FLOOD RISK ASSESSMENT

Proposed Bothy, Eilean Loch Oscair, off Isle of Lismore, Argyll

Prepared for:

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Quality Assurance

The data used in this document and their input and reporting have undergone a quality assurance review which follows established TransTech procedures. The information and results presented herein constitute an accurate representation of the data collected and analysed.

Indemnity

All comments and opinions contained in this report, including any conclusions are based on information available to TransTech during our investigations. The conclusions drawn by TransTech could therefore differ if the information is found to be inaccurate, incomplete, or misleading. TransTech accepts no liability should this prove to be the case, or, if additional information exists or becomes available with respect to the potential development site to which this assessment applies.

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Document Details

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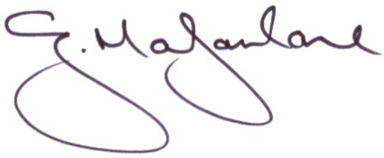

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List of Abbreviations

CFB	Coastal Flood Boundary
CFBM	Coastal Flood Boundary Method
DEFRA	Department of Environment, Farming and Rural Affairs
DEM	Digital Elevation Model
EA	Environment Agency
FFL	Finished Floor Level
FRMT	Flood Risk Management Team
GIS	Geographical Information System
LA	Local Authority
mAOD	Metres Above Ordnance Datum, Newlyn
SEPA	Scottish Environment Protection Agency
UKHO	United Kingdom Hydrographic Office

EXECUTIVE SUMMARY

This flood risk assessment has been prepared for the erection of a bothy on Eilean Loch Oscair, a small island situated in Loch Linnhe off the west coast of Isle of Lismore. At the time of this FRA, a precise location for the bothy has not yet been chosen.

Given that a bothy is proposed, according to SEPA guidance, this has to be assessed against a 1:1000 year (0.1% annual probability) flood event(1).

The predicted 1:1000 year Coastal Flood Boundary sea level for the coastline adjacent to the island was obtained from the most recent EA GIS datasets and is 4.16 mAOD(2). The CFB level is often referred to as the “still water” level as it does not include an allowance for climate change nor does it account for the potential effects of funnelling, local bathymetry and wave action raising flood levels. SEPA’s flood map only provides an indication of where the “still water level” may lie according to the maps underlying DEM which can often be inaccurate, particularly in rural locations.

The most up to date climate change uplift prediction for the Argyll (West) river basin area within which Lismore falls is a cumulative rise of 0.86 m from 2017 to 2100(3).

Funnelling and bathymetry is not predicted to affect flood levels at the island due to the open geometry of Loch Linnhe in its location and the lack of significant shoaling in the local near shore bathymetry.

In terms of wave effects, joint probability analysis of the likelihood of a 1:1000 year sea level and a wave occurring simultaneously was carried out along the direction of maximum wind fetch (and hence wave height) towards the island. The maximum fetch is from the SWbW and will result in the highest expected wave heights as the strongest winds nearly always blow from a SW to NW direction. The results of this analysis plus the allowance for climate change results in a peak predicted water level of 5.78 mAOD.

Topographical levels for the island suggest that it should be able to accommodate a bothy at ≥5.78 mAOD as areas between 6 to 10 mAOD are available.

The Argyll and Bute Council FRMT and SEPA generally requires ≥600 mm FFL freeboard above the predicted flood level. As such, for the bothy the FFL needs to be ≥6.38 mAOD.

Our conclusion is that, with the location of the bothy on ground ≥5.78 mAOD, it will not be at risk of coastal flooding and as such will be compliant with Argyll and Bute Local Plan Policy LP SERV 8: Flooding and Land Erosion(4), SEPA’s Technical Flood Risk Guidance for Stakeholders(5) and Scottish Planning Policy(6).

1.0 INTRODUCTION

1.1 The only identified potential flood risk to the proposed bothy comes from elevated water levels in Loch Linnhe. This flood risk assessment has been prepared to determine an appropriate land level for its location.

1.2 This report is based on the following information:

i) Topographical survey drawing provided by DM Hall, Chartered Surveyors.
ii) The extreme still water level at the island based on the Coastal Flood Boundary Method[2].
iii) SEPA's climate change allowances for flood risk assessment in land use planning[3].
iv) Revetment Systems Against Wave Attack, A Design Manual, HR Wallingford[7].
v) British Standard 6399 1997, Loading for buildings - Part 2: Code of practice for wind loads[8].
vi) Flood and Coastal Defence Appraisal Guidance[9].
vii) SEPA indicative flood map[10].
viii) UKHO digital Admiralty chart.
ix) EA/DEFRA guidance on the use of joint probability methods in flood management[11].

2.0 REGULATORY GUIDANCE

2.1 Scottish Planning Policy - Managing Flood Risk and Drainage[6] provides the regulatory framework and guidance for planning authorities in relation to flood issues for new developments. Any application lodged with a local Planning Authority will be considered in conjunction with this guidance, and dependant on the nature and location of the application, the Planning Authority may request a flood risk assessment as part of the planning application.

2.2 The planning process requires that it be demonstrated that land proposed to be developed can be done so with an acceptable risk of flooding and that any works needed to manage flood risk are sustainable over the likely life of the development.

2.3 The Planning Authority's Flood Risk Management Team along with SEPA can be consultees to planning applications in relation to flood risk.

3.0 TOPOGRAPHY OF ISLAND

3.1 The island is located at NM 86280 45520.

3.2 Topographical levels indicate that land is available at 6 to 10 mAOD (figure 1).

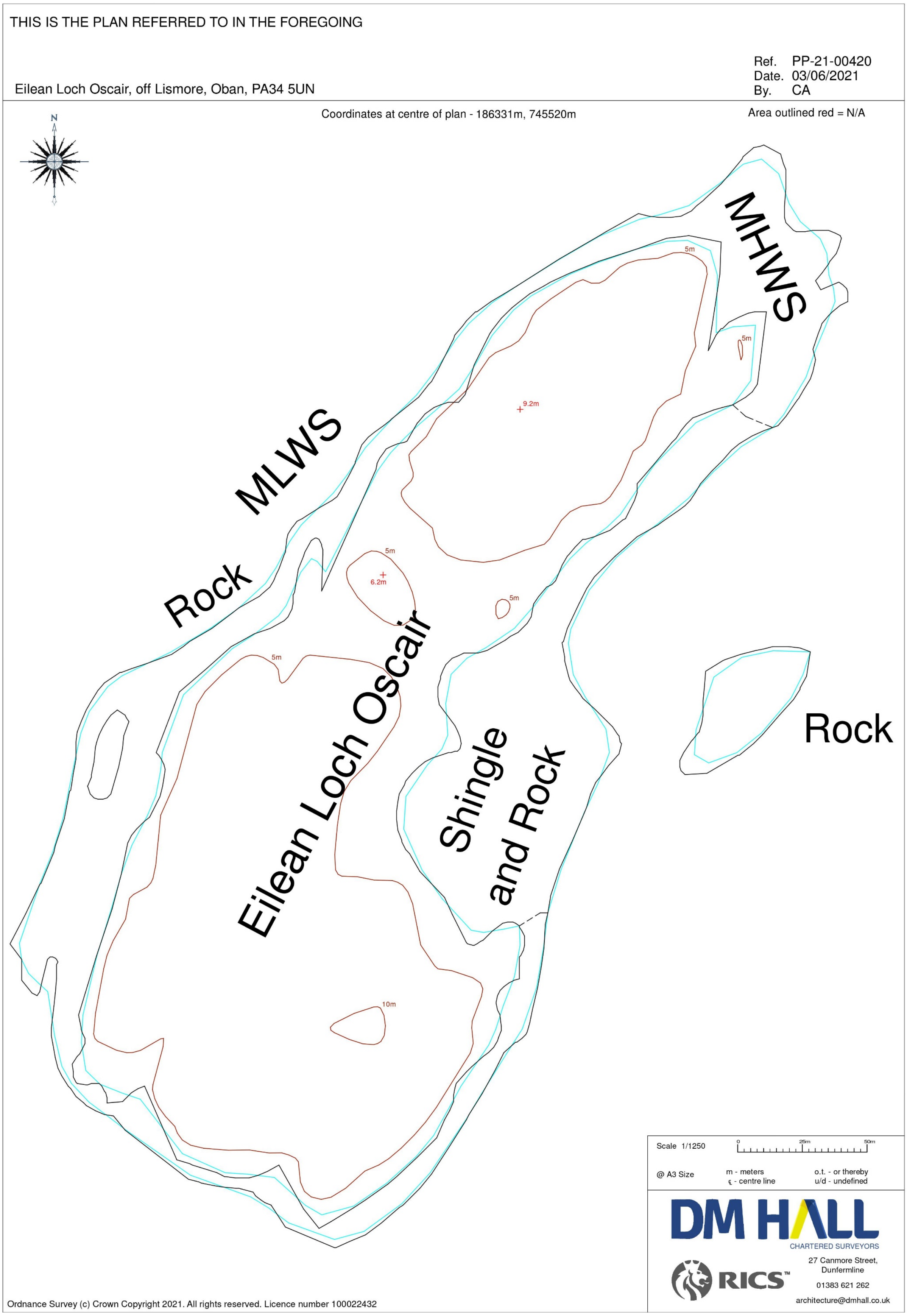


Figure 1. Topography of Eilean Loch Oscair.

4.0 INDICATIVE FLOOD INUNDATION & HISTORICAL FLOODING

4.1 SEPA's indicative flood maps provide an estimate of the areas of Scotland with a 0.1%, 0.5% and 1% probability of being flooded in any given year (1:1000, 1:200 and 1:10 year events respectively). Copyright restrictions do not permit the maps to be shown within this report but they are available at: https://www.sepa.org.uk/environment/water/flooding/flood-maps/.

4.2 The SEPA map indicates that much of the island is out with the 1:1000 year coastal flood extent. However, the map is indicative in nature (not absolute) and as such could be over-predicting or under-predicting the actual flood risk. It does not provide enough detail to accurately estimate the flood risk associated with individual properties or specific point locations. Importantly, the map also does not include the anticipated effects of climate change on sea level rise and the potential effects of funnelling, local bathymetry, and wave action on flood levels.

4.3 No fluvial or surface water flood risk to the island is shown on the flood map. TransTech concurs with this given that there are no watercourses on the island and the landform permits rainfall to drain freely towards the sea.

4.4 Details of historical flooding are not available particularly given that the island is uninhabited.

5.0 METHODOLOGY & RESULTS

5.1 Predicted 1:1000 Year Coastal Flood Level

5.1.1 The Coastal Flood Boundary Method 1:1000 year coastal flood level for the island was obtained from the most recent EA GIS datasets(2). The closest 1:1000 flood level is 4.16 mAOD which is located at 184925.5 E 746517.1 N, c. 1.7 km from the MHWS contours on the island (figure 2).

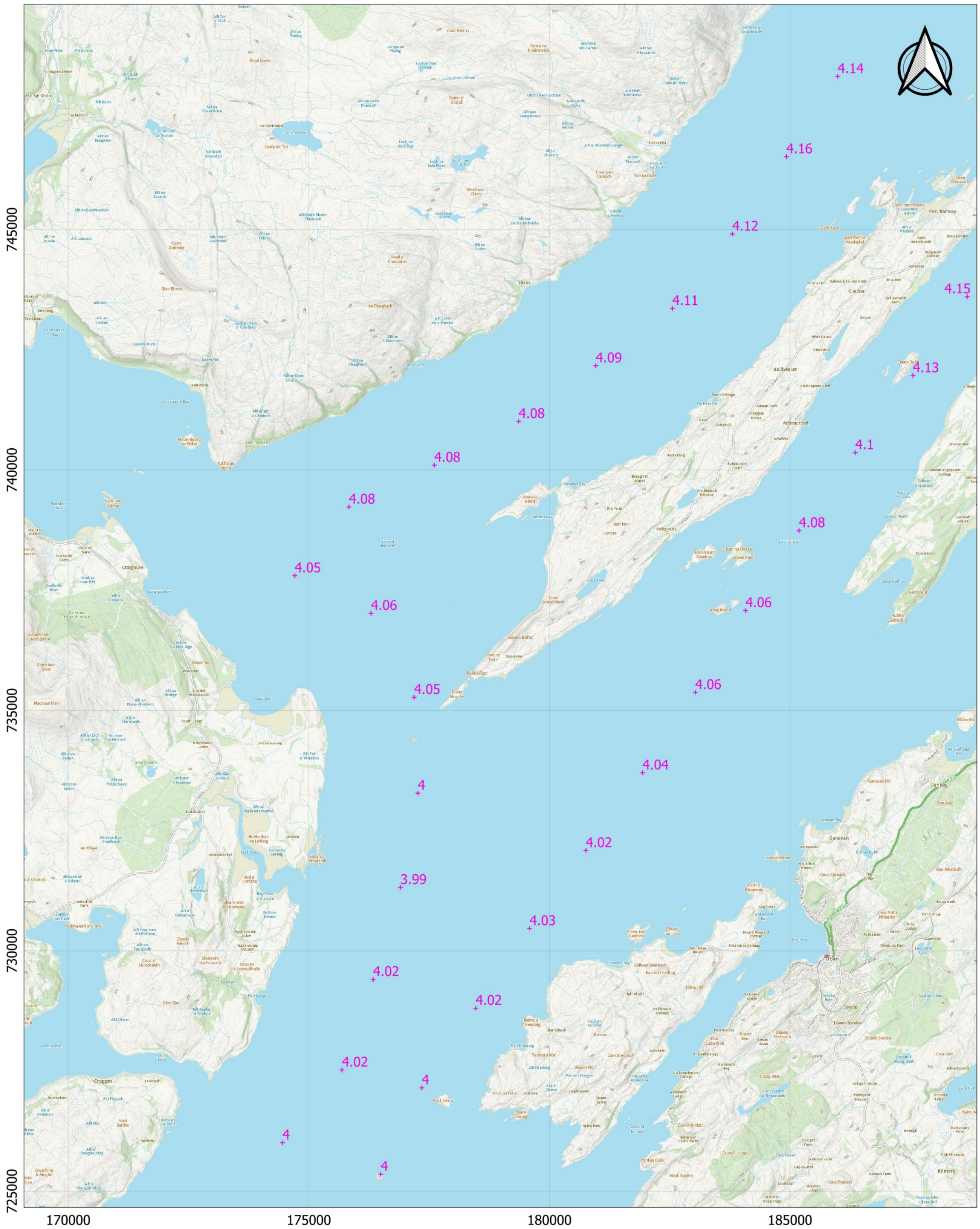
5.1.2 The CFBM is the result of research commissioned by the Environment Agency's Evidence Directorate and funded by the joint EA/DEFRA Flood and Coastal Erosion Risk Management Research and Development Programme. This method was introduced in February 2011 and significantly updated in 2018.

5.1.3 It uses GIS software to determine extreme sea levels of annual exceedance probability ranging from one in 1 year to one in 10000 years, around the UK coast, islands, and estuaries. The CFB level does not consider the potential effects of climate change, wave action, funnelling and local bathymetry but does include storm surge.

5.1.4 The concept of return period is commonly used in assessing the severity of extreme natural events such as a flood. Return period can be defined as the number of years on average between the occurrence of events of a specified magnitude. Return period implies a long length of time. It is important to note with the definition of return period that the 1000 year event may occur or be exceeded more than once in any 1000 year period or may not occur at all. It may also occur in successive years.

5.1.5 Assessment against a 1:000 year flood return period needs to be undertaken for the bothy as it falls under the 'Most Vulnerable Use' as defined by SEPA's Land Use Vulnerability Guidance(1).

5.1.6 The 1:1000 year still water flood level of 4.16 mAOD is shown in figure 2.



Legend
+ CFB Extreme Sea Levels

Drawing Title: CFB 1:1000 Year Sea Level
Drawing No: EILO-0321-1
Drawn By: Garret Macfarlane
Date: 12/07/2021

0 1,000 2,000 3,000 4,000 m
Scale 1 : 100,000 @ A4

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Figure 2. 1:1000 year Coastal Flood Boundary sea level at Eilean Loch Oscair.

5.2 Predicted Effects of Climate Change on Sea Levels to 2100

5.2.1 The author has reviewed the latest climate change predictions. The projections indicate that for Argyll there is going to be a significant rise in sea level over the next 80 years due to the global heating and expansion of ocean water and melting of ice sheets and glaciers. In most of Scotland the land surface is actually rising due to post-glacial rebound. However, this is not rapid enough to negate sea level rise but it reduces the absolute amount. For the proposed development's location SEPA predicts a cumulative rise of 0.86 m to 2100(3).

5.2.2 This figure differs significantly from past predictions which were often ≥50% lower.

5.2.3 Table 1 provides the latest CFB(2) sea levels for a range of return periods up to the 1:1000 year event.

Table 1. Extreme sea levels at the potential development site.

Return Period (Years)	Extreme Sea Level (mAOD)	Extreme Sea Level + 0.86 m Climate Change Uplift (mAOD)
1	2.89	3.75
2	3.00	3.86
5	3.16	4.02
10	3.28	4.14
20	3.40	4.26
50	3.57	4.43
100	3.70	4.56
200	3.83	4.69
1000	4.16	5.02

5.3 Predicted Wave Height

5.3.1 Wave heights have been calculated by TransTech for the wind fetch across Loch Linnhe using an industry standard method outlined in the document Revetment Systems Against Wave Attack - A Design Manual(7) by HR Wallingford. This method is based on work published by Yarde et al(12) and was principally designed for application to wave estimation in dams and inland reservoirs. However, the method is theoretically applicable to any wide stretch of water sheltered from the open sea.

5.3.2 The HR Wallingford method is preferred when hydrodynamic modelling can be avoided as the latter incurs significant additional expense to the client. Indeed, the former is the recommended approach by many LAs located on the west coast of Scotland.

5.3.3 The Yarde method involves calculating an appropriate design wind speed and then equating wave heights using this information. The method involves two principal steps as outlined below:

STEP A: Design wind speeds

To calculate wave heights, one must first obtain an estimate of a return period wind speed for the site of interest.

The 1:50 year basic wind speed was obtained from British Standard 6399 1997, Loading for buildings - Part 2: Code of practice for wind loads[8]. This indicates a wind speed at the potential development site of approximately 25.5 m/s.

To convert the 50 year wind speed to other return period wind speeds, the Yarde approach provides the following conversion equation:

$$U_D = U_b * S_a * S_d * S_p * S_f * S_w$$

Where:

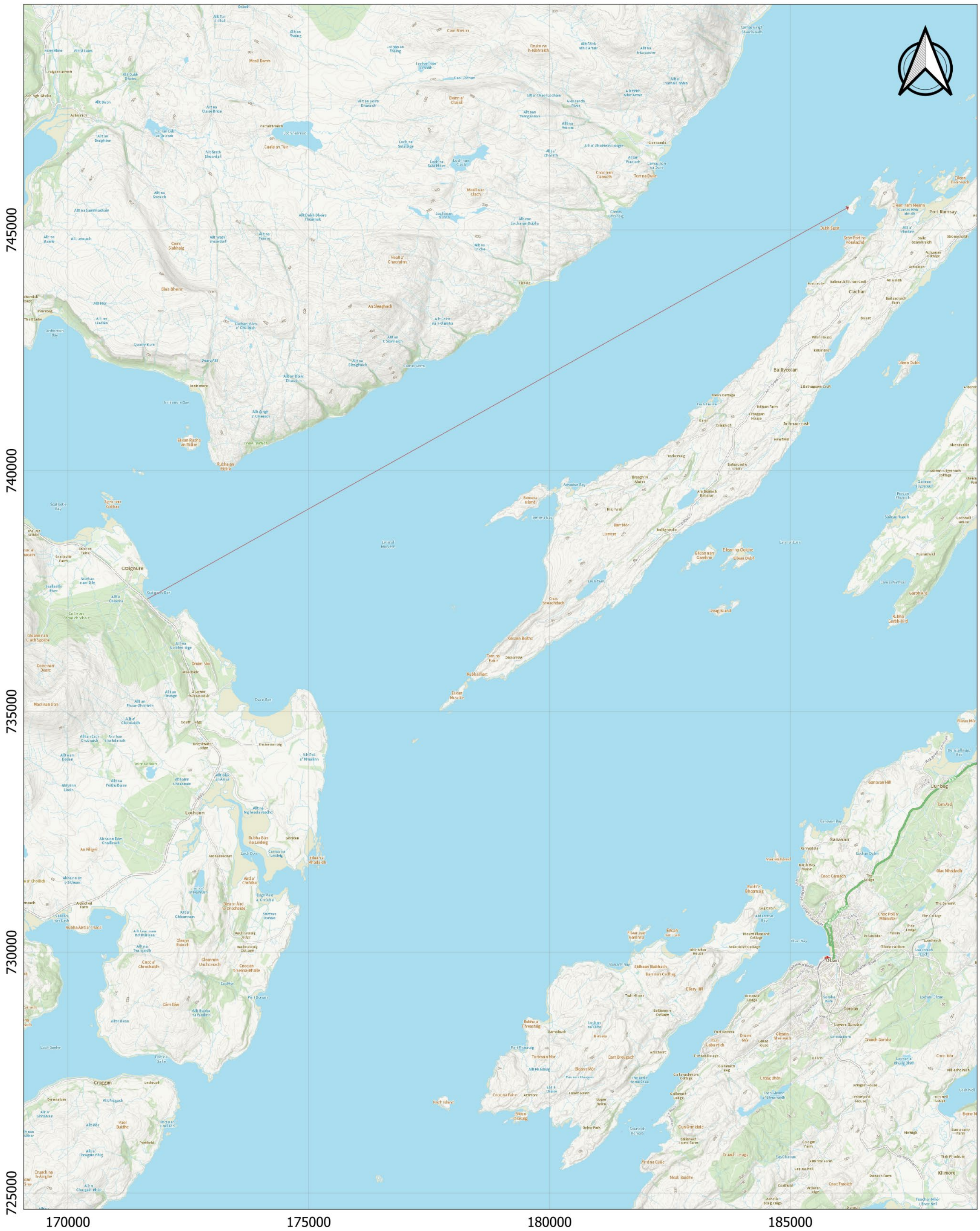
U_D = design wind speed (m/s) at subject site(s);
U_b = basic hourly wind speed (m/s) for design event;
S_a = an altitude factor;
S_d = a factor to account for the wind direction;
S_p = a factor to adjust for different return periods;
S_f = a factor to convert hourly wind speed to a more appropriate duration for the water body under study, and
S_w = an over-water speed-up factor to account for the effect of reduced friction as wind travels over water. This value is based on fetch.

Appropriate values for the above parameters are chosen from tables given by McConnell[7]. As indicated by the equation, fetch, and wind direction, which are related variables, have a significant impact on wave heights.

The land proposed for development is sheltered from direct effects of ocean swells. Wind waves could however be generated and cause localised wave effects.

As Atlantic depressions pass by the UK the wind typically starts to blow from the SW, but later comes from the W or NW as the depression moves away. The range of directions between SW and NW accounts for the majority of occasions and the strongest winds nearly always blow from these.

For this study, the shoreline is most exposed to waves generated by a SWbW wind blowing from 240.796° Grid North, and in order to provide a worst-case scenario, it is this direction that has been used in the calculations (see figures 3 and 4) along with a maximum fetch distance of 16,691 m.



Legend

Maximum Wind Fetch Towards Island

Drawing Title: Maximum Wind Fetch
Drawing No: EILO-0321-2
Drawn By: Garret Macfarlane
Date: 12/07/2021

0 1,000 2,000 3,000 4,000 m
Scale 1 : 100,000 @ A4

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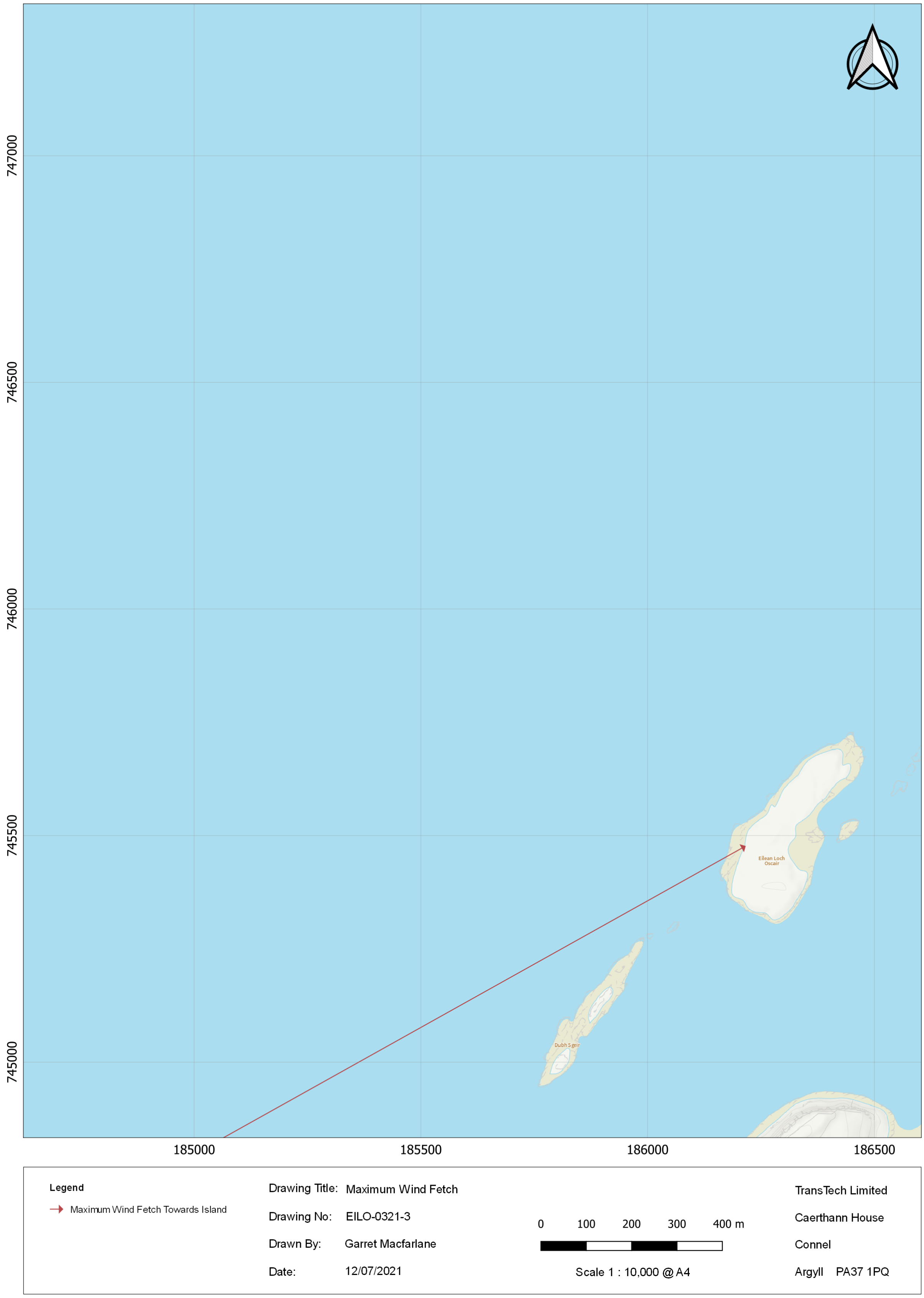
Figure 3. Maximum uninterrupted wind fetch (16,691 m) towards the island.



<u>Figure 4. Closer view of maximum uninterrupted wind fetch at island.</u>

Given the above, the parameters used for the wave height analysis are provided in table 2.

Table 2. Factors used to calculate design wind speed (without wind speed climate change allowance).

Factor	Correction Applied
S_a	1 (based on Sa=1+0.001*Δ_s, where Δ_s is altitude above mean sea level in metres), from McConnell(7) p63
S_d	1.00 from table 7.1 of McConnell
S_p	Various (0.67 for 1 year wind speed, 1.00 for 50 year wind speed and 1.10 for the 1:200 year wind speed), from McConnell p64
S_f	1.05 (based on a 15 min duration, UK recommended value), from table 7.3 of McConnell
S_w	1.31 from table 7.4 of McConnell

STEP B: Design Wave Heights

To calculate design wave heights from design wind speeds, McConnell(7) provides the following equation:

$$H_s = 0.00178 * \mathrm{U_D} * \frac{\sqrt{\mathrm{F}}}{\sqrt{\mathrm{g}}}$$

Where:

H_s = significant wave height (m). This is the mean wave height (trough to crest) of the highest third of the waves;
U_D = design wind speed (m/s);
F = fetch length (m); and
g = acceleration due to gravity (9.81 m/s²).

Design wave heights for the water body based on this equation and the wind speeds calculated above are given for a range of return periods in table 3.

Table 3. Design wave heights (without wind speed climate change allowance).

Return Period (years)	S_p	Design Wind Speed U_D (m/s)	Significant Wave Height* H_s (m)
1	0.67	23.50	1.73
2	H_s derived from wave height growth curve		2.01
5	0.83	29.11	2.14
10	0.88	30.87	2.27
20	0.93	32.62	2.40
50	1.00	35.08	2.58
100	1.05	36.83	2.70
200	1.10	38.58	2.83
1000**	1.19	41.74	3.06

* Significant wave height is the wave's amplitude i.e. the distance from its trough to crest.
** Derived from the Sp growth curve parameters (5 paramount logistic curve fit, r^2 = 0.999).

Note: The 50 year return period wind speed is greater than 25.5 m/s because the Yarde method directional factor (S_d) has been applied.

Consideration has been given to the potential for climate change to affect the local wind speeds and hence wave heights. No specific SEPA guidance on the effects of climate change on wind speed could be found. Therefore, the flood and coastal defence appraisal guidance(9) which recommends a 10% increase in wind speeds for dates 2055 to 2110 was applied (table 4).

Table 4. Design wave heights (with wind speed climate change allowance).

Return Period (years)	S_p	Design Wind Speed U_D (m/s)	Significant Wave Height H_s (m)
1	0.67	25.85	1.90
2	H_s derived from wave height growth curve		2.01
5	0.83	32.02	2.35
10	0.88	33.95	2.49
20	0.93	35.88	2.63
50	1.00	38.58	2.83
100	1.05	40.51	2.97
200	1.10	42.44	3.12
1000	1.19	45.91	3.37

5.4 Joint Probability Analysis

5.4.1 For this appraisal, the joint probability of a high wind (and hence wave) and an extreme sea level (including climate change uplift) occurring simultaneously has been calculated. This analysis is based on the desktop method outlined in DEFRA Report FD2308/TR2, Use of Joint Probability Methods in Flood Management[11].

5.4.2 In figure 4.1 of FD2308/TR2 (reproduced in figure 5 below), Loch Linnhe solely falls within the well correlated (Tobermory) levels of dependence between large waves and high sea levels. Based on this, ρ was set to equal 0.39, representing the lower end of "well correlated".

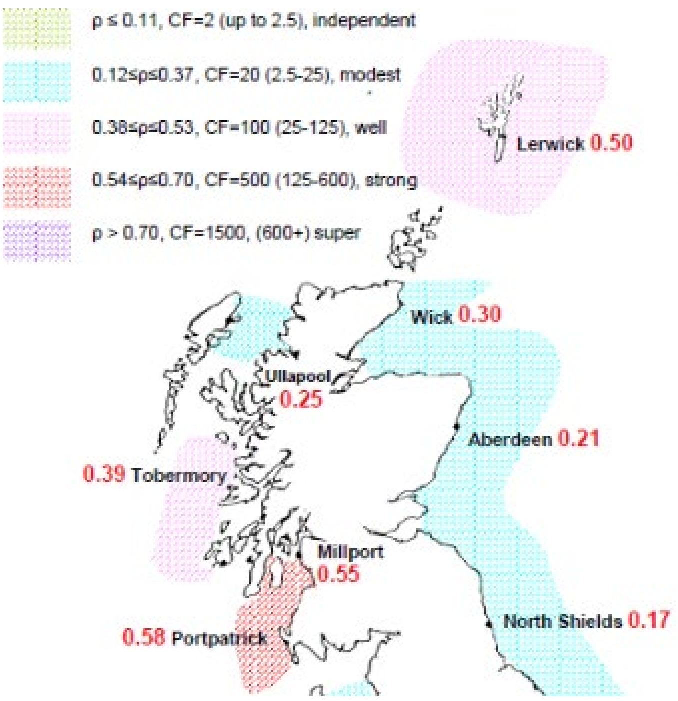


Figure 5. Correlation coefficients: all wave directions combined.

5.4.3 The combination results of the probability analysis are presented in table 5.

Table 5. Joint probability results: Joint exceedance return period of 1000 years.

Variable 1: Sea Level (incl. climate change allowance)		Variable 2: Wave Conditions (incl. climate change allowance)	
Return Period (Years)	Extreme Sea Level (mAOD)	Return Period (Years)	Significant Wave Height* H_s (m)
1	3.75	83.27	2.93
2	3.86	41.63	2.79
5	4.02	16.65	2.59
10	4.14	8.33	2.45
20	4.26	4.16	2.28
50	4.43	1.67	1.98
100	4.56	0.83	1.87
200	4.69	0.42	1.76
1000	5.02	0.08	1.51

5.4.4 From the above calculation the joint probability of a 1:1000 year sea level and a wave occurring simultaneously will result in a flood level of **5.78 mAOD** i.e., 5.02 + (1.51 divided by 2 as the significant wave height is from trough to crest).

5.5 Predicted Funnelling & Bathymetric Effects

5.5.1 TransTech deems that funnelling will not influence flood levels at Eilean Loch Oscair because of the adjacent physical geometry of the part of Loch Linnhe within which the island is located.

5.5.2 Given the lack of significant shoaling (figure 6), especially for a 1:1000 year sea level, in the local near shore bathymetry there are no predicted effects of bathymetry on the 1:1000 year flood level.

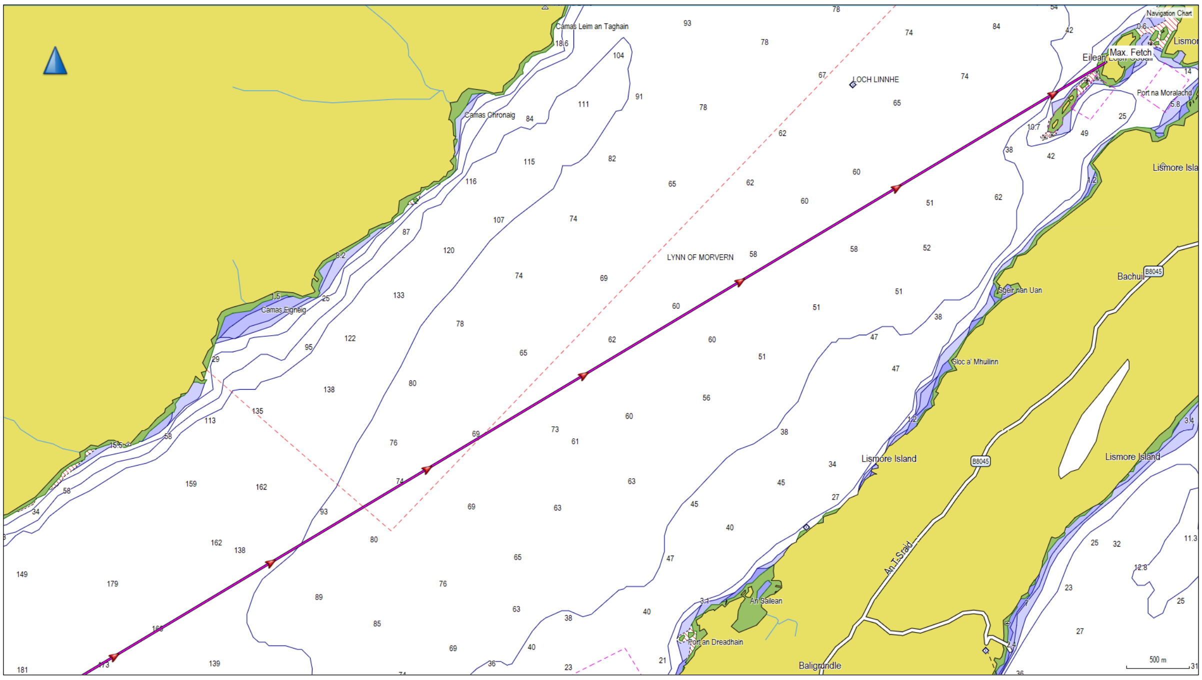


Figure 6. Admiralty chart extract showing Eilean Loch Oscair and the line of maximum fetch towards it.

6.0 DISCUSSION

6.1 Predicted Extreme Coastal Flood Level and its Implications to Development of the Bothy

6.1.1 The assessment of the joint probability of a high sea level and wave effects occurring simultaneously produces a 1:1000 year extreme coastal flood level of 5.78 mAOD. Thus, the bothy should be located on ground above this level.

6.1.2 Topographical levels for the island suggest that it should be able to accommodate a bothy at ≥5.78 mAOD as areas between 6 to 10 mAOD are available (figure 1).

6.2 Finished Floor Level

6.2.1 The Argyll and Bute Council FRMT and SEPA generally requires ≥600 mm FFL freeboard above the predicted flood level. As such, for the bothy the FFL needs to be ≥6.38 mAOD.

6.3 Access and Egress

6.3.1 Safe access to and egress from the development during extreme flood events needs to be considered. As the FRMT notes in their advice provided via email on 06/07/2021, visiting Eilean Loch Oscair will be similar to visiting other small islands such as Cramond Island in the Firth of Forth.

6.3.2 It is therefore recommended that appropriate signage be provided informing visitors of the flood risk, with recommendations against accessing the island during extreme weather events.

7.0 CONCLUSIONS

7.1 Our conclusion is that, with the location of the bothy on ground ≥5.78 mAOD, it will not be at risk of coastal flooding and as such will be compliant with Argyll and Bute Local Plan Policy LP SERV 8: Flooding and Land Erosion(4), SEPA's Technical Flood Risk Guidance for Stakeholders(5) and Scottish Planning Policy(6).

FILES ACCOMPANYING THIS REPORT

The following file accompanies this report:

- Eilean Loch Oscair flood risk assessment checklist.pdf
  – *SEPA Checklist*

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(1) Flood Risk and Land Use Vulnerability Guidance. LUPS-GU24. Version 4. Scottish Environment Protection Agency. 10 July 2018. Website link.

(2) Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels 2018 (March 2020 update). Website link.

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  Website link.

NB: The website links above are current and may expire.