

## Viking CCS Pipeline

# 9.26 Breach Water Level Depth Technical Note – Revision A (Tracked)

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Applicant: Chrysaor Production (U.K.) Limited,  
a Harbour Energy Company  
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The Infrastructure Planning (Applications: Prescribed Forms  
and Procedure) Regulations 2009 - Regulation 5(2)(q)  
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# Technical Note

<b>Project name</b> Viking CCS Pipeline	<b>Project number</b> 60668955	<b>Client</b> Harbour Energy	<b>Subject</b> Breach Flood Water Depth Analysis
<b>Date</b> June 2024	<b>Issued by</b> AECOM	<b>Reason for issue</b> Additional Information for Environment Agency	<b>Prepared by</b> Jo Somerton <a href="#">Becci Ward</a>
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## 1. Introduction

The Environment Agency provided comments with regards the Viking CCS Flood Risk Assessment (FRA) in the Statement of Common Ground which include the following:

*“Table 15: The level of flood risk is unclear as this paragraph states average breach depths rather than potential maximum breach depths (2006 0.5% and 0.1% breach maximum depths are greater), and*

*Table 18: Climate change: the level of flood risk is unclear as this paragraph states average breach depths rather than potential maximum breach depths (2006 0.5% and 0.1% breach maximum depths are greater)”.*

Following further discussions with the Environment Agency on 7<sup>th</sup> March 2024 it was agreed that AECOM would provide further details as to how the breach flood depths for the current day and climate change scenarios have been derived to inform the FRA.

This technical note outlines the methodology used to establish the use of average maximum flood depths across the sites rather than the maximum breach flood water depths within the sites.

[This Technical Note was updated in June 2024 in response to Environment Agency comments on the previous version issued as part of the Examination Timetable Deadline 2 submission where they noted it is helpful that breach depths were used to derive a breach flood level at Immingham and that this would be useful for the Theddlethorpe Facility sites also. The Environment Agency noted that proposed mitigation and freeboard could then be related to levels expressed in m AOD. This update, therefore, has, as requested, derived approximate breach flood levels for the two Theddlethorpe Facility sites.](#)

## 2. Environment Agency Breach Water Depths

In June 2023 the Environment Agency, as part of an additional data request from AECOM, provided the breach flood water depth modelling outputs from the 2010 Northern Area Tidal Modelling Study for the Immingham and Theddlethorpe Facility locations. The breach flood water depths were compared against ground levels for the same areas from the Digital Terrain Model (DTM).

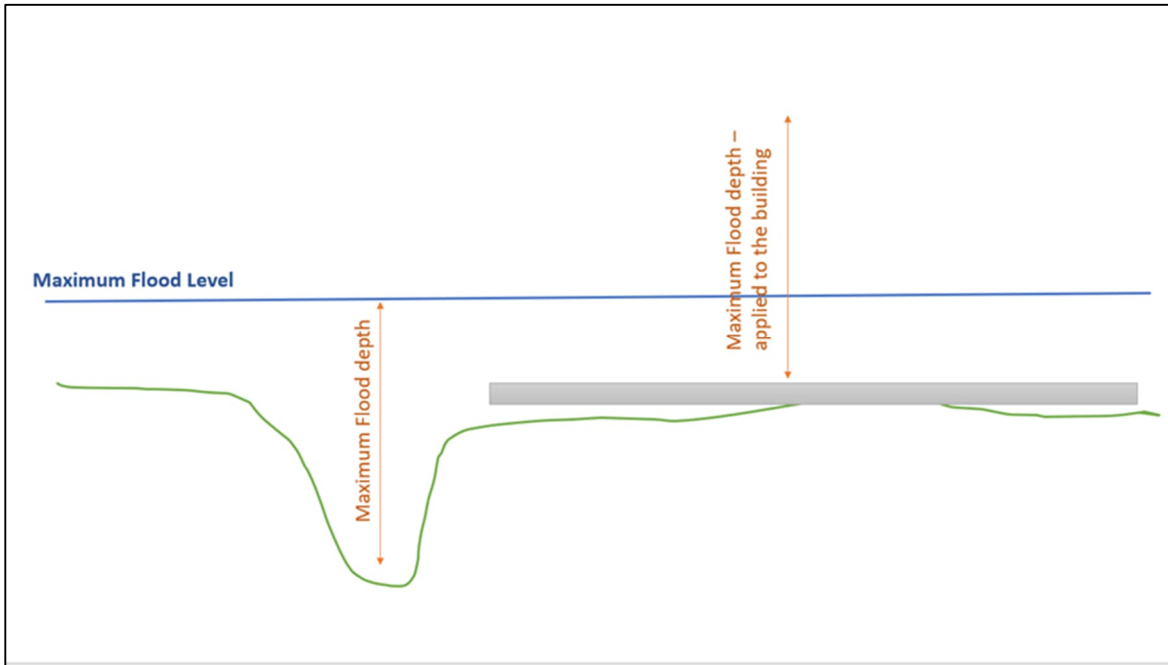
The modelled breach flood depths for the Yr 2115 in the 2010 Northern Area Tidal Modelling Study are based on the current standard of protection provided by the tidal flood defences. No allowance has been included for the raising of the flood defences in line with climate change.

## 3. Breach Water Depth Analysis

The DTM used in the EA breach model is on a coarse grid and not directly comparable to the current LIDAR DTM for the site. It has, therefore, not been possible to derive the maximum flood levels at the sites. Undulations in the underlying DTM mean that in some places the modelled flood depth is artificially high and not representative of the typical maximum flood depth at the sites.

Analysis of the breach flood water depth modelling output indicated that the maximum flood depths in the 2010 Northern Area Tidal Modelling Study were generated in the areas of lowest topography within the site boundaries. The Sites for the proposed Facilities are generally flat, therefore small areas of low topography were generating artificially high flood depths when applied to the average site topographic level and, therefore, were not representative of breach flood water levels across the site. **Figure 3-1** shows how the maximum flood depth, when applied to the average site level can overestimate the breach flood water level.

**Figure 3-1. Application of the Maximum Flood Depth**



Average (maximum) breach flood depths were therefore calculated for the modelled present day (2006) and climate change (2115) scenarios.

### 3.1 Immingham Facility

The proposed Immingham Facility is located at the northern end of the Scheme on an area of disused land to the south of the VPI Immingham site. The existing land comprises a gravelled area with sparse vegetation cover.

Ground levels within the Immingham Facility site range from a minimum of 2.45m AOD towards the east to a maximum of 5.48m AOD along the site periphery to the west in proximity to the railway embankment. The site therefore generally slopes from west to east.

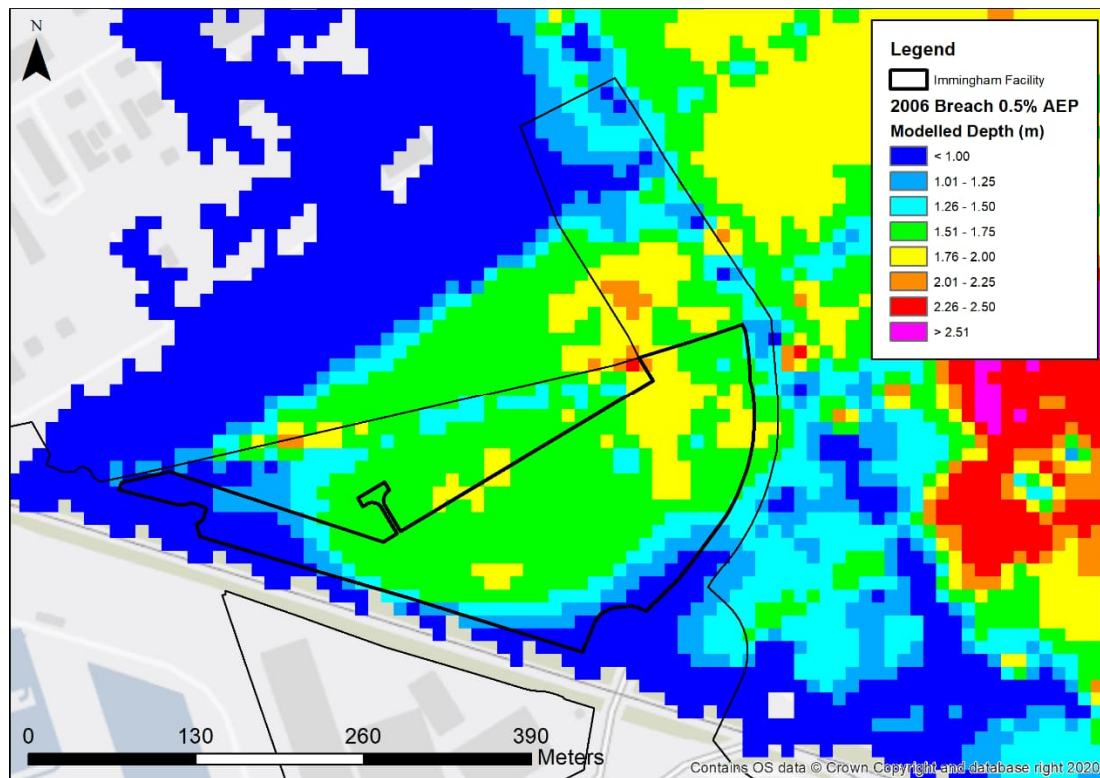


Figure 3-2. Maximum Flood Depths 0.5% AEP Breach Model – Immingham Facility

Table 3.1 Flood Depth Statistics for Immingham

Breach Event Scenario	Average Ground Level (m AOD)	Minimum Depth (m)	Average Depth (m)	Maximum Depth (m)
Immingham Breach 200	3.294	0.398	1.517	2.013
Immingham Breach 1000		0.530	1.812	2.309
Immingham Breach 200CC		1.071	3.033	3.534
Immingham Breach 1000 CC		1.168	3.253	3.755

Figure 3-2 shows that the majority of flooding at the Immingham Facility for a 0.5% AEP breach flood event has a depth between 1.5m – 1.75m and a smaller area has a depth between 1.75m – 2.0m, with small isolated areas outside this range. The other events show a similar pattern, with the range between minimum and maximum depth across the site dependent on the underlying topography as is expected the breach flood level (m AOD) will be reasonably consistent across the site.

The calculated average depth was validated for the 0.1% AEP climate change event by checking against the flood depths at locations across the site highlighted in yellow in Figure 3-3 as shown in Table 3.3. Whilst there is a range of modelled depths the approximate equivalent water level is similar across the site, ranging from 6.2 to 6.3m AOD. The equivalent derived flood level using the average depth is similar, and slightly higher, and thus the average depth provides a suitable basis to inform mitigation for the scheme and the required facility levels in relation to existing ground levels. Specific design levels will be derived during later stages of design when the building positions have been fixed.

Table 3.3 Flood Depth Checks - Immingham

Point location	Modelled Depth (m)	Model Ground Level (m AOD)	Derived approximate water level (m AOD)
13143	2.69	3.61	6.3
12899	3.47	2.74	6.2
11815	3.02	3.32	6.3

Point location	Modelled Depth (m)	Model Ground Level (m AOD)	Derived approximate water level (m AOD)
11667	3.47	2.78	6.3
11522	3.45	2.85	6.3
11622	3.56	2.64	6.2
11600	3.49	2.74	6.2
<i>Average</i>	<i>3.25</i>	<i>3.29</i>	<i>6.5</i>

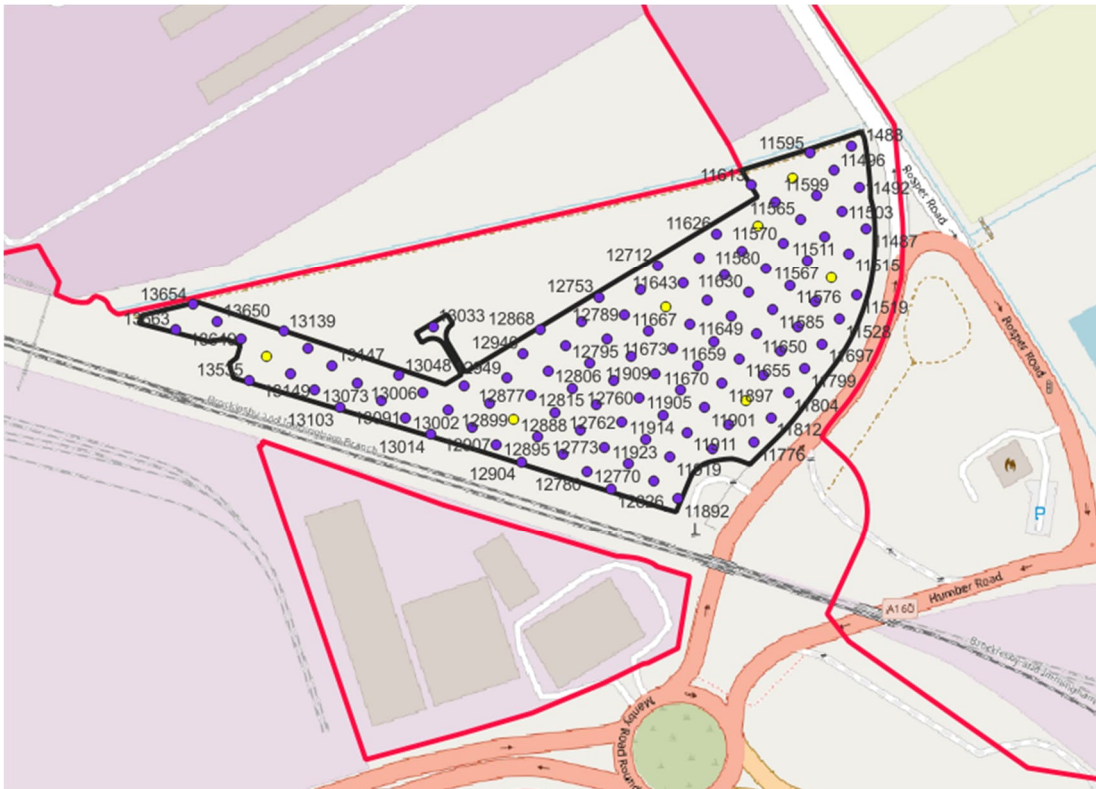


Figure 3-3 Flood depth validation points

### 3.2 Theddlethorpe Facility

There are currently two options for locating the Theddlethorpe Facility. Further details are provided below.

#### 3.2.1 Theddlethorpe Facility – Option 1

The first site option for the proposed Theddlethorpe Facility is located on the former Theddlethorpe Gas Terminal site. The site is currently cleared with a mixture of hard standing, stoned areas and pipeline stubs.

Ground levels within the Site are generally flat and range from a minimum of 1.66m AOD to a maximum of 2.4m AOD towards the western and southern site area.

Figure 3-4. Maximum Flood Depths 0.5% AEP Breach Model – Theddlethorpe Facility Option 1

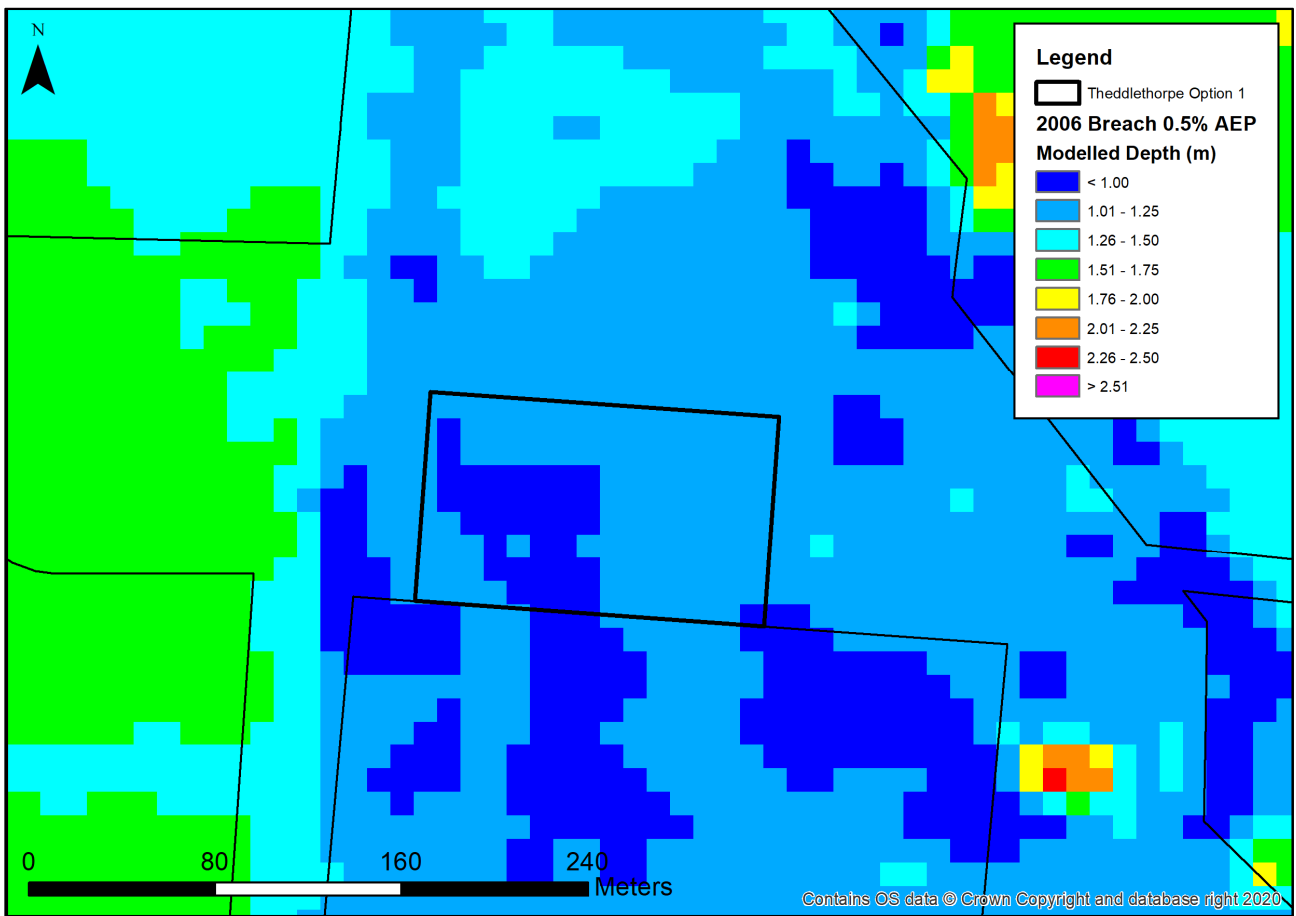


Table 3.4 Flood Depth Statistics for Theddlethorpe Option 1

Column heading	Average Ground Level (m AOD)	Minimum Depth (m)	Average Depth (m)	Maximum Depth (m)
Theddlethorpe1 Breach 200	2.052	0.880	1.051	1.174
Theddlethorpe1 Breach 1000		0.993	1.162	1.288
Theddlethorpe1 Breach 200CC		1.441	1.608	1.739
Theddlethorpe1 breach 1000CC		1.561	1.729	1.865

| [Figure 3-4](#)

Figure 3-4 shows that the majority of flooding at Theddlethorpe Facility (Option 1) for a 0.5% AEP breach flood event has a depth between 1.01m – 1.25m or lower, with an average depth of flooding calculated as 1.05m, as presented in Table 3.4. The maximum modelled flood depth at the Theddlethorpe Facility (Option 1) is not significantly higher at 1.17m associated with a localised topographic low point in the southern and eastern area of the Site. This is the same for all the modelled events with a small difference (<150mm) between the average and maximum depth across the site. It is likely that this low point will be lost through development of the Site, should this option be taken forward. This demonstrates that the average flood depth value provides an appropriate estimate for the typical maximum flood depth on which to base the assessment of mitigation.

The calculated average depth was validated for the 0.1% AEP climate change event by checking against the flood depths at locations across the site highlighted in yellow in Figure 3-5 as shown in Table 3.5. Whilst there is a range of modelled depths the approximate equivalent water level is similar across the site, ranging from 3.6 to 3.9m AOD. The equivalent derived flood level using the average depth is similar and thus the average depth provides a suitable basis to inform mitigation for the scheme and the required facility levels in relation to existing ground levels. Specific design levels will be derived during later stages of design when the building positions have been fixed.

Flood depth checks were carried out using LIDAR DTM 2022 at 1 metre resolution, downloaded 28 June 2024.

**Table 3.5 Flood Depth Checks - Theddlethorpe Facility Option 1**

<u>Point location</u>	<u>Modelled Depth (m)</u>	<u>Model Ground Level (m AOD)</u>	<u>Derived approximate water level (m AOD)</u>
<u>2</u>	<u>1.79</u>	<u>1.99</u>	<u>3.8</u>
<u>11</u>	<u>1.83</u>	<u>1.98</u>	<u>3.8</u>
<u>13</u>	<u>1.68</u>	<u>2.15</u>	<u>3.8</u>
<u>15</u>	<u>1.64</u>	<u>2.02</u>	<u>3.7</u>
<u>24</u>	<u>1.82</u>	<u>2.12</u>	<u>3.9</u>
<u>26</u>	<u>1.67</u>	<u>2.10</u>	<u>3.8</u>
<u>34</u>	<u>1.71</u>	<u>1.93</u>	<u>3.6</u>
<u>Average</u>	<u>1.73</u>	<u>2.05</u>	<u>3.8</u>



**Figure 3-5. Flood depth validation points based on LIDAR data**



### 3.2.2 Theddlethorpe Facility – Option 2 (No longer included in the DCO application)

Please note that this option is only included for completeness as the work was undertaken before the ExA had accepted the change request which has subsequently removed Theddlethorpe Facility Option 2 from the Proposed Development and DCO.

The second site option for the Theddlethorpe Facility is located to the west of the former Theddlethorpe Gas Terminal site, located on arable land directly west of The Cut.

Ground levels within the Site are generally flat and range from a minimum of around 1.3m AOD towards the east to a maximum of around 2.0m AOD to the west.

Figure 3-6. Maximum Flood Depths 0.5% AEP Breach Model – Theddlethorpe Facility Option 2

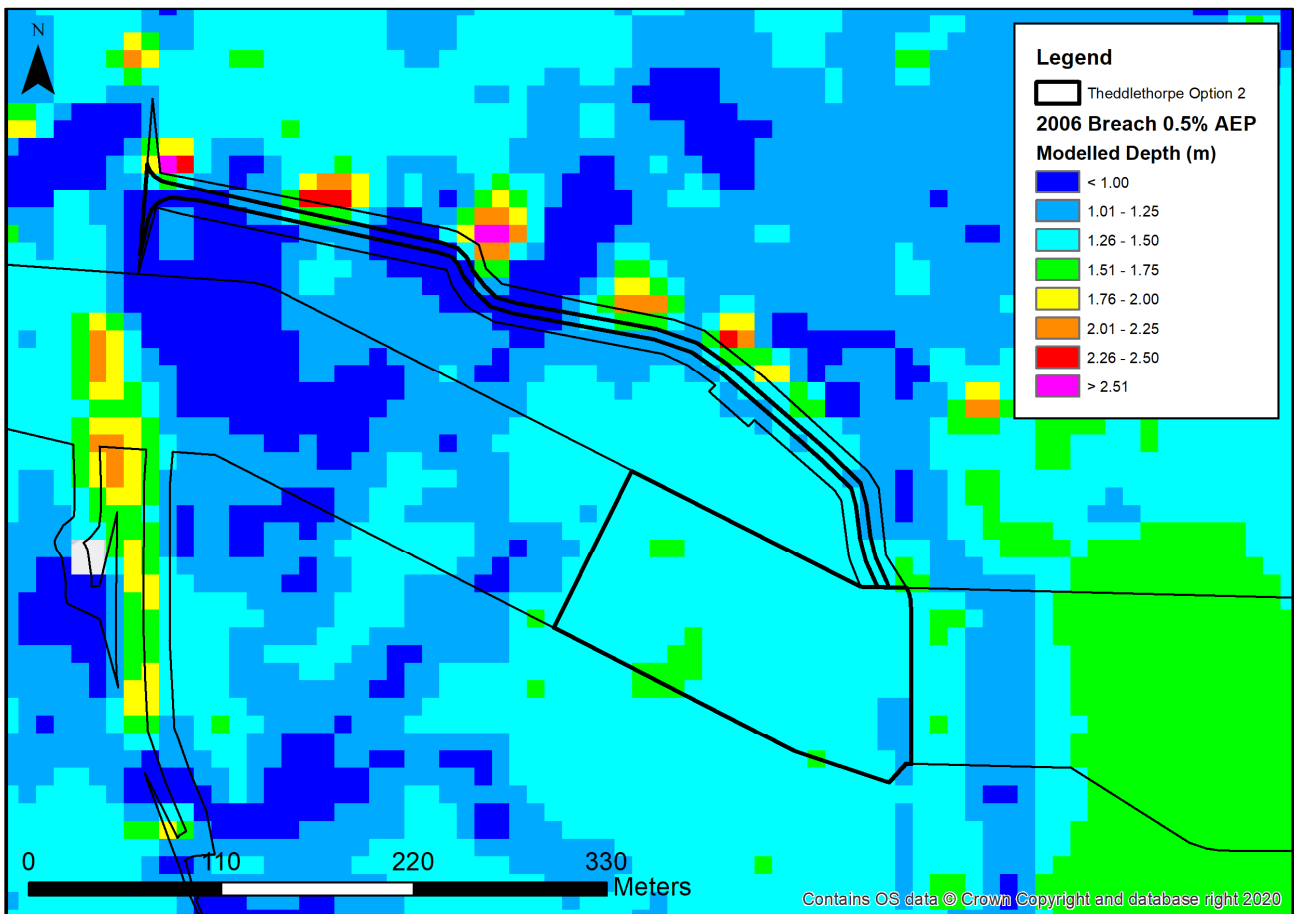


Table 3.6 Flood Depth Statistics for Theddlethorpe Option 2

Breach Event Scenario	Average Ground Level (m AOD)	Minimum Depth (m)	Average Depth (m)	Maximum Depth (m)
Theddlethorpe 2 Breach 200	1.497	1.148	1.421	1.517
Theddlethorpe2 Breach 1000		1.267	1.539	1.635
Theddlethorpe 2 Breach 200CC		1.706	1.979	2.075
Theddlethorpe 2 Breach 1000CC		1.789	2.060	2.152

Figure 3-6 shows that the majority of flooding at Theddlethorpe Facility (Option 2) for a 0.5% AEP breach flood event has a depth between 1.26m – 1.5m, with an average depth of flooding calculated as 1.42m, as presented in Table .6. The maximum modelled flood depth at the Theddlethorpe Facility (Option 2) is higher at between 1.51m and 1.75m, however this flood depth is localised to a small number of isolated topographic low points. As for Theddlethorpe (Option 1) there is only a small difference between the calculated average and maximum depth across the site (<100mm) and therefore the average depth provides a good estimate of the typical maximum flood depth on which to base the assessment of mitigation.

The calculated average depth was validated for the 0.1% AEP climate change event by checking against the flood depths at locations across the site highlighted in yellow in Figure 3-7 and shown in Table 3.7. Whilst there is a range of modelled depths the approximate equivalent water level is similar across the site, ranging from 3.3 to 3.6m AOD. The equivalent derived flood level using the average depth is at the upper end of this range and thus the average depth provides a suitable basis to inform mitigation for the scheme and the required facility levels in relation to existing ground levels. Specific design levels will be derived during later stages of design when the building positions have been fixed.

Flood depth checks were carried out using LIDAR DTM 2022 at 1 metre resolution, downloaded 28 June 2024.

**Table 3.7 Flood Depth Checks - Theddlethorpe Facility Option 2**

<u>Point location</u>	<u>Modelled Depth (m)</u>	<u>Model Ground Level (m AOD)</u>	<u>Derived approximate water level (m AOD)</u>
<u>38</u>	<u>1.50</u>	<u>1.84</u>	<u>3.3</u>
<u>42</u>	<u>1.62</u>	<u>1.78</u>	<u>3.4</u>
<u>49</u>	<u>1.90</u>	<u>1.73</u>	<u>3.6</u>
<u>51</u>	<u>1.95</u>	<u>1.53</u>	<u>3.5</u>
<u>55</u>	<u>2.12</u>	<u>1.45</u>	<u>3.6</u>
<u>59</u>	<u>2.07</u>	<u>1.52</u>	<u>3.6</u>
<u>68</u>	<u>2.12</u>	<u>1.42</u>	<u>3.5</u>
<u>73</u>	<u>2.11</u>	<u>1.45</u>	<u>3.6</u>
<u>78</u>	<u>2.02</u>	<u>1.46</u>	<u>3.5</u>
<u>Average</u>	<u>2.06</u>	<u>1.50</u>	<u>3.6</u>

**Figure 3-7. Flood depth validation points based on LIDAR data**

