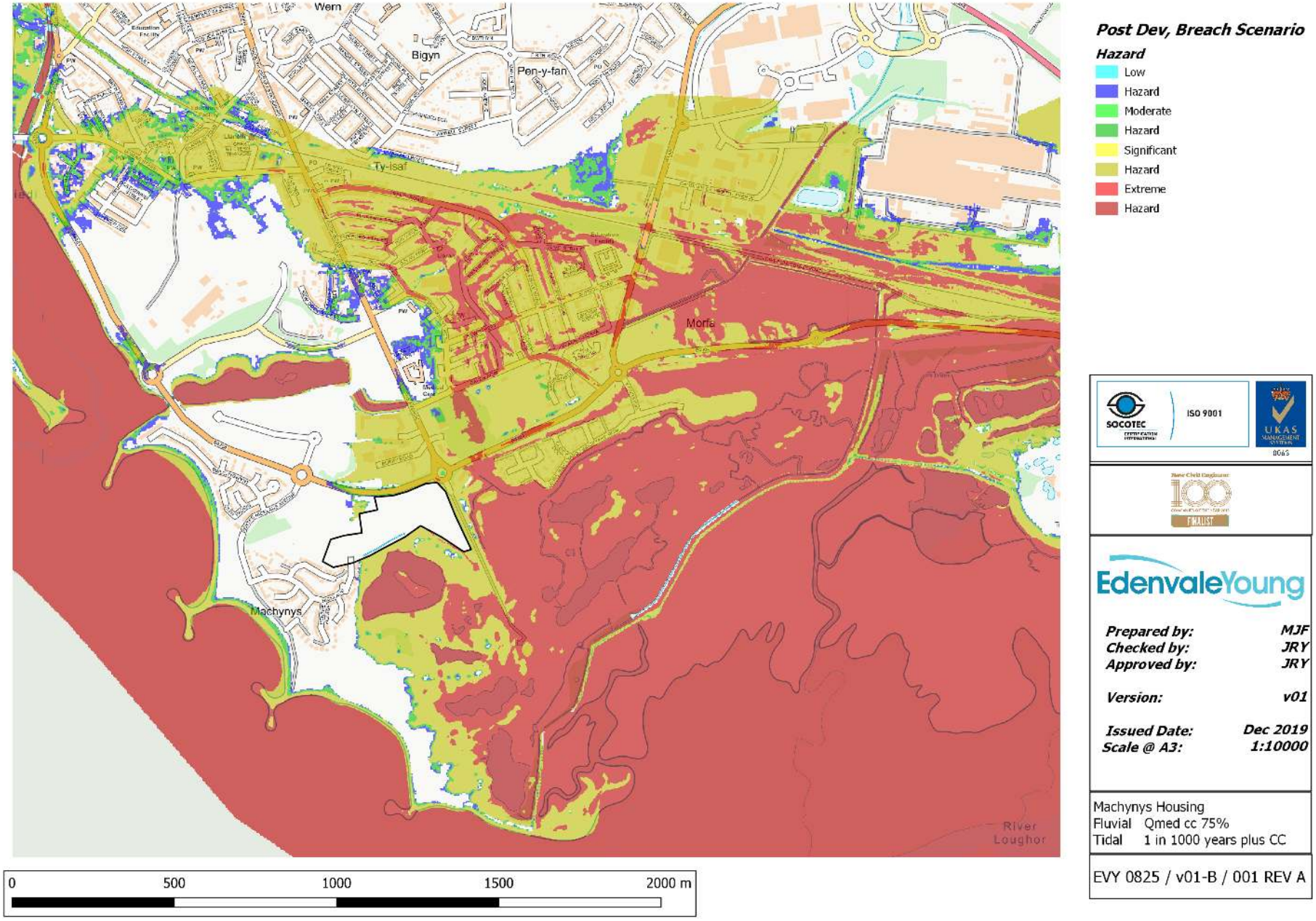


Figure A.17: Post-Development Model Results - Peak Hazard - Tidal 0.1 %AEP 2120 in conjunction with Fluvial QMED 75% CC Breach

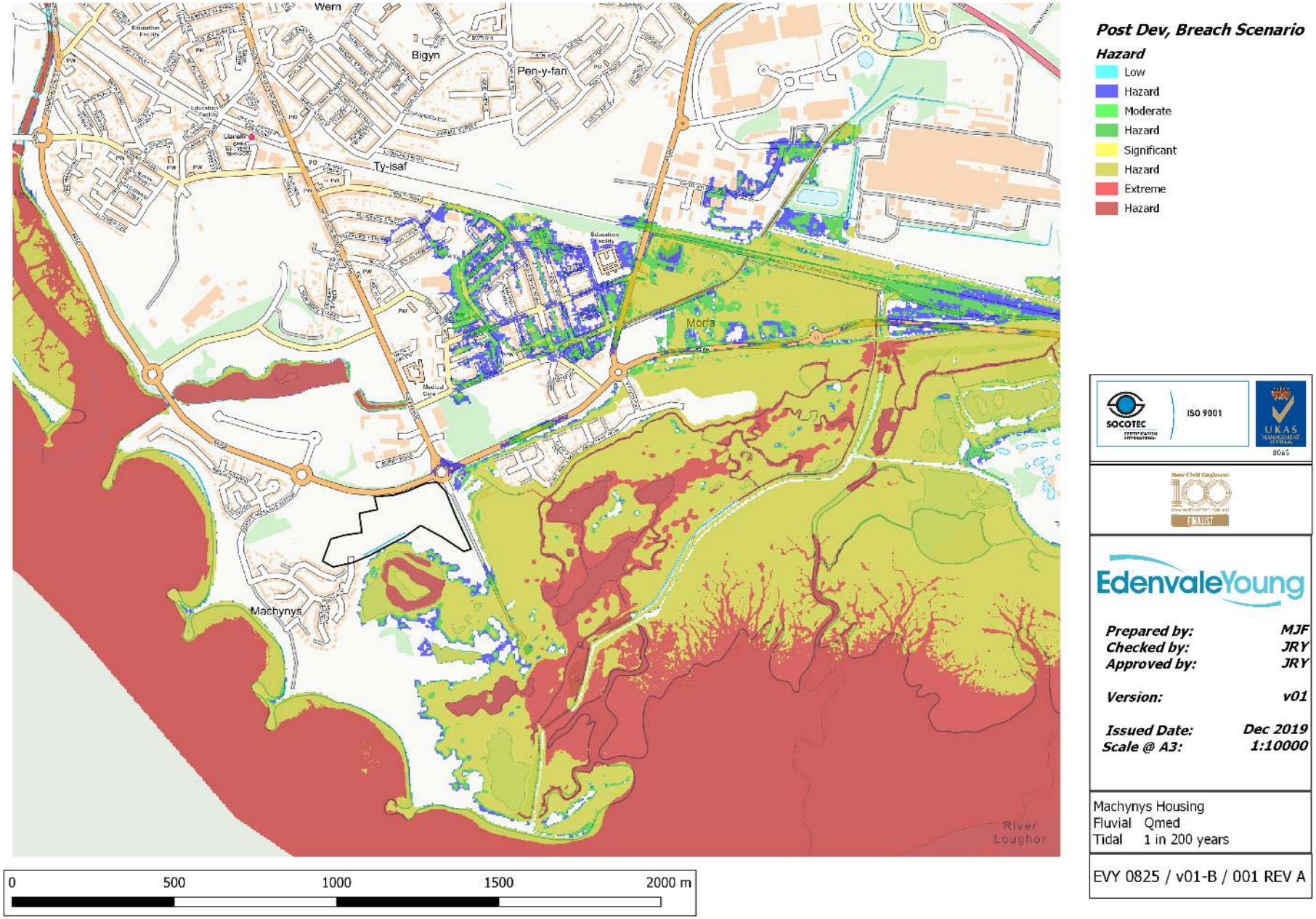


Figure A.18: Post-Development Model Results - Peak Hazard - Tidal 0.5 %AEP 2020 in conjunction with Fluvial QMED Breach

Appendix E

190211 EVY Llanelli Modelling Report v9 Rev E - Drawings

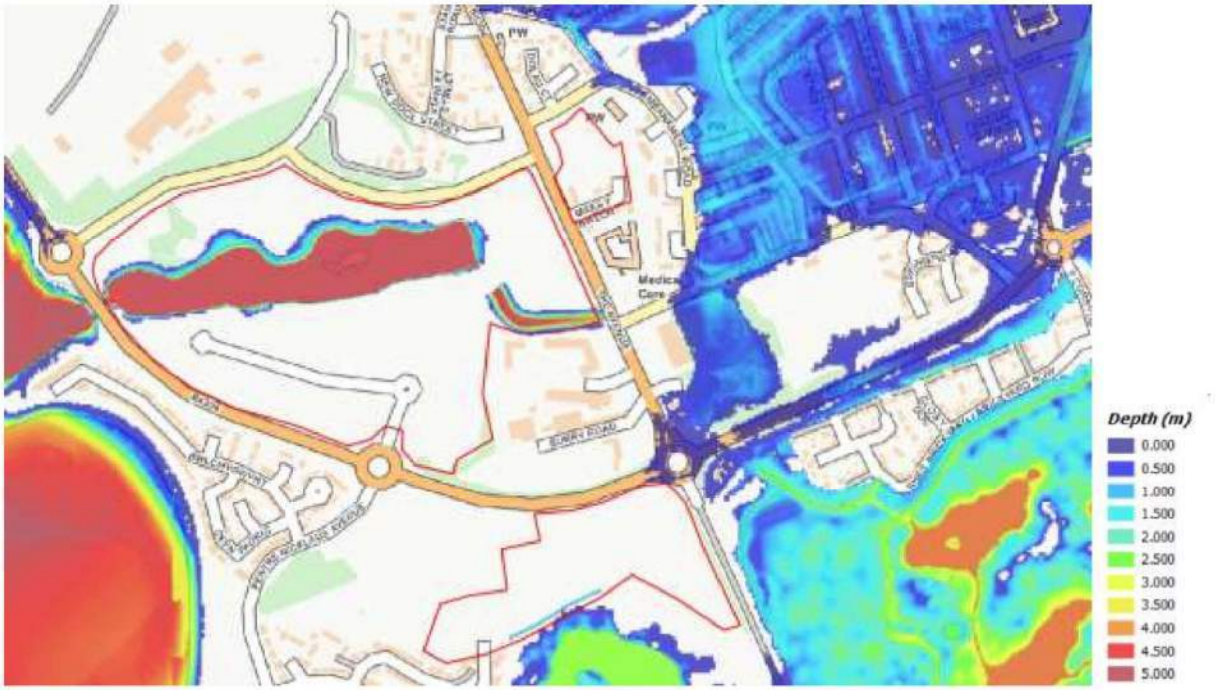


FIGURE 4-1| PRE DEVELOPMENT FLUVIAL QMED WITH 75% CLIMATE CHANGE IN CONJUNCTION WITH TIDAL / SURGE 0.5% AEP CC

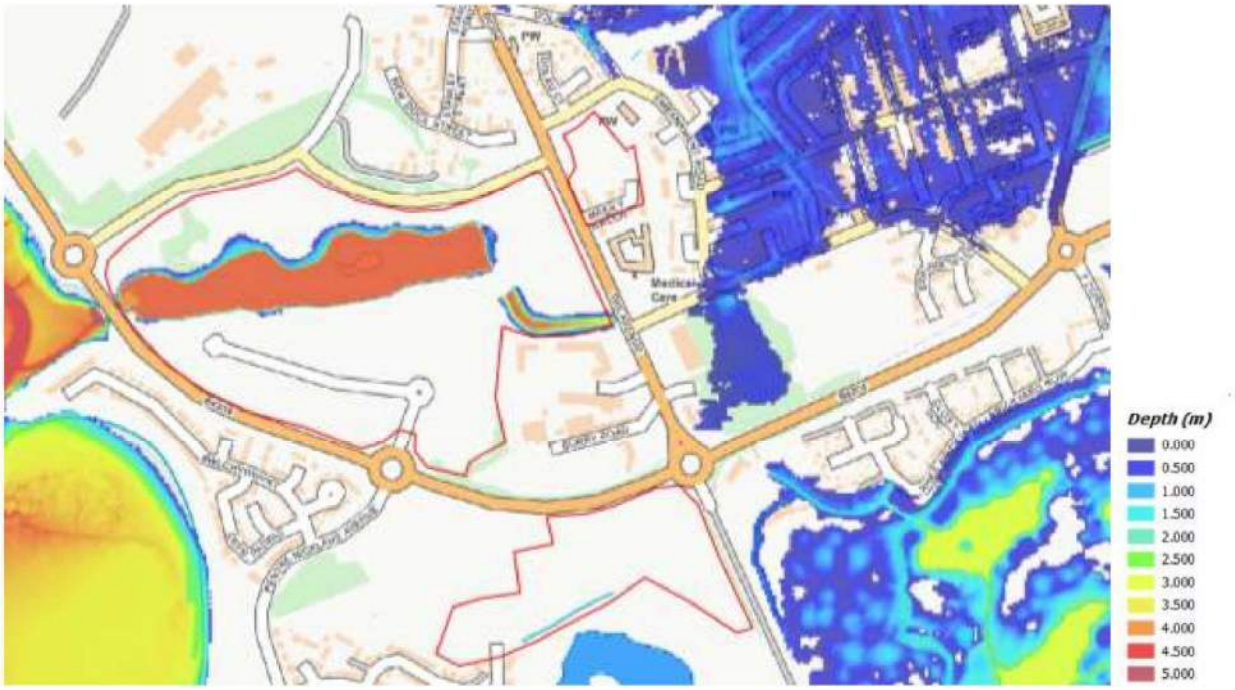


FIGURE 4-2| PRE DEVELOPMENT FLUVIAL 1% AEP WITH 75% CLIMATE CHANGE IN CONJUNCTION WITH TIDAL MHWS CC

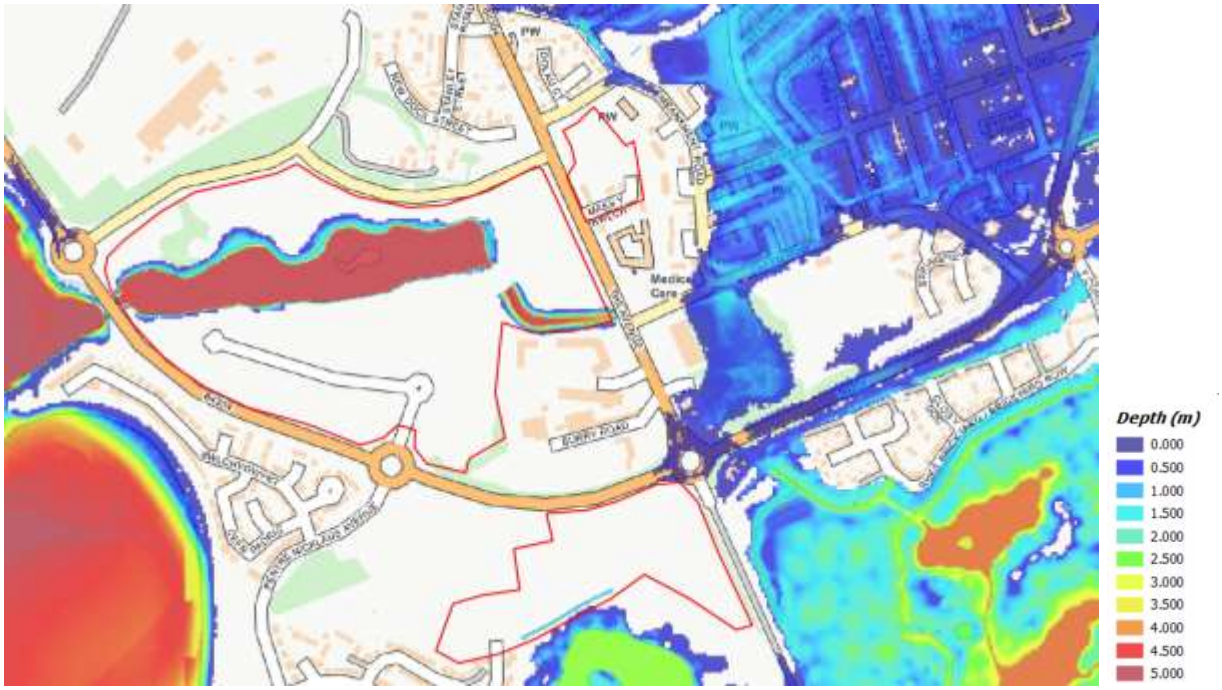


FIGURE 4-3| POST DEVELOPMENT FLUVIAL QMED WITH 75% CLIMATE CHANGE IN CONJUNCTION WITH TIDAL / SURGE 0.5% AEP CC

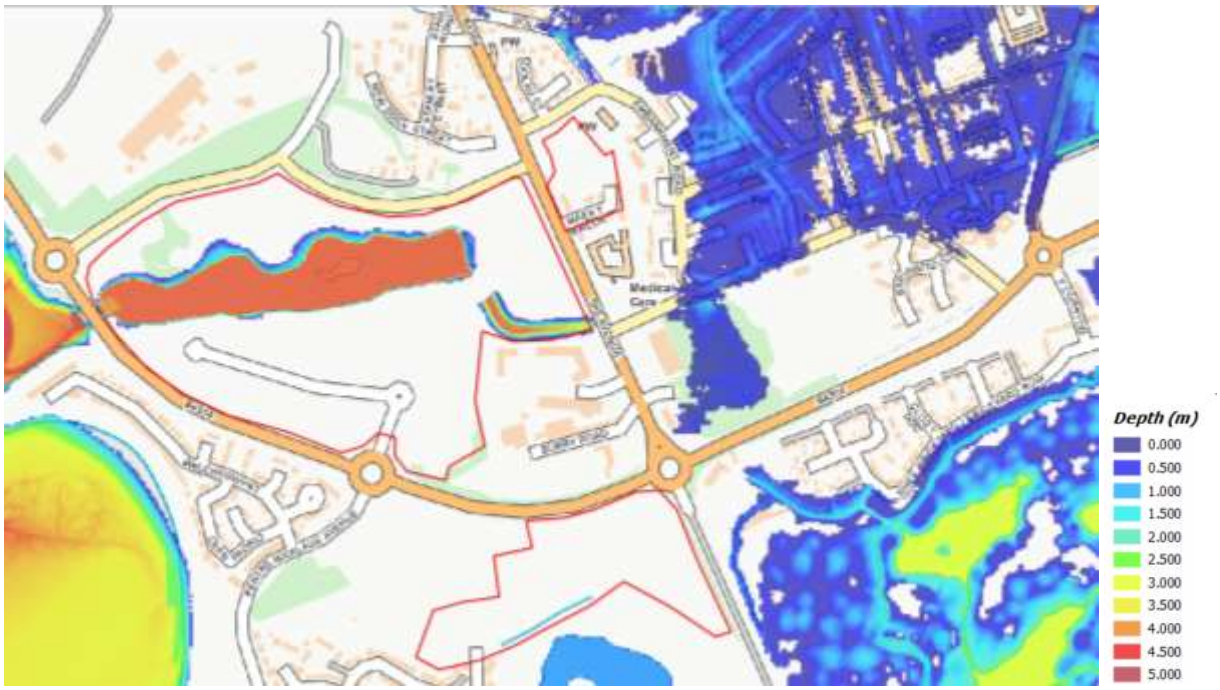
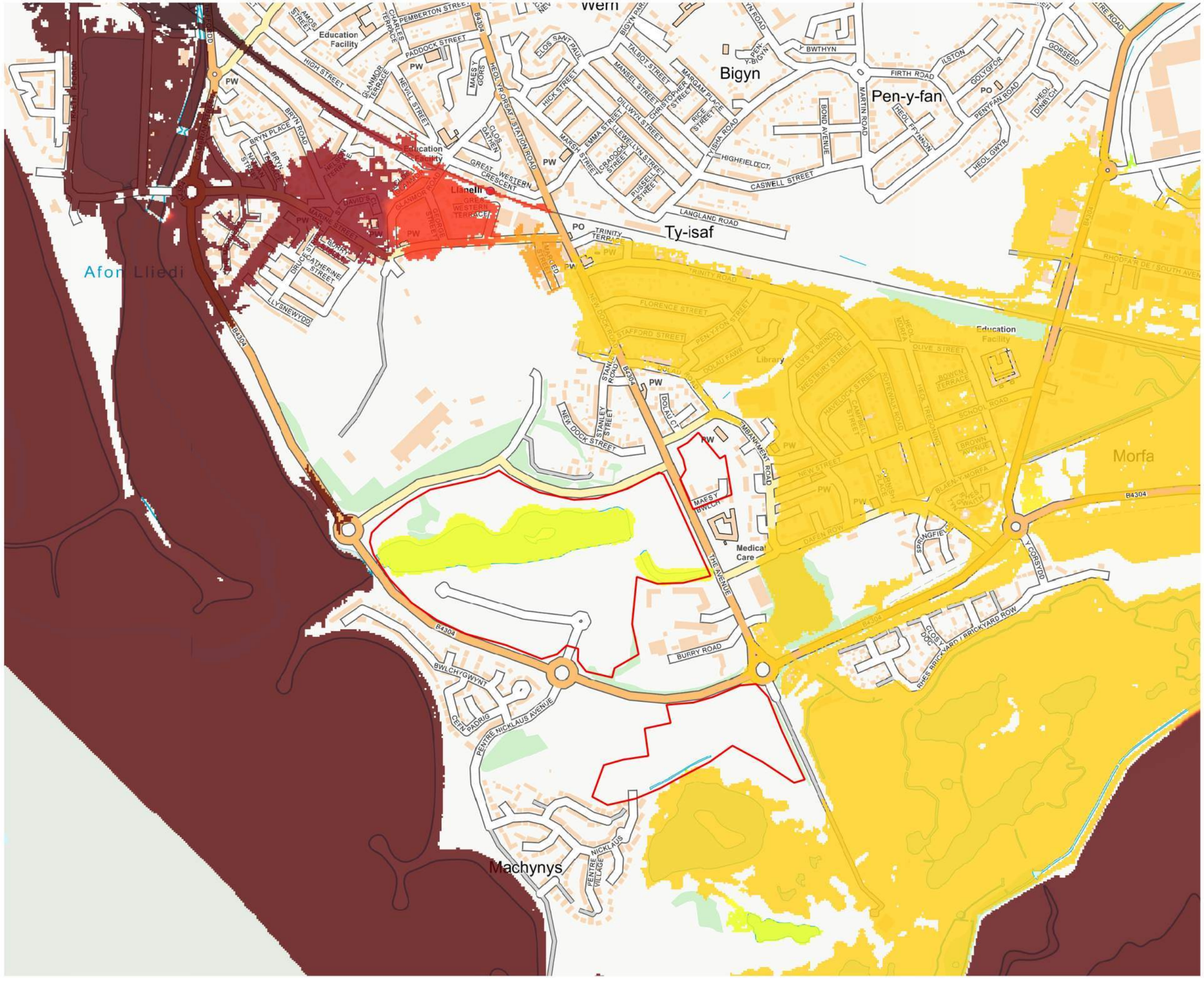


FIGURE 4-4| POST DEVELOPMENT - FLUVIAL 1% AEP WITH 75% CLIMATE CHANGE IN CONJUNCTION WITH TIDAL MHWS CC



SOCOTEC CERTIFICATION INTERNATIONAL ISO 9001 UKAS MANAGEMENT SYSTEMS 0063

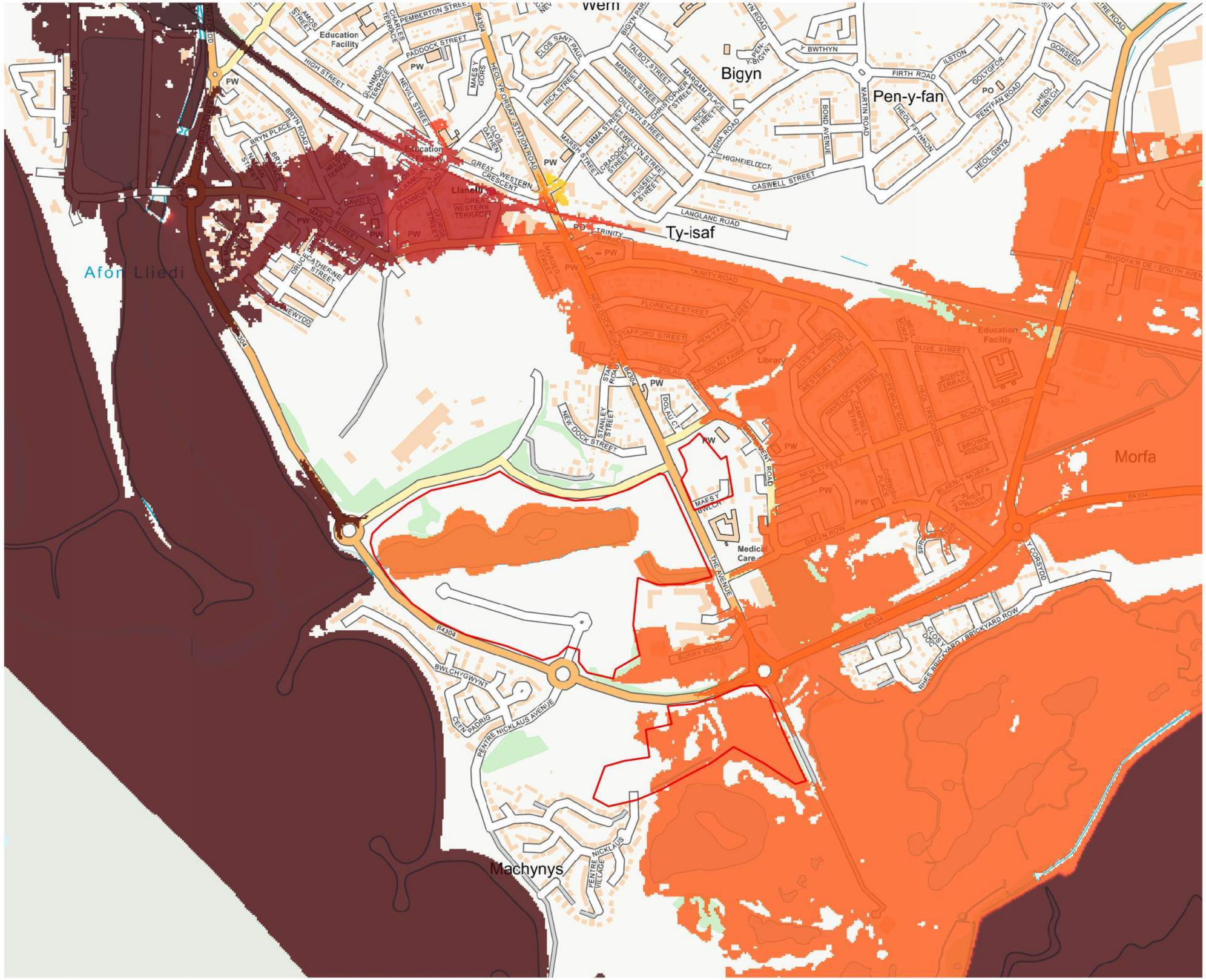
New Civil Engineer 100 COMPANIES OF THE YEAR 2018 FINALIST

EdenvaleYoung

Prepared by:	***MJF***
Checked by:	***JRY***
Approved by:	***JRY***
Version:	***v34***
Issued Date:	***Feb 2019***
Scale @ A3:	***1:25000***

Llanelli, Delta Lakes
Fluvial QMED cc 75%
Tidal 0.5% AEP cc

EVY 0729 / v34-H / 005 REV E



Pre Development

Maximum Water Level (mAOD)

- < 2.50
- 3.00
- 3.50
- 4.00
- 4.50
- 5.00
- 5.50
- 6.00
- 6.50
- 7.00
- >7.50

0 500 1000 1500 2000 m

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New Civil Engineer 100 COMPANIES OF THE YEAR 2019 FINALIST

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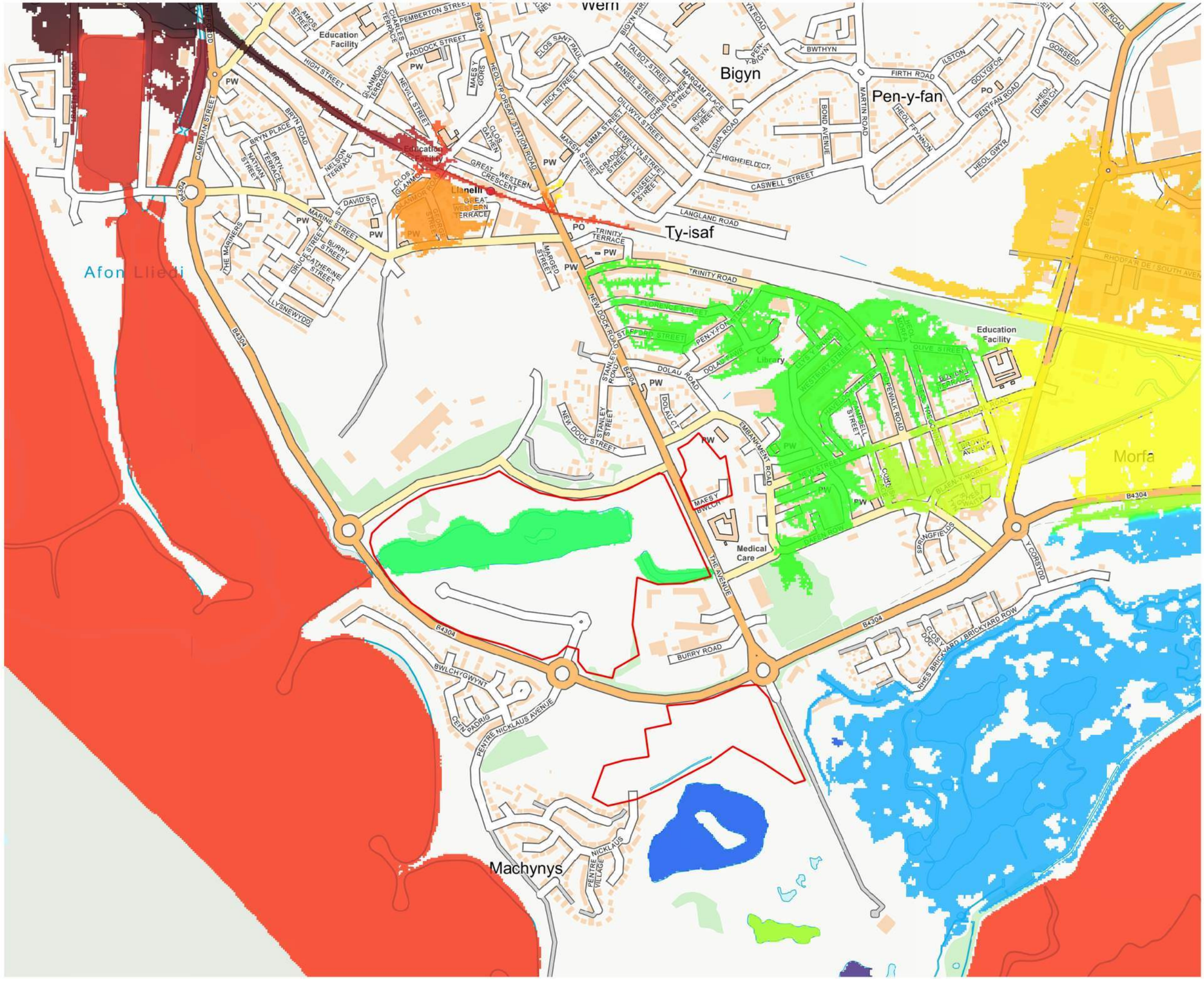
Approved by:	***JRY***
Version:	***v34***
Issued Date:	***Feb 2019***
Scale @ A3:	***1:25000***

Llanelli, Delta Lakes
Fluvial QMED cc 75%
Tidal 0.1% AEP cc

EVY 0729 / v34-H / 006 REV E



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New Civil Engineer 100 COMPANIES OF THE YEAR 2018 FINALIST

EdenvaleYoung

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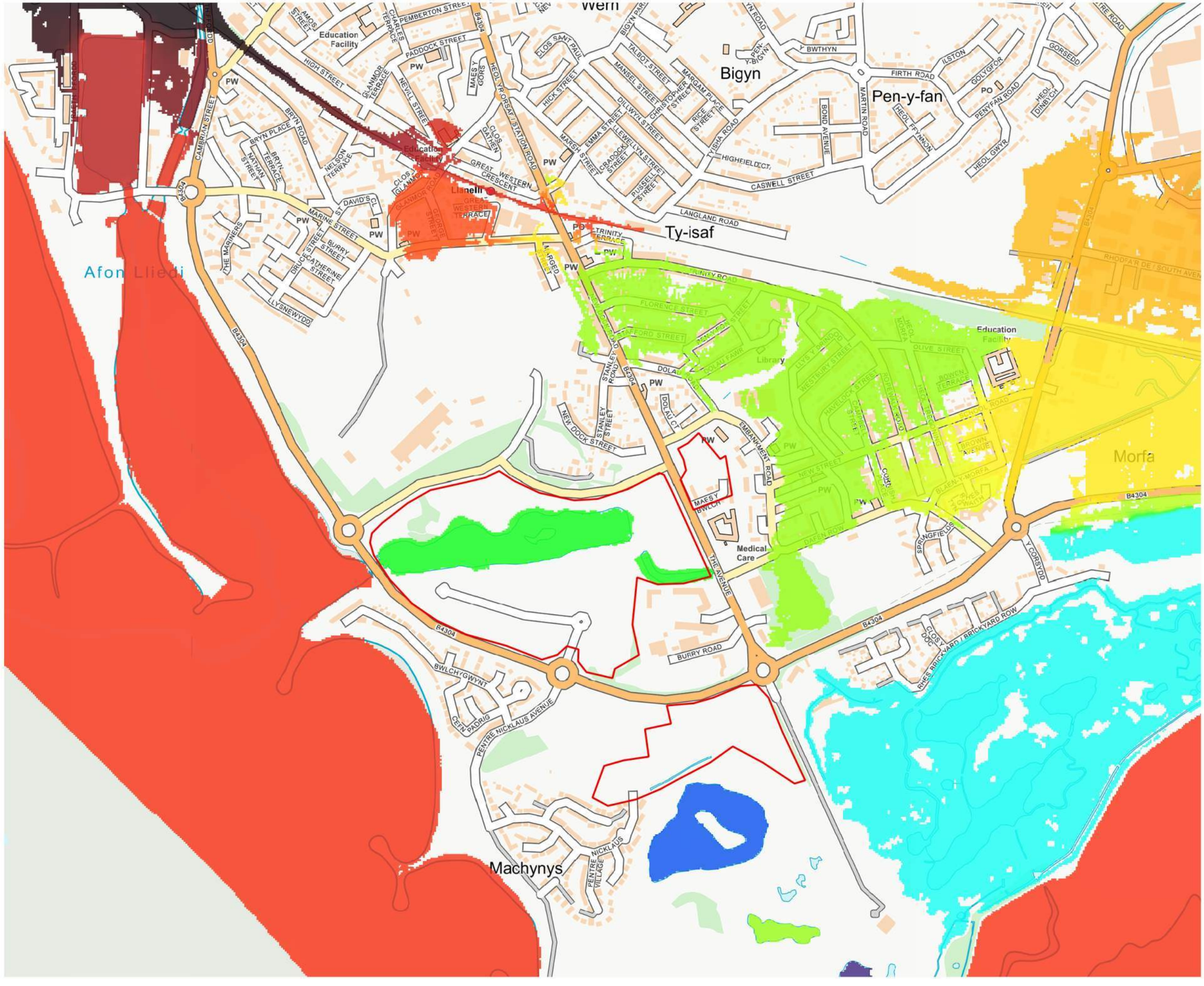
Version:	***v34***
Issued Date:	***Feb 2019***
Scale @ A3:	***1:25000***

Llanelli, Delta Lakes
Fluvial 1% AEP cc 30%
Tidal MHWS cc

EVY 0729 / v34-H / 008 REV E



SOCOTEC CERTIFICATION INTERNATIONAL ISO 9001 UKAS MANAGEMENT SYSTEMS 0063

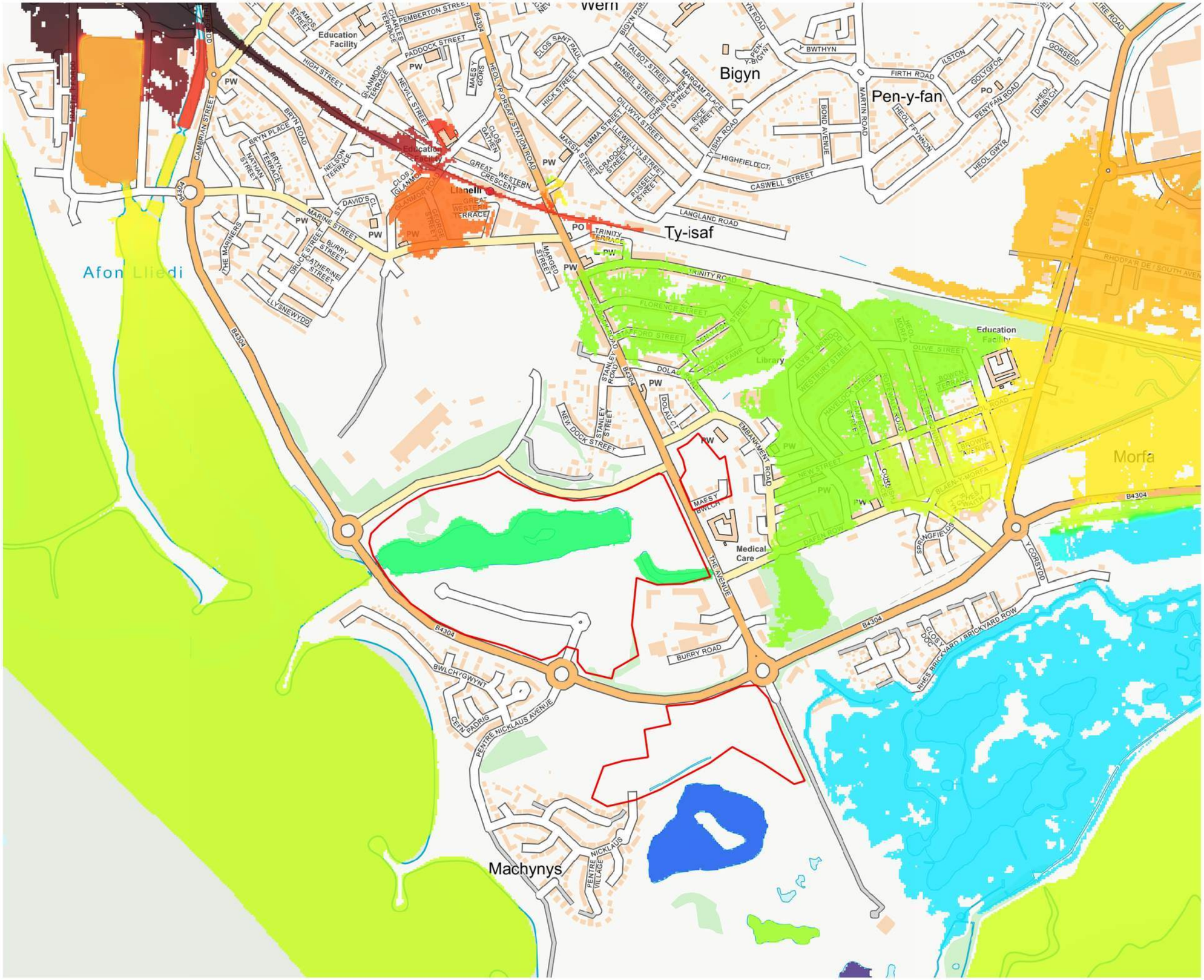
New Civil Engineer 100 COMPANIES OF THE YEAR 2018 FINALIST

EdenvaleYoung

Prepared by:	***MJF***
Checked by:	***JRY***
Approved by:	***JRY***
Version:	***v34***
Issued Date:	***Feb 2019***
Scale @ A3:	***1:25000***

Llanelli, Delta Lakes
Fluvial 1% AEP cc 75%
Tidal MHWS cc

EVY 0729 / v34-H / 009 REV E



SOCOTEC CERTIFICATION INTERNATIONAL ISO 9001 UKAS MANAGEMENT SYSTEMS 0063

New Civil Engineer 100 COMPANIES OF THE YEAR 2019 FINALIST

EdenvaleYoung

Prepared by:	***MJF***
Checked by:	***JRY***
Approved by:	***JRY***
Version:	***v34***
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Scale @ A3:	***1:25000***

Llanelli, Delta Lakes
Fluvial 0.1% AEP
Tidal MHWS

EVY 0729 / v34-H / 010 REV E