APPENDIX UES13-4

OVERTOPPING CALCULATIONS

ABLE MARINE ENERGY PARK
(Material Change 2 – TR030006)

COVER SHEET

HR Wallingford

Project	Able Marine Energy Park - Material Change Application (April 2021)		
Contract	DER6453	Calc No.	1
Section	\\	File	DER6453/CALC/1
Subject	Overtopping calculation	Job No.	DER6453
Department	Engineering	Project Manager	Kate Rossington

	Total Sheets	Made by	Date	Checked by	Date	Comments
ORIGINAL	1	FAM	09/04/2021	MJJ	09/04/2021	
REV 1						
REV 2						
REV 3						
REV 4						
REV 5						
REV 6						

Superseded by Calculation No. \\ Date \\

Subject: **Overtopping Assessment on a quay wall**

1. Assessment of the overtoping discharge on a vertical quay for an extreme event with a return period of 200yrs and taking into account 100yrs of sea level rise.

International standard and guidelines

1. EurOtop (2018). Manual on wave overtopping of sea defences and related structures. An overtopping manual largely based on European research, but for worldwide application. Van der Meer, J.W., Allsop, N.W.H., Bruce, T., De Rouck, J., Kortenhaus, A., Pullen, T., Schüttrumpf, H., Troch, P. and Zanuttigh, B., www.overtopping-manual.com.

References

1. R.810 The Humber Tidal Database and Joint Probability Analysis of Large Waves and High Water Levels Annex II: Addendum to Data Report (April 2007, amended October 2007).
2. Flood Risk Assessment and Drainage Strategy. Final Report, August 2011 (JBA Consulting).
3. Tidal Level Location Map Lincolnshire & Northamponshire Area
4. Humber Extreme Water Levels (2020). Version 2, 18th February 2021
5. AME-033-10203 Section A-A Typical Cross Section

Higher Central Scenario

										Equation 7.6 Design approach (Max Overtopping)			Equation 7.16 Oblique wave effect (Min Overtopping)		
										Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
H_{m0} (m)	Crest level 1 (mCD)	Crest level 2 (mCD)	Crest level 3 (mCD)	SWL (mCD)	SLR (m)	R_c 1 (m)	R_c 2 (m)	R_c 3 (m)	β	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)
2.38	10.0	10.2	10.4	6.34	0.9	2.76	2.96	3.16	52	34	28	22	6	5	3
2.37	10.0	10.2	10.4	7.07	0.9	2.03	2.23	2.43	52	75	60	48	21	15	11
2.18	10.0	10.2	10.4	7.80	0.9	1.30	1.50	1.70	52	131	103	81	50	35	25
1.62	10.0	10.2	10.4	8.54	0.9	0.56	0.76	0.96	52	162	117	85	85	52	33
1.10	10.0	10.2	10.4	8.86	0.9	0.24	0.44	0.64	52	127	79	49	78	39	19
0.88	10.0	10.2	10.4	8.90	0.9	0.20	0.40	0.60	52	89	49	27	54	22	9
0.66	10.0	10.2	10.4	8.96	0.9	0.14	0.34	0.54	52	60	27	12	37	11	4
0.55	10.0	10.2	10.4	9.02	0.9	0.08	0.28	0.48	52	54	21	8	36	9	2
0.44	10.0	10.2	10.4	9.05	0.9	0.05	0.25	0.45	52	42	13	4	29	5	1
0.33	10.0	10.2	10.4	9.09	0.9	0.01	0.21	0.41	52	34	7	1	26	3	0
0.22	10.0	10.2	10.4	9.11	0.9	-0.01	0.19	0.39	52	Flooded	2	0	Flooded	1	0

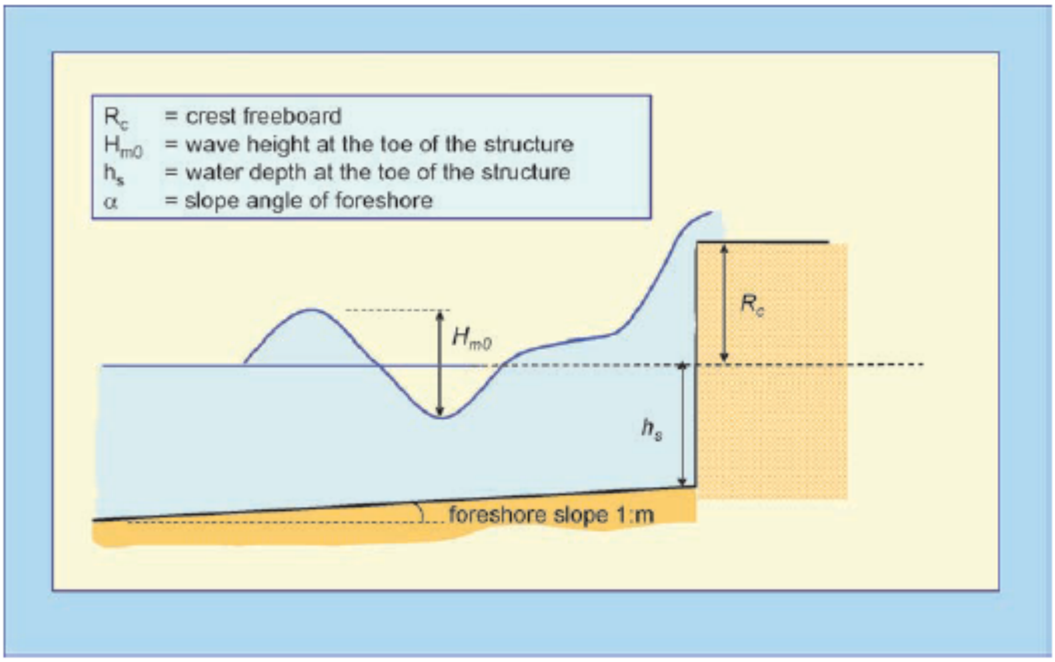
Upper End Scenario

										Equation 7.6 Design approach (Max Overtopping)			Equation 7.16 Oblique wave effect (Min Overtopping)		
										Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
H_{m0} (m)	Crest level 1 (mCD)	Crest level 2 (mCD)	Crest level 3 (mCD)	SWL (mCD)	SLR (m)	R_c 1 (m)	R_c 2 (m)	R_c 3 (m)	β	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)	q (l/s/m)
2.38	10.0	10.2	10.4	6.34	1.14	2.52	2.72	2.92	52	45	36	29	10	7	5
2.37	10.0	10.2	10.4	7.07	1.14	1.79	1.99	2.19	52	98	79	63	31	22	16
2.18	10.0	10.2	10.4	7.80	1.14	1.06	1.26	1.46	52	175	138	109	77	54	38
1.62	10.0	10.2	10.4	8.54	1.14	0.32	0.52	0.72	52	238	172	125	150	93	58
1.10	10.0	10.2	10.4	8.86	1.14	0.00	0.20	0.40	52	224	139	87	181	90	44
0.88	10.0	10.2	10.4	8.90	1.14	-0.04	0.16	0.36	52	Flooded	100	55	Flooded	64	27
0.66	10.0	10.2	10.4	8.96	1.14	-0.10	0.10	0.30	52	Flooded	70	32	Flooded	47	15
0.55	10.0	10.2	10.4	9.02	1.14	-0.16	0.04	0.24	52	Flooded	66	25	Flooded	48	12
0.44	10.0	10.2	10.4	9.05	1.14	-0.19	0.01	0.21	52	Flooded	53	16	Flooded	42	7
0.33	10.0	10.2	10.4	9.09	1.14	-0.23	-0.03	0.17	52	Flooded	Flooded	10	Flooded	Flooded	4
0.22	10.0	10.2	10.4	9.11	1.14	-0.25	-0.05	0.15	52	Flooded	Flooded	3	Flooded	Flooded	1

H_{m0} (m)	Estimate of significant wave height
Crest level (mCD)	Crest elevation of the structure
SWL (mCD)	Still water level (1in200 joint probability extreme level)
SLR (m)	Sea Level Rise (100 years considered)
R_c (m)	Crest freebord of structure
β	Angle of wave attack relative to normal on structure
q (l/s/m)	mean overtopping discharge per meter structure width

OVERTOPPING CALCULATIONS: EXAPLANATORY NOTE

1. Definition Sketch for assessment of Overtopping at Plain Vertical Walls



2. Column: H_{m0} (m)

Refer to the definition sketch above.

The figures in this column are obtained adding a 10% increase to wave heights (H_S) for the 1:200-year event contained Table 30 of '*The Humber Tidal Database and Joint Probability Analysis of Large Waves and High Water Levels Annex II/; Addendum to Data Report*', (ABP Mer, April 2007 (Amended October 2007), Project Reference R/3689/1, Report No. R.810). The 10% increase represents 100 years of climate change, in accordance with current EA guidance as reproduced below:

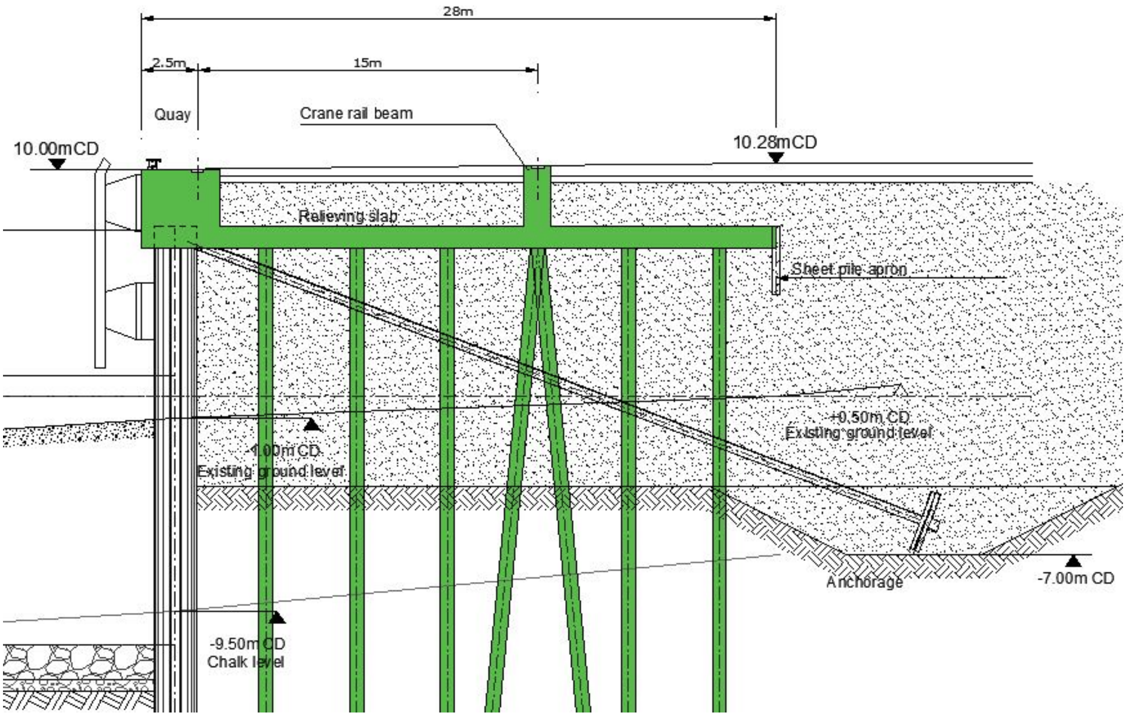
Table 5: offshore wind speed and extreme wave height allowance (based on a 1990 baseline)

Applies all around the English coast	2000 to 2055	2056 to 2125
Offshore wind speed allowance	5%	10%
Offshore wind speed sensitivity test	10%	10%
Extreme wave height allowance	5%	10%
Extreme wave height sensitivity test	10%	10%

https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

3. **Columns: Crest Level 1/2/3**

Crest Level 1 is the top level at the front of the consented AMEP quay. Crest levels 2 and three are 200mm and 400mm higher respectively. In the consented scheme, the quay slopes up from the front at a 1% gradient to a level of 10.28m AOD, see figure below.



4. **Columns: SWL (mCD)**

Still water level of the water body in the 1:200-year event, derived as follows:

EA Humber 2100+ data for North Killingholme stretch of the estuary provides a 1:200-year water level of 5.21m AOD in 2021 for the Higher Central scenario (70^{th} percentile),

0m AOD = 3.9mCD, so 5.21m AOD = 9.11m CD, and

In Table 30 of '*The Humber Tidal Database and Joint Probability Analysis of Large Waves and High Water Levels Annex II/; Addendum to Data Report*', (ABP Mer, April 2007 (Amended October 2007), Project Reference R/3689/1, Report No. R.810), the 1991, 1:200-year water level that is associated with the smallest (non-zero) wave height is 5.04m AOD. Therefore, to account for climate change between 1991 and 2021, 0.17m (5.21m – 5.04m) is added to all 1:200-year water levels in Table 30.

5. **Column: SLR**

   The figure in this column represent 100 years of sea level rise between 2021 and 2121 for the Higher Central and Upper End scenarios as advised by the Environment Agency.

6. **Column: R_c**

   This is the crest freeboard between the SWL and the top level of the quay along its front face, refer to the definition sketch above.

7. **Column: β**

   The angle of wave attack.

8. **Columns: Equation 7.6 Design Approach (Max Overtopping)**

   Overtopping rate based on direct wave attack.

9. **Columns: Equation 7.16 Design Approach (Max Overtopping)**

   Overtopping rate based on oblique wave attack, as reported in the original FRA, Appendix H.

   The expected overtopping will be in the range between the two set of values using either equation 7.6 or 7.16, but is probably closer to the minimum overtopping as the maximum values derive from a conservative approach.

10. **'FLOODED'**

    Mean that there is crest freeboard (R_c) is negative, but does not take account of the rising levels landward the quay.

11. The design of the quay includes for adding 200mm to the quay level in the future subject to actual climate change effects.