APPENDIX 10.1

Land south of Glan Usk Primary School, Herbert Road, Newport

Flood Consequence Assessment

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Executive Summary

Waterman was commissioned by Pobl Group to undertake a Flood Consequence Assessment to support the updated planning application for Herbert Road, located to the north of Newport town centre.

The development proposals are for a residential scheme for the provision of 206 units. Vehicular access would be provided from the southwest.

The site is located within defended Flood Zone 3, DAM Zone B and C1, and is therefore considered to be at a high probability of tidal and fluvial flooding.

Due to the River Usk, tidal flooding is anticipated to be the major source of flood risk to the site, however the potential for fluvial flooding from the on-site watercourse also needs to be considered. Modelling has been undertaken to assess the peak flood levels at the site for both watercourses. Modelling shows that the peak water levels at the site in the 0.5%+CC AEP even would be 9.90m and 9.80m AOD for the northern and southern parts of the site respectively.

To ensure safety as part of the proposals, flooding would be mitigated by raising ground levels above the 0.5%+CC AEP maximum tidal water level. Finished Floor Levels would be set at 10.4m AOD for the northern part of the site, and 9.95m AOD for the southern part of the site. The ordinary watercourse which runs through the site would be increased in size to provide mitigation from fluvial flooding from the ordinary watercourse, and for surface water runoff from the development.

Amendment and extension of the ordinary watercourse ensures that fluvial flood water would remain within bank. This ensures the site would not be impacted by fluvial flood flows.

Modelling shows that there are wide scale tidal flood risk benefits as a result of the development, with flood levels in the area generally reducing. However, there are localised, minor increases in tidal flood depths to the north. It is noted that these small increases (less than 0.04m) are located in areas where the existing tidal flood depth is already severe (up to 0.8m flood depth). This small increase is located in a facility (primary school) that would be closed during a tidal flood event, and given the minimum 16 hours warning time of potential inundation it is highly likely to be unoccupied when a flood event occurs. Furthermore, during construction of the school, Finished Floor Levels were raised to 10.4mAOD, 0.5m above the modelled flood level in this area (9.9m AOD), proving that the school building would remain safe. Therefore, the increase in this area is considered negligible as it would not cause an impact to the school, and it is deemed that the wider reductions in tidal flood risk provide betterment over the existing situation.

A safe dry escape route would be available from the proposed development during the 0.1% AEP event. For pedestrians this is through the pedestrian link adjacent to the emergency vehicle access route in the north of the site, and through the underpass beneath the railway embankment that leads to Charnwood Road. It has been confirmed that the pedestrian link will remain open at all times. For emergency vehicles, this would be through the emergency vehicle access route through Glan Usk School to Bank Street. A significant warning time is expected as the main access route from the site is only flooded during the third tidal cycle. It is recommended that residents sign up to Natural Resources Wales' flood warning service.

The site is considered to be at a low risk of flooding from sewers and artificial sources. It is envisioned that groundwater flooding would be controlled through ground raising and creation of an engineered plateau upon which the development would be founded. The identified pluvial flooding on-site is anticipated to be managed through amendment to the existing watercourse and through the on-site drainage network.

The drainage strategy has been developed by Steve Morgan Associates, and proposes to drain surface water runoff from the development into the ordinary watercourse. Petrol/oil interceptors would also be incorporated.

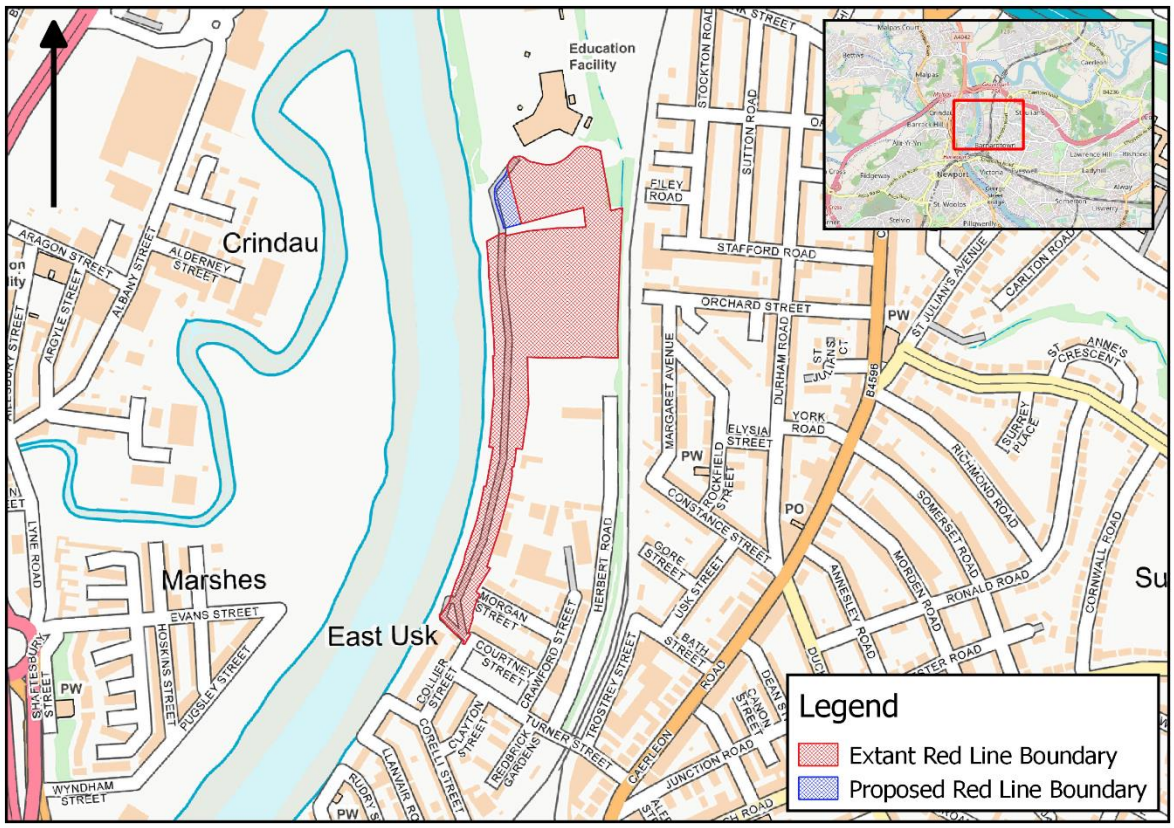
This report demonstrates that the site can be developed safely, without exposing the new development to an unacceptable degree of flood risk. Flood risk off-site would generally be decreased as a result of the proposals, and any minor increases are considered negligible. It is considered that the information provided within this report satisfies the requirements of Technical Advice Note 15, Natural Resources Wales and local planning guidance.

1. Introduction

1.1. The Welsh Government's Planning Policy Wales (PPW)[i] provides the planning policy framework under which Local Planning Authorities (LPAs) must accord with when drafting their Local Development Plans (LDPs). PPW is supplemented by a number of Technical Advice Notes (TANs), including TAN 15: Development and Flood Risk (TAN 15)[ii].

1.2. The Welsh Assembly's TAN 15 Development Advice Map shows that the site (hereafter referred to as 'the Site') lies within Flood Zones B and C1. The risk designations indicated within TAN 15 require a Flood Consequence Assessment (FCA) be undertaken in support of a planning application.

Figure 1: Site Location



Scheme Background and Site Description

1.3. In November 2012 Waterman was commissioned to undertake a FCA for the development, in accordance with the recommendations of TAN 15.

1.4. Following submission of the FCA to Natural Resources Wales (NRW) in November 2013, new guidance from Welsh Government required new development to be assessed for a lifetime of 100 years. An updated FCA was submitted in March 2014, which was accepted and the initial development achieved planning consent.

1.5. A new application is now being submitted. This includes details relating to Phase 2, and also encompasses extension to the red line boundary of 0.17ha.

1.6. The Site measures a total of 5.22ha and is located approximately 1km northeast of Newport town centre on the east bank of the River Usk. The Site location plan highlights the redline boundaries for

both this application and the extant planning permission. The Site is bound to the north by Glan Usk Primary School and to the east by the railway embankment. The western boundary is formed by the tidal River Usk, and mixed residential and commercial development is located to the south.

1.7. The Site is located (at least in part) on a former industrial/domestic landfill site. This is reflected in the topography of the main part of the site which varies between 7.0m AOD and 8.0m AOD. The ground running immediately adjacent to the River Usk along the western boundary of the site is generally higher, with levels rising from 9.0m AOD in the north to approximately 10.0m AOD halfway along the Site, before dropping to 9.5m AOD at the southern extent.

1.8. Flood defences in the Newport area vary in form and protection level but generally the defences on the west bank of the river are of a higher protection level than on the east. The formal defences along the east (left) bank of the River Usk end at the downstream boundary of the proposed Site, adjacent to Courtney Street.

1.9. There is a raised embankment with a formed pathway on top that runs along the left bank of the River Usk from the southern extent of the proposed Site to beyond the M4 Motorway Bridge and Glebelands Park to the north. The crest level of this embankment is circa 9.5m AOD at the downstream extent. This rises to approx. 10.3m AOD for a short section before returning to levels of generally 9.3m to 9.5m AOD. The lowest section of the bank is located at the outfall of the small drainage ditch to the River Usk where ground levels are circa 9.1m AOD.

Development Proposals

1.10. It is proposed to construct 206 dwellings within the Site, comprising a mixture of flats and houses on a raised platform, allowing level access to the buildings. Vehicular access would be along a new access road to the south, running between the main Site and Collier Street. A plan of the proposed development has been included in Appendix A.

Historic Flooding

1.11. There are no known records of flooding at the proposed development Site other than those provided in the national scale development advice maps. This mapping indicates that there is evidence of historical flooding (often in the form of alluvial deposits) but does not classify the duration or recurrence interval of those floods.

Scope of Report

1.12. This report presents the findings of the FCA, which has been undertaken in line with TAN 15. The aim of the FCA is to analyse flood risk from all sources, and demonstrate that the Site can be developed safely, without exposing the new development to an unacceptable degree of flood risk, and assess the impacts of the development on third parties. The objectives of this FCA are to:

- Identify potential sources of flooding and assess the risk they pose to the Site;
- Consider the effect of predicted climate change on future flood risk to the Site;
- Assess the impact of the proposed development on flood risk to third parties;
- Recommend appropriate flood risk mitigation measures; and
- Supplement the submission of an environmental statement in support of the development.

2. Planning Policy Considerations

2.1. Most of the Site lies within Zone C1 of the Welsh Government's Development Advice Map (DAM), presented in Appendix B. This designates the Site as being at risk of flooding in an extreme event, but one that is served by significant infrastructure including defences.

2.2. The far north of the Site is classified as Zone B, or land that has been flooded in the past where there is evidence of historic flooding. Development can only take place within Zone C subject to satisfactory application of the planning tests set out in Sections 6 and 7 of TAN 15, and in accordance with local government initiatives and policies.

TAN 15 planning tests

Justification Test

2.3. Under Section 6 of TAN 15, new development within Zone C1 and C2 must be justifiable to the satisfaction of the planning authority. Development will only be justified if it can be demonstrated that:

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

2.4. Section 6 also states that it must abide by the following:

- It concurs with the aims of PPW and meets the definition of previously developed land; and
- 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 6, 7 and Appendix 1 is found to be acceptable.

2.5. As the Site has extant planning permission, it is assumed that these principles have been met and satisfied.

Acceptability of Flooding Consequences

2.6. Under Section 7 of TAN 15, the planning authority must be satisfied that the consequences of flooding for the proposed development are acceptable. In addition, the proposals should not have a significant impact on the flood risk to third parties. To this end, a FCA, which provides a full understanding of likely flooding mechanisms and consequences, must be submitted with planning applications for sites located in Zone C1.

3. Potential Sources of Flooding

Fluvial

Main River

3.1. The River Usk runs along the western edge of the Site. This major watercourse rises in the mountains of mid-Wales and flows in a southerly direction through several urban areas before reaching the Severn Estuary at Newport. Given the high fluvial flows and relatively flat channel slopes the land around the River Usk tends to very sensitive to changes in water level of the river. As such, NRW have carried out a considerable amount of analytical work on the catchment.

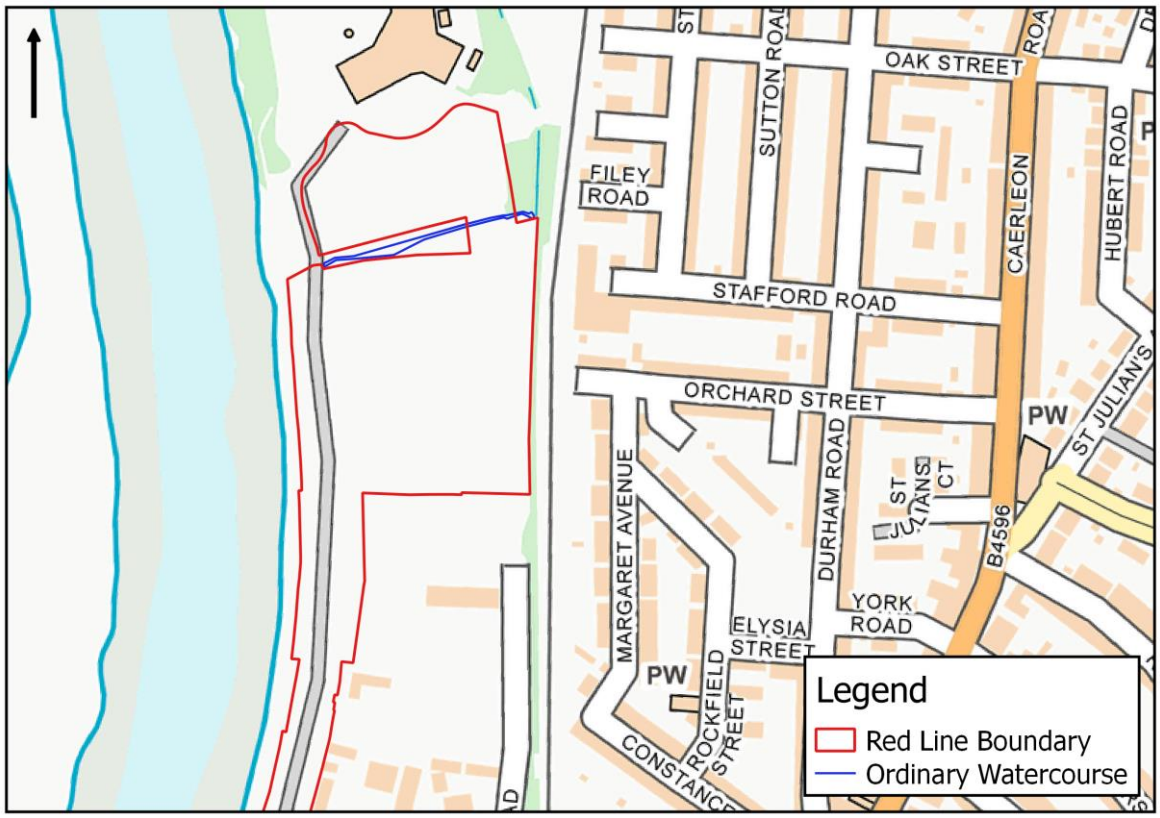
3.2. The NRW Flood Map for Planning is included in Appendix B. It shows that most of the Site is located in Flood Zone 3, land considered as having a greater than 1 in 100 annual probability (1% AEP) of fluvial flooding, or greater than 1 in 200 annual probability (0.5% AEP) of tidal flooding. This area is also shown to be in an area benefitting from defences. The northern part of the Site is partly in Flood Zone 2, land considered as having between 1 in 100 and 1 in 1000 chance of fluvial flooding and between 1 in 200 and 1 in 1000 annual probability (0.5% AEP and 0.1% AEP) of tidal flooding. The very northern extent of the Site is in Flood Zone 1, land considered to have a less than 1 in 1000 annual probability (0.1% AEP) of tidal or fluvial flooding.

3.3. As the SFRM model focuses on the tidal flood risk from the River Usk, using only QMED as a fluvial inflow, it can be assumed that the tidal flood risk to the site will have more influence than the fluvial flood risk.

Ordinary Watercourse

3.4. A small drainage ditch flows through the Site (Figure 2). The ditch flows adjacent to the railway line to the north of the Site, before turning 90 degrees and flowing due west across the Site and discharging into the River Usk. The flood risk to and from the Site from this ordinary watercourse has been assessed as part of the hydraulic modelling undertaken for this project.

Figure 2: Location of the ordinary watercourse



Tidal

3.5. The coastal geomorphology of the Bristol Channel and Severn Estuary results in large tidal ranges. The tidal flows are constricted as they propagate up the estuary and as such, the further up the estuary the greater the tidal range. The City of Newport is located in the upper part of the Severn Estuary, and as a result the coastal fringe of Newport is potentially at risk from tidal flooding.

3.6. Hydraulic modelling has been undertaken to assess the potential risk to the development. The results of the hydraulic modelling presented in Appendix E will be used to assess tidal flood risk to the development. For all events simulated the existing Site is inundated by the extreme tidal events.

Pluvial

3.7. Pluvial flooding results from rainfall-generated overland flow, prior to the runoff entering a watercourse or sewer. It is generally associated with extreme rainfall events, saturated ground or a combination of both factors.

3.8. NRW's Surface Water Flood Map, presented in Appendix B shows that a small area of the Site in the vicinity of the ordinary watercourse is classified as 'medium risk' of surface water flooding, or land that has between a 1 in 30 and 1 in 100 annual probability of suffering from surface water flooding. The central area of the Site is considered to be at a 'low' risk of surface water flooding and is classified as having between 1 in 100 and 1 in 1000 annual probability of flooding. Flood depths in a 1000 year rainfall event are predicted to be between 0.15m and 0.30m. The railway embankment along the eastern edge of the Site generally prevents surface water from off-Site impacting the Site. Overall the risk of pluvial flooding to the Site can be considered low.

Sewer

3.9. Sewer flooding takes place as a result of a blockage or surcharge of existing drainage systems. The associated overland flows have the potential to flood highways or properties that lie in their path. The existing drainage on the Site (Appendix C) comprises an 1800mm combined sewer running along the western edge of the Site, and a similar pipe running along the eastern edge. Both pipes then join a larger 2100mm combined sewer flowing into the Site from the northeast. This subsequently crosses the River Usk and conveys flow away from the Site.

3.10. There are three records of sewer flooding from Dwr Cymru Welsh Water presented in the Preliminary Flood Risk Assessment (PFRA) for Newport[iii] to the east of the site.

3.11. Should the capacity of these pipes be exceeded (through either rainfall exceedance or blockages) there is potential for the Site to be flooded by outflows from the associated surface water manholes. Due to the constrained nature of the Site by embankments along both its eastern and western edge it is unlikely that these flows would be able to leave the proposed Site in its existing condition. However, sewer flooding is considered unlikely given the anticipated depth of the assets (as the sewer passes beneath the River Usk), and therefore the overall risk of flooding from sewers is considered likely to be low.

Groundwater

3.12. Groundwater flooding takes place when water emerges from the ground when the water table is high. It is generally associated with porous sub-surface geology. The Site overlies a minor sandstone aquifer and is found in an area characterised by a perched water table. The risk of groundwater flooding can therefore be considered moderate.

Artificial Sources

3.13. Flooding from artificial sources refers to flooding in event of a breach from significant man-made bodies of water such as lakes, reservoirs or canals. Examination of NRWs Reservoir Flood Risk map, presented in Appendix B, shows that most of the Site would be at risk of flooding in the event of a breach from Llandegfedd Reservoir. In this event flooding on the Site is predicted to be between 0.3m and 2.0m deep, with velocities predicted to be between 0m/s and 0.5m/s. Llandegfedd is a 174ha reservoir found roughly 9km northeast of the Site. Examination of OS mapping and satellite imagery shows that there are no other artificial bodies of water likely to affect the Site.

4. Hydraulic Modelling

4.2. Hydraulic modelling has been undertaken in support of this FCA, to assess the risk of tidal flooding from the River Usk, combined with tide locked fluvial flooding from the ordinary watercourse.

4.3. NRW previously provided the Newport Strategic Flood Risk Mapping (SFRM) model. We have used version 3.1 (Version 3, dated 2011) of the Newport Tidal model for our assessment. We are aware that there have been updates in guidance (which has been incorporated into our Version 3 of the model) and the implementation of a number of flood defence schemes being constructed since 2011. However, it has been established that our updated version of the 2011 model produces higher flood levels across the proposed development site in comparison to the current NRW model (Version 6). This is due to fewer flood defences included within the 2011 model (Version 3) compared with the current day situation (Version 6), which allows more floodwater to flow into the area. As a result, NRW have confirmed that using our model (Version 3) to assess the development platform and finished floor levels against would be acceptable, as it takes a precautionary approach in relation to flood risk from the tidal River Usk. For more details please see the Modelling Technical Note in Appendix D.

Model Amendments

Fluvial Flows

4.4. Fluvial flows were used to define a base flow in the River Usk, and to confirm the tidal interactions within the model.

4.5. The estimate of QMED provided with the original SFRM model of Newport has been used as the fluvial inflow on the River Usk. For the climate change scenarios 25% was added to these inflows, which equates to the central estimate for the Severn river basin.

Peak Tidal Levels

4.6. The tidal boundaries were updated as part of this project to reflect the latest guidance from NRW. The FCA has presented the model outputs from the 0.5% AEP event in 2117 as the 'Design Event'. This accords with planning policy.

4.7. The results of the 0.1% AEP event in 2017 have been presented as a sensitivity to examine the impacts of an extreme tidal event on the development. These scenarios used the 'base' peak tidal level estimates as supplied by NRW, with the appropriate increment used to account for sea level rise.

4.8. The results of the 0.1% AEP event in 2117 have also been presented to show that the consequences of flooding in an extreme tidal event can be managed throughout the lifetime of the development. All events simulated were the upper confidence interval events to provide a conservative estimate of the potential tidal flood risk to the development. The peak tidal water level used for each event is presented in Table 1.

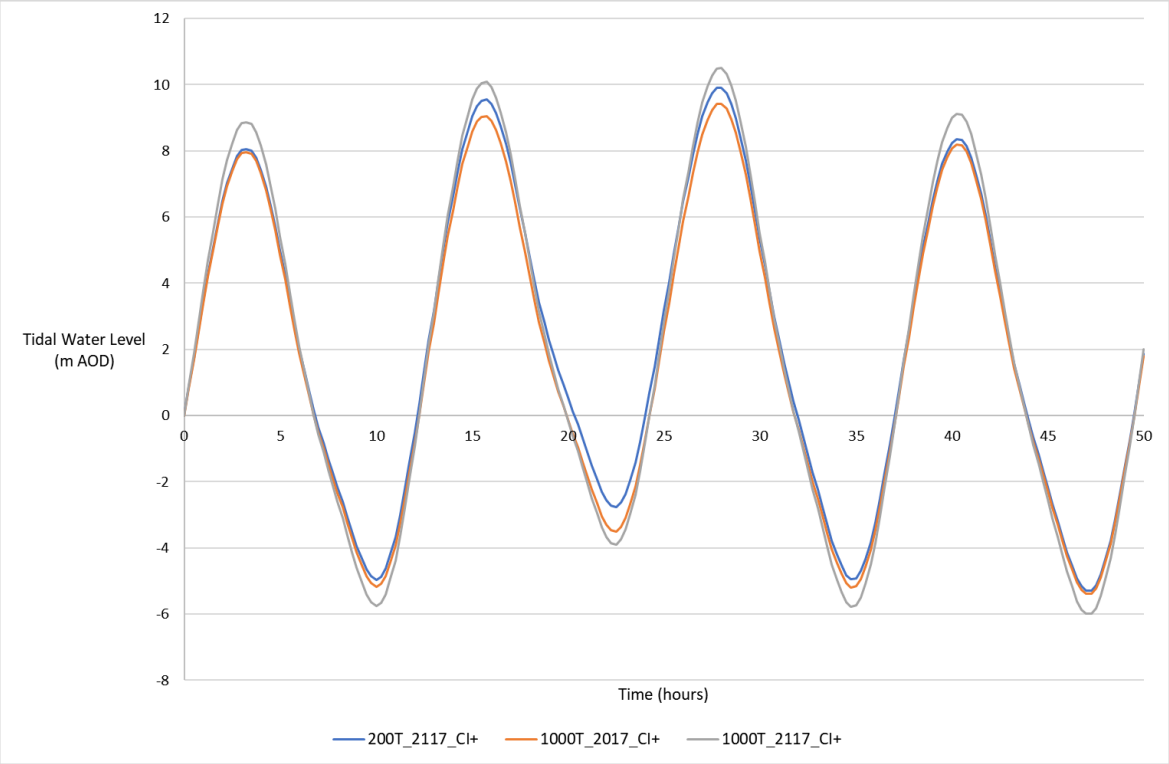
Table 1: Peak tidal water levels

Event	Peak Tidal Water Level
0.5% AEP+CC	9.91m AOD
0.1% AEP	9.42m AOD

0.1% AEP+CC	10.50m AOD

4.17. The model was simulated for four tidal cycles, with the third having the highest peak water level. These are presented in Figure 3. This was to allow the effects of a series of extreme tides on the Site to be assessed. This provides a worst-case scenario for the effects of the tidal flooding on the development.

Figure 3: Tidal cycles used



Ordinary Watercourse

4.18. The ordinary watercourse was included in the model, and the model grid was lowered to the levels provided as part of the topographic survey for the Site (Appendix F). The outfall culvert to the River Usk was represented with a 1m circular culvert as per surveyed drawings.

4.19. The peak of the 1% AEP event for the catchment drained by the ordinary watercourse was calculated as 0.2m^3/s using FEH rainfall runoff methods, and accepted by NRW as part of the previous modelling study. To provide a conservative estimate of flooding from the ordinary watercourse this was applied as a constant value to the top of the watercourse during all tidal events.

Existing Scenario Model Results

4.20. The model has been used to define the risk of tidal and fluvial flooding in the existing situation. These results are presented in Appendix E.

Tidal Flood Risk

4.21. In the 0.5%+CC AEP tidal event the embankment to the west is overtopped in the second tidal cycle.

Most of the Site is flooded to a depth greater than 1m, although flood depths are less along the western edge and in the north of the Site (between 0.8m and 1.0m). The largest water velocities of 0.6m/s are found in the north of the Site, with the rest of the Site having velocities of up to 0.3m/s.

In the 0.1% AEP tidal event the central part of the site is flooded to a depth of 0.2m, with maximum velocities of 0.3m/s. In the 0.1%+CC AEP tidal event the entire site is flooded to a depth greater than 2m and maximum velocities of 1.2m/s.

4.22. The results of this hydraulic modelling suggest that the risk of tidal flooding in the existing situation can be considered high.

Ordinary Watercourse Flooding

4.23. The flood depths on and around the Site at 14.5 hours into the 0.5%+CC AEP tidal event are presented in Appendix E. This presents the modelling results before the tidal water levels overtopped the embankments, showing the likely flooding patterns from the ordinary watercourse. The main flow route for floodplain flows runs parallel to the railway embankment and conveys flow along the eastern edge of the Site towards the industrial estate to the south. Flood depths are up to 0.7m along the eastern edge of the Site, and up to 0.5m in the industrial estate. Velocities along this flow route are low, with a maximum value of 0.1m/s.

4.24. The hydraulic modelling suggests that flood risk to the Site from the ordinary watercourse can be considered moderate.

Flood Mitigation

4.25. To manage the risk of flooding to the Site, several mitigation measures have been included as part of the development. These are discussed in the sections below and have been included in the proposed situation model. For more information regarding the implementation of these measures please see Appendix D.

Ground Raising

4.26. To reduce the risk of tidal flooding to the development the entire Site has been raised according to an extant condition to produce a platform above the maximum water level in the 0.5% AEP+CC tidal event. The northern portion of the Site (to the north of the ordinary watercourse) has been raised to 10.40m AOD. The remainder of the Site has been raised to 9.95m AOD. The Finished Floor Levels of the properties are proposed to be at the same level as the platform on which they are sited to enable level access.

Ordinary Watercourse

4.27. The existing ordinary watercourse has been extended to hold the entire volume of the 1% AEP+CC tidal event as part of an extant condition. The watercourse has been slightly extended to the south, and the southern bank re-profiled to increase the capacity of the watercourse. The outfall to the River Usk has been replaced with a flapped outfall to prevent the inundation of the ordinary watercourse by extreme tidal events.

Surface Water Management

4.28. Surface water flood risk to the Site would be managed by the proposed surface water drainage strategy, prepared by Steve Morgan Associates in July 2017[iv].

4.29. The strategy proposes to discharge surface water from the proposed impermeable areas to the ordinary watercourse via four outfalls. Two of these would be adopted by the Local Authority Highways Department and two by Dwr Cymru Welsh Water (DCWW). The enlarged ordinary watercourse provides sufficient capacity to cope with the surface water runoff from the impermeable areas in the tidal lock scenario. All surface water discharge would pass through a Class 1 petrol/oil interceptor. Please refer to the surface water drainage strategy for further information.

4.30. Given that the pluvial flood risk to the site originates from the site itself the provision of new surface water infrastructure and expansion of the ordinary watercourse will also mitigate this risk.

Reservoir Flooding

4.31. Reservoirs are periodically inspected by engineers to ensure their safety, Welsh Water is tasked with managing Llandegfedd reservoir. Due to the high standard of protection and regular inspections, a breach from the reservoir is considered highly unlikely. In the unlikely event of a breach from Llandegfedd Reservoir the 10km distance between the Site and slow velocity of water by the time water reached the Site, would allow residents to evacuate to the high ground around Glan Usk Primary School which is not inside the maximum extent of inundation.

4.32. As a result, no specific mitigation measures are considered necessary, However, through ground raising to protect against tidal flooding additional protection would be provided.

Groundwater Flooding

4.33. There are no basements proposed as part of the scheme, and therefore there would be no impact on the existing groundwater regime post development. Furthermore, any risk of flooding from groundwater would be mitigated by the construction of a raised impermeable platform on which the entire development will be sited.

Proposed Scenario Model Results

4.34. These model results which account for the proposed development and mitigation measures have been used to define flood risk following construction. They are presented in Appendix E. Maps presenting the change in flood risk as a result of the development are also provided to assess the impacts of the proposed development on third parties.

4.35. Modelling shows that the peak water levels at the site in the 0.5%AEP+CC event would be 9.90m and 9.80m AOD for the northern and southern parts of the Site respectively.

Tidal Flooding

4.36. Following the construction of the raised platform the Site would be safe from flooding in the 0.5% AEP+CC event (the southern part of the site is 0.1m above peak water levels). The Site is also predicted to be flood free in the 0.1% AEP event (the southern part of the Site is 0.20m above peak water levels). In the modelled 0.1%+CC AEP event, the northern part of the Site would be flooded to a depth of 0.4m and the southern part of the Site to just over 0.6m. The maximum velocity found on Site in the 0.1%+CC AEP event is 1.5m/s, however the majority of the site has velocities of around 0.20m/s.

4.37. In the 0.5% AEP+CC event, there would be reductions in flood depth (of between 0.10m and 0.20m) up to 1km to the southeast of the Site. Smaller reductions (0.01m to 0.10m) are also predicted up to 2.3km southeast of the Site. There is the potential for flood depths to increase by up to 0.04m to the north of the Site. It should be noted that in these areas the flood depth is predicted to be up to 0.80m

in the existing situation, and therefore such a small increase would have no material impact on flood risk off-site. Furthermore, the constructed FFLs of the affected building to the north are set 0.5m above the associated flood level (flood level of 9.9m AOD, FFL of 10.4m AOD), ensuring protection. In the 0.1% and 0.1%+CC AEP events the only changes in flood depth off-site are found within the ordinary watercourse. This is expected as part of the scheme as more flood water is stored in this location as a designated flood attenuation measure.

Ordinary Watercourse Flooding

4.38. A comparison of the flood depths predicted at 14.5 hours of the 0.5%AEP+CC event simulation shows that the flow route which conveys flow from the ordinary watercourse through the development to the industrial estate to the south has been removed following the proposed improvement works to the ordinary watercourse.

4.39. As expected, flood depths have increased in the ordinary watercourse itself, and there are areas of increased flooding where the watercourse has been extended. These increases in flood depth are part of the mitigation measures proposed for the development.

4.40. This proves that by reprofiling and enlarging the existing watercourse there would be no adverse impact on fluvial flood flows due to raising ground levels at the Site, nor any flows diverted elsewhere which could increase flood risk to others. The inflow volume used in the model simulations ($0.2m^3/s$ for 50 hours) is significantly greater than the volume of inflow calculated for the 1% AEP fluvial event (a 2 hour storm with a peak of $2m^3/s$). Therefore, it can safely be assumed that the extension to the existing ditch provides sufficient volume to mitigate the 1% AEP+CC flood event for the ordinary watercourse.

5. Application of Policy

5.1. The results of the hydraulic modelling have been compared to the policy requirements below in the relevant sections.

Planning Policy Requirements

5.2. TAN 15 identifies residential development as being 'highly vulnerable' to the potential impacts of flood risk. The proposed development is in risk category B and C1. Zone C1 (the most at risk of these areas) is classified as ‘areas served by significant flood defence infrastructure, including flood defences’.

5.3. The hydraulic modelling undertaken for this assessment suggests that the Site is at risk of flooding during an extreme tidal event, and partly at risk of flooding from the ordinary watercourse running through the Site. This designation requires an assessment of the potential consequences of a flood event, in accordance with Section 6 and 7 of Appendix 1 of TAN 15, to address any potential flood risk issues.

Justification Test

5.4. Outline planning permission was granted in October 2000 for the construction of a replacement primary school, together with the proposed residential development (also referred to as the 'Glebelands' site). These proposals included raising the Site to limit the consequences of an extreme tidal event. The principle of this development has therefore been accepted, and the planning consent has been implemented through construction of the primary school.

5.5. Further justification for locating this development in Zone C1 is found within the Newport Local Development Plan 2011-2026[v]. The proposed Site is located within the 'Glebelands' site H(5), an area designated as a main source of housing. It is further detailed in the Deposit Plan that the Glebelands Site has 'existing commitments for residential development' and the Site would need to be raised to 'ensure that adequate flood risk management levels are achieved'.

5.6. The Site is also classified as previously developed land by PPW. Therefore, as long as the consequences of flooding are adequately managed the Site would be in line with Section 6 of Tan 15.

Acceptability of Consequences

5.7. The acceptability of the consequences of flooding is based on the model results and depth comparisons between the existing and proposed situation outputs, presented in Appendix E.

5.8. Although the consequences of flooding under the existing scenario would be severe, due to ground raising the Site would remain safe and flood free in the design tidal flood event (0.5% AEP+CC), and also the 0.1% AEP (extreme) event. Flooding from the ordinary watercourse is also predicted to be removed following the construction of the proposed development. This ensures that the criteria of Table A1.14 in TAN 15 are met by the proposed development.

5.9. TAN 15 requires that the development be safe for users under extreme flood conditions for the lifetime of the development. This is assessed by examining the depth of flooding, rate of rise of floodwaters, maximum speed of inundation and maximum velocity of floodwaters. These are set out for the 0.1%+CC AEP event in Table 2.

Table 2: Comparison between conditions on site during a 0.1%+CC AEP event and non prescriptive tolerances

	Maximum depth of flooding (mm)	Maximum rate of rise (m/hr)	Maximum speed of inundation (hrs)	Maximum velocity of flooding (m/s)
Tolerable	600	0.1	4	0.15
On site	620	0.15	15	1.5

5.10. Many of these values, especially the velocity are significantly greater than the values typically allowed for residential development. However, the maximum velocity values are highly localised and are typically more in the region of 0.20m/s. NRW have confirmed that the above figures provide a guide, and are not prescriptive.

5.11. The precautionary nature of the water levels predicted by Version 3 of the hydraulic model, mean that the flood risk is likely to be significantly less in Version 6 of the hydraulic model. The on-Site water levels predicted by our updated model (Version 3) are around 10.80m AOD, compared to a water level of 9.8m AOD predicted in NRW Version 6 model, which includes for the latest defences.

5.12. Given that Version 6 is built using the latest topographic information it is likely to give a more accurate representation of the flood risk the development. A water level of 9.8mAOD would be lower than the minimum level of the raised platform (9.95m AOD). As a result, the development can be considered to be safe in an extreme flood event for its entire expected lifetime and section A1.15 of TAN 15 can be satisfied.

5.13. When the proposed scenario is compared with the existing scenario, there are significant reductions in modelled flood depths to the south and east of the development, as well as the complete removal of some areas of flooding (including the development platform).

5.14. There are small increases in flood risk found in the area covered by Glan Usk Primary School located to the north, considered 'highly vulnerable' development by TAN 15. However, this area does not flood until the second tidal cycle, and therefore the operators would have a minimum of 16 hours to ensure the facility is vacant. The increases in flood depth (40mm) within this area, are already predicted to flood to 800mm in the existing situation, and would therefore have no impact on the overall flood risk to the facility.

5.15. As the facility is highly likely to be empty during an extreme tidal event the small increase in flood depth found in this area would not increase the potential risk for users. Furthermore, it is understood that the FFLs of the school have been set at 10.4m AOD, which lie 0.5m above the maximum design flood level of 9.9m AOD ensuring safety. Wide-scale reductions in flood depth for much of central Newport contribute to a large overall reduction in flood risk as a result of the development.

5.16. It can therefore be considered that the consequences of flooding can be satisfactorily managed by the development, and is therefore in line with Section 7 of TAN 15.

Emergency Access and Egress

5.17. The emergency access and egress routes to and from the development must also be reviewed against the TAN 15 requirements. For residential developments, TAN 15 stipulates that a maximum depth of floodwater should not exceed 600mm and the velocity not exceed 0.30m^3/s over the stipulated egress route during a 0.1% AEP+CC event.

5.18. During the modelled 0.1% AEP+CC tidal event, flood depths on the main access route along Turner Street (to the south of the Site) exceed the 0.60m non-prescriptive depth threshold during the third tidal cycle. It will still be possible for emergency responders to reach the Site via the emergency route found in the north of the Site, emergency vehicles will be able to access this location from Bank Street and through Glan Usk Primary School. It will be possible for pedestrians to leave the Site through a pedestrian link adjacent to the emergency vehicle access route in the north of the Site, and through the underpass beneath the railway embankment that leads to Charnwood Road. It will then be possible to head towards higher ground to the east. It has been confirmed that the pedestrian link will remain open at all times.

5.19. The preceding two tidal cycles before the main access route becomes inundated would act as sufficient warning to allow residents to evacuate the Site if necessary. Given the highly predicted nature of tidal flood events it is likely that residents would have more than the approximately 24 hours warning time provided by the tidal cycles, and they should be encouraged to sign up to the NRW flood warning service.

6. Conclusions

6.1. Waterman was commissioned by Pobl Group to undertake a FRA to support the updated planning application for Herbert Road, located to the north of Newport town centre.

6.2. The development proposals are for a residential scheme for the provision of 206 units. Vehicular access would be provided from the southwest.

6.3. The Site is located within defended Flood Zone 3, DAM Zone B and C1, and is therefore considered to be at a high probability of tidal and fluvial flooding.

6.4. Due to the River Usk, tidal flooding is anticipated to be the major source of flood risk to the Site, however the potential for fluvial flooding from the on-Site watercourse also needs to be considered. Modelling has been undertaken to assess the peak flood levels at the Site for both watercourses. Modelling shows that the peak water levels at the Site in the 0.5%+CC AEP even would be 9.90m and 9.80m AOD for the northern and southern parts of the Site respectively.

6.5. To ensure safety as part of the proposals, flooding would be mitigated by raising ground levels above the 0.5%+CC AEP maximum tidal water level. Finished Floor Levels would be set at 10.4m AOD for the northern part of the Site, and 9.95m AOD for the southern part of the Site. The ordinary watercourse which runs through the Site would be increased in size to provide mitigation from fluvial flooding from the ordinary watercourse, and for surface water runoff from the development.

6.6. Amendment and extension of the ordinary watercourse ensures that fluvial flood water would remain within bank. This ensures the Site would not be impacted by fluvial flood flows.

6.7. Modelling shows that there are wide scale tidal flood risk benefits as a result of the development, with flood levels in the area generally reducing. However, there are localised, minor increases in tidal flood depths to the north. It is noted that these small increases (less than 0.04m) are located in areas where the existing tidal flood depth is already severe (up to 0.8m flood depth). This small increase is located in a facility (primary school) that would be closed during a tidal flood event, and given the minimum 16 hours warning time of potential inundation it is highly likely to be unoccupied when a flood event occurs. Furthermore, during construction of the school, FFLs were raised to 10.4mAOD, 0.5m above the modelled flood level in this area (9.9m AOD), proving that the school building would remain safe. Therefore, the increase in this area is considered negligible as it would not cause an impact to the school, and it is deemed that the wider reductions in tidal flood risk provide betterment over the existing situation.

6.8. A safe dry escape route would be available from the proposed development during the 0.1% AEP event. For pedestrians this is through the pedestrian link adjacent to the emergency vehicle access route in the north of the Site, and through the underpass beneath the railway embankment that leads to Charnwood Road. It has been confirmed that the pedestrian link will remain open at all times. For emergency vehicles this would be through the emergency vehicle access route and through Glan Usk School to Bank Street. A significant warning time is expected as the main access route from the Site is only flooded during the third tidal cycle. It is recommended that residents sign up to NRW's flood warning service.

6.9. The Site is considered to be at a low risk of flooding from sewers and artificial sources. It is envisioned that groundwater flooding would be controlled through ground raising and creation of an engineered plateau upon which the development would be founded. The identified pluvial flooding on-Site is anticipated to be managed through amendment to the existing watercourse and through the on-Site drainage network.

6.10. The drainage strategy has been developed by Steve Morgan Associates, and proposes to drain

surface water runoff from the development into the ordinary watercourse. Petrol/oil interceptors would also be incorporated.

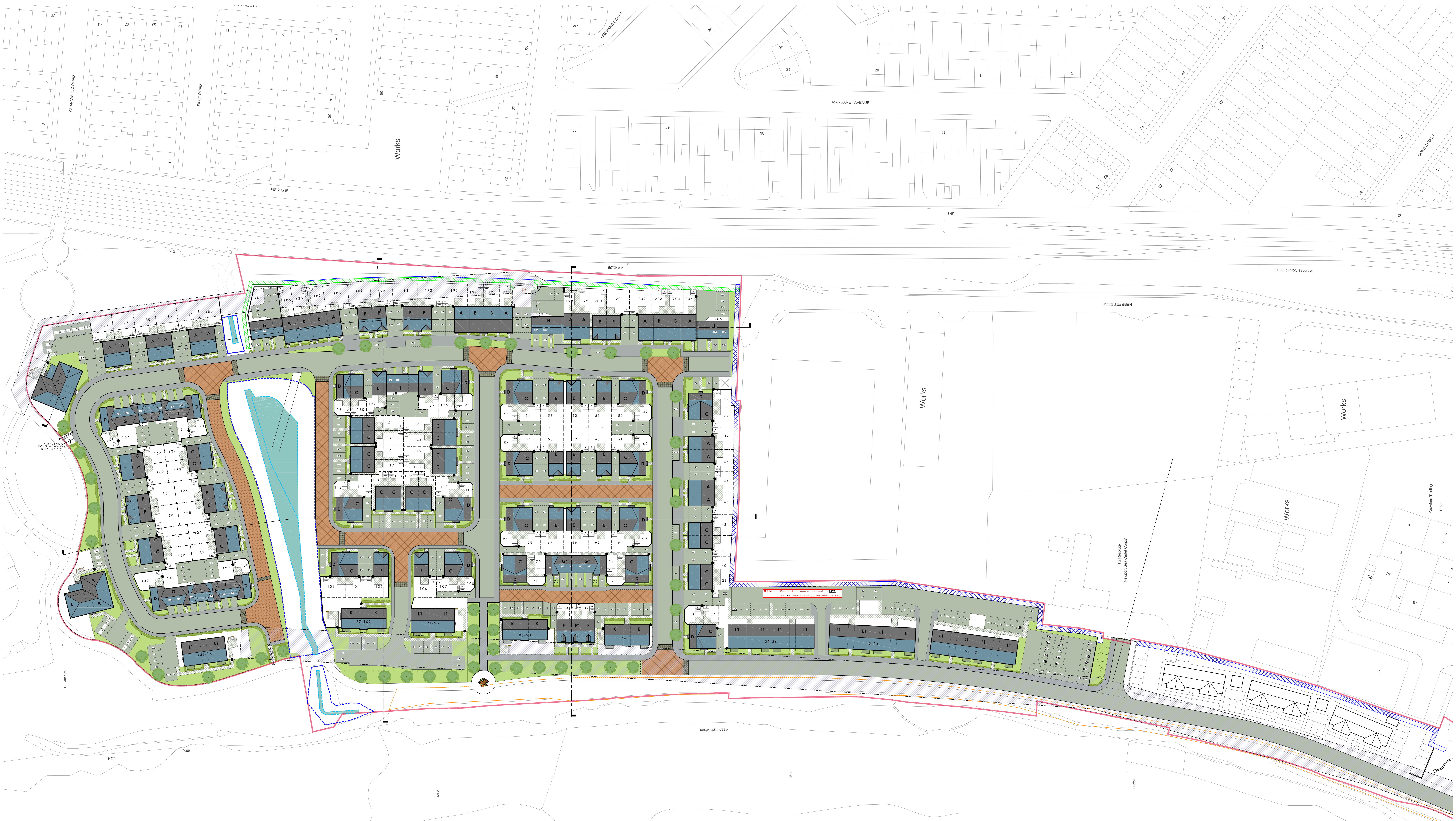
6.11. This report demonstrates that the Site can be developed safely, without exposing the new development to an unacceptable degree of flood risk. Flood risk off-Site would generally be decreased as a result of the proposals, and any minor increases are considered negligible. It is considered that the information provided within this report satisfies the requirements of TAN 15, NRW and local planning guidance.

7. References

[i] Welsh Assembley Government, 2016. Planning Policy Wales,
[ii] Welsh Assembley Government, 2004. Technical Advice Note 15: Development and Flood Risk
[iii] Newport City Council, 2011. Preliminary Flood Risk Assessment
[iv] Steve Morgan Associates, 2017. Drainage Strategy for: Residential Development, Herbert Road, Newport
[v] Newport City Council, 2015. Newport Local Development Plan

APPENDICES

a. Development Plans



Denotes Brick walls

Denotes 900mm high Ball Top railings

Denotes 1.8m high Ball Top railings

Denotes 1.8m high treated close boarded fence

Gates in screen walls & fences

Denotes areas of tarmacadam to roads, carparking spaces and private drives.

Denotes areas of block paviours to private drives and road junctions.

Denotes granite sett rumble strip.

Denotes areas available for soft landscaping. See Landscape Architect's plan for details of Planting.

Denotes paths within curtilage of dwellings and paved area to rear garden, concrete slip resistant paving slabs.

Shed — Denotes 2x2m robust treated timber framed shed, providing 2x1.5m space for 2no. bicycles with 2no Sheffield type steel framed bike racks and 1m² garden storage space. All to be bolted down to concrete base. Door to be fitted with a security lock, in compliance with BS3621.

New tree.
See Landscape Architect's Plan for details of Planting.

Denotes drainage easement zone. Ref: SMA Engineers' drawings.

Denotes extents of the Reen and its retaining structure. Ref: SMA Engineers' drawings.

Denotes existing retaining boundary treatments. Ref: SMA Engineers' drawings.

Denotes Original PROW

Denotes Diverted PROW

NORTH

SCHEDULE

A	(858)	4 Person, 2 Bed House	18
B	(988)	5 Person, 3 Bed House	06
C	(764)	4 Person, 2 Bed House	40
D	(842)	5 Person, 3 Bed House	20
E	(851)	5 Person, 3 Bed House	23
F	(1016)	5 Person, 3 Bed House	03
G	(722)	3 Person, 2 Bed FOG Flat	04
H	(769)	3 Person, 2 Bed FOG Flat	04
I	(485)	2 Person, 1 Bed FOG Flat	02
J	(414)	2 Person, 1 Bed FOG Flat	02
K	(495)	2 Person, 1 Bed Com. Flat	30
L	(635)	3 Person, 2 Bed Com. Flat	06
L1	(584)	3 Person, 2 Bed Com. Flat	48
TOTAL			206

D 12/01/18
Notes for car space numbering of Flats 1-36 added. PROW lines revised and notes added for them.

C 11/01/18
V12 & V13 amended. Front garden gates between Deatched House Type'E' omitted, replaced with fence. Area of diverted PROW included.

B 10/01/18
Visitor car spaces V13,V14,V15 and their planting area revised. Footpath provided in front of Plot 197, and amendments to House type 'H' & its F&B gardens.

A 08/01/18
Visitor car parking spaces & its planting areas adjacent Plot 37 to 48 revised as requested.

Client
Pobl Group

Project Title
Herbert Road Replan
Newport

Drawing Title
Site Layout

Project No	Drawing No	Revision
3073	(04)100	C

Drawn	Director	Date
WWM	JM	20/12/17

Project Status: Preliminary P, Tender T, Planning PL, Construction C

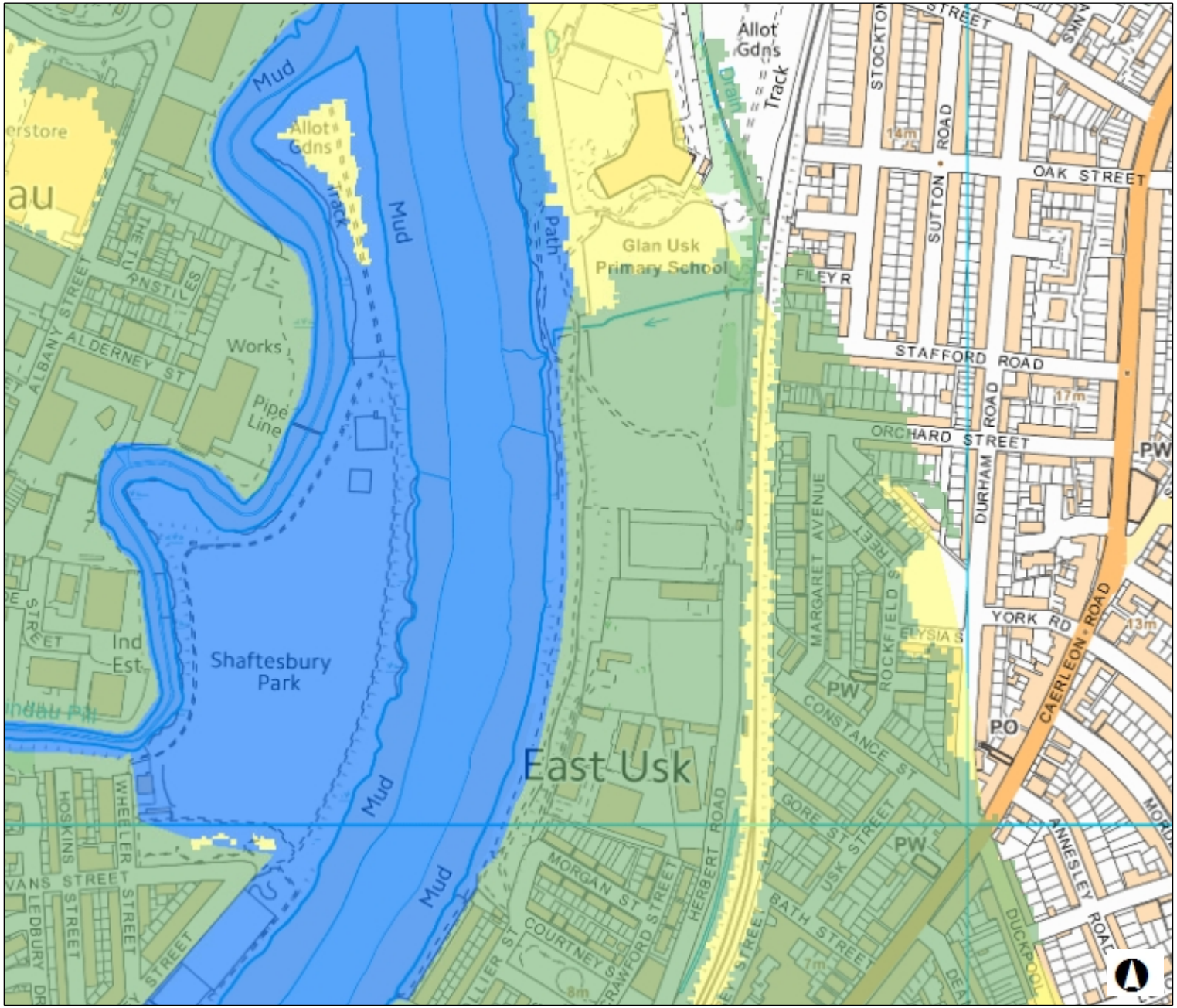
Stage: PL

Scale: 1:500
Sheet size: A0

eos ARCHITECTS

Eos Architects Limited
Tregleath House, 1 Serpentine Road, Newport, South Wales, NP20 4PF
Tel: 01633 254711
www.eosarchitects.co.uk

b. Natural Resources Wales Data



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

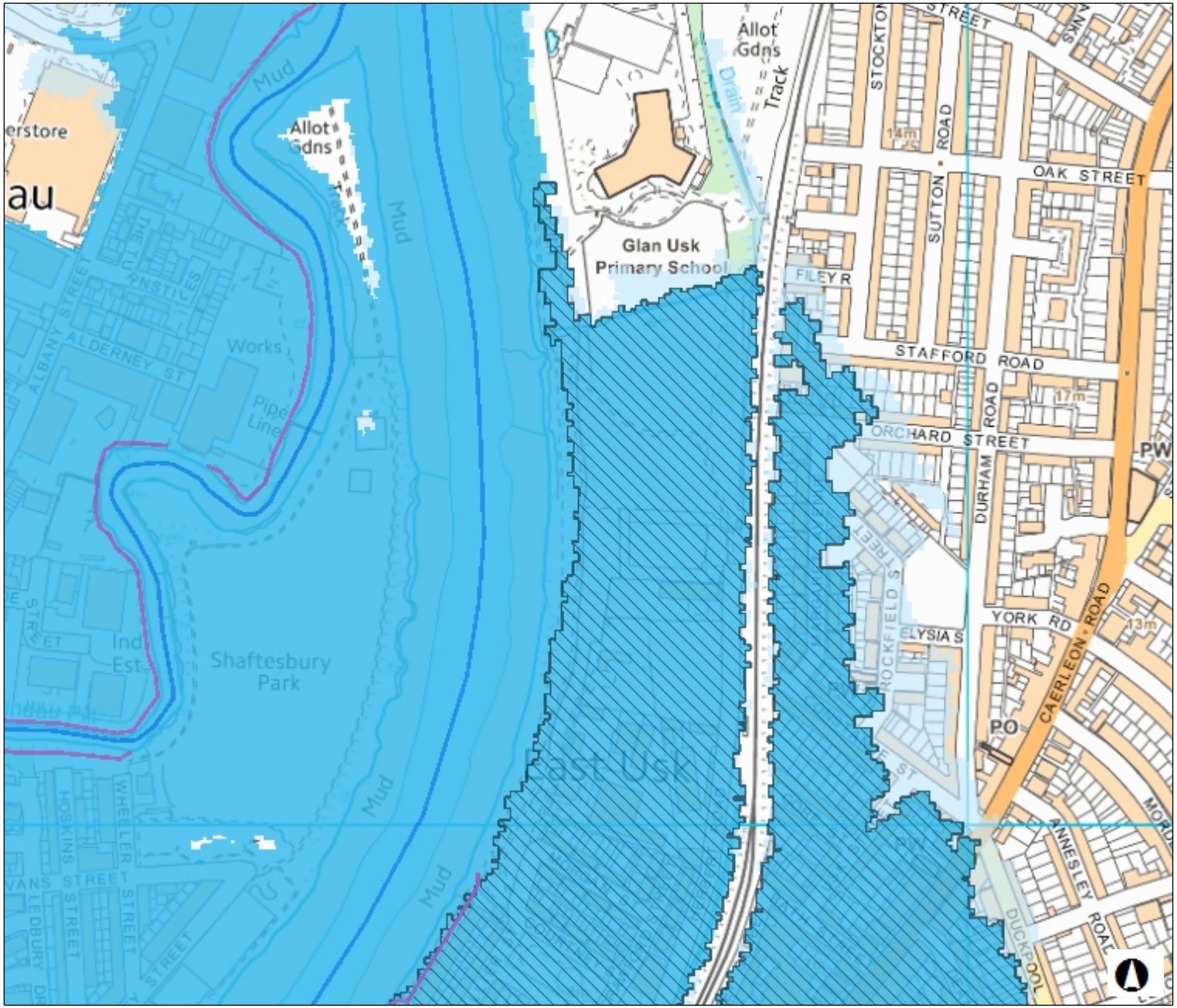
- Zone C1
- Zone C2
- Zone B
- Zone A

Graddfa / Scale 1: 5,093

Dyddiad / Date
04/12/2017

0.3 0 0.13 0.3

British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

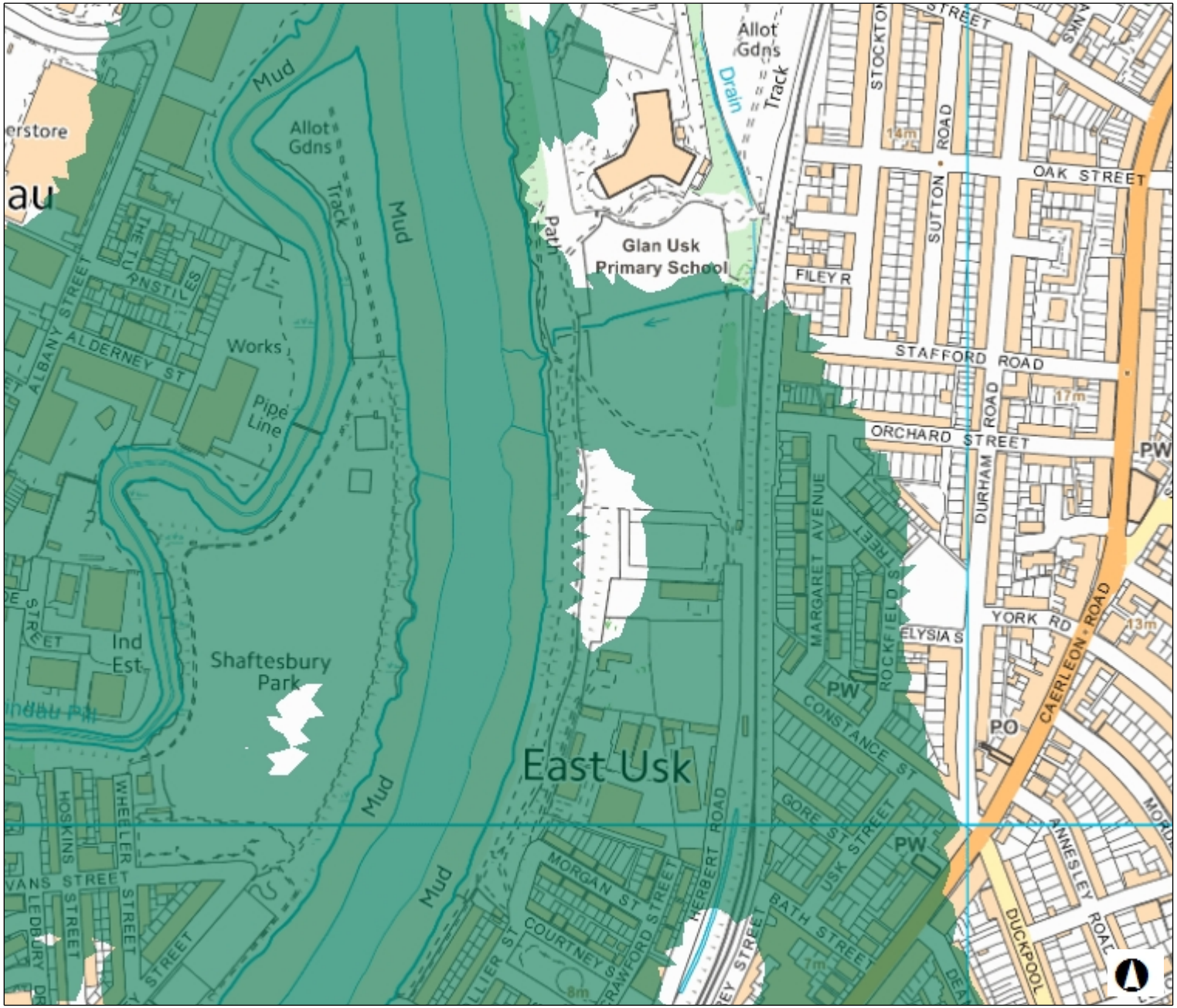
- Main Rivers
- Flood Defences
- Areas Benefiting from Flood Defences
- Flood Storage Areas
- Floodmap Flood Zone 3
- Floodmap Flood Zone 2

Graddfa / Scale 1: 5,093

Dyddiad / Date
04/12/2017

0.3 0 0.13 0.3

British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

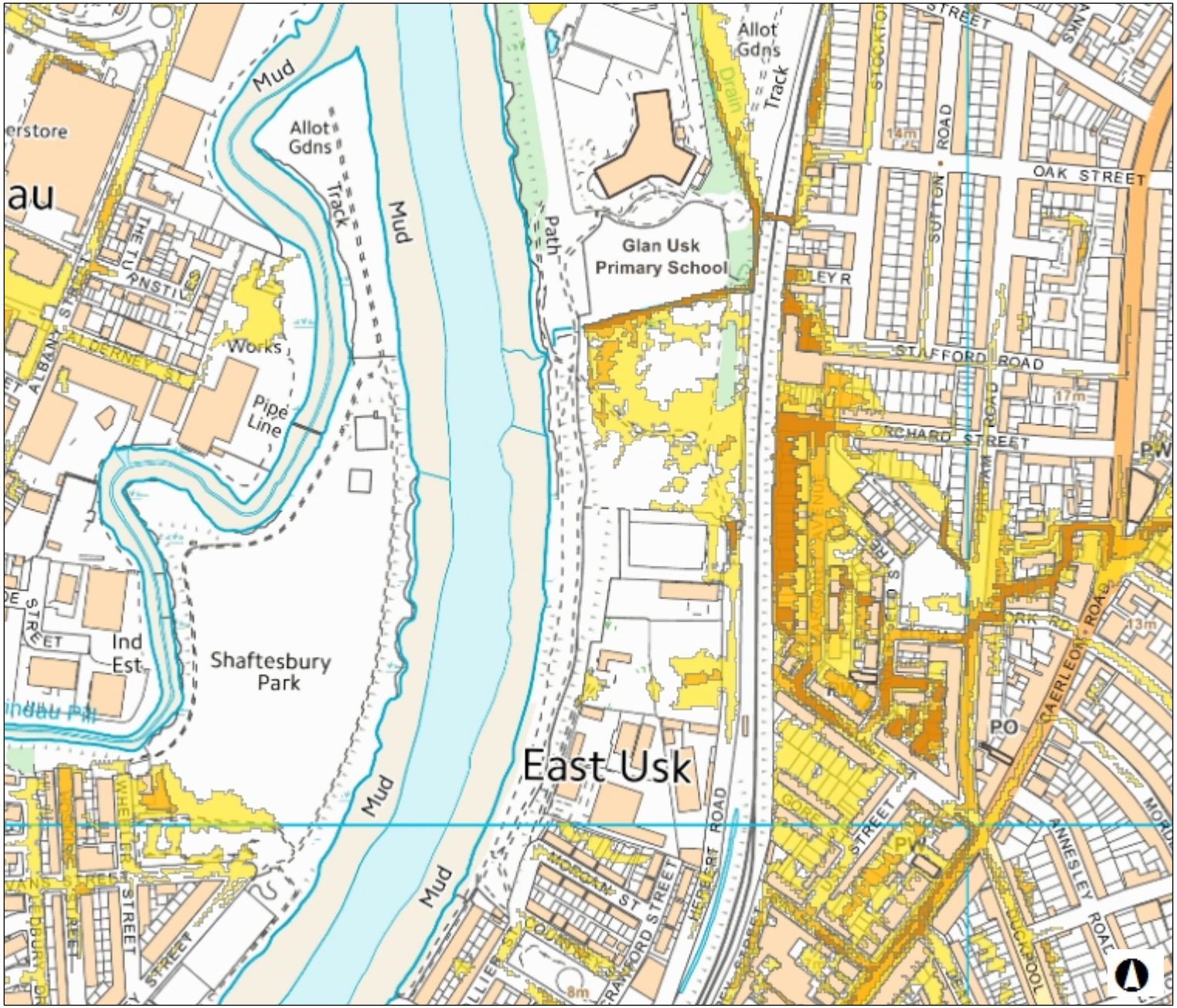
- Reservoir Extents

Graddfa / Scale 1: 5,093

Dyddiad / Date
04/12/2017

0.3 0 0.13 0.3

British_National_Grid Kilometers



Cyfoeth Naturiol Cymru
Natural Resources Wales

Map Title

Map Perygl Llifogydd / Flood Risk Map

Allwedd / Map Key

- High Surface Water Flood Risk - Extent
- Medium Surface Water Flood Risk - Extent
- Low Surface Water Flood Risk - Extent

Graddfa / Scale 1: 5,093

Dyddiad / Date
04/12/2017

0.3 0 0.13 0.3

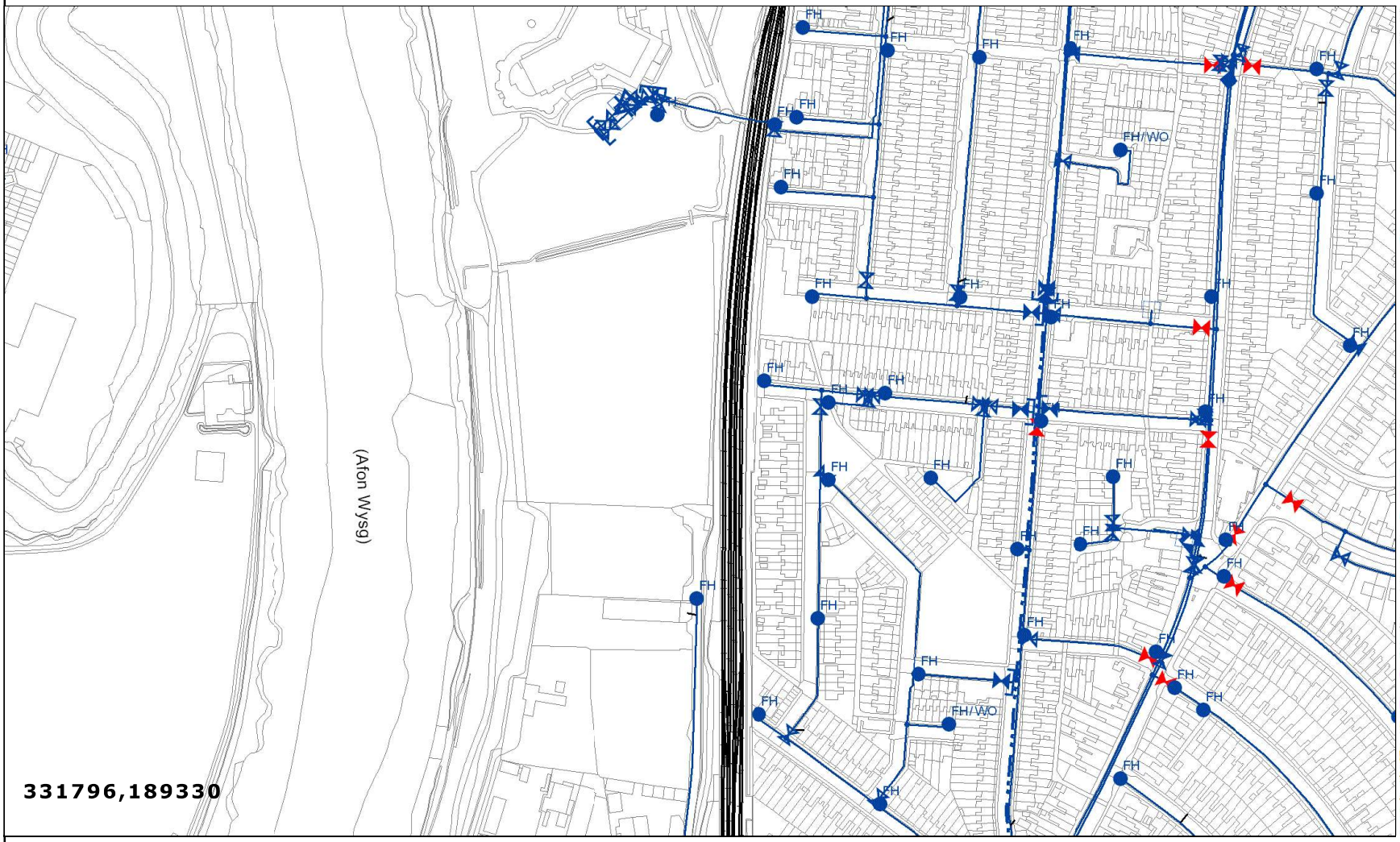
British_National_Grid Kilometers

c. Dwr Cymru Welsh Water Sewer Recors

Dŵr Cymru
Welsh Water

20/11/2012

HerbertRd_Water



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

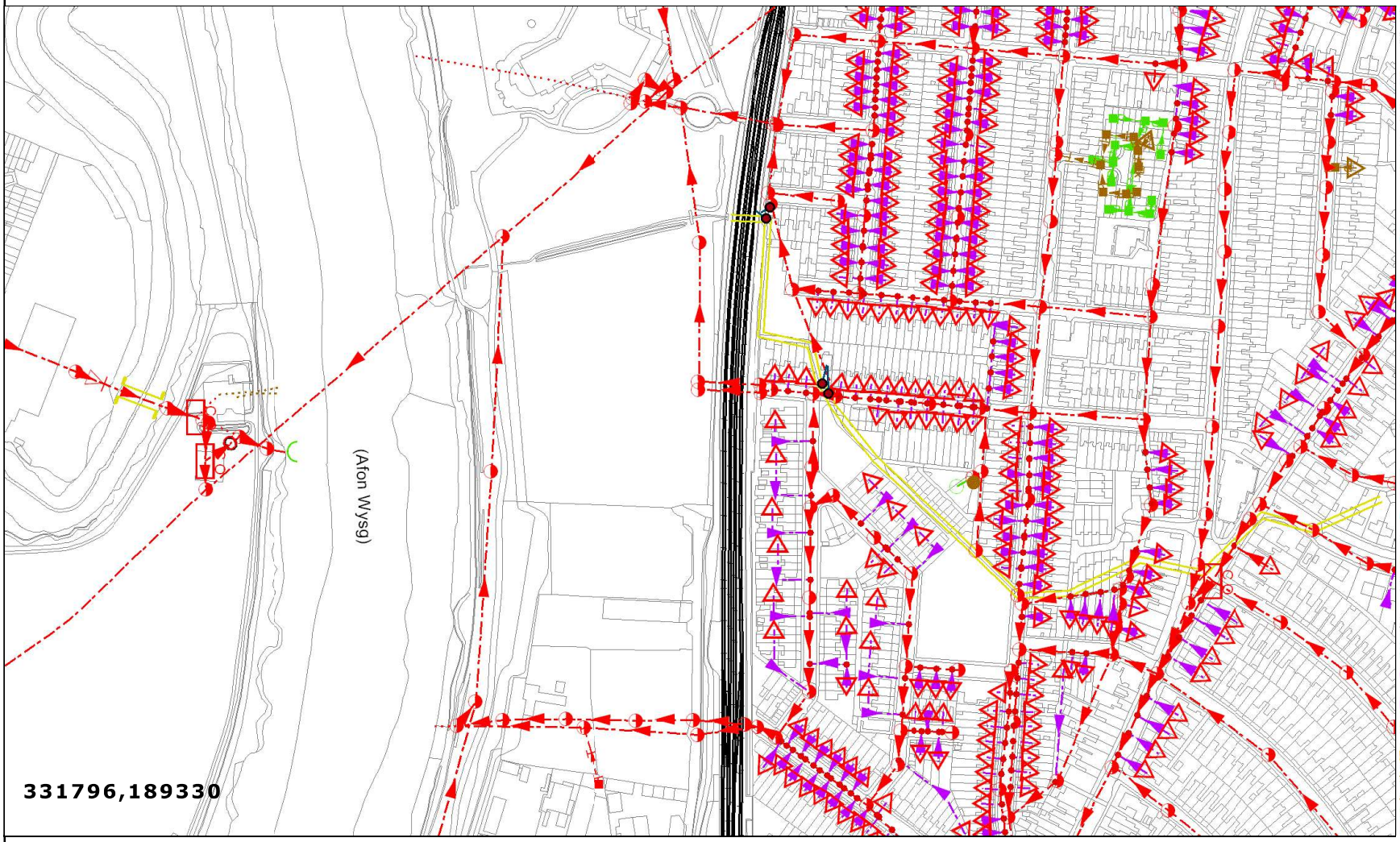
EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

Scale: 1:4037

Dŵr Cymru
Welsh Water

20/11/2012

HerbertRd_Sewerage



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
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Sewerage External

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- Treatment Works
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- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

Scale: 1:4037

d. Hydraulic Modelling Technical Note

Waterman Infrastructure & Environment Limited
Pickfords Wharf, Clink Street, London, SE1 9DG
www.watermangroup.com

Herbert Road FCA - Modelling Technical Note

Date: 11/12/2017

Client Name: Pobl Group

Document Reference: WIE12961-101-3-1-1 – Modelling Technical Note

This document has been prepared and checked in accordance with
Waterman Group's IMS (BS EN ISO 9001: 2015, BS EN ISO 14001: 2015 and BS OHSAS 18001:2007)

Issue	Prepared by	Checked & Approved by
001	Matthew Savill Flood Risk Engineer	Chris Cameron-Hann Principal Flood Risk Engineer

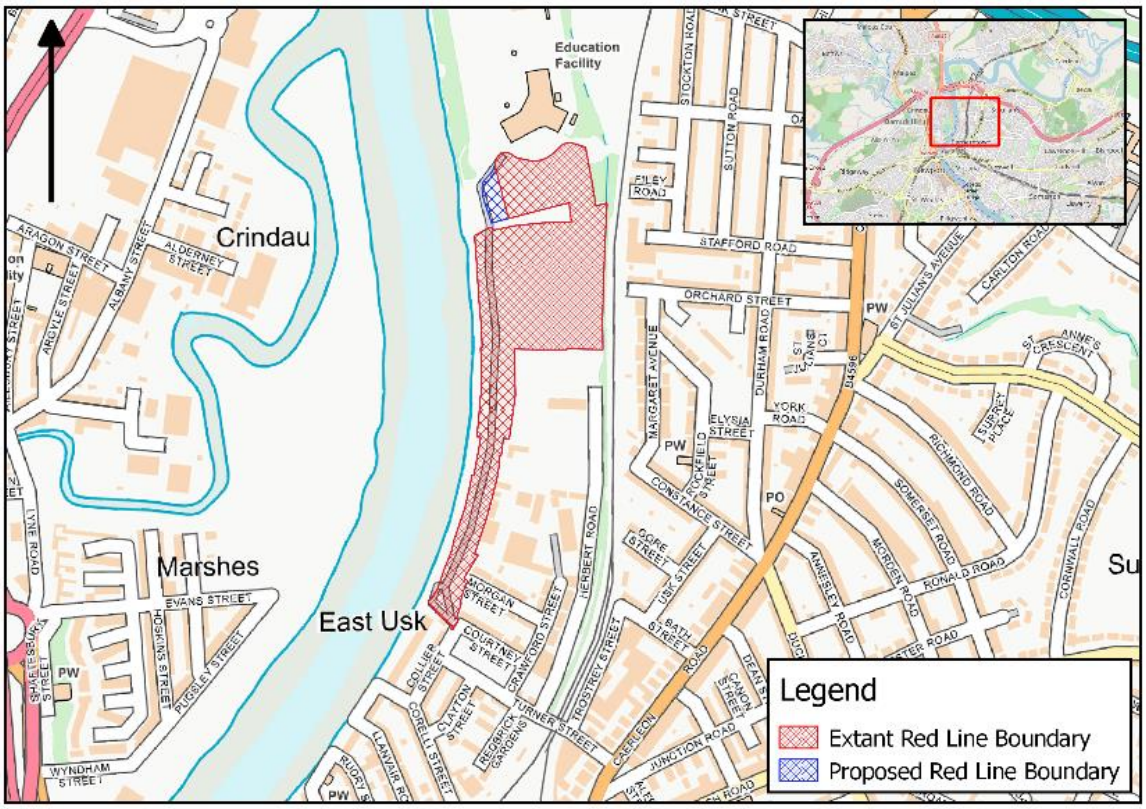
1. Introduction

This technical note has been produced to document the modelling undertaken to support the development of the land south of Glan Usk Primary School, Herbert Road, Newport (henceforth referred to as "the Site"). The Site is allocated for residential purposes in the adopted Unitary Development Plan for 206 dwellings.

1.1 Background

The Site is located at an approximate National Grid Reference 331718E 189369N, approximately 1km north east of Newport town centre on the east bank of the River Usk between the Newport to Hereford railway line and the River Usk (Figure 1).

Figure 1: Site location



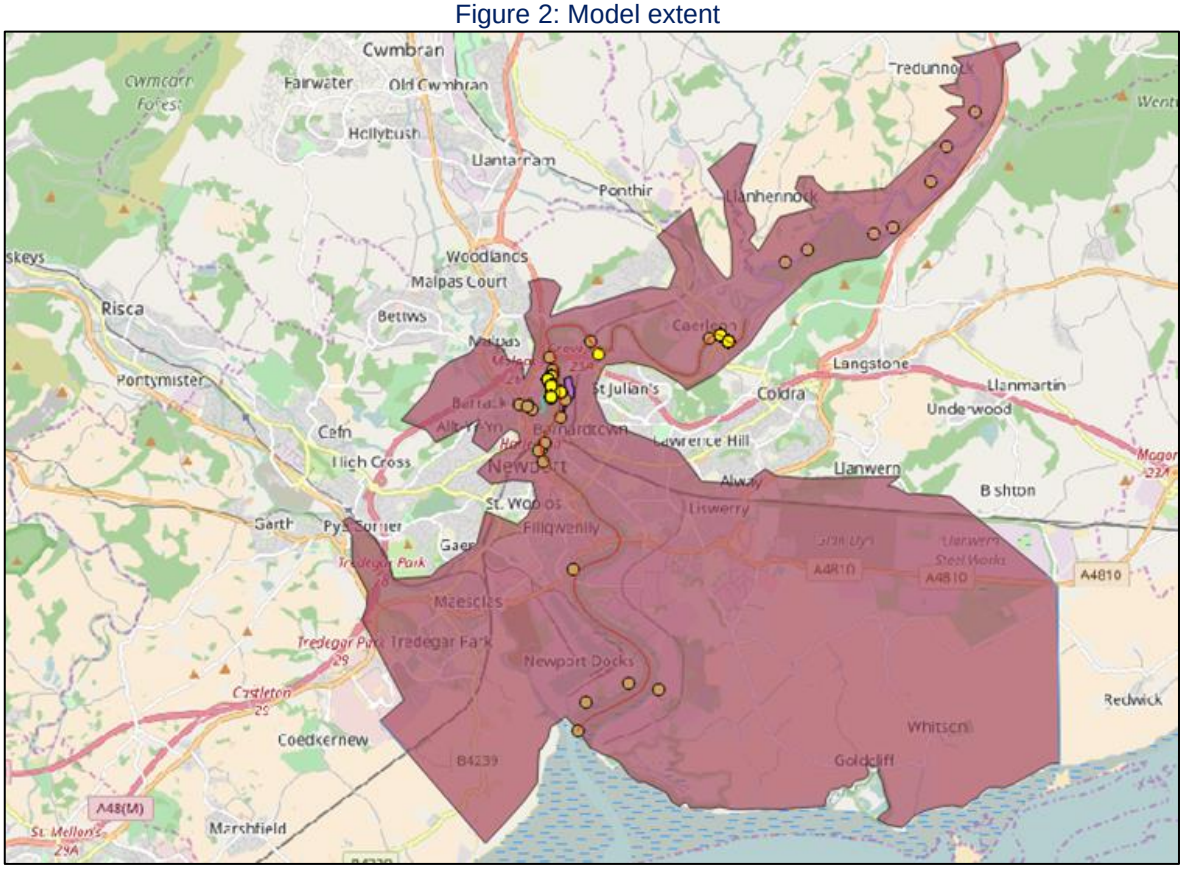
2. Model Summary

The following section provides details of the model provided by NRW and the proposed modelling approach for this project,

2.1 Model Details

The model provided for use by NRW is v3.1 of the Newport Strategic Flood Risk Mapping (SFRM) Model, this is an update of the Newport Tidal hydrodynamic 1d/2d ESTRY-TUFLOW model completed in December 2011. The model provided was run using: Build: 2011-09-AC-iDP-w64, Double Precision; 64-bit. The model extent is presented in Figure 2.

Figure 2: Model extent



We have used an older version of the Newport Tidal model (3.1, 2011) for our assessment, which does not use the latest topographical survey information. We are aware that there have been updates in guidance and the implementation of a number of flood defence schemes being constructed since 2011. However, it has been established that our updated version of the 2011 model produces higher flood levels across the proposed development site in comparison to the current NRW version (6) of the model. This is due to the reduction in extent of flood defences in 2011 (Version 3) compared with the current day situation (Version 6), which allows more floodwater to convey into the area. As a result using our model (Version 3) to set the development platform and

finished floor levels of the would be acceptable as it takes the precautionary approach to the flood risk from the tidal River Usk.

The model represents the River Usk and tributaries as they run through Newport. The watercourses near the site; the River Usk and Crindau Pil were represented in 1D modelling software ESTRY and the floodplain was represented by 2D modelling software TUFLOW. The model represents both the fluvial and tidal flood risk to the city of Newport. Table 1 shows the models provided by NRW.

Table 1: The models provided by NRW

Model version	tcf	tgc	Tbc	ecf
003b T200 Baseline	USK_DEF_T200_2064_WTD003b	USK_DEF_WTD003b.tgc	USK_DEF_WTD002.tbc	USK_DEF_WTD003b
003b T1000 Baseline	USK_DEF_T1000_2014_WTD003b	USK_DEF_WTD003b.tgc	USK_DEF_WTD002.tbc	USK_DEF_WTD003b
010 T200 Proposed	USK_DEF_T200_2064_WTD205	USK_DEF_WTD205.tgc	USK_DEF_WTD002.tbc	USK_DEF_WTD003b
010 T1000 Proposed	USK_DEF_T1000_2014_WTD205	USK_DEF_WTD205.tgc	USK_DEF_WTD002.tbc	USK_DEF_WTD003b
011 T200+Cl Proposed	USK_DEF_T200_2064_Cl+_WTD205	USK_DEF_WTD205.tgc	USK_DEF_WTD002.tbc	USK_DEF_WTD003b

2.2 Modelling Approach

The modeltaken forward for use with this project was the “010 T1000 Proposed” model as the updates included as part of the proposed case have been constructed and therefore this scenario provides the best representation of the current conditions.

2.2.1 Tidal Driven

Given that the tidal flood risk from the River Usk is more significant to the development site than the fluvial flood risk, this modelling used QMED or QMED+CC as the fluvial inflows and varied the tidal water level. The tidal water level was applied at the downstream extent of the River Usk in the model using a QH boundary. The model was run for four tidal cycles; the largest of which was the third tidal cycle. This was done to represent the ‘worst case’ scenario.

2.2.2 Ordinary Water Course

The model was also updated to represent the risk of flooding from the ordinary watercourse that runs through the site. Due to the long duration of the tidal cycles compared to the short duration of flood events on the Ordinary Watercourse it was possible to assess the flood risk posed by the Ordinary Watercourse during the same simulation as the tidal flood risk. It was assumed that the flood patterns after 14.5 hours of the simulation, before the tidal water level breached the banks of the River Usk would represent the expected flooding patterns from the ordinary watercourse.

3. Model Updates

The SFRM model provided by NRW was updated to improve the representation of the flooding mechanisms in the vicinity of the site. The following section documents the updates to the model carries out as part of this project.

3.1 1D Model Updates

After a review of available data, the representation of the River Usk in the model was considered fit for purpose so 1D updates to the model were kept to a minimum. However, several minor updates were made:

- The representation of CRD1325 (Lyne Road culvert on Crindau Pil) was updated to a rectangular culvert with a width of 6.5m and a height of 3.7m. The bend losses were also removed from the culvert representation.
- The outfall culvert from the Ordinary Watercourse was represented as a circular, flapped 1m culvert, linked to the nearest cross-section on the River Usk. Upstream invert: 6.20m AOD, Downstream Invert: 5.80m AOD.

3.1.1 2D Model Updates

The major 2D update to the hydraulic model was related to the ensuring the ordinary watercourse was accurately represented. The existing elevations of the watercourse were extracted from the topographic survey and implemented in the model using a Z-Shape.

The inflow to the ditch was applied to the model using a 2d_SA layer. This applied the inflow to the lowest cell in the polygon, before distributing the flow as more cells became wet. In this case the lowest cell was near the outfall point from the existing culvert into the ditch. This method of applying flow ensured that all flow was applied to the Ordinary Watercourse itself and not the areas surrounding it.

There were a few minor 2D updates not related to the representation of the Ordinary Watercourse:

- The 2d_mat layer was not applied to the area represented by the 1D channel to reduce convergence issues.
- The tidal boundary conditions were moved slightly to match the edge of the 2D domain

3.1.2 Peak Tidal Levels

The tidal boundaries used to represent the extreme tidal events in the model were updated to reflect the latest guidance from NRW. The NRW model was supplied with the peak tide levels for the 0.5% Annual Exceedance Probability (AEP) and the 0.1% AEP for the current-day scenario when the model was developed (2011).

These required updating to reflect the projected impacts of climate change on peak tidal water levels. Table 2 provides a summary of the net sea level allowances in the vicinity of the proposed development site.

Table 2: Net sea level rise allowances for Wales

Administrative Region	Net Sea Level Rise (mm/yr)			
	2009 to 2025	2026 to 2055	2056 to 2085	2085 to 2116
Wales	3.5	8.0	11.5	14.5

In 2011, DEFRA carried out a 'Technical Report Design sea levels[i]" study which was designed to produce a nationally consistent set of extreme sea levels. These levels were derived using a tidal model calibrated to UK tidal gauge data, and produced estimates for the extreme tidal events for the baseline year (2008). In order to derive the 0.5% AEP plus CC for the year 2117, 0.1% AEP tidal levels for the year 2017 and the 0.1% AEP plus CC for the year 2117; the 2008 year levels have been extrapolated based on current DEFRA guidance for sea level rise. The peak tidal levels used to inform this FCA are summarised in Table 3.

Table 3: Peak tidal level estimates

	0.5% AEP+CC (2117)	0.1% AEP (2017)	0.1% AEP+CC (2117)
Tide Level (m AOD)	9.91	9.42	10.50

3.2 Fluvial Inflows

The QMED estimates for the River Usk and its tributaries provided with the SFRM model were retained for this project. For the climate change scenarios modelled the central estimate of the climate change allowance for the Severn River Basin (25%) was applied to these flows. This approach was considered acceptable as the modelling of the River Usk was focusing on the tidal flood risk to the development.

The inflow to the Ordinary Watercourse was derived using ReFH Rainfall Runoff methods. The peak flow estimate for the 1% AEP event was calculated as 0.2m^3/s with a critical storm duration of 2 hours. To provide a conservative estimate of the inflow from this catchment 0.2m^3/s was applied as a constant inflow. This ensured that the volume of flow applied to the Ordinary Watercourse significantly exceeded the volume calculated for the 1% AEP+CC flood event.

3.3 Post-development Case

The proposed scheme was represented in the post-development case models. The following amendments were made to the baseline model:

- The entire site was raised to represent the land raising proposed as part of the development. The northern part of the site was raised to 10.4m AOD and the southern part of the site was raised to 9.95m AOD. This was implemented in the model using a Z-Shape with the 'No Merge' function specified.

- The Ordinary Watercourse was expanded and deepened to increase its capacity using a Z-Shape. The levels were taken from the drainage strategy produced by Steve Morgan Associates in November 2017.

3.4 Input Files

The files used to carry out the model amendments described above are presented in Table 4. The MapInfo files used during the model simulations were retained from the SFRM model.

Table 4: Files used to carry out the model amendments

File	Purpose
bc_dbase_USK_2117_DesignTides_v07.csv	Boundary Condition Database for the present day scenarios
bc_dbase_USK_2117_DesignTides_v08.csv	Boundary Condition Database for the climate change scenarios
1d_nwk_CRD_558_mj01.shp	Crindau Pil network with updated representation of Lyne Road culvert
1d_nwk_DitchOutfall_mj01.shp	Outfall from the Ordinary Watercourse in the pre-development case
1d_nwk_DitchOutfall_HR_002.shp	Outfall from the Ordinary Watercourse in the post-development case
2d_bc_USK_WTD002_L_mj01.shp	HQ boundary allowing water to drain from the eastern and western edges of the model.
2d_SA_INFL_mj03.shp	2d_SA layer applying inflows to the Ordinary Watercourse that runs through the site
2d_bc_sx_DitchOutfall_001_P.shp	SX file that links the Ordinary Watercourse to the River Usk outfall culvert in the pre-development case
2d_bc_sx_DitchOutfall_002_L.shp	SX file that links the Ordinary Watercourse to the River Usk outfall culvert in the post-development case
2d_zsh_ditch_003_polyline.shp	Z-Shape line used to define the area of the Ordinary Watercourse in the pre-development case
2d_zsh_ditch_002_point.shp	Z-Shape points to set the elevations of the ditch in the post-development case
2d_zsh_development_platform_HR_004_R.shp	Z-Shape region file used to define the area proposed for land raising

2d_zsh_development_platform_HR_004_P.shp	Z-Shape point file to allow for a smooth slope between the north and south parts of the site
2d_zsh_ditch_HR_004_R.shp	Z-Shape region defining the location of the extended ditch in the post-development case
2d_zsh_ditch_HR_004_L.shp	Z-Shape lines setting the bed level of the extended ditch in the post-development case
2d_zsh_ditch_HR_004_P.shp	Z-Shape points setting the elevation of the banks for the extended ditch in the post-development case
2d_mat_USK_water_007_R_mj01.shp	Amended materials file that removes the materials definition from the 1D channel
2d_mat_site_boundary_001_R.shp	Materials file used to set the entire development site as 'open space'
2d_mat_proposed_masterplan_R.shp	Materials file used to define the roads and buildings in the proposed development. Read in after 2d_mat_site_boundary_001_R.shp

4. Model Runs

The model runs simulated for the project are presented in Table 5. All models were run using TUFLOW build 2016-03-AE-iDP-w64, the most recent version of TUFLOW available at project start up.

Table 5: Model runs simulated for the project

Scenario	Event	.tcf
Pre-development	T200_2117	USK_DEF_T200CI+_2117_WTD0205_v10.tcf
Pre-development	T1000_2017	USK_DEF_1000T_2017_CI+_WTD0205_v09.tcf
Pre-development	T1000_2117	USK_DEF_1000T_2117_CI+_WTD0205_v10.tcf
Post-development	T200_2117	USK_DEF_T200CI+_2117_WTD0205-Post_v14.tcf
Post-development	T1000_2017	USK_DEF_1000T_2017_CI+_WTD0205-Post_v13.tcf
Post-development	T1000_2117	USK_DEF_1000T_2117_CI+_WTD0205-Post_v14.tcf

4.1 Model Stability

The stability of the TUFLOW model can be assessed by examining the warning messages outputted by the modelling software, the number of negative depths and analysing the dVOL and Mass Balance of the model.

The warnings messages outputted by TUFLOW are presented in Table 6. It shows that all warning messages were related to the 1D ESTRY elements of the model, which has been retained from the SFRM model provided by NRW. It can therefore be assumed that their impact on model results can be considered negligible.

Table 6: The warning messages outputted by TUFLOW before and during the model simulation

Warning	Justification
WARNING 1036 - Maybe problems with interpolating n values for channel "######". Interpolating n using channel n and downstream XSL n. Check n values.	These message is related to the 1D ESTRY elements of the model, retained from the SFRM model provided by NRW. It can therefore be assumed that their impact on model results can be considered negligible.
WARNING 1100 - Structure ####### crest/invert (*****) is below bed (*****) of primary downstream channel #######.	
WARNING 1253 - Unused 1d_ta line with attributes:	
WARNING 1991 - 0:23:45: Negative depth at Node CRD0529.1: y = -2.17 Bed = 0.36 Iter =1	The number of negative depths in each model simulation is justified below.

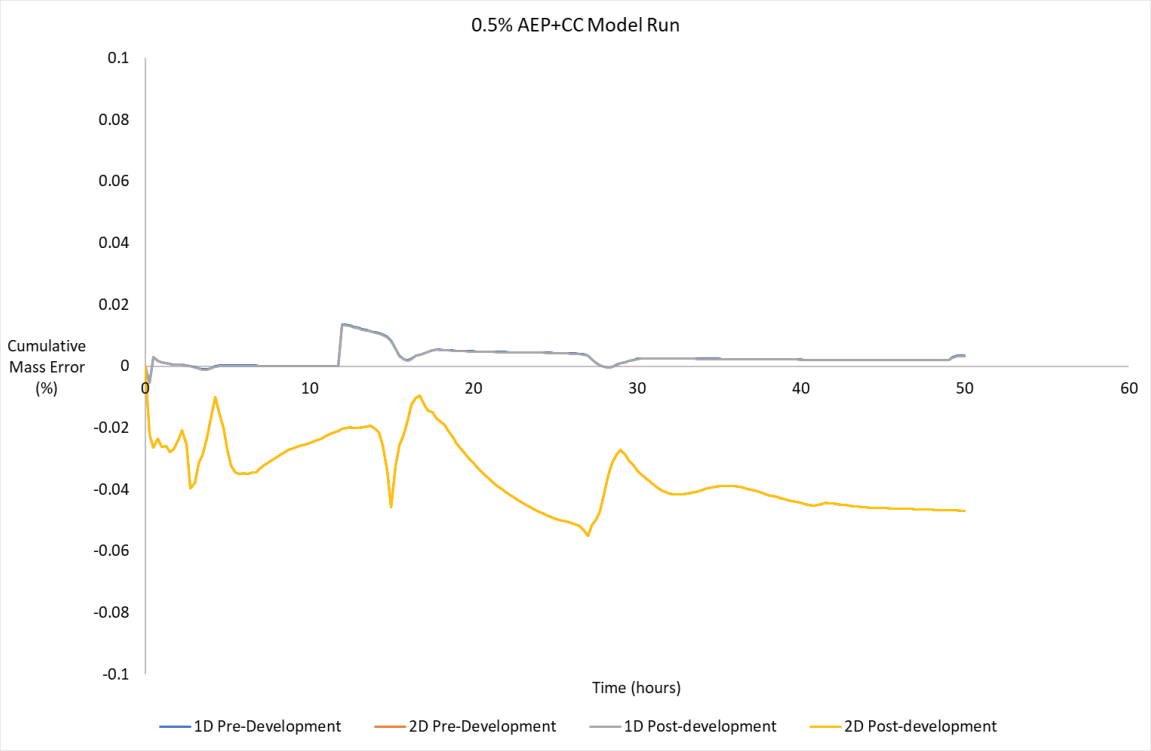
The number of negative depths in the model simulations are presented in Table 7. There are large numbers of 1D negative depths in all model simulations. However, there are significantly less than the approximately 2200 found in the SFRM model provided by NRW. This model can therefore be considered to be an improvement on the model provided. Furthermore, there are no new locations for the negative depths when they are compared with the model provided.

Table 7: The number of negative depths during the model simulations

Scenario	Event	1D Negative Depths	2D Negative Depths
Pre-development	T200_2117	881	0
Pre-development	T1000_2017	1066	0
Pre-development	T1000_2117	885	0
Post-development	T200_2117	872	0
Post-development	T1000_2017	1059	0
Post-development	T1000_2117	875	0

The mass balance of a model is assessed by examining the cumulative mass error during the model simulation. This is a measure of the volume of water gained or lost from the model as a percentage of the volume of water in the model through the model simulation. Figure 3 presents the cumulative mass error for the tidal design event (0.5% AEP+CC). It shows that the 1D and 2D cumulative mass error are both well within the ±1% generally considered acceptable throughout the model run for both the pre-development and post-development scenarios.

Figure 3: Cumulative mass error for the design tidal event



The dVol is a measure of the volume of water passing from the 1D to the 2D model t each timestep and can be used to can be used to assess the stability of the 1D/2D links during a model simulation. It is presented for the tidal design event (0.5% AEP+CC) in Figure 4. The dVol curve shown is typical of a tidal model simulation where the volume of flow passing the between the 1D and 2D models follows the tidal cycles. The smooth curve with no oscillations suggests that the 1D/2D links for the model are stable throughout the model simulation.

Figure 4: dVol for the design tidal event

Overall the hydraulic model can be considered stable and healthy throughout the model simulation and the results can therefore be considered reliable. The presence of 1D negative depths could suggest that the model is unstable during the model simulation. However, the mass balance and dVol results suggest that these are having a limited impact on overall model results.

5. Summary

Waterman Infrastructure and Environment have undertaken hydraulic modelling to support a FCA for the proposed residential development near Herbert Road, Newport.

NRW provided a SFRM model of Newport for this purpose. The SFRM model was amended to aid model stability and improve the representation of the areas in the vicinity of the proposed site, producing the pre-development scenario model. This was then updated with the details of the proposed development to produce the post-development scenario model.

The model was run for the 0.1% AEP, 0.5% AEP+CC and the 0.1% AEP+CC tidal events. Investigation of the model stability showed that the model was healthy and stable for all tidal events simulated.

[i] Environment Agency, 2011. Coastal Flood Boundary Conditions for the Mainland UK Coasts and Islands

e. Model Results Figures

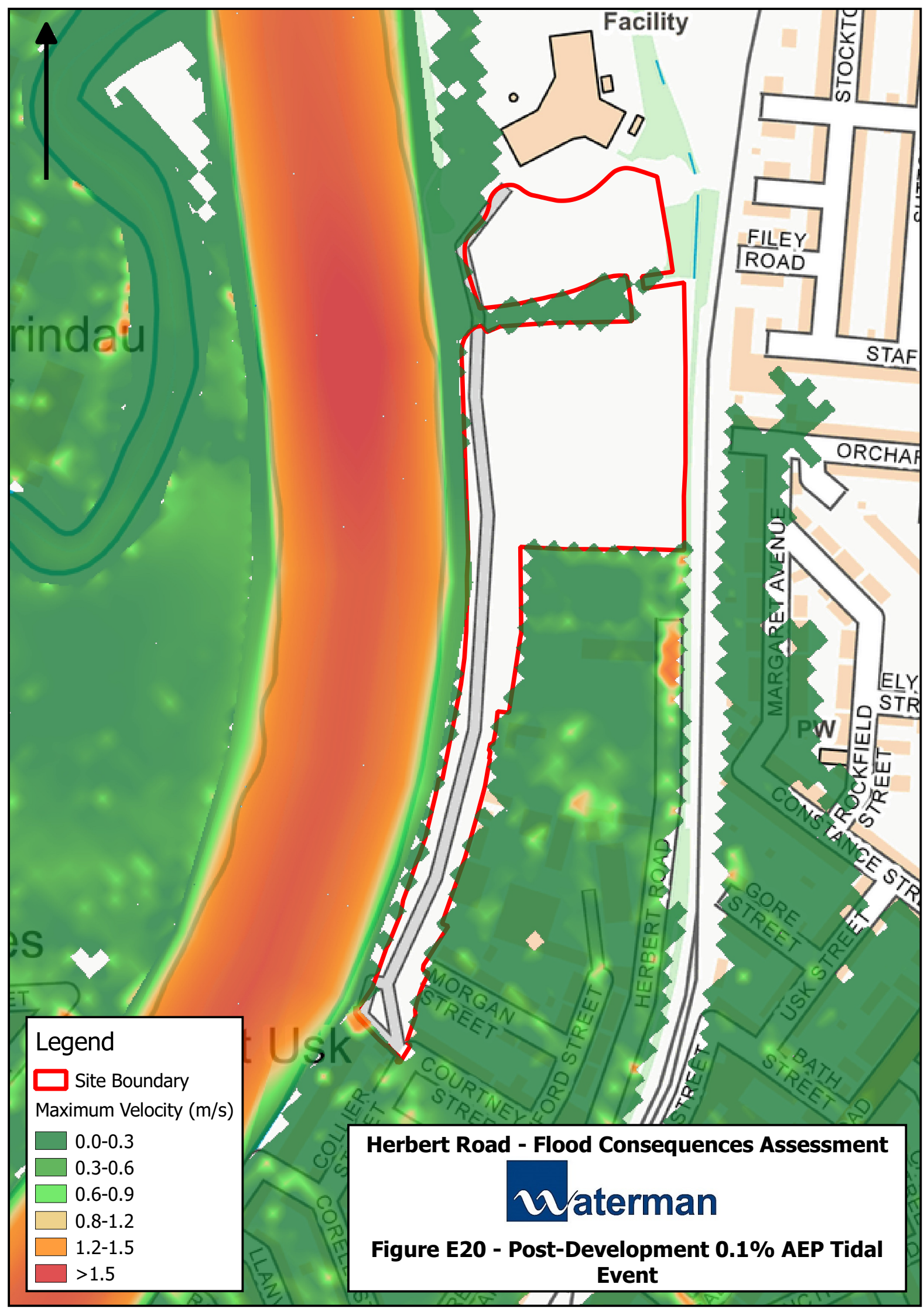


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Figure E20 - Post-Development 0.1% AEP Tidal Event

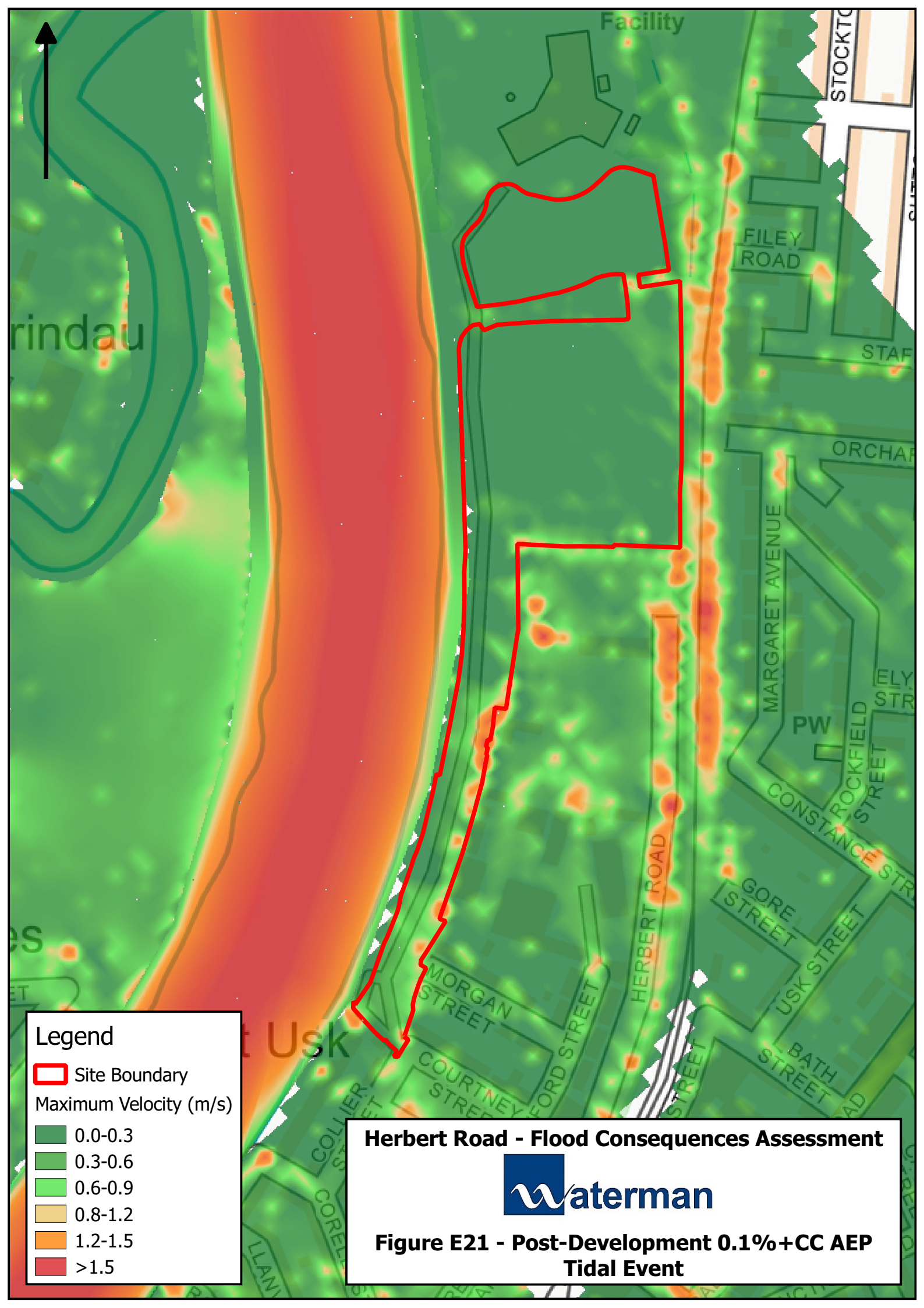

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Figure E21 - Post-Development 0.1%+CC AEP Tidal Event

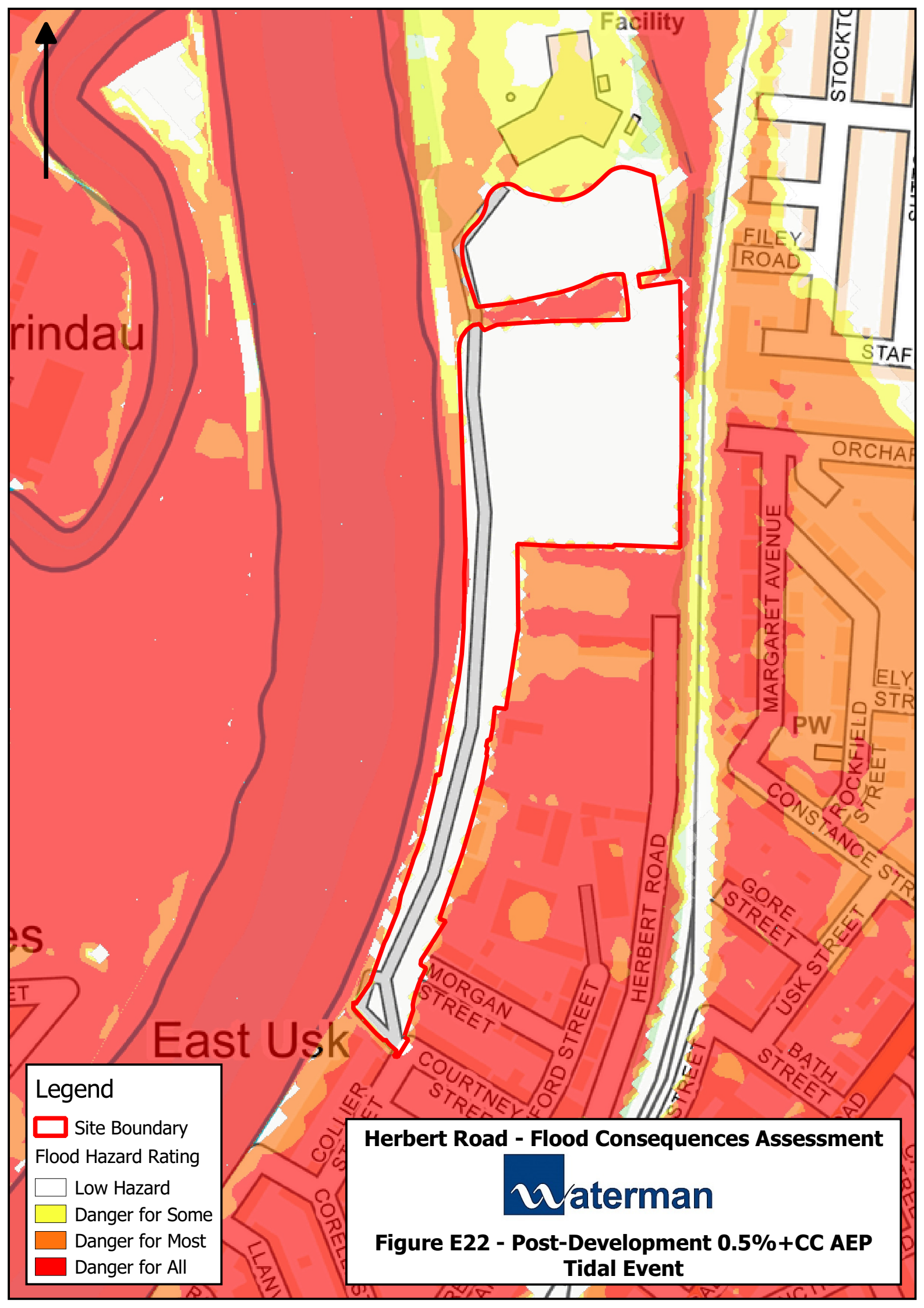

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Figure E22 - Post-Development 0.5%+CC AEP Tidal Event

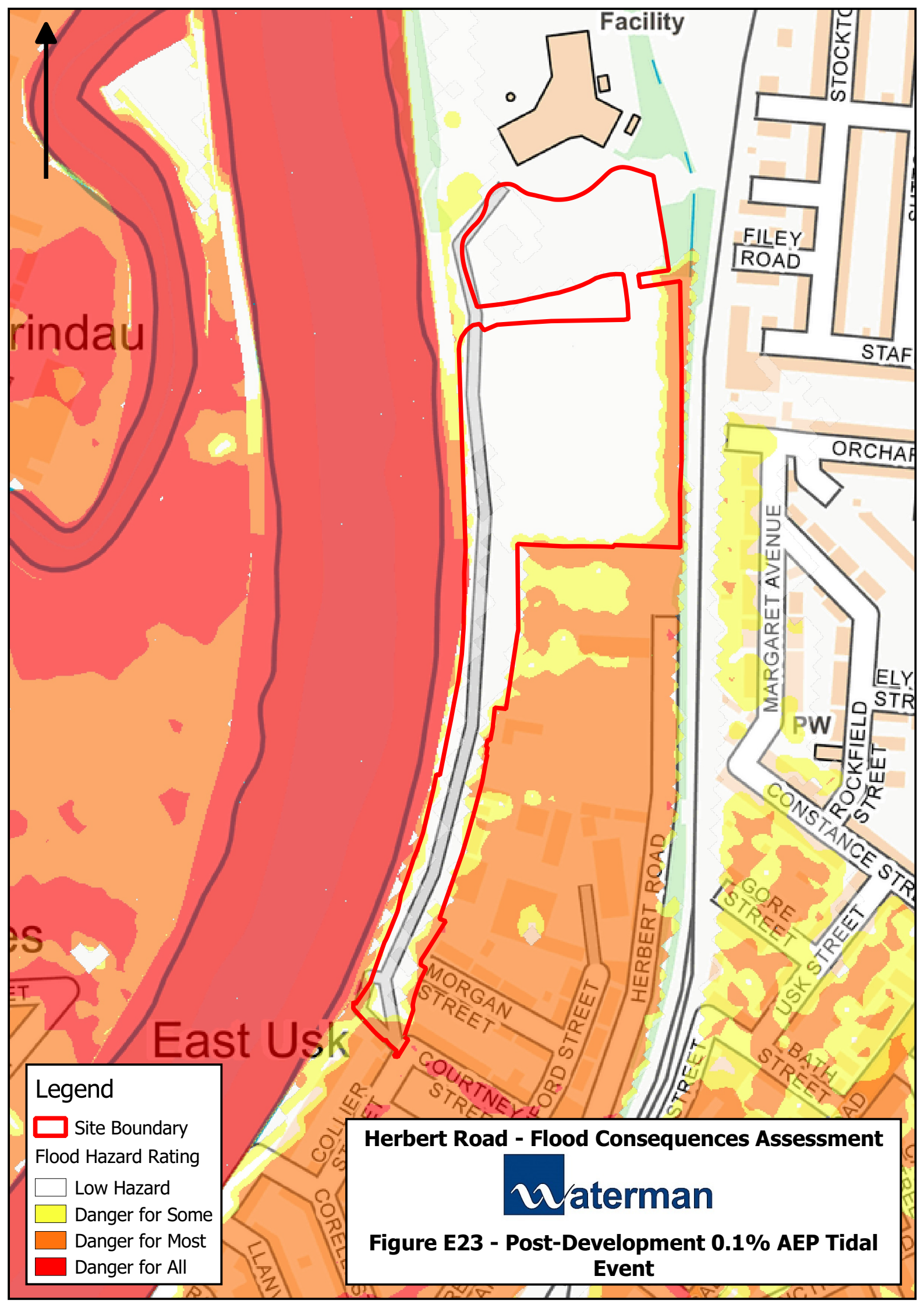

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Figure E23 - Post-Development 0.1% AEP Tidal Event

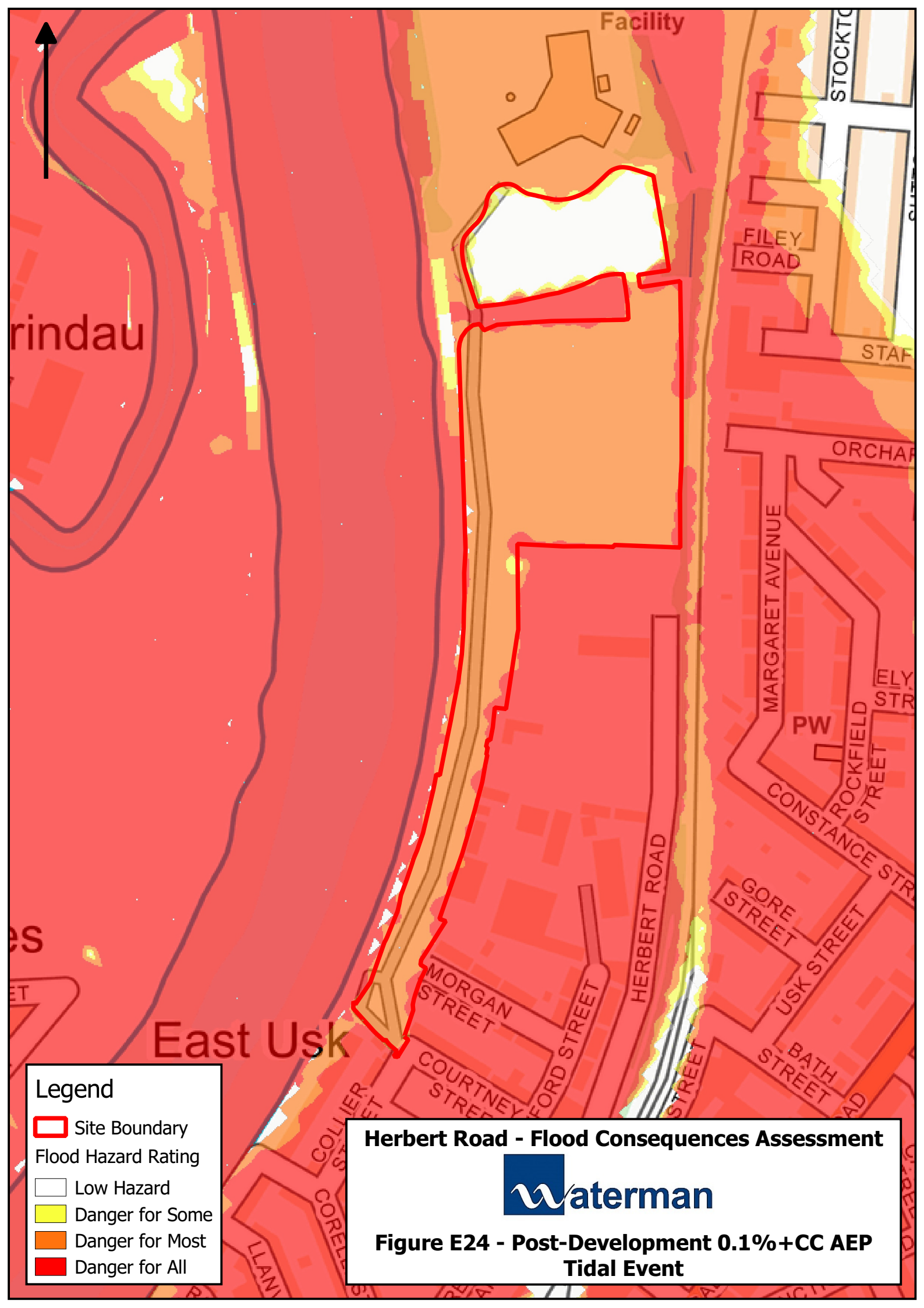

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Figure E24 - Post-Development 0.1%+CC AEP Tidal Event

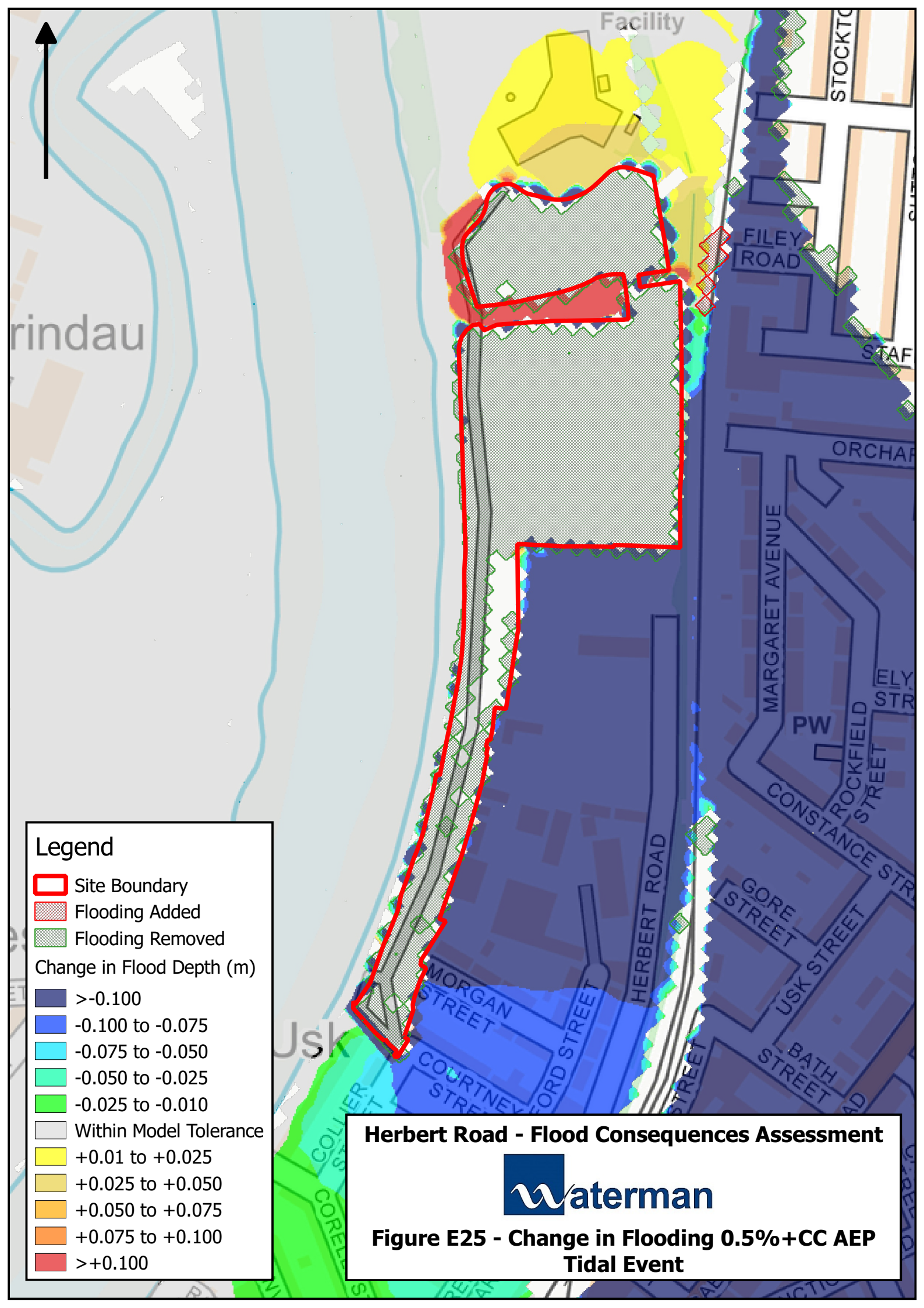

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Figure E25 - Change in Flooding 0.5%+CC AEP Tidal Event

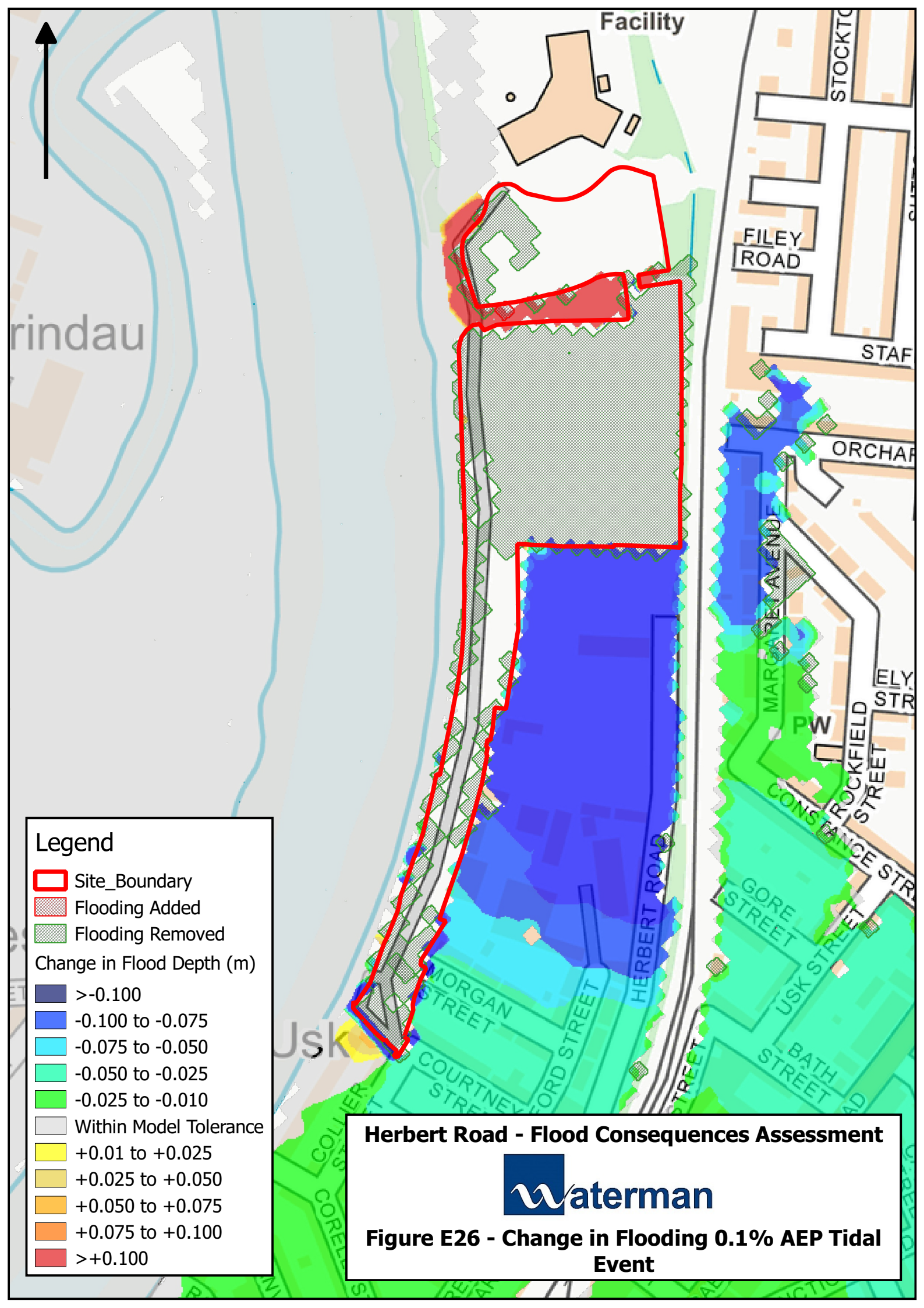

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Figure E26 - Change in Flooding 0.1% AEP Tidal Event

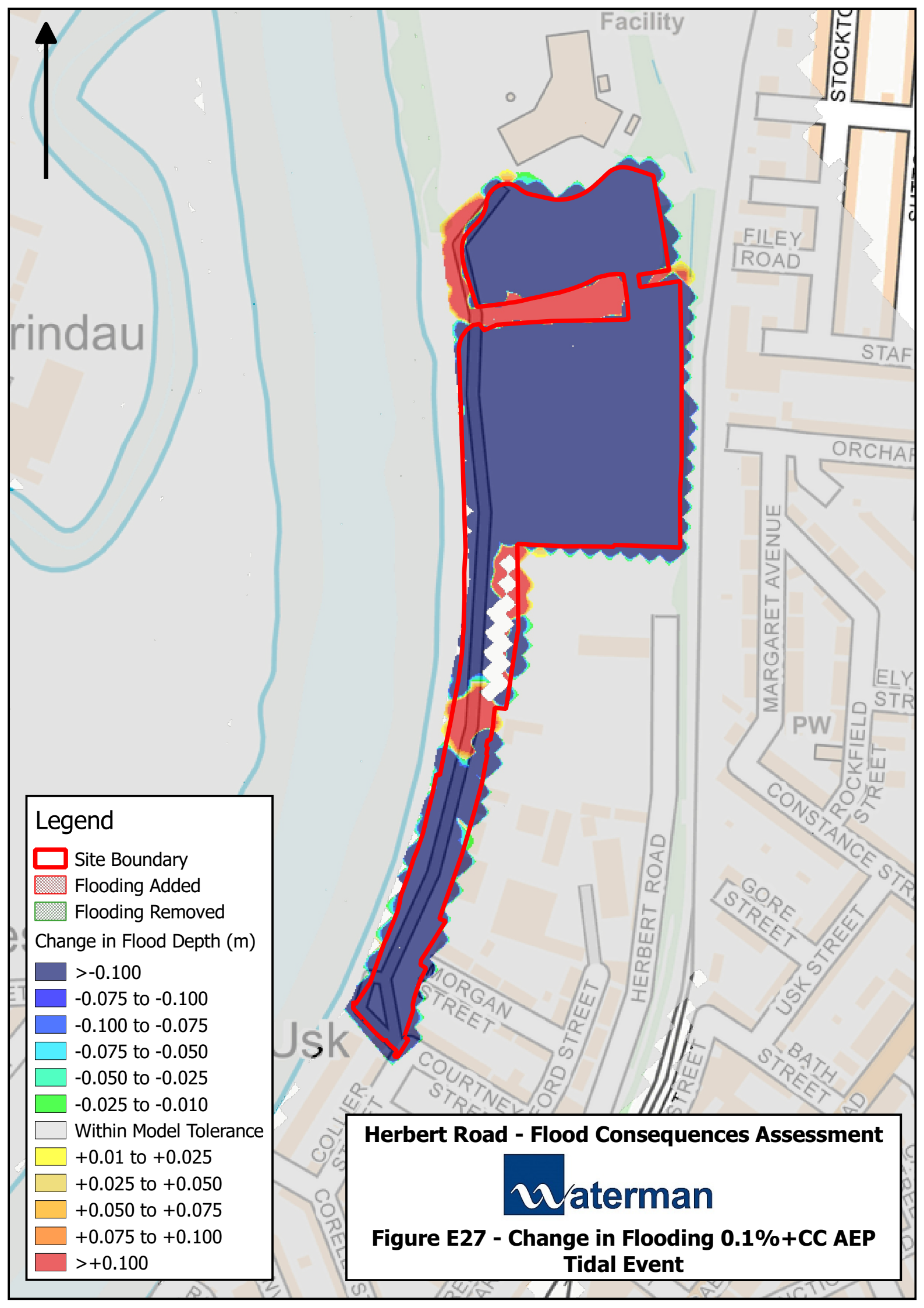

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Figure E27 - Change in Flooding 0.1%+CC AEP Tidal Event

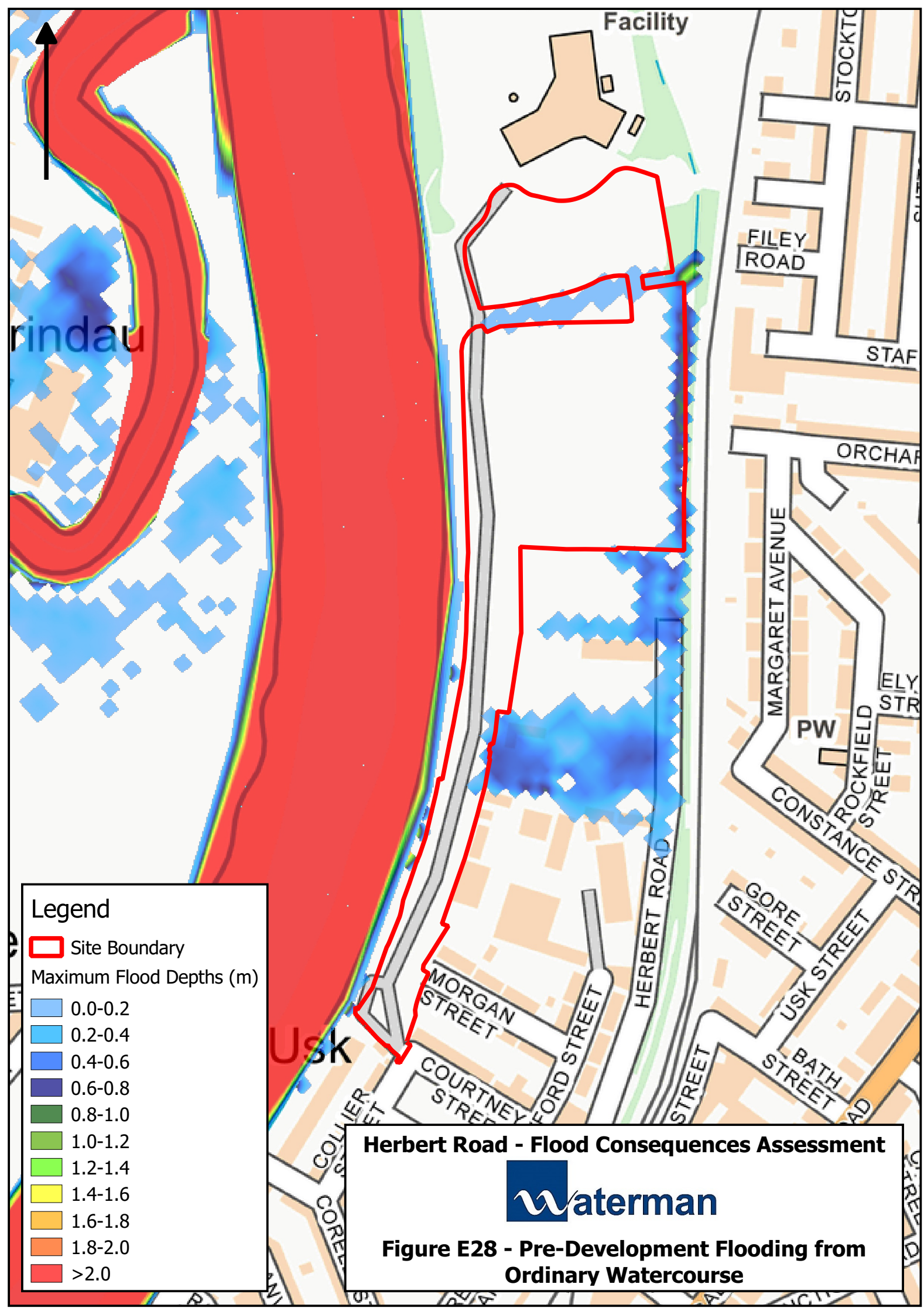

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Figure E28 - Pre-Development Flooding from Ordinary Watercourse

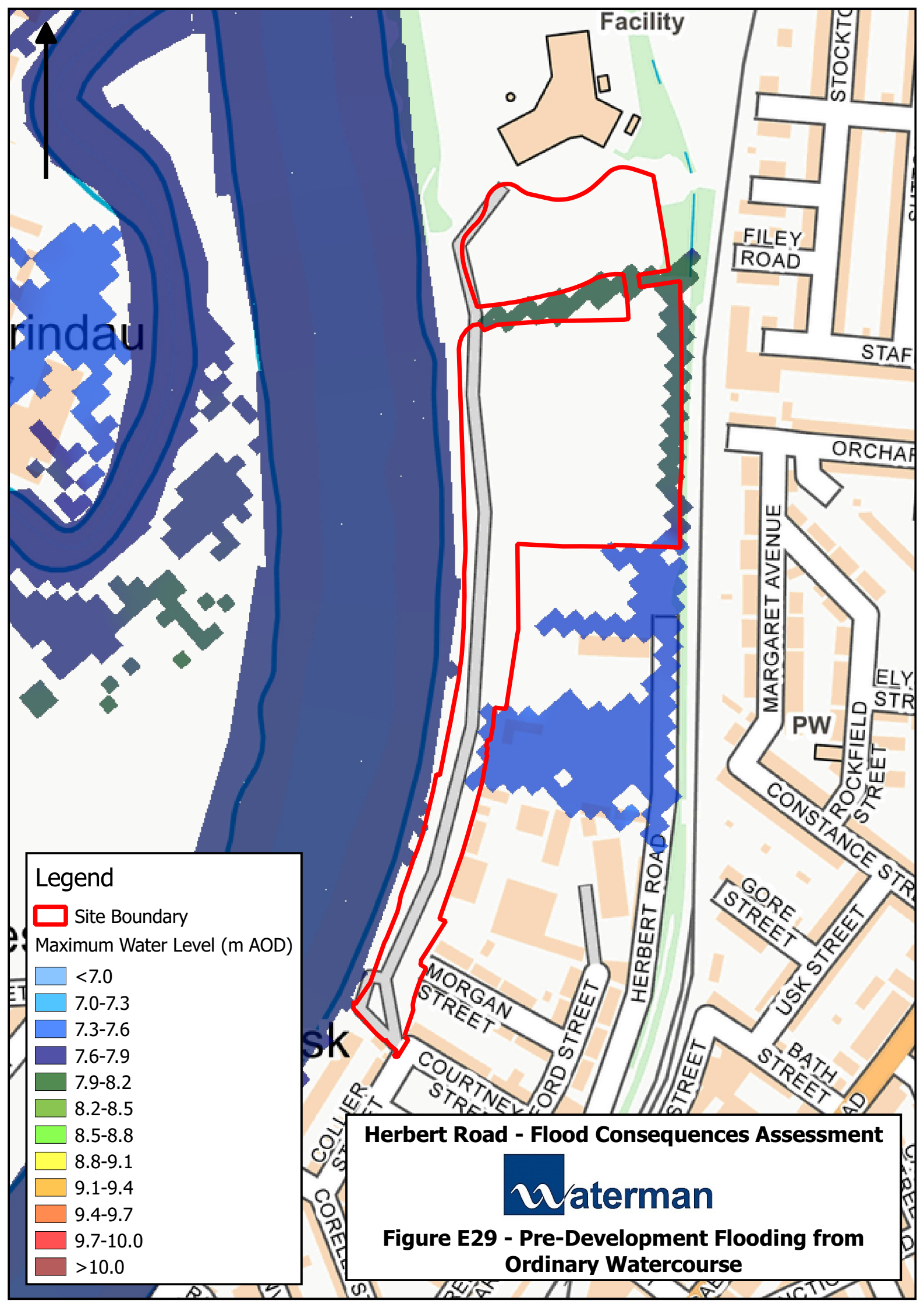

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Figure E29 - Pre-Development Flooding from Ordinary Watercourse

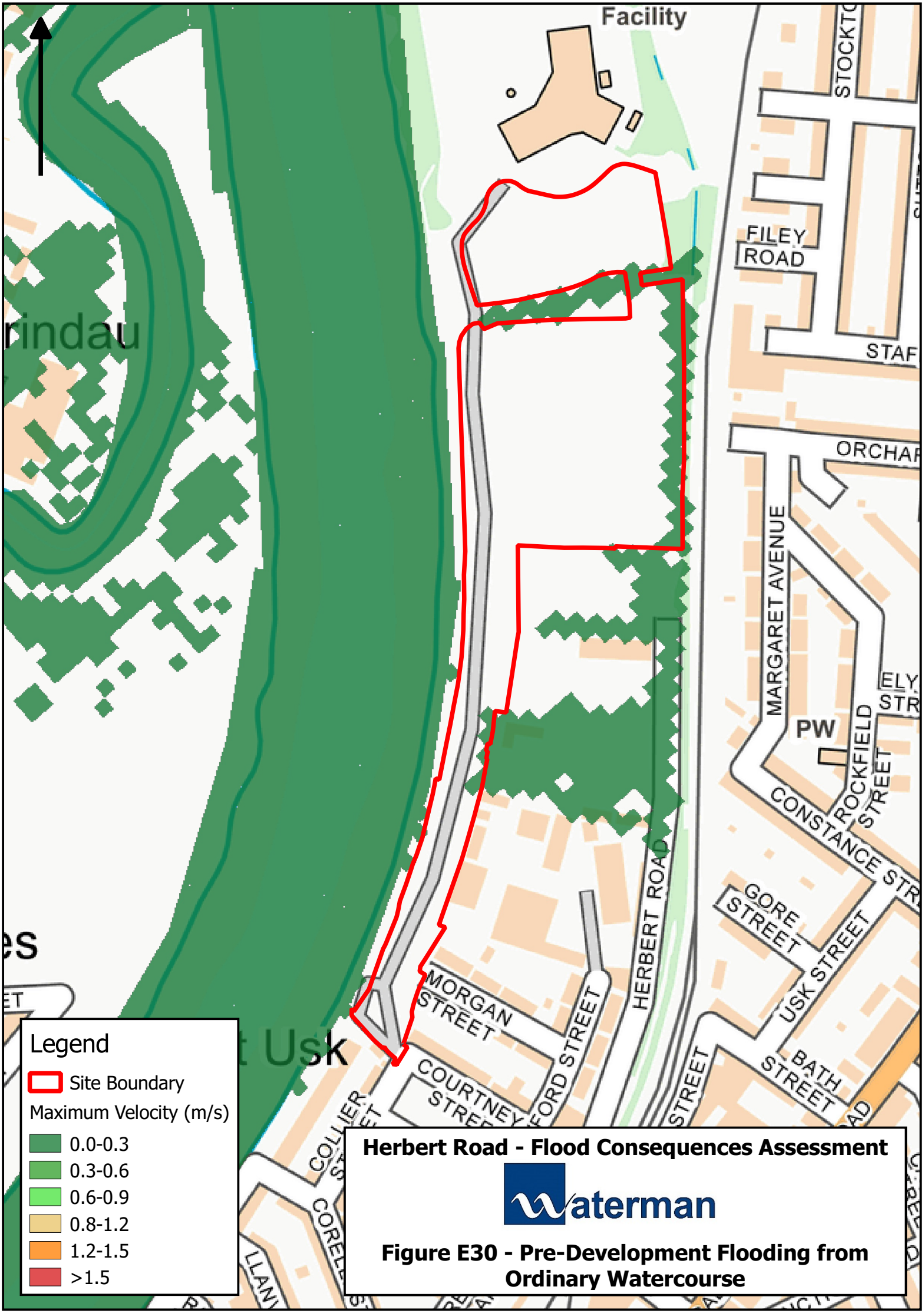

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Figure E30 - Pre-Development Flooding from Ordinary Watercourse

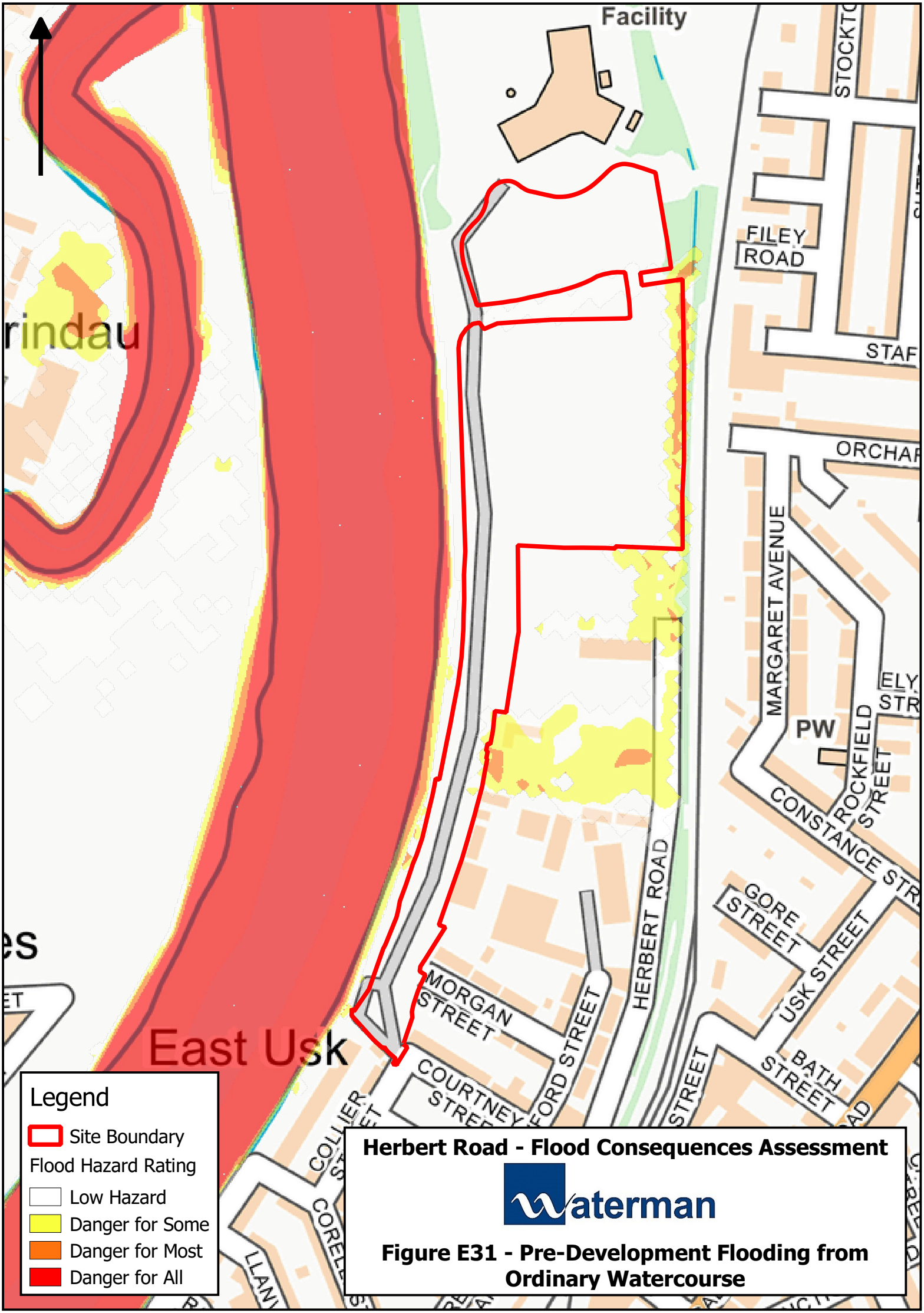

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Figure E31 - Pre-Development Flooding from Ordinary Watercourse

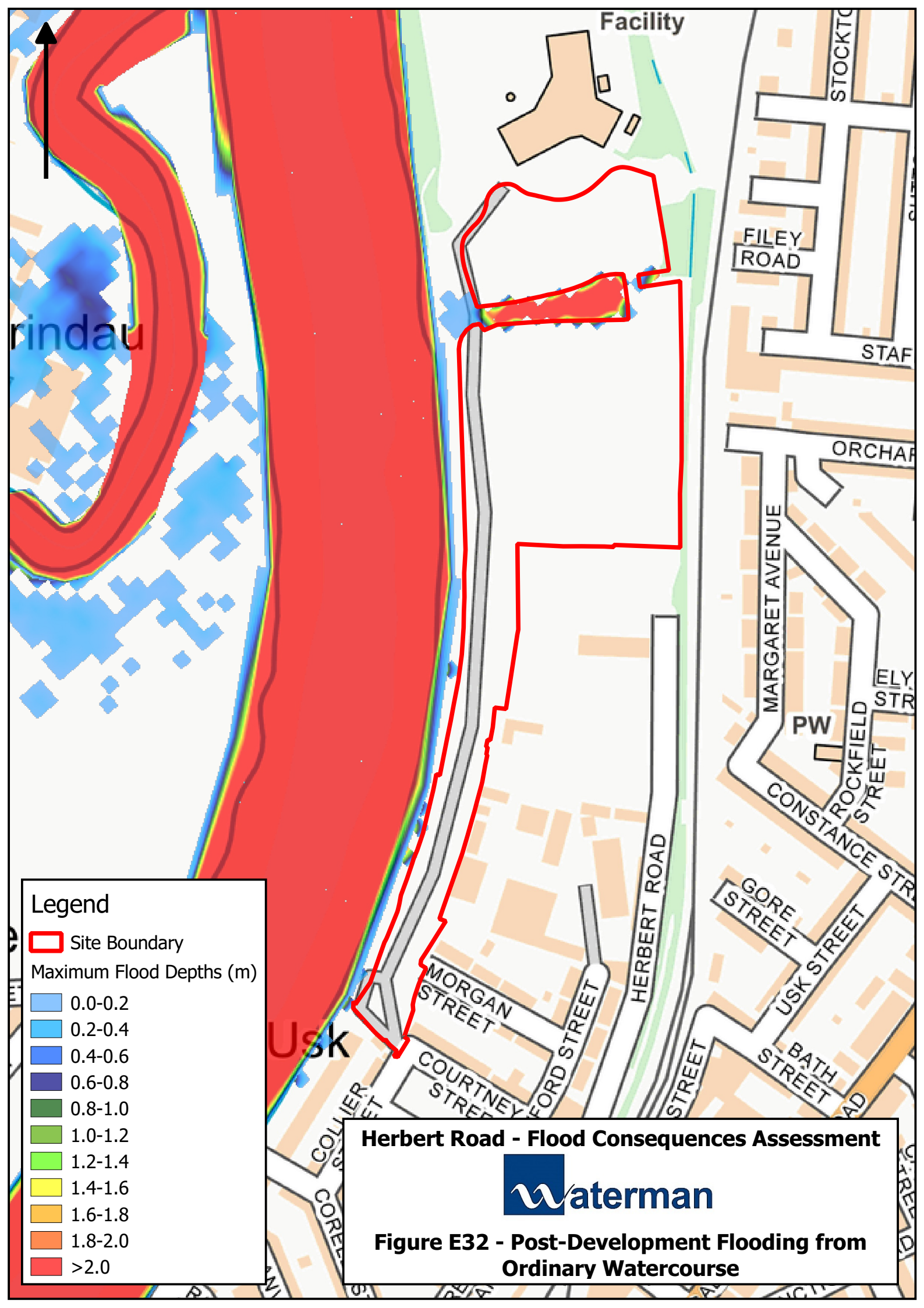

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Figure E32 - Post-Development Flooding from Ordinary Watercourse

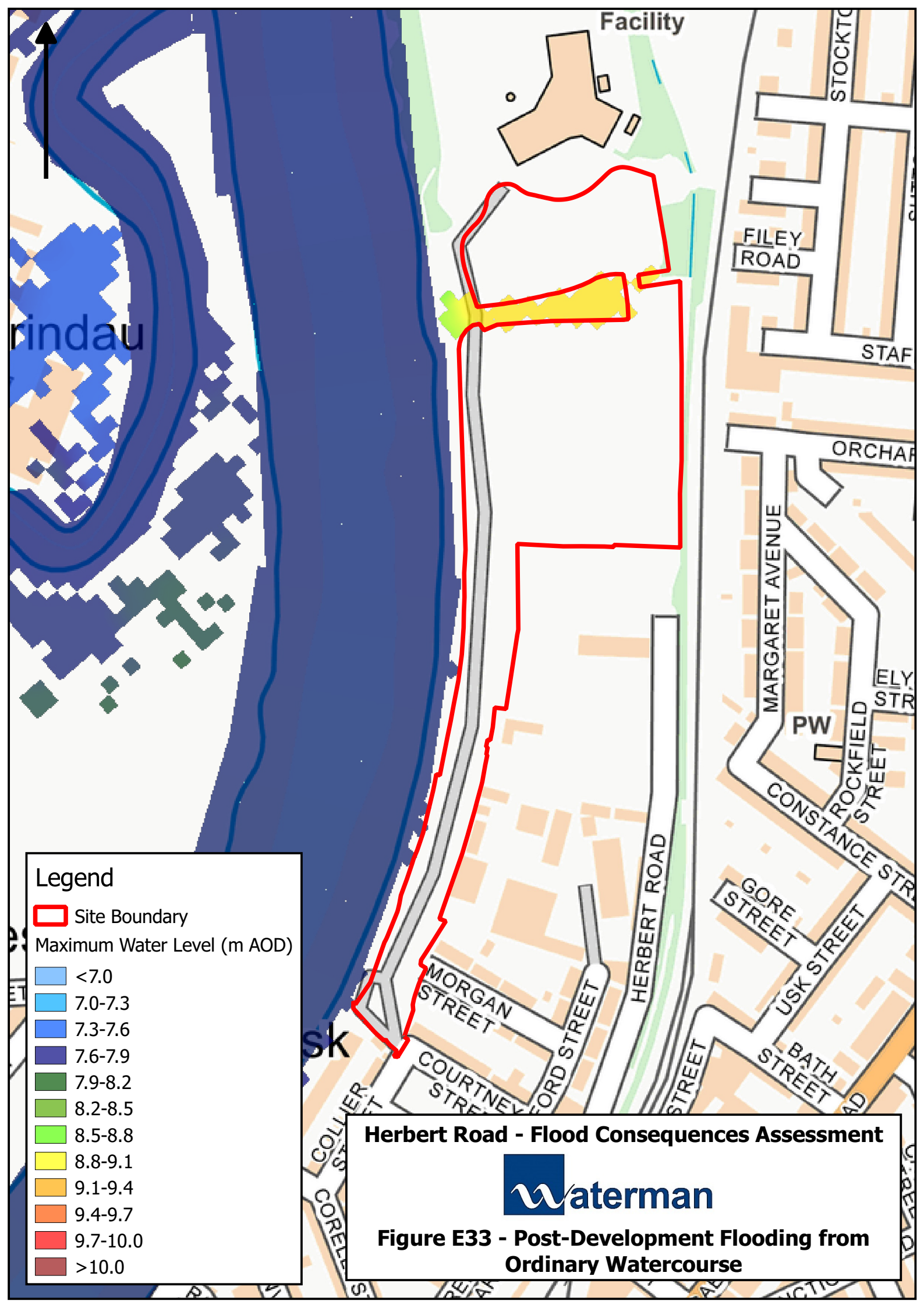

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Figure E33 - Post-Development Flooding from Ordinary Watercourse

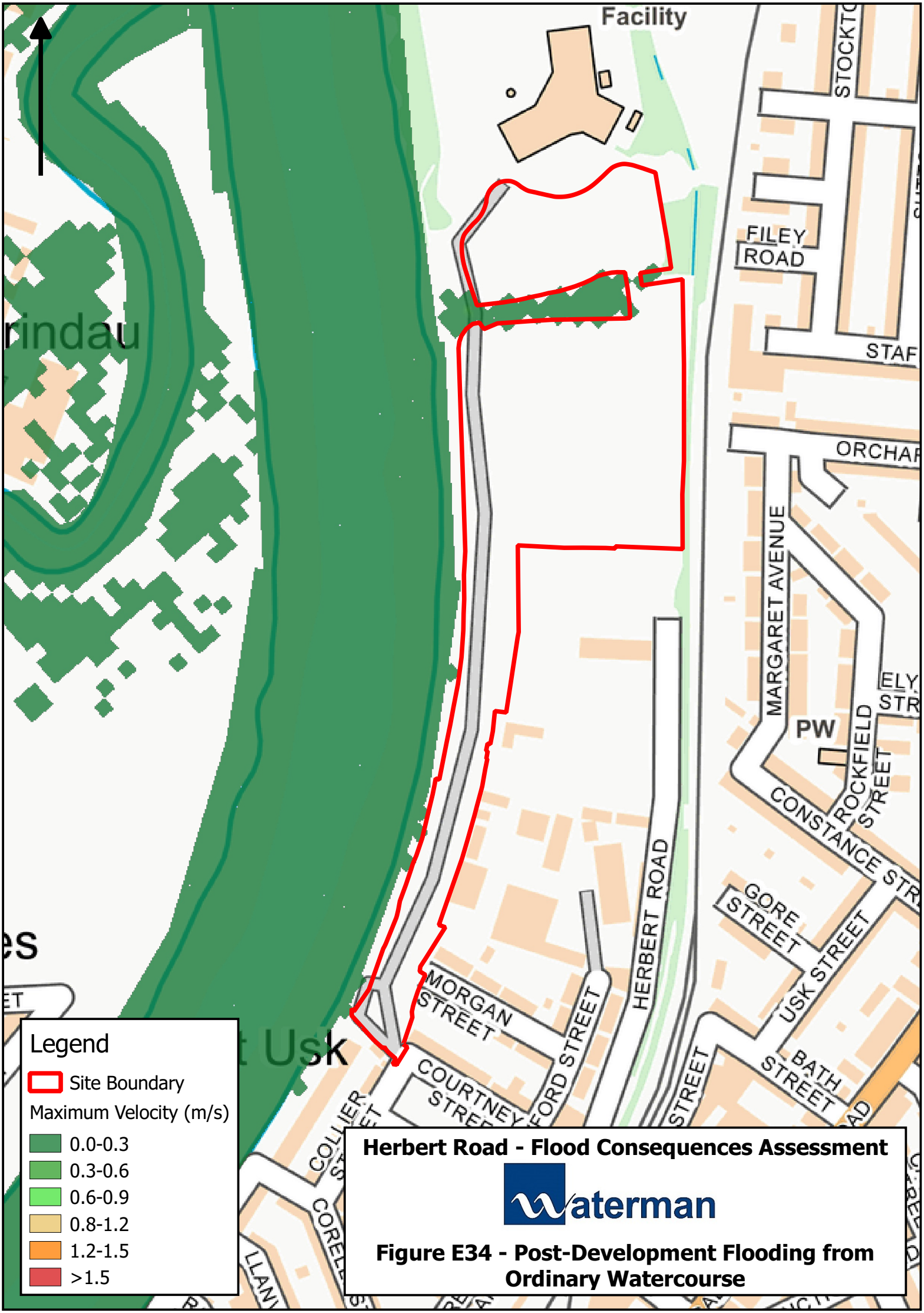

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Figure E34 - Post-Development Flooding from Ordinary Watercourse

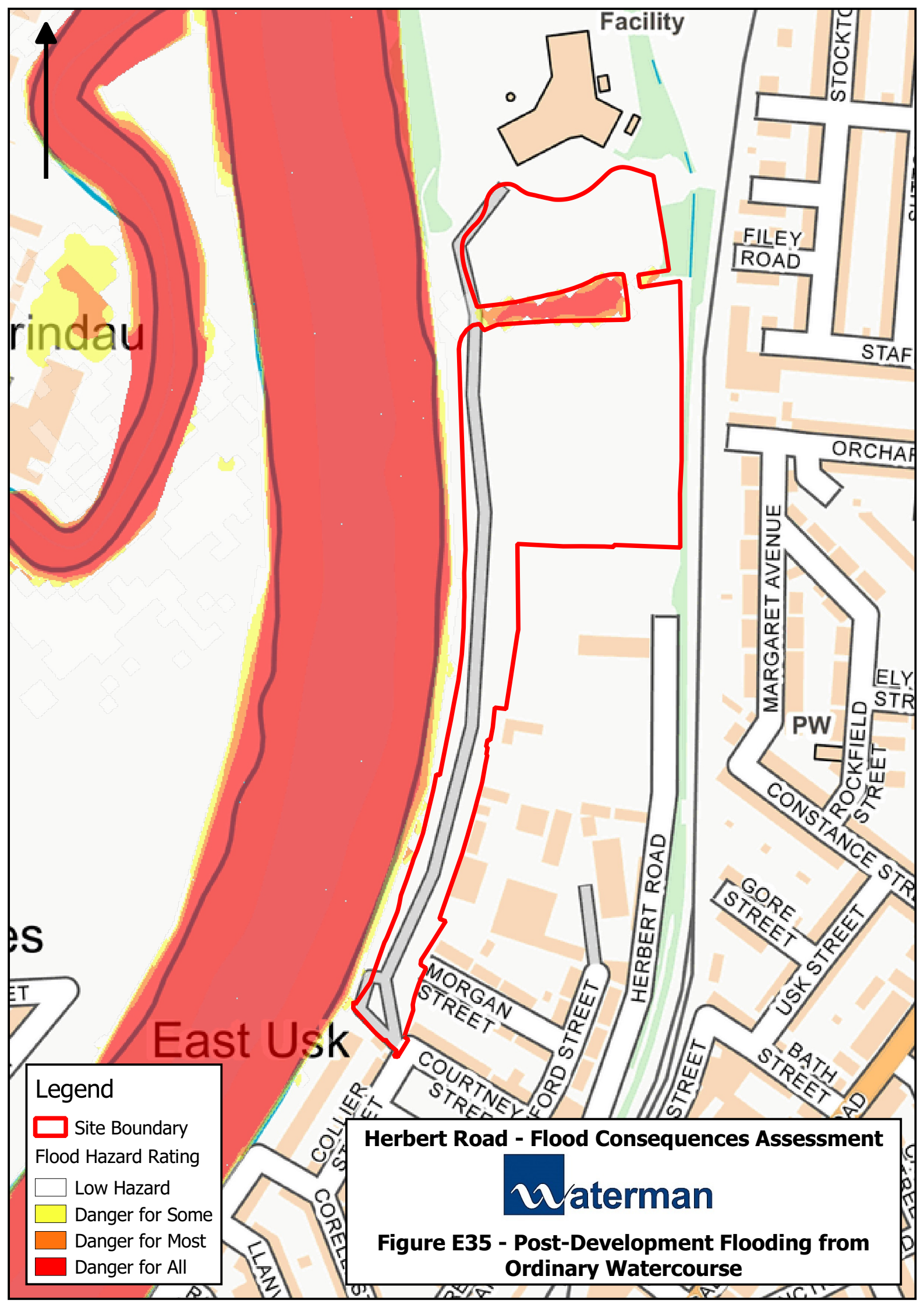

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Figure E35 - Post-Development Flooding from Ordinary Watercourse

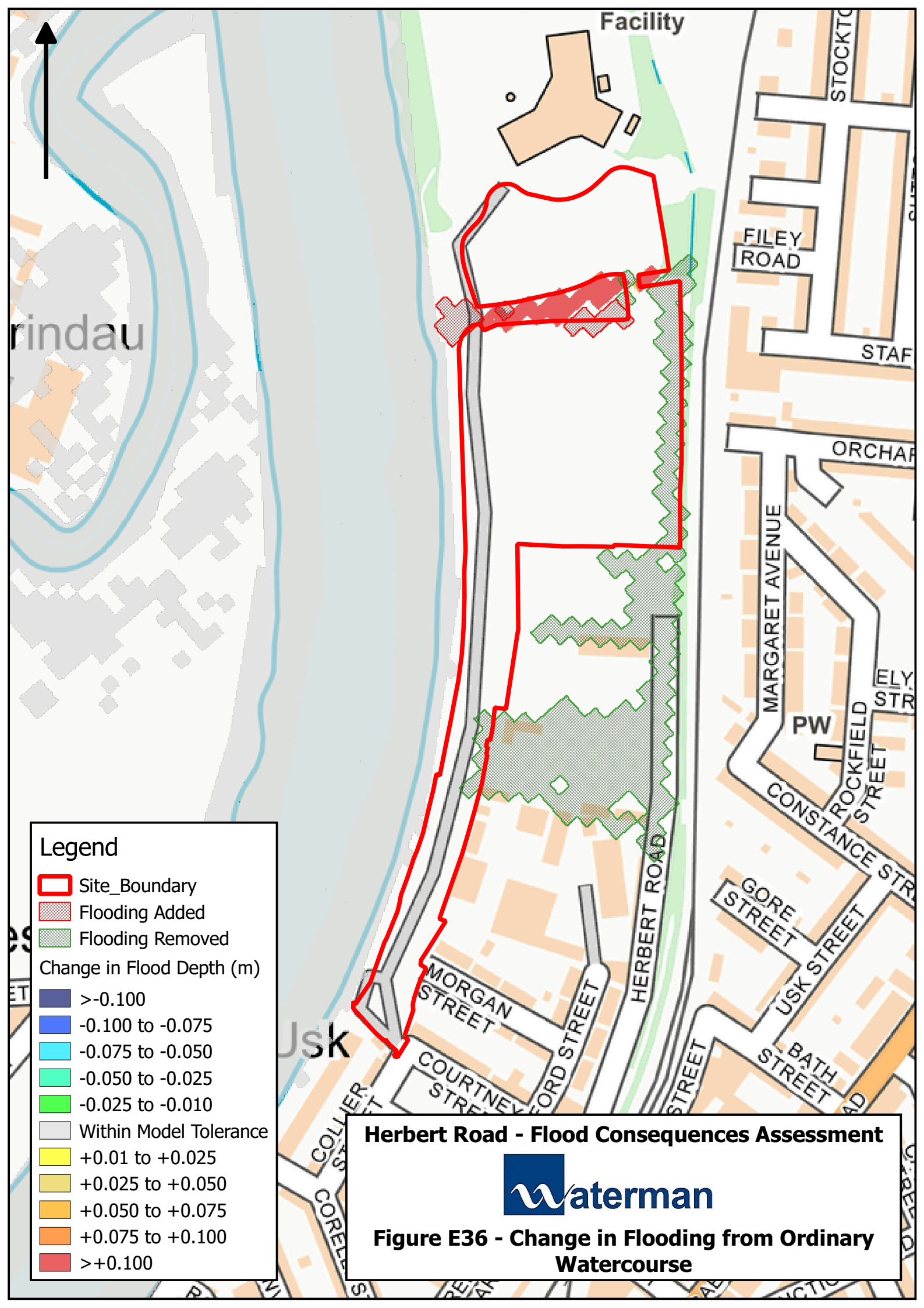

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Figure E36 - Change in Flooding from Ordinary Watercourse

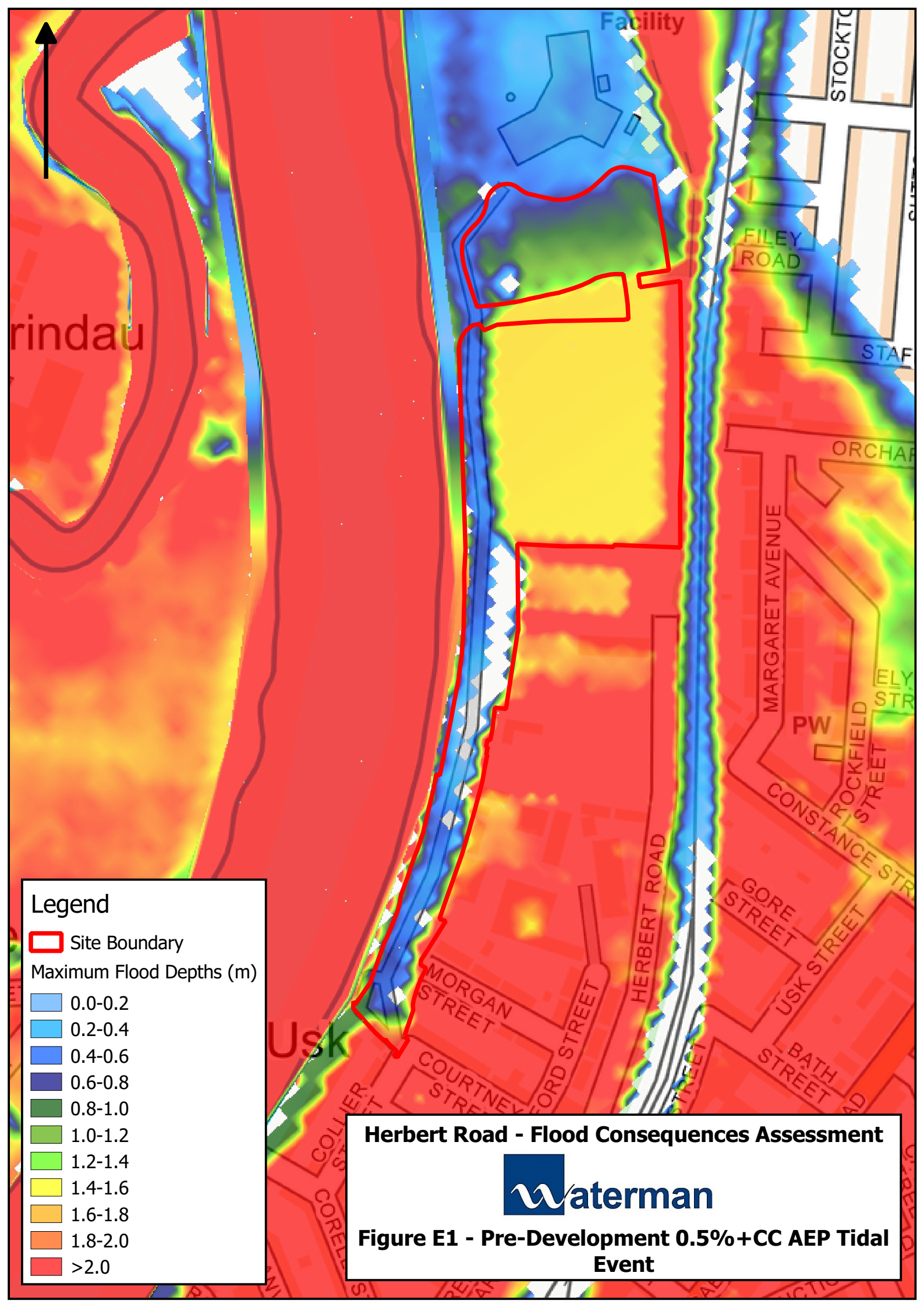

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Figure E1 - Pre-Development 0.5%+CC AEP Tidal Event

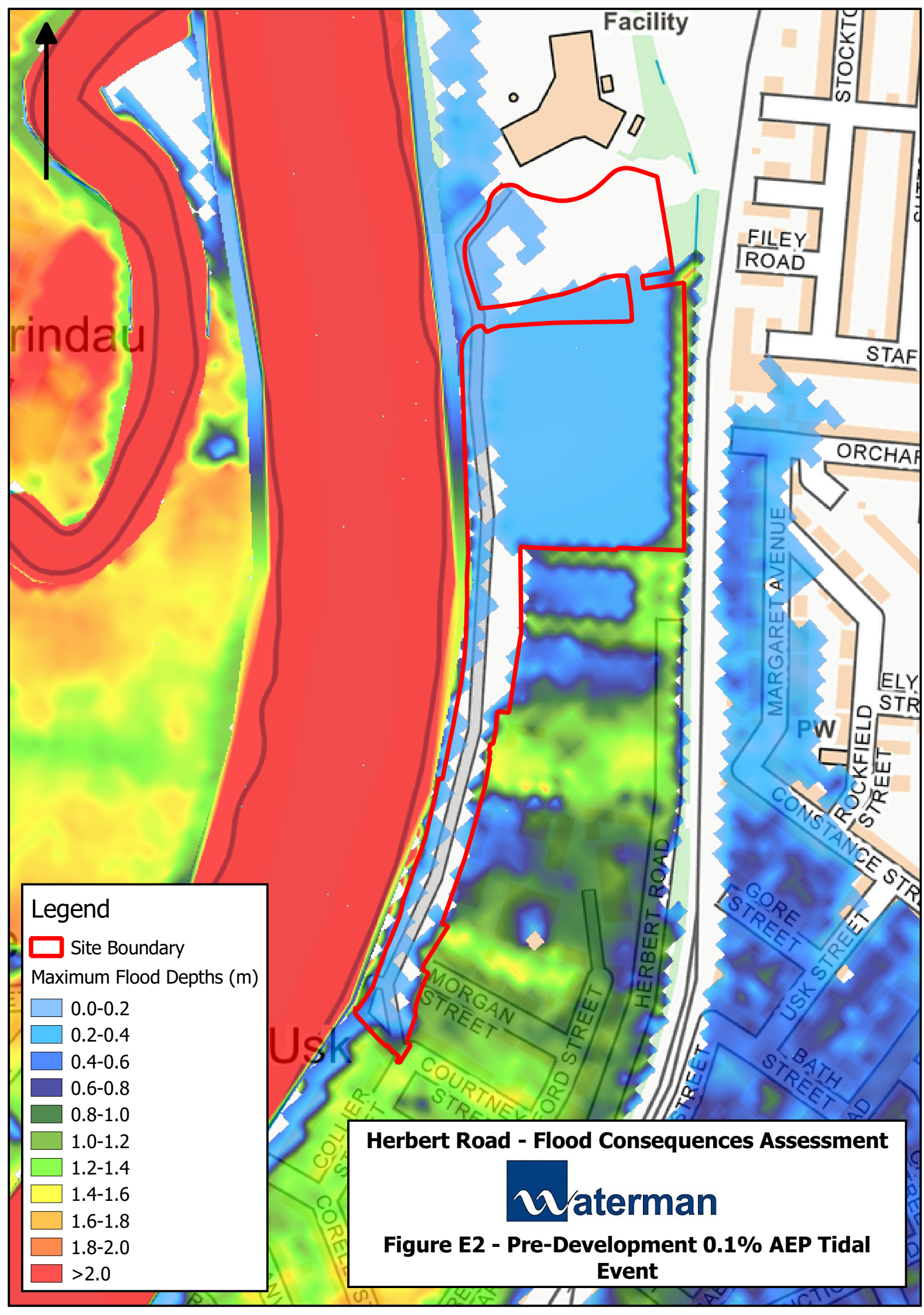

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Figure E2 - Pre-Development 0.1% AEP Tidal Event

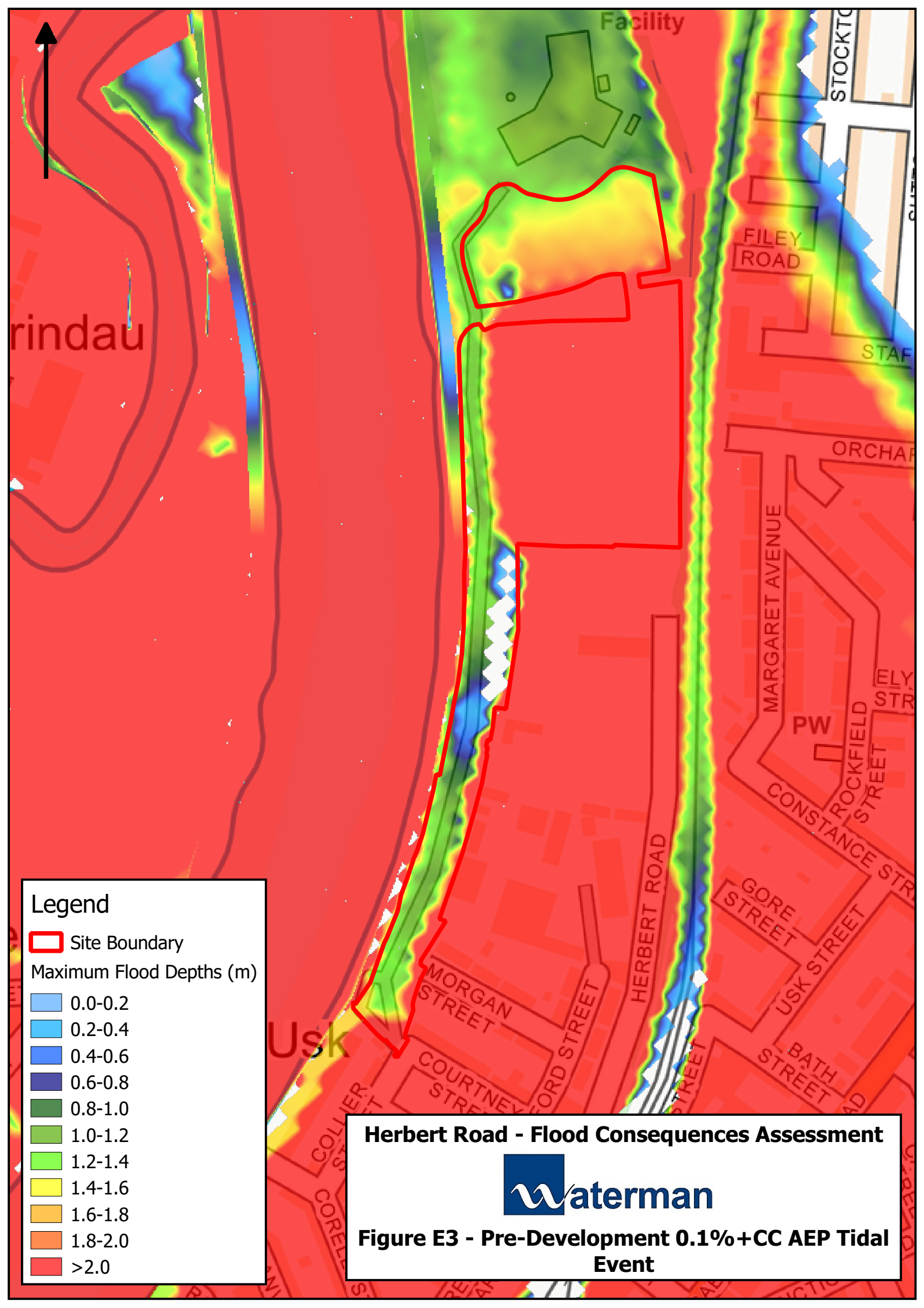

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Figure E3 - Pre-Development 0.1%+CC AEP Tidal Event

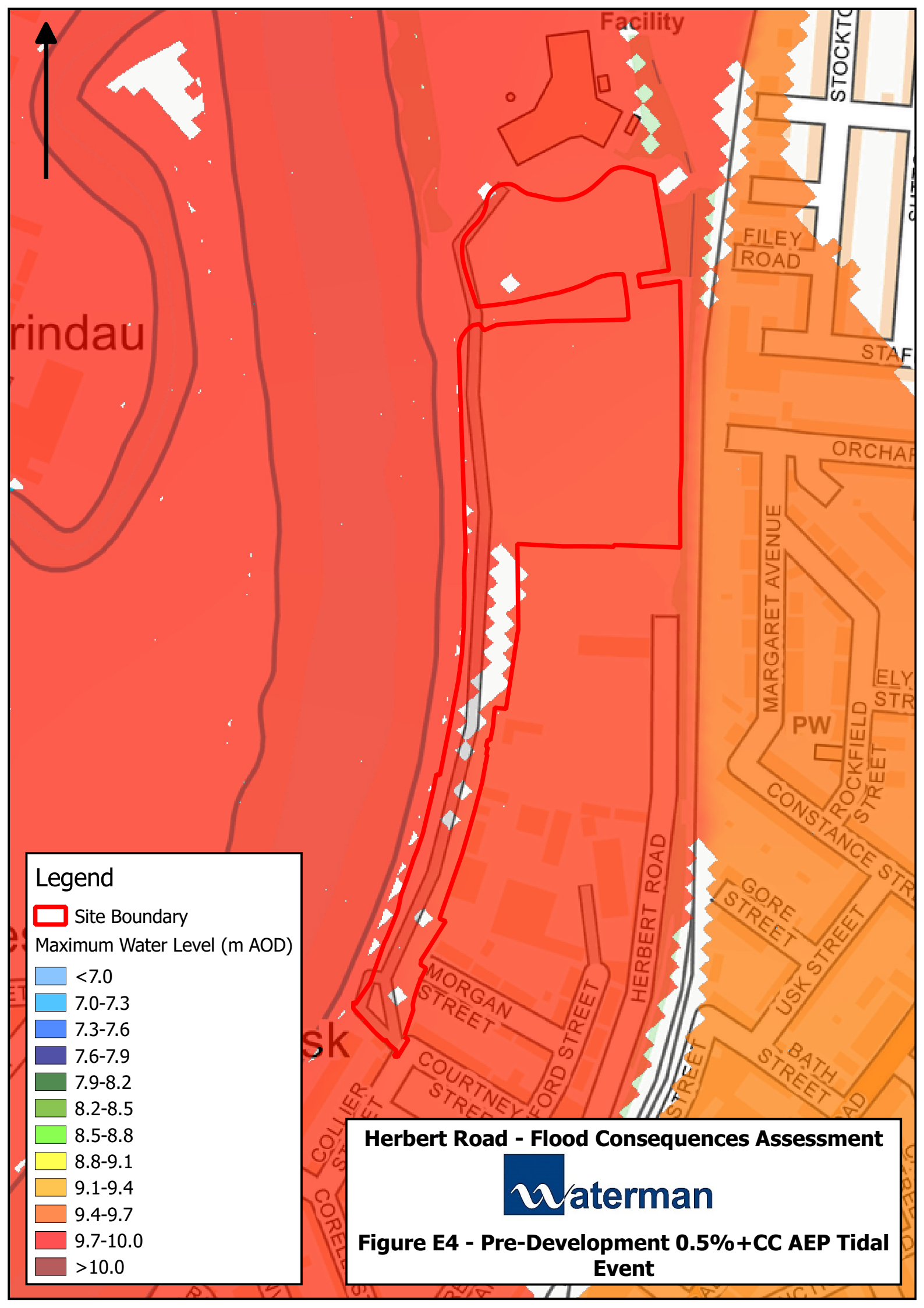

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Figure E4 - Pre-Development 0.5%+CC AEP Tidal Event

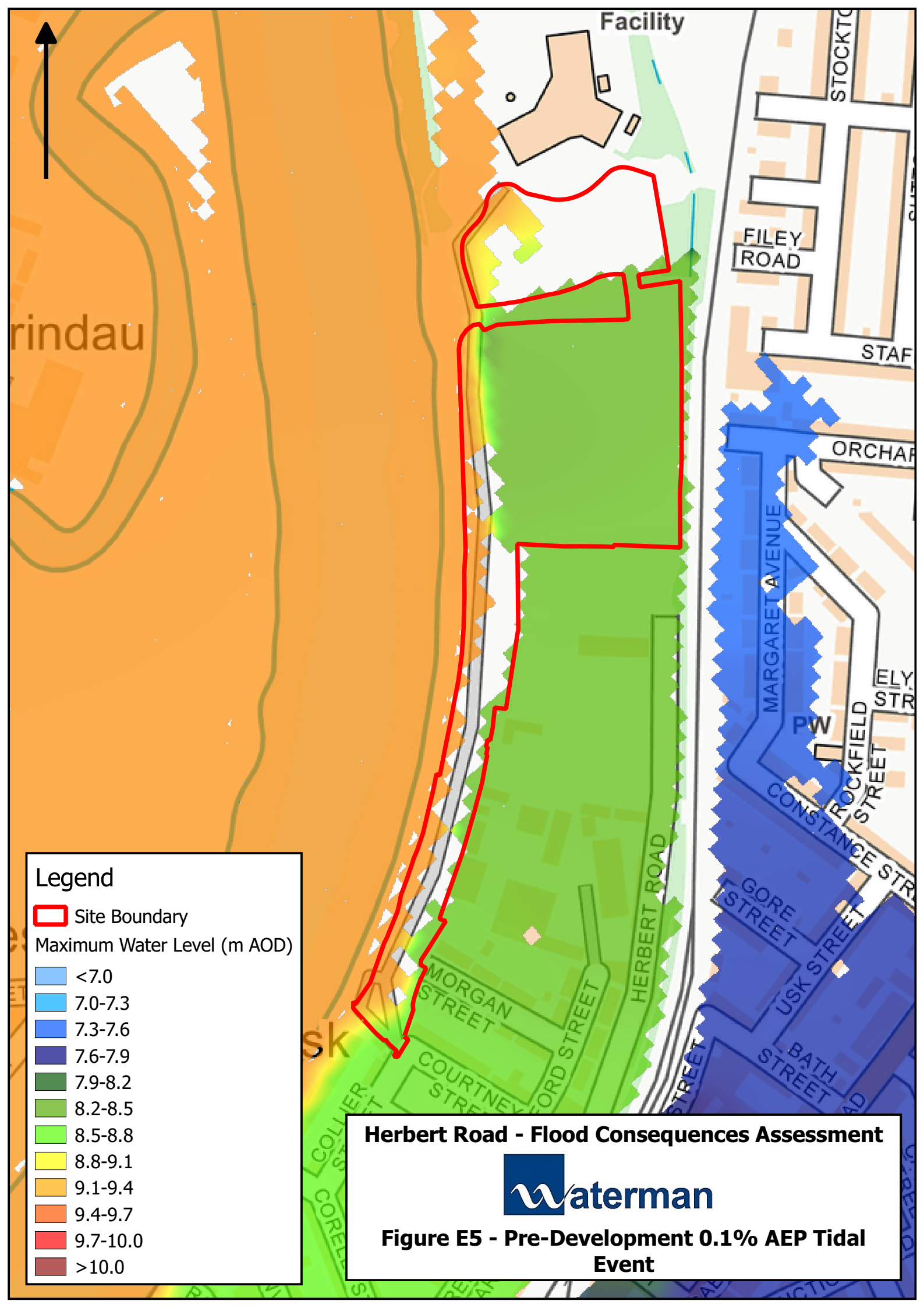

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Figure E5 - Pre-Development 0.1% AEP Tidal Event

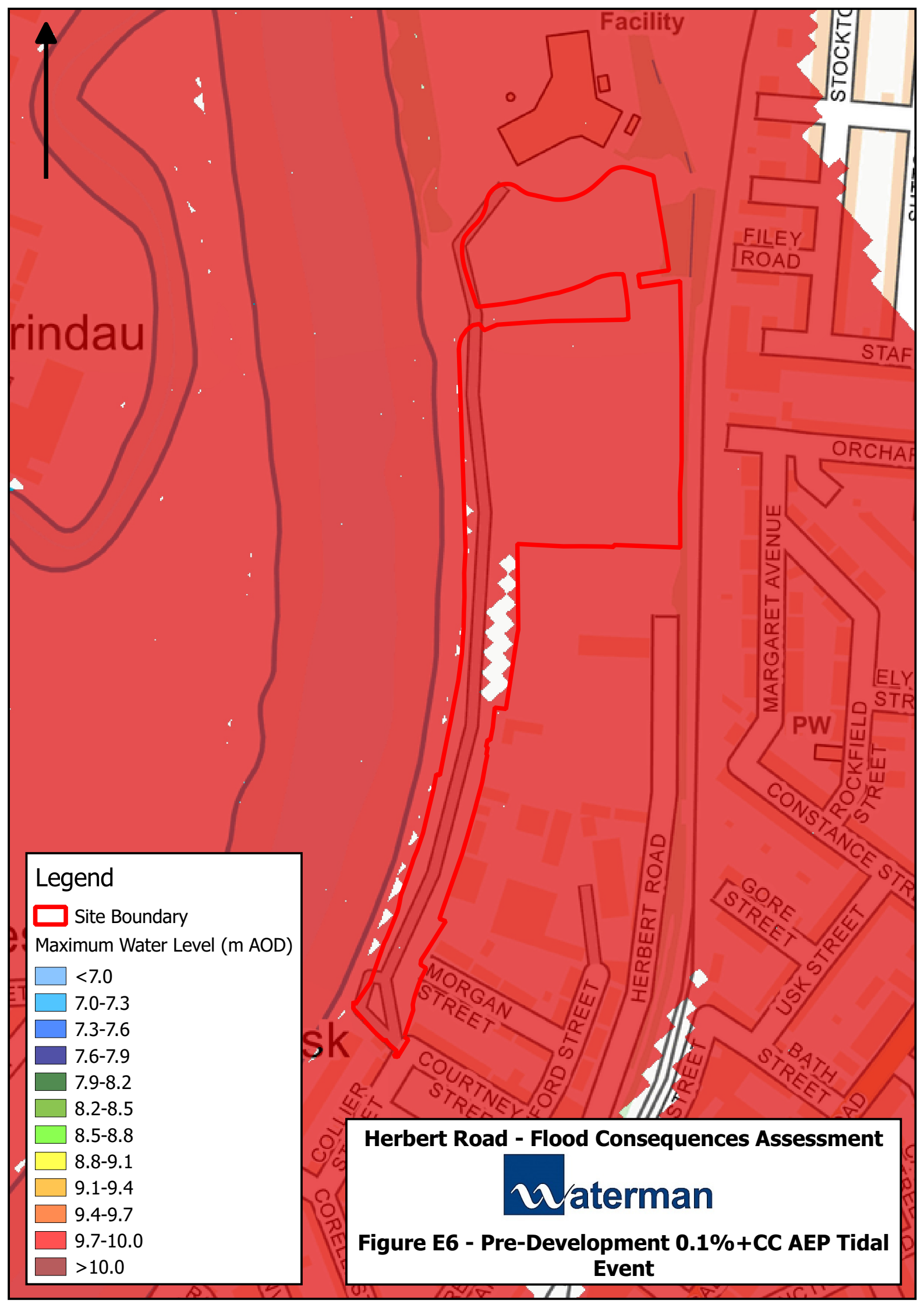

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Figure E6 - Pre-Development 0.1%+CC AEP Tidal Event

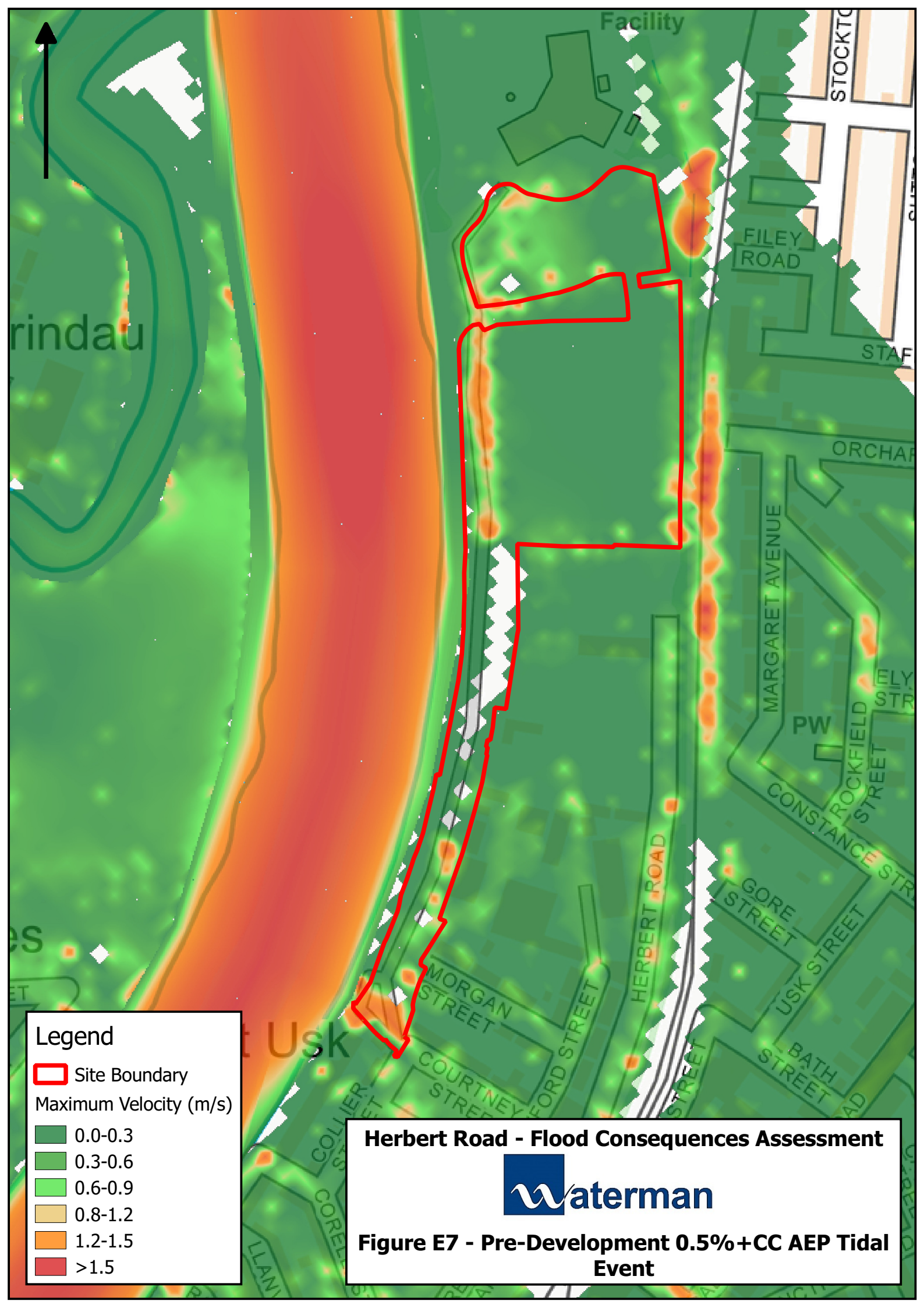

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Figure E7 - Pre-Development 0.5%+CC AEP Tidal Event

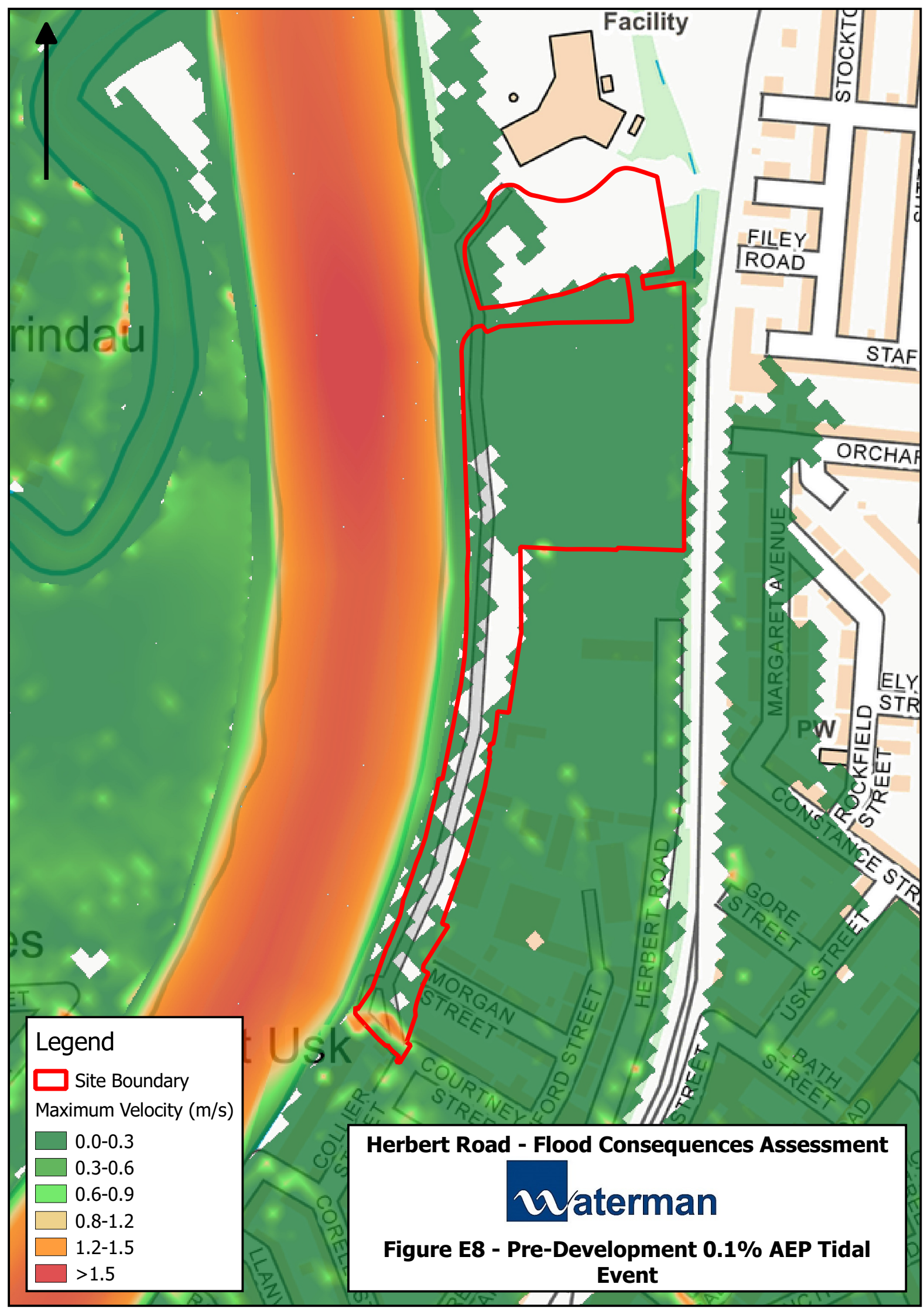

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Figure E8 - Pre-Development 0.1% AEP Tidal Event

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Figure E9 - Pre-Development 0.1%+CC AEP Tidal Event

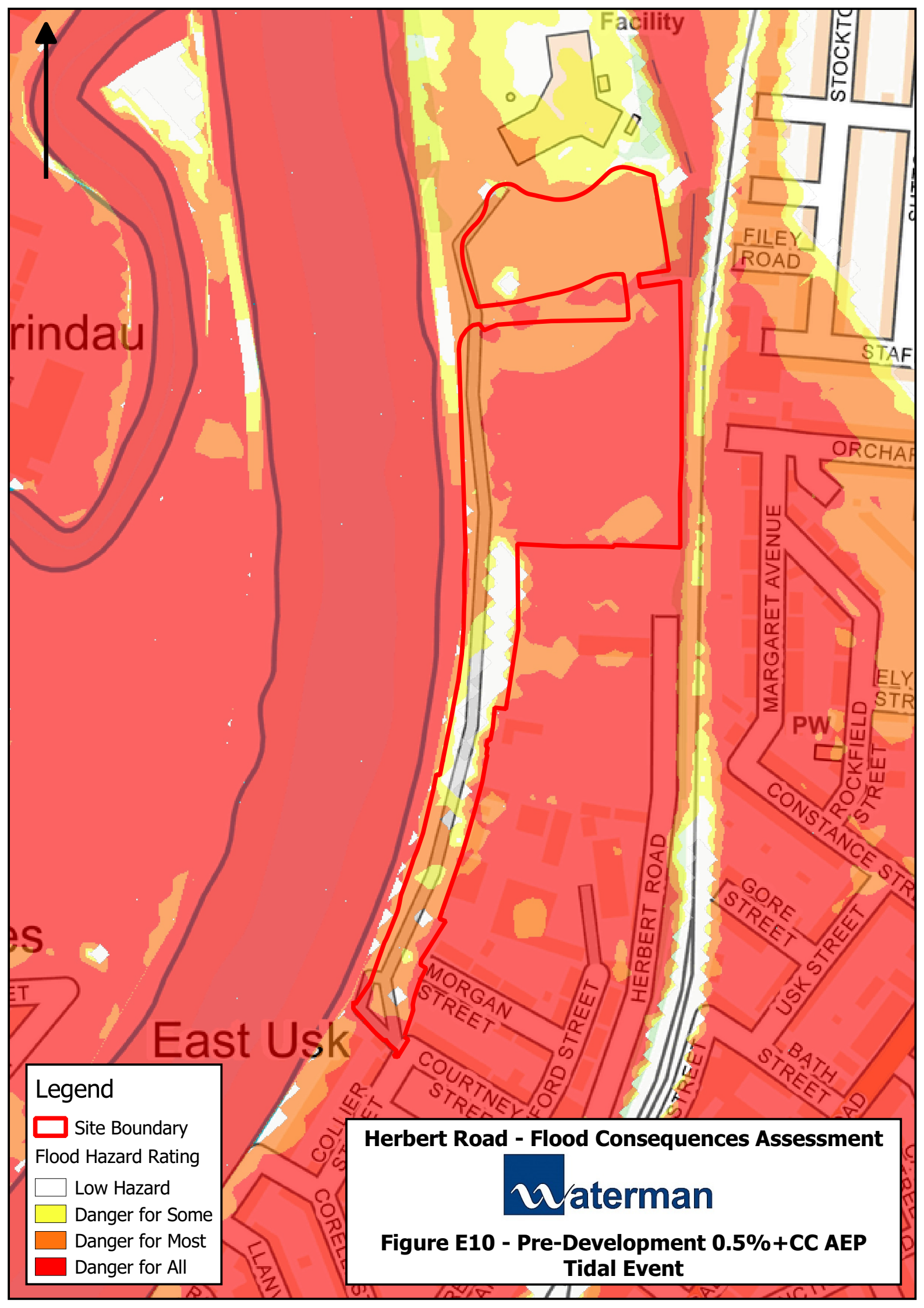

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Figure E10 - Pre-Development 0.5%+CC AEP Tidal Event

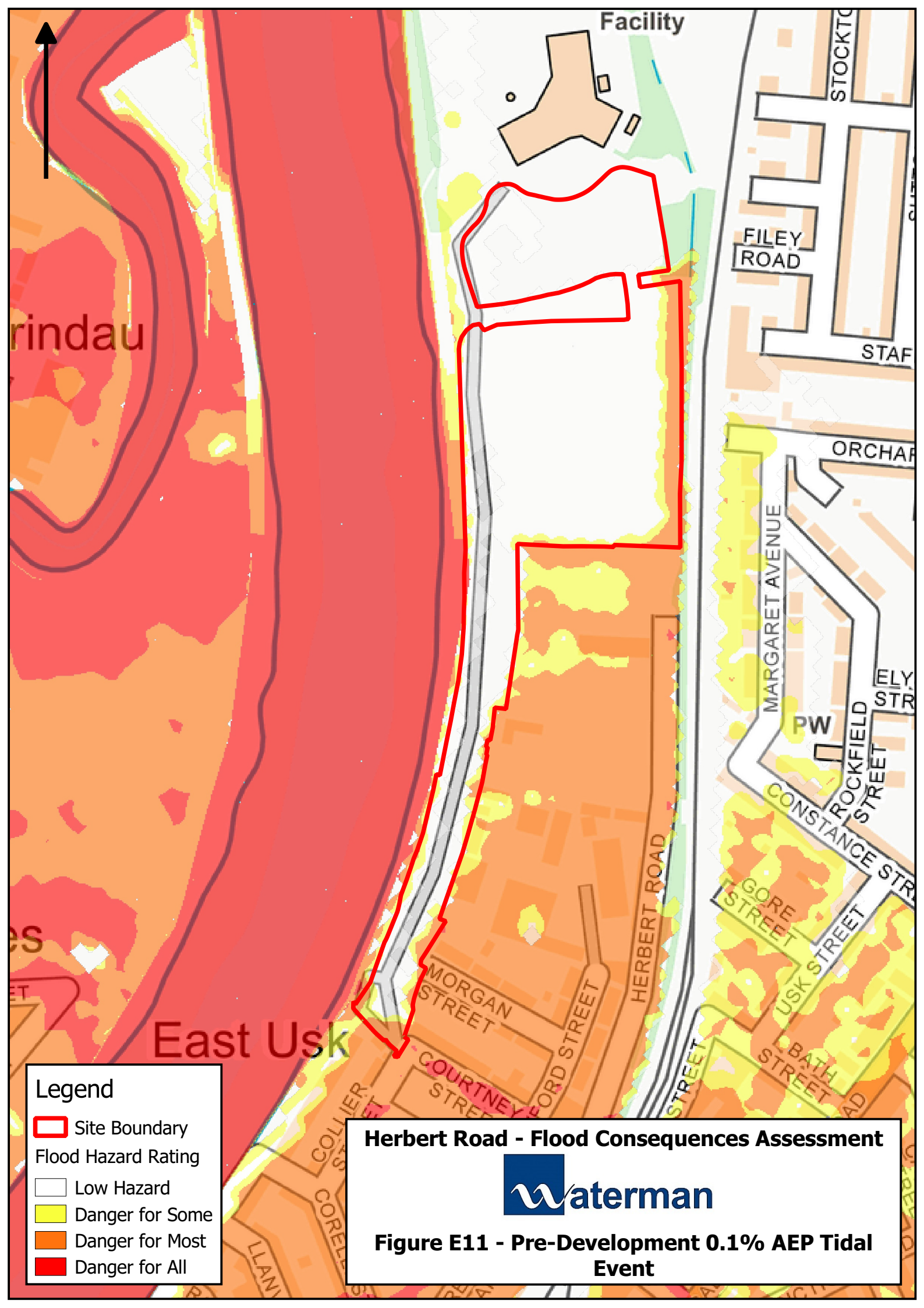

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Figure E11 - Pre-Development 0.1% AEP Tidal Event

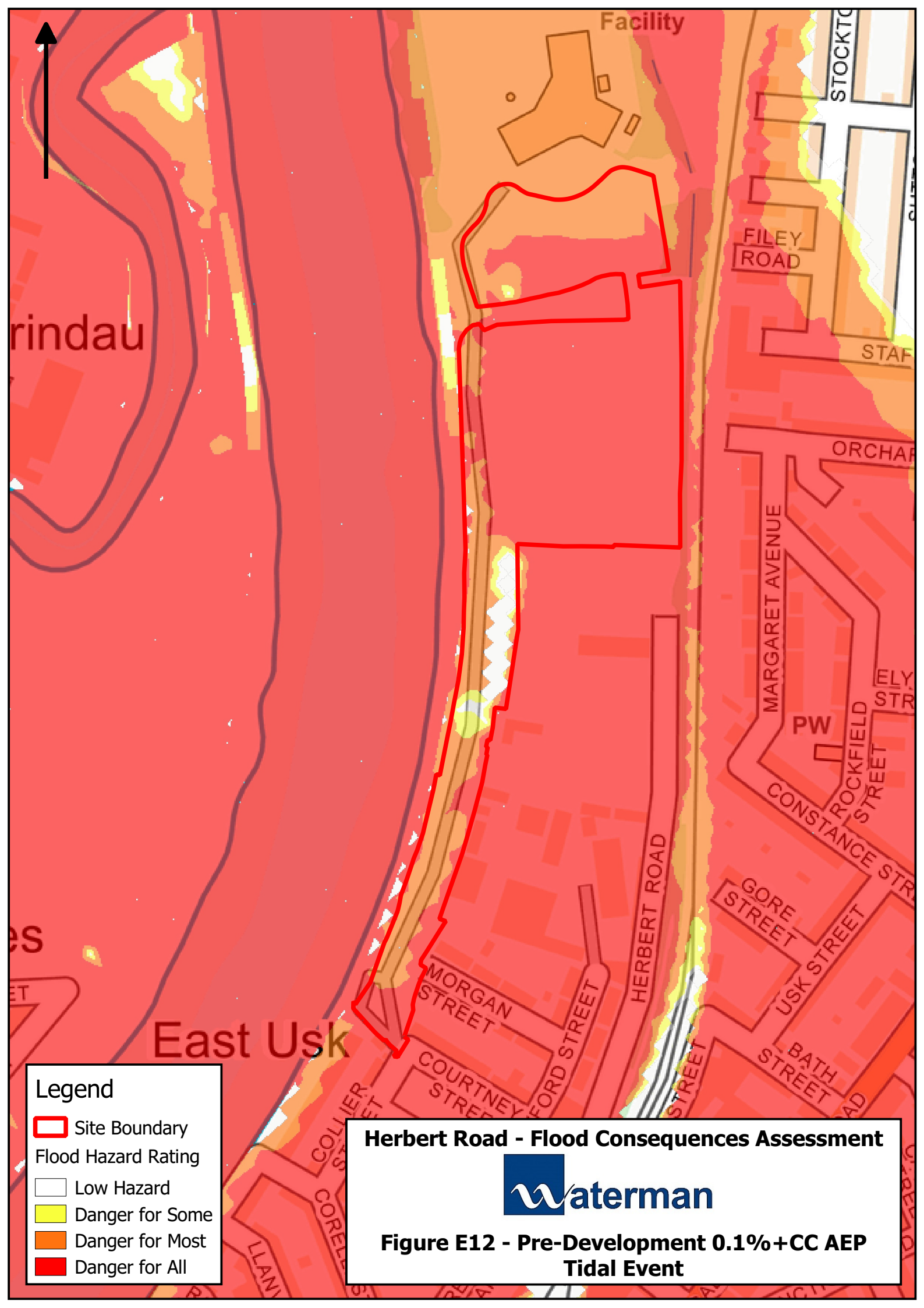

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Figure E12 - Pre-Development 0.1%+CC AEP Tidal Event

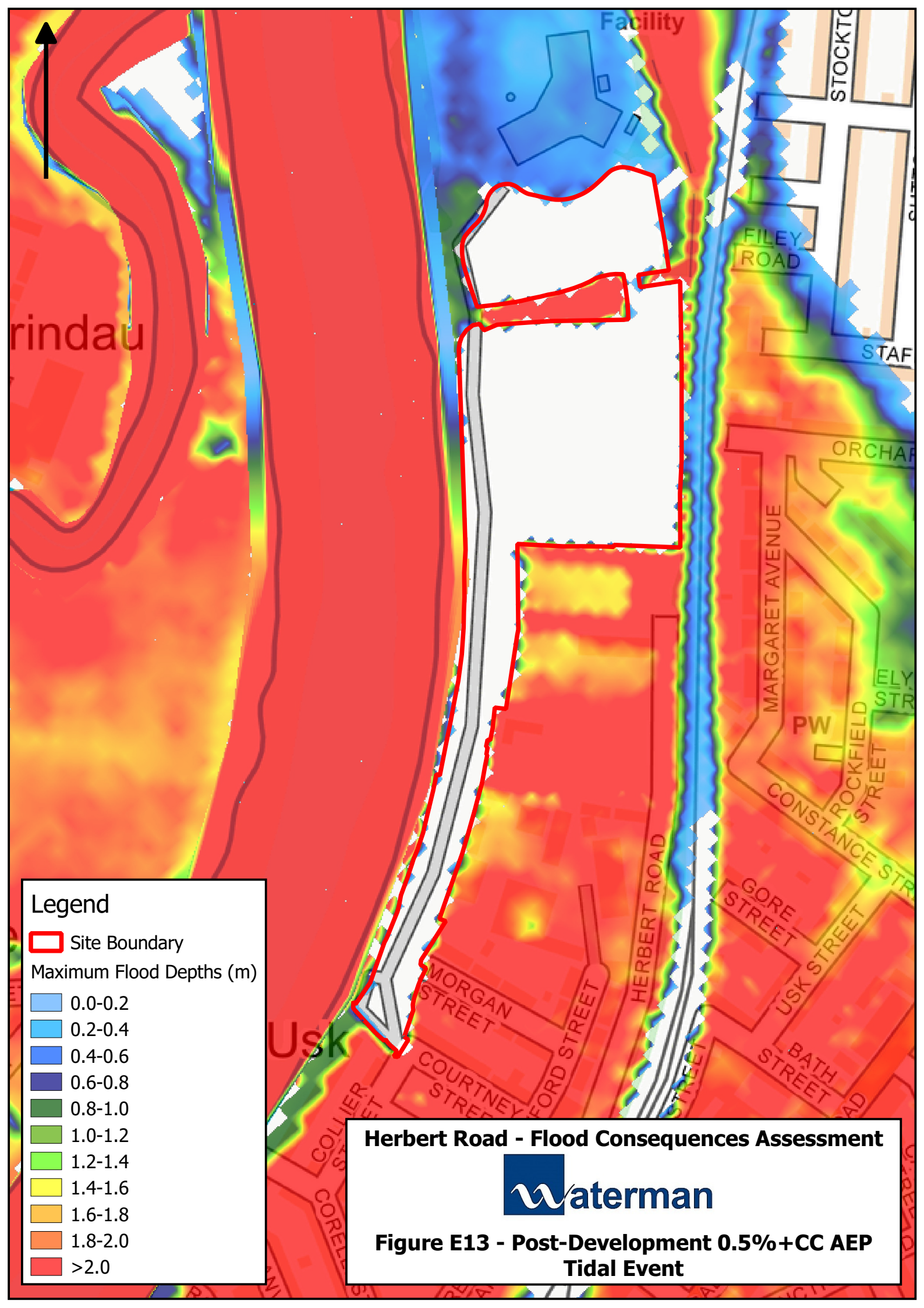

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Figure E13 - Post-Development 0.5%+CC AEP Tidal Event

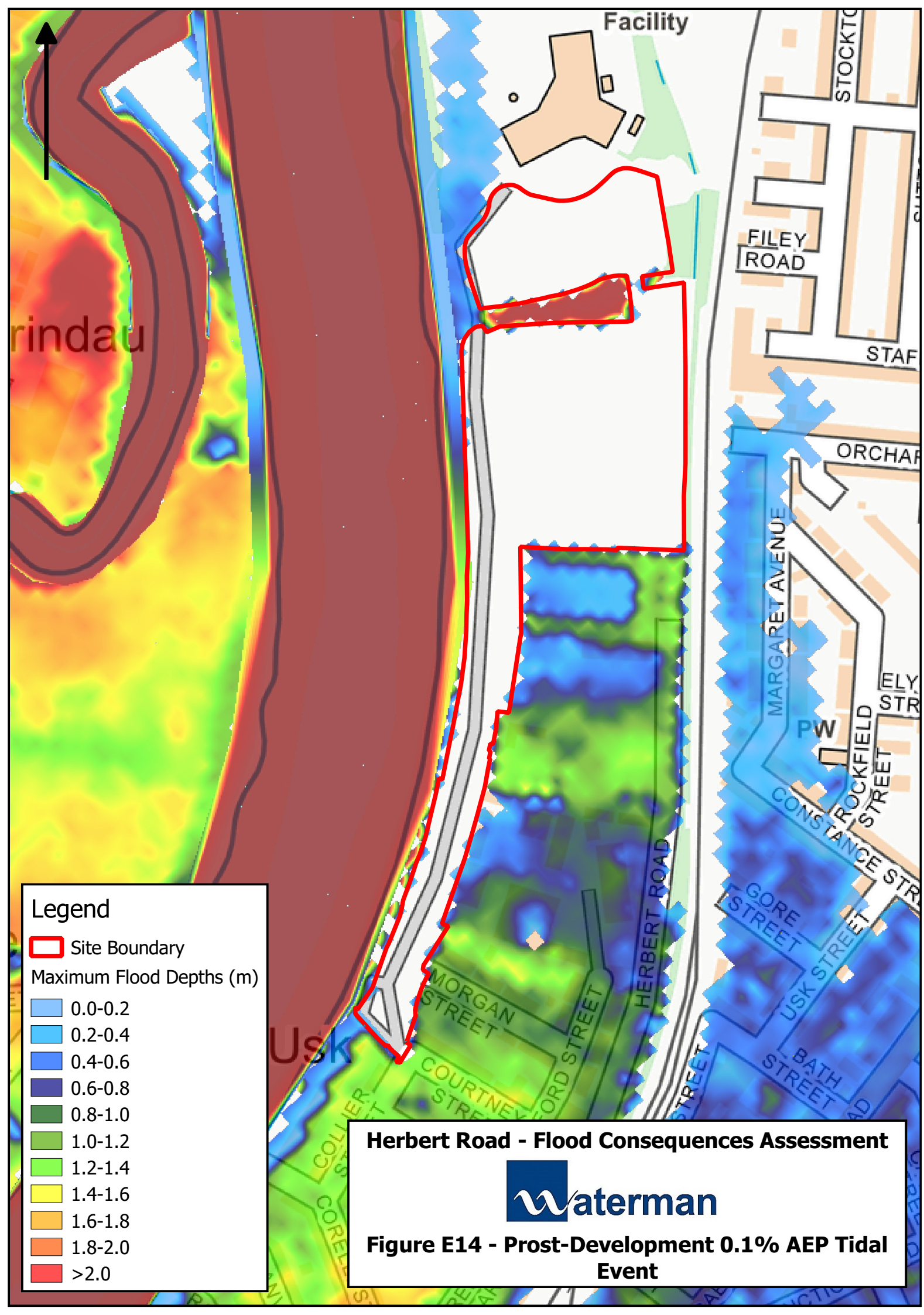

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Figure E14 - Prost-Development 0.1% AEP Tidal Event

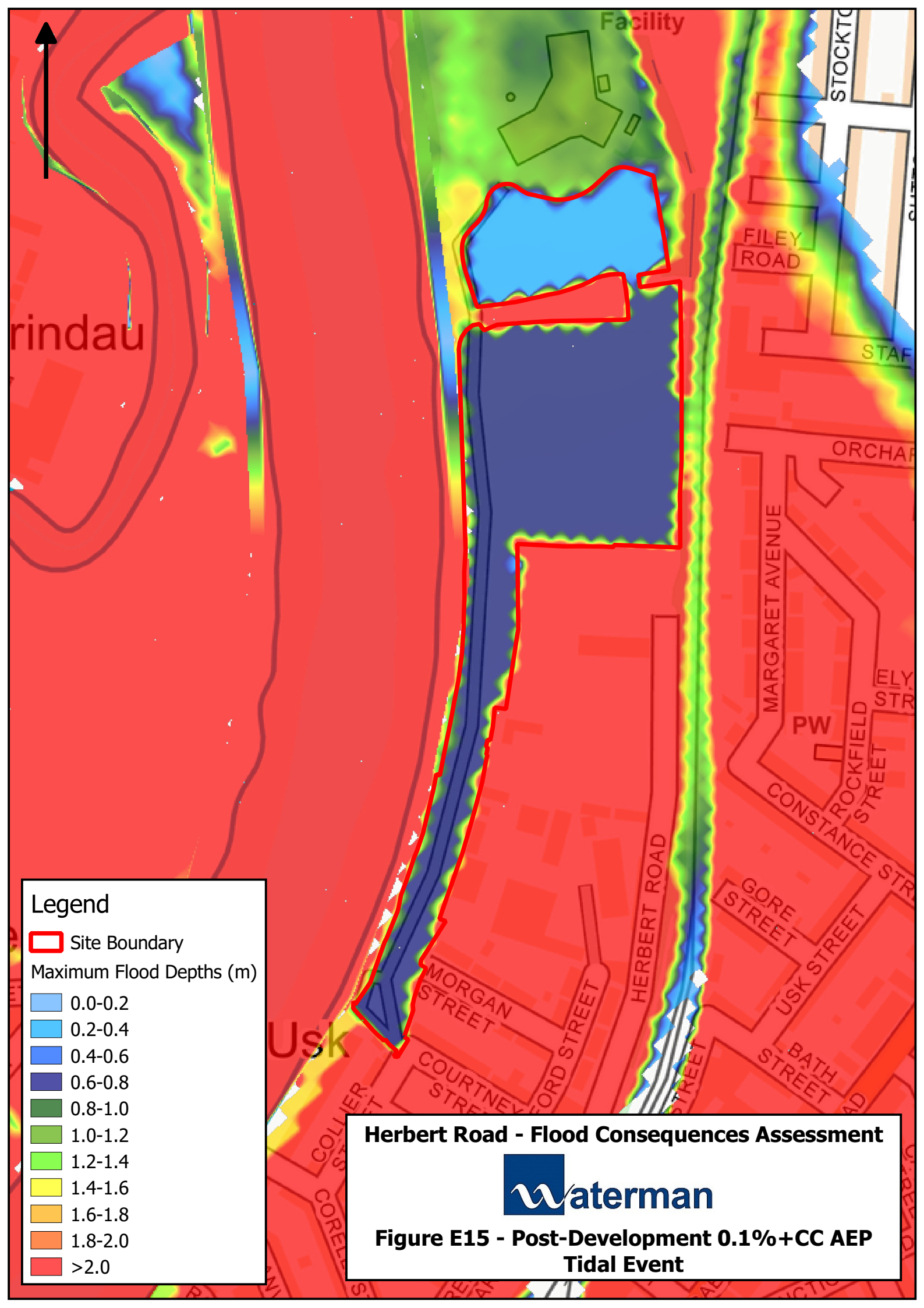

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Figure E15 - Post-Development 0.1%+CC AEP Tidal Event

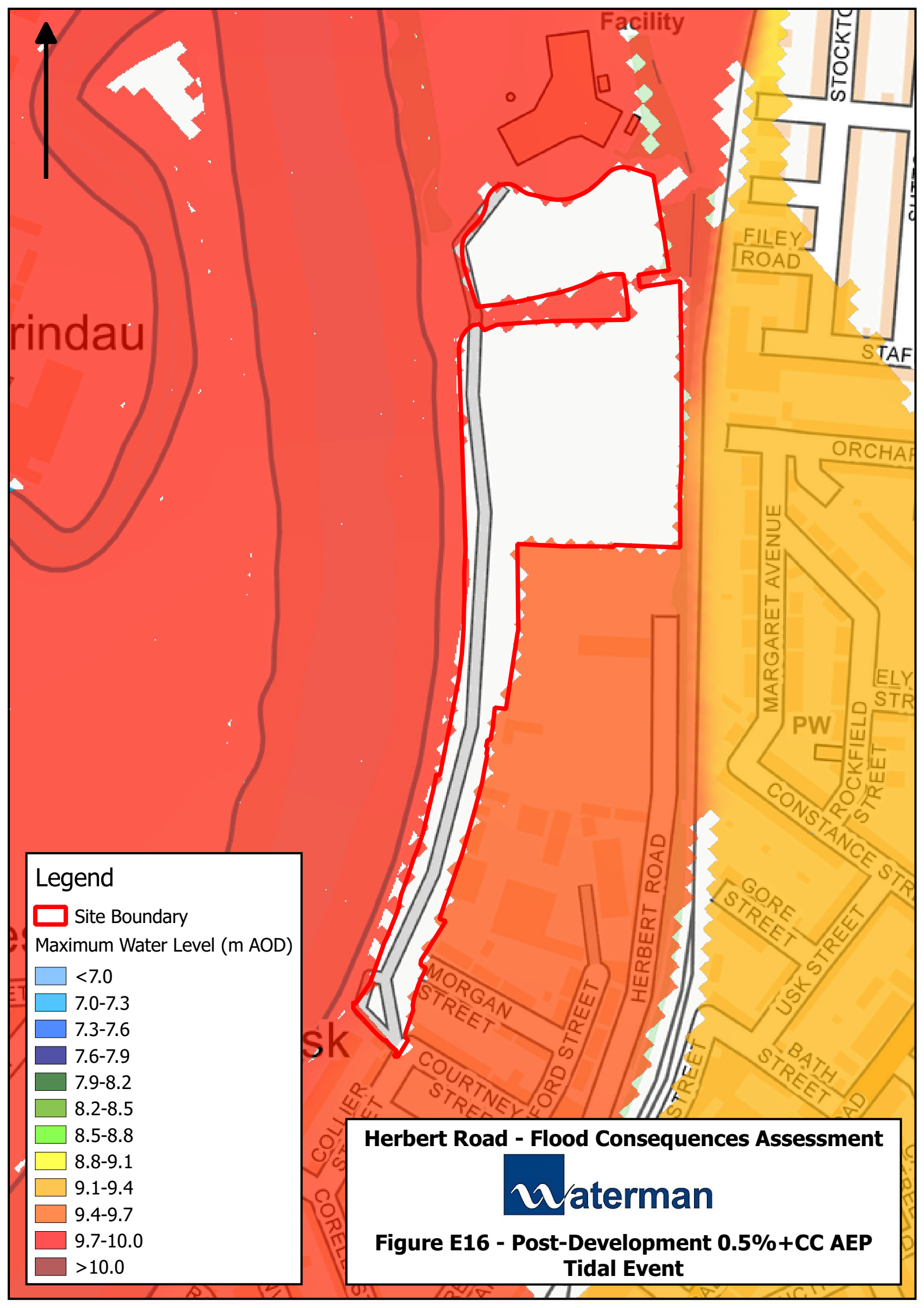

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Figure E16 - Post-Development 0.5%+CC AEP Tidal Event

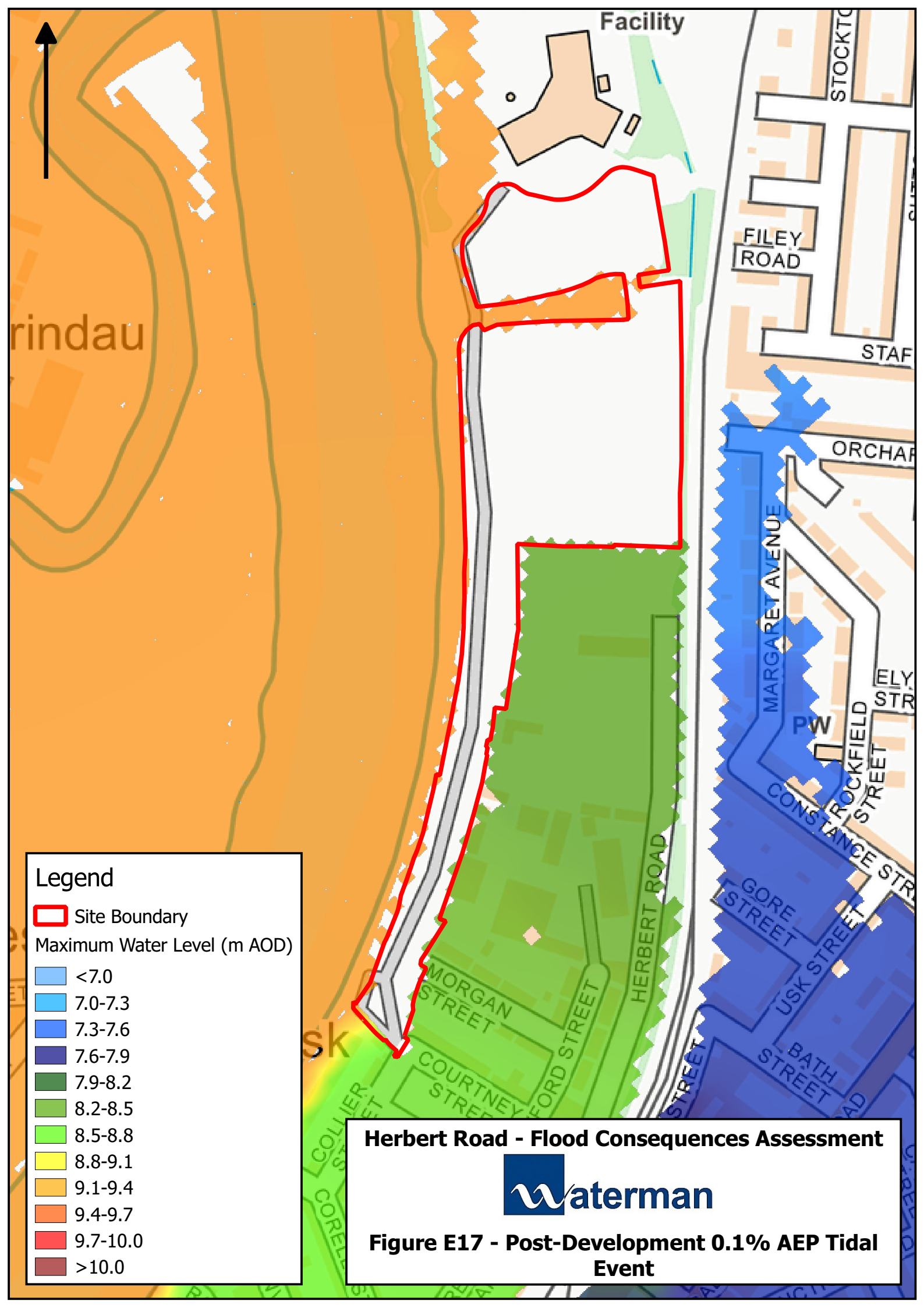

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Figure E17 - Post-Development 0.1% AEP Tidal Event

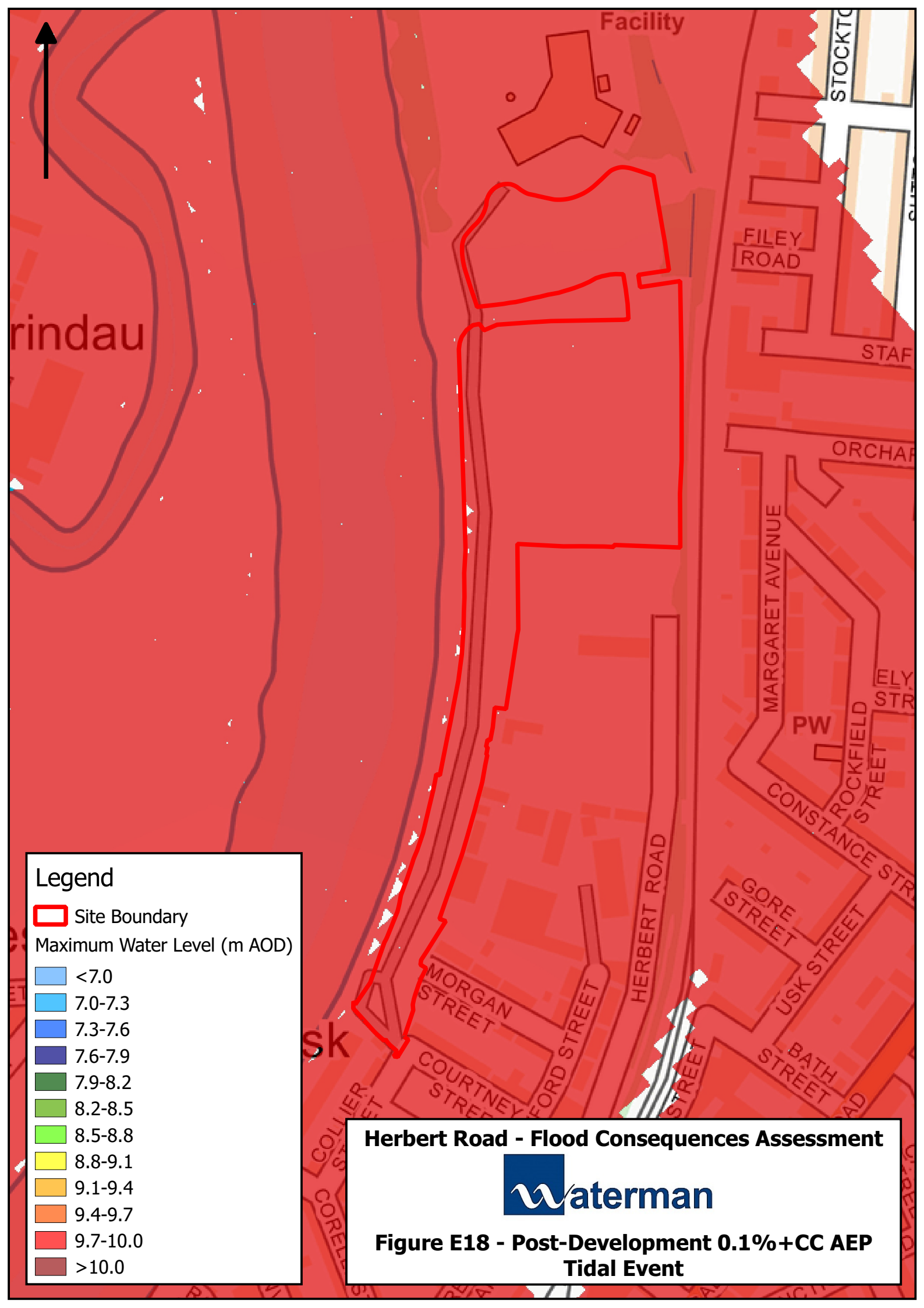

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Figure E18 - Post-Development 0.1%+CC AEP Tidal Event

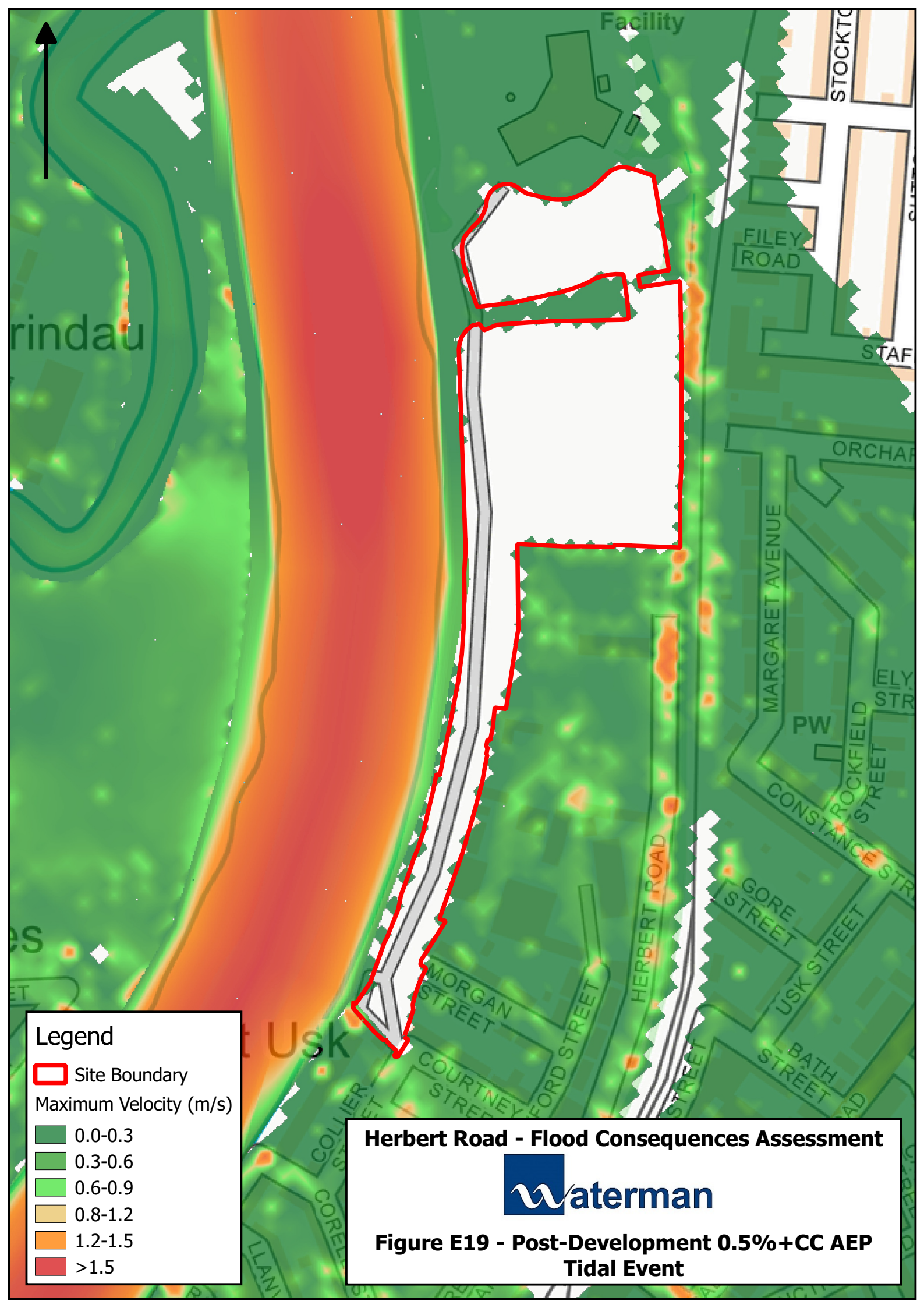

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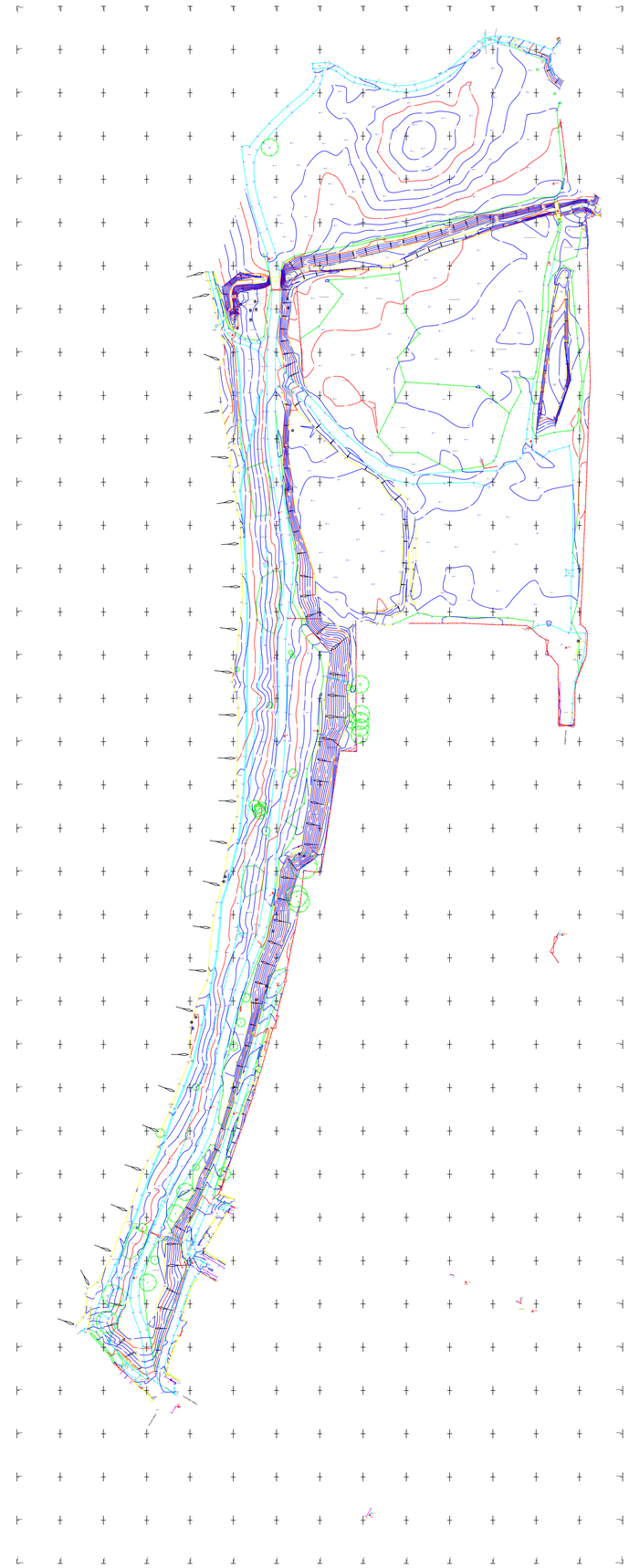
Figure E19 - Post-Development 0.5%+CC AEP Tidal Event

f. Topographic Survey



Key to Abbreviations

Asp.	Asphalt
B	Bollard
BB	Belisha Beacon
BH	Bush
Bl.	Block wall
Br.	Brick wall
BT	British Telecom Cover
B/W	Barbed Wire
CB	Telephone Control Cabinet
C/B	Close Boarded
CCTV	Closed Circuit Television
CDP	Cable Draw Pit
C/I	Corrugated Iron
CL	Cover Level
C/L	Chain Link
C/P	Chestnut Paling
Conc.	Concrete
Elec.	Electricity Inspection Cover
El Sub Stn	Electricity Sub Station
EP	Electricity Pole
ER	Earth Rod
FH	Fire Hydrant
FW	Foul Water
G	Gully
Gab.	Gabion Wall
GV	Gas Valve
IC	Inspection Chamber
IL	Invert Level
I/R	Iron Railings
LB	Litter Bin
L/L	Larch Lap
LP	Lamp Post
MH	Manhole
Mkr	Marker
P/R	Post and Rail
RE	Rodding Eye
RS	Road Sign
RWP	Rain Water Pipe
SL	Sump Level
St.	Stone Wall
SV	Stop Valve
SW	Surface Water
TL	Traffic Light
TOW	Top of Wall
TP	Telegraph Pole
TV	Cable Television Cover
UTL	Unable to Lift
VP	Vent Pipe
WL	Water Level
WM	Water Meter

LINE TYPES

- Building
- Canopy
- Edge of Surfaces
- Embankments and ditches
- Fences
- Overhead cables
- Vegetation
- Walls, Kerbs etc.
- Hedges

Kerb levels are channel levels unless otherwise stated.

Notes

Sheet Layout

North Point

All levels related to:-
Ordnance Survey Datum derived by GPS.

Title

HERBERT ROAD,
NEWPORT.

Client

GREEN HILL

Scale:- N.T.S.@A0	Date:- October 2012
Surveyed by:-D McNeil-Jones	Checked by:- A H Davies
Drawing Number:- 2396	Rev.

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