Table 2-1 Summary of relevant SMP Policies for the Denes to Walberswick (reproduced from SMP7)

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
BLY 9.1	The Denes	HTL	HTL	HTL	Maintaining the integrity of beach and dune defence, allowing the dunes to respond naturally.
BLY 9.2	Harbour Entrance (north and South)	HTL	HTL	HTL	Maintain and improve the harbour structures in line with use and development of the harbour.
BLY 9.3	Harbour Reach north	HTL	HTL	HTL	Improve defence and raise in 50 years in line with harbour use. Policy will have to be reviewed if not technically feasible and/or economically justifiable using private funding.
BLY 9.4	Harbour reach south side	HTL	MR	MR	Redevelop defences in line with harbour use but maintain defence to Walberswick.
BLY 9.5	Walberswick dunes	MR	MR	MR	Retain beach and dunes as a defence.
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

Table 2-2 Summary of relevant SMP Policies for the Blyth inner estuary (reproduced from SMP7)

Policy Unit		Policy Plan			
		2025	2055	2105	Comment
BLY 10.1	Lower inner estuary	MR	MR	MR	Maintaining the northern defences, subject to confirmation of funding.
BLY 10.2	A12	HTL	HTL	HTL	Improve defence.
BLY 10.3	Upper estuary	NAI	NAI	NAI	
Key: HTL - Hold the Line, A - Advance the Line, NAI – No Active Intervention MR – Managed Realignment					

The SMP advised Hold the Line throughout all three time horizons to 2105 for the Denes, the Harbour Entrance (North and South), and Harbour Reach north side. For the Harbour Reach south side, Hold the Line is advised up to 2025 only, followed by Managed Realignment after that, whilst for the Walberswick dunes, Managed Realignment is advised throughout the whole period. The SMP also recognised the need for some estuary defences to be realigned.

2.3.4 Monitoring

Although monitoring recommendations were made as part of the BES and SMP to aid future understanding of the processes, no such monitoring has been undertaken (this position has been established through consultation with Natural England, Water Management Alliance and the EA).

2.4 Stakeholders

2.4.1 Blyth Estuary Group (BEG)/ Blyth Estuary Partnership (BEP)

The opening page of the website (Ref: FN.17) for the Blyth Estuary Group (BEG) begins thus:

"Following the September 2005 publication of the Environment Agency's (EA) Blyth Estuary Strategy 'Preferred Options', local people became deeply concerned that the proposed 'managed realignment' of the southern river banks would have a serious effect on the future of Southwold Harbour and the safety of navigation within it. The Blyth Estuary Group (BEG) was formed in February 2006 to address local concerns, oppose the EA's Blyth Estuary Strategy and investigate and challenge the science claimed to back the 'Managed Realignment' proposals".

The BEG comprises representatives from:

- Waveney District Council,
- Suffolk Coastal District Council,
- Southwold Town Council,
- Walberswick Parish Council,
- Walberswick Sea Defence Group,
- Reydon Parish Council,
- Blythburgh Parish Council,
- Wenhaston Parish Council,
- Southwold RNLI,
- Southwold Harbour & River Blyth Users Association,
- Southwold Sailing Club,
- landowners – Andrew Blois of the Blois Estates and Walberswick Common Lands Charity (south banks), Andrew Hall of Old Hall Farm and Suffolk Wildlife Trust (north banks), Hektor Rous of Henham Park and Richard Steward from Walberswick (technical advisor to the BEG).

BEG encompasses a broad range of people and organisations with commercial, community and regulatory interests. The stated aims of BEG are:

1. To protect and preserve the Blyth Estuary, it's Harbour and infrastructure for the next generation.
2. To investigate the science behind the EA's strategy and challenge those elements the group considers flawed.
3. To develop an affordable 'contingency plan' for the reinstatement and future maintenance of the clay walls.
4. To undertake repairs identified by the 'contingency plan' and develop a program for ongoing maintenance.
5. To seek cooperation through continued dialogue with the Government Agencies to facilitate advancement of our aims.
6. To campaign for a change in the 1991 'Water Resources Act' to give the EA a statutory duty to maintain our estuary defences to an agreed and acceptable standard.

In 2017 the BEG became the Blyth Estuary Partnership (BEP) to better align itself with the new Defra policy of Partnership Funding[20] to finance flood and coastal erosion risk management projects and other local partnerships with similar aims for other estuaries/ sections of coastline. This was a change in name only, with membership and objectives remaining the same (i.e. as set out above).

2.4.2 Other interested parties

The following list of other interested parties in relation to the use of the harbour at Southwold has been compiled (contact details will be provided at project commencement):

- Gary Doy - Fisherman/ RNLI/ third generation Harbour users
- Archer Ginn - Fisherman (long standing)
- Nigel Hayter - Fisherman
- Richard Steward - Blyth Estuary Partnership and Harbour user
- Richard Burrell - Fisherman
- Marcus Gladwell - local business man operating boat trips from the Harbour (Coastal Voyager)
- Mike Pickles - Foreman HMS boatyard/ Champion dinghy racer
- Graham Hay-Davidson – Southwold Harbour & River Blyth Users Association

[20] Ref: Flood and coastal resilience partnership funding, Defra, 2013 https://www.gov.uk/government/publications/flood-and-coastal-resilience-partnership-funding

- Peter Simmons/Jerry Hilder – Harbour Master/ Deputy Harbour Master

The above are all users of the harbour and have a wealth of information in relation to its current performance.

2.4.3 Pre-project stakeholder engagement

The aim of the pre-project stakeholder engagement has been to determine principally what the stakeholders would like to have delivered by this project (i.e. what technical requirements need to be met for them to continue with their existing business or leisure activities) and what information they can provide to aid understanding of the Harbour Entrance hydrodynamic behaviour. The following questions were asked via e-mail:

1. What are your requirements (e.g. water depth, time related factors, wave height, current etc) to enable you to continue with your current operation?
2. In your opinion, why are the North Wall moorings under-used?
3. In your opinion, what would you like to see changed/ happen in the future in terms of the Harbour structures, if anything?
4. Are you able to assist the project team in understanding the behaviour of waves, currents and sedimentation at the estuary mouth by sharing your experiences and/ or any information that you may have?
5. Are you willing for your contact details to be passed on to and held by the consultant who will be appointed to undertake this project so that they can contact you for more information?
6. Is there anything further you wish to share with us at this stage?

The responses received are located in Appendix A. Essentially, the responses received highlight several issues, as follows:

- Wave activity at the North Wall, particularly around High Water, make mooring challenging, especially for smaller vessels.
- The speed of the tidal current into and out of the Harbour make navigation at the Entrance and within the Harbour more difficult for smaller vessels. However, it is acknowledged that there does need to be a relatively fast current to prevent the entrance from silting up.
- The design of the new North Wall is such that it is not suitable for the vessels that visit the Harbour other than the largest fishing vessels.
- Sediment build up on the south side of the channel in combination with the North Wall extending a further 2m into the channel than it did previously increases the speed of the rising and falling tide and restricts turning in this area. Consequently, vessels have to turn further upstream of the North Wall but downstream of the Bailey Bridge.
- Shallow water at the Harbour Entrance and in the turning area upstream of the North Wall restricts vessels to being able to enter the Harbour only at certain states of the tide (around High Water).
- The Bailey Bridge restricts progression of vessels further in to the estuary.

From this initial consultation we have determined that the Harbour users minimal requirements (i.e. must be achieved) and aspirations ('nice to haves') are as follows:

- Minimal requirements:
    - Wave height at the North Wall should be reduced by 50%.
    - The largest vessel that needs to be accommodated is 70ft, which has a draft of around 3m.
    - The current should not exceed 3.5 knots on the ebb and 2.5 knots on the flood.
- Aspirations:
    - Modify the North Wall structure itself to ensure it is appropriate for the use of leisure craft.

- Improve visitor awareness on how to navigate the Harbour Entrance and access the moorings.

Appendix A – Stakeholder questionnaire responses

Marcus Gladwell – Coastal Voyager

1. What are your requirements (.e.g. water depth, time related factors, wave height, current etc) to enable you to continue with your current operation?
    - Can currently operate at any state of the tide at present. 9m vessel with a draft of just over 1m.

2. In your opinion, why are the North Wall moorings under-used?
    - Tide restriction due to shallow water. Vessels > 40ft, most will have a draft that will stop them being able to come in and out. There are areas of shallow water at the north dock wall, also a shallow area at the entrance. Max vessel would be ~70ft (3m draft). Historically there has been an area of mud close to the Harbour Master which aids turning for vessels.
    - The swell is also an issue.
    - There are a lot of more sheltered marinas that are less tidally restrictive and therefore more attractive for mooring.

3. In your opinion, what would you like to see changed/ happen in the future in terms of the Harbour structures, if anything?
    - Need to change the south harbour arm.

4. Are you able to assist the project team in understanding the behaviour of waves, currents and sedimentation at the estuary mouth by sharing your experiences and/ or any information that you may have?
    - Yes.

5. Are you willing for your contact details to be passed on to and held by the consultant who will be appointed to undertake this project so that they can contact you for more information?
    - Yes.

6. Is there anything further you wish to share with us at this stage?
    - Silting on the south side of the harbour entrance – one past the Knuckle there is a decrease in the flow rate which causes sediment to settle there on the south side. But this area of sediment build up acts as a baffle to break eh waves, restricting their progression further in.
    - Mags (or Maggs?) Coroner has written some detailed description about silting in the harbour.
    - The current regime is far more consistent than that experienced in the 80s, but it is still changing.

Mike Pickles, Foreman – Harbour Marine Services

1. What are your requirements (e.g. water depth, time related factors, wave height, current etc) to enable you to continue with your current operation?
    - The harbour is a living entity which changes from season to season and the users, both commercial and leisure, learn to adapt to them. Some years this adaptation has been harder than others and in truth weather conditions have been the main contributory factor, notably in the winter months, where strong easterlies can have a dramatic effect on harbour mouth navigation. Human intervention has tended to be largely fruitless and, in some cases, has made things worse rather than better.
    - My specific requirements vary depending on what size and type of vessel I am operating at the time. The deeper draft vessels of up to 2.5m draft currently can gain entry at around 2 hours either side of low water or in other words the harbour entrance is usable for such draft for 8 out of the 12-hour tidal cycle.
    - Flow rates are obviously variable and depend on numerous factors but on average in normal conditions the flow is up to around 3.5 knots on the ebb and 2.5 knots on the

flood tide. This has a bearing on the type of vessel as smaller, low powered craft will struggle to enter against a strong ebb tide. For example, a typical 25ft sailing yacht will have a water line length of around 20ft, which has a maximum displacement hull speed of 6 knots but in practice this is likely to be around 20% less at around 5 knots. For such a boat to enter against an ebb tide, she would have to run at maximum speed, for a considerable length of time as she would only be making 1.5 knots over land. Obviously smaller displacement craft would be in a worse situation. This is a known issue and is something we live with day to day, with our only concern being that we hope the flow rate will not increase significantly over time.

- Any unprotected harbour (those without a breakwater) will suffer in on shore winds and Southwold is no different from other harbours like the Deben, the Ore, and even Lowestoft which all have issues when onshore winds exceed 20 to 25knots. Southwold has, in these conditions, a series of standing waves that form in the entrance which makes passage uncomfortable at best and downright scary at worse and has the potential of catching the unprepared out.
- The Northerly flow though the South wall, does mitigate this to some extent so if a vessel is turned by a wave on entering, towards the wall the flow tends to push it away.
- We also find that towards low tide the entrance conditions become slightly easier which is what many would not expect to find.
- Again we are used to the conditions and know what to expect in the entrance and would be keen to maintain the status quo unless there is compelling evidence to the contrary.
- There are three main shallow areas in the main channel and all these are well inside the entrance:
    - The first is on the seaward side of the lifeboat station.
    - The next is opposite the sluice at the inward end of the harbour wall.
    - The last one is a little variable around 200m further upstream with another little blip where the power cable runs over to Walberswick.
- It should be pointed out however that the whole south side of the river adjacent to the harbour wall is too shallow for most yachts apart from an hour either side of high water.

2. In your opinion, why are the North Wall moorings under-used?
    - The North wall is frankly not fit for purpose for anything other than large commercial fishing craft.
    - The fendering is very poor.
    - The Sheet piling is such that boat fenders will disappear in the valleys and become useless.
    - The concrete abutment overhangs and in any swell there is a constant danger of stanchions, davits and even cabin sides getting crushed.
    - There are no sub level cleats or mooring bollards to tie up to. The only option is to lasso a ladder rung and dash up or hope someone is on land who can take your lines.
    - The wall was rebuilt 2m into the main channel, effectively reducing the main channel width. This also means that mooring here is subjected to some of the highest flow rates.
    - Due to the shallows on the south side of the river at this point, turning vessels at this point to moor into the tide, can be quite difficult and at lower tides, impossible.
    - The entrance has historically had a bad reputation due to its difficult conditions. Although this reputation is lessening off now.

3. In your opinion, what would you like to see changed/ happen in the future in terms of the Harbour structures, if anything?
    - A lead in mark, approximately 3/4 nm off the entrance to facilitate correct entry and exit angles. It is very important to get the lead in and out correct especially with the developing sandbank to the North and East of the entrance.
    - A review of what can be done with the exit of Dunwich Creek into the river to try and reduce the spoil and sediment build up on the south side of the river adjacent to the harbour wall. Fixing this would have a significant effect on the usability of the harbour

wall both in terms of reducing flow rates, possibly reducing the swell and allowing movement inside the harbour at all states of the tide.
- Floating pontoons off the harbour wall would also be beneficial but only if/ when the main channel is made wider after solving the Dunwich creek issue.
- Removal of the Bailey Bridge and replacement with a swing Bridge (apparently there was a survey of the bridge recently which concluded that it was falling down). This would open up the estuary to navigation.
- Need to educate users how and where to turn, and how to enter the harbour more generally.

4. Are you able to assist the project team in understanding the behaviour of waves, currents and sedimentation at the estuary mouth by sharing your experiences and/ or any information that you may have?
   - Yes I am more than will to assist with this though its a subject that is best discussed in person rather than via email, I can also pull on a number of other very experienced river users.

5. Are you willing for your contact details to be passed on to and held by the consultant who will be appointed to undertake this project so that they can contact you for more information?
   - Yes. I work at the harbour every day.

6. Is there anything further you wish to share with us at this stage?
   - I am giving you the benefit of the doubt as we have been consulted before and then promptly ignored and overruled by external experts leading to the current harbour wall fiasco and other dubious decisions I realise that you are to produce a brief and have little control over future decisions but still you can understand my slight reservations on the process.

Archer Ginn, Fisherman

1. What are your requirements (e.g. water depth, time related factors, wave height, current etc) to enable you to continue with your current operation?
   - The present low water depth of 1.5 metres is workable for my operations using a boat of 1.1 metre draught by 6.2 metres long and the boat copes with existing tidal flows.
   - Wave height is weather dependent and as I only operate in fine to moderate weather this depth of water is workable and I can vary my times of sailing accordingly, this can be better explained face to face.

2. In your opinion, why are the North Wall moorings under-used?
   - Strong currents and wave action in heavy weather makes laying alongside in heavy weather untenable to all but large craft.
   - Expecting marina conditions in a dock only 300 metres from the open sea with the current layout is somewhat hopeful.
   - My historical knowledge commenced when I crewed for full time fishermen as a schoolboy in 1957. Anecdotally I was told the harbour used to be twice as wide opposite the North Wall until the construction of the South Pier from Walberswick Quay to the harbour mouth in 1939, until this time they laid their boats alongside the North wall wave but thereafter conditions became impossible for them and they moved upriver to the stages that are used today.
   - I can only remember a few large visiting vessels being moored in the dock over the years apart from an attempt to start a short life sea aggregates dredging operation in the 1970s.
   - When the South Pier was rebuilt in the 1960s panels were broken through the Walberswick wall in an attempt to dissipate wave energy and reduce wave action in the dock, this has only been partly successful to give the conditions we have today.

3. In your opinion, what would you like to see changed/ happen in the future in terms of the Harbour structures, if anything?

- The South Training Arm as the South Pier is referred to today requires rebuilding having been neglected far beyond it's expected life. I would like to see this rebuilt in it's current form to maintain the cross-section profile in the harbour mouth channel so as to maintain safe navigation.
- I am concerned that the desire to improve wave conditions against the North Wall will bring changes that could adversely affect the channel, the overall wellbeing of the harbour is paramount as those of us of long experience who have enjoyed 30 years of safe harbour use without suffering the channel blockages and vessel strandings of old.

4. Are you able to assist the project team in understanding the behaviour of waves, currents and sedimentation at the estuary mouth by sharing your experiences and/ or any information that you may have?
    - I would be pleased to pass on my experience and knowledge of quirks of currents around the harbour mouth ideally as a face to face.

5. Are you willing for your contact details to be passed on to and held by the consultant who will be appointed to undertake this project so that they can contact you for more information?
    - I am happy for my contact details to be passed on within this scope and can be contacted on.

6. Is there anything further you wish to share with us at this stage?
    - I think I have covered that subject so far.

Appendix B – Other stakeholder feedback

Opinion expressed by Graham Hay-Davidson (Harbour Users Group) on the scope of the SHIP project (February 2018):

Let me say at the outset that I am not a hydrographer and the opinions expressed hereunder are mine and not necessarily the views of all Harbour Users. The best people to talk to are those who have lived and fished from Southwold throughout their working lives. People like Archer Ginn, Gary Doy, Nigel Hayter and Richard Burrell will all know more about the harbour entrance in all weather conditions although they may not all agree amongst themselves as to the solution. I have piloted my 35ft ketch into the harbour in difficult conditions and it can be quite exciting to maintain control if you do not know what to expect.

It is, I believe, true to say that the south training arm was given only five more years of life over twenty years ago. In that time nothing has been done to the training arm or to create a sinking fund to meet the cost of replacement. In order to assess the viability of any proposals we need to know the wave pattern and tidal flows at the harbour entrance. We also know that for the last twenty years we have not suffered any blockages of the harbour entrance through the shifting south of the Hayle Bank during northerly gales or the migration north of the sands in the bight in south easterly gales. It is understood that the speed of the spring ebb tide is a contributory factor in washing the silt and shingle clear of the harbour entrance.

Whatever we do to the south training arm must not lead to a reduction in the speed of the flow on the ebb or diminish the self-cleansing of the entrance.

The south arm used to have sheet piling along its whole length but many years ago holes were cut through the piling creating what are referred to as the windows to over-come a problem on entering the harbour. Gary Doy will know chapter and verse on this issue but my recollection is that without the windows it was difficult to enter against an ebb tide. The creation of the windows allowed a certain level of permeability through the arm reducing the concentration of the flow within the entrance.

We have, at present, no firm idea as to what we can do to support the failing structure. My guess is that we shall have to simply abandon the concrete frame and build a new wall immediately to the south of the arm which will protect the remains of the concrete structure from future demolition by a southerly gale. There is no future in considering solutions which cannot be justified bearing in mind the size of the harbour and there are many solutions which come into this category which I have discounted as being simply unaffordable.

My best guess is that of creating a rock mole adjacent to and integrated with the existing structure using those massive rocks that Norway seems to specialise in for the whole length of the arm. Placing the rocks would be simplified by the facility of mooring the rock barge in the harbour entrance and craning the rocks over the arm and placing them where required to create a mole or breakwater finishing somewhat higher that the existing structure. This, I think, would be the cheapest satisfactory solution.

The question that we would like you to ask the [Consultant] is what would the effect be upon the ebb and flow at the harbour entrance through adopting this proposed solution? Can they think of a better solution that would achieve that same aims?

The other problem which is inhibiting the use of the dock wall by visiting vessels is the swell in the harbour under certain weather conditions; mostly south easterly winds.

On the south side of the harbour opposite the fisherman's compound there is a shoal bank which is exposed at low water springs. When we have an easterly wind swells enter the harbour and, upon reaching the shoal, commence to swell up in the shallow water preparatory to breaking and it is this swell that causes discomfort for vessels moored to the dock wall. My proposal to eliminate this swell is to erect a 'baffle' projecting from the south arm a little east of the lifeboat station position of perhaps twenty or thirty feet into the flow at right angles to the wall hopefully to stop the swell reaching the shoal. This could be erected on a temporary basis to see if it worked and if so then it could be made a permanent fixture. The question for the [consultant] is what would the erection of such a baffle have upon tidal flow within the harbour and at the entrance? If we can kill the swell before it reaches the shoal the harbour would remain calm. In the alternative what proposal would he advance to cure the problem?

Notes from Telecon with Richard Steward – member of the BEP and Harbour Users Group

- Confirmed that the aims and membership of the BEP were the same as the BEG.
- It is the intention of BEP to maintain the existing banks throughout the estuary and raise them.
- Breaches did occur to the banks during the 2013 surge, but these were repaired by the BEP EA, NE and local volunteers.

Issues:

- Main issue is the swell in the Harbour which makes mooring on the new North Wall problematic. Something needs to be done to stop the waves from entering the harbour. If the waves could be halved, that would be beneficial. The waves are an issue at high water. Waves of 0.5m are a real problem. Smaller boats and fishing boats don't want to moor on the north wall in winter or summer.
- South harbour arm is in poor condition with lots of holes in it. Some people (e.g. Ginn) say that the holes should not be filled in as they keep the entrance free of sand/ shingle (ebb tide).
- The Blackshore area, where all the fishermen and businesses are, plus 6 or so houses at the west end and a pub: This area is low lying (~1.6mODN) and is therefore vulnerable to flooding. The area tends to flood once/ twice a year, being flooded in the 2013 to a depth of 0.9m.

Possible options:

- Fill the south harbour arm structure up to the top with rock armour or build a 3.8m ODN rock mole just to the south of the south pier.
- A 3.8m ODN rock reef SE facing about 100m long off the south pier.
- Some sort of wave baffling system on the south side, west of the knuckle.
- There needs to be a good 'seal' between the channel and the Walberswick beach to prevent the beach there being lost into the channel.

Processes:

- EA reported that the tidal prism would increase by 60% in the future and therefore the estuary mouth needs to widen. BEP disputes this: Ken Pye report (2009) supports the BEP position that the marshes are siling up by 10mm/year.
- BEP also did some monitoring that supported this. Net sea level rise is 3.5mm/year, therefore the tidal prism in the estuary is actually decreasing each year.
- Harbour mouth must not be widened as otherwise it will fill up with sand/ shingle.
- The beach at Walberswick is held in place by the concrete piles of the old harbour structure. Some of these have broken off and resulted in scour (see area highlighted on Google Earth image below.
- The narrow harbour entrance does significantly restrict the incoming tide during large surge events that breach and overtop the downstream walls, which is illustrated by the fact that the surge water level at the Bailey Bridge is significantly lower than that at the Harbour Entrance. Surge events that do not overtop the walls are the same throughout the estuary.

Southwold Harbour Study

Stakeholder Workshop 1

Amy Savage
13 November 2019
Project related

Agenda

Aims and Objectives for this workshop	10.30
Introduction - Project Team & the Project	10.35
What are the key issues for the future management of the harbour?	10.55
Condition of the harbour structures	11.15
Waves & tides in harbour & estuary	11.35
BREAK	12.10
The future management strategy	12.20
Review workshop outcomes	13.00
Next Steps	13.10
FINISH	13.15

Aims and Objectives for this Workshop

- Introductions – to the project and to each other
- Understand the project issues and your views about them
- Identify any additional data
- ***Anything else?***

Introductions

Project Team

- East Suffolk Council
- Coastal Partnership East
- Royal HaskoningDHV

Blyth Estuary Partnership

Blyth Estuary Partnership

Introduction to the project

Continue the stakeholder led approach, informed by data

- **WORKSHOP 1 - Understand your issues and local interactions** **TODAY**
  - ***Task*** - Condition of structures – inspection, consider options
  - ***Task*** **-** Metocean survey – enhance baseline data for modelling

- WORKSHOP 2 – Use local knowledge to make sure the baseline and approach to modelling is right
  - ***Task*** - Modelling – informed by these discussions, the existing data and potential options

- WORKSHOP 3 – review modelling results against your experience
  - ***Task*** - Finalise modelling
  - ***Task*** - Recommendations for management approach
  - ***Task*** - Investment plan

- WORKSHOP 4 – conclusions and recommendations

Project Objectives

To develop a realistic investment plan to inform future funding needs and decisions relating to prioritisation of works and the interrelation of processes:

- Understand the hydrodynamic regime of the harbour and estuary
- Understand the condition, performance and usability of the harbour structures
- Understand the impacts of the flood risk management strategy on the harbour
- Investigate options that achieve a satisfactory wave climate for mooring
- Develop an Investment Plan

Anything else?

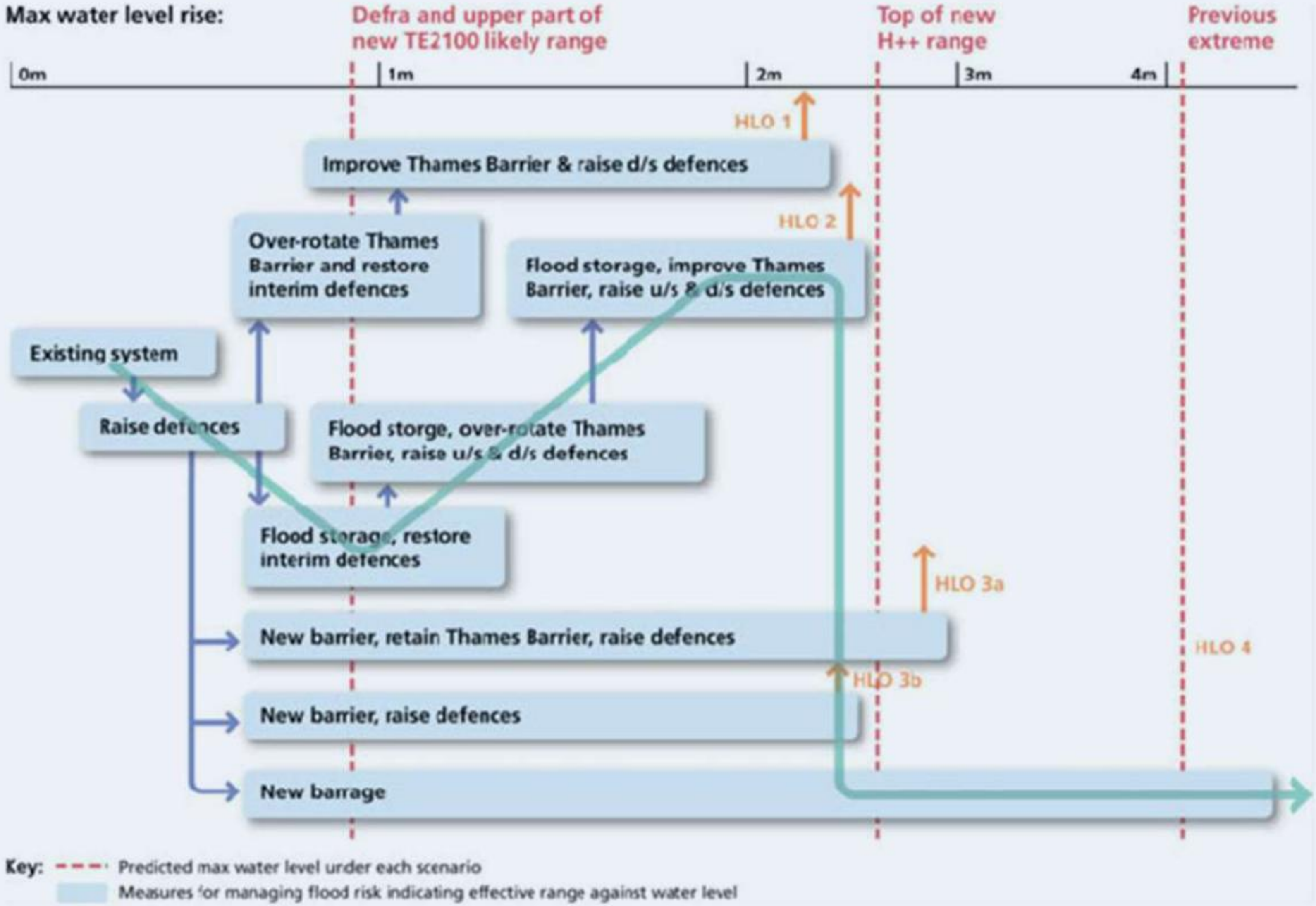
The Investment Plan

Cost of future capital and maintenance works for ongoing viability of the Harbour

- Navigation to / from / within the Harbour and safe mooring
- Coast protection
- Flood defence
- Management of flood risk in the estuary

- Short (20 years) & medium (20-50 years) terms
- Each strategic scenario
- Allow for risk and uncertainty
- Justify cost assumptions

Decision pathway example



Royal HaskoningDHV

What are the key issues (general)?

Points for discussion:

- Condition of the harbour structures
- Constraints on use of the harbour (waves, tides, sediment, usability)
- Management approach for the wider estuary – how this impacts on the harbour

Anything else?

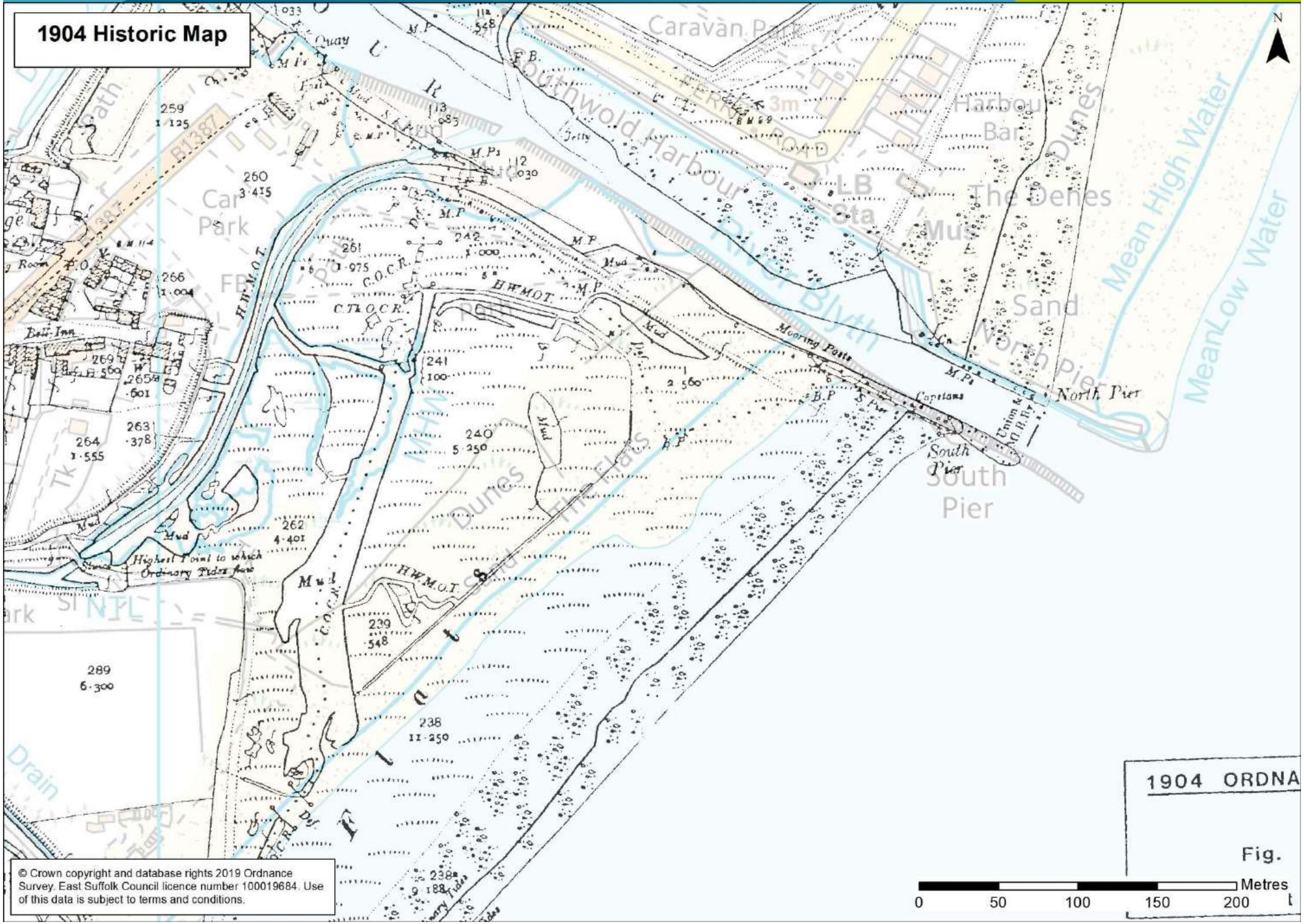
Condition of the Harbour Structures

Objective - assess options for improvement to develop Investment Plan

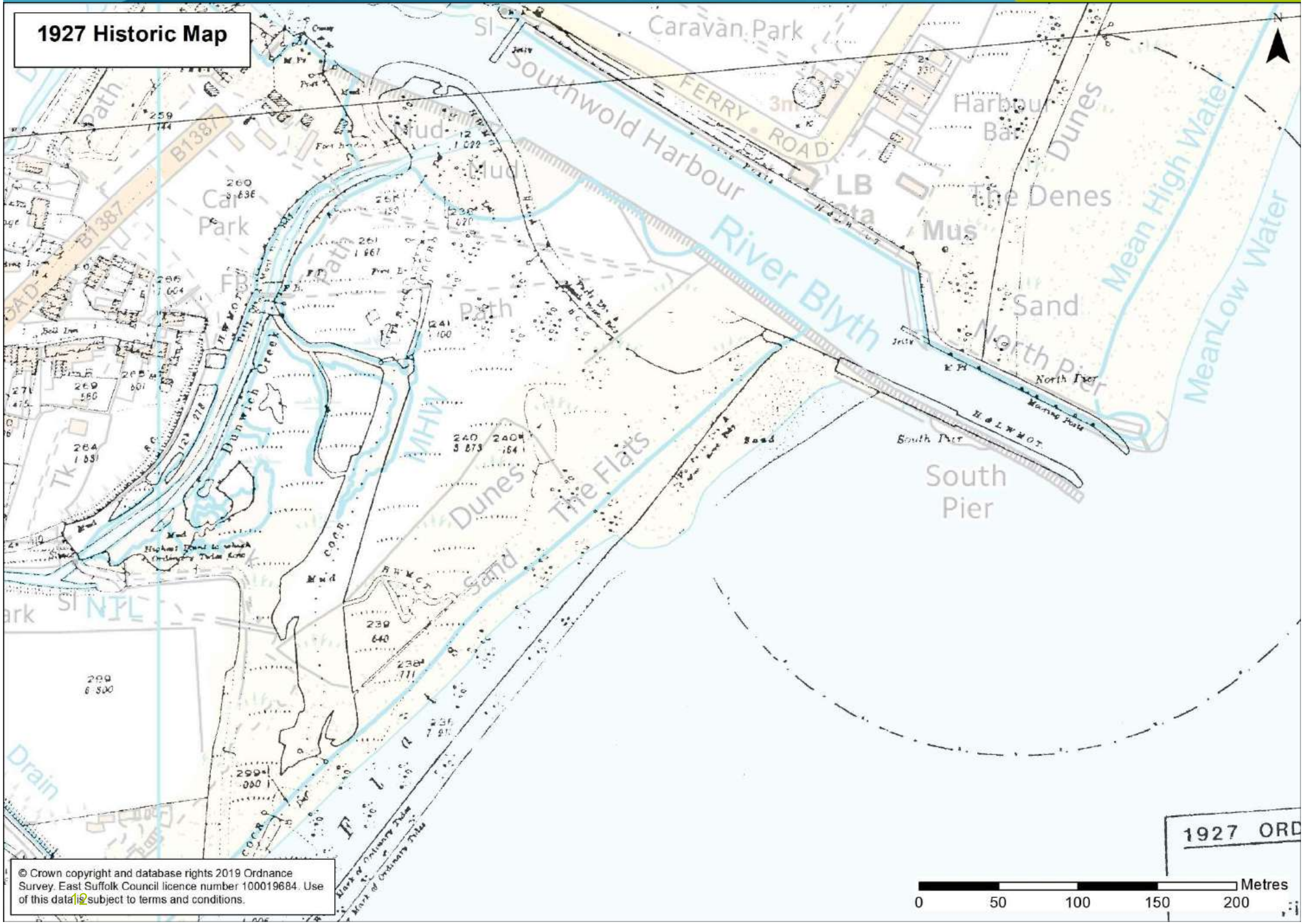
Understand condition of structures and what is possible:

- South Pier
- South Training Arm
- North Pier
- Knuckle
- North Wall
- Estuary banks
- Other structures?

1904 Historic Map

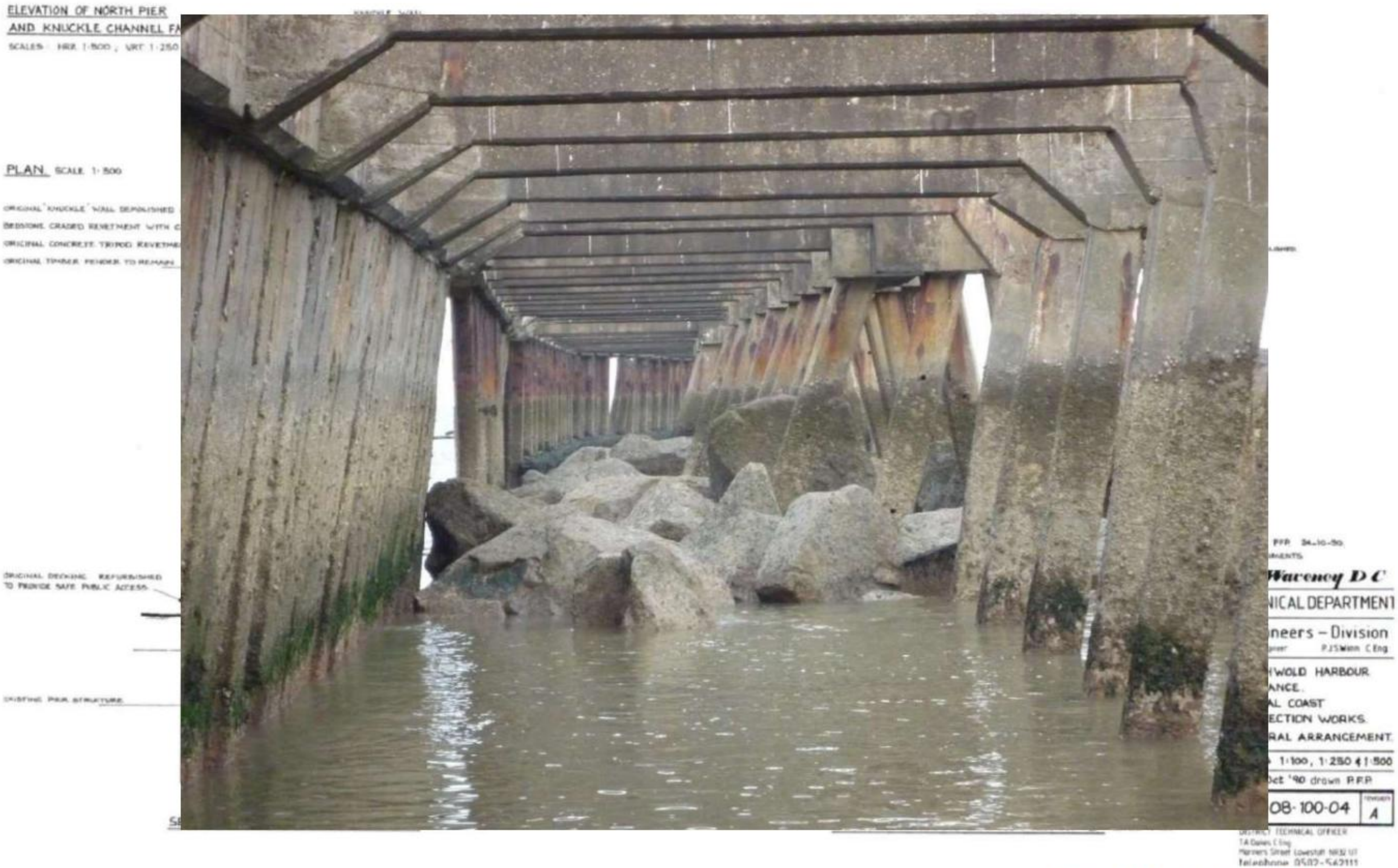


1927 Historic Map




Drain
Path
B1387
B1387
OAD
Car Park
FB
Path
Mud
Mud
Sl
Caravan Park
FERRY ROAD
3m
Southwold Harbour
Harbour Bar
Dunes
LB Sta
Mus
The Denes
Mean High Water
Mean Low Water
River Blyth
Sand
North Pier
Path
MHW
Tk
Tk
Dunes
The Flats
Sand
South Pier
ark
Sl
NTL
Drain
N
Metres
0
50
100
150
200

Capital works 1990



Royal HaskoningDHV

Constraints on use of the harbour

Waves, tides & navigation issues

- Narrow entrance limits surge penetration, but confines ebb flow
- Low powered vessels struggle against strong ebb tide
- Standing waves form during onshore winds
- Easier to navigate entrance on low tide
- Gaps in South Pier help with navigation
- Tidal currents more consistent than in 1980s
- Increasing tidal prism could mean that the entrance wouldn't be navigable
- Increased flows could result in scour that destabilises the entrance structures.

Any other key issues or information?

Video – harbour entrance

Constraints on use of the harbour

Sediment

- Concentrated flows through entrance channel keep it clear
- Sediment blockage in the past (e.g. 1987), but not for last 20 years
- Shoal bank opposite North Wall affects hydrodynamics
  - Swells build over bank
  - Acts as baffle to break waves
  - Influence of flows and sediment from Dunwich Creek?

Any other key issues?

Constraints on use of the harbour

Use of the North Wall

- Shallow water, inaccessible to vessels >40ft
- Swell during easterly and south-easterly winds limits use
- Poor fendering, and boat fenders lost between piles
- Overhanging concrete abutment risks damage
- Mooring bollards needed
- Alignment has reduced channel width by 2m
- Restricted width for turning

Anything else?

Constraints on use of the harbour

Initial questions:

- Are wave and tidal conditions at the N Wall a significant constraint for mooring? Or is the main issue the form of construction?
- How have the wave and tidal conditions at the N Wall got worse with the new wall?
- How does flow through South Pier affect conditions at the North Wall?
- Interactions of physical processes at shoal bank
- Why have currents become more consistent?
- Reduced sediment – increased tidal flows?
- Observed changes in tidal flows since embankment breaches?

Constraints on use of the harbour

Discussion - Aspirations for future conditions

- Accommodate vessels up to 70m, 3m draft
- Reduce wave height by 50%
- Ebb current <3.5 knots
- Flood current <2.5 knots
- Maintain self-clearing channel
- Modify form of construction of N Wall

Anything else?

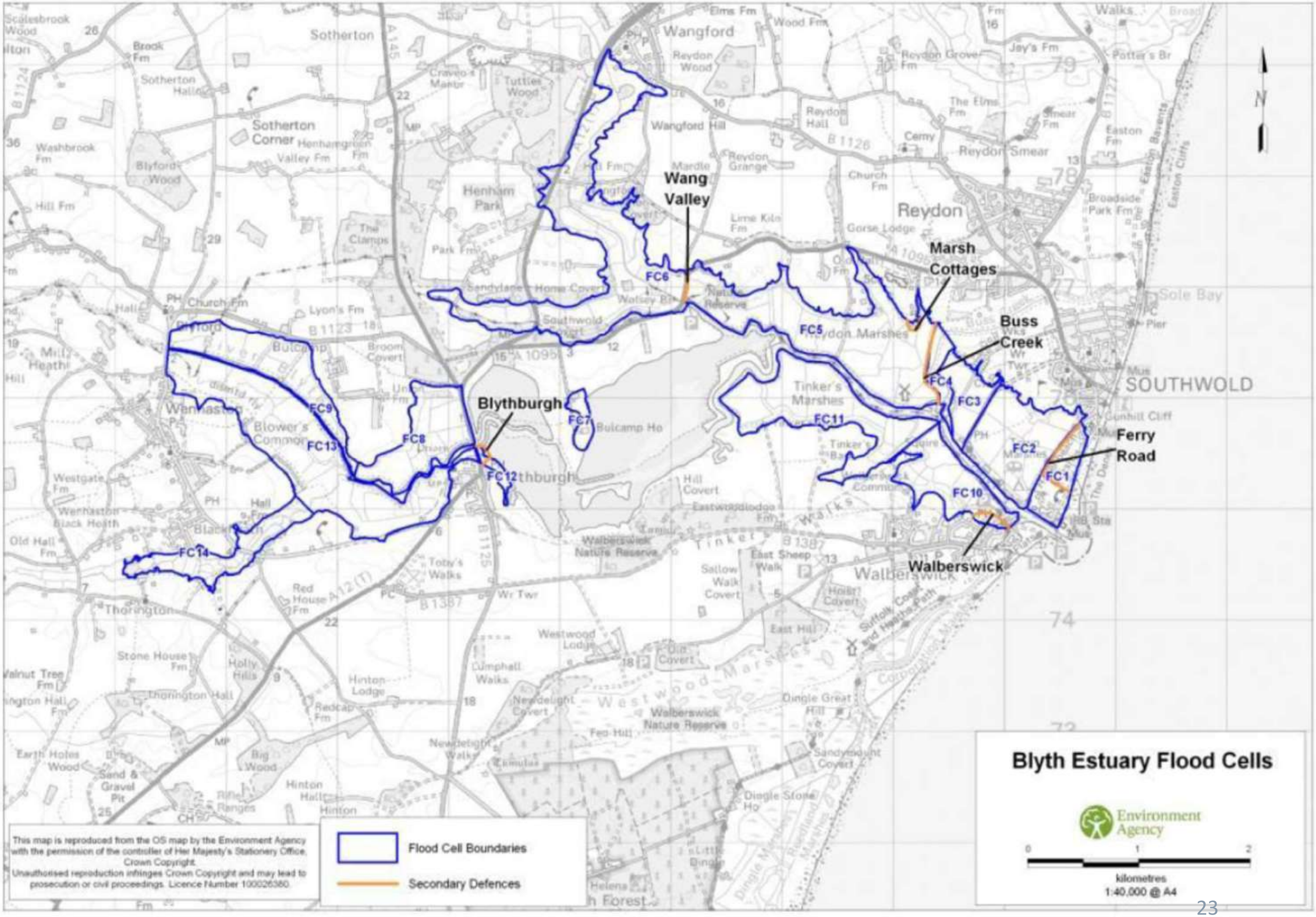
Future use of the Harbour

What might happen in the future?

- Embankment breach
- Climate change
- Increasing tidal prism and flow rates?
- Further constraints on navigation
- More scour, risk of undermining and failure of Harbour entrance structures
- Retreat of dunes (Denes and Walberswick)
- Loss of use of harbour
- Flooding / erosion of Southwold and Walberswick

Management Policies and Relevant Studies

- EA Strategy
- SMP
- Marsh Sedimentation Report
- BEP proposals


Blyth Estuary Flood Cells
Wang Valley
Marsh Cottages
Buss Creek
Blythburgh
Ferry Road
Walberswick
SOUTHWOLD
FC1
FC2
FC3
FC4
FC5
FC6
FC7
FC8
FC9
FC10
FC11
FC12
FC13
FC14
Flood Cell Boundaries
Secondary Defences
Environment Agency
0
1
2
kilometres
1:40,000 @ A4
This map is reproduced from the OS map by the Environment Agency with the permission of the controller of Her Majesty's Stationery Office. Crown Copyright.
Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil proceedings. Licence Number 100026380.

Outcomes & Next steps

- Comments on this workshop
- What the Project Team will do next
  - Condition survey of structures – January
  - Bathymetric survey, current measurements, sediment samples - Feb/March TBC
- Next workshop
  - Options
  - Proposed approach to modelling

Southwold Harbour Study

Stakeholder Workshop 2

13 July 2020

Agenda

Welcome	13.30
Aims and Objectives for this workshop	13.35
Feedback on shared information	13.40
Progress with wave and tidal modelling, including discussion of results	13.50
BREAK	*14.30*
Condition of harbour structures	14.35
Options for South Pier	14.45
Issues / options for performance & use of harbour	15.00
Conclusions & Next Steps	15.20
FINISH	15.30

Welcome

- Local residents and harbour users, including Blyth Estuary Partnership representatives
- Project team (ESC, CPE, RHDHV)

Aims and Objectives for this Workshop

1. Share findings from the baseline modelling

2. Confirm the issues to be addressed by the management strategy

3. Explore options for the harbour structures

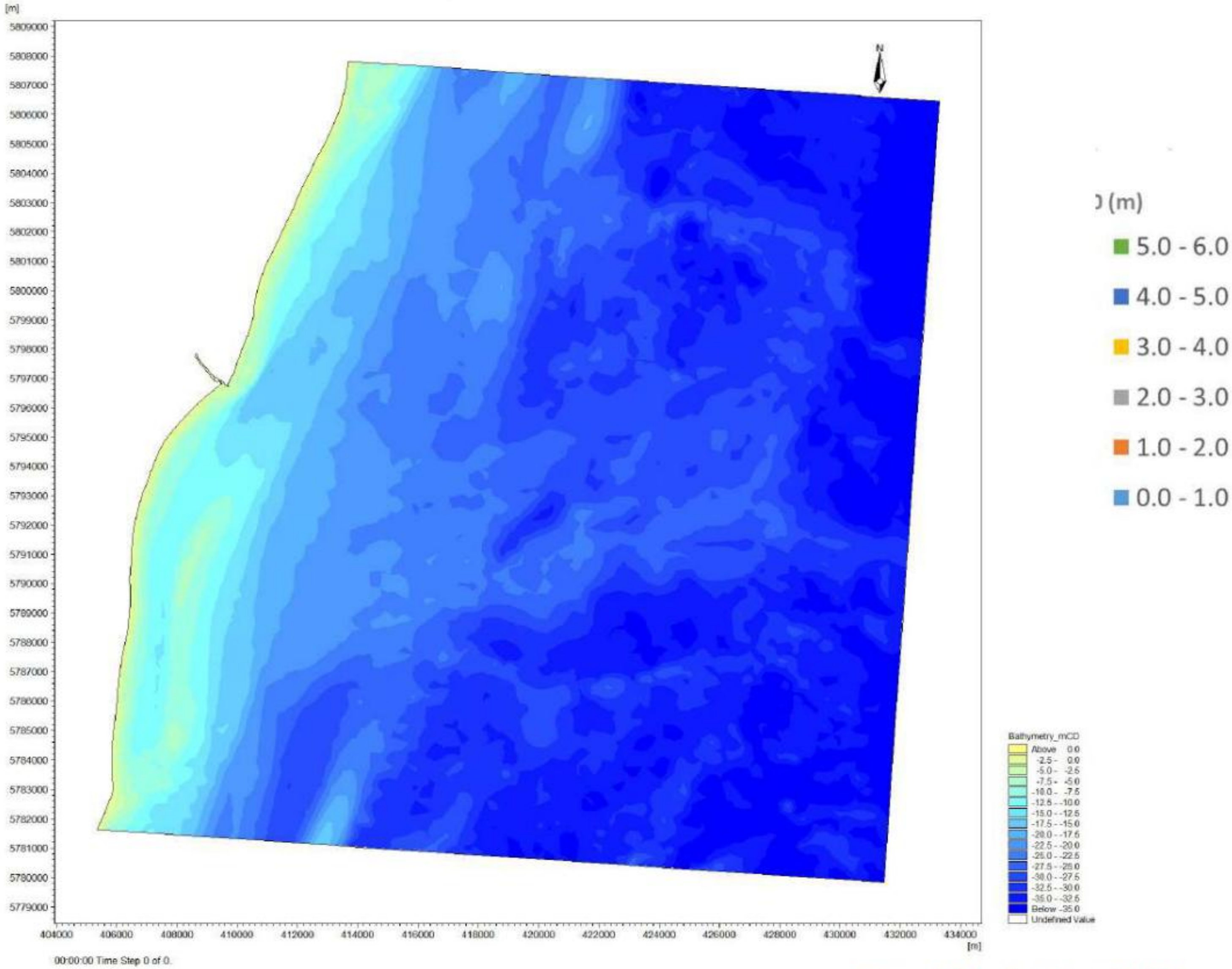
Feedback on shared information

- GIS
- Modelling approach
- Any other comments?

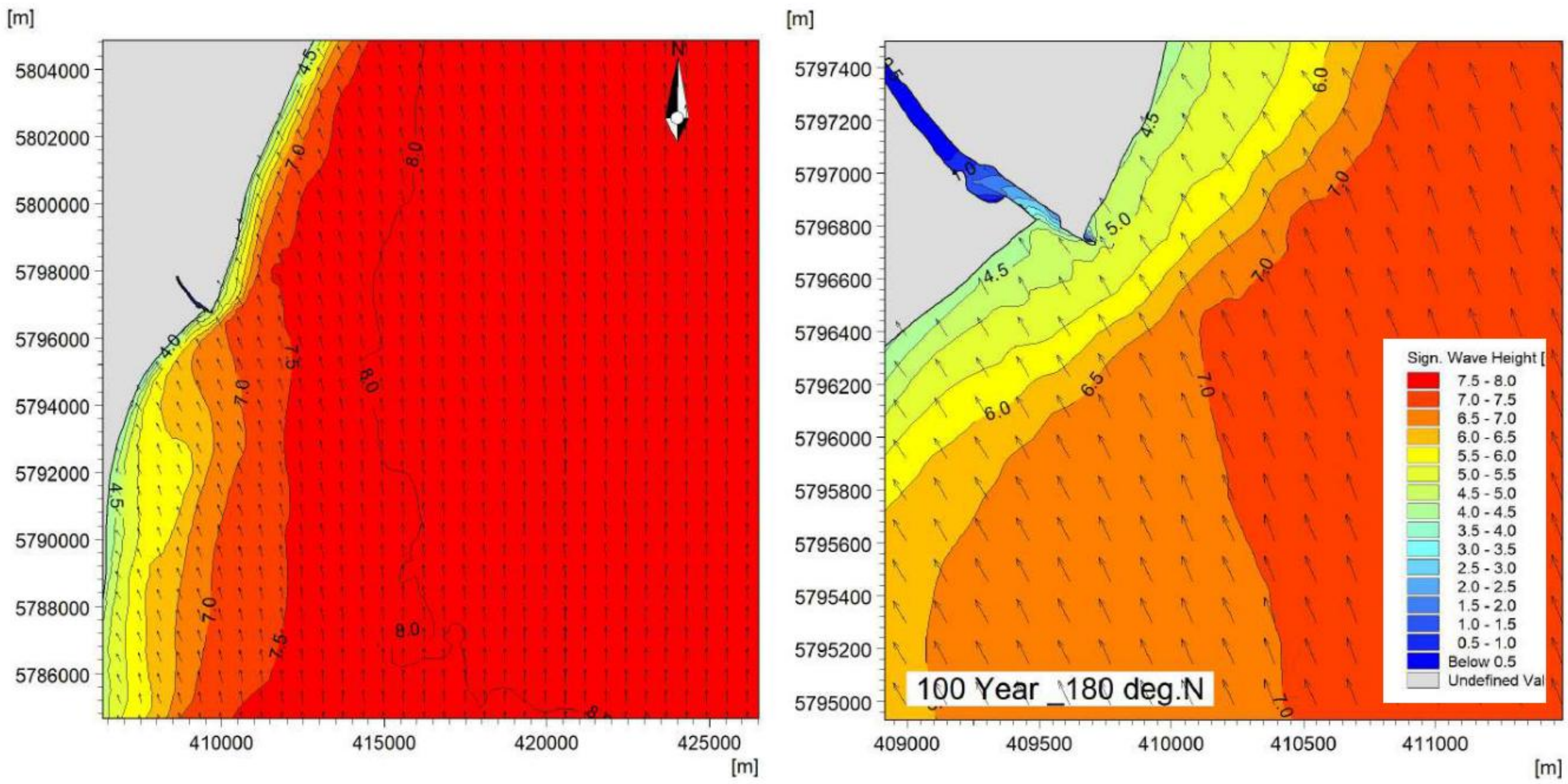
Baseline wave modelling

- How the model was developed
- Results of baseline modelling
- DISCUSSION - your observations

Offshore data to nearshore

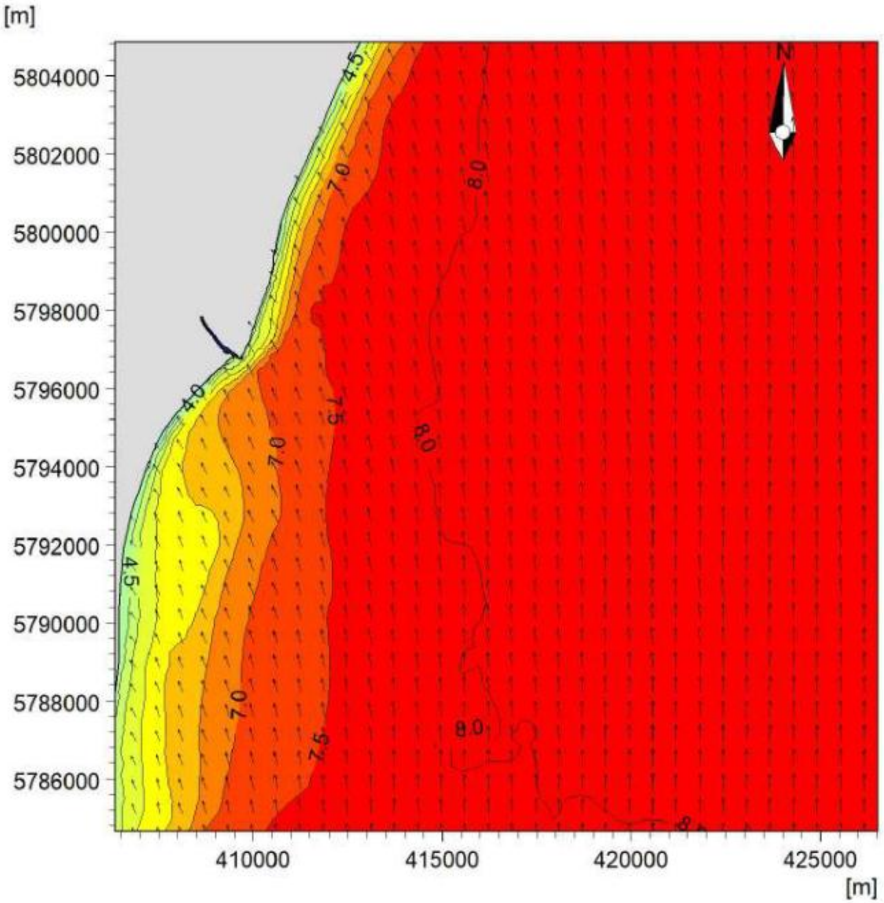


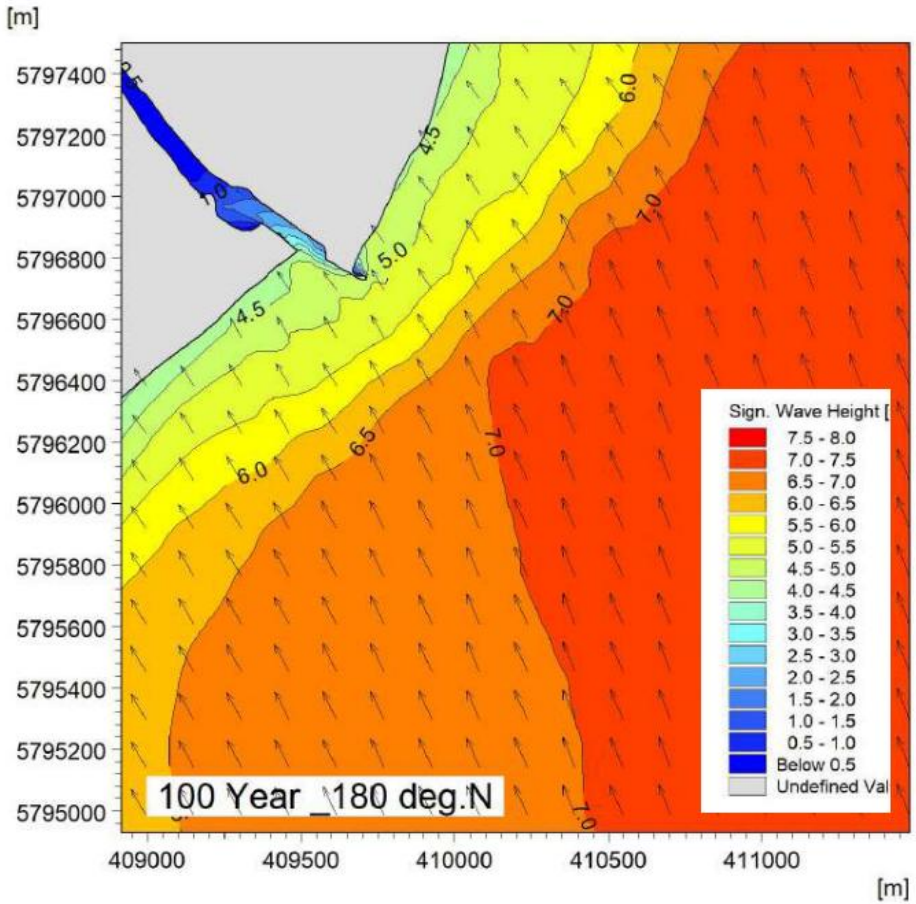
Wave transformation results



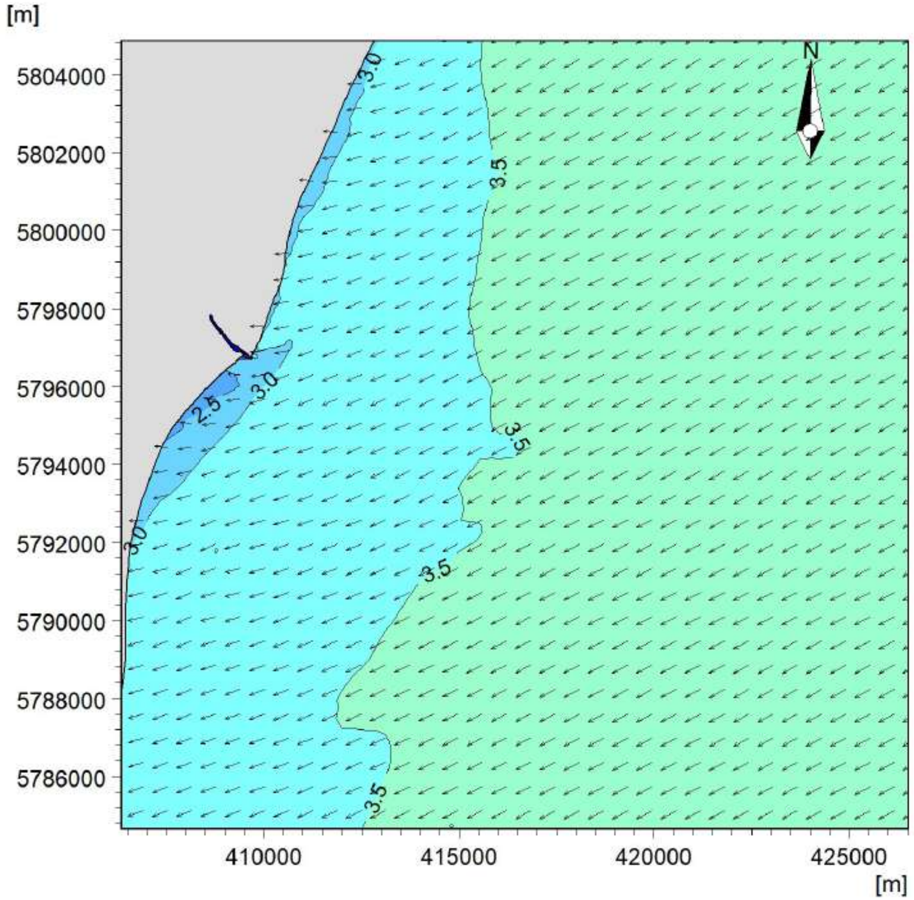
Royal HaskoningDHV

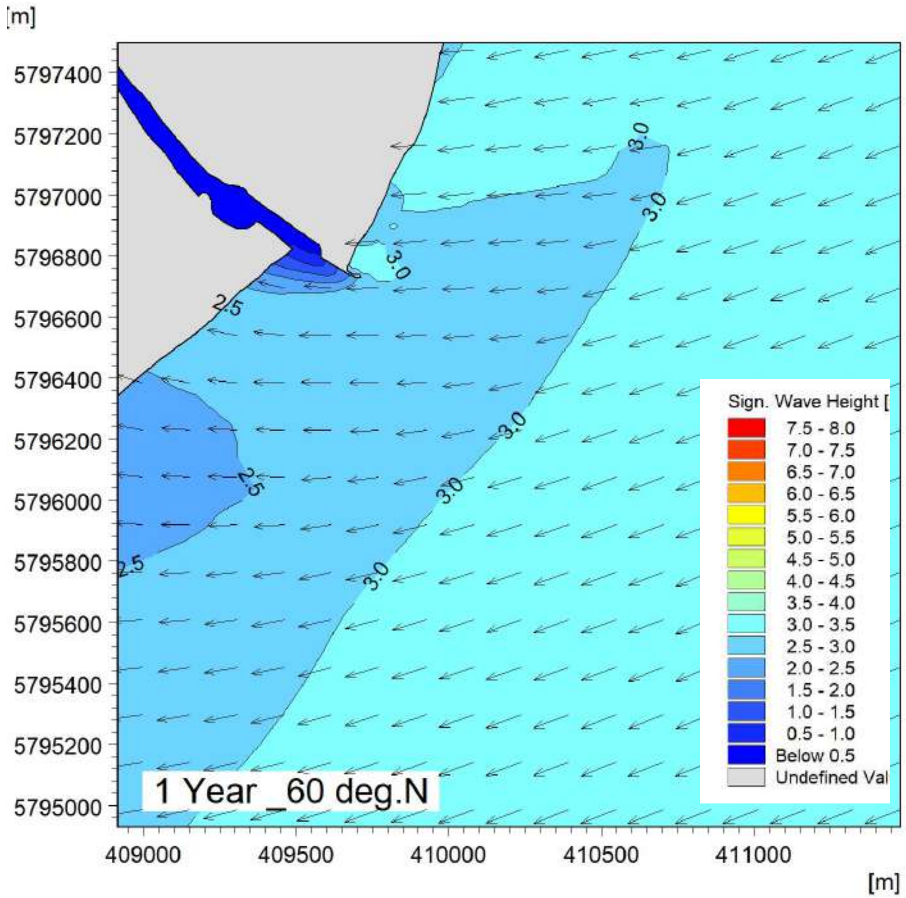
Wave transformation results



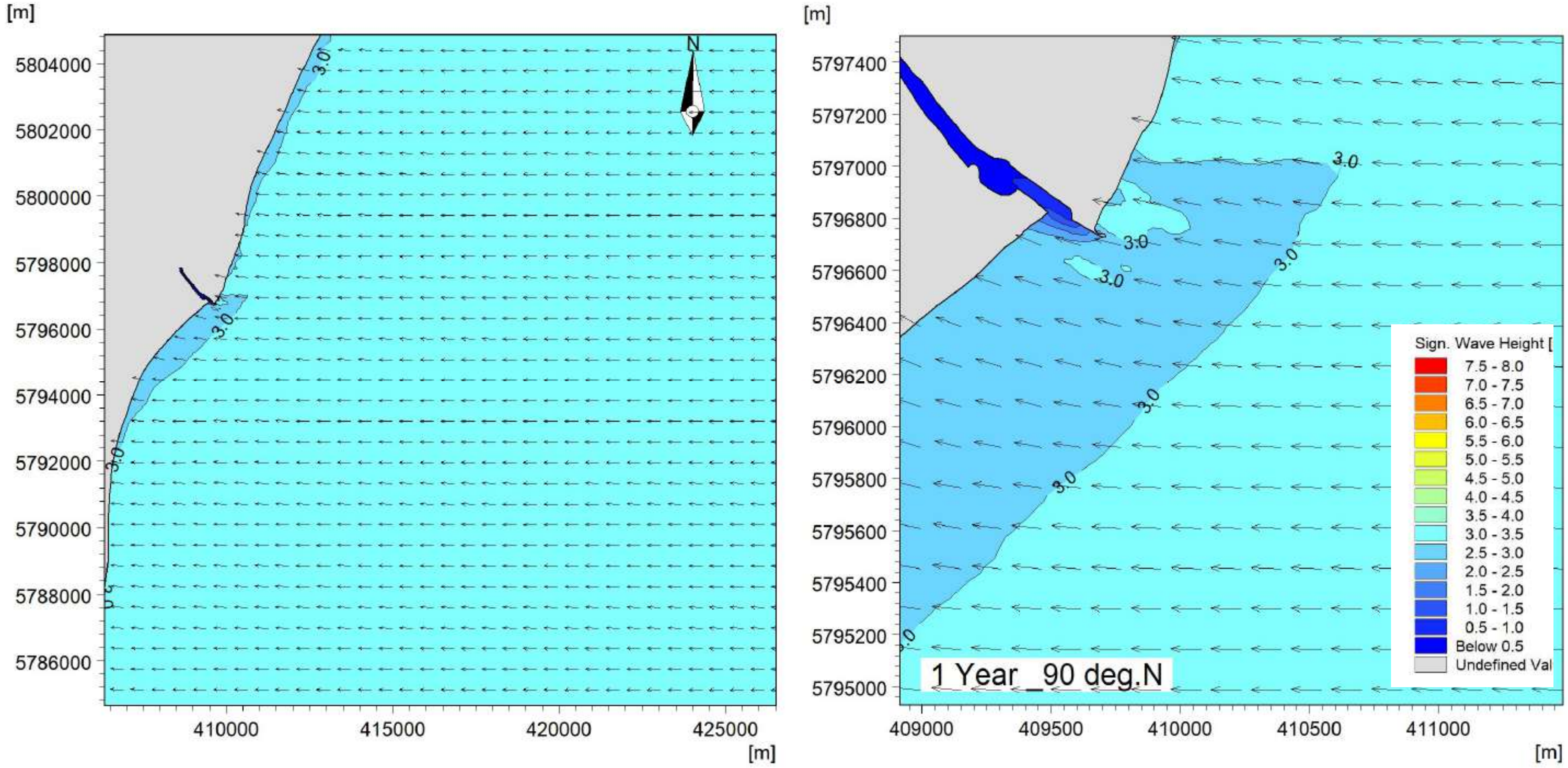


Wave transformation results



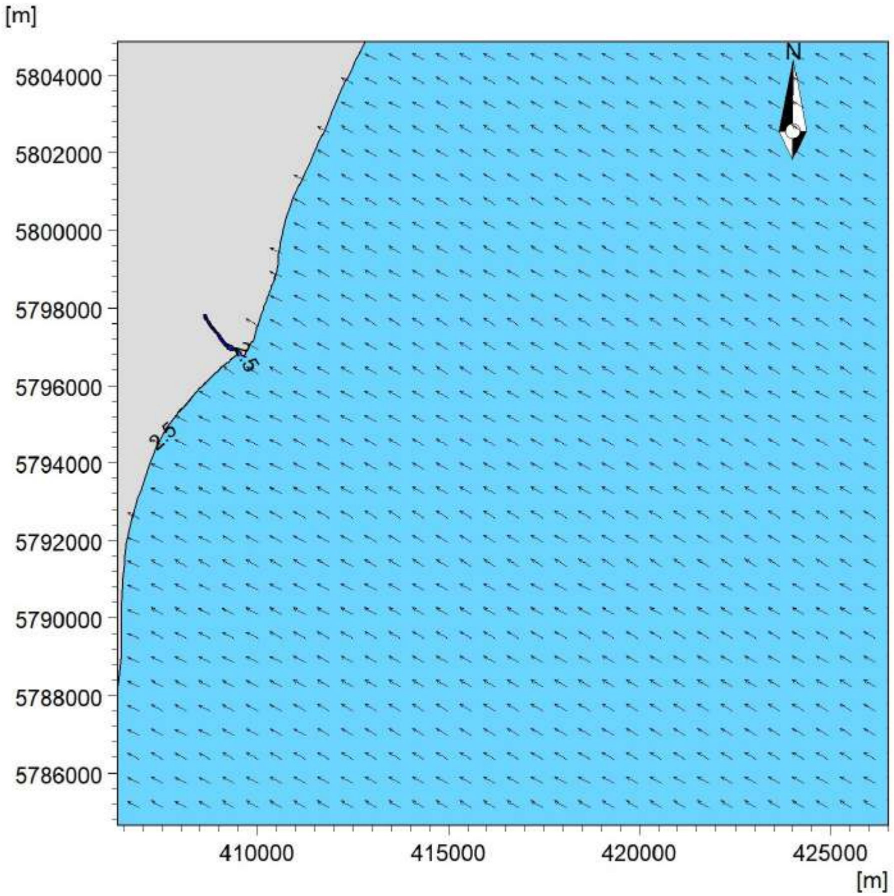


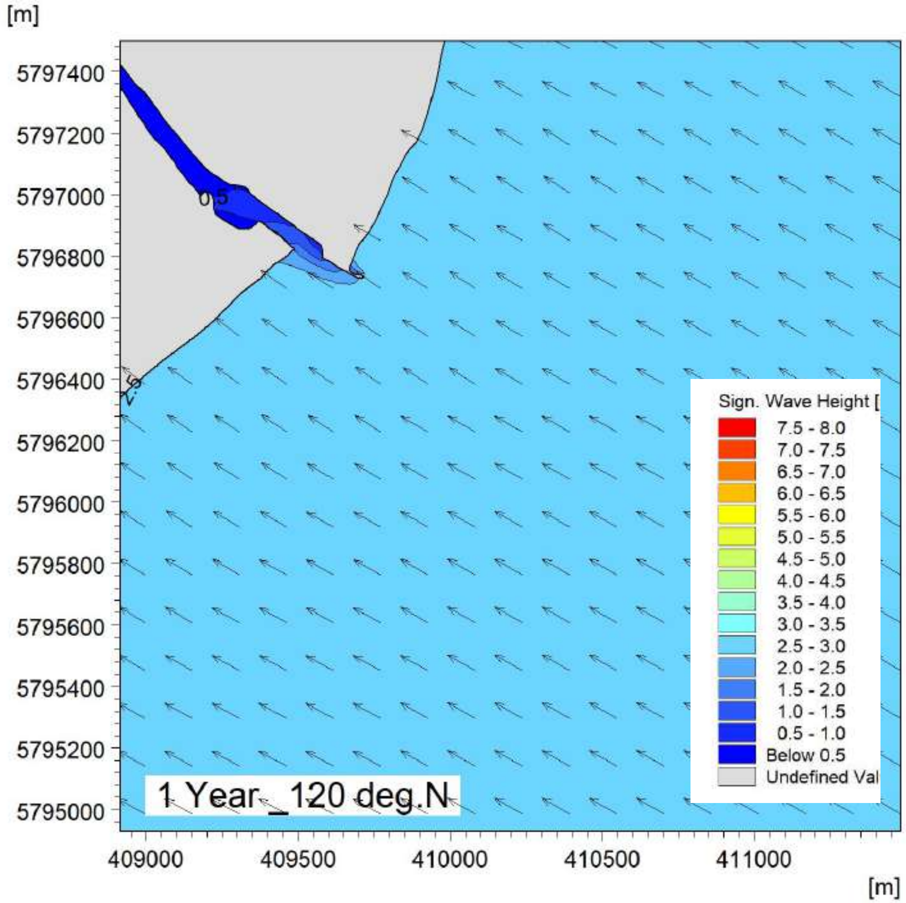
Wave transformation results



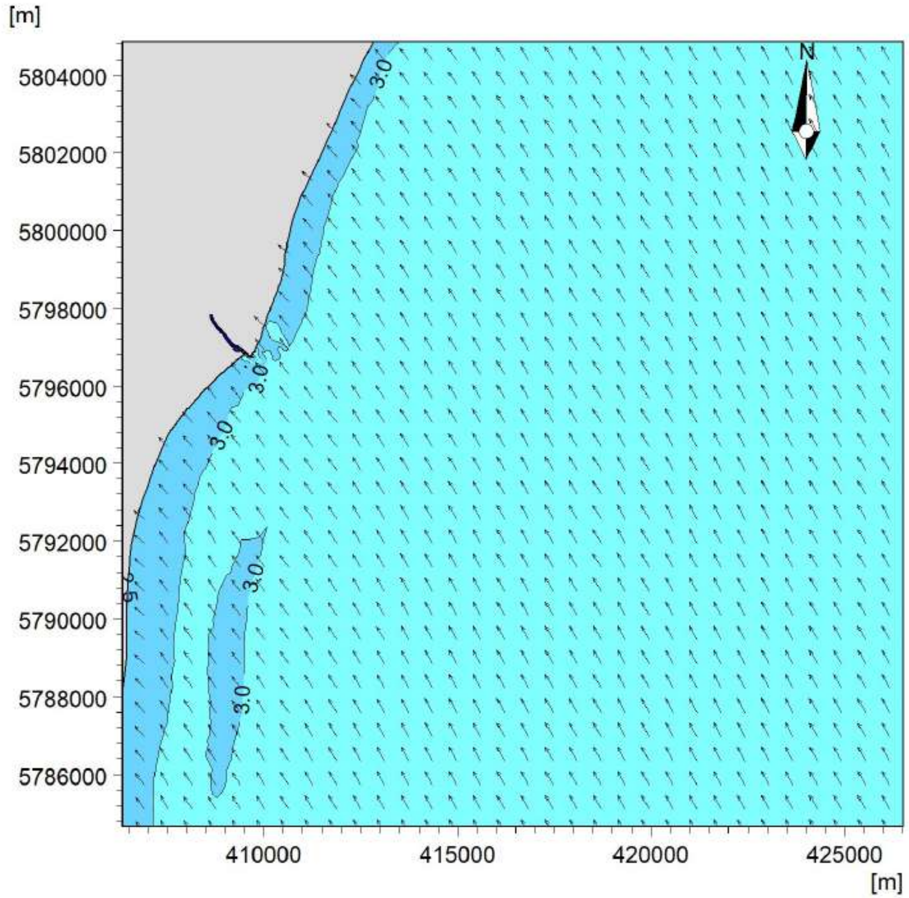
Royal HaskoningDHV

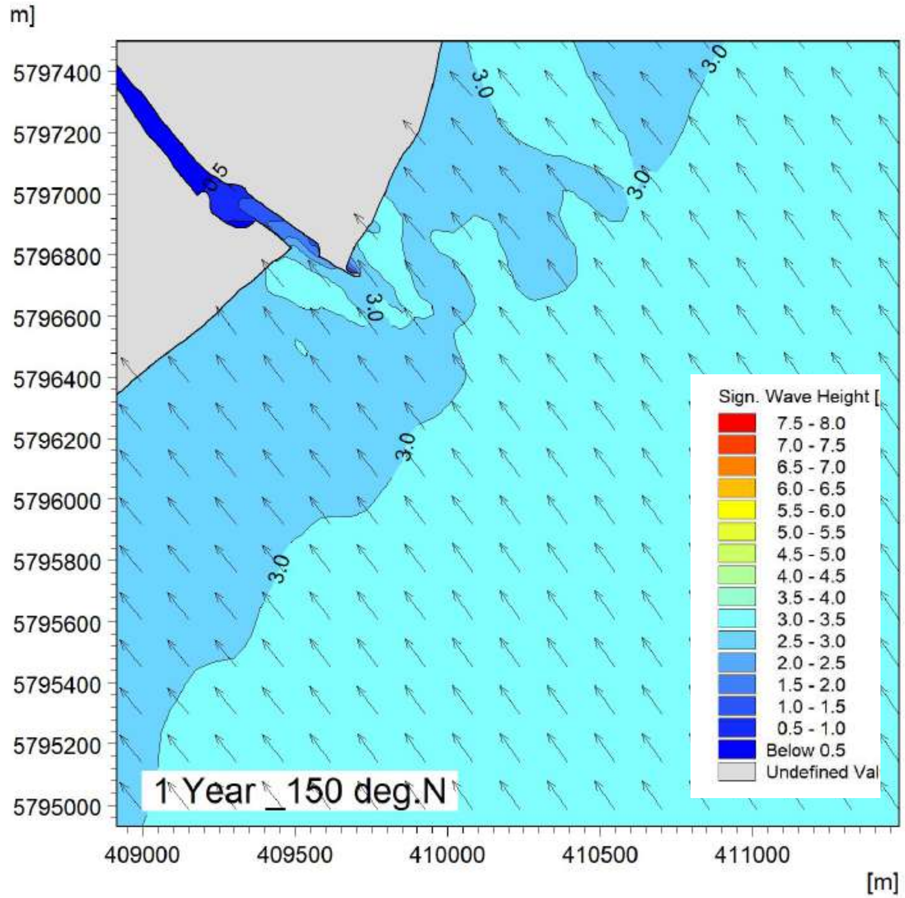
Wave transformation results





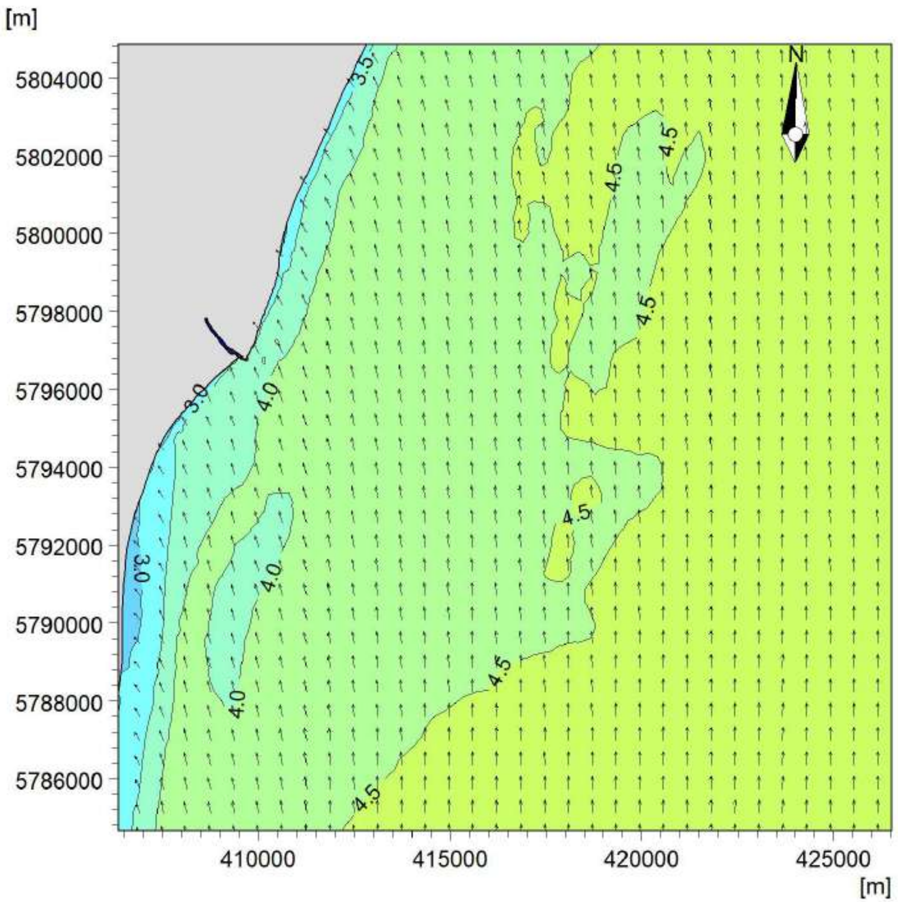
Wave transformation results

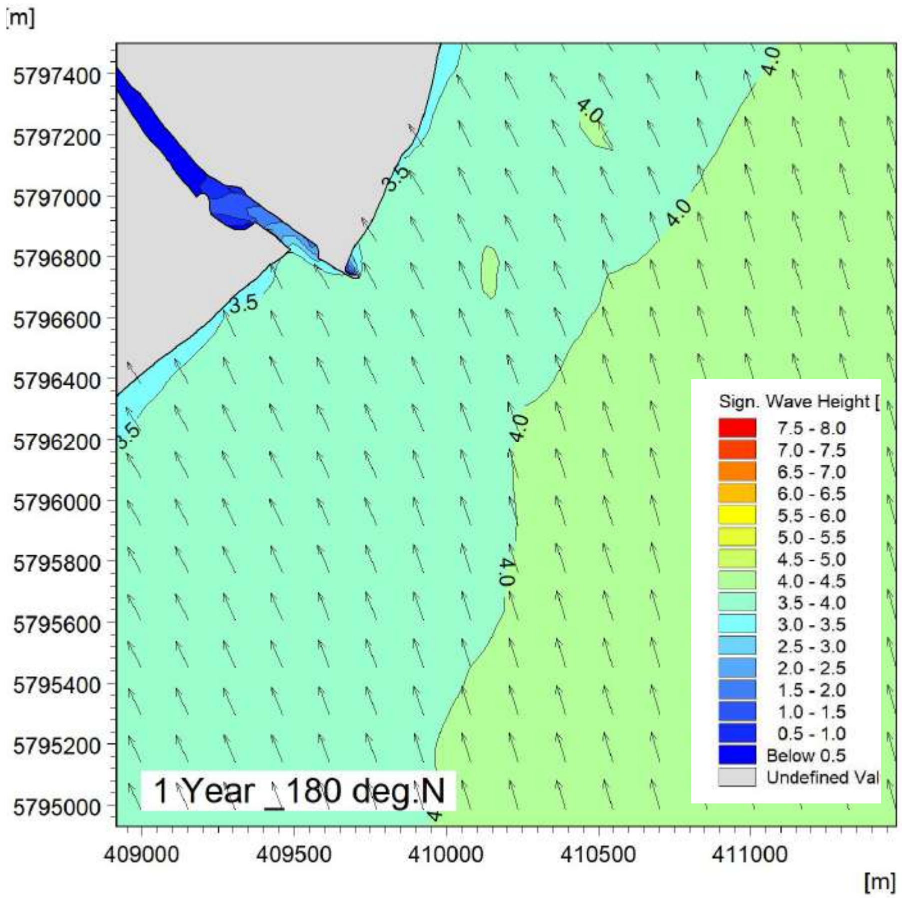




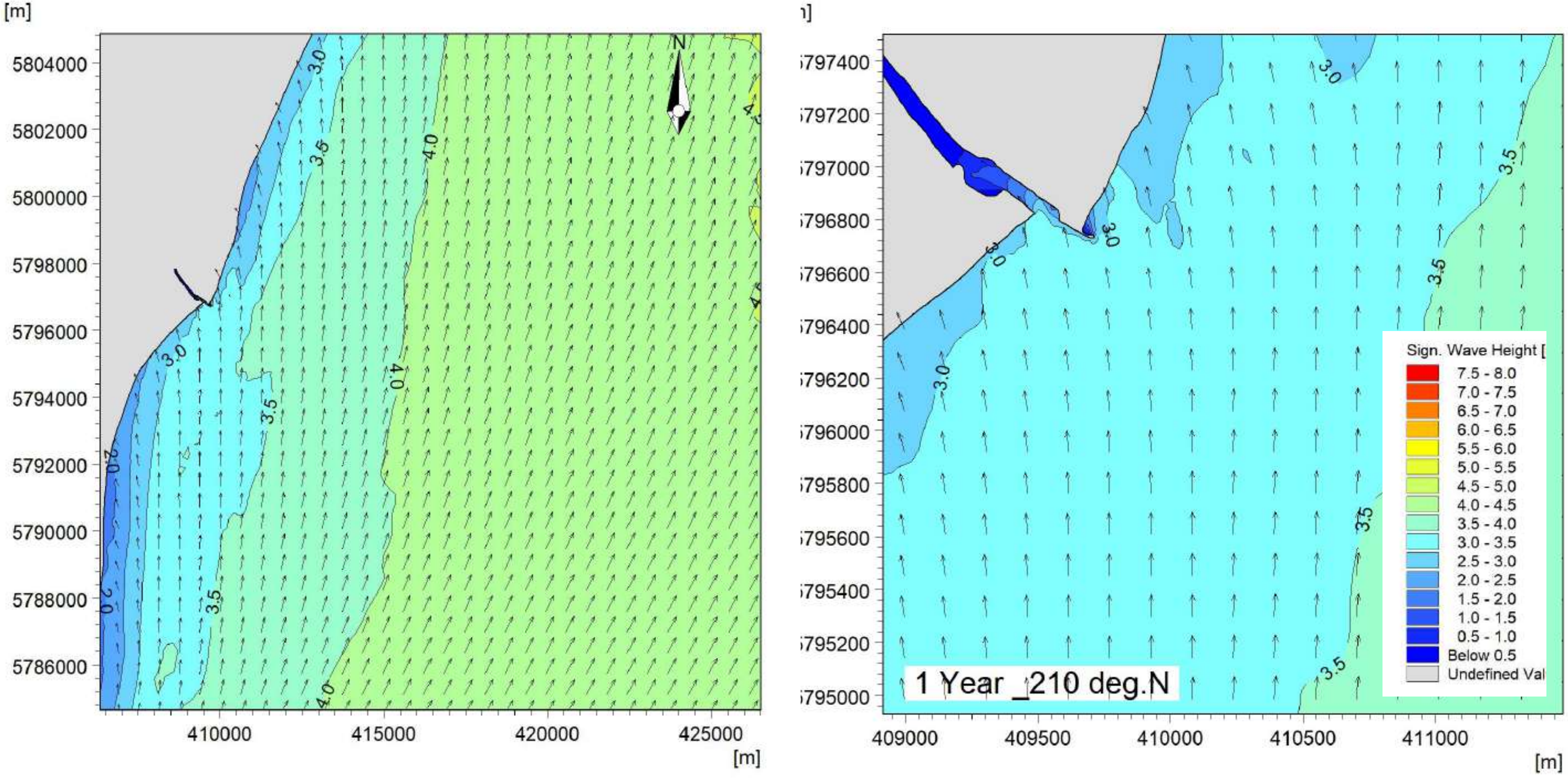
Royal HaskoningDHV

Wave transformation results

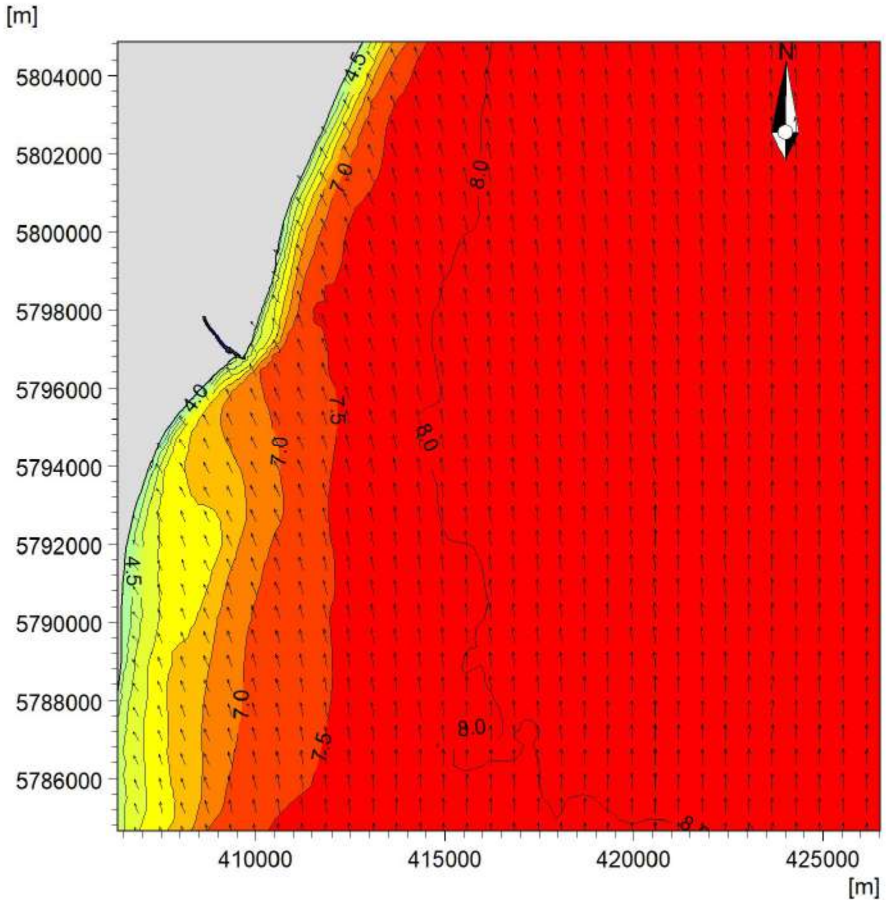


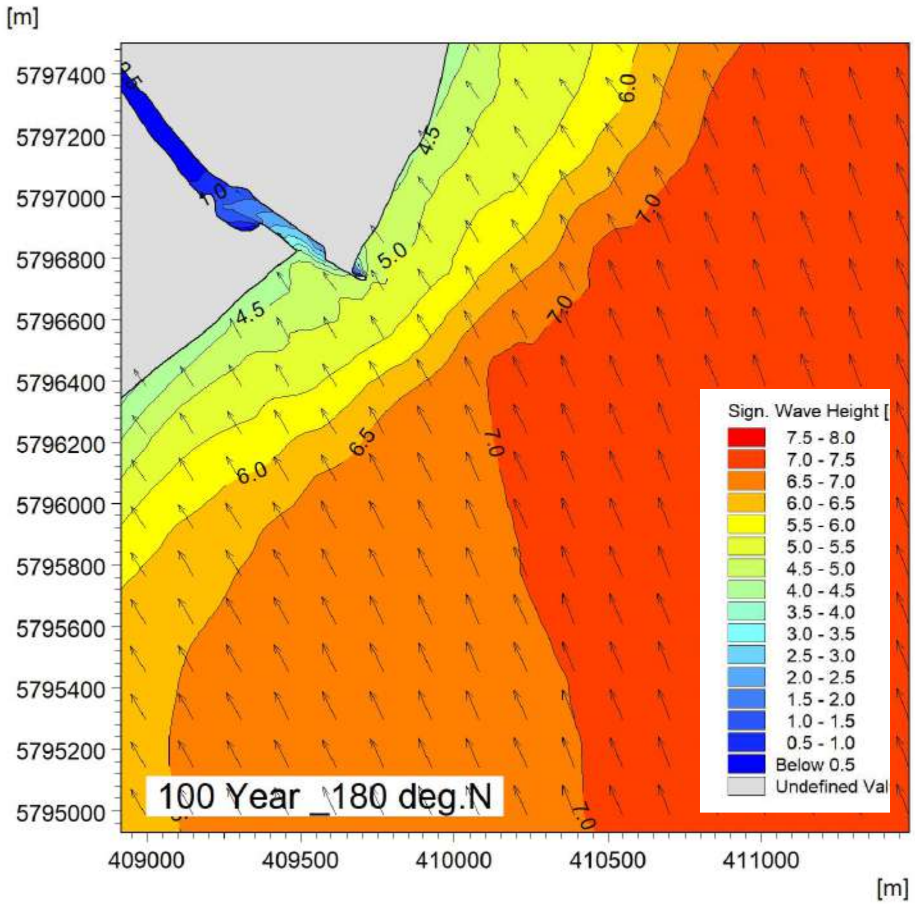


Wave transformation results



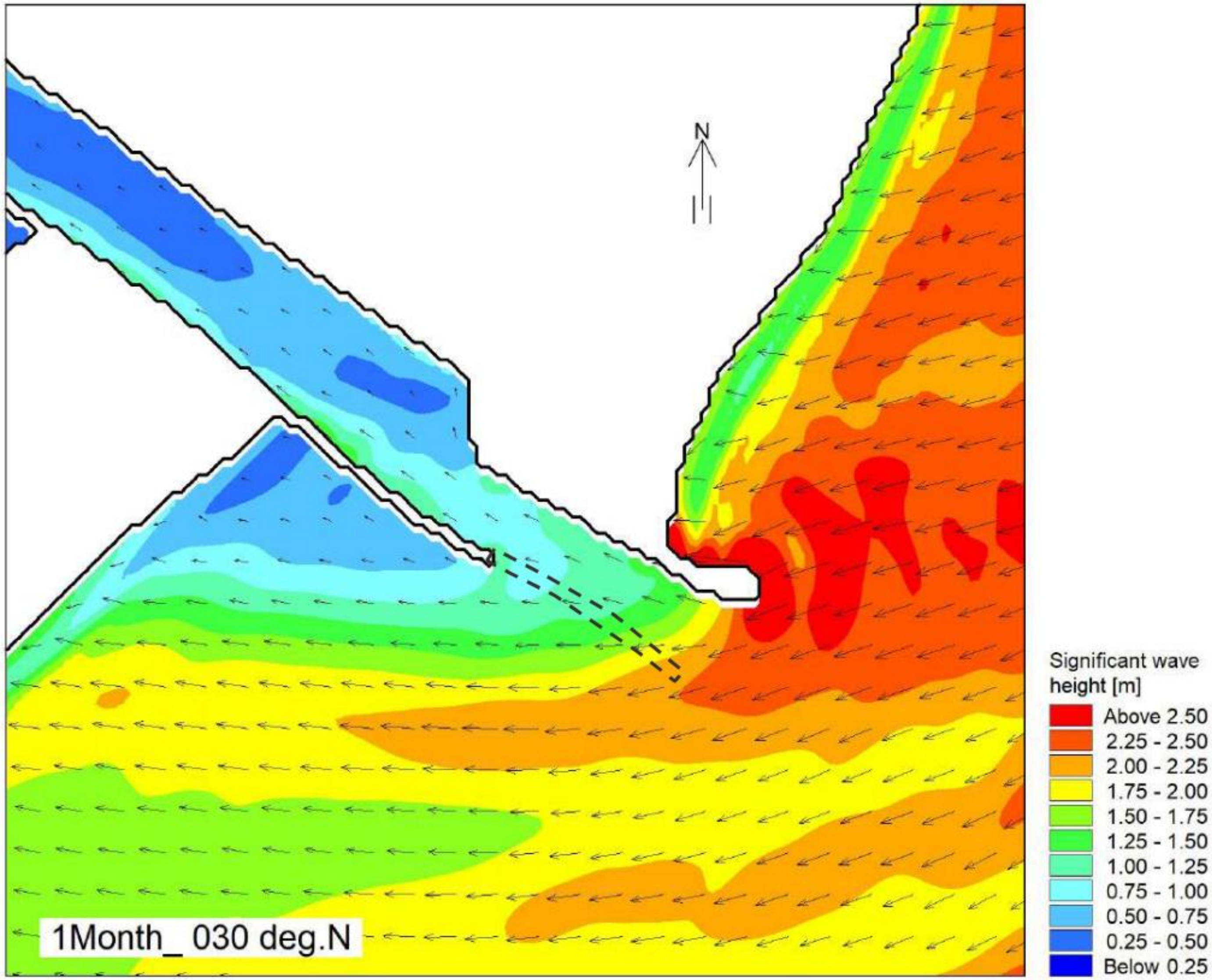
Wave transformation results



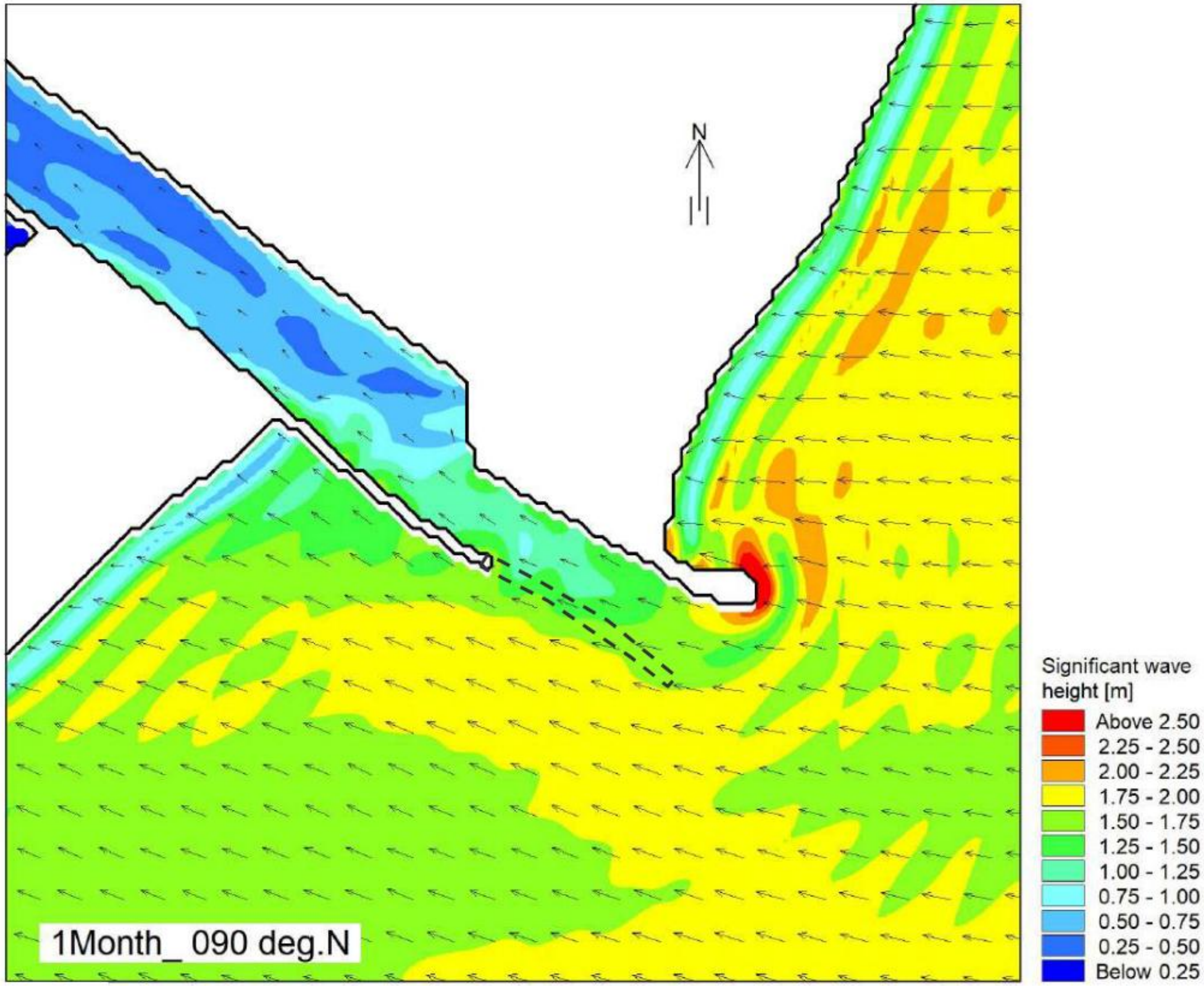


Royal HaskoningDHV

Wave conditions in the outer harbour

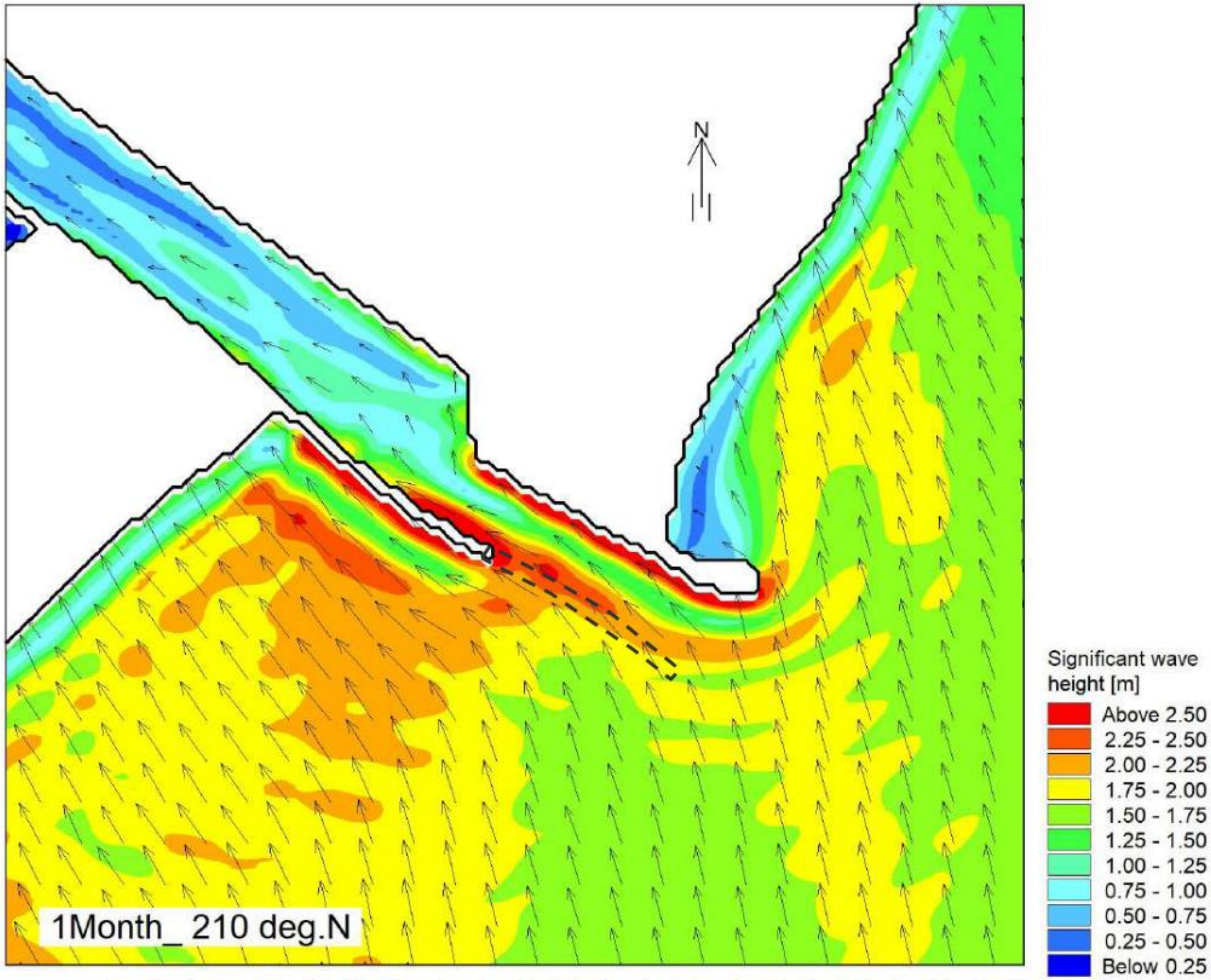


Wave conditions in the outer harbour

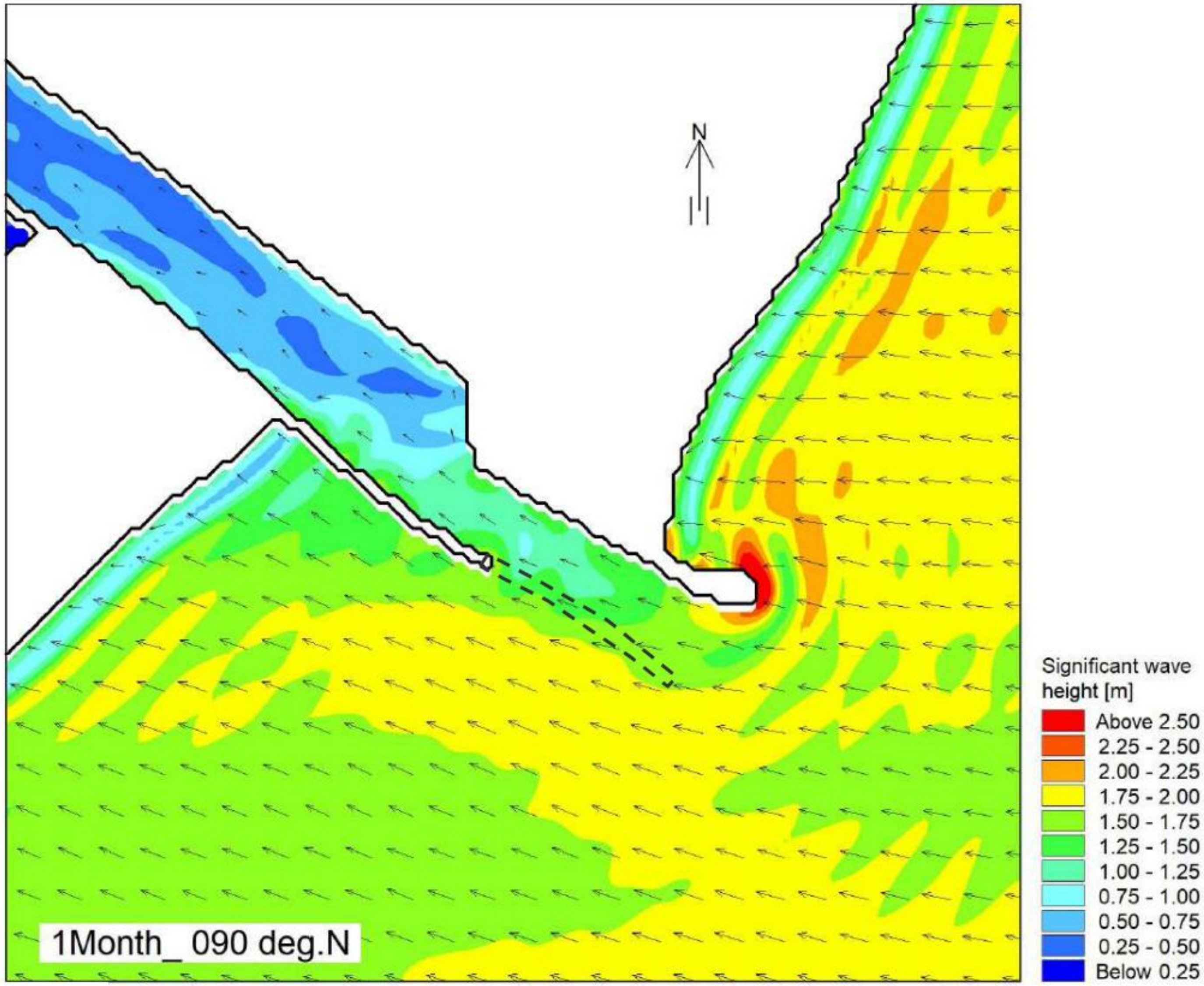


Royal HaskoningDHV

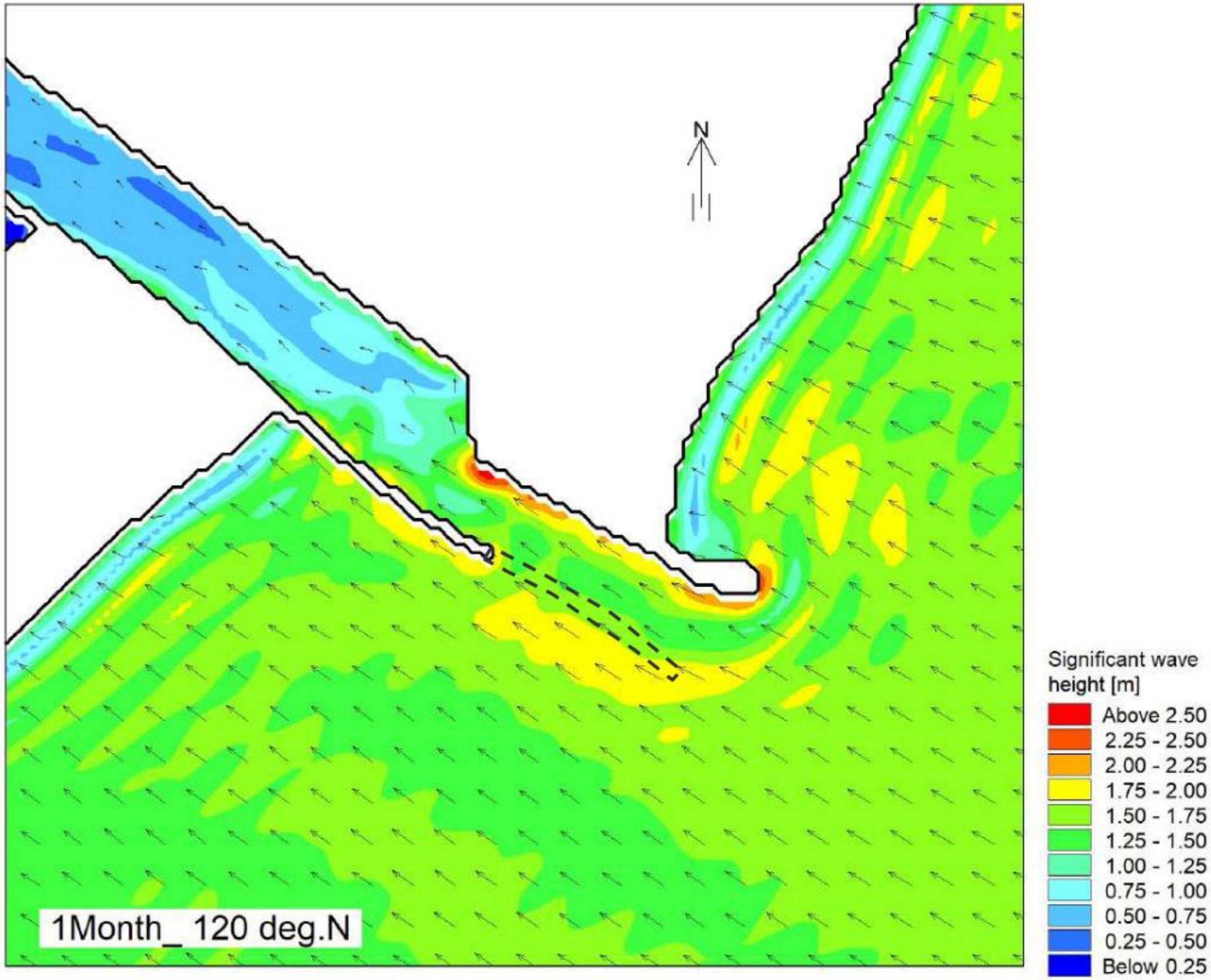
Wave conditions in the outer harbour



Wave conditions in the outer harbour

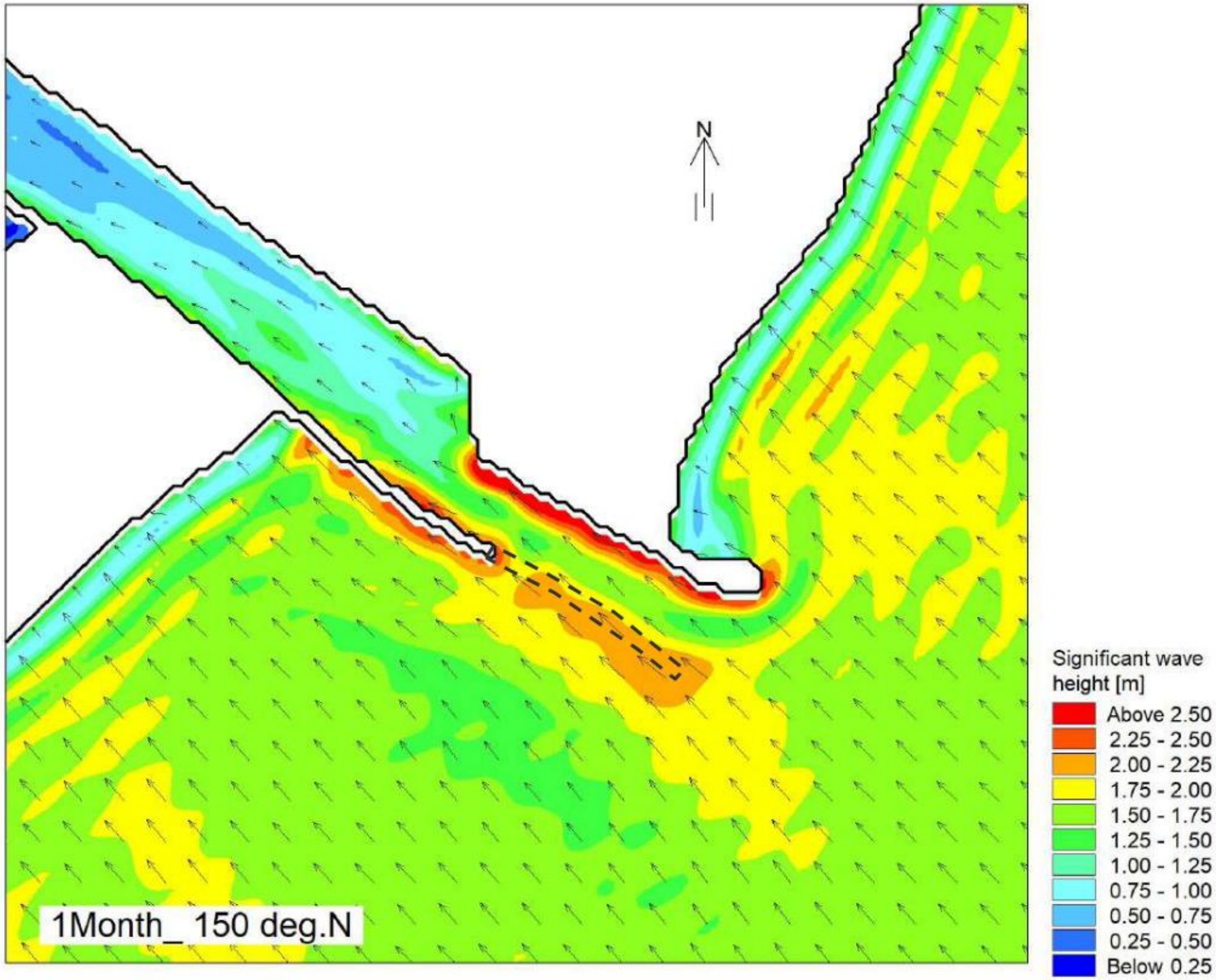


Wave conditions in the outer harbour



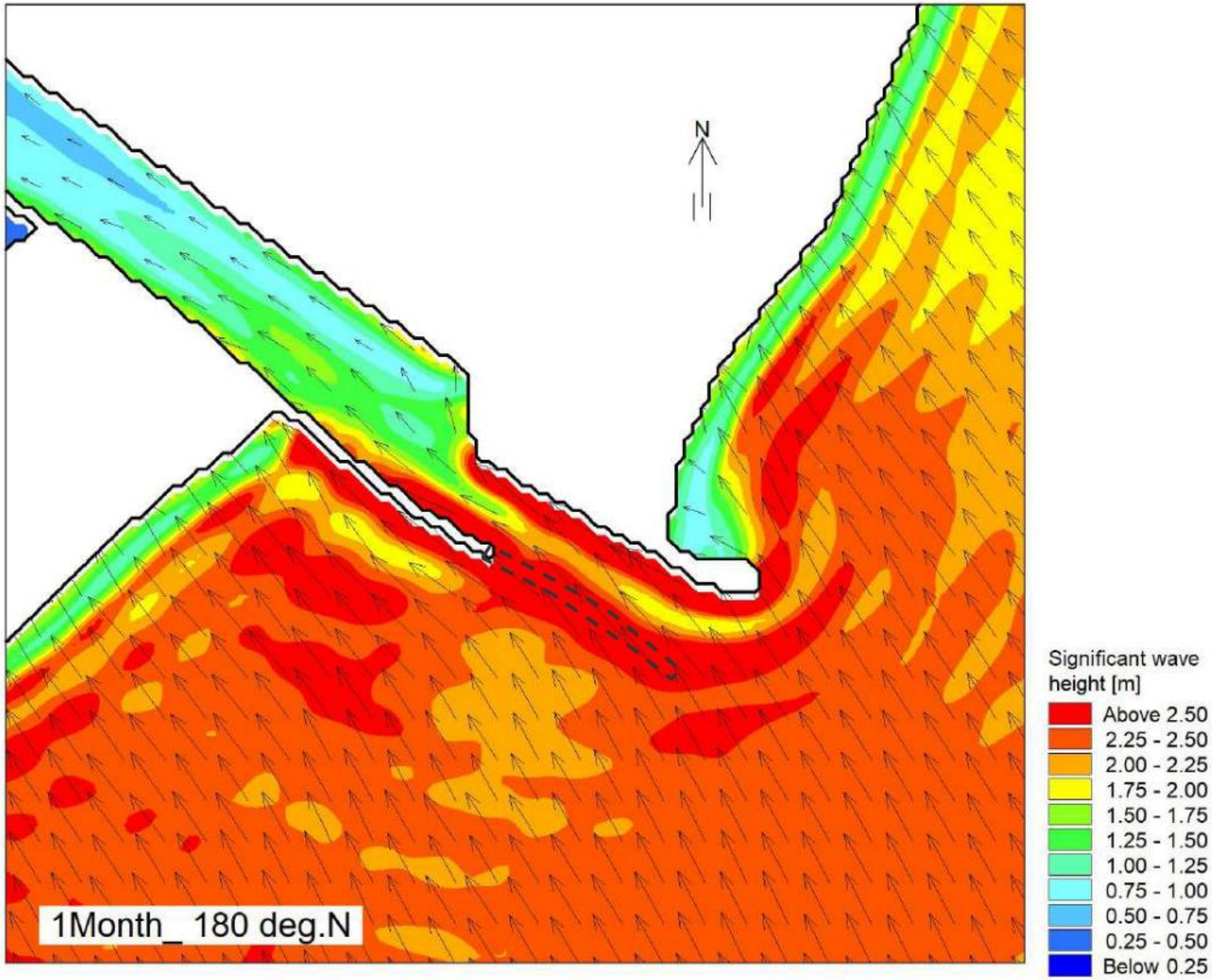
Royal HaskoningDHV

Wave conditions in the outer harbour



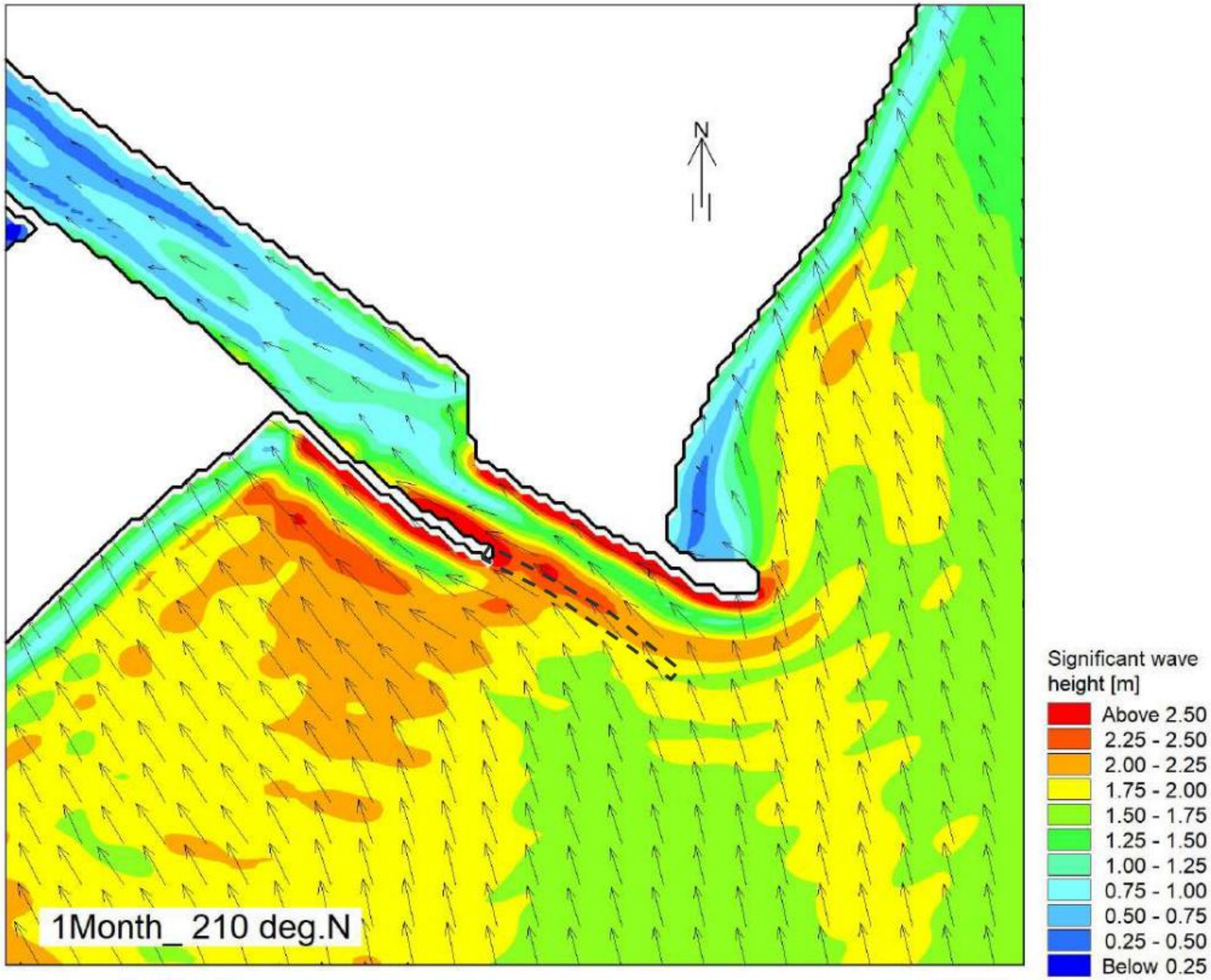
Royal HaskoningDHV

Wave conditions in the outer harbour

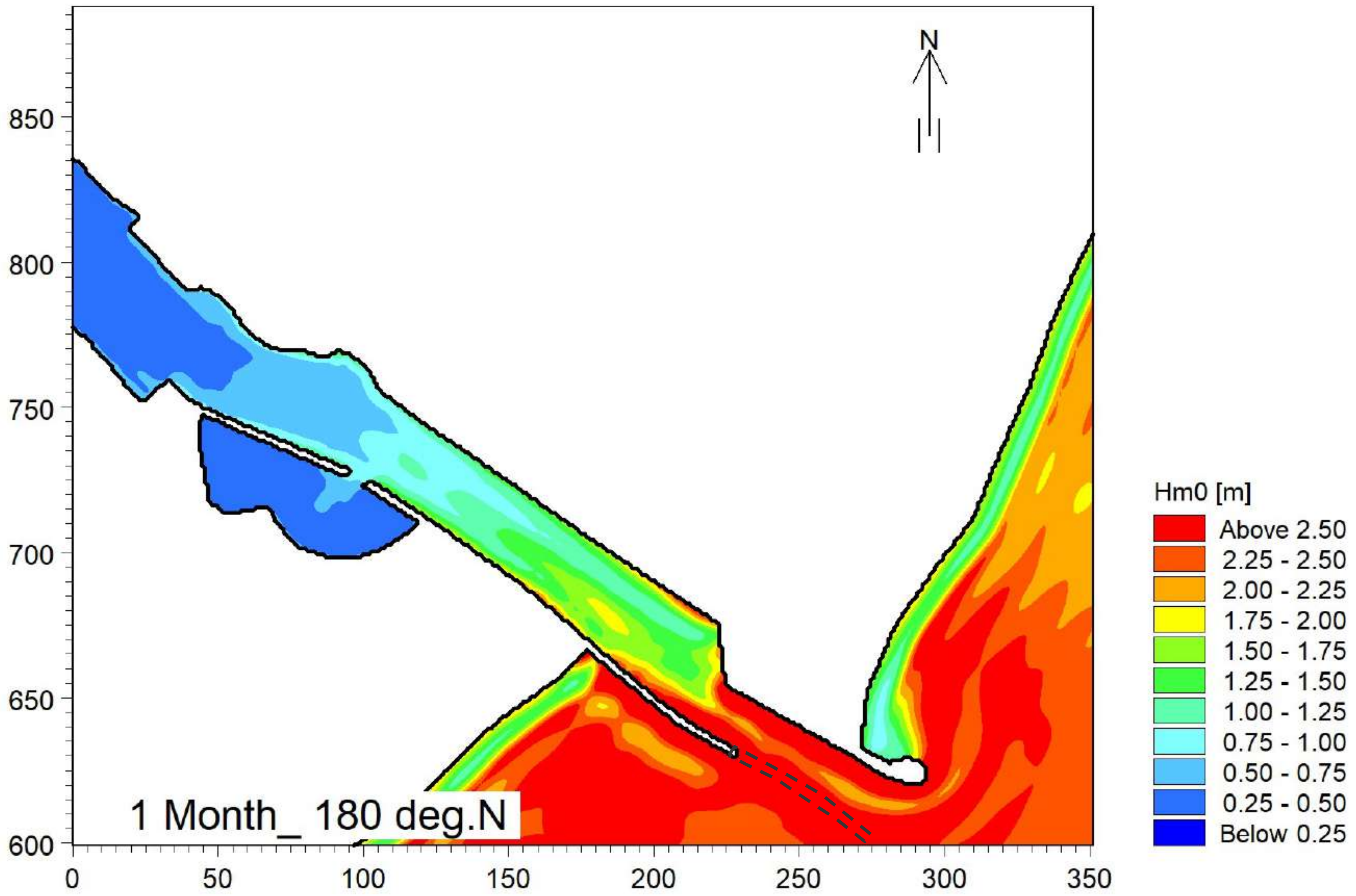


Royal HaskoningDHV

Wave conditions in the outer harbour

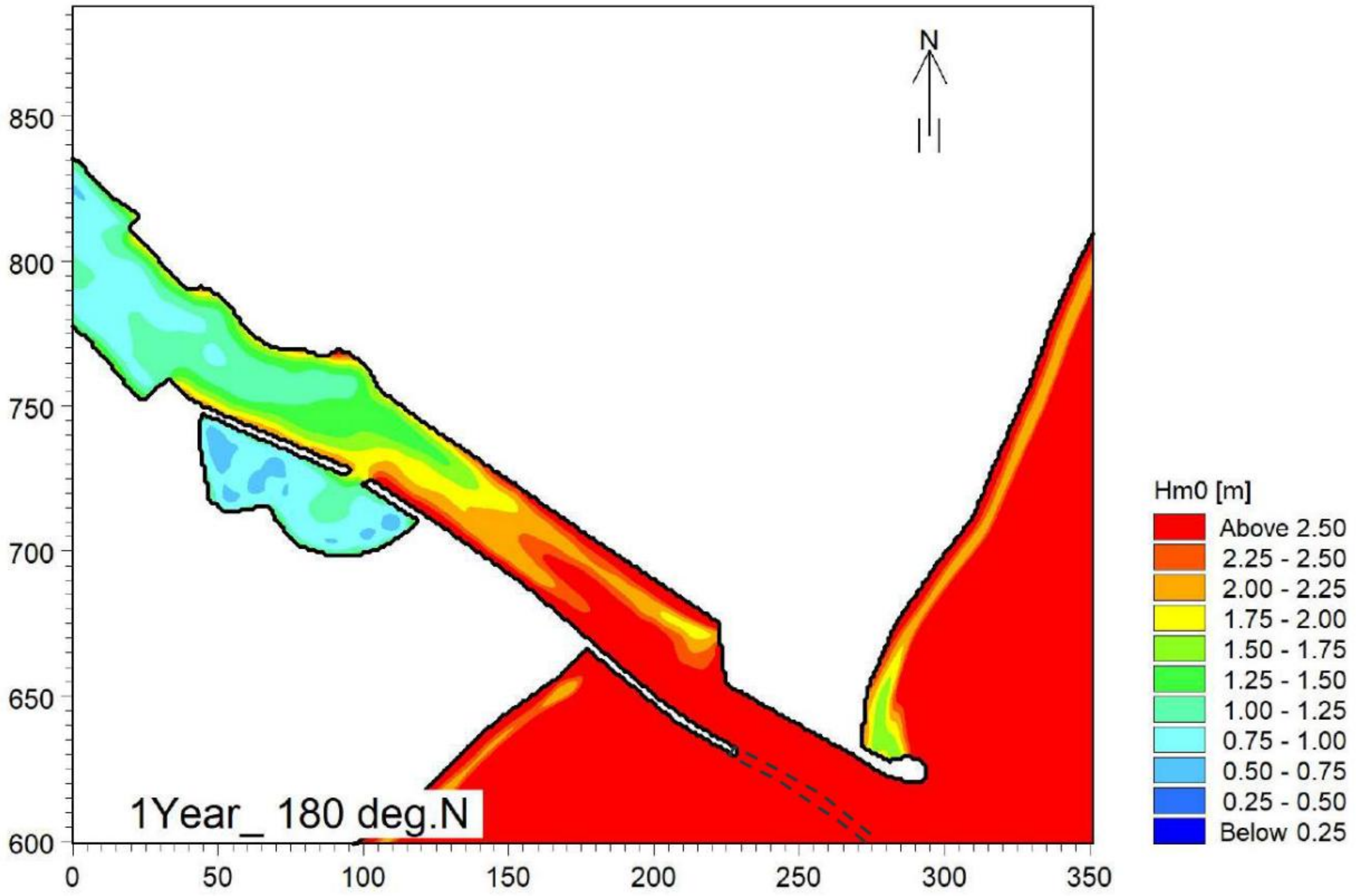


Wave conditions in inner harbour



Royal HaskoningDHV

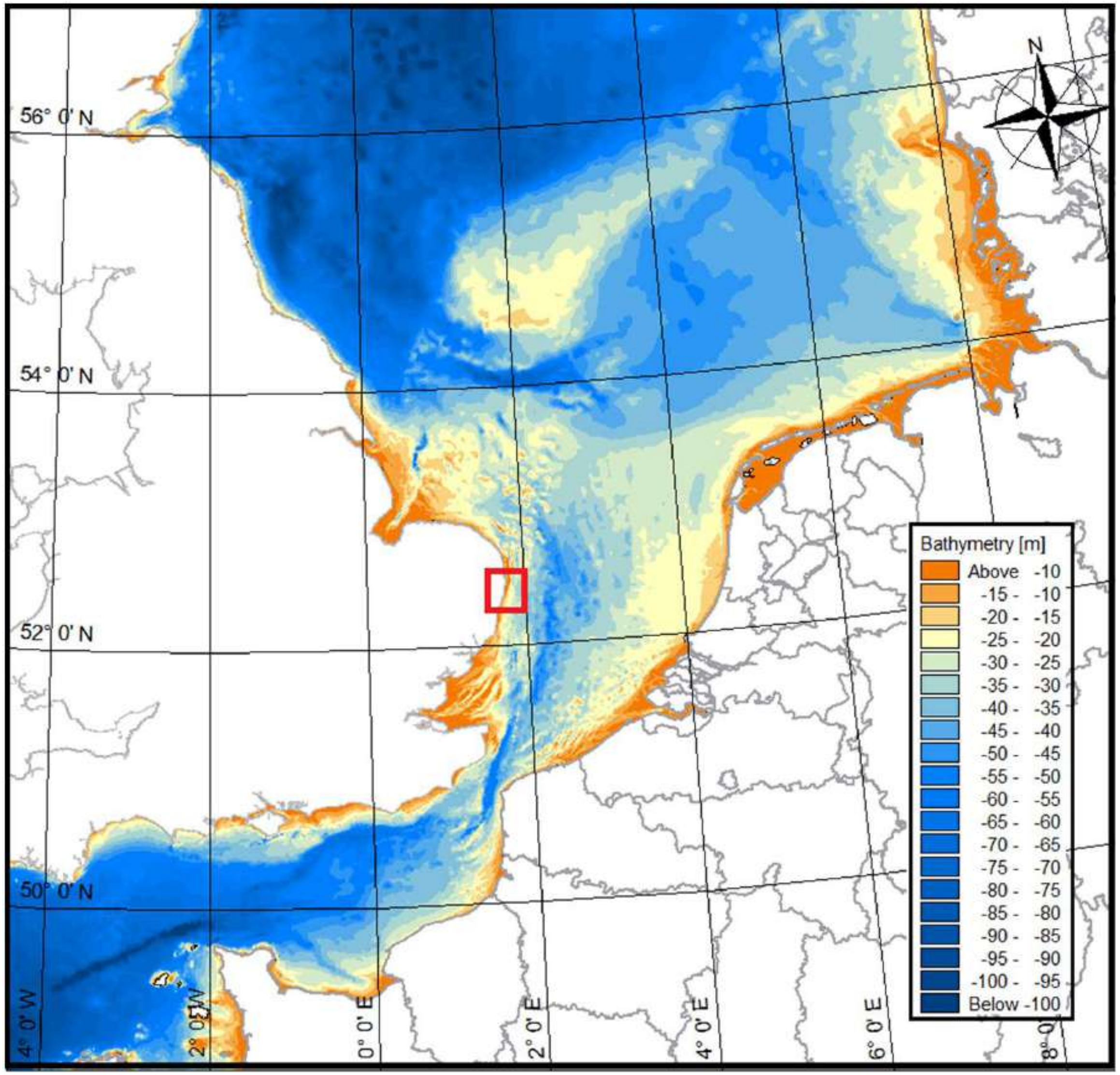
Wave conditions in inner harbour



Tidal model development

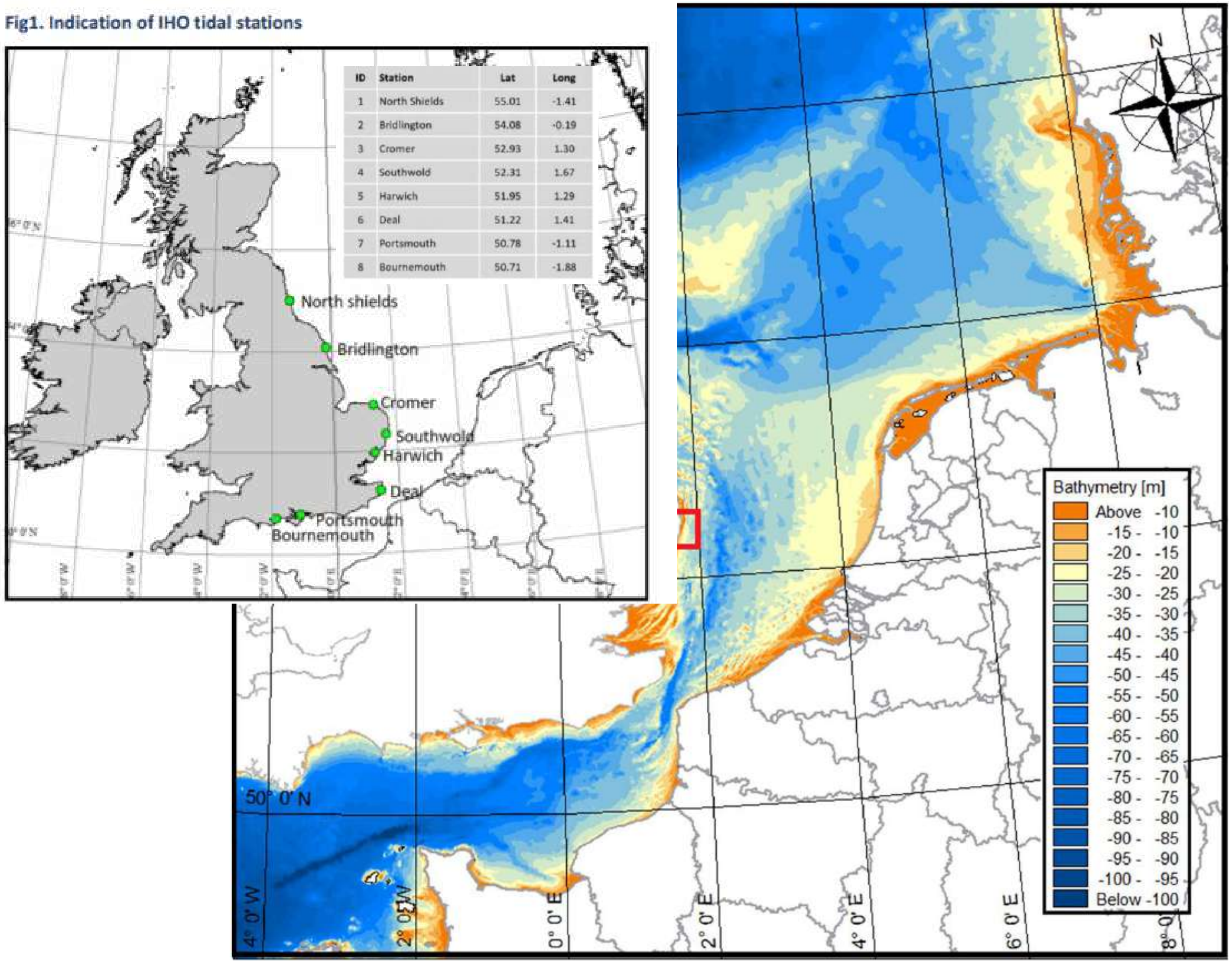
- Regional model update and calibration
- Local model around the project area, nested within the large-scale model
- Calibration against survey data
- Validation against December 2013 event

Regional model



Regional model

Fig1. Indication of IHO tidal stations

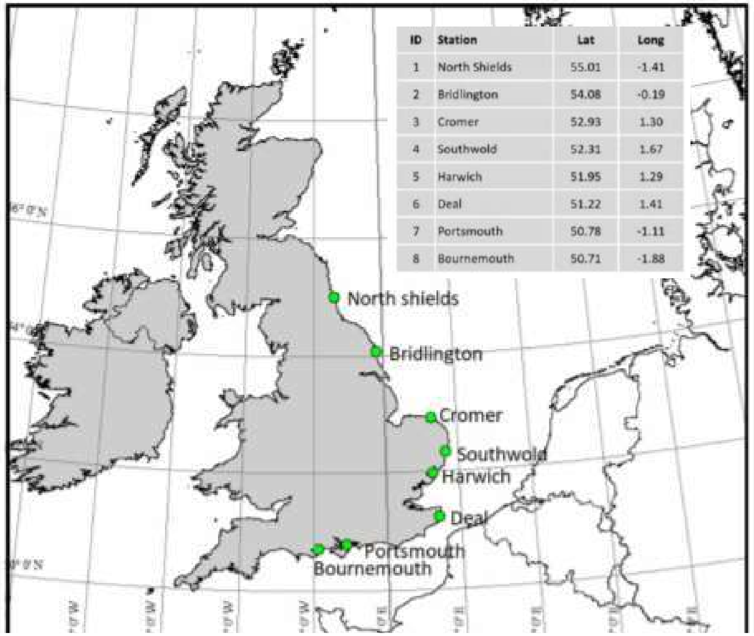


ID	Station	Lat	Long
1	North Shields	55.01	-1.41
2	Bridlington	54.08	-0.19
3	Cromer	52.93	1.30
4	Southwold	52.31	1.67
5	Harwich	51.95	1.29
6	Deal	51.22	1.41
7	Portsmouth	50.78	-1.11
8	Bournemouth	50.71	-1.88

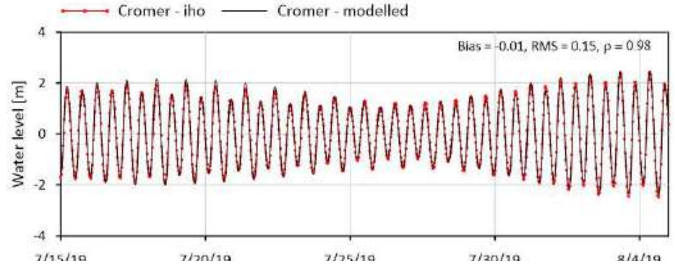
Royal HaskoningDHV

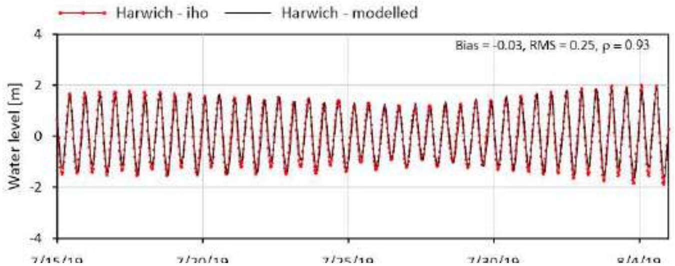
Regional model

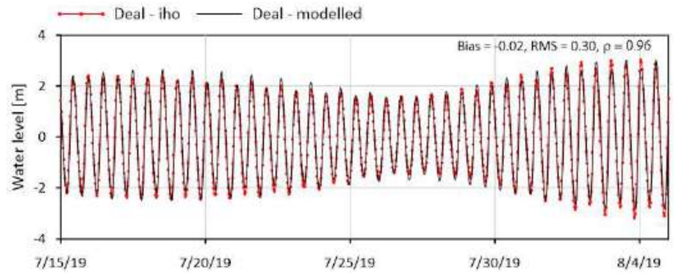
Fig1. Indication of IHO tidal stations

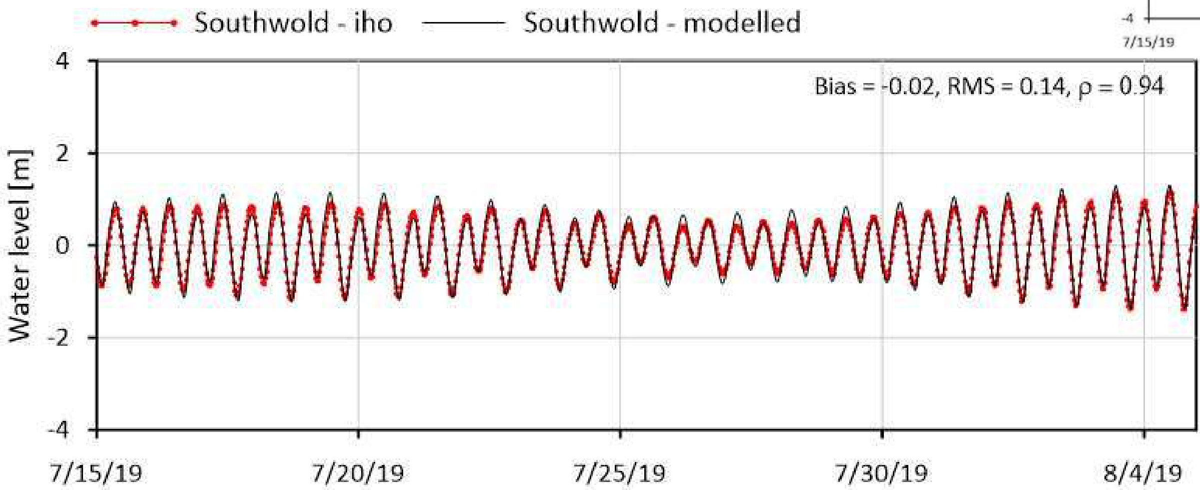


ID	Station	Lat	Long
1	North Shields	55.01	-1.41
2	Bridlington	54.08	-0.19
3	Cromer	52.93	1.30
4	Southwold	52.31	1.67
5	Harwich	51.95	1.29
6	Deal	51.22	1.41
7	Portsmouth	50.78	-1.11
8	Bournemouth	50.71	-1.88



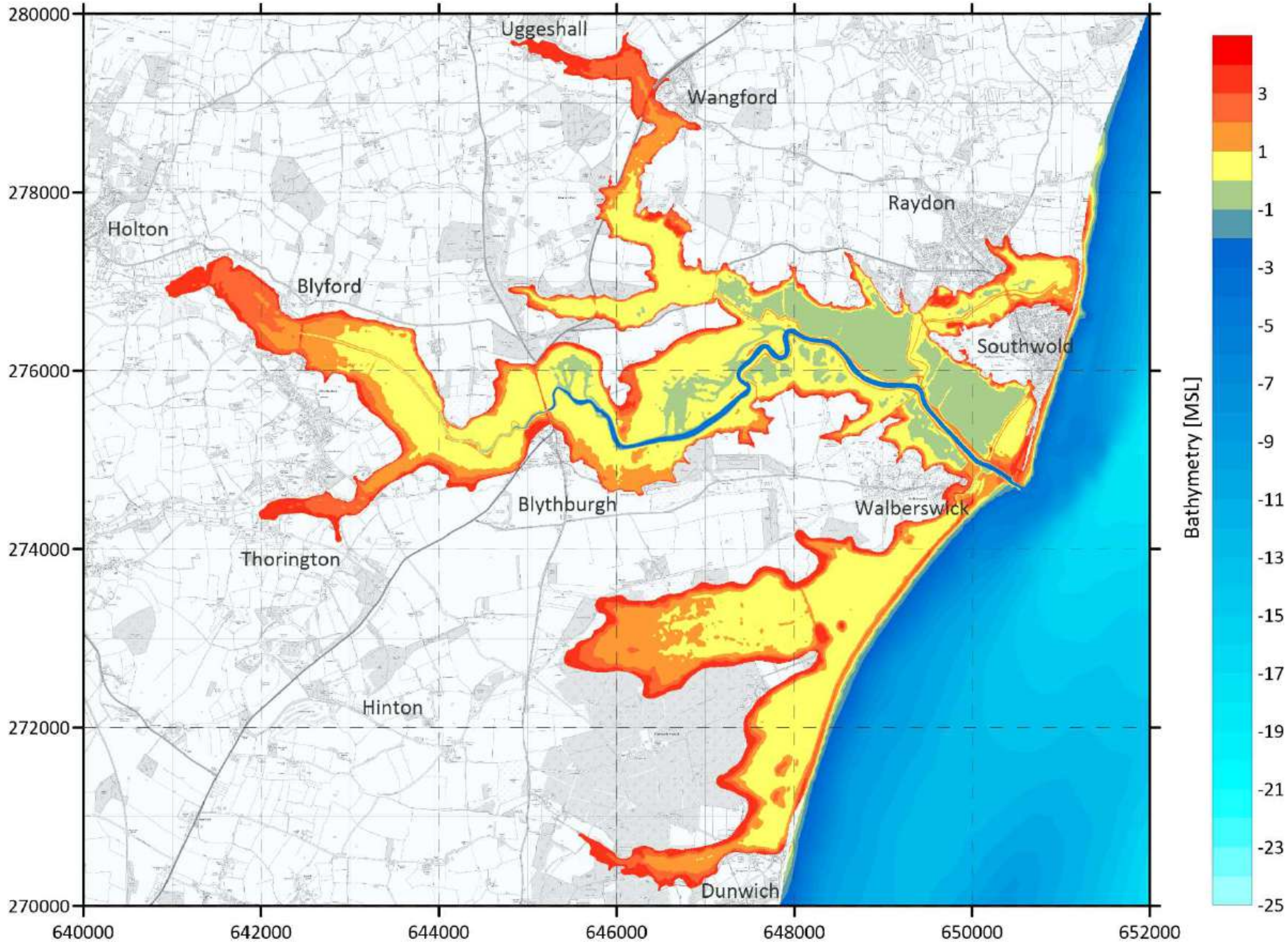






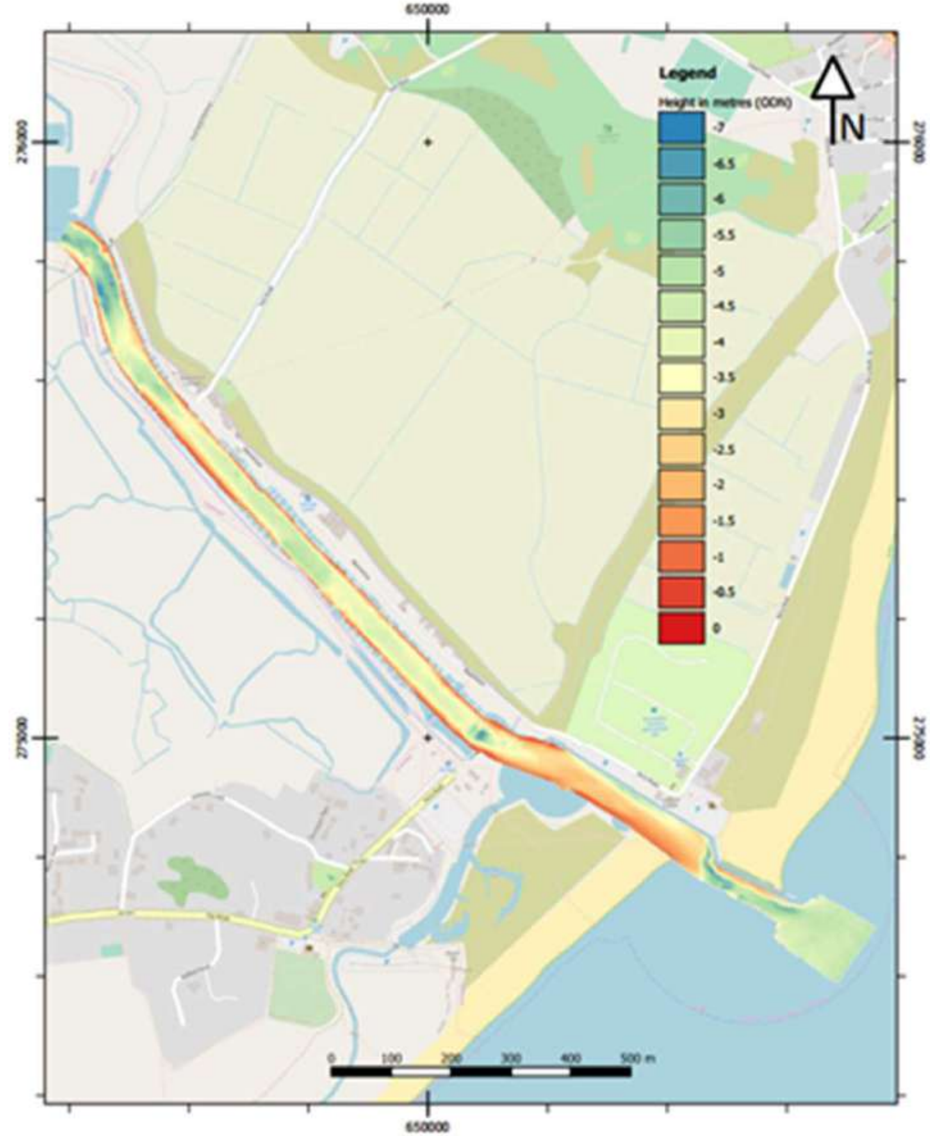
Royal HaskoningDHV

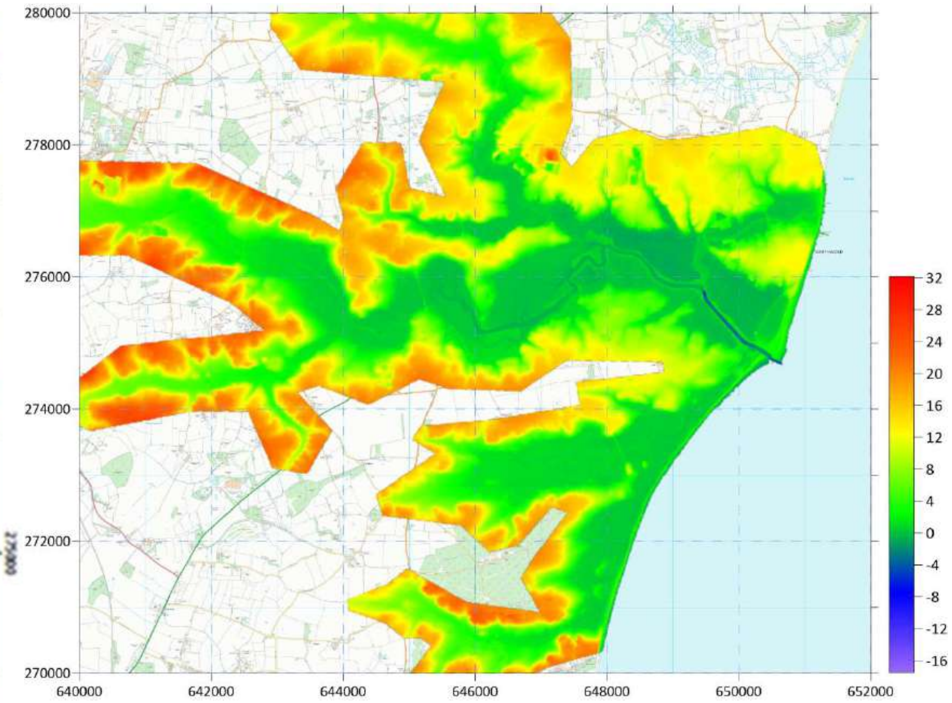
Local model



Royal HaskoningDHV

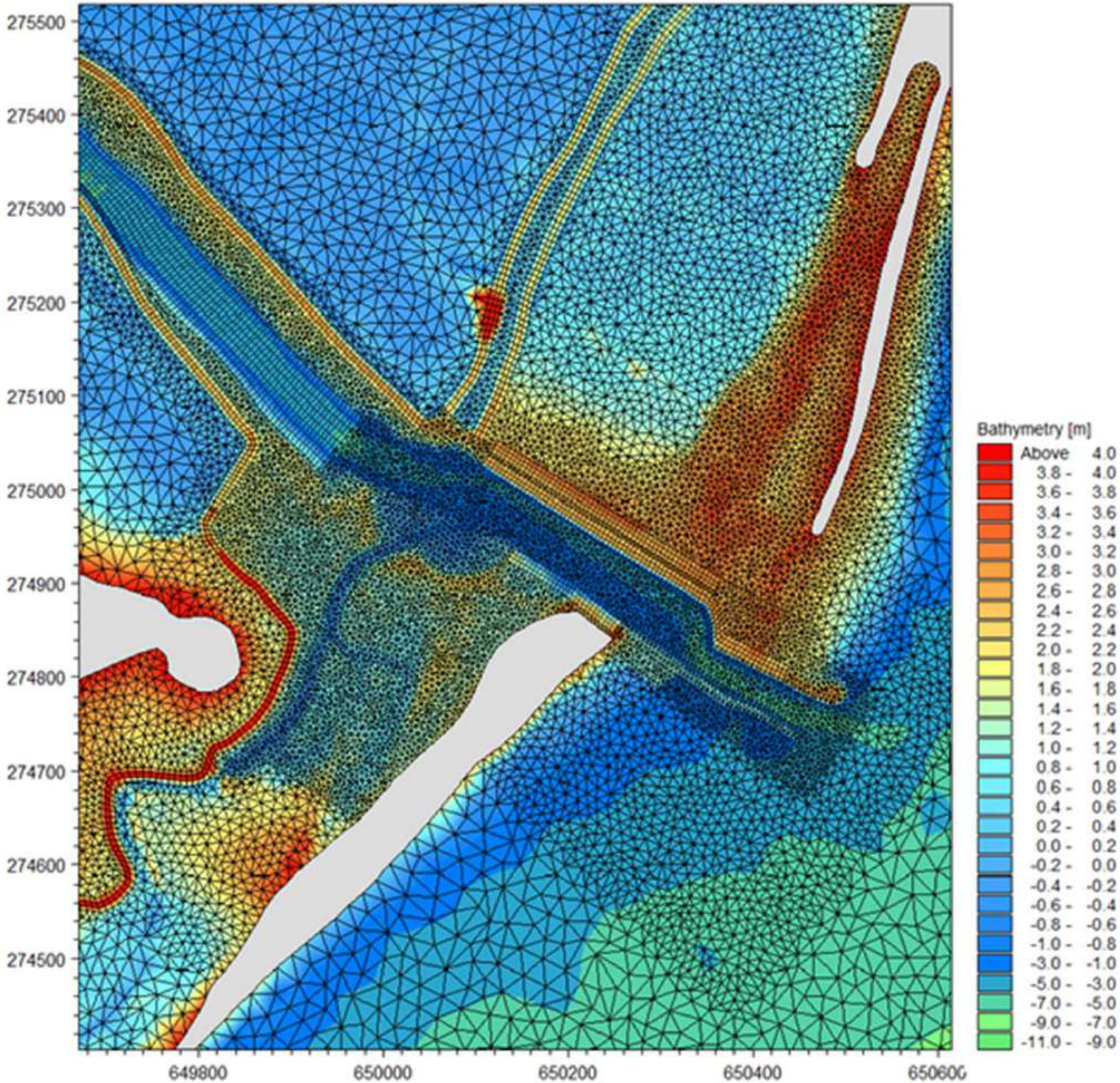
Local model





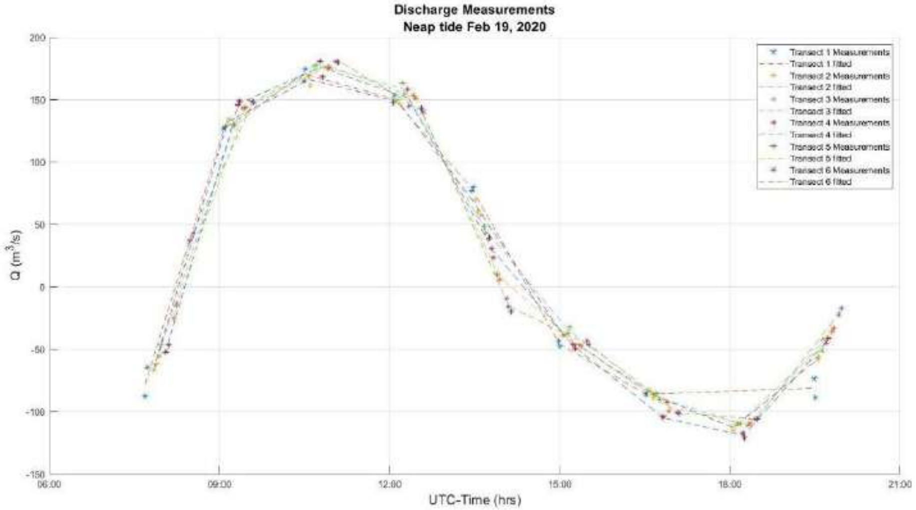
Royal HaskoningDHV

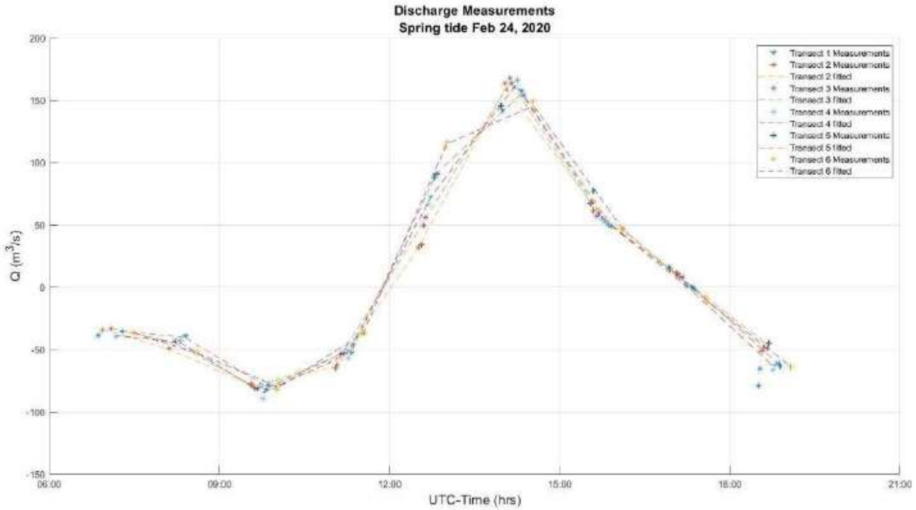
Local model



Royal HaskoningDHV

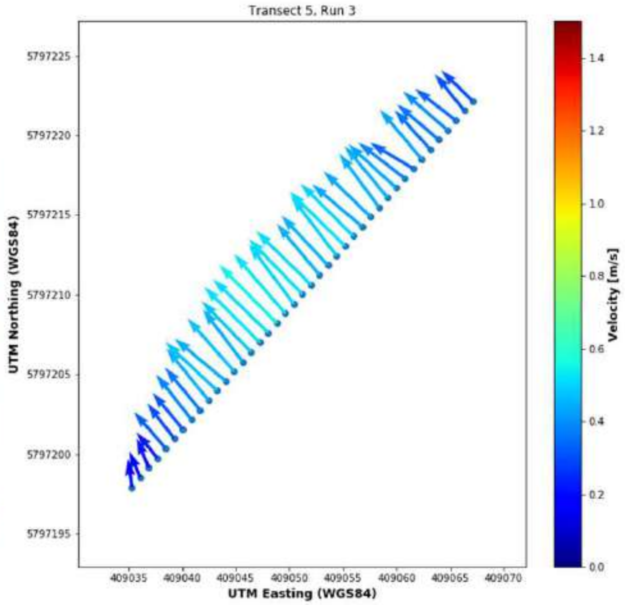
Local model



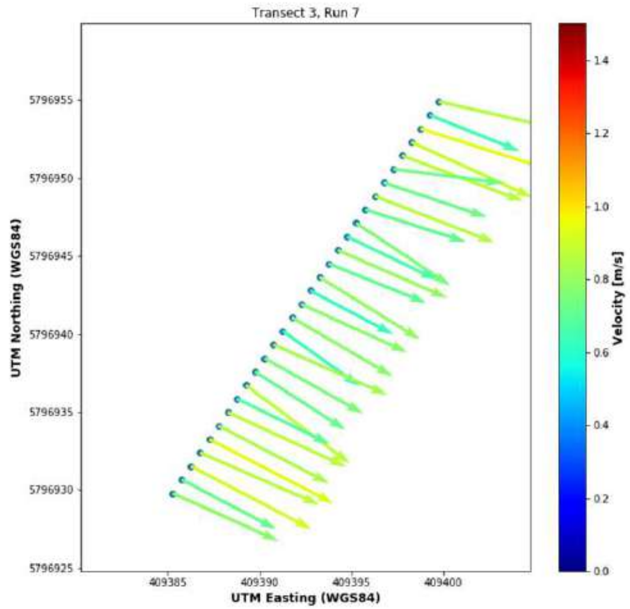


Royal HaskoningDHV

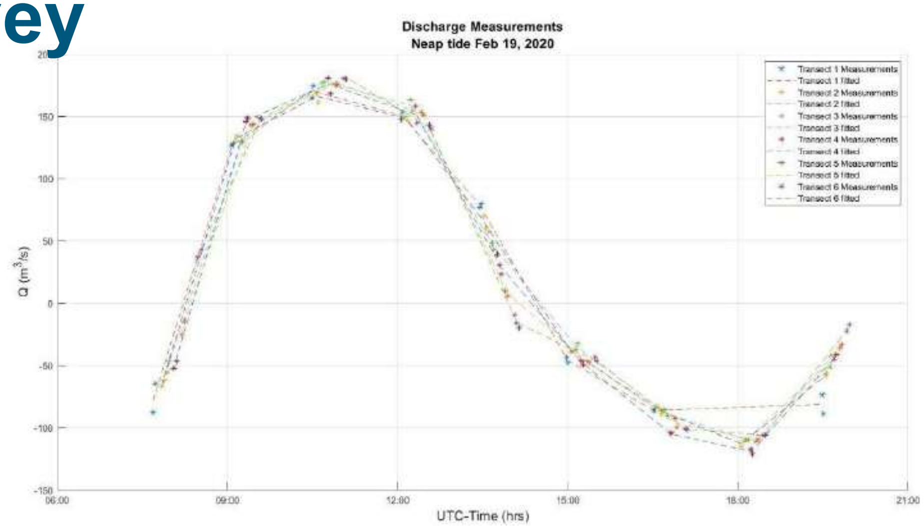
Local model

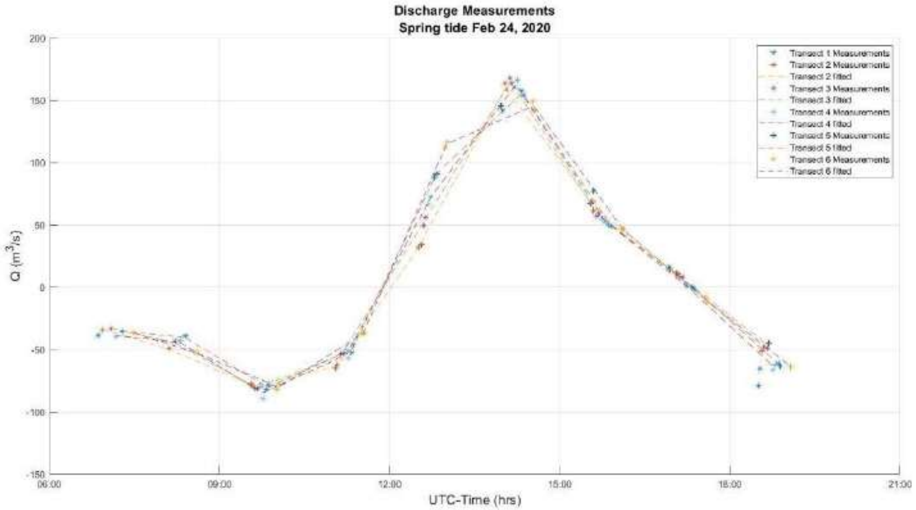


Water Level [m ODN]



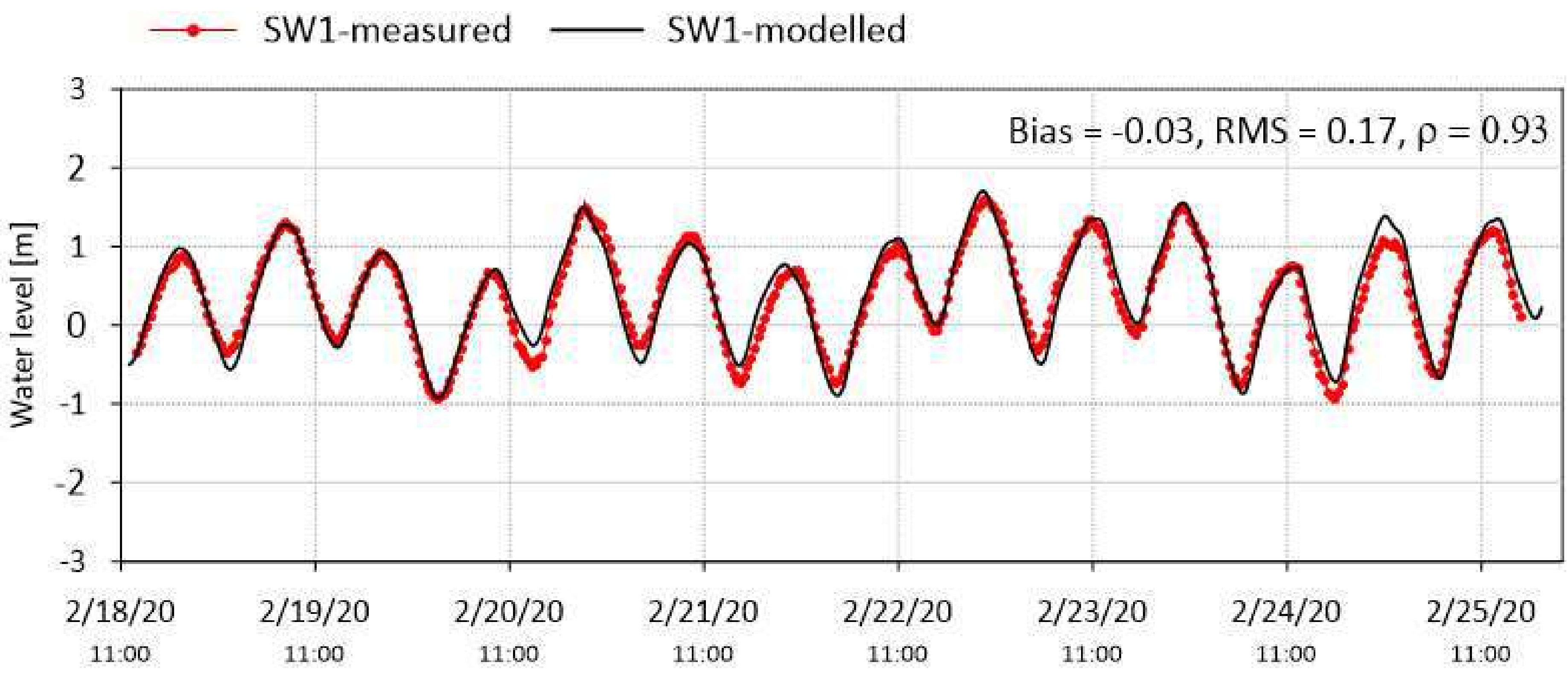
Calibration against survey



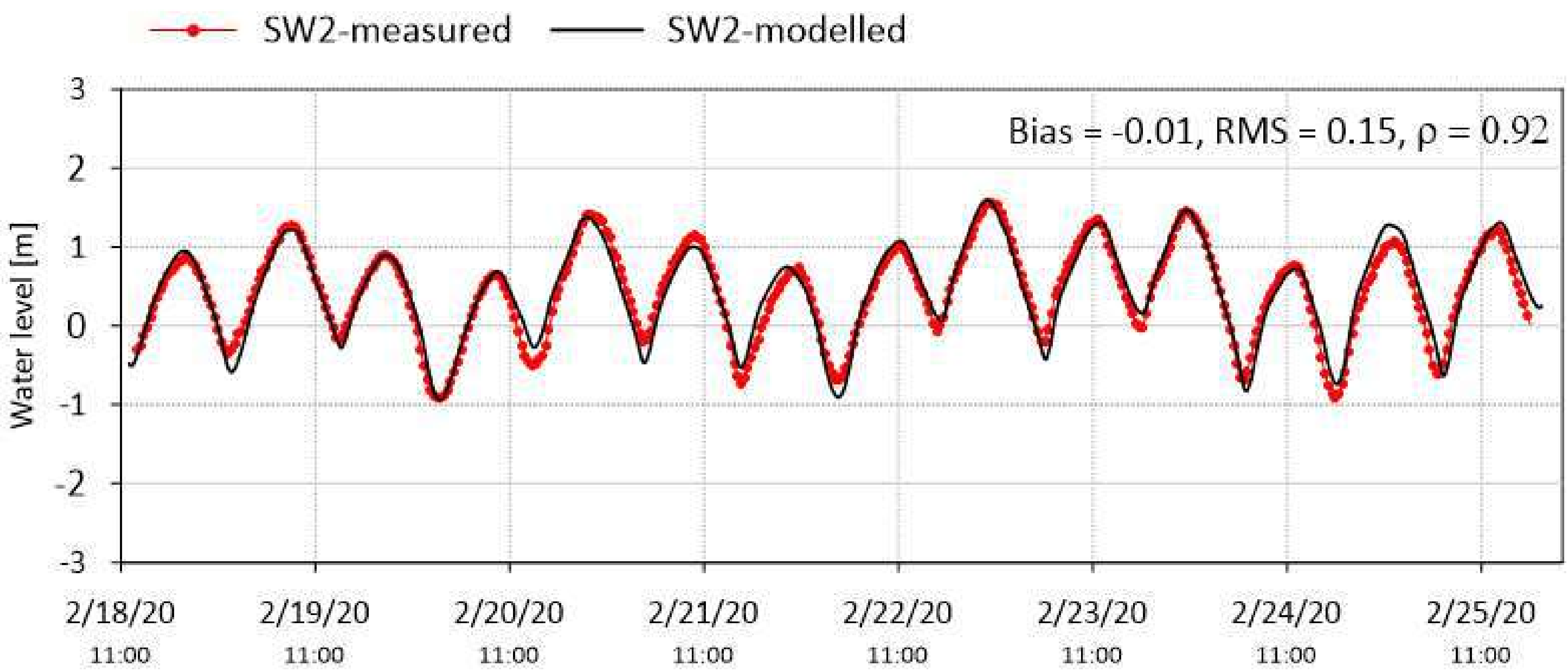


Royal HaskoningDHV

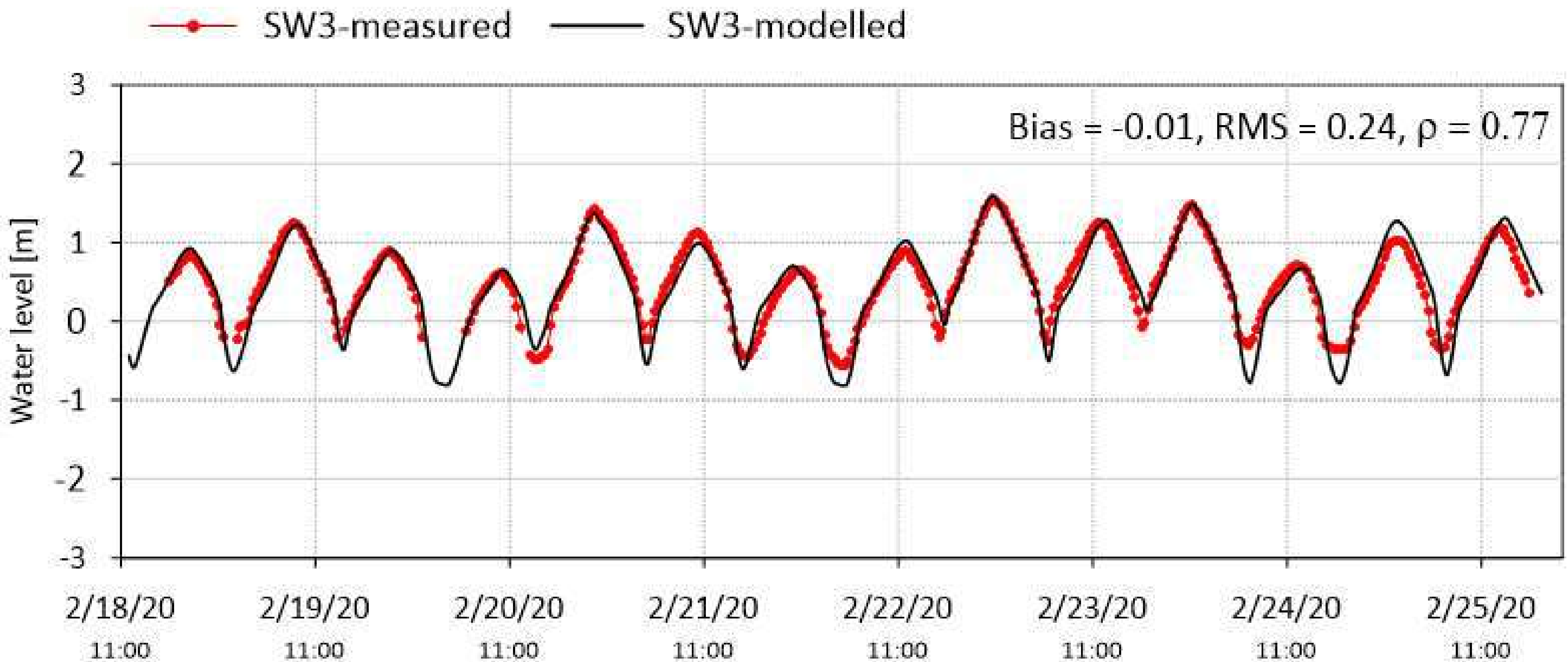
Calibration against survey



Calibration against survey

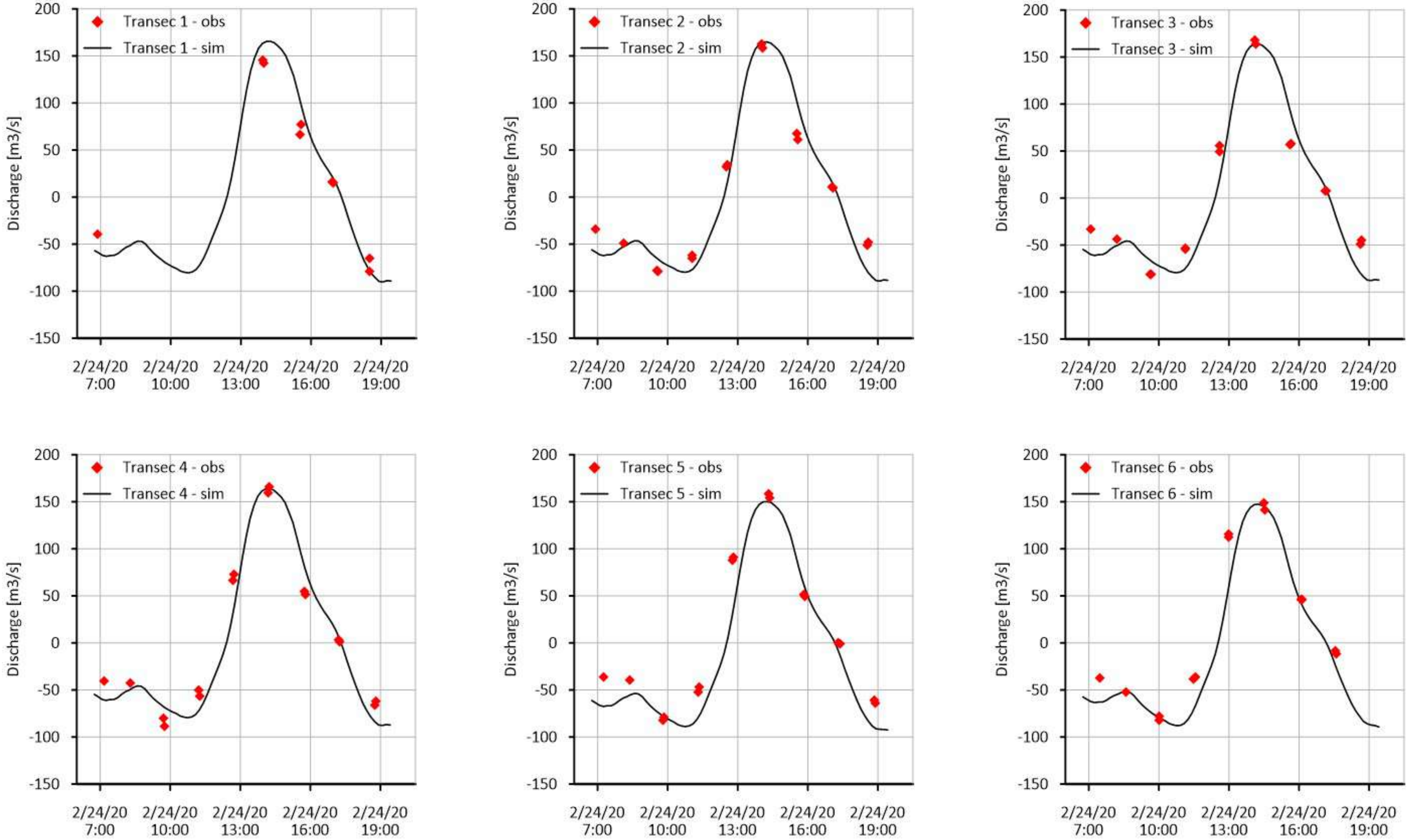


Calibration against survey



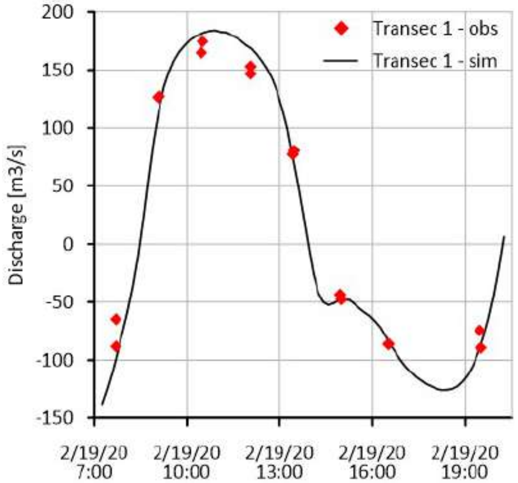
Royal HaskoningDHV

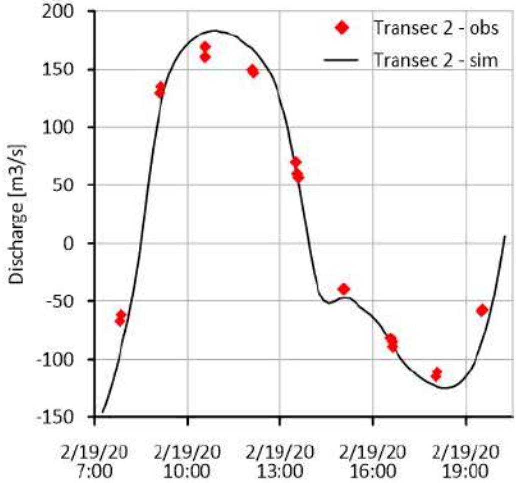
Calibration against survey

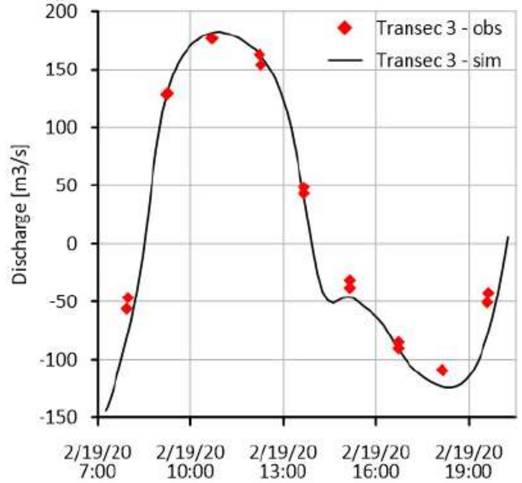


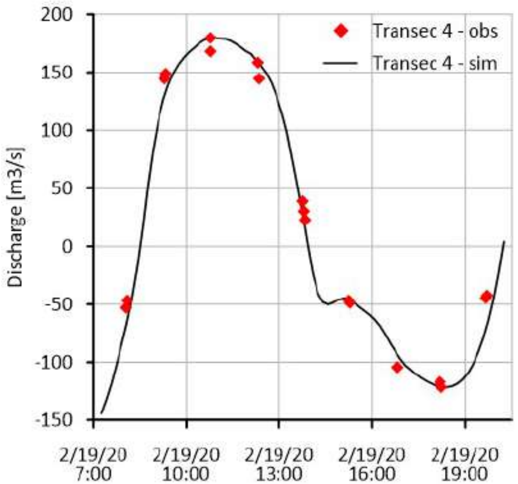
Royal HaskoningDHV

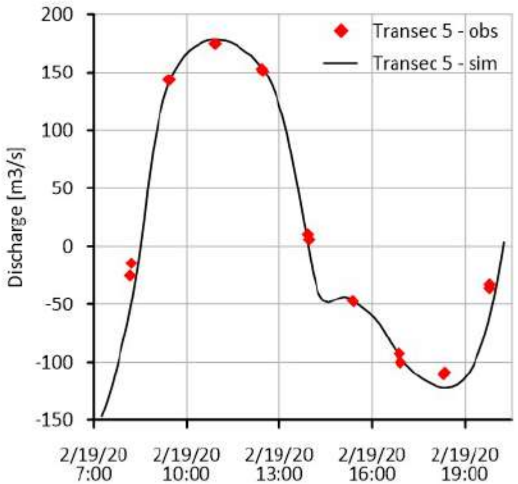
Calibration against survey

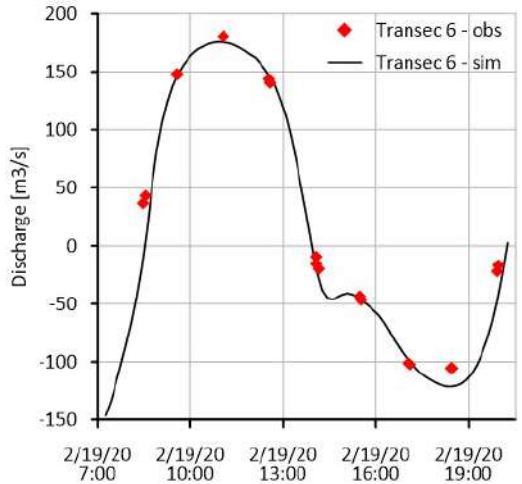




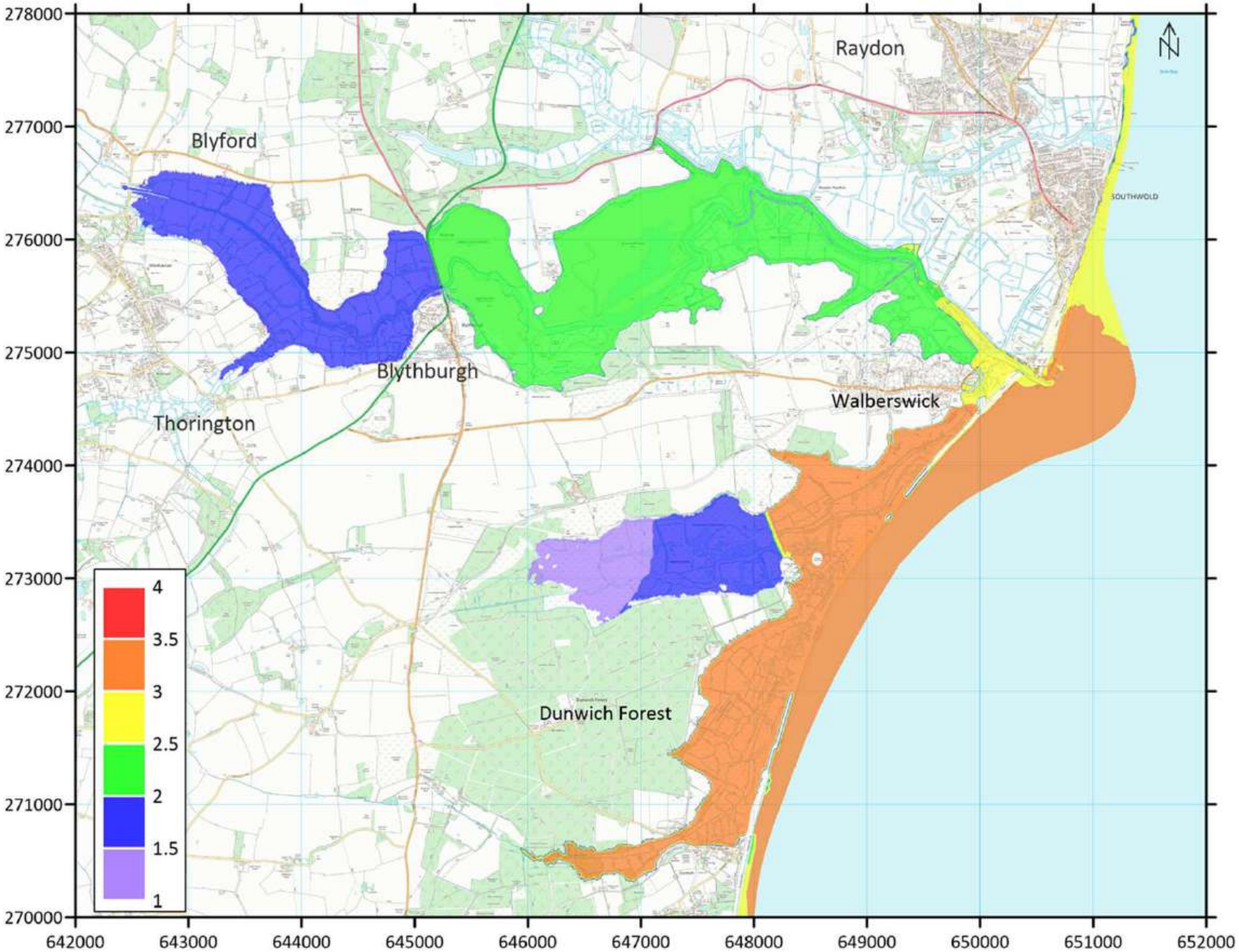






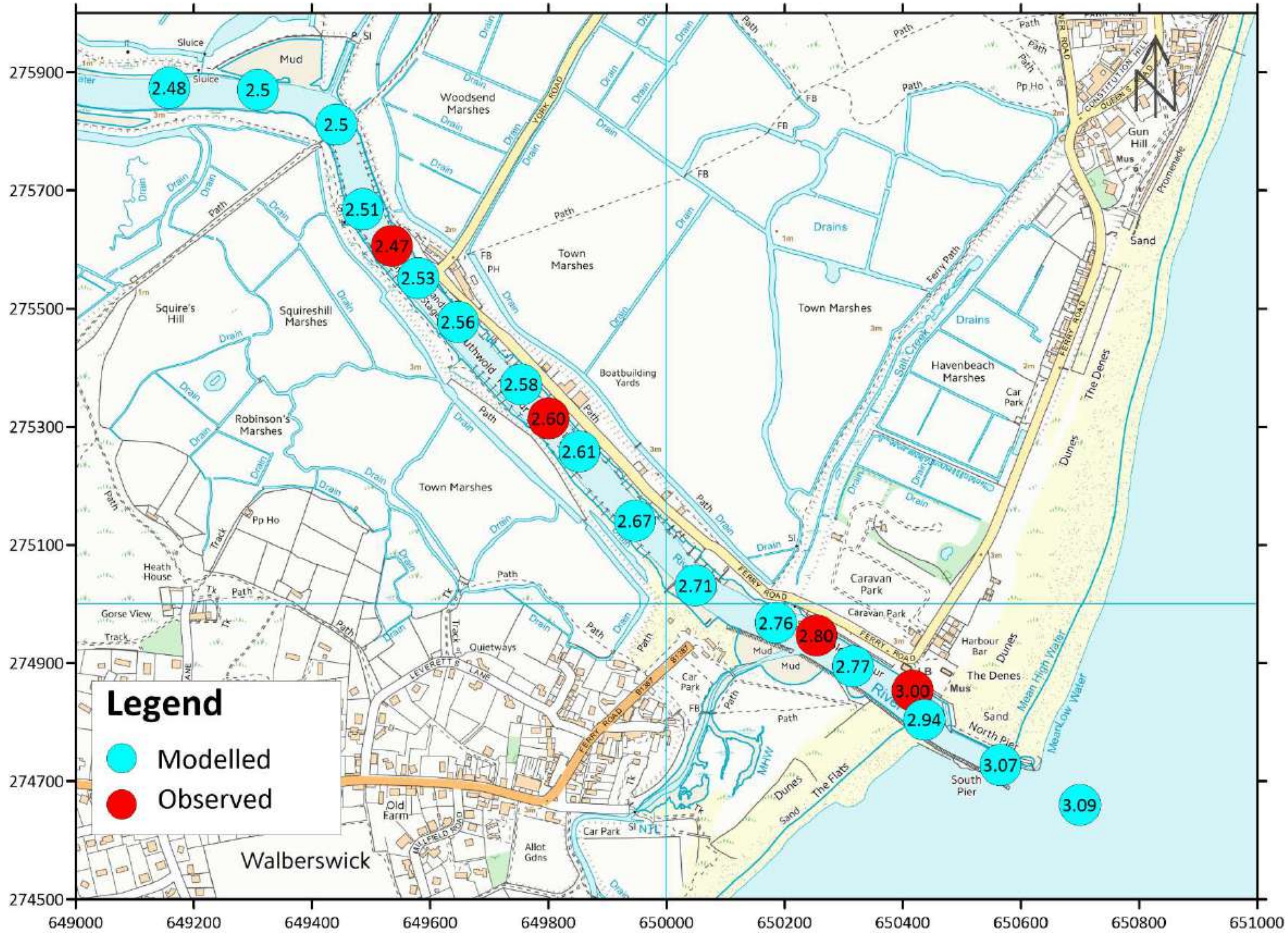


December 2013 – flood extent



Royal HaskoningDHV

December 2013



Royal HaskoningDHV

Conclusions from baseline modelling

- Based on discussions, are we comfortable with the representation of wave conditions?
- Tidal model well calibrated against survey data
- Tidal model shows what happened during the December 2013 event

BREAK

- 5 min comfort break!

Objective - assess options for improvement of harbour and develop Investment Plan

Issues to address

- <u>Primary concerns</u>

Condition of structures and risk of failure.

Considering future scenarios for estuary & potential impacts (e.g. flooding).

- <u>Secondary issues</u>

Performance and usability - improve conditions for navigation and moorings

Risk of failure of harbour structures

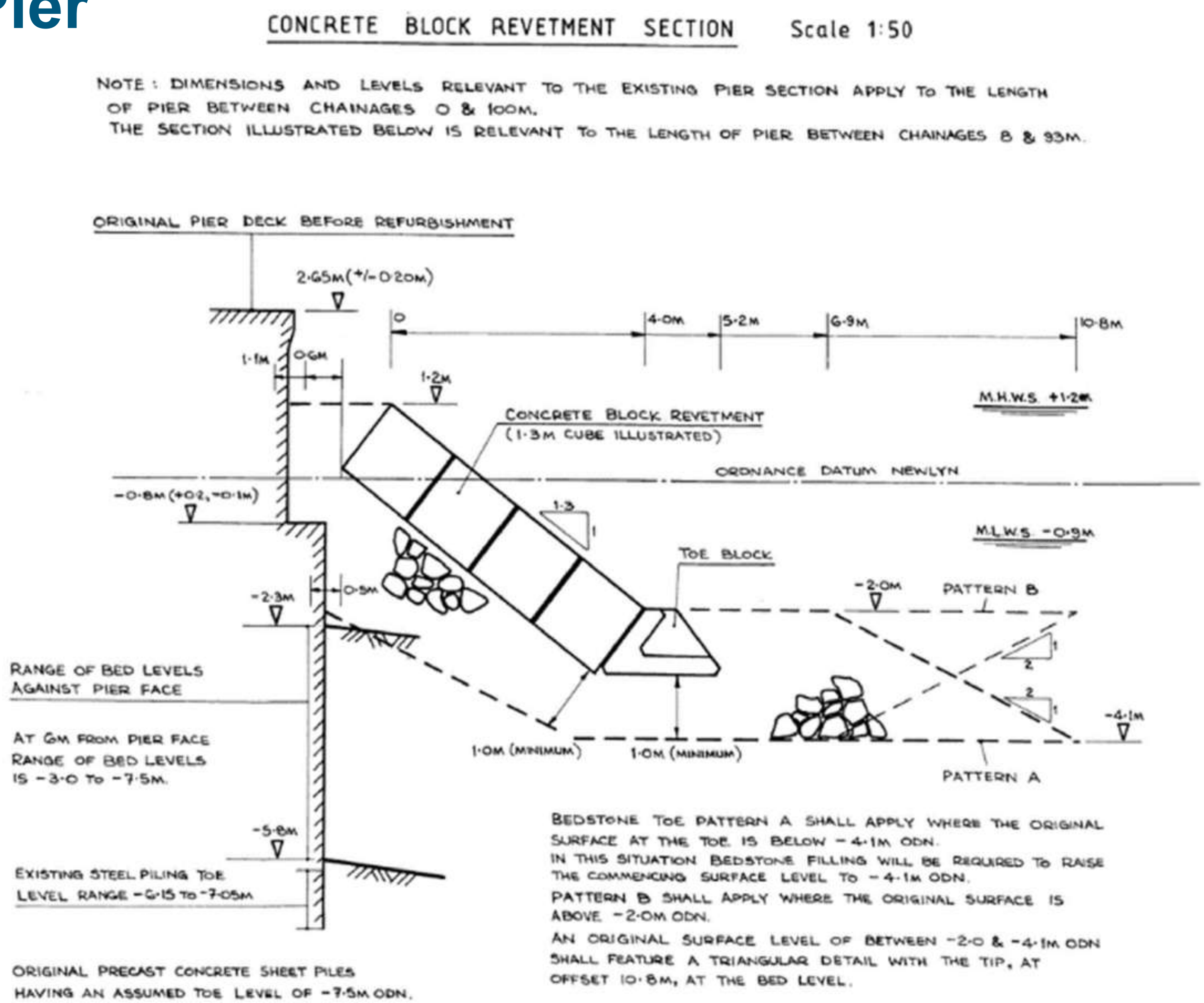
Within the Harbour (N Wall, Dunwich Creek)

- Not currently at risk of failure – secondary issues relating to performance / usability

North Pier

- Not currently at risk of failure
- Limited change in condition since works in 1990s.
- Stable bathymetry since 1990s – not currently at risk of undermining

North Pier



CONCRETE BLOCK REVETMENT SECTION
Scale 1:50
NOTE: DIMENSIONS AND LEVELS RELEVANT TO THE EXISTING PIER SECTION APPLY TO THE LENGTH OF PIER BETWEEN CHAINAGES 0 & 100M.
THE SECTION ILLUSTRATED BELOW IS RELEVANT TO THE LENGTH OF PIER BETWEEN CHAINAGES 8 & 93M.
ORIGINAL PIER DECK BEFORE REFURBISHMENT
2·65M(+/-0·20M)
0
4·0M
5·2M
6·9M
10·8M
1·1M
0·6M
1·2M
M.H.W.S. +1·2M
CONCRETE BLOCK REVETMENT
(1·3M CUBE ILLUSTRATED)
ORDNANCE DATUM NEWLYN
-0·8M(+0·2,-0·1M)
1·3
1
M.L.W.S. -0·9M
TOE BLOCK
-2·3M
0·5M
-2·0M
PATTERN B
2
1
RANGE OF BED LEVELS AGAINST PIER FACE
AT 6M FROM PIER FACE RANGE OF BED LEVELS IS -3·0 TO -7·5M.
1·0M (MINIMUM)
1·0M (MINIMUM)
-4·1M
PATTERN A
-5·8M
EXISTING STEEL PILING TOE LEVEL RANGE -6·15 TO -7·05M
ORIGINAL PRECAST CONCRETE SHEET PILES HAVING AN ASSUMED TOE LEVEL OF -7·5M ODN.
BEDSTONE TOE PATTERN A SHALL APPLY WHERE THE ORIGINAL SURFACE AT THE TOE IS BELOW -4·1M ODN.
IN THIS SITUATION BEDSTONE FILLING WILL BE REQUIRED TO RAISE THE COMMENCING SURFACE LEVEL TO -4·1M ODN.
PATTERN B SHALL APPLY WHERE THE ORIGINAL SURFACE IS ABOVE -2·0M ODN.
AN ORIGINAL SURFACE LEVEL OF BETWEEN -2·0 & -4·1M ODN SHALL FEATURE A TRIANGULAR DETAIL WITH THE TIP, AT OFFSET 10·8M, AT THE BED LEVEL.

North Pier

Bathymetry

- 2020 survey
- Comparison with previous surveys (2013 to 2020)
- Comparison with previous surveys (2013 to 2015)

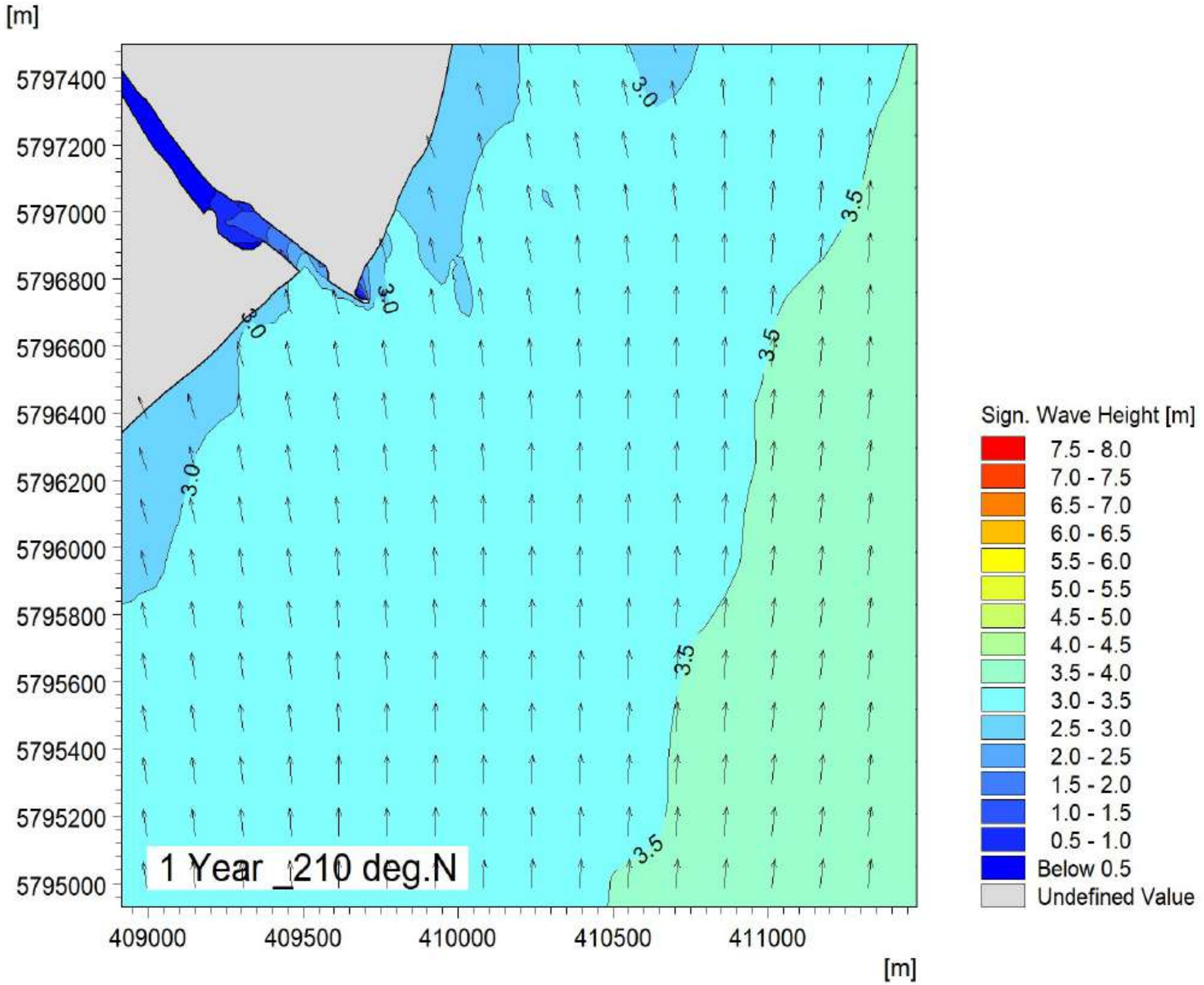
Risk of failure of harbour structures

South Pier

- Structure at greatest risk of failure
- Limited change in condition and risk of failure since 1990s
- Length C has failed, although not collapsed – can’t take design load
- Wave impact could cause collapse – just hasn’t happened yet

Failed section of South Pier

Failed section of South Pier

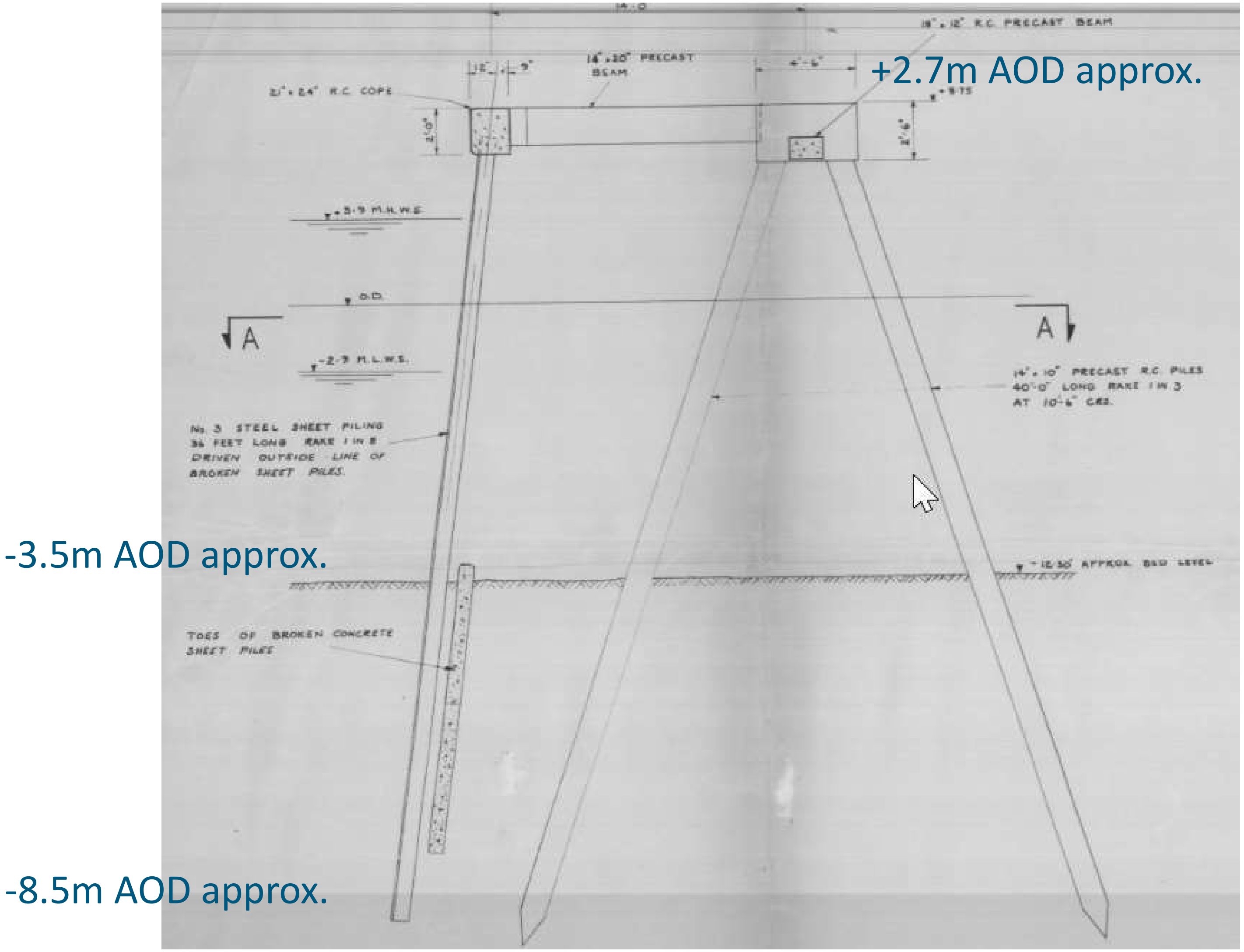


Risk of failure of harbour structures

South Pier

- Structure at greatest risk of failure
- Limited change in condition and risk of failure since 1990s
- Length C has failed, although not collapsed – can’t take design load
- Wave impact could cause collapse – just hasn’t happened yet
- The structure could last another 15-20 years or more if Length C was repaired.
- **Depends on erosion in front of piles.**

South Pier – form of construction



Royal HaskoningDHV

South Pier

Bathymetry

- 2020 survey
- Comparison with previous surveys (2013 to 2020)
- Comparison with previous surveys (2013 to 2015)

Options for South Pier?

1. Do Nothing
2. Do Minimum
3. Sustain
4. Replace
    a) Like for like
    b) Solid, vertical pier
    c) Rock armour breakwater

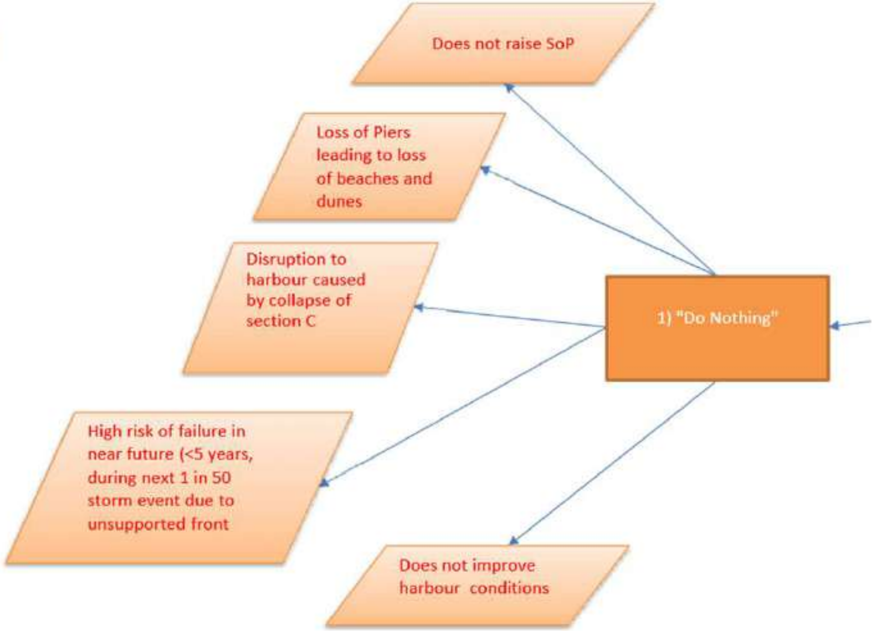
Do Nothing

Baseline case, assumes no future intervention

- Structural condition allowed to deteriorate
- High risk of failure of S Pier in short term
  (Possible undermining of and failure of N Pier longer term)

- ➢ Unable to use harbour once S Pier has failed
- ➢ Impacts on coast to north and south

- **Doesn’t meet objectives**
- Include for financial comparison



Royal HaskoningDHV

Do Minimum

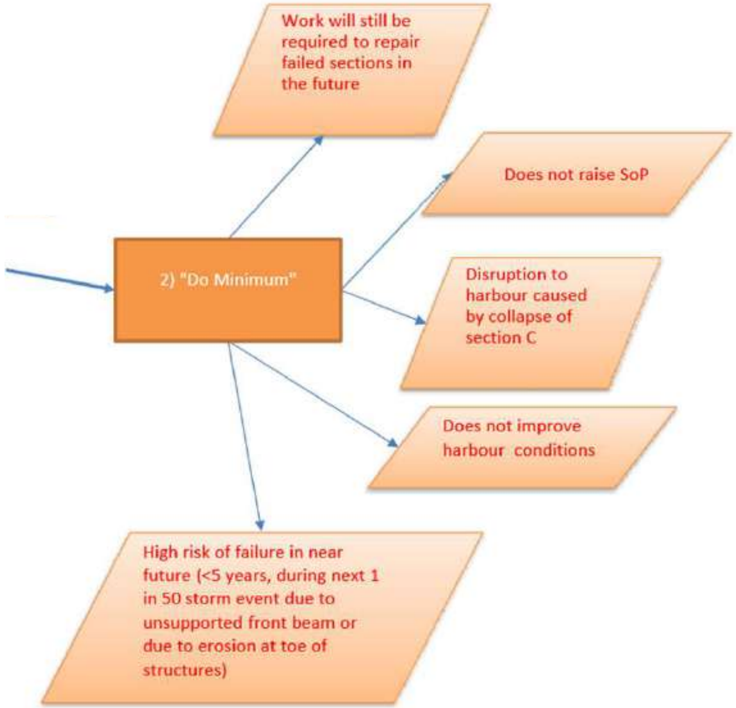
Reactive option, minimum level of intervention

- Structural condition allowed to deteriorate
- High risk of failure of S Pier in short term

  (Possible undermining of and failure of N Pier longeı
- Repair structures when failure occurs

- ➢ Failure allowed, so repairs likely to cost more
- ➢ Impacts on harbour operation, safety risks
- ➢ No improvement in structural or harbour conditions

- **Doesn't meet objectives**
- Include for financial comparison



Royal HaskoningDHV

Sustain

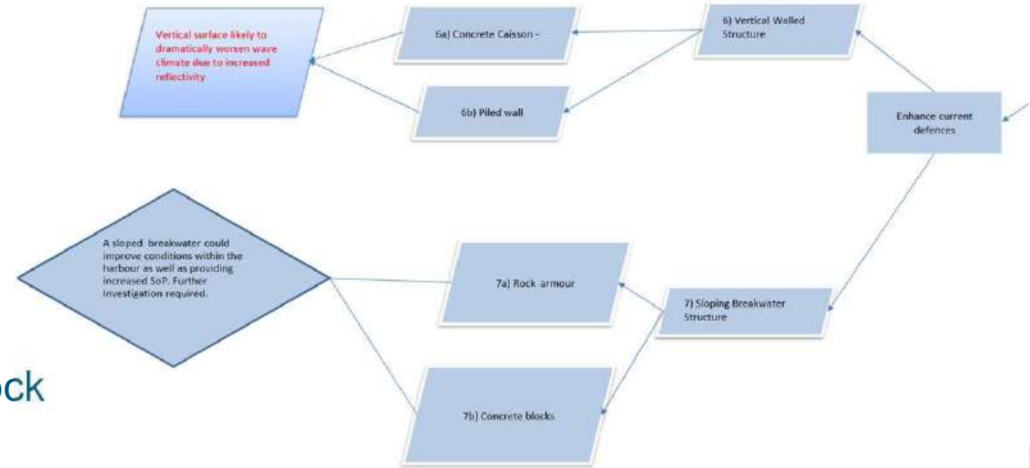
Proactive approach, sustain the existing structure for as long as possible

- Replace Section C of South Pier
- Patch repairs to whole structure
- Monitor channel bed level, toe piling when needed
- Monitor condition of other structures, repair as needed and replace before end of life

- ➢ Addresses immediate failure risk
- ➢ Further works to S Pier may be needed in ~20 years
- ➢ Monitoring needed to optimise timing of further works and associated investment

- Potential to sustain existing structure for ~50 years
- Doesn’t improve harbour conditions without other works

Replace



- Replace South Pier
  - Like-for-like
  - Vertical walled solid pier
  - Sloping breakwater – concrete or rock

- Significant investment required
- Immediate vs longer-term option?
- Could improve conditions – reduced reflection in channel

- Option to realign harbour mouth

Royal HaskoningDHV

Like-for-like replacement

- Aim to sustain existing conditions
- Design to address risk of continued erosion
- High cost / difficult operation to remove existing structure
- Option to realign harbour mouth

Vertical solid pier

- Concrete caissons or vertical sheet piles
- Design to address risk of continued erosion
- Likely to result in increased wave reflection without other measures
- High cost / difficult operation to remove existing structure
- Option to realign harbour mouth
- Could increase width of channel

Concrete or rock armour breakwater

- Reduced wave reflection, improved channel conditions
- Design to address risk of continued erosion
- Cut down existing structure, use as toe to new breakwater, avoid full removal
- Lower cost than other replacement options
- Option to realign harbour mouth
- Constraints on full realignment options
- Could optimise crest level to allow wave transmission

Royal HaskoningDHV

Discussion

- Replace: like-for-like vs rock breakwater
- Realignment of harbour mouth

Issues & options re. Performance & Usability

Improve conditions for navigation and moorings

Reduce wave heights by 50%?

- Shoal bank
- Wave baffles
- Dunwich Creek entrance
- Modifications to North Wall

Shoal bank / wave baffles

Dunwich Creek

North Wall options

- Options to reduce wave heights at wall? *Particular issue from E / SE swell*
  - Wave baffles
  - Revetment to inner section of S Pier?

- Modify form of construction
  - Fendering
  - Overhanging crest
  - Mooring bollards

Outcomes & Next steps

- What we will do next
  - Confirm future scenarios and options to be modelled
  - Progress modelling of options
  - Consider Investment Plan timeline
- Next workshop
  - Results of options modelling
  - Preferred solution

Southwold Harbour Study

Stakeholder Workshop 3

20 October 2020

Welcome

- Local residents and harbour users
- Project team (ESC, CPE, RHDHV)
- Apologies

Agenda

Welcome & Agenda	13.00
Aims & objectives for this workshop	13.05
Approach to options modelling	13.25
Wave modelling results	13.35
Tidal modelling results	13.55
Discussion of findings	14.25
Conclusions & Next Steps	14.45
FINISH	15.00

Royal HaskoningDHV

Aims and Objectives of this Workshop

- Share and discuss findings from the options modelling
- Review the potential next steps

Approach to options modelling

- Wave model - with options for harbour structures, based on the long-list assessment
- Tidal model - future scenarios for estuary management
- Sensitivity to climate change
- Surge event (2013)

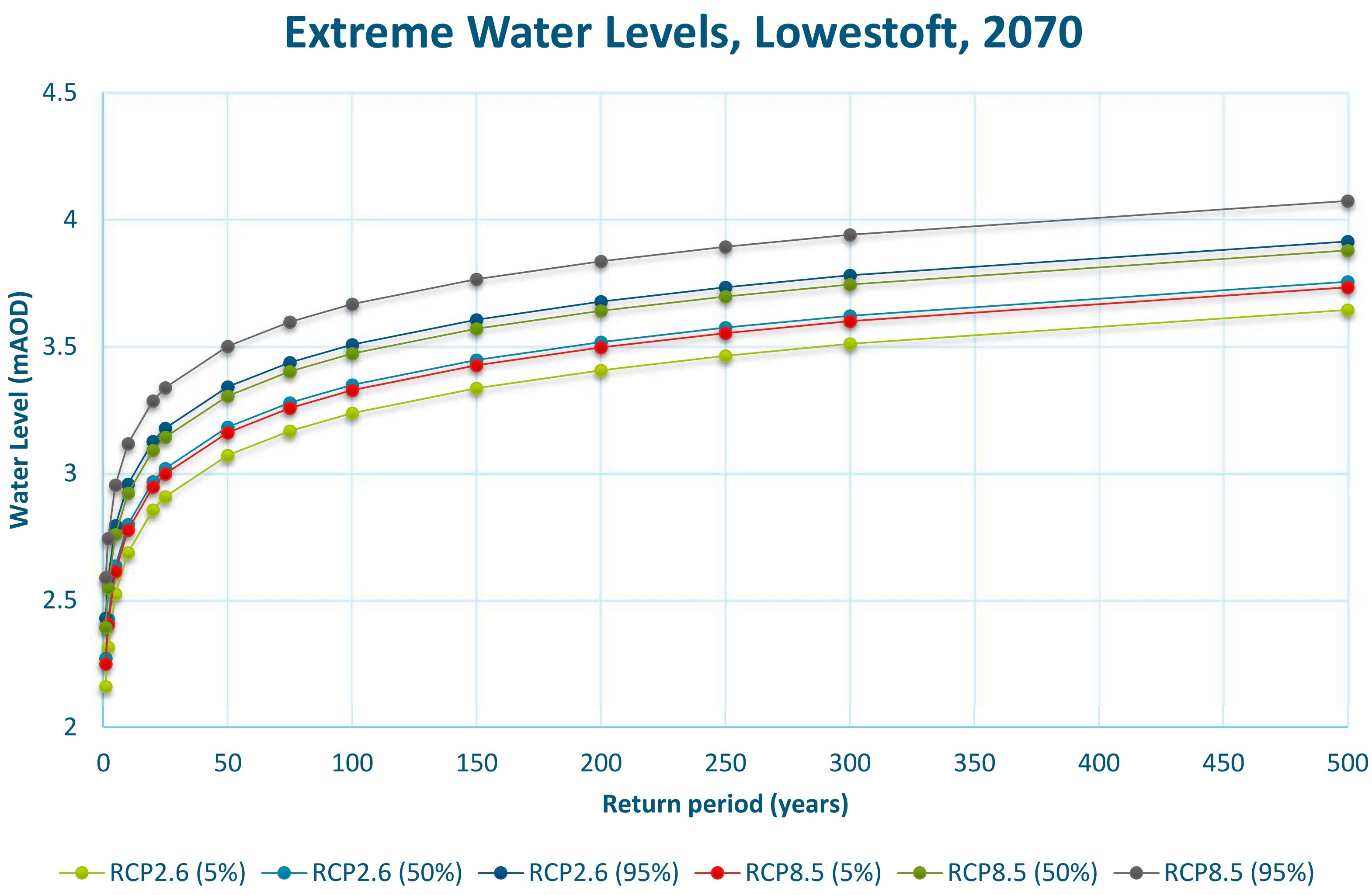
Water level scenarios

- **Wave modelling**
  - 1:1 year present day return period water level
  - Water level increase with climate change has limited impact on wave conditions for this scenario (TBC)
- **Tidal model - Present Day**
  - 24th February 2020 – calibration against survey
  - 1.49mOD water level at harbour mouth
  - Approx. 0.4m surge on MHWS
- **Climate change to 2070**
  - *Based on UKCP18 RCP2.6 (50%) – low emissions (TO BE CHECKED)*
  - 4.7mm/yr SLR (MSL), no acceleration
  - 50 years SLR added to 24th February conditions
  - 2.04mOD water level at harbour mouth
  - Approx. present-day 1:1 year return period

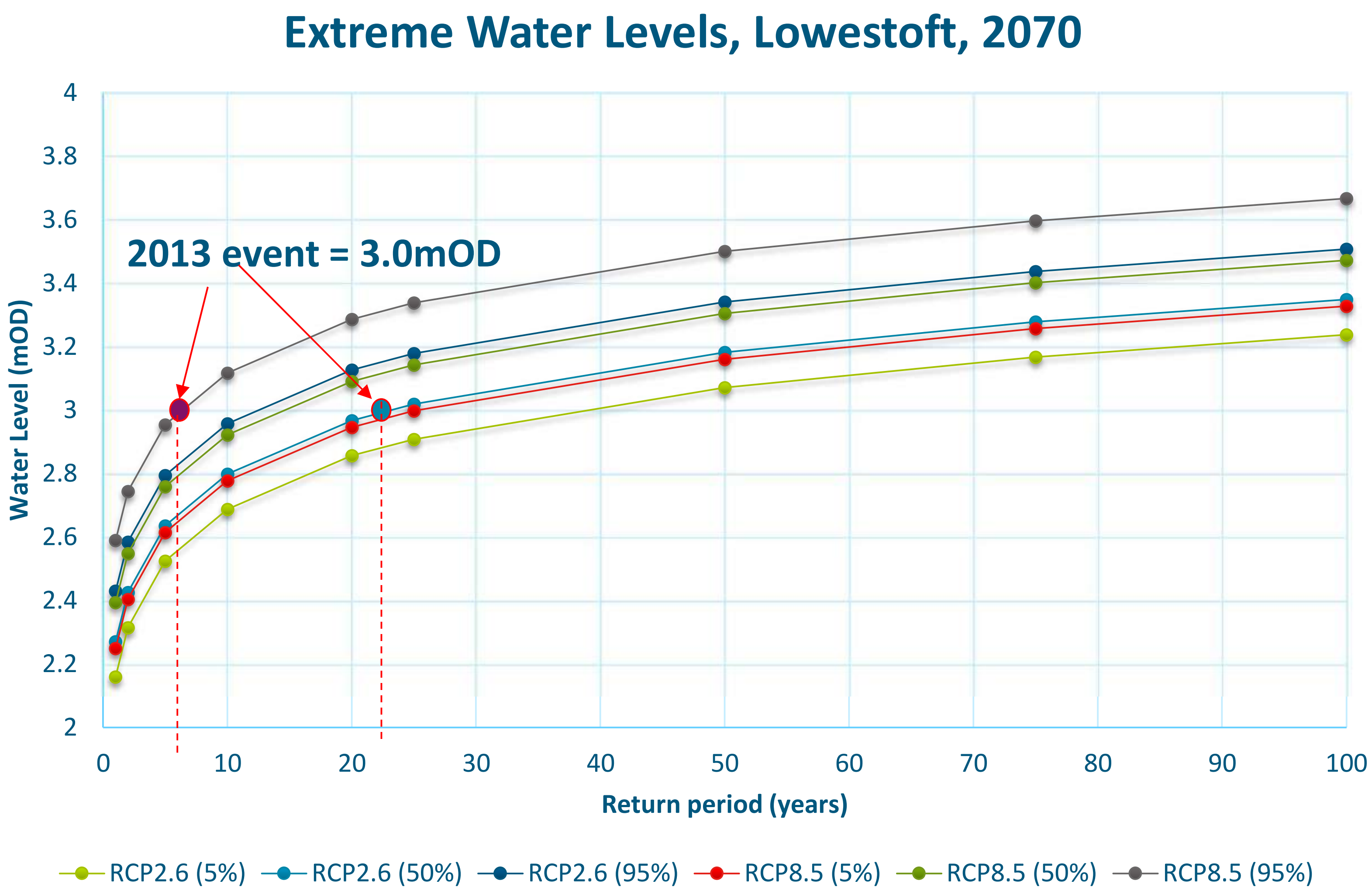
Water level scenarios

- 2013 event
  - Water level of 3.1mOD at harbour mouth
  - Present day return period of ~1:100
  - Return period reduces to 1:5 - 1:25 with 50 years SLR

- Very high – UKCP18 RCP8.5 (95%)
  - 7-14mm/yr SLR (MSL), accelerating
  - Currently applied to 2013 event (worst case)
  - Water level >2m higher than 2020 conditions, 3.59mOD at harbour mouth



Royal HaskoningDHV



Royal HaskoningDHV

Wave modelling options

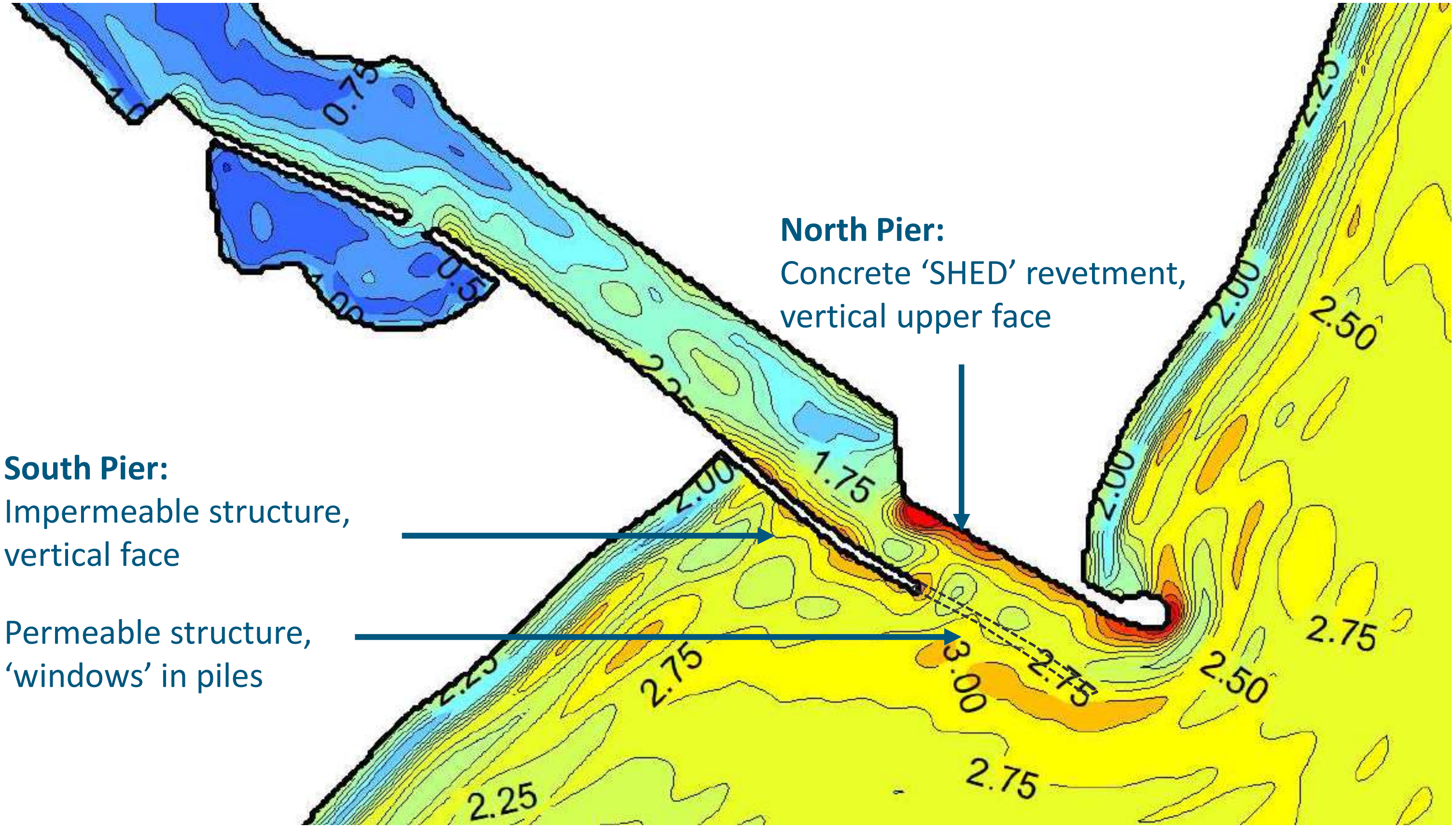
- Present Day
- Rock breakwater
- Rock breakwater with concrete baffles
- Rock breakwater with revetment
- Do Nothing – failure of outer part of S Pier

Present Day

North Pier:
Concrete 'SHED' revetment,
vertical upper face

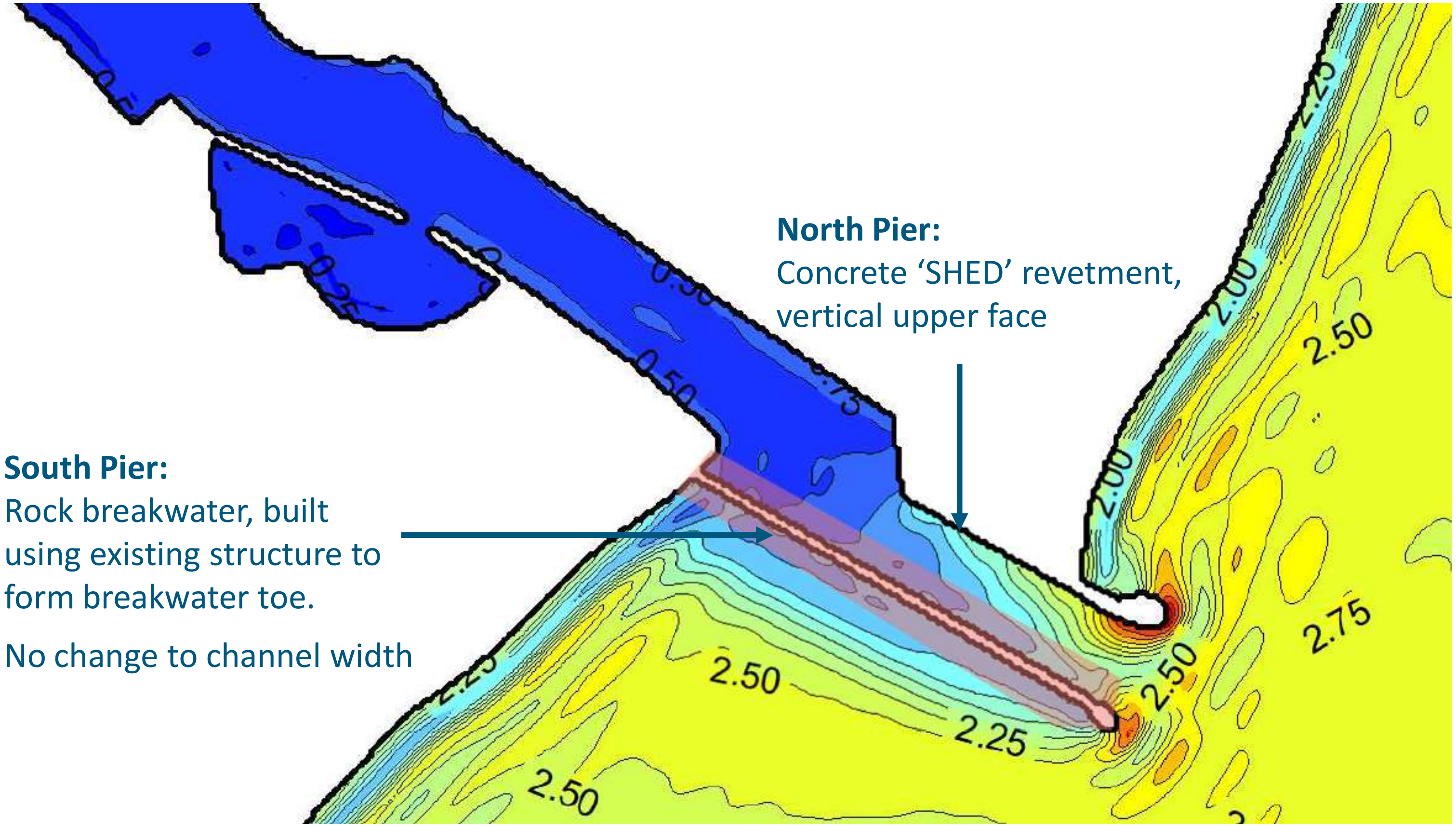
South Pier:
Impermeable structure,
vertical face

Permeable structure,
'windows' in piles



Background wave conditions are for the present-day harbour layout, waves from 120 degrees

Rock breakwater



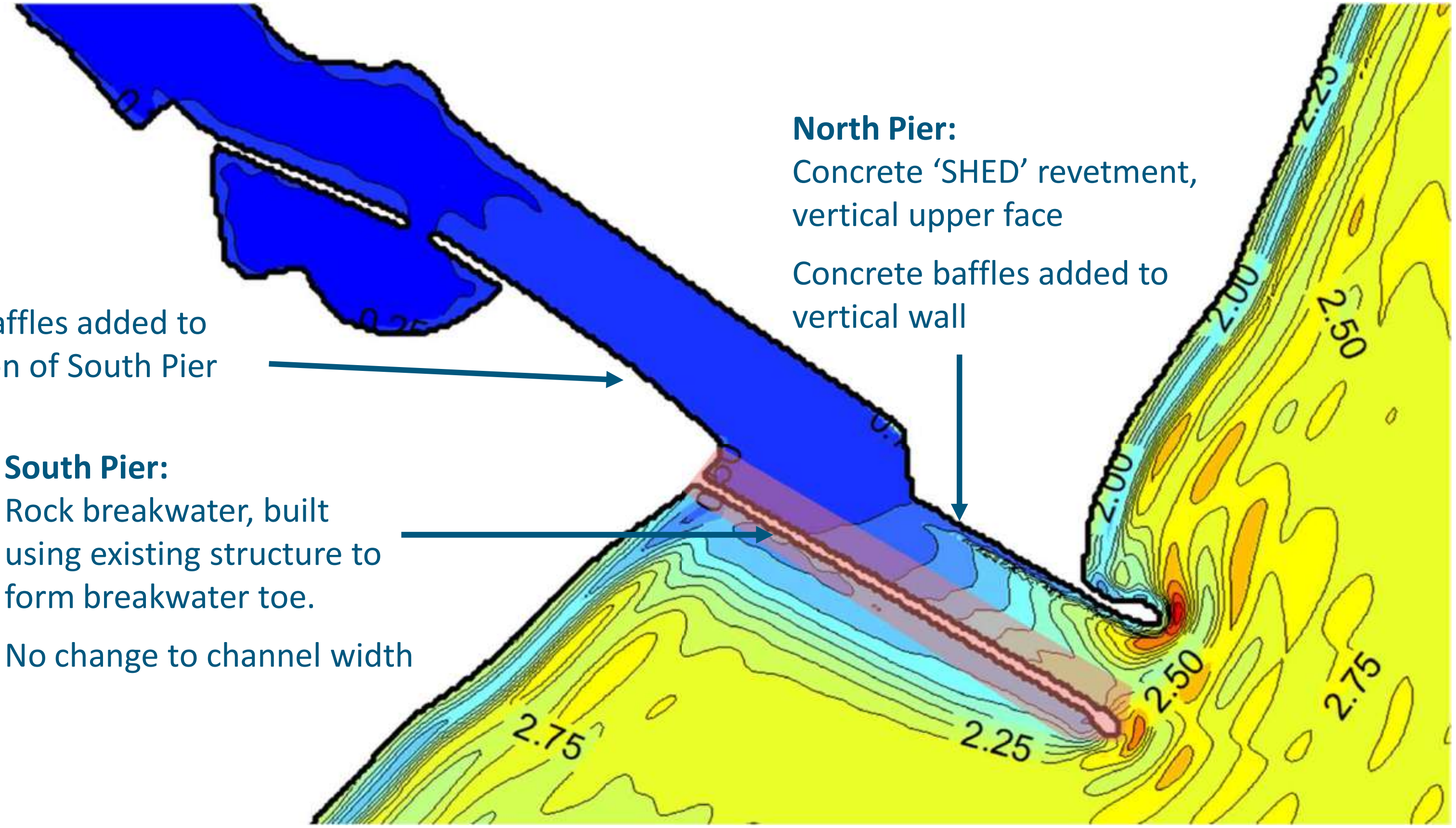
North Pier:
Concrete 'SHED' revetment, vertical upper face

South Pier:
Rock breakwater, built using existing structure to form breakwater toe.

No change to channel width

Background wave conditions are for a rock breakwater to replace the S Pier, waves from 120 degrees

Rock breakwater + baffles



North Pier:
Concrete 'SHED' revetment, vertical upper face

Concrete baffles added to vertical wall

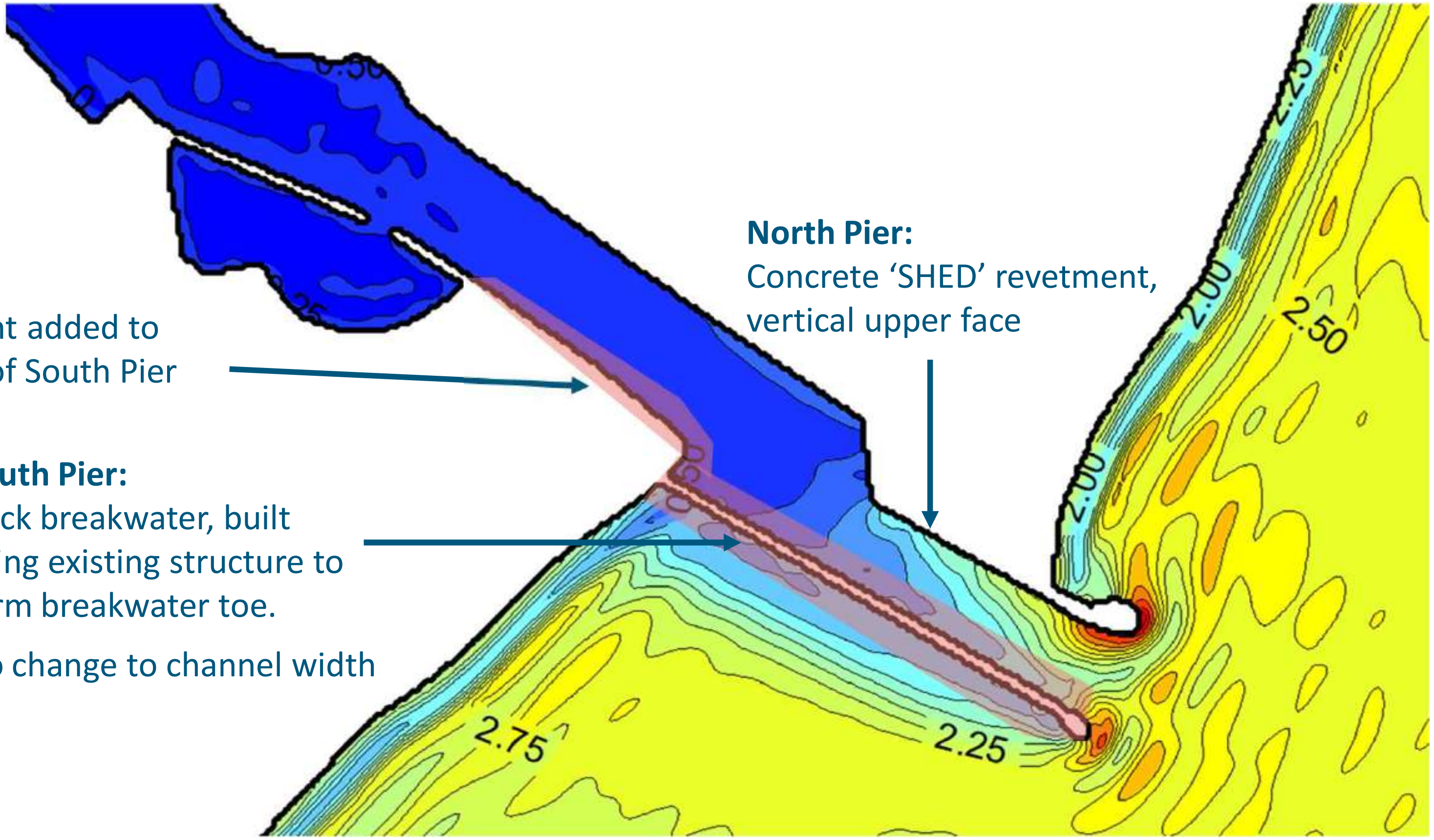
Concrete baffles added to inner section of South Pier

South Pier:
Rock breakwater, built using existing structure to form breakwater toe.

No change to channel width

Background wave conditions are for a rock breakwater + concrete baffles, waves from 120 degrees

Rock breakwater + revetment



Rock revetment added to inner section of South Pier

North Pier:
Concrete 'SHED' revetment, vertical upper face

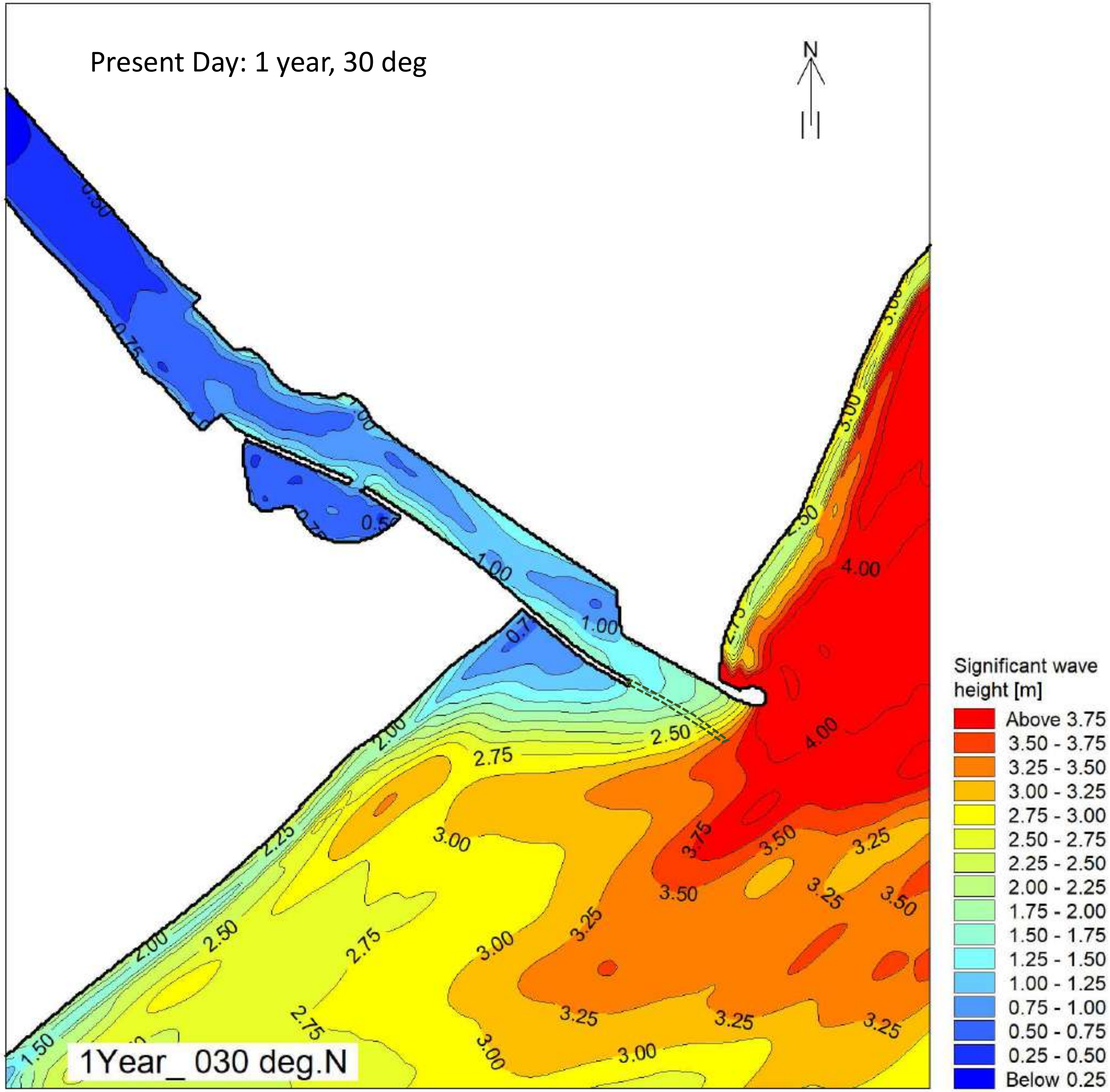
South Pier:
Rock breakwater, built using existing structure to form breakwater toe.

No change to channel width

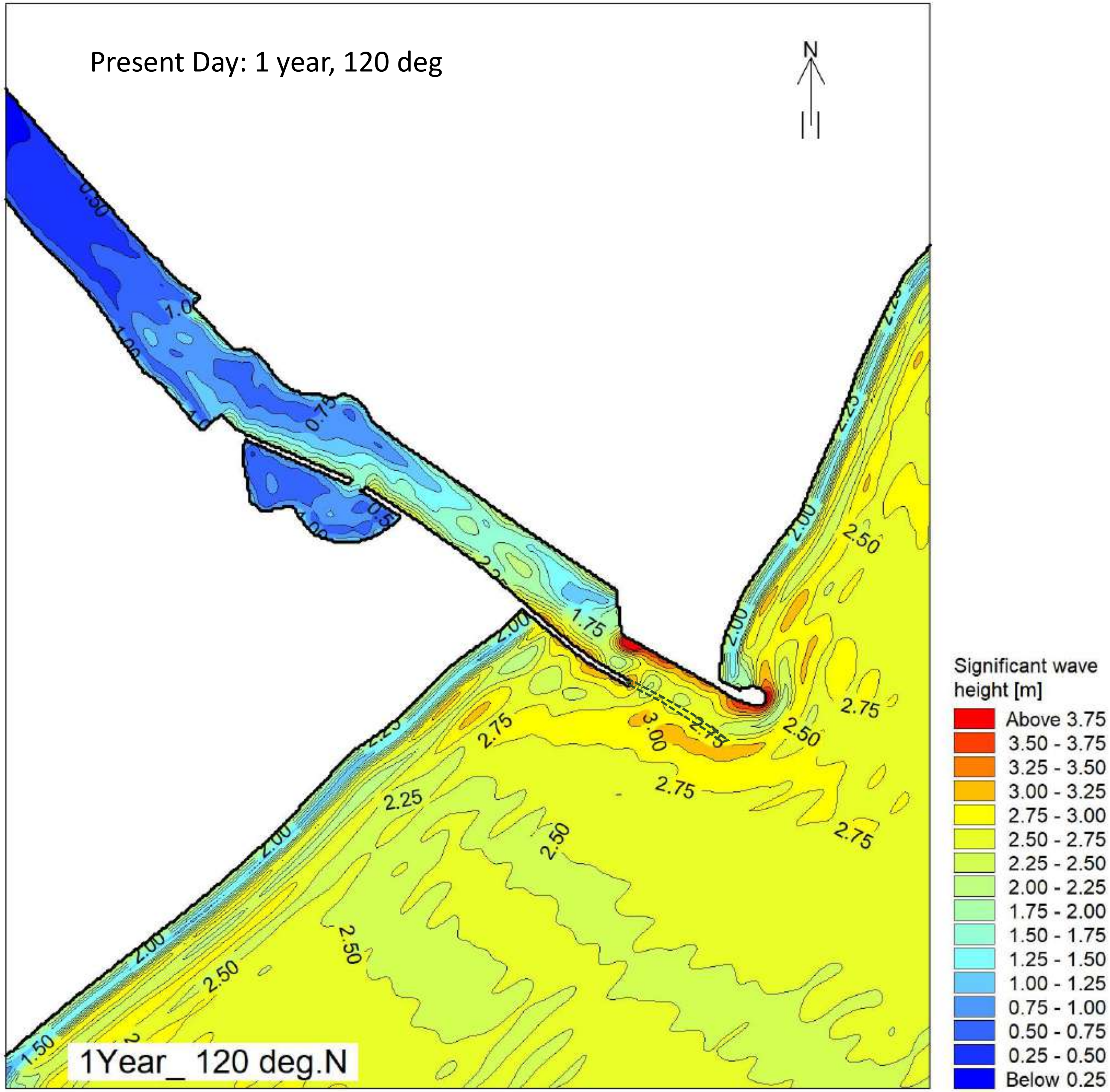
Background wave conditions are for a rock breakwater + revetment up to Dunwich Creek, waves from 120 degrees

Wave modelling results

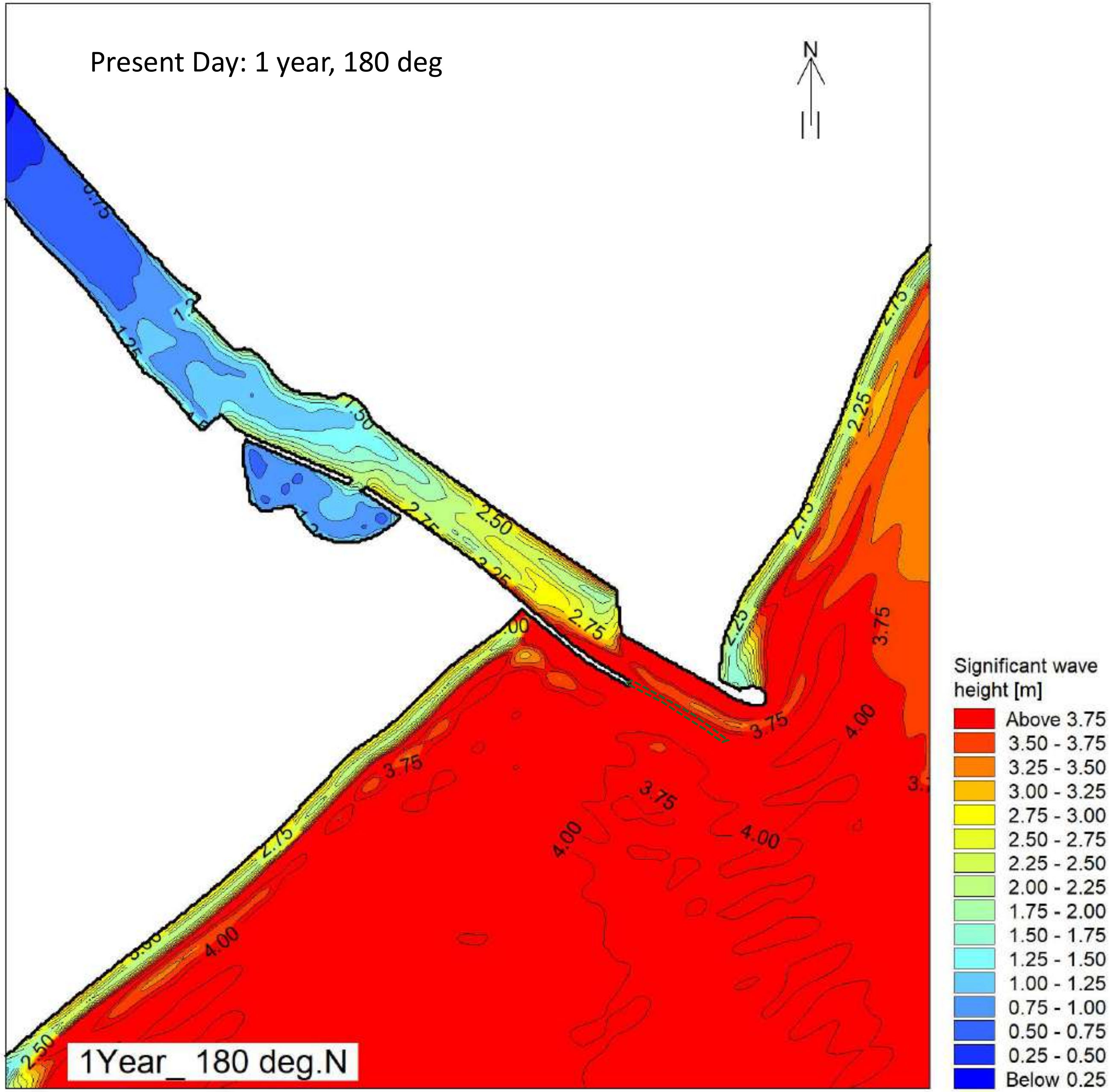
- Results for each option
- Objectives re. wave conditions:
  - Minimise disturbance in entrance channel
  - Max 0.5m at North Wall
- Comments / discussion

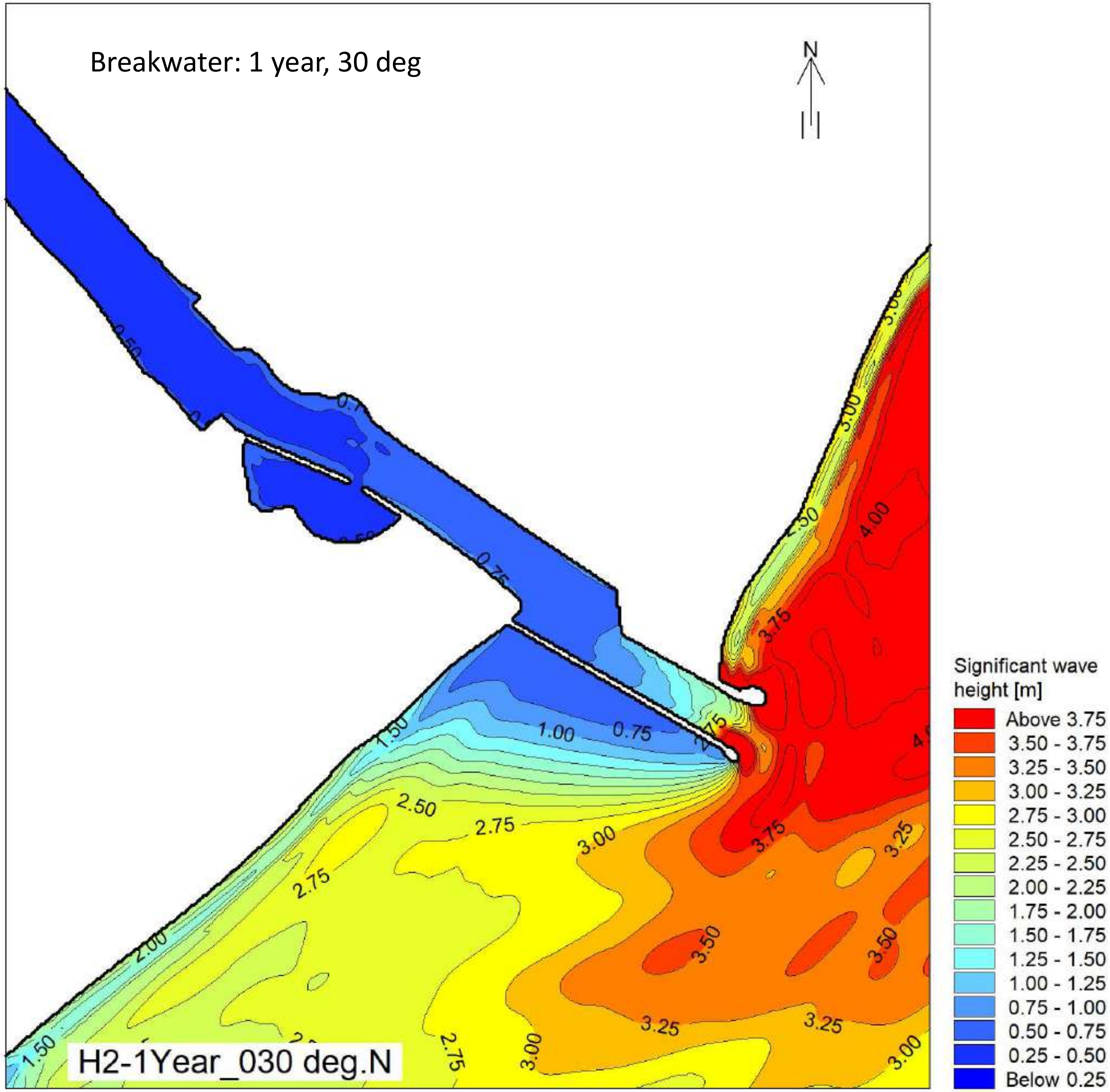


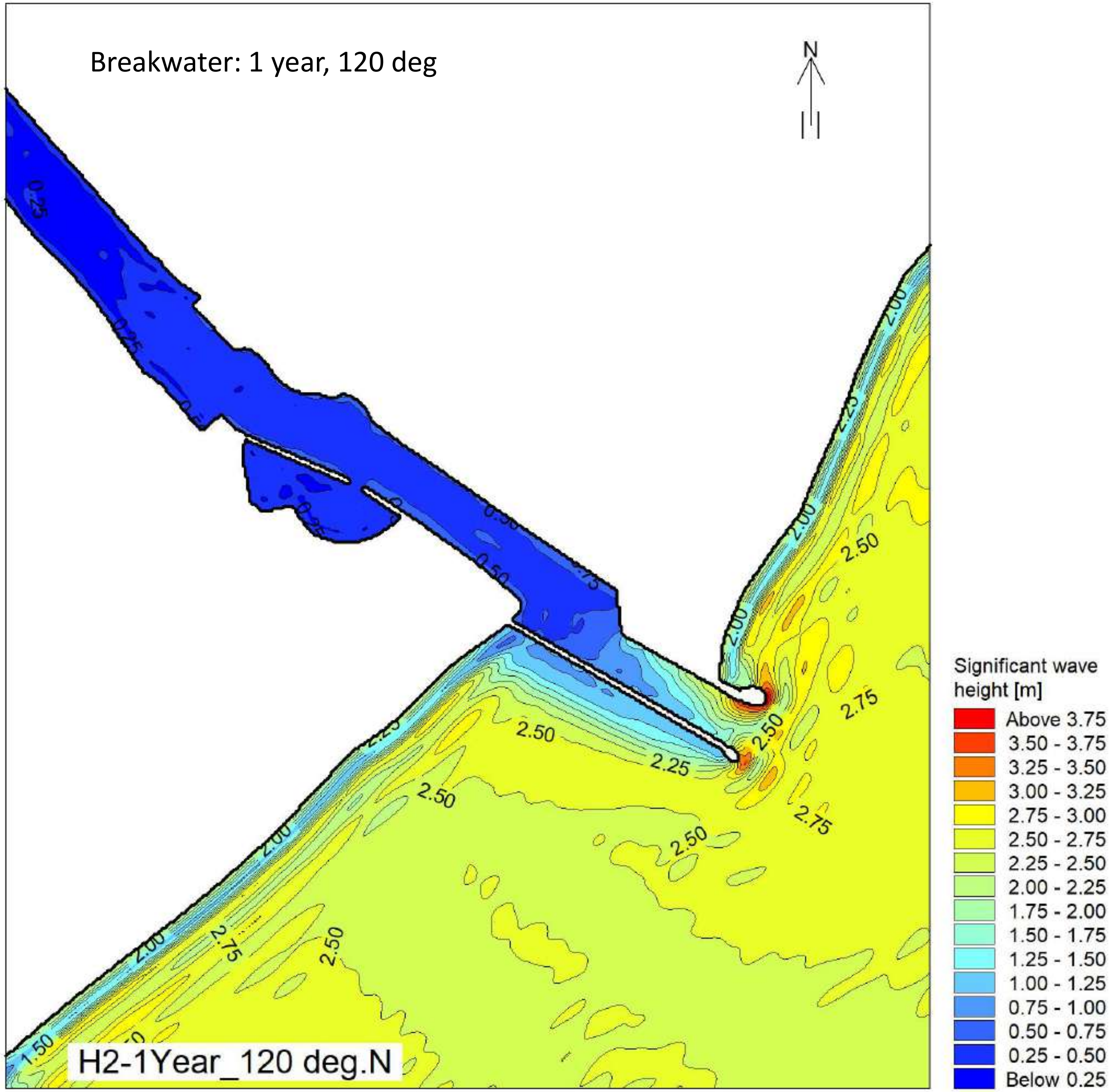
Present Day: 1 year, 30 deg
N
1Year_ 030 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25



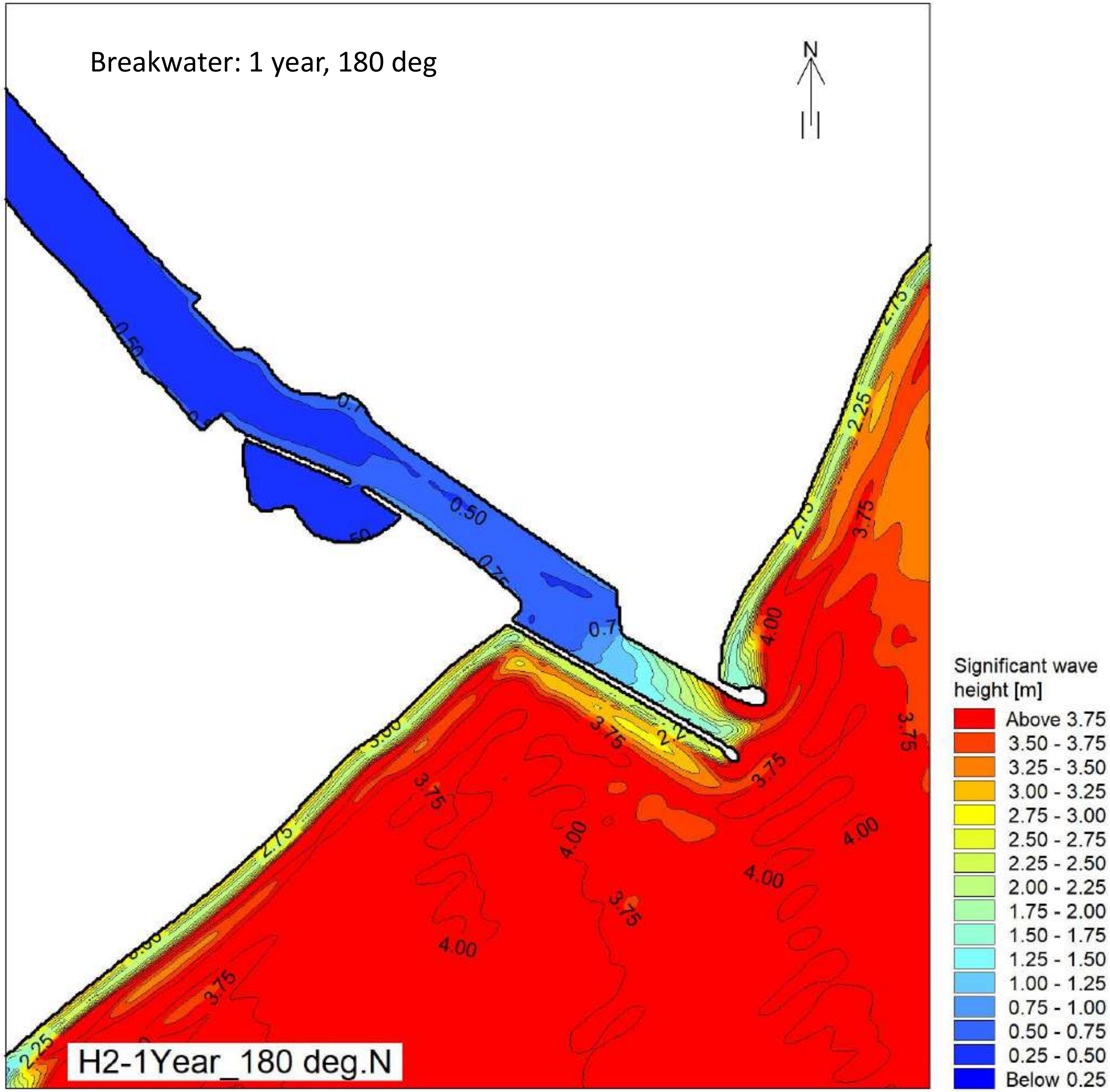
Present Day: 1 year, 120 deg
N
1Year_ 120 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

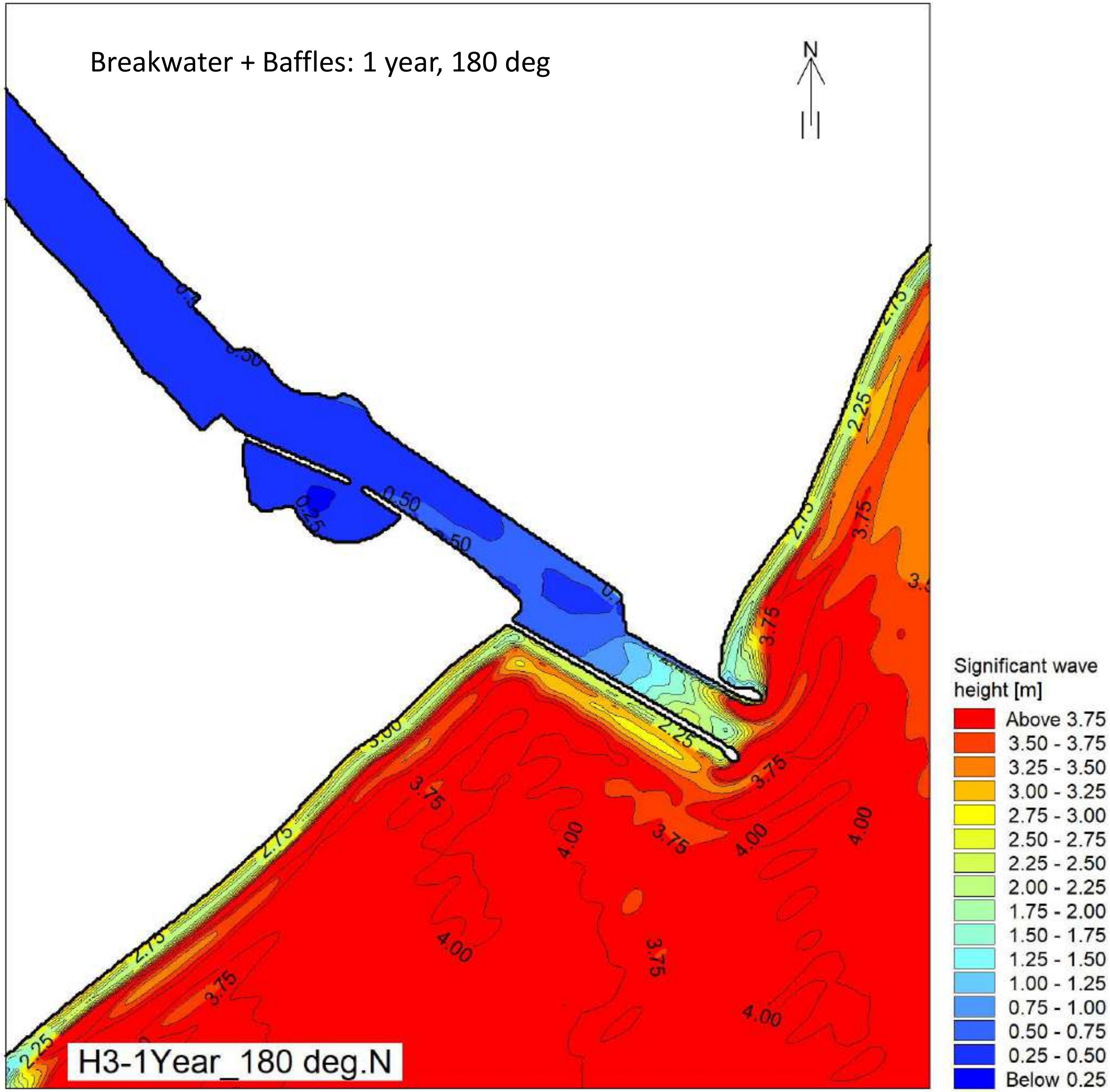

Present Day: 1 year, 180 deg
N
1Year_ 180 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25


Breakwater: 1 year, 30 deg
N
H2-1Year_030 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

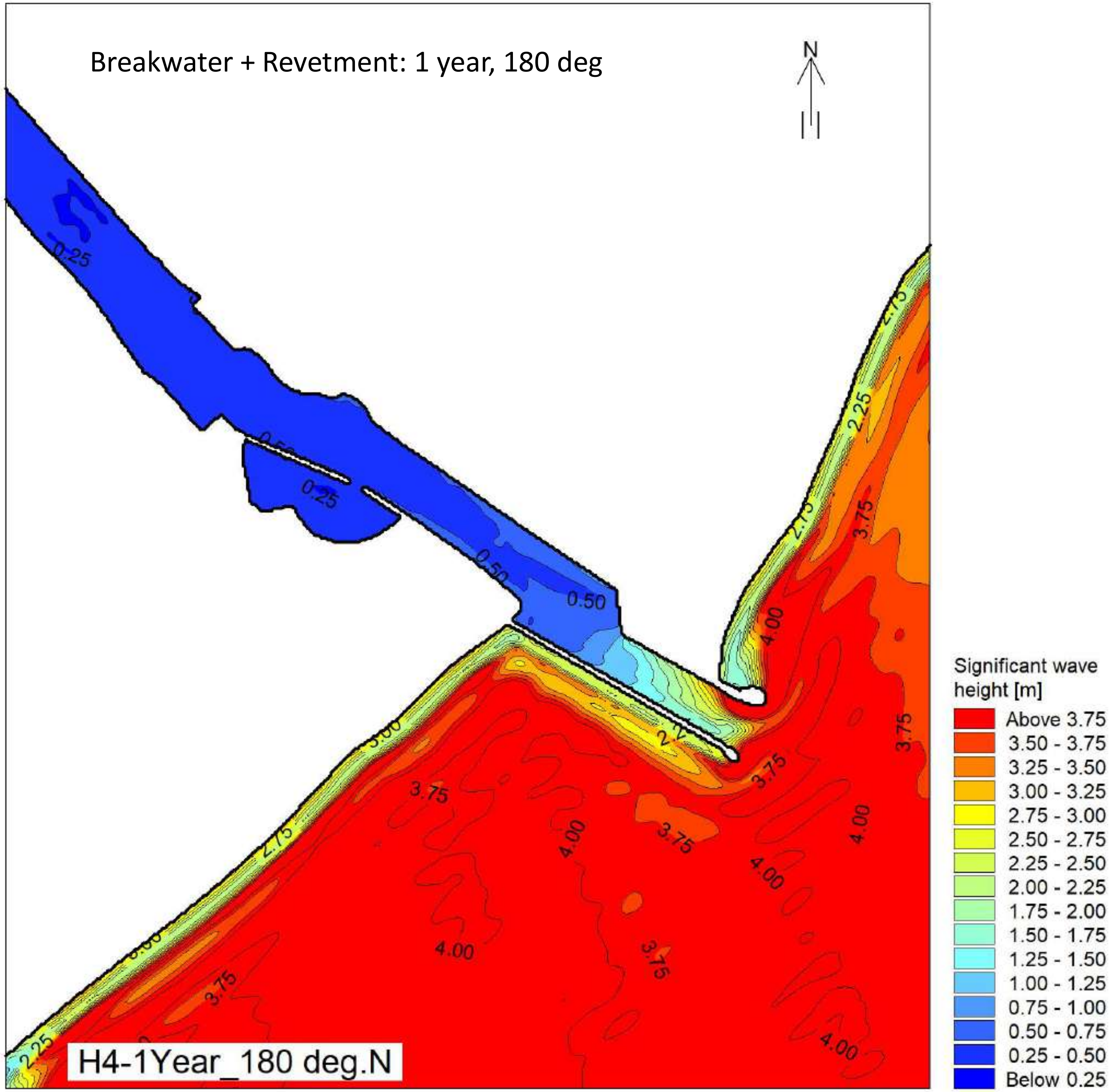


Breakwater: 1 year, 120 deg
N
0.25
0.25
0.25
0.50
0.50
2.00
2.25
2.00
2.50
2.00
2.75
2.50
2.50
2.25
2.25
2.50
2.75
2.50
2.00
2.00
2.75
2.50
1.50
H2-1Year_120 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

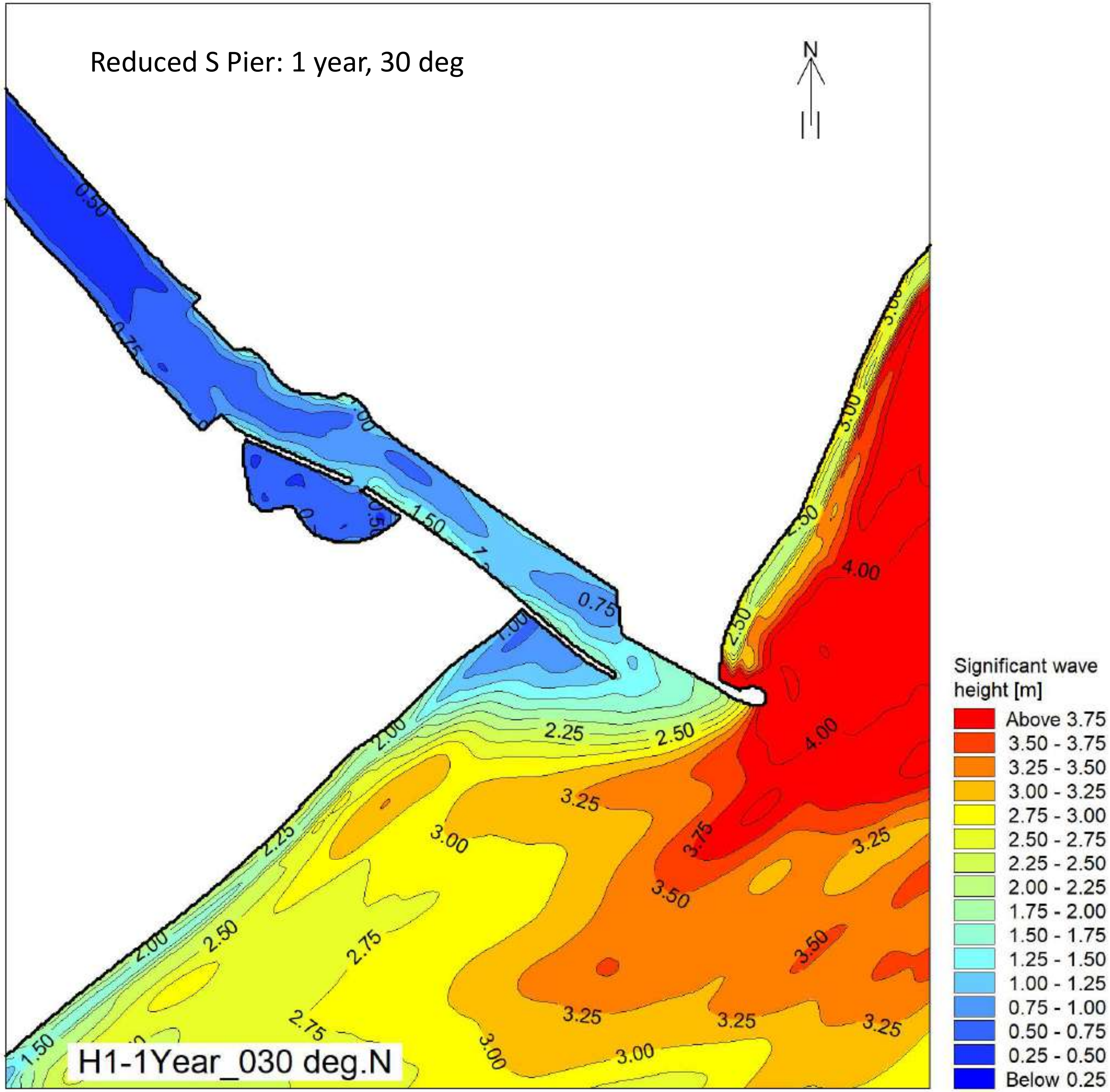

Breakwater: 1 year, 180 deg
N
H2-1Year_180 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25



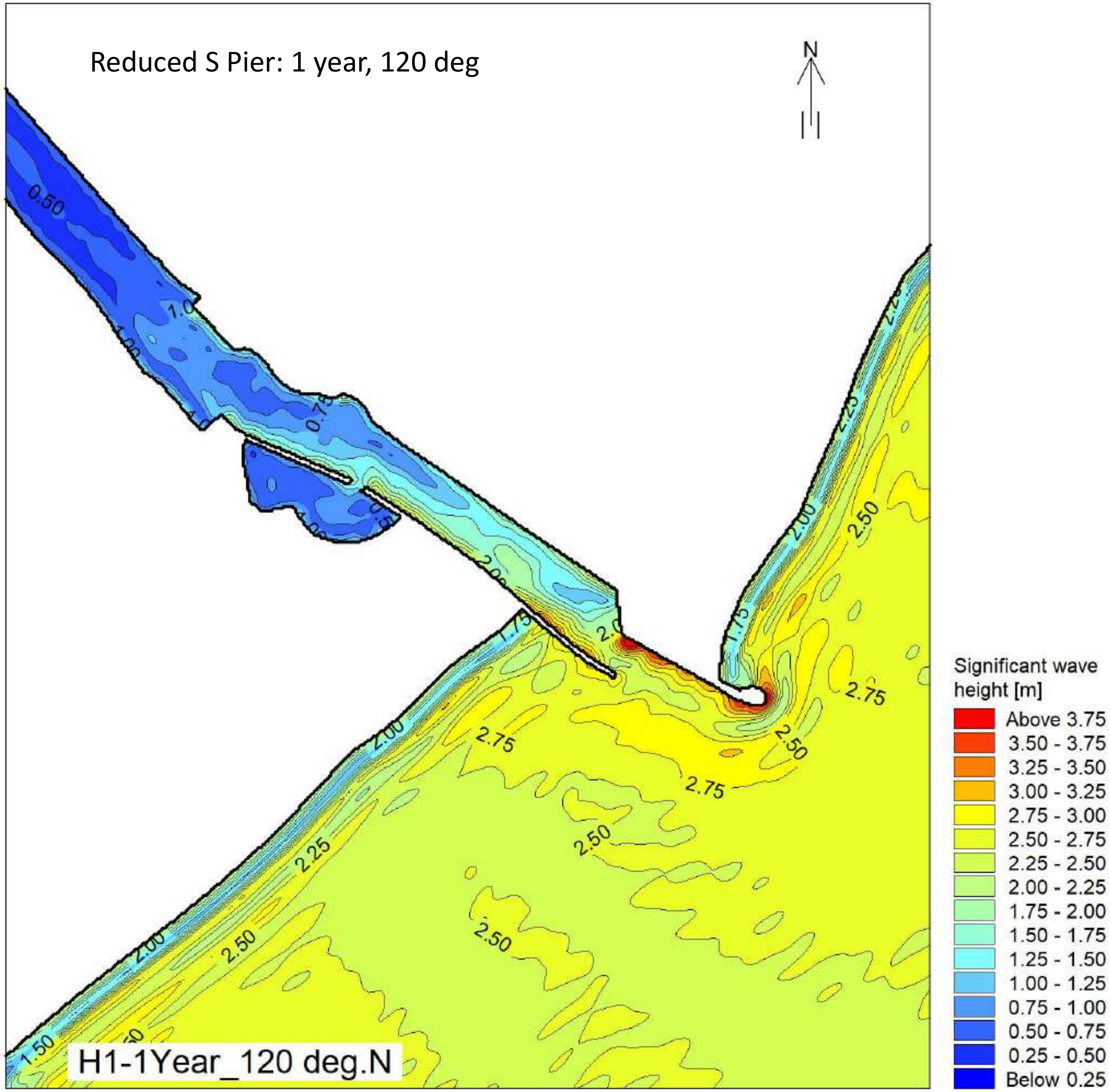
Breakwater + Baffles: 1 year, 180 deg
N
H3-1Year_180 deg.N
0.50
0.25
2.25
2.75
3.75
3.00
4.00
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

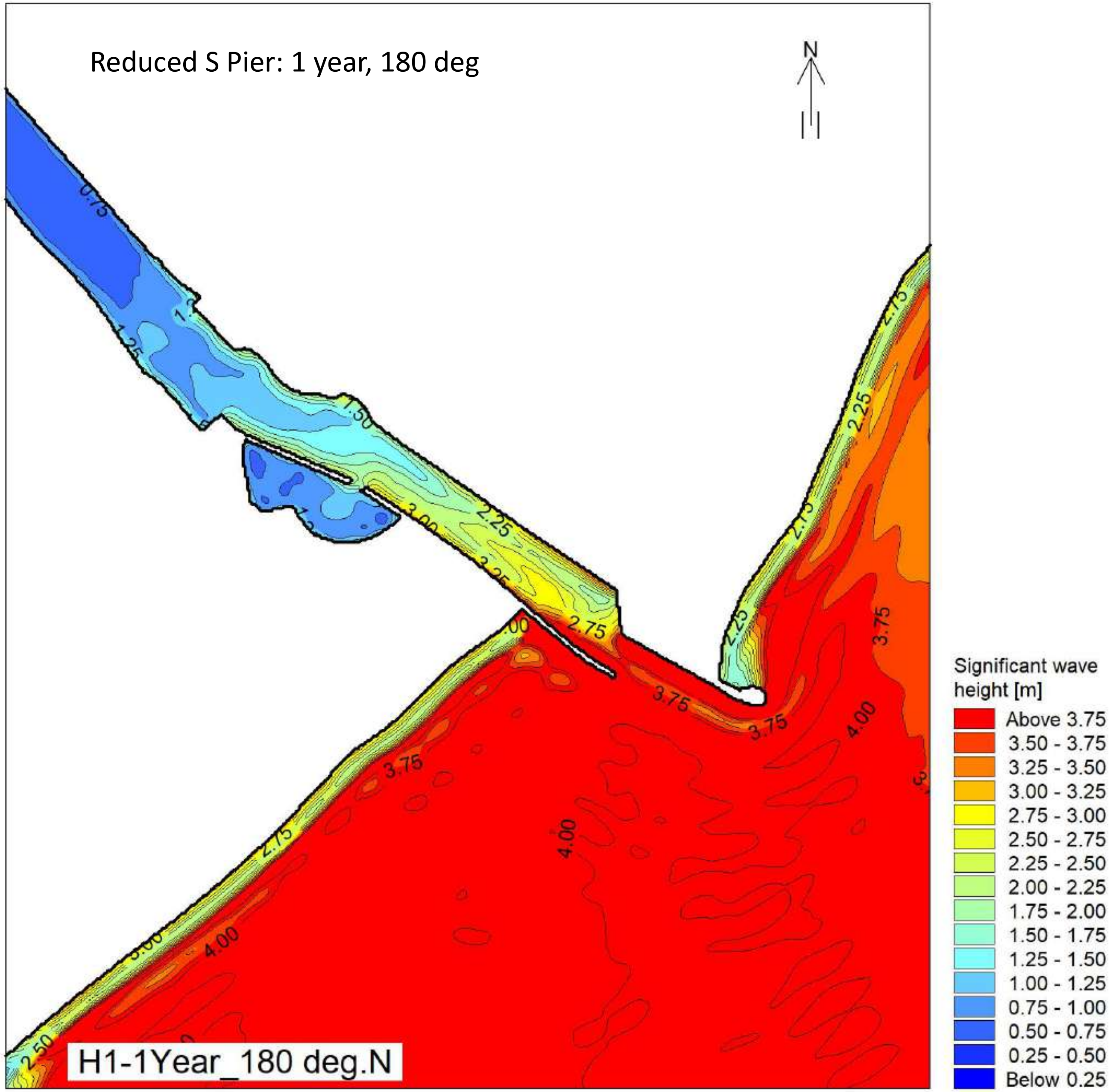


Breakwater + Revetment: 1 year, 180 deg
N
0.25
0.50
0.25
0.50
0.50
2.75
2.25
3.75
2.75
4.00
3.75
3.75
4.00
3.75
4.00
2.75
4.00
3.75
3.75
4.00
2.25
H4-1Year_180 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25


Reduced S Pier: 1 year, 30 deg
N
0.50
0.75
1.50
0.75
1.00
2.00
2.25
2.50
3.00
2.50
2.50
4.00
4.00
3.25
3.00
3.75
3.25
2.25
3.50
2.00
2.50
2.75
3.50
1.50
2.75
3.25
3.25
3.25
3.00
3.00
H1-1Year_030 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

Reduced S Pier: 1 year, 120 deg




Reduced S Pier: 1 year, 180 deg
N
0.75
1.25
1.50
2.25
2.75
3.75
4.00
2.50
H1-1Year_180 deg.N
Significant wave height [m]
Above 3.75
3.50 - 3.75
3.25 - 3.50
3.00 - 3.25
2.75 - 3.00
2.50 - 2.75
2.25 - 2.50
2.00 - 2.25
1.75 - 2.00
1.50 - 1.75
1.25 - 1.50
1.00 - 1.25
0.75 - 1.00
0.50 - 0.75
0.25 - 0.50
Below 0.25

Wave modelling results

- Rock breakwater makes a significant difference
- Wave heights typically ~0.5m at the N Wall (1:1 return period, worse-case than typical tide)
- Baffles or revetment would improve the conditions, but not significantly
- Other works to Dunwich Creek area would have limited additional benefit
- Shorter breakwater has less of an effect than expected. Baseline model may be over-estimating wave heights (no comments at last workshop)?
- Significant impact of rock breakwater on wave heights; could optimise breakwater length if this would have other benefits (e.g. flow rates).

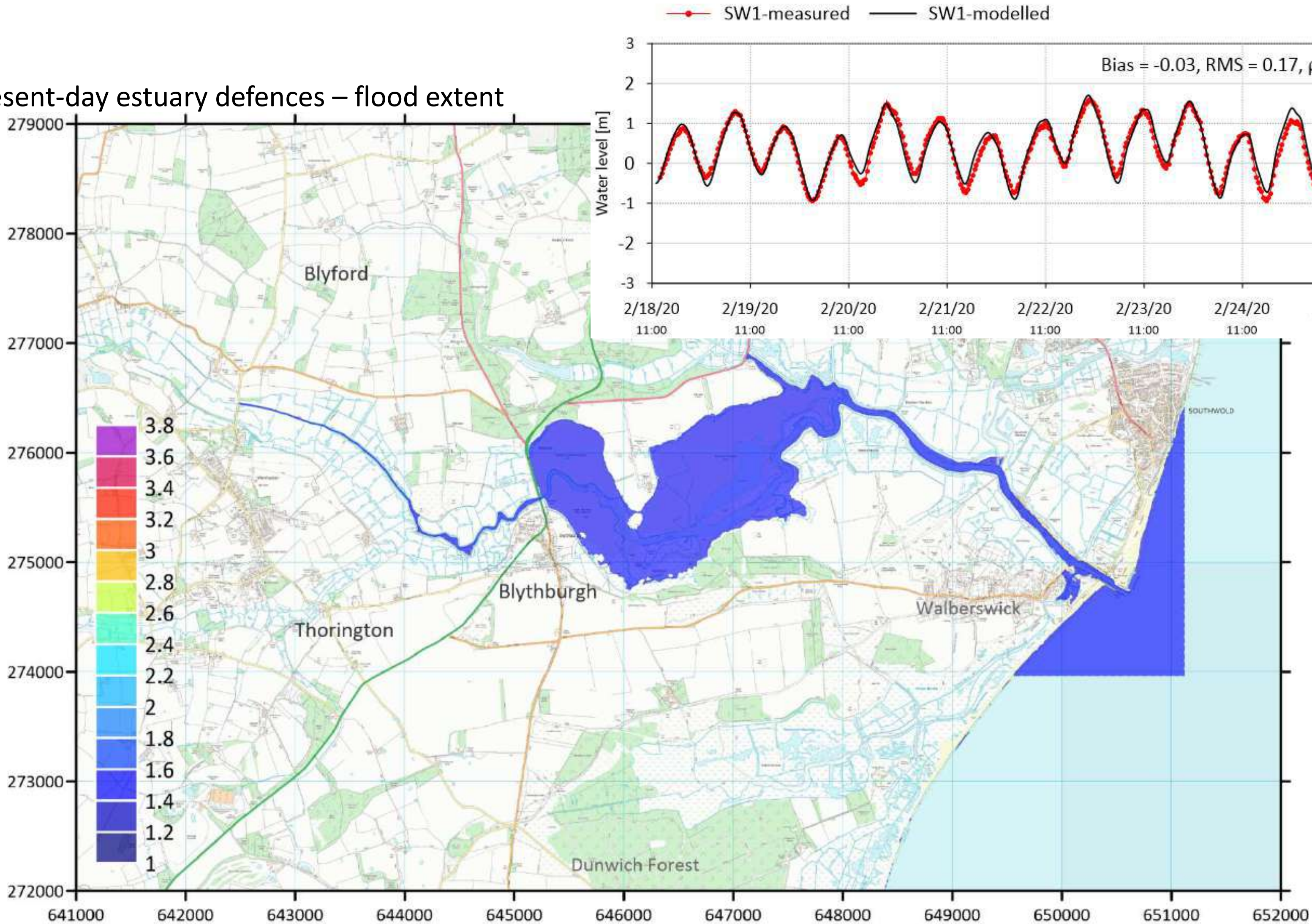
Tidal modelling scenarios

- Present Day
- Do Nothing
- Raise embankments
- Raise N banks, S banks can be overtopped
- Present day + failure of outer part of S Pier

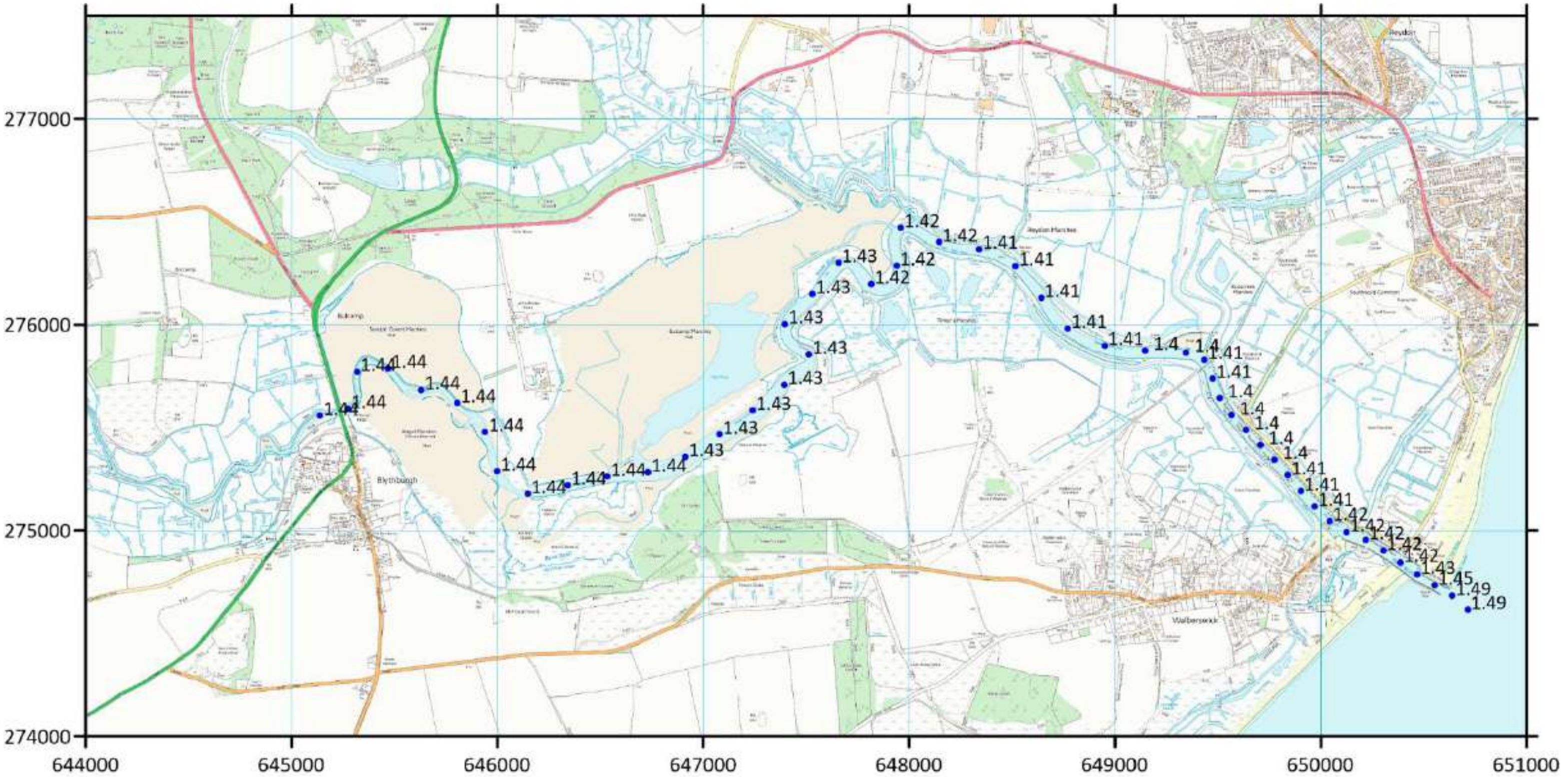
Tidal modelling results

- Results for each option
- Comparison against objectives:
  - Minimise flood risk to the wider area
  - Minimise flood risk to Blackshore
  - Flow in entrance channel <3.5 knots
  - Minimise scour risk
- Comments / discussion

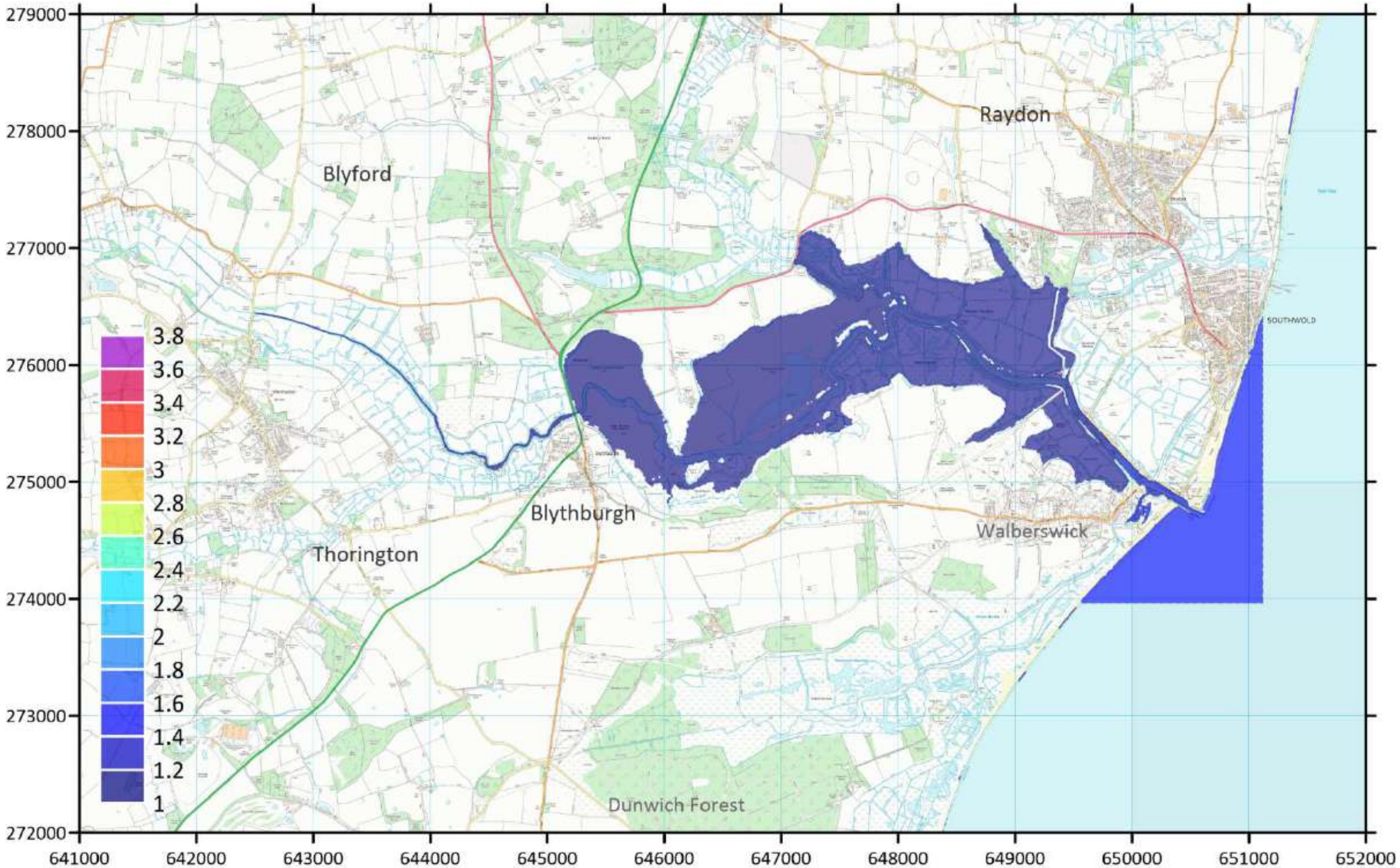
2020: Present-day estuary defences – flood extent



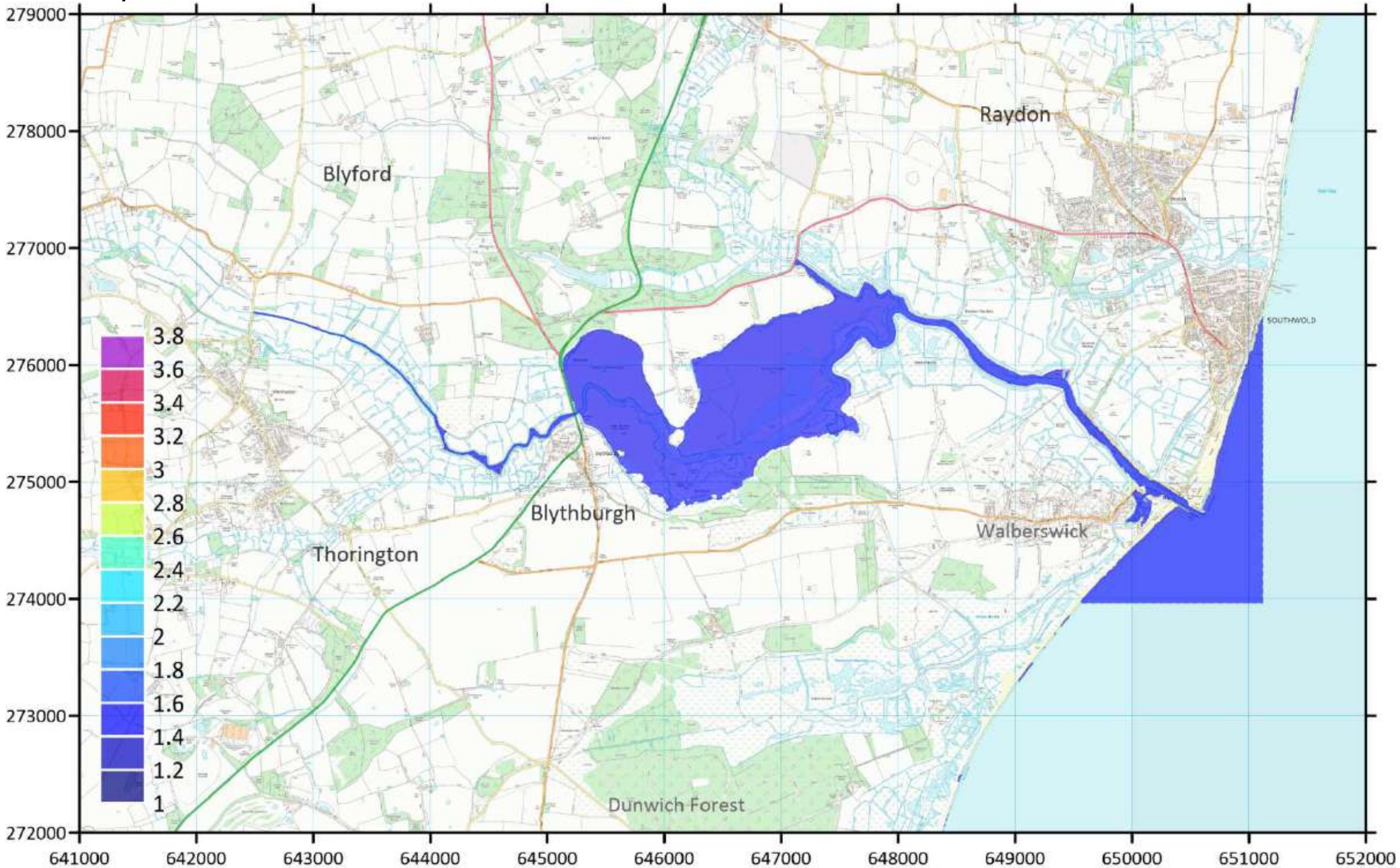
2020: Present-day estuary defences – water levels



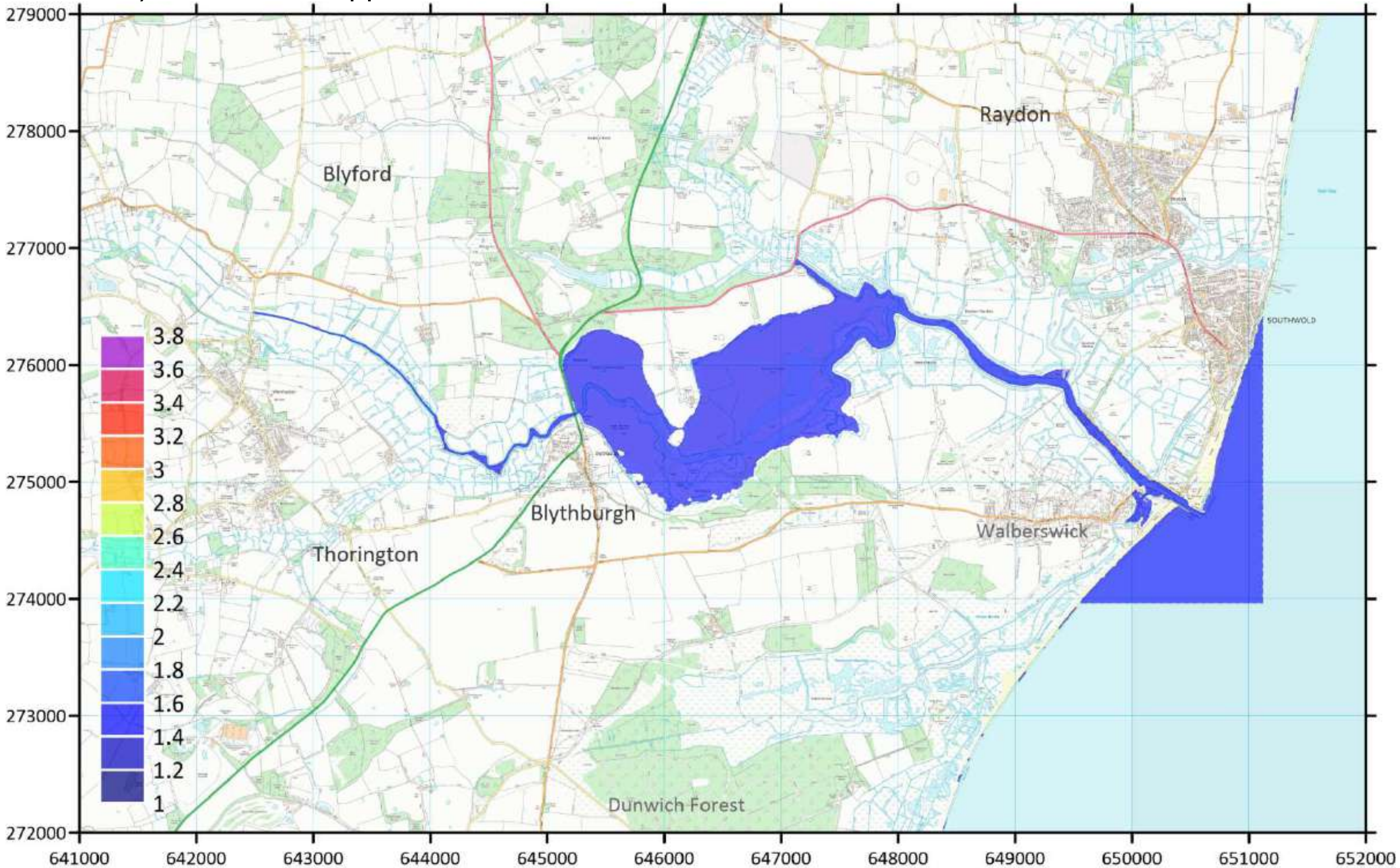
2020: Do Nothing - All embankments failed (undefended) – flood extent



2020: Raise estuary defences – flood extent

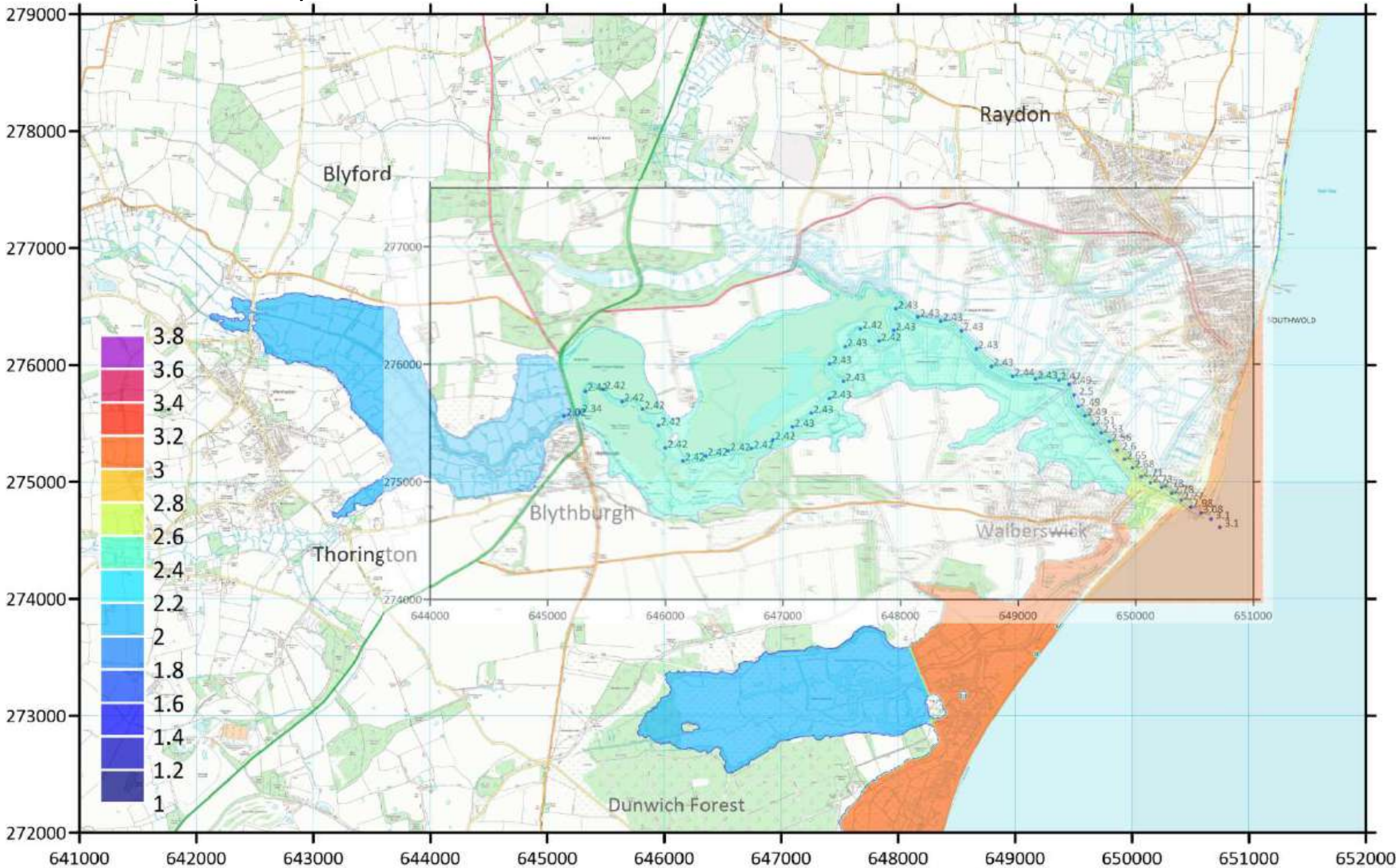


2020: Raise N banks, S banks overtopped – flood extent

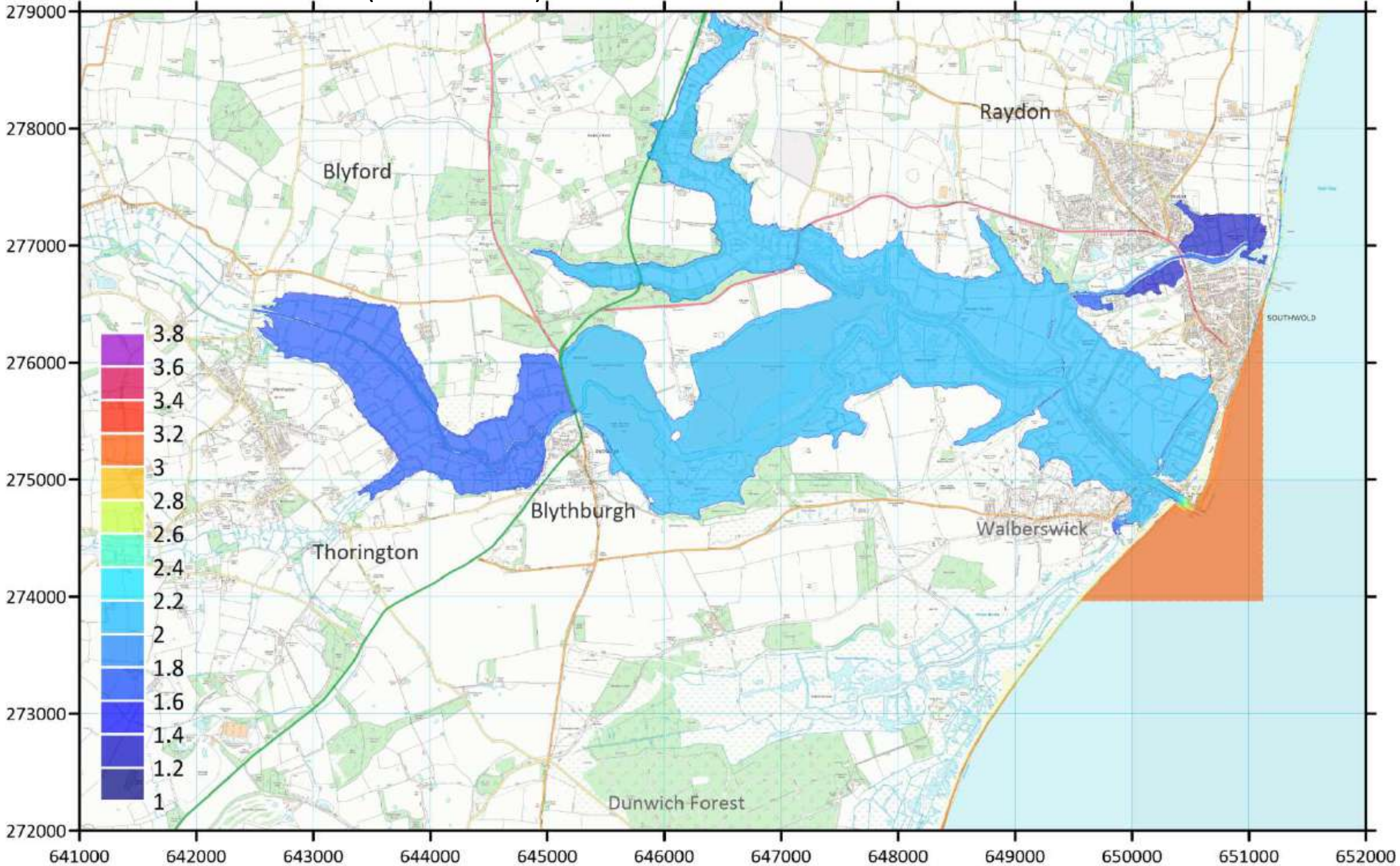


2020: Present day estuary defences, reduced S Pier – flood extent

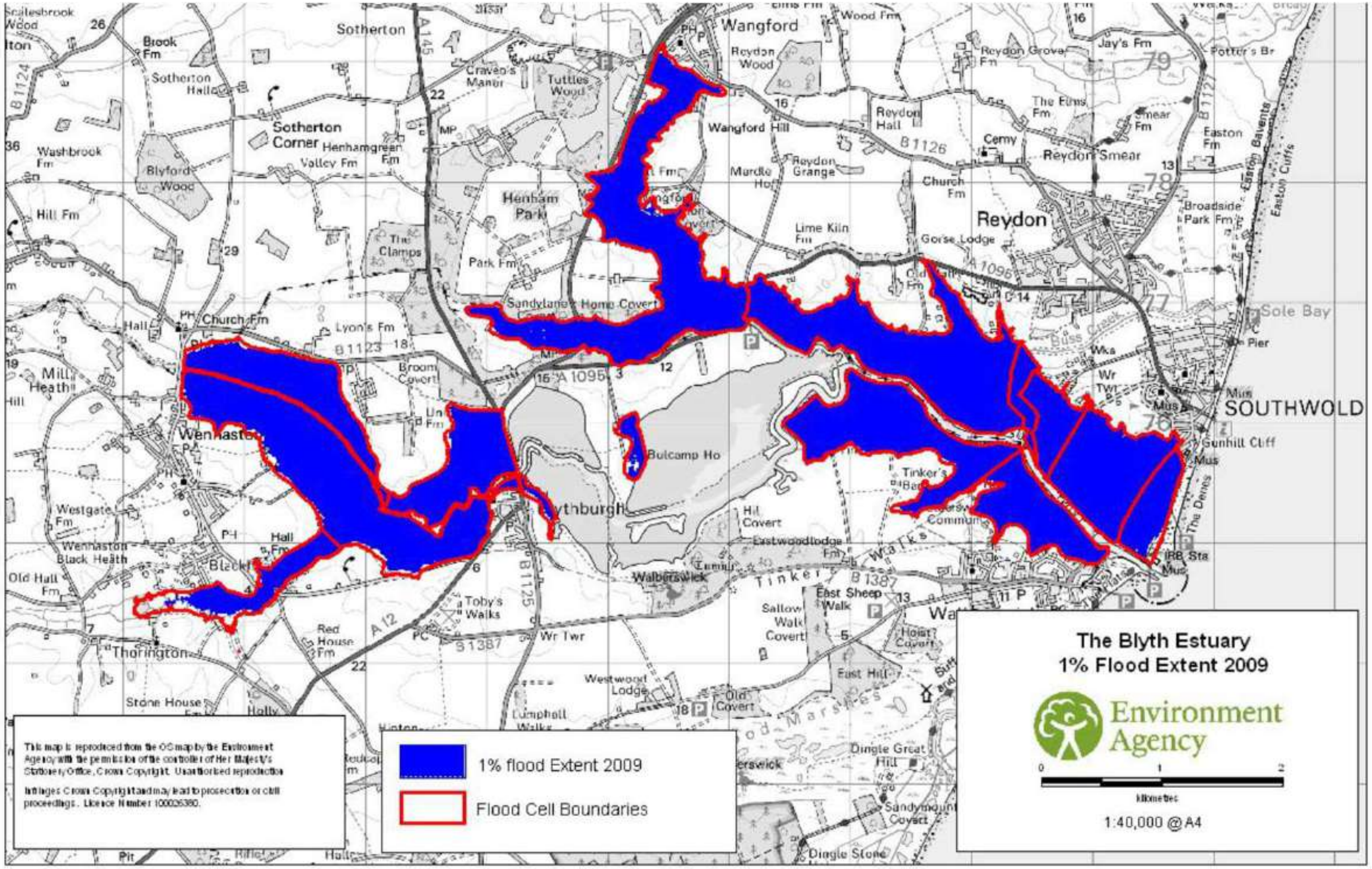
2013 event - Present-day estuary defences – flood extent + water levels



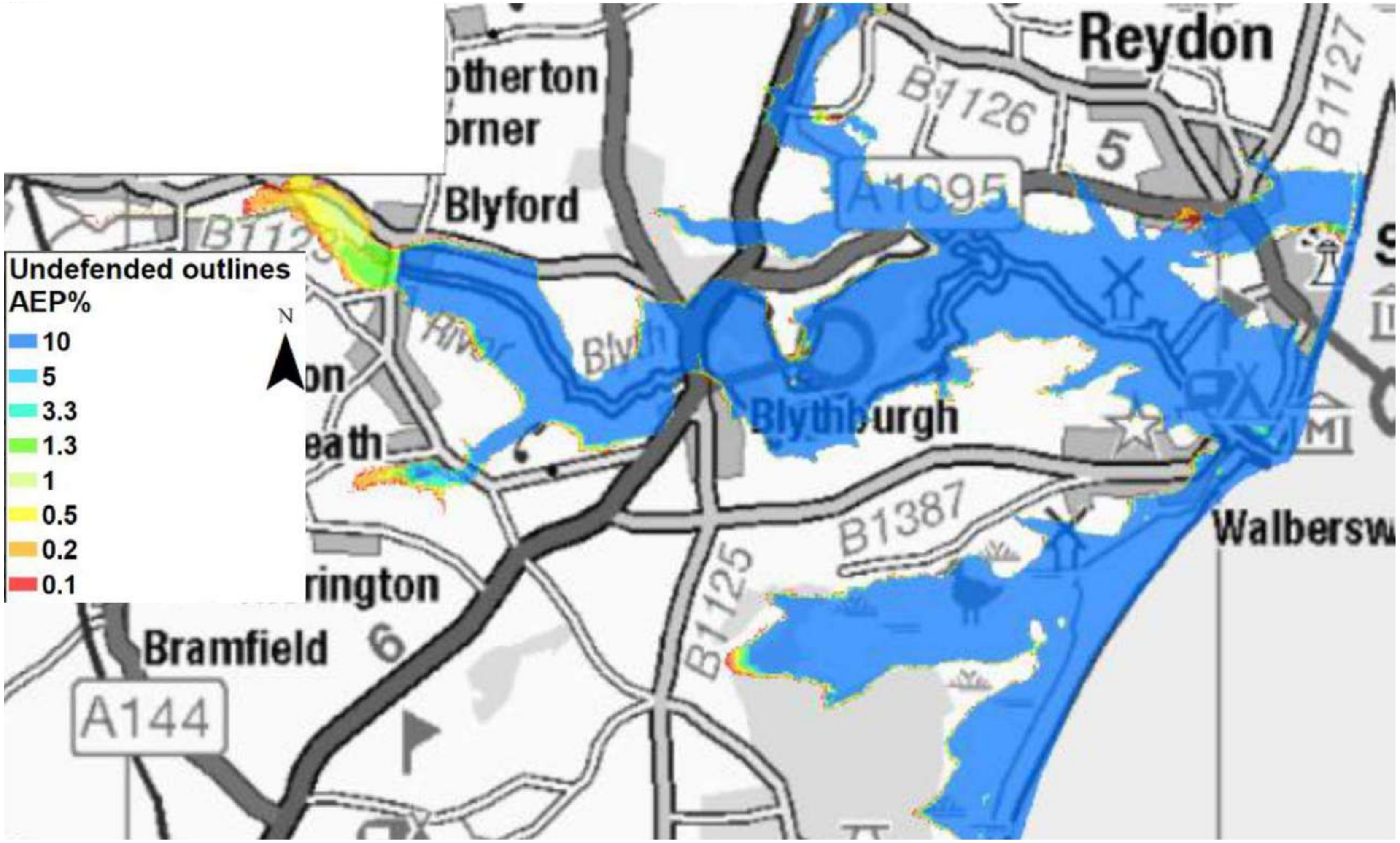
2013 event - All embankments failed (undefended) – flood extent



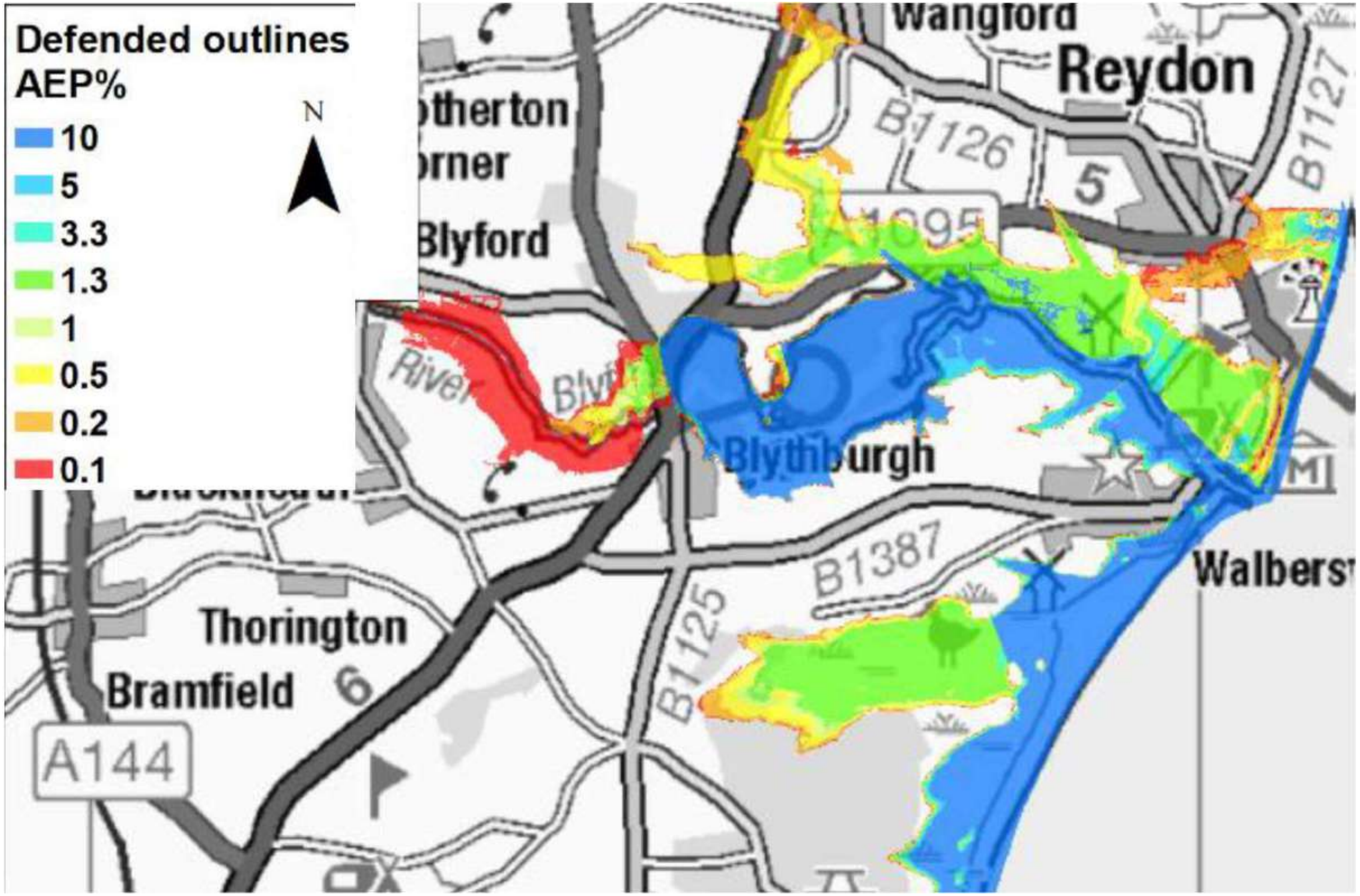
2013 event – Comparison with EA Strategy 1% (1:100) Flood Extent 2009



Comparison with East Anglian Coastal Modelling (JBA) 2019: Undefended scenario, present day

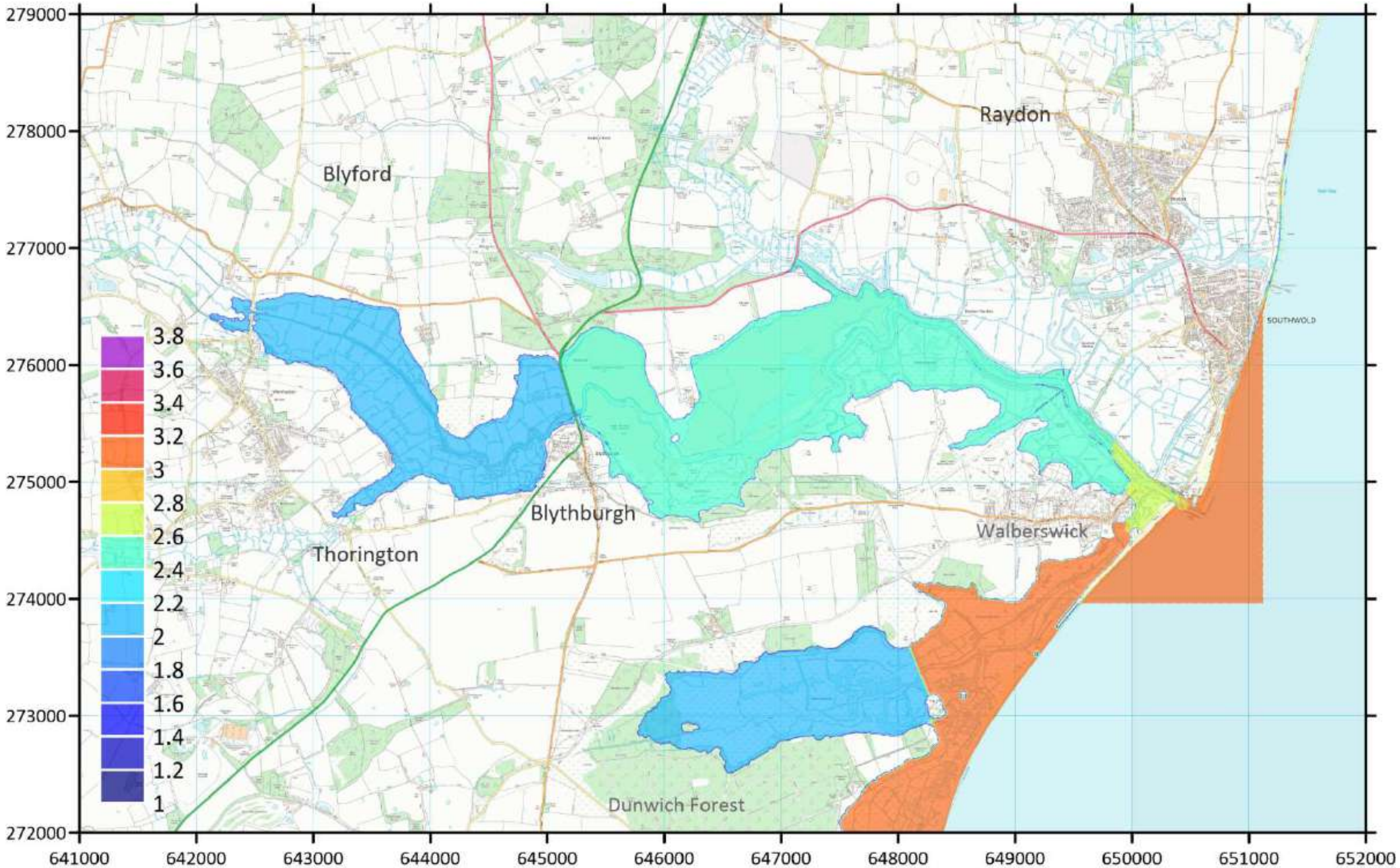


Comparison with East Anglian Coastal Modelling (JBA) 2019: Defended scenario, present day

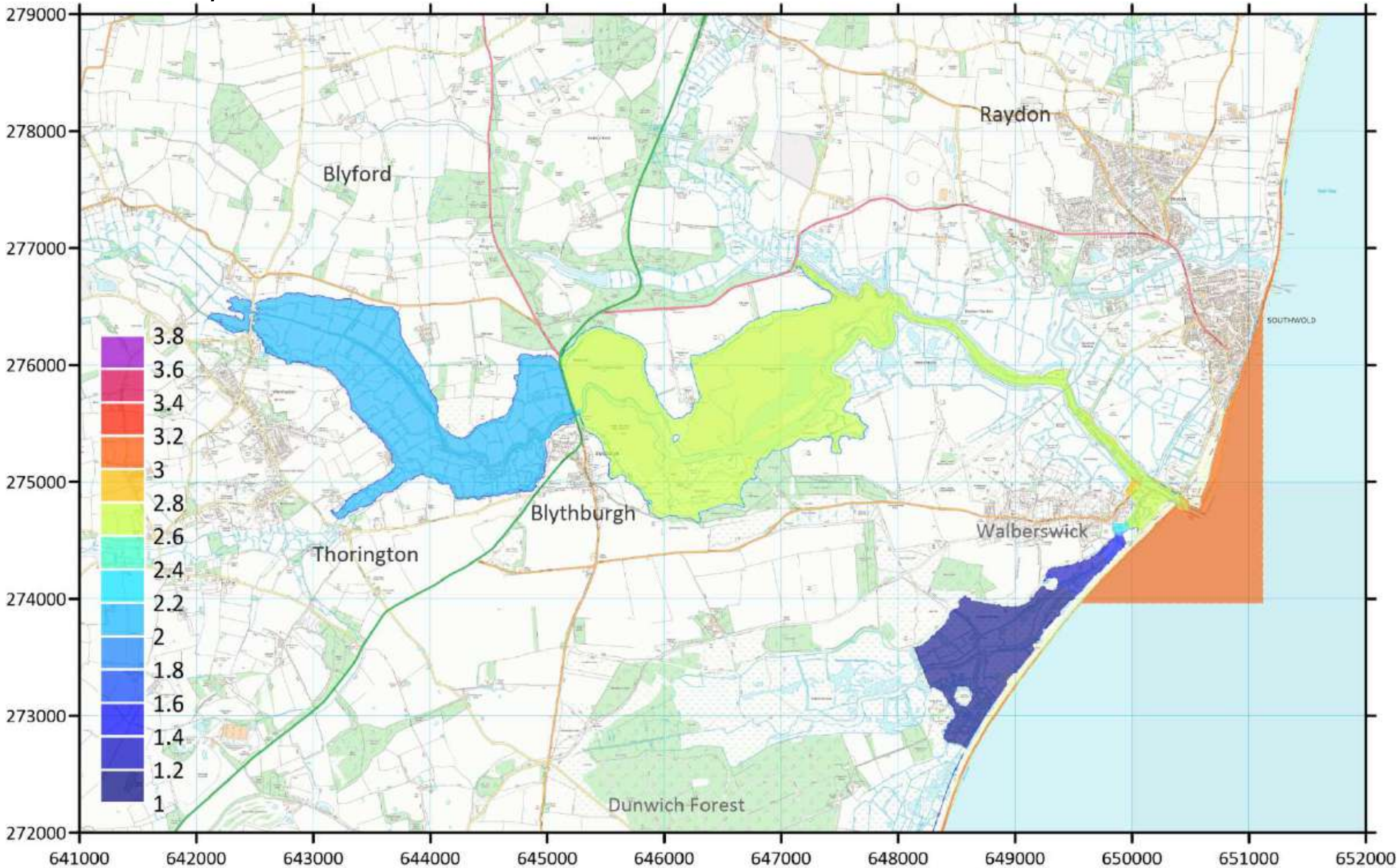


2013 event - Present-day estuary defences – flood extent.

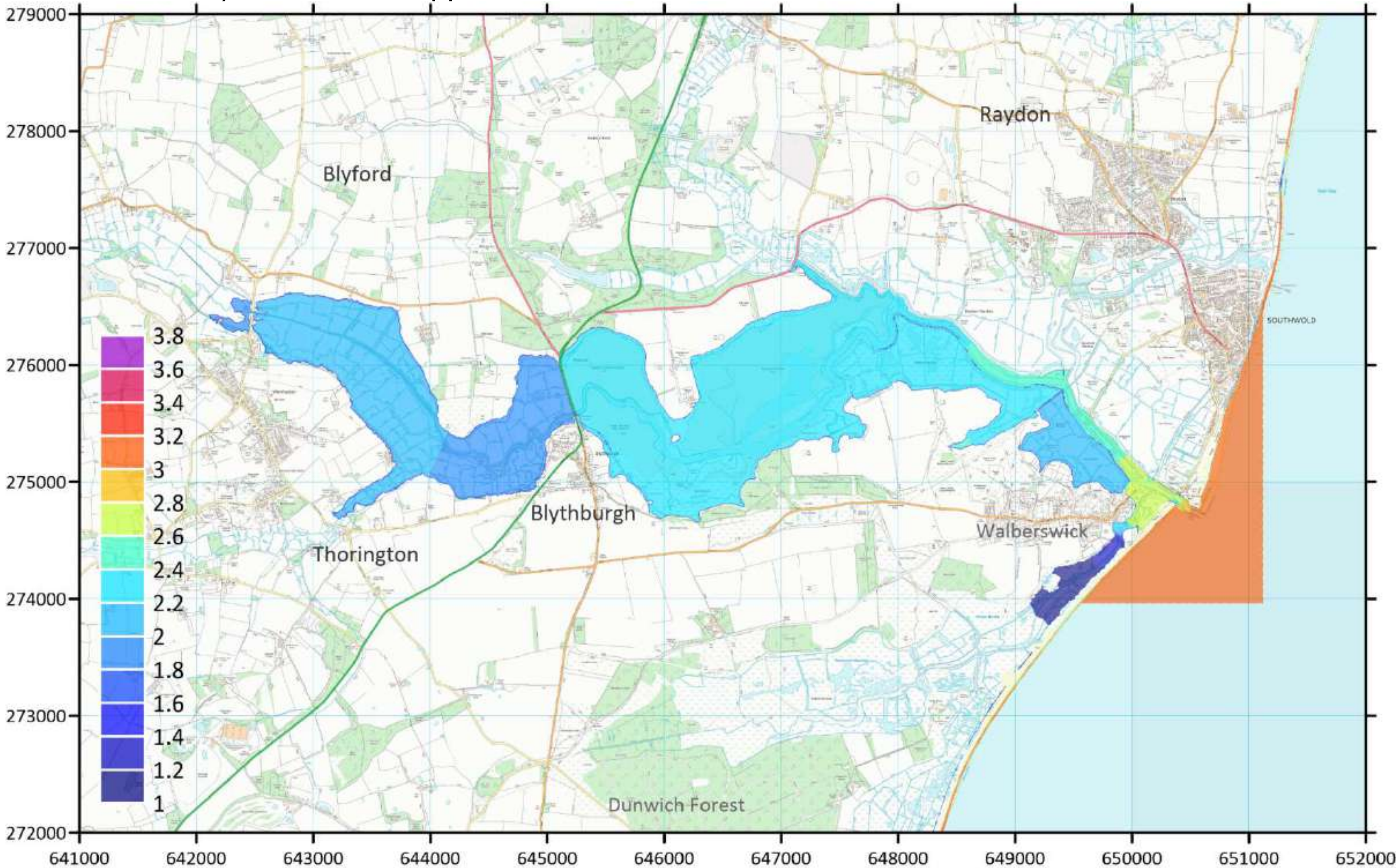
Assumptions re. level of N banks will be checked and compared with JBA model.



2013 event: Raise estuary defences – flood extent

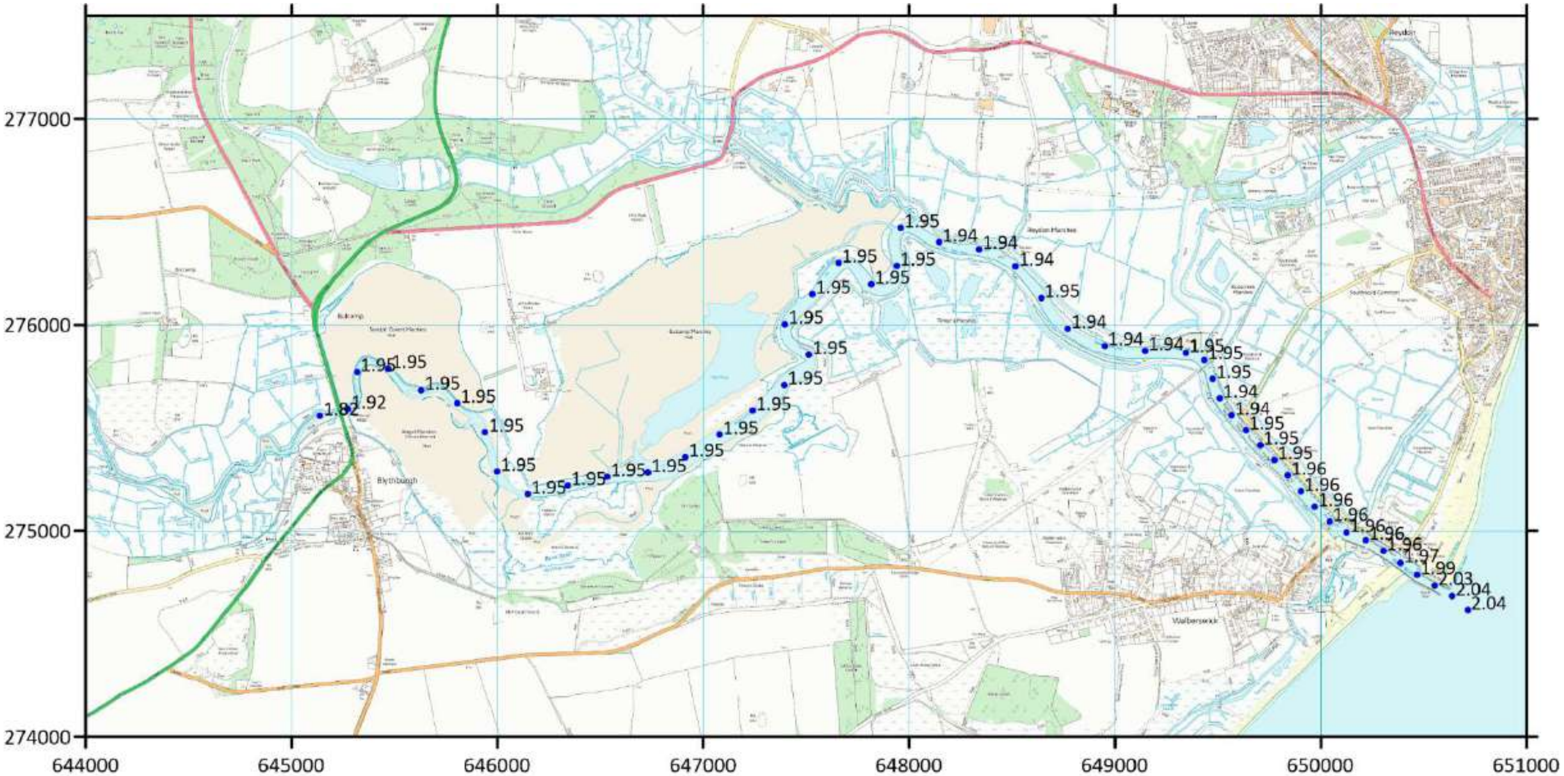


2013 event: Raise N banks, S banks overtopped – flood extent

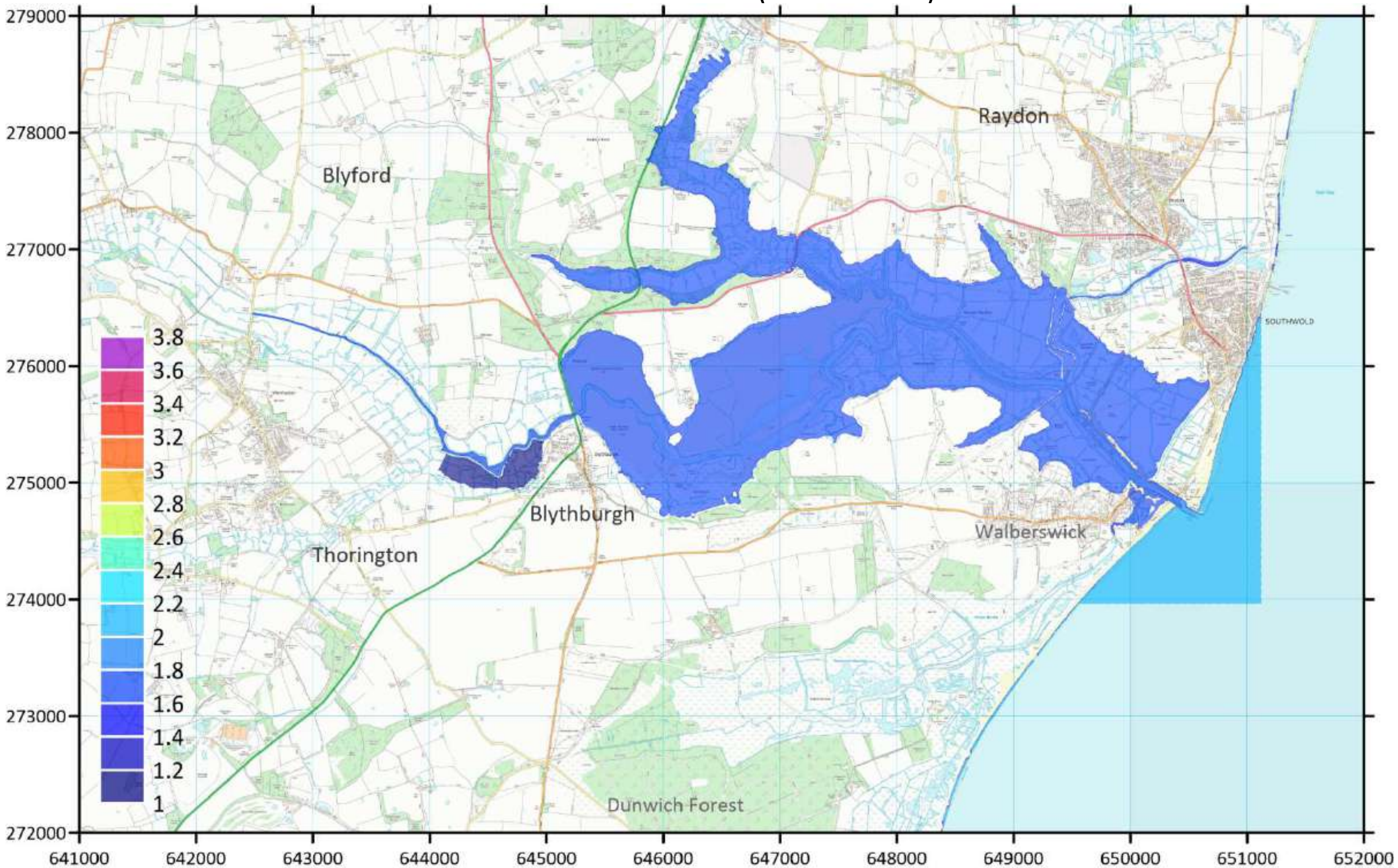


2070 with 0.6m SLR from 2002 conditions – Present day defences – flood extent

2070 with 0.6m SLR from 2002 conditions : Present-day estuary defences – water levels



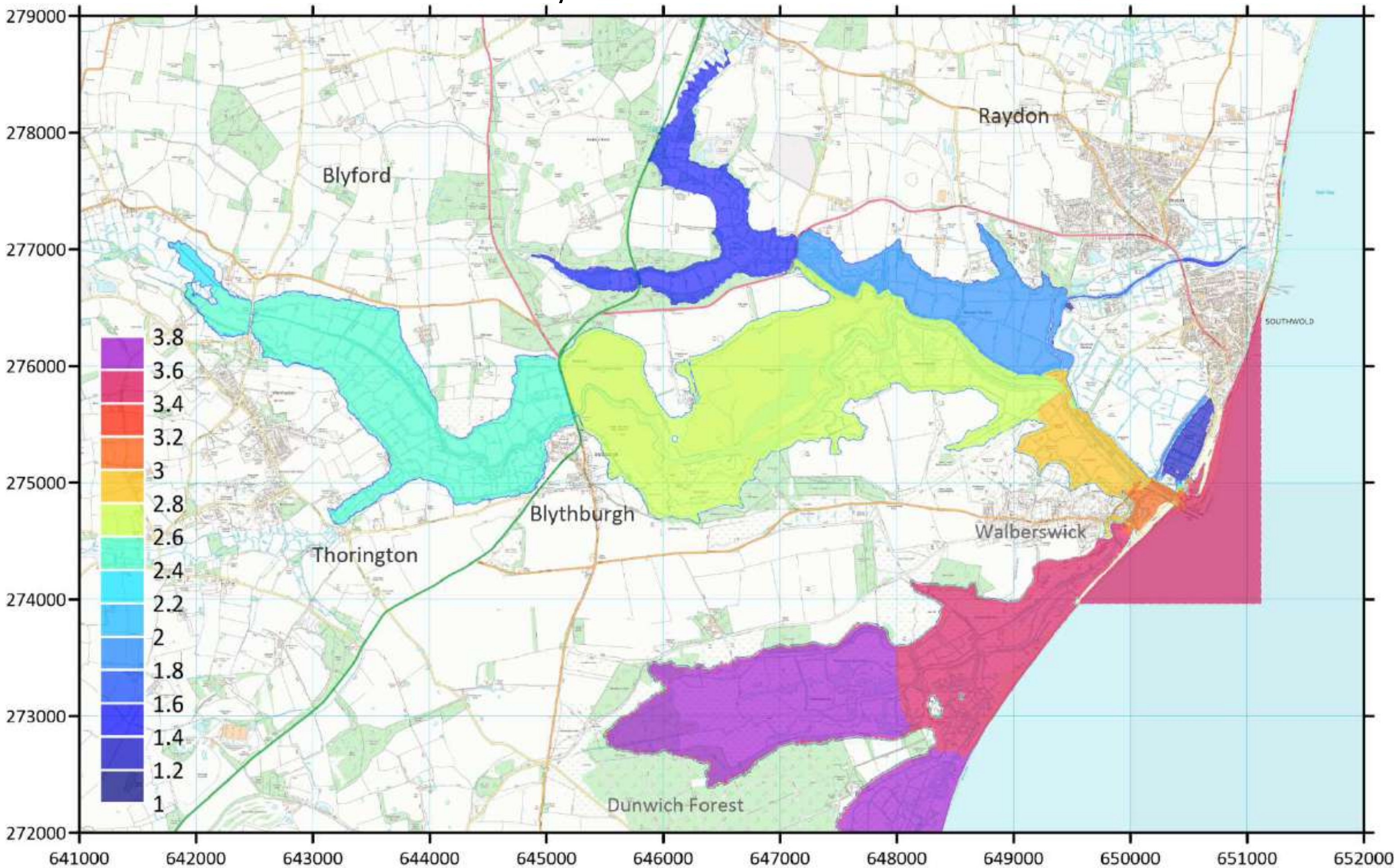
2070 with 0.6m SLR from 2002 conditions: All embankments failed (undefended) – flood extent



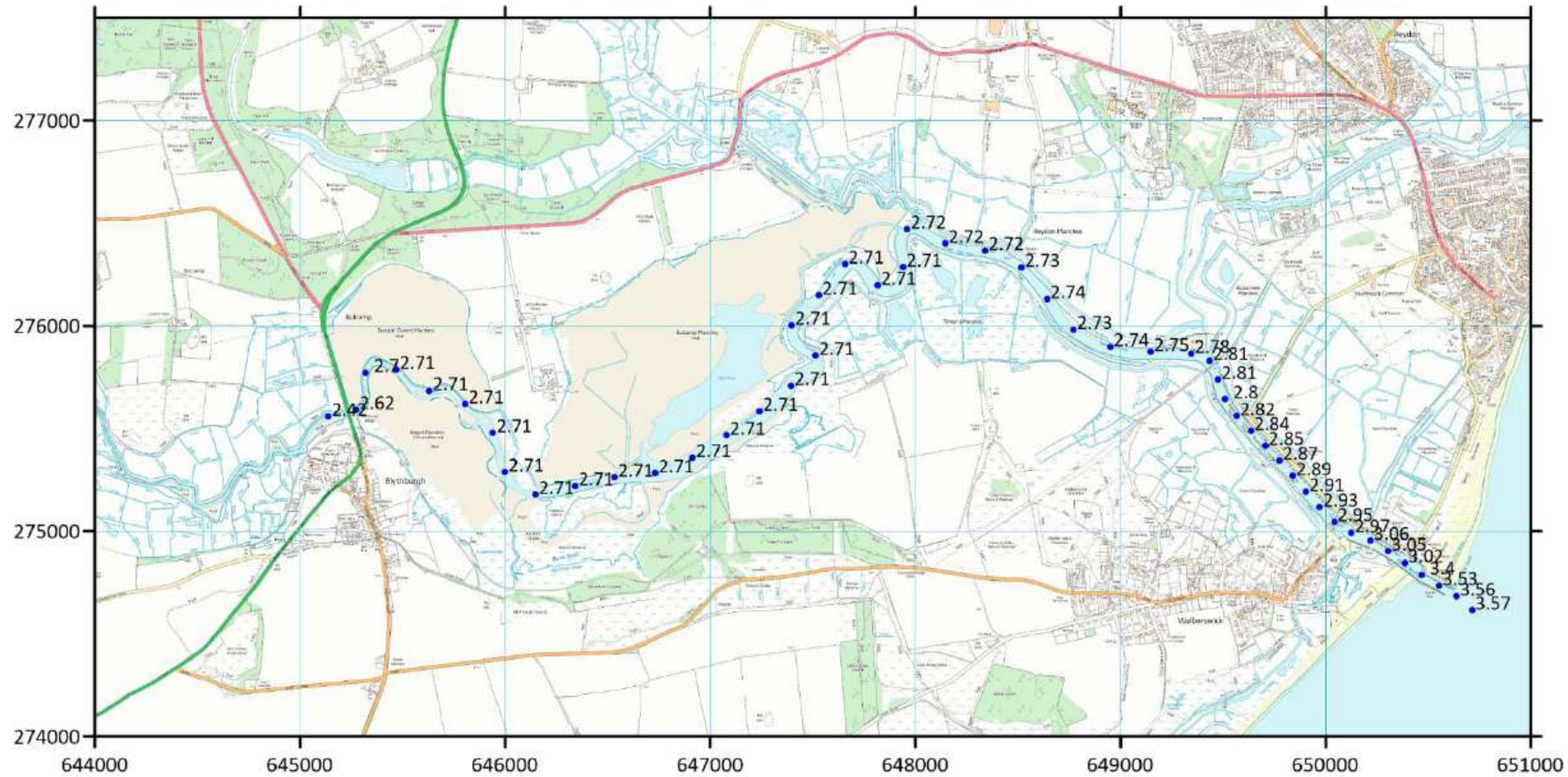
2070 with 0.6m SLR from 2002 conditions: Raise estuary defences – flood extent

2070 with 0.6m SLR from 2002 conditions: Raise N banks, S banks overtopped – flood extent

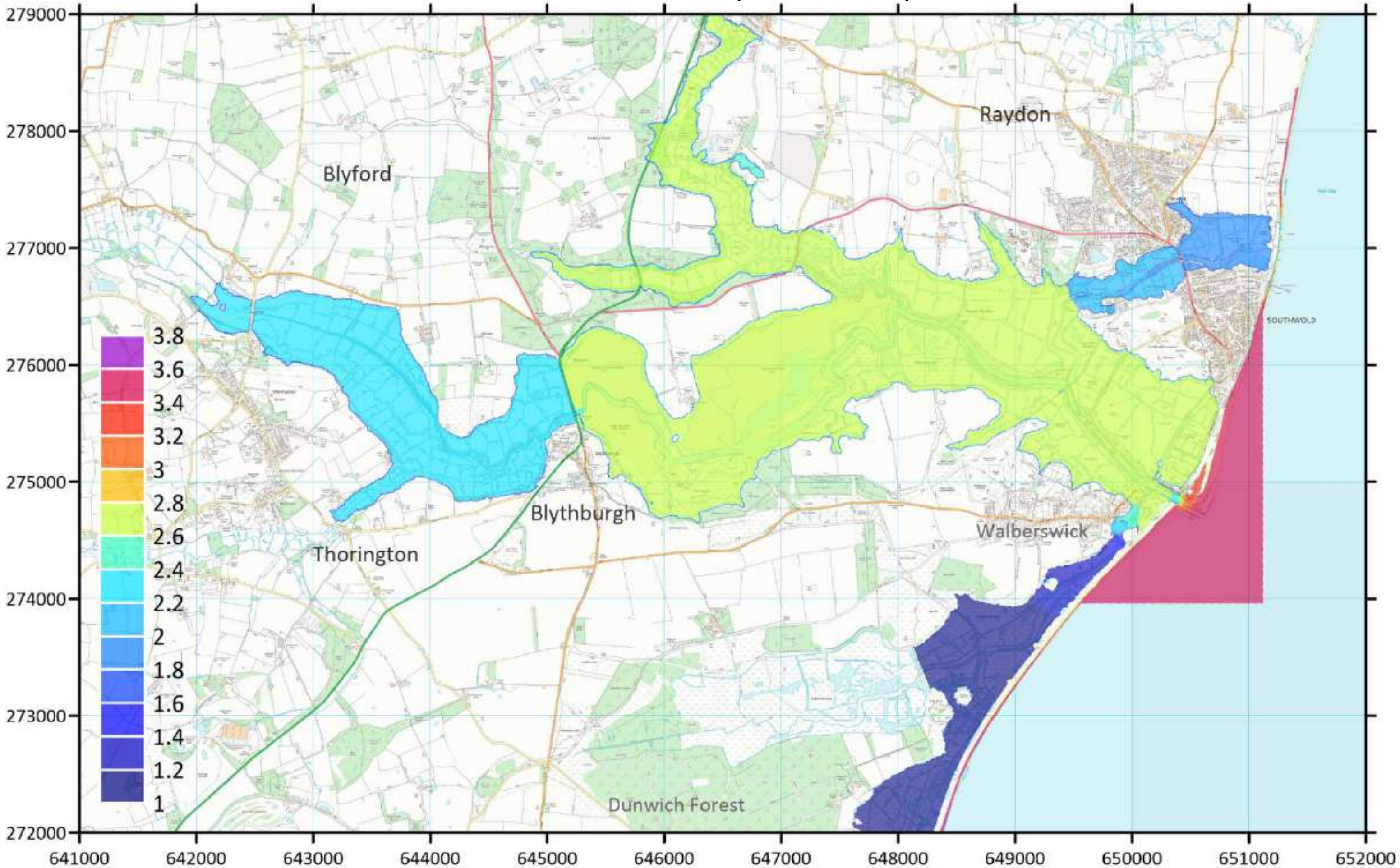
2070 with 2m SLR from 2002 conditions: Present day defences – flood extent



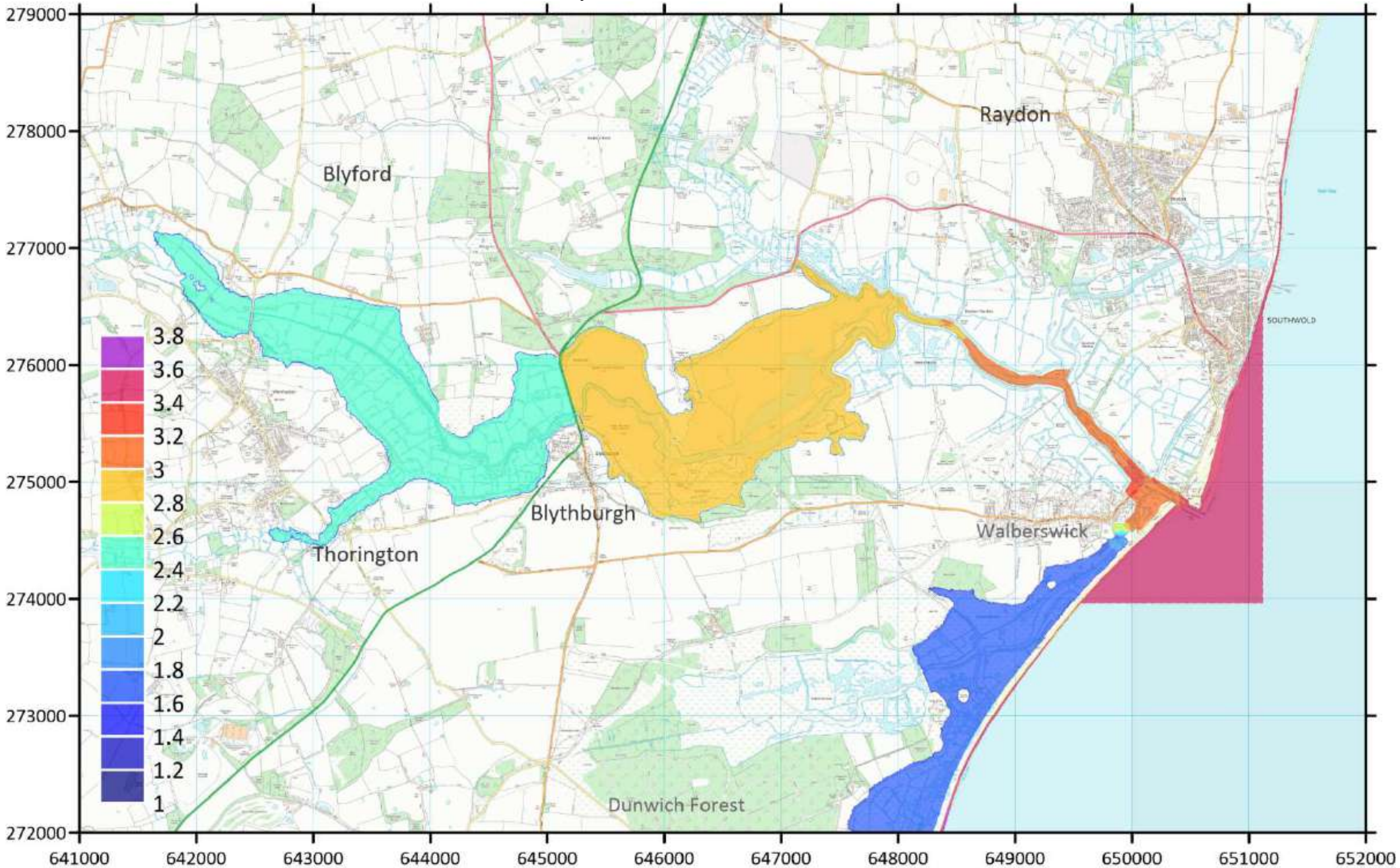
2070 with 2m SLR from 2002 conditions: Present day defences – water levels



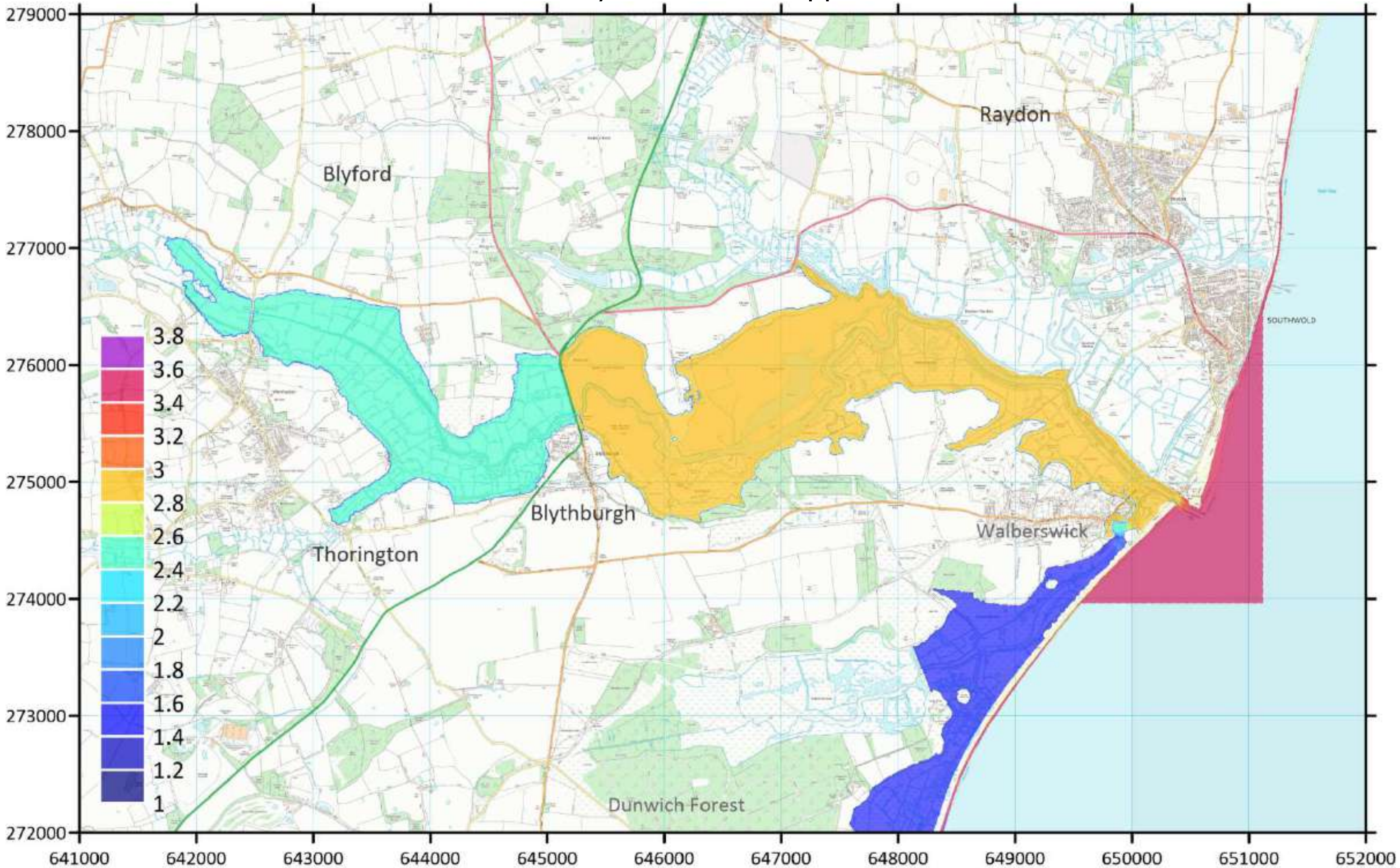
2070 with 2m SLR from 2002 conditions: All embankments failed (undefended) – flood extent



2070 with 2m SLR from 2002 conditions: Raise estuary defences - flood extent



2070 with 2m SLR from 2002 conditions: Raise N banks, S banks overtopped – flood extent



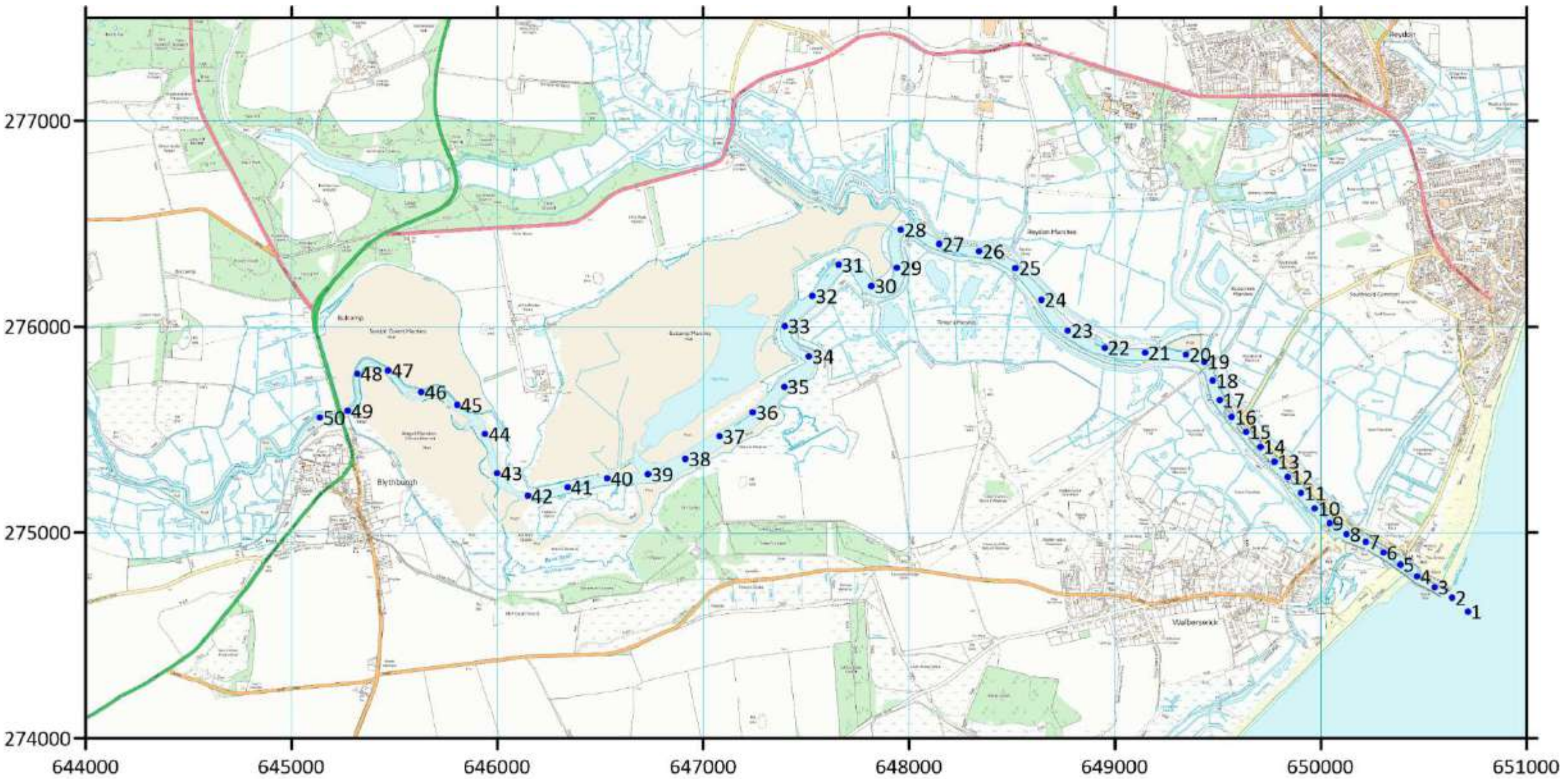
Tidal modelling – flood extents

- Present day and 2013 event – results as expected, validates model set up
- RCP2.6 (+0.6m) no flooding to downstream areas, although increased risk upstream of A12
- 1:100, RCP8.5 (+2m) – extensive flooding with present day defence levels
- Delay works to estuary defences depending on actual sea level rise

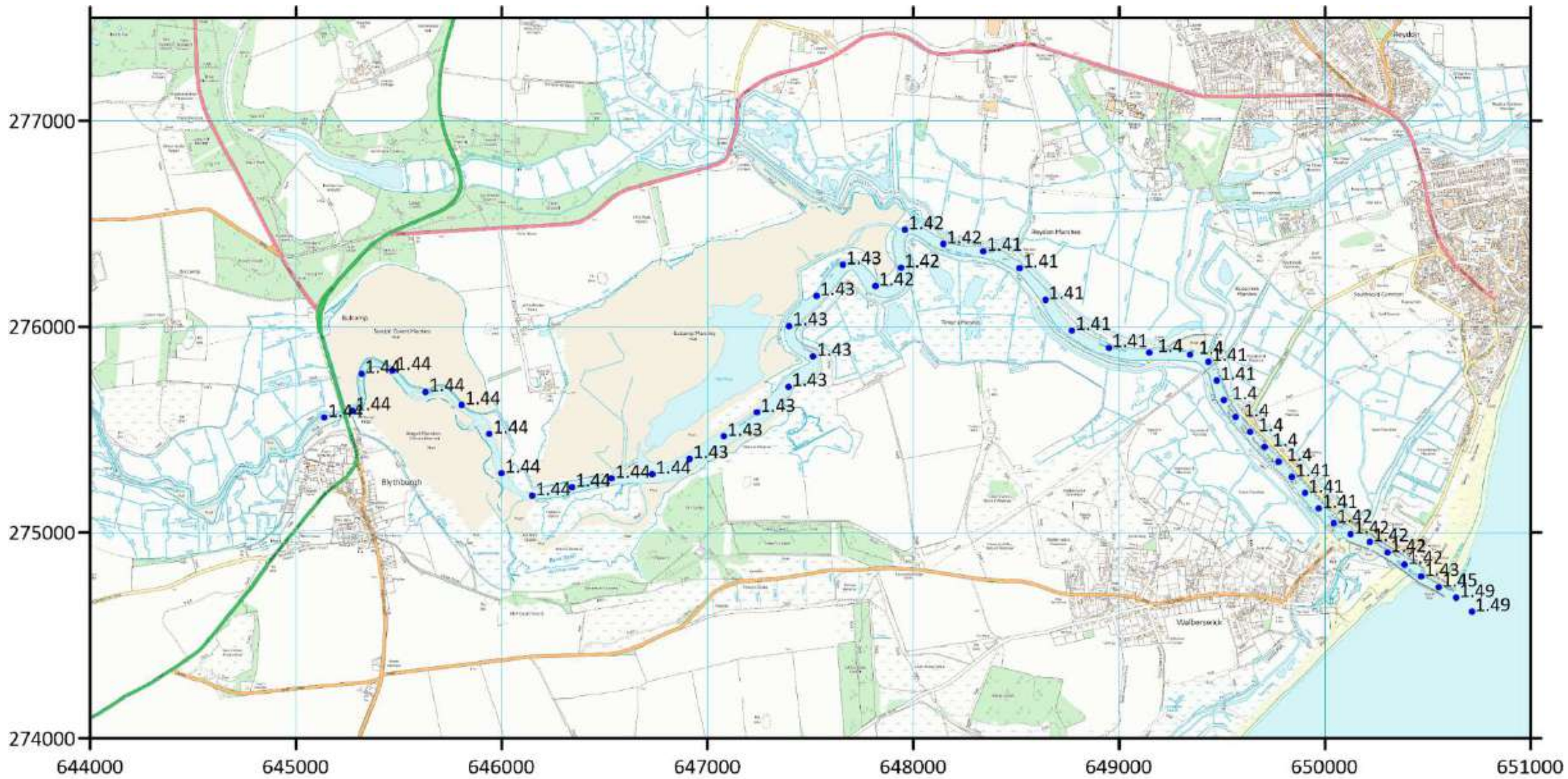
Tidal modelling – water levels

- Comparison of water levels in the channel
- Consider flood risk to the Blackshore

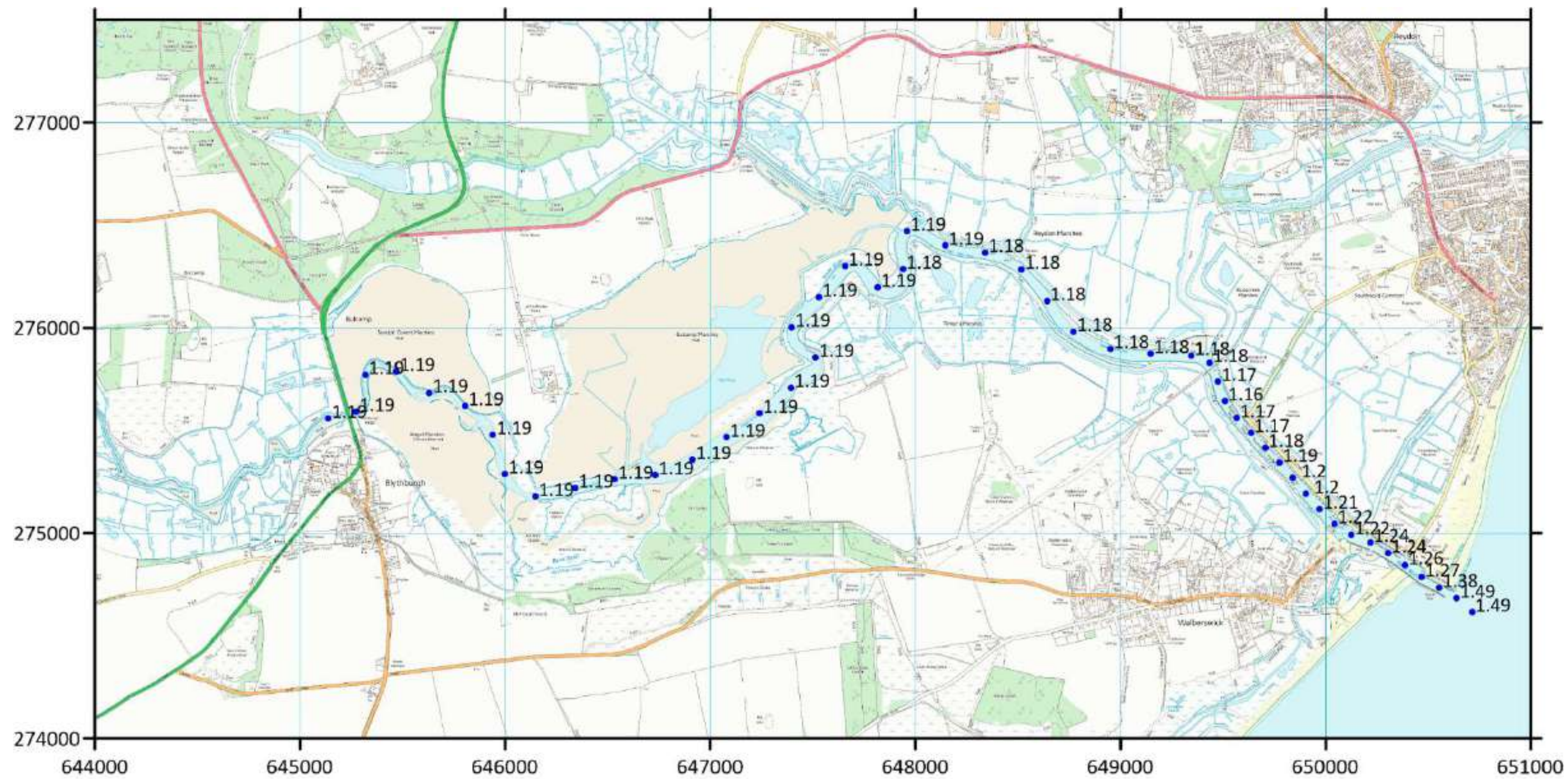
Output locations for maximum water levels and current speeds



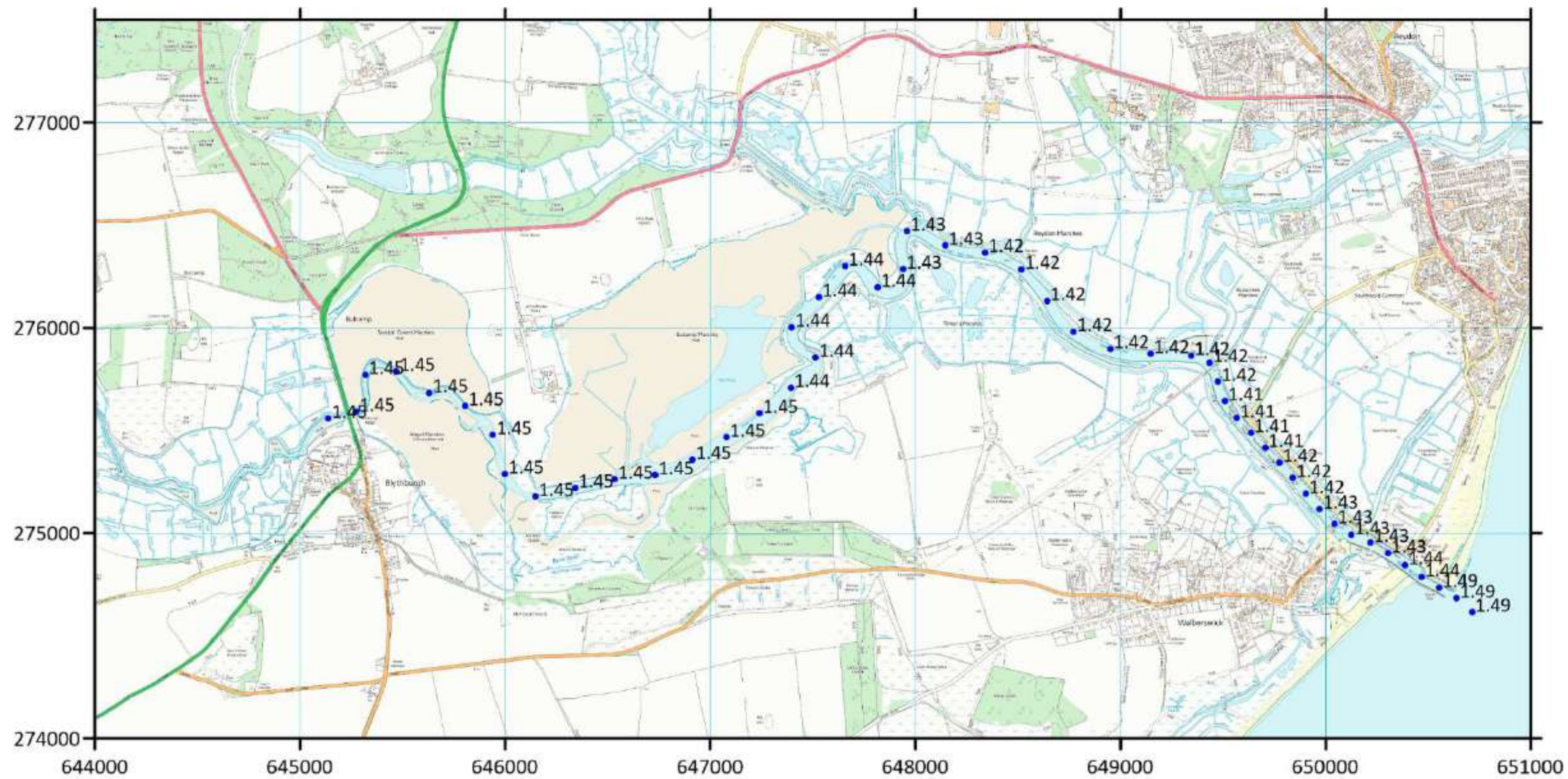
2020: Present-day estuary defences – water levels



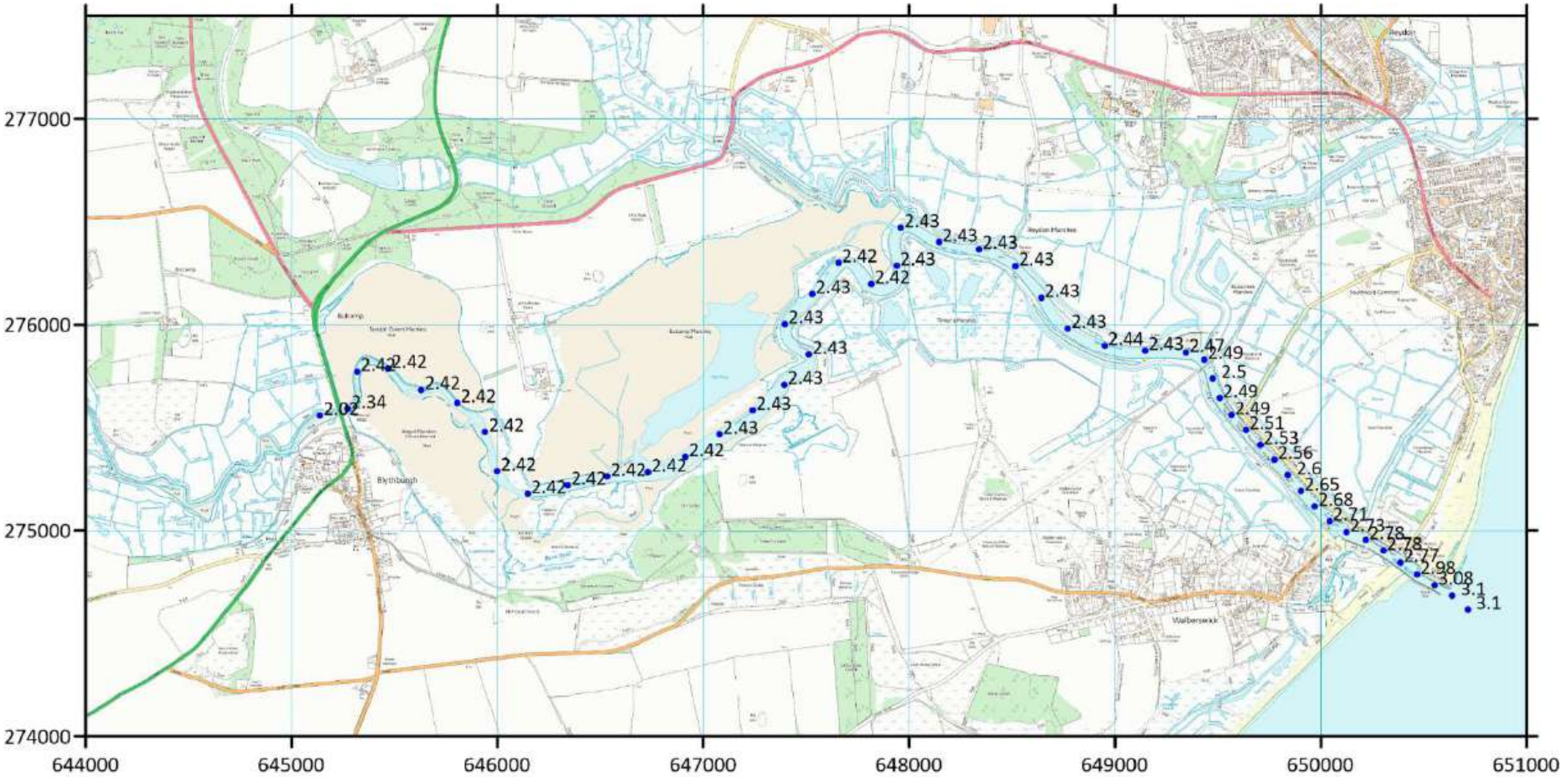
2020: All embankments failed (undefended) – water levels



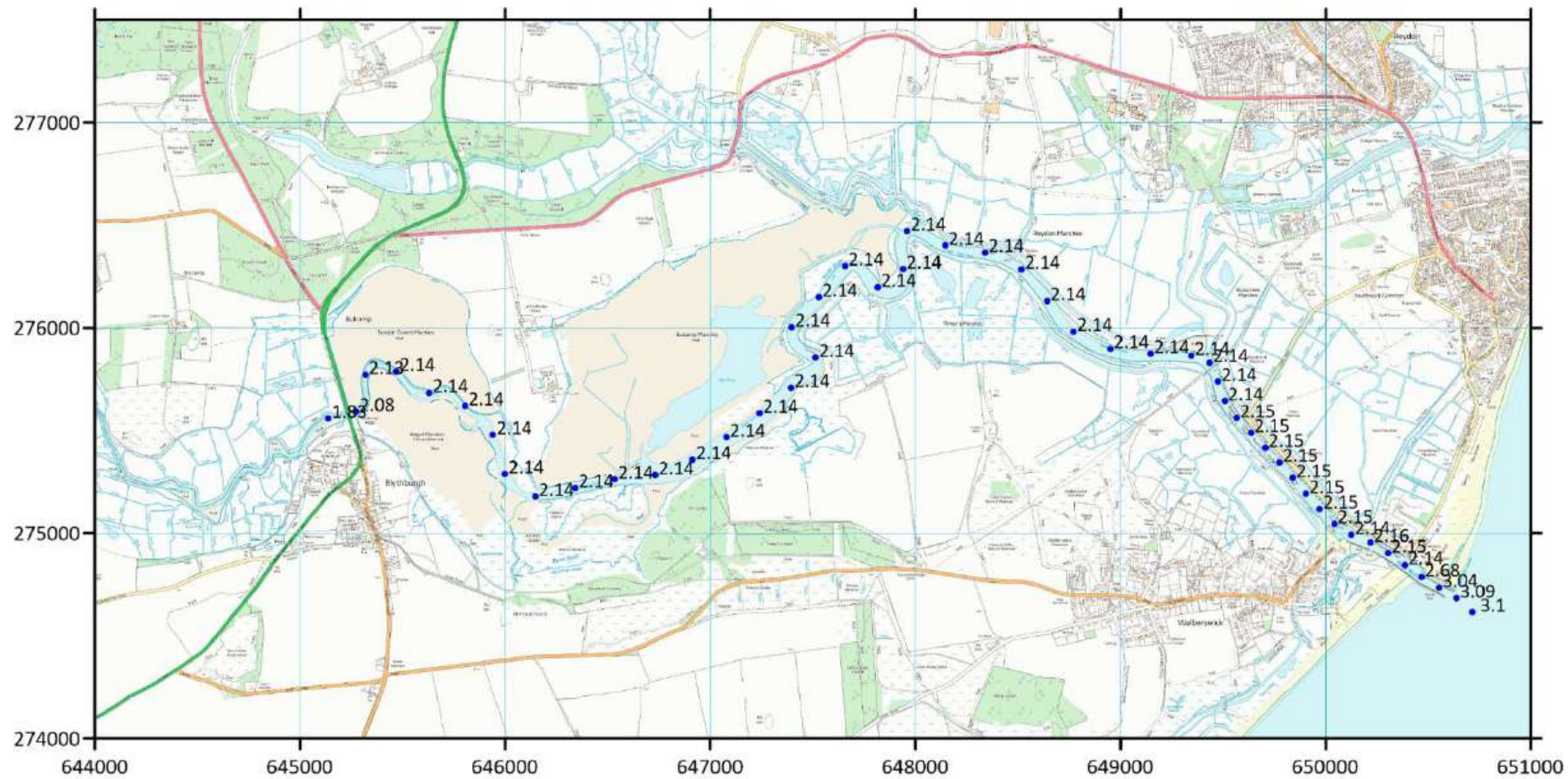
2020: Present day estuary defences, reduced S Pier – water levels



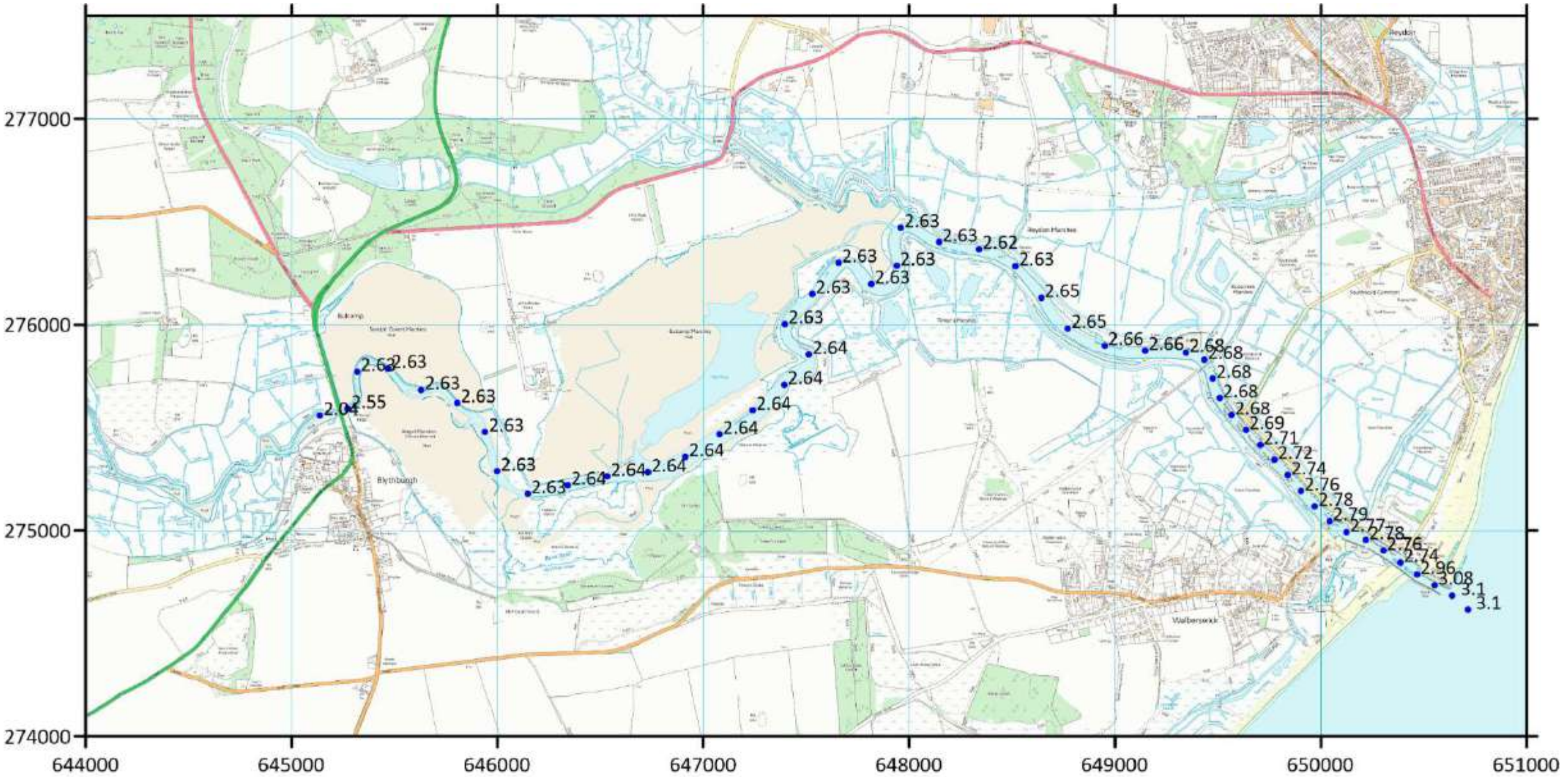
2013 event: Present-day estuary defences – water levels



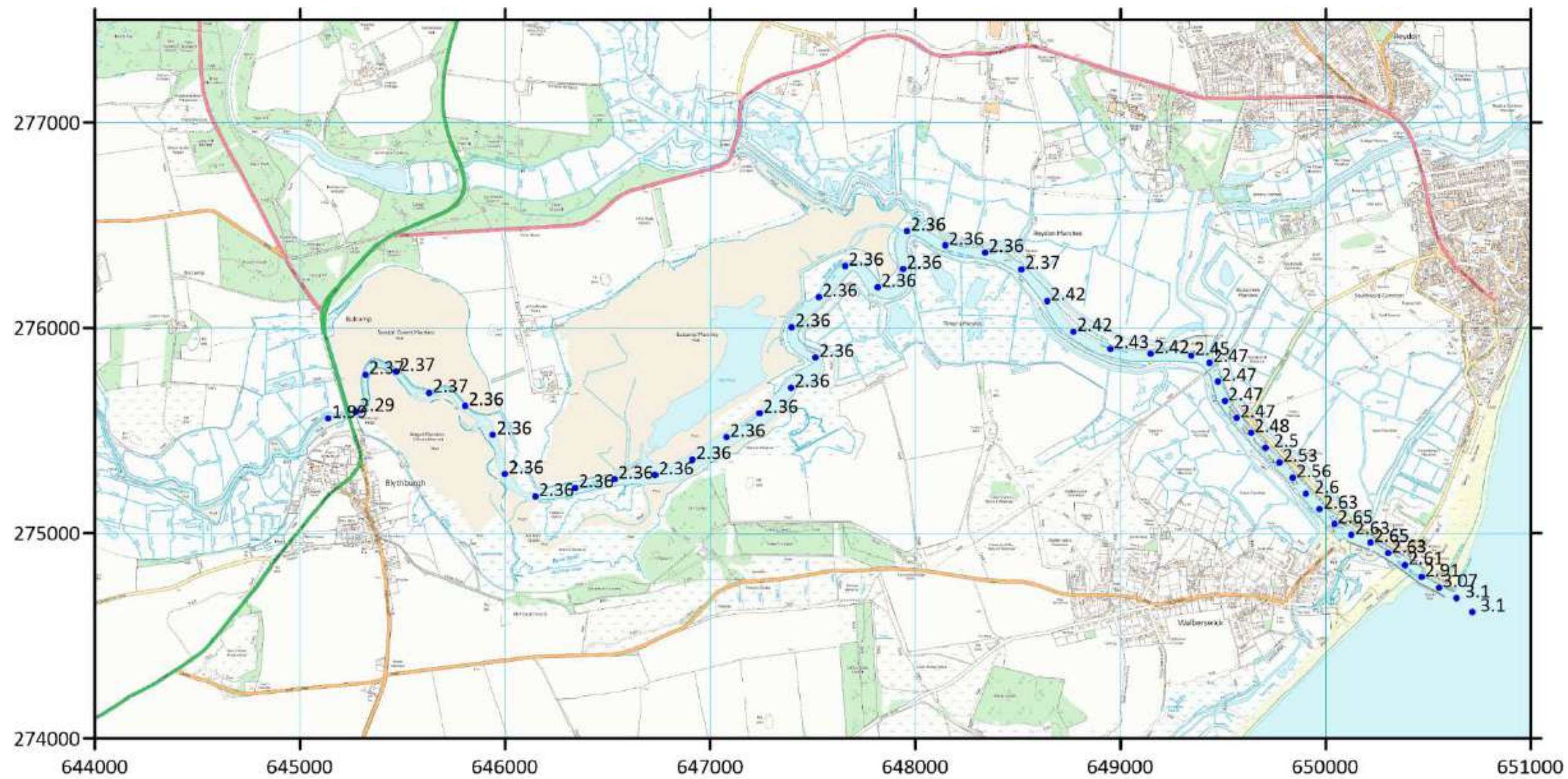
2013 event: All embankments failed (undefended) – water levels



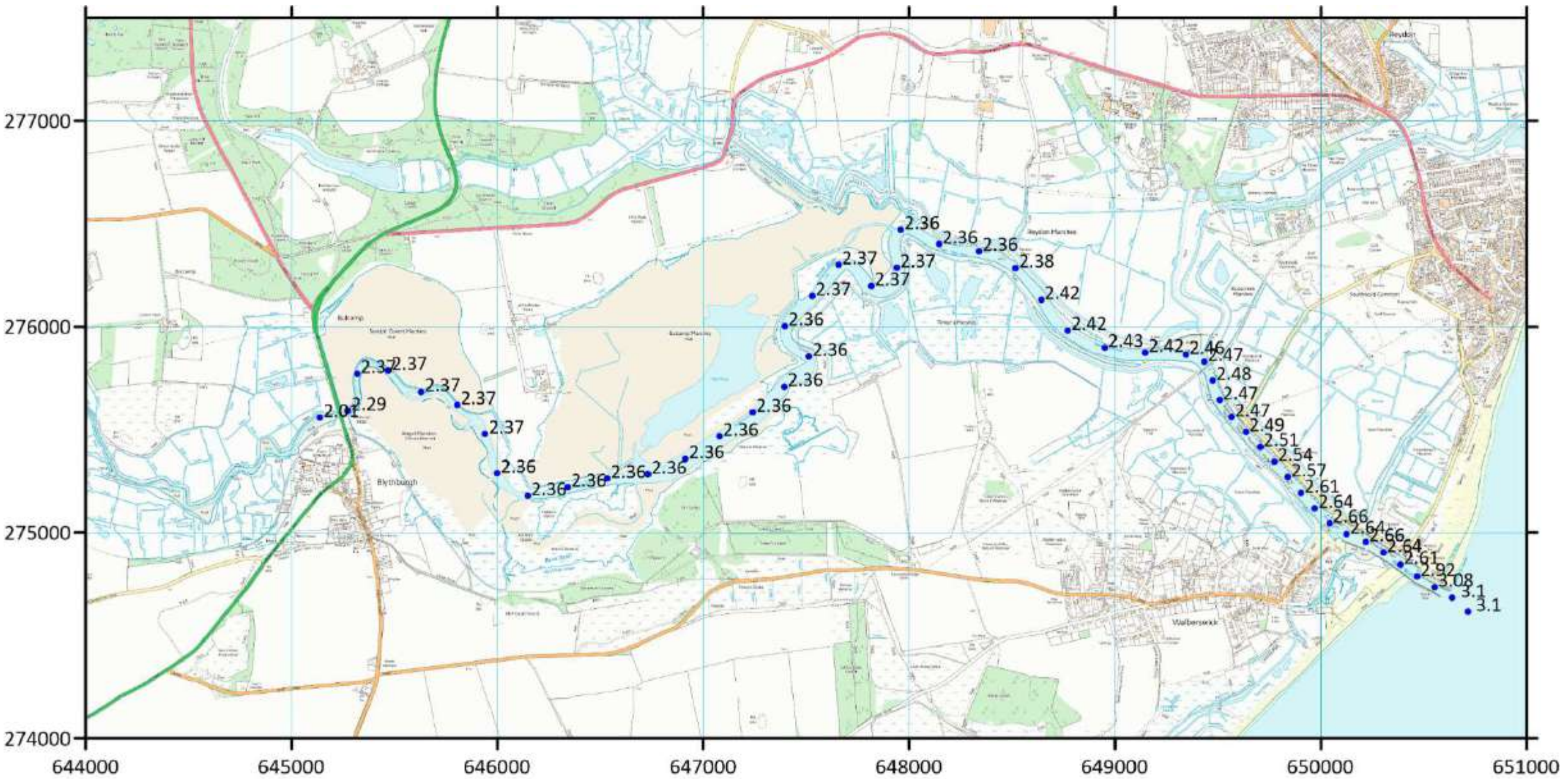
2013 event: Raise estuary defences – water levels



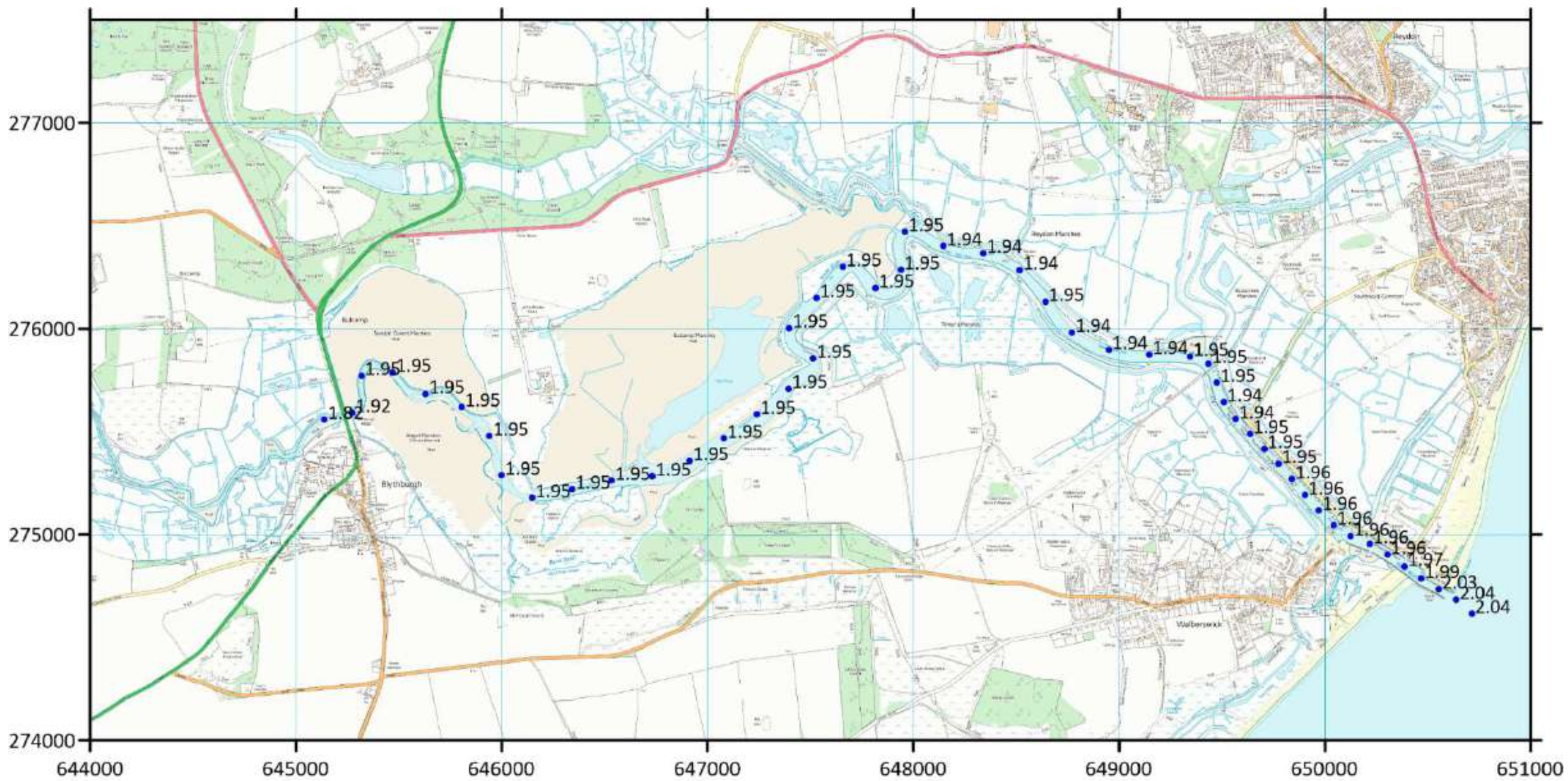
2013 event: Raise N banks, S banks overtopped – water levels



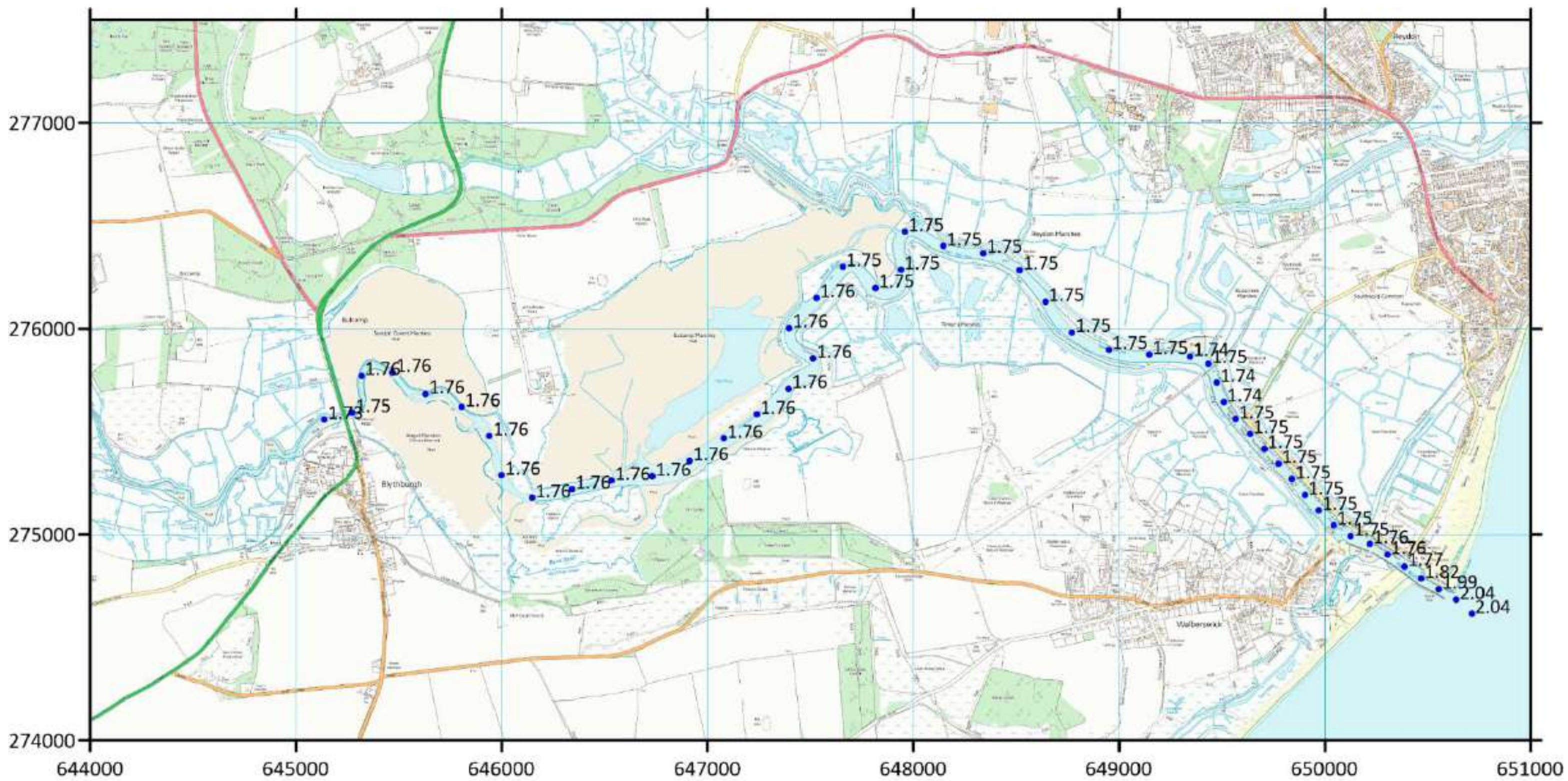
2013 event: Present day estuary defences, reduced S Pier – water levels



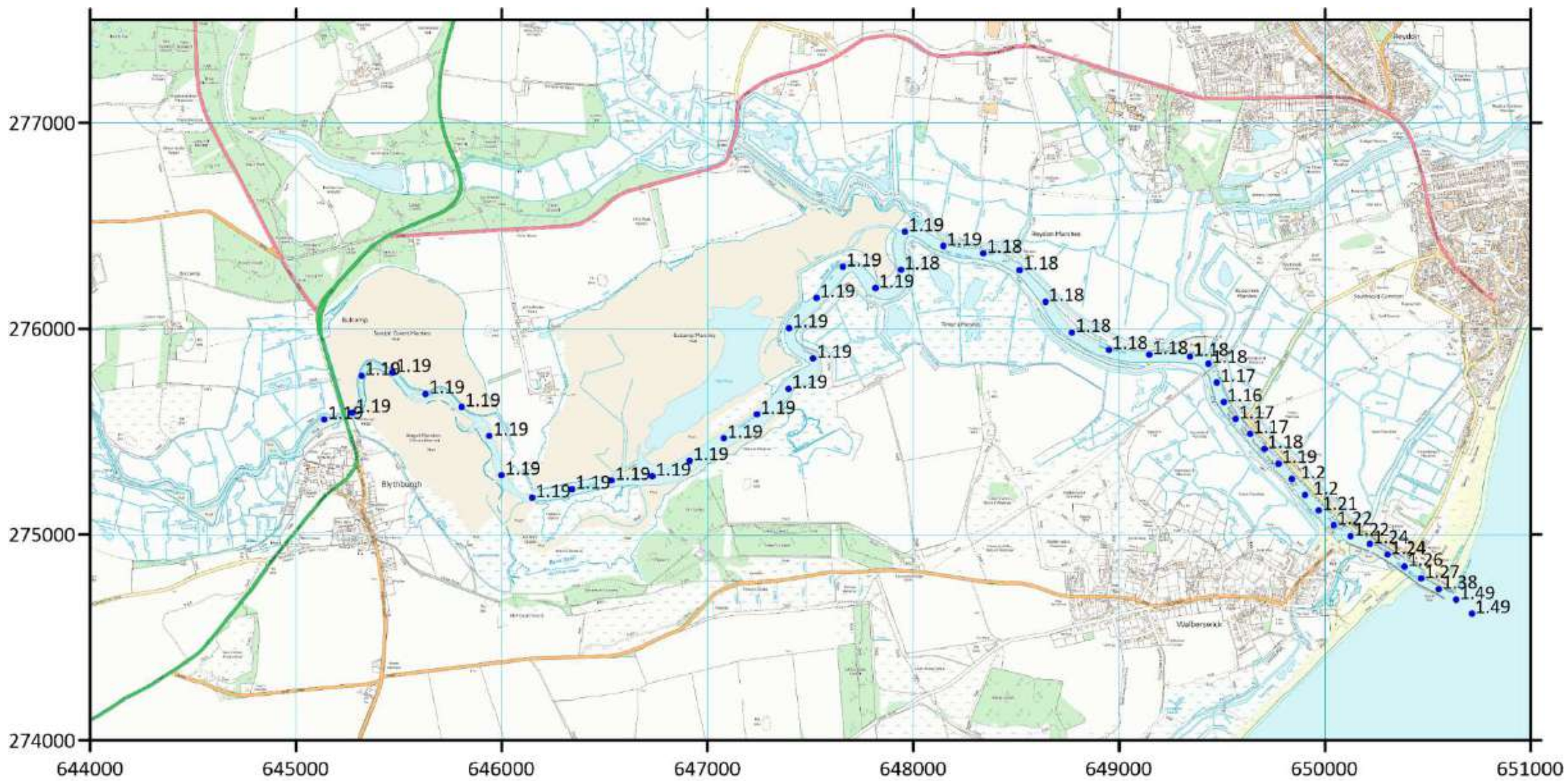
2070 with 0.6m SLR from 2020 conditions: Present-day estuary defences – water levels



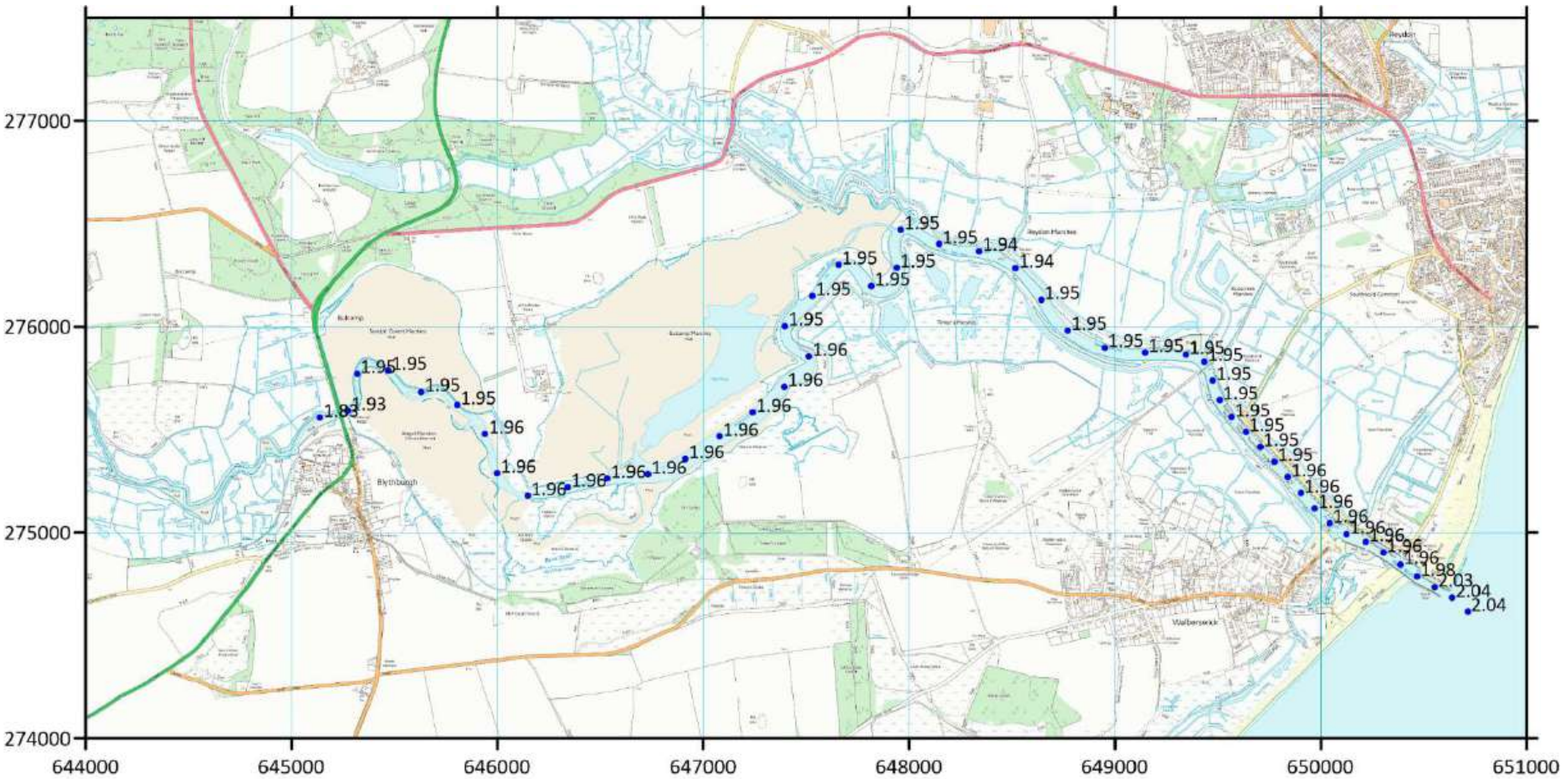
2070 with 0.6m SLR from 2020 conditions: All embankments failed (undefended) – water levels



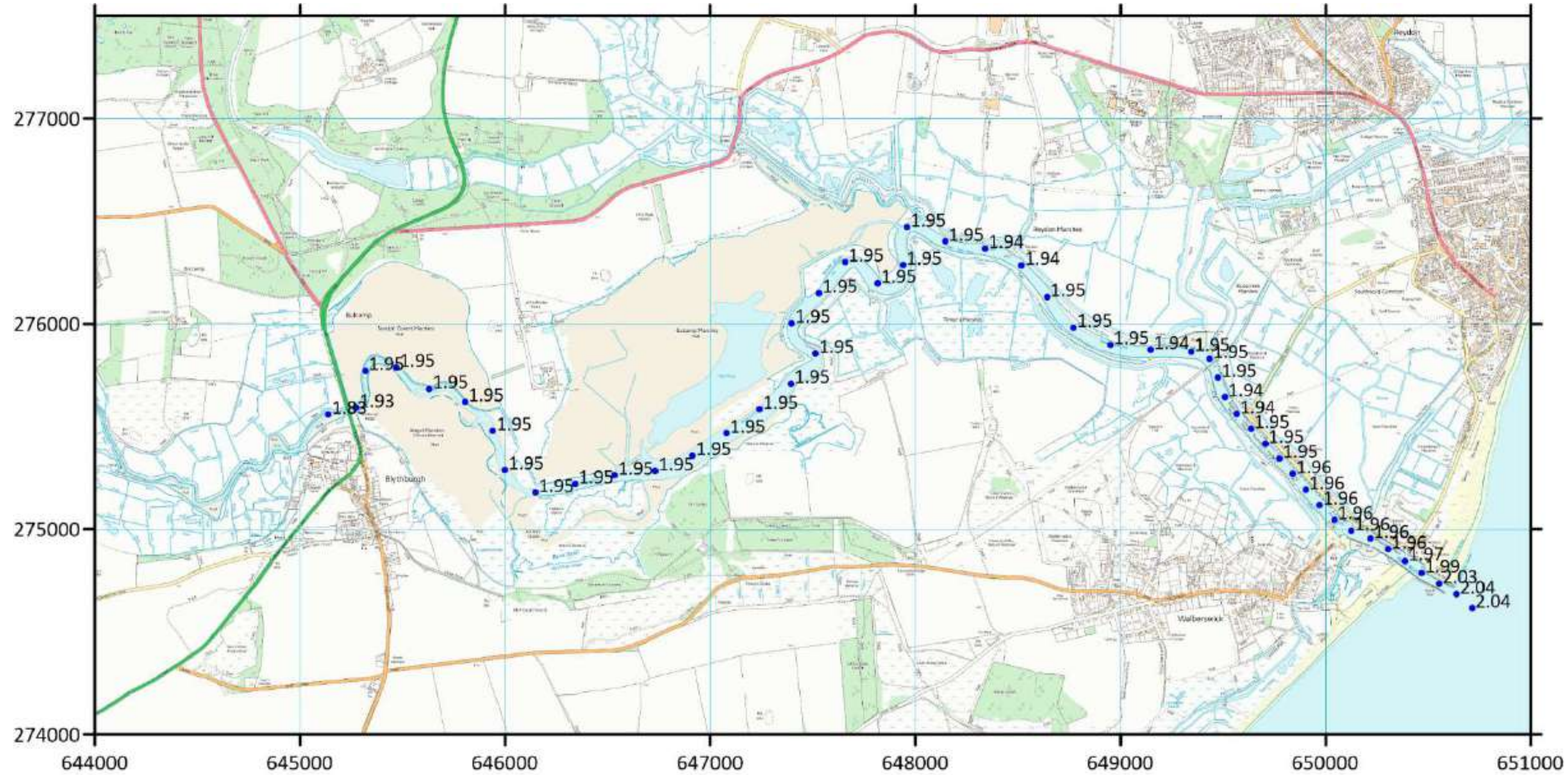
2070 with 0.6m SLR from 2020 conditions: All embankments failed (undefended) – water levels



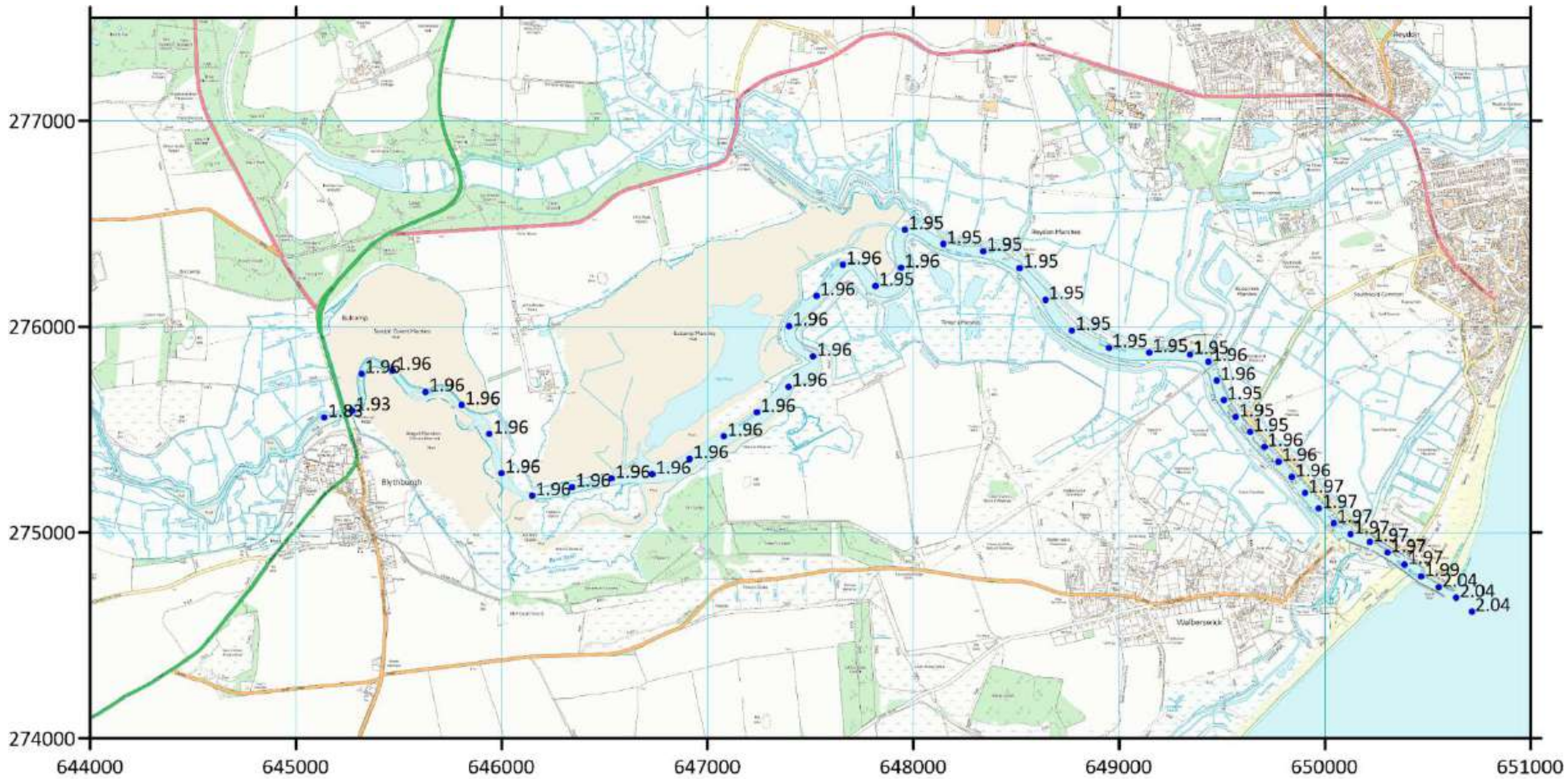
2070 with 0.6m SLR from 2020 conditions: Raise estuary defences – water levels



2070 with 0.6m SLR from 2020 conditions: Raise N banks, S banks overtopped – water levels



2070 with 0.6m SLR from 2020 conditions: Present day estuary defences, reduced S Pier – water levels



Tidal modelling – water levels

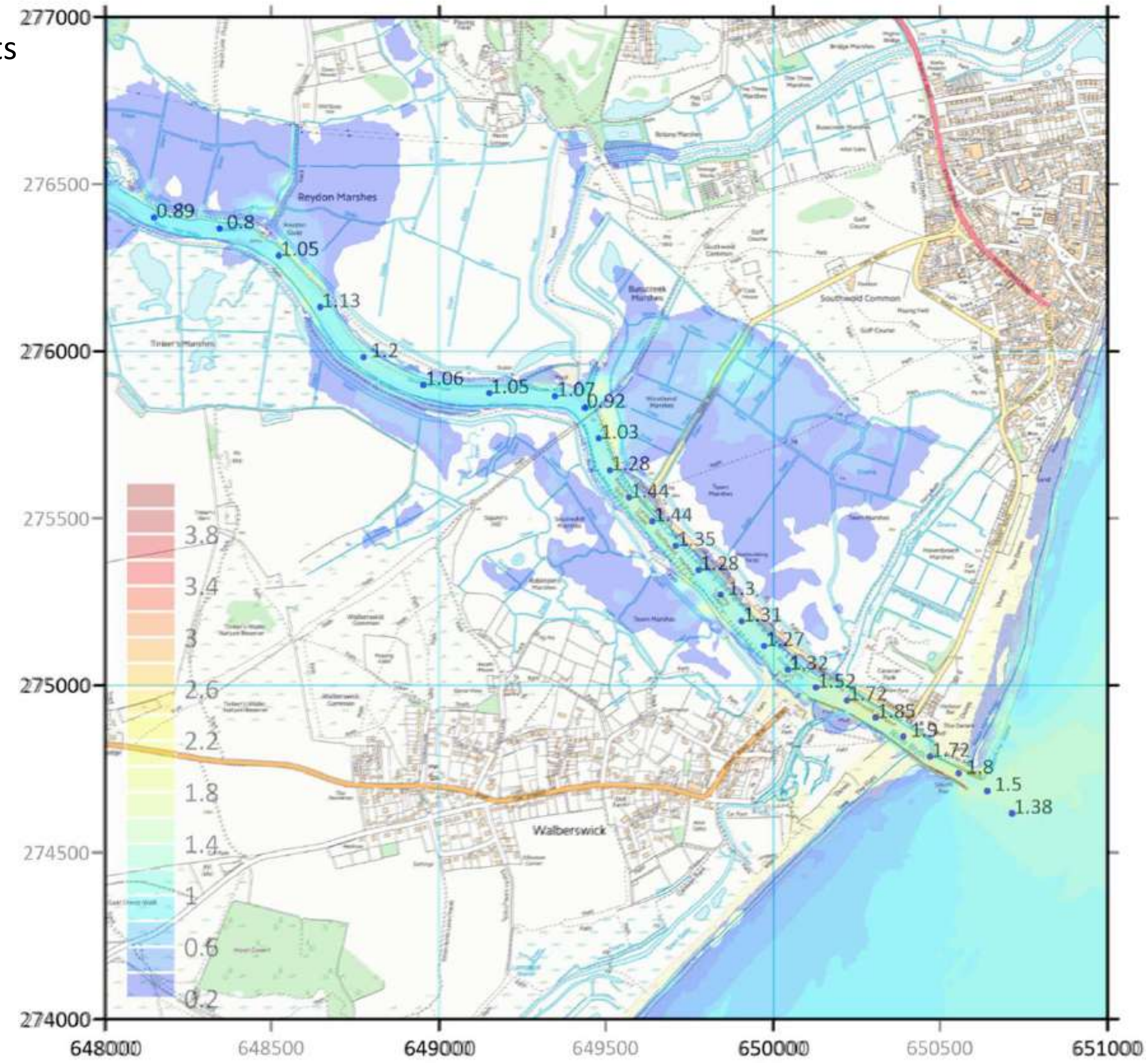
- For the 2013 event, water levels at Blackshore would have been 200mm higher if defences were raised.
- Allowing flooding of marshes reduces flood risk to the Blackshore
- Allowing overtopping of only south banks gives a slight improvement compared to present day defence levels
- Shorter breakwater brings a slight improvement
- 2013 event shows these trends more strongly, emphasises entrance channel constraint

Tidal modelling – flow rates

- Maximum flow rate in the channel during the modelled tidal cycle
- Key issue is flow rate in entrance channel – for navigation (<3.5 knots) and scour

2020: Present-day estuary defences – flow rates (m/s)

2020: All embankments
failed (undefended)
- flow rates (m/s)



2020: Raise estuary Defences
– flow rates (m/s)

2020: Raise N banks,
S banks overtopped
- flow rates (m/s)

2020: Present day estuary defences, reduced S Pier - flow rates m/s

2070 with 0.6m SLR from 2020 conditions: Present day defences – flow rates (m/s)

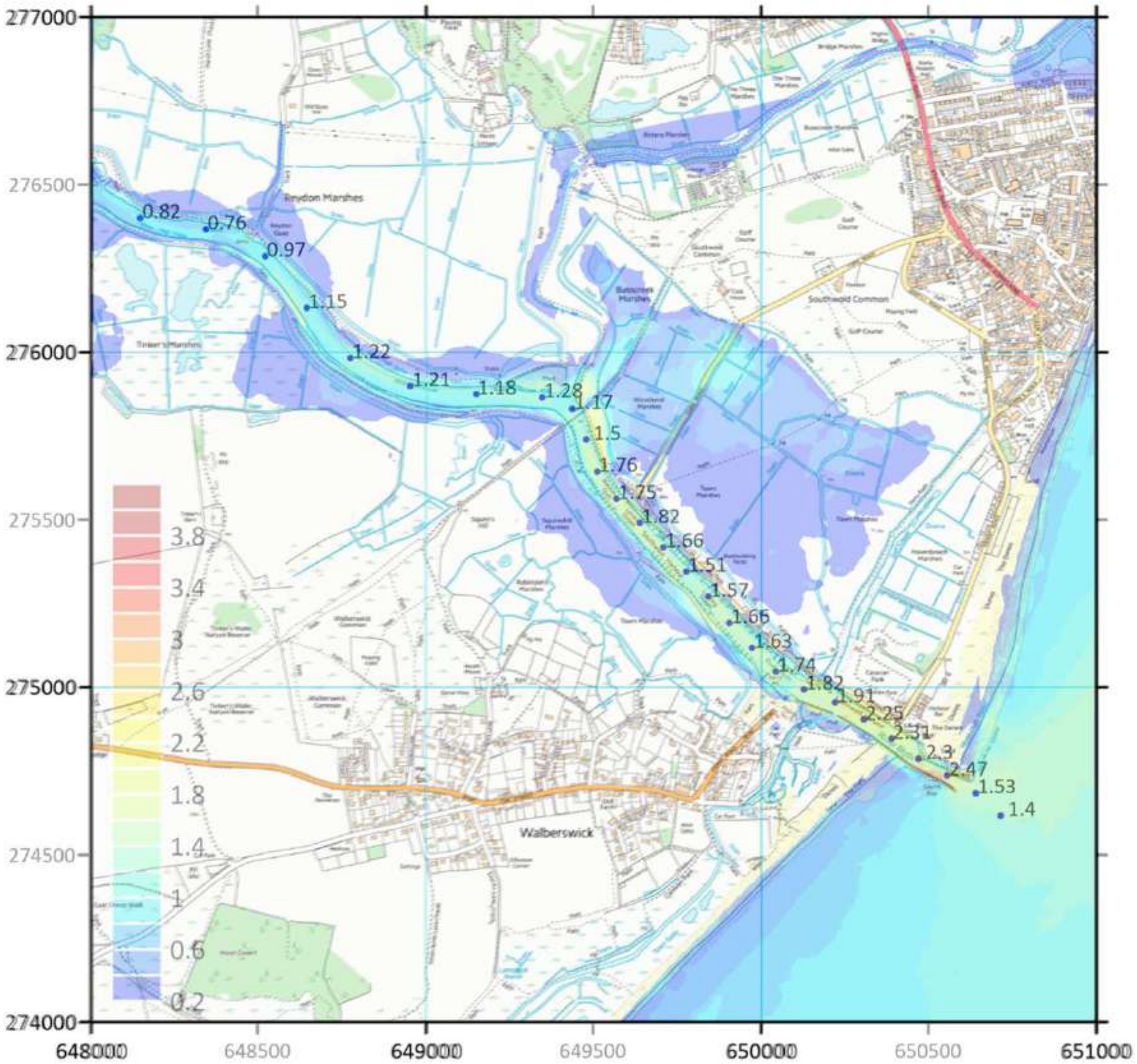
Point name	Coord		Chainage	2070 RCP2.6 50% - flow rate (knots)					2070 RCP2.6 50% - 2020 (% of 2020)				
	x	y		E0	E1	E2	E3	H1	E0	E1	E2	E3	H1
1	650589.35	274654.97	0	2.74	2.72	2.76	2.76	2.77	3%	1%	3%	3%	2%
2	650514.59	274722.30	100	2.83	2.98	2.86	2.90	3.00	2%	2%	2%	2%	2%
3	650429.40	274774.28	200	2.94	4.81	2.98	2.92	2.62	9%	37%	9%	8%	2%
4	650343.21	274825.04	300	2.97	4.48	2.99	2.81	2.96	8%	34%	8%	8%	8%
5	650262.46	274884.60	400	2.84	4.49	2.90	2.85	3.08	5%	22%	6%	5%	6%
6	650179.89	274941.34	500	2.89	4.37	2.87	2.93	2.99	4%	22%	5%	4%	5%
7	650094.48	274993.96	600	2.73	3.72	2.64	2.68	2.76	2%	11%	0%	0%	2%
8	650001.26	275031.31	700	2.53	3.54	2.40	2.48	2.61	6%	20%	6%	5%	6%
9	649918.05	275085.46	800	2.35	3.39	2.33	2.33	2.38	13%	32%	12%	12%	12%
10	649846.47	275156.49	900	2.21	3.17	2.21	2.20	2.24	11%	28%	11%	10%	11%
11	649779.40	275230.59	1000	2.23	3.22	2.21	2.21	2.25	14%	26%	15%	14%	14%
12	649716.29	275308.45	1100	2.21	3.05	2.13	2.21	2.24	10%	21%	9%	11%	10%
13	649650.36	275383.94	1200	2.04	2.93	2.04	2.04	2.08	9%	18%	9%	9%	9%
14	649581.39	275456.68	1300	2.24	3.23	2.26	2.24	2.29	6%	23%	6%	6%	6%
15	649511.58	275528.58	1400	2.54	3.53	2.56	2.54	2.58	11%	26%	11%	11%	10%
16	649441.52	275600.24	1500	2.36	3.40	2.38	2.35	2.41	6%	22%	7%	6%	7%
17	649384.13	275682.37	1600	2.14	3.41	2.15	2.15	2.17	5%	37%	5%	5%	5%
18	649351.39	275777.07	1700	1.65	2.91	1.68	1.66	1.68	10%	45%	10%	9%	10%
19	649310.60	275869.80	1800	1.55	2.28	1.56	1.55	1.57	7%	28%	6%	6%	6%
20	649220.73	275904.08	1900	1.80	2.50	1.81	1.81	1.84	8%	20%	8%	7%	8%
21	649022.63	275912.96	2100	1.70	2.30	1.70	1.69	1.73	9%	13%	9%	9%	9%
22	648826.39	275937.35	2300	1.73	2.35	1.73	1.73	1.76	8%	15%	9%	8%	8%
23	648647.76	276021.18	2500	1.88	2.37	1.88	1.87	1.91	7%	2%	7%	7%	7%
24	648517.55	276170.37	2700	1.70	2.24	1.71	1.70	1.73	5%	2%	5%	5%	5%
25	648393.18	276324.90	2900	2.04	1.89	2.04	2.03	2.07	10%	-7%	10%	9%	10%

2070 with 0.6m SLR from 2020 conditions: Raise estuary defences – flow rates (m/s)

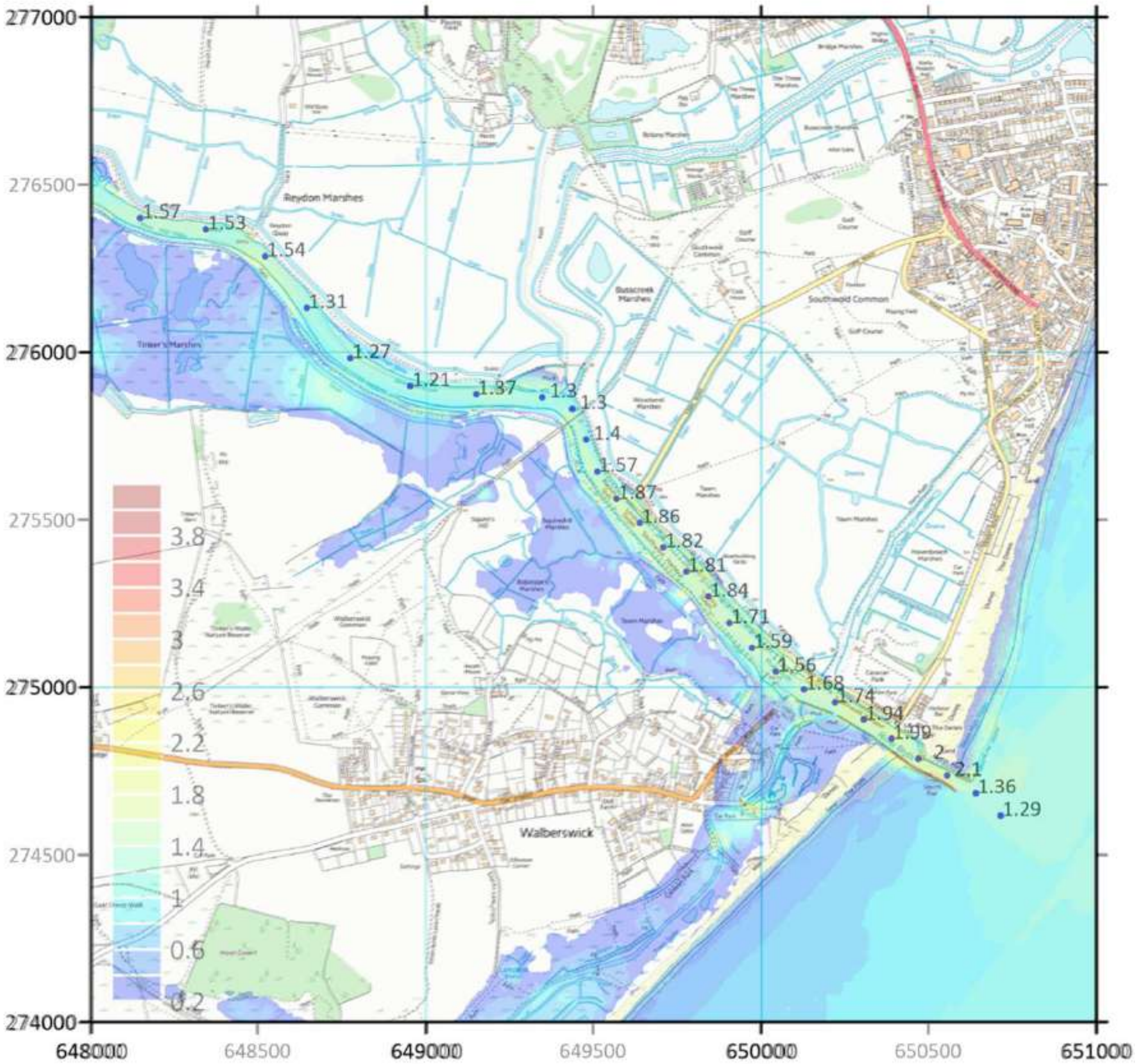
2070 with 0.6m SLR
from 2020 conditions:
Raise N banks,
S banks overtopped
– flow rates (m/s)

2070 with 0.6m SLR from 2020 conditions: Present day estuary defences, reduced S Pier – flow rates (m/s)

2070 with 0.6m SLR from 2020 conditions: All embankments failed (undefended) – flow rates (m/s)

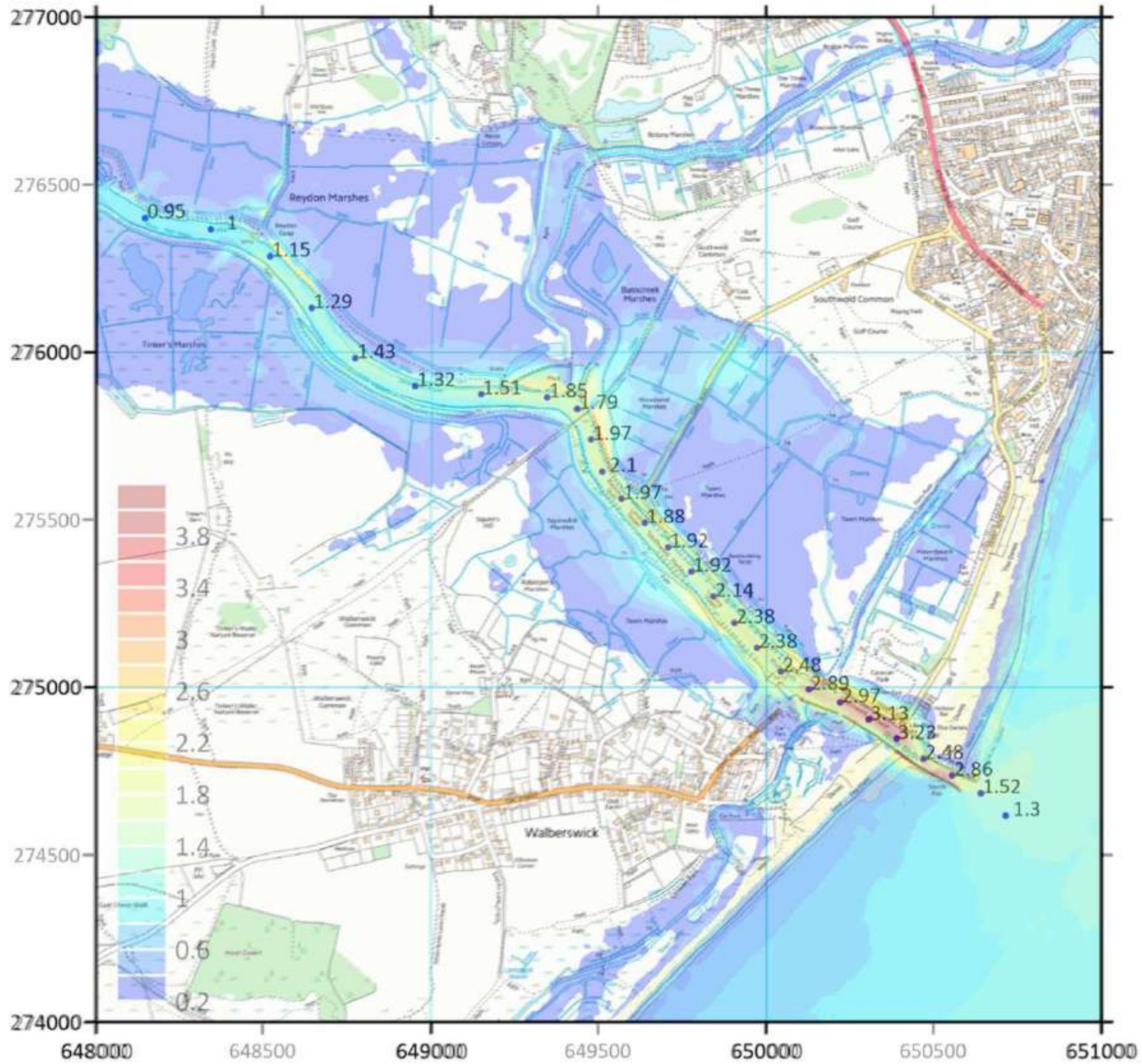


2013 event:
Present-day estuary
Defences
– flow rates (m/s)

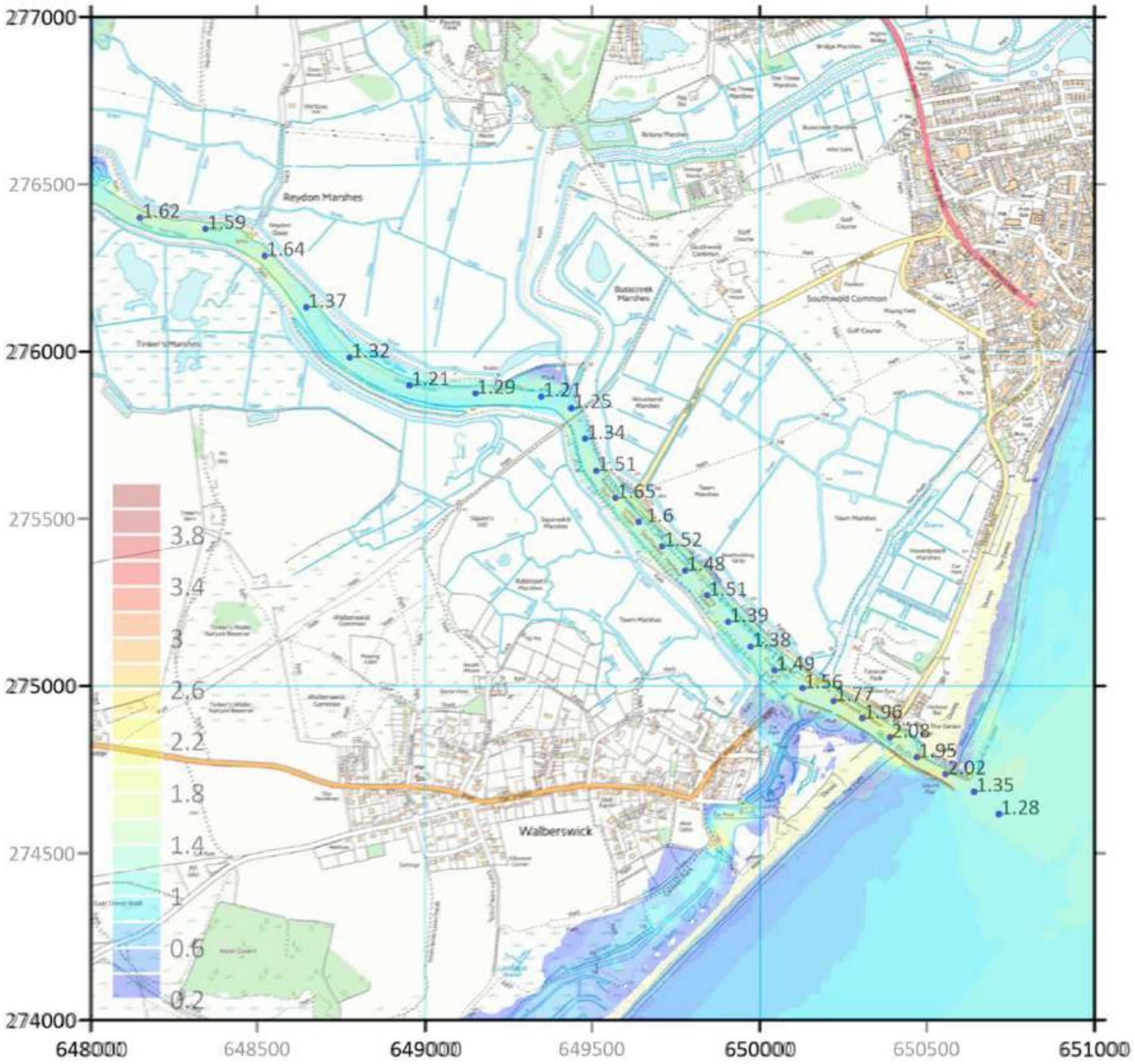


Point name	Coord		Chainage	2013 event - flow rate (knots)					2013 event - 2020 (% of 2020)				
	x	y		E0	E1	E2	E3	H1	E0	E1	E2	E3	H1
1	650589.35	274654.97	0	2.50	2.53	2.50	2.51	2.51	-12%	-12%	-14%	-12%	-14%
2	650514.59	274722.30	100	2.64	2.95	2.62	2.68	2.72	-10%	2%	-13%	-10%	-14%
3	650429.40	274774.28	200	4.07	5.56	3.93	3.82	3.21	99%	114%	86%	80%	49%
4	650343.21	274825.04	300	3.90	4.83	3.79	3.54	3.63	80%	86%	71%	69%	62%
5	650262.46	274884.60	400	3.87	6.28	4.04	4.35	4.52	83%	137%	92%	118%	107%
6	650179.89	274941.34	500	3.78	6.08	3.81	4.23	4.19	71%	135%	76%	98%	93%
7	650094.48	274993.96	600	3.38	5.77	3.43	3.83	3.82	51%	141%	59%	83%	80%
8	650001.26	275031.31	700	3.27	5.61	3.03	3.43	3.43	72%	175%	67%	88%	77%
9	649918.05	275085.46	800	3.03	4.83	2.90	2.86	2.87	88%	170%	76%	74%	68%
10	649846.47	275156.49	900	3.09	4.63	2.69	2.77	2.82	107%	170%	68%	76%	78%
11	649779.40	275230.59	1000	3.32	4.64	2.70	2.97	3.01	136%	159%	78%	104%	101%
12	649716.29	275308.45	1100	3.57	4.16	2.93	3.21	3.25	153%	125%	96%	119%	117%
13	649650.36	275383.94	1200	3.52	3.72	2.89	3.17	3.20	171%	97%	105%	135%	134%
14	649581.39	275456.68	1300	3.54	3.73	2.95	3.23	3.24	131%	82%	75%	102%	98%
15	649511.58	275528.58	1400	3.62	3.65	3.12	3.33	3.33	113%	59%	68%	87%	82%
16	649441.52	275600.24	1500	3.63	3.83	3.21	3.35	3.37	124%	72%	87%	99%	96%
17	649384.13	275682.37	1600	3.06	4.09	2.93	2.90	2.87	97%	125%	83%	80%	76%
18	649351.39	275777.07	1700	2.73	3.84	2.61	2.59	2.56	158%	177%	138%	138%	131%
19	649310.60	275869.80	1800	2.53	3.49	2.42	2.35	2.31	144%	186%	125%	118%	109%
20	649220.73	275904.08	1900	2.52	3.59	2.34	2.37	2.34	99%	142%	77%	80%	72%
21	649022.63	275912.96	2100	2.67	2.94	2.50	2.51	2.49	138%	86%	118%	118%	110%
22	648826.39	275937.35	2300	2.35	2.58	2.36	2.31	2.28	91%	49%	94%	87%	79%
23	648647.76	276021.18	2500	2.47	2.77	2.56	2.50	2.47	80%	37%	88%	84%	74%
24	648517.55	276170.37	2700	2.54	2.51	2.67	2.58	2.54	111%	28%	124%	116%	106%
25	648393.18	276324.90	2900	3.00	2.24	3.20	3.07	3.01	121%	19%	141%	127%	116%

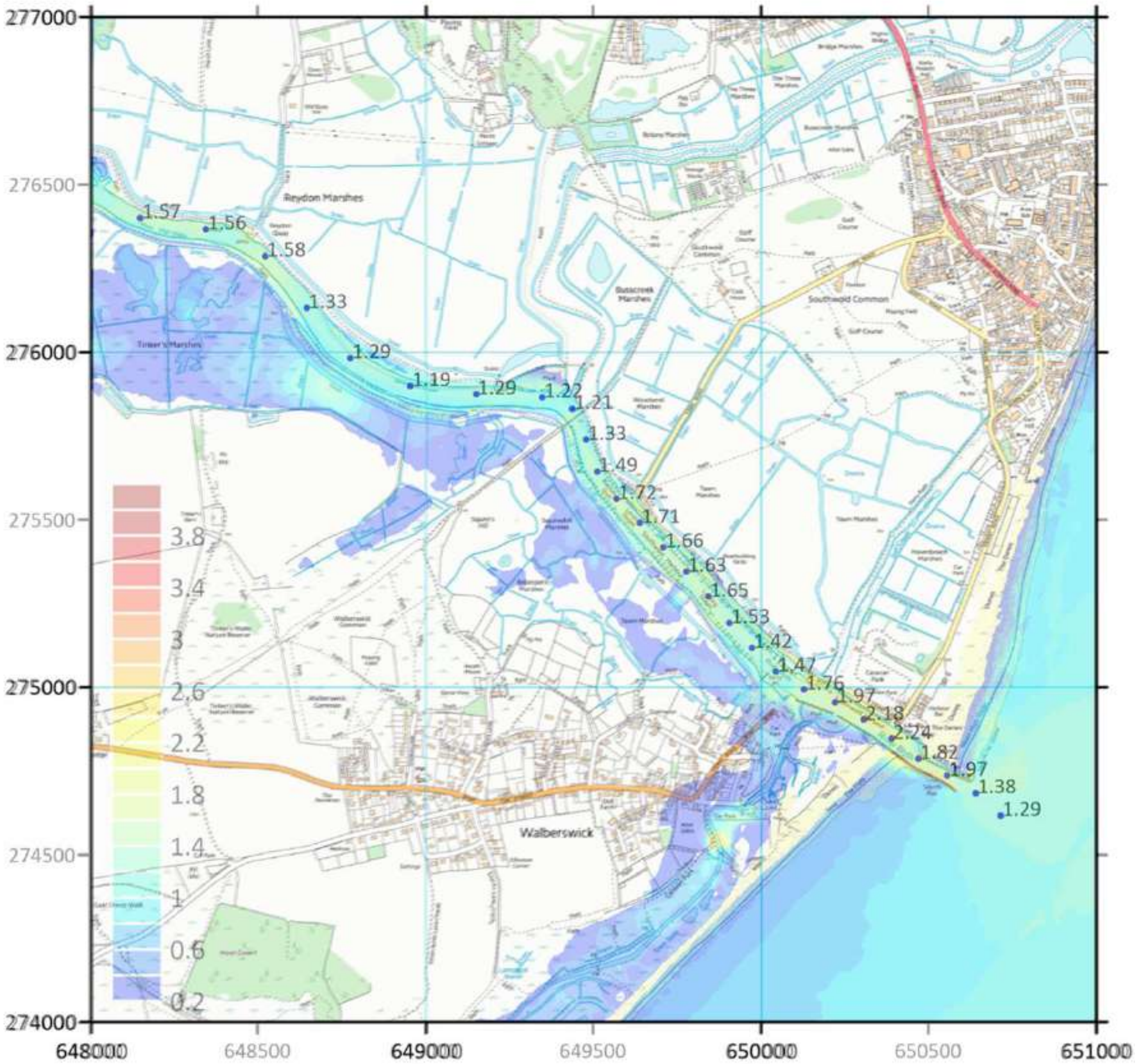
2013 event:
All embankments failed (undefended) – flow rates (m/s)



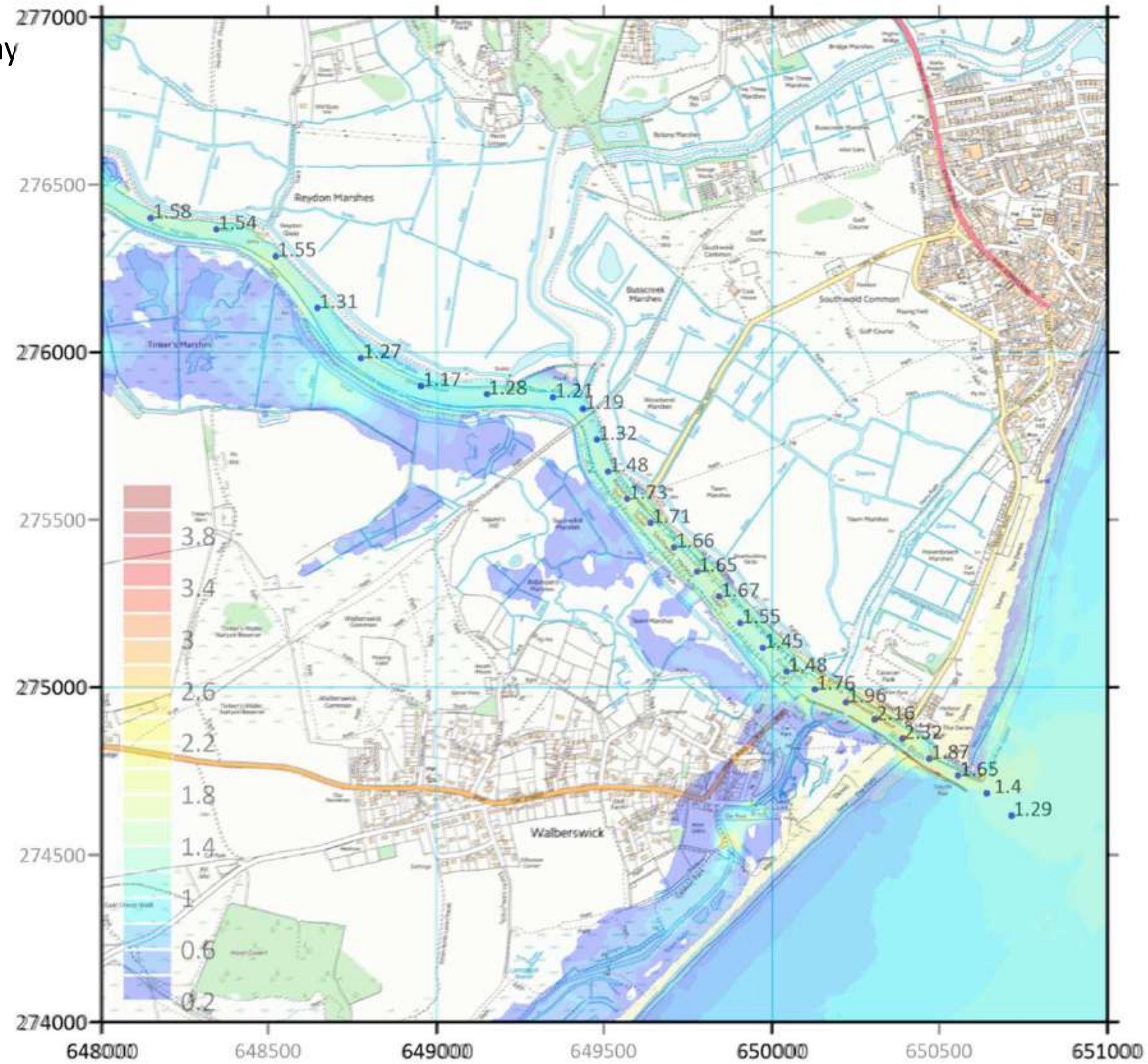
2013 event: Raise estuary defences – flow rates (m/s)



2013 event: Raise N banks, S banks Overtopped – flow rates (m/s)



2013 event: Present day estuary defences, reduced S Pier – flow rates (m/s)



Tidal modelling – flow rates

- Do Nothing (undefended) scenario:
  - Faster flow rates in entrance channel than all other options due to larger tidal prism
  - Lower rates upstream due to flooding
- Raising only N banks increases flow rates in entrance channel but less of an impact than Do Nothing
- Raising all embankments reduces the tidal prism and therefore flow rate
- Reducing the length of the South Pier allows water out quicker
  - Faster flow rates at entrance
  - Reduced flow rates upstream
  - Not as much benefit for flow rates as expected
- For more extreme conditions (2013 event, climate change), trends are emphasised.

Tidal modelling – flow rates

- With climate change (+0.6m water level)
  - Only floods for Do Nothing (undefended) scenario
  - Increase in flow rates due to limited increase in tidal prism (channel only)
  - Flow rate only exceeds 3.5 knots for Do Nothing
  - Conditions manageable with present day defences

Tidal modelling – comparison of options

Do Nothing (undefended)

- Bad for flooding
- Bad for flow rates

Raised defences

- Good for wider flooding
- Bad for flooding at Blackshore
- Good for flow rates

Raise N banks only, allow S to overtop (SMP)

- Addresses flood risk to properties
- Better for flow rates than Do Nothing
- Better for Blackshore than raising all defences

Present day defence levels

- With limited SLR, conditions are manageable
- Monitor to optimise timing of interventions

Discussion of options modelling results

- Rock breakwater preferred solution for S Pier
  - Other solutions in inner harbour wouldn’t have much impact on wave conditions
  - May need timber fendering
  - Dredge shoal bank so N Wall can be used?
  - Design landward end of breakwater to minimise impact on dunes
  - Design toe to address scour risk
  - Design crest level for overtopping
  - Further optimise channel width and alignment of mouth?

Discussion of options modelling results

- Low CC scenario:
  - MHWS conditions are manageable with present day defence levels
  - What return period event would cause overtopping?
  - What frequency of overtopping is manageable?
  - Criteria for needing to change management approach?
- Preferred option would then be to raise N Banks only, allowing overtopping into Tinkers / Robinsons at reinforced spillways
- Optimise timing of interventions
- Needs monitoring against defined trigger points

Outcomes & Next steps

- What we will do next
  - Address any comments / issues with this modelling
  - Analysis of climate change scenarios to define trigger points for monitoring
  - Agree any further scenarios to be modelled (optimization)
  - Confirm costing of options for Investment Plan
  - Develop Investment Plan timeline

- Next workshop
  - Any additional modelling results
  - Proposed Investment Plan

Comments / questions (1)

The following comments and questions were raised during the meeting. These issues will be addressed in the next workshop or the project report.

1. Details of climate change scenarios considered to be provided *(slides 6-7). Further analysis of climate change scenarios to be completed.*
2. *Connection of any new breakwater to the beach needs to be designed to achieve a seal – so beach/dune material isn't sucked into the harbour (slides 12-14). Comment to be added to options assessment tables.*
3. Comments made on the impact of the width of the entrance channel on flood risk. *Model results show that the constrained entrance slows the ebb tide (flow out of the estuary), increasing water levels and flood risk to the Blackshore. A wider entrance channel would allow more wave penetration, but maximum tidal are lower (compare slide 60 with 64).*

Comments / questions (2)

The following comments and questions were raised during the meeting. These issues will be addressed in the next workshop or the project report.

4. Comments made on the impact of the width of the entrance channel on flow rates. *An increased entrance channel volume would reduce flow rates. Further assessment of this issue may be possible as part of additional optimization modelling, if agreed with the Council.*
5. Comments made on whether a rock breakwater could cause the same issues for navigation of the entrance channel as led to the windows being created in the South Pier. *Transmission through the S Pier was included in the baseline model, but it is difficult to analyze this issue in detail without complex 3D modelling. Reducing the crest level of sections of the breakwater to allow some overtopping could address this issue. It may be possible to assess this as part of any optimisation modelling.*

Comments / questions (3)

The following comments and questions were raised during the meeting. These issues will be addressed in the next workshop or the project report.

6. Overtopping will damage embankments which would need to be repaired. Reinforced spillway approach would be preferred *(slide 94).*
7. Sedimentation Study – marsh accretion could reduce tidal prism and associated flow rates *(additional analysis to be completed to compare future tidal prism).*
8. Could a simple surge barrier solution be modelled? *Response given that barrier options would have a high cost and be difficult to implement. This option will be added and reviewed in the long-list of options.*
9. Important to address risks and uncertainties associated with any decisions made in setting out the Investment Plan.

Southwold Harbour Study

Stakeholder Workshop 4

23 February 2021

Agenda

- Welcome & Agenda 11.30
- Aims & objectives for this workshop 11.35
- Issues raised following last workshop 11.40
- Sensitivity to marsh level (tidal prism) 11.45
- Sensitivity to entrance channel width 12.00
- Transmission through South Pier 12.25
- Tidal barrier solutions 12.45
- Next Steps 12.55
- FINISH 13.00

Aims and Objectives of this Workshop

- Address issues raised after last meeting
- Review the next steps

Summary of issues raised

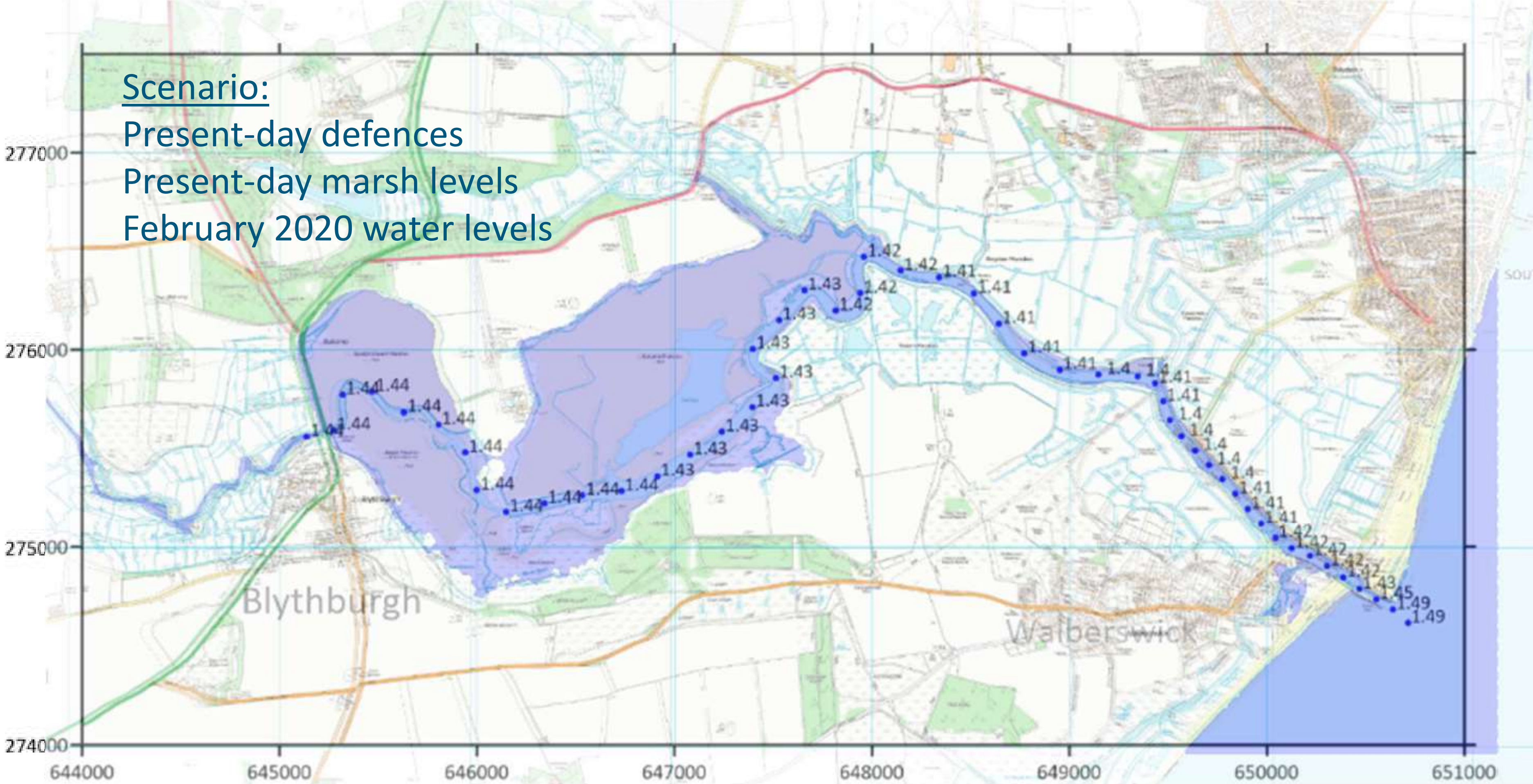
1. Sensitivity to marsh level (tidal prism)
2. Sensitivity to width of entrance channel
3. Maintaining transmission through South Pier
4. Tidal barrier options
5. Flood risk to the Blackshore
6. Spillway option

Anything else?

Sensitivity to marsh sedimentation (water levels, flow rates)

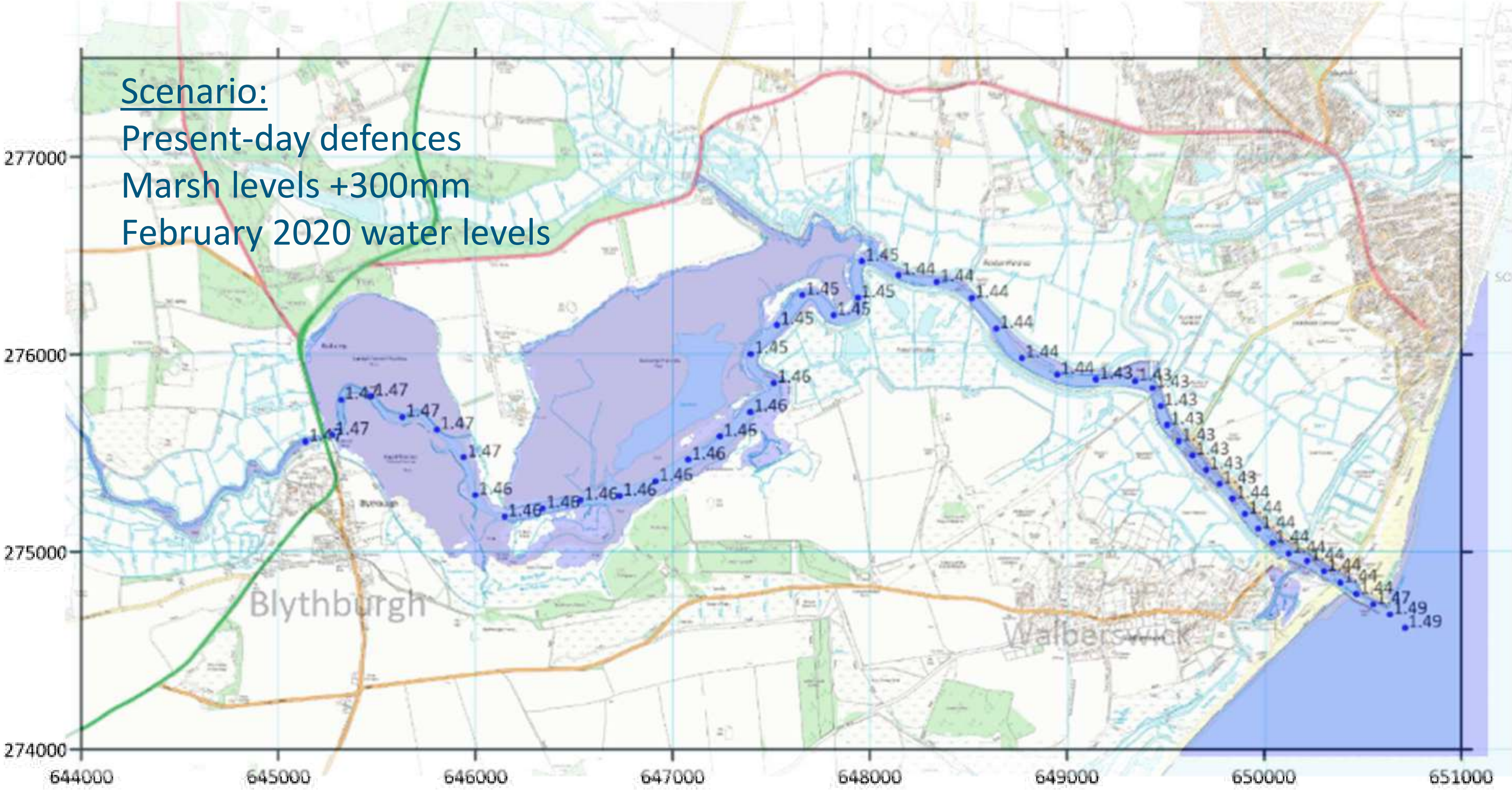
- Water levels and flow rates in the channel depend on the tidal prism (volume of water in the estuary). Tidal prism depends on:
  - Sea level rise - will increase tidal prism
  - Marsh levels – sedimentation will reduce tidal prism
  - Sedimentation will offset sea level rise
- Modelling to date assumed no future increase in marsh levels
  - Worst case scenario for harbour
- Sensitivity testing for marsh sedimentation:
  - Marsh level raised 300mm
  - Feb 2020 and 2013 water level conditions

Sensitivity of water level to marsh level

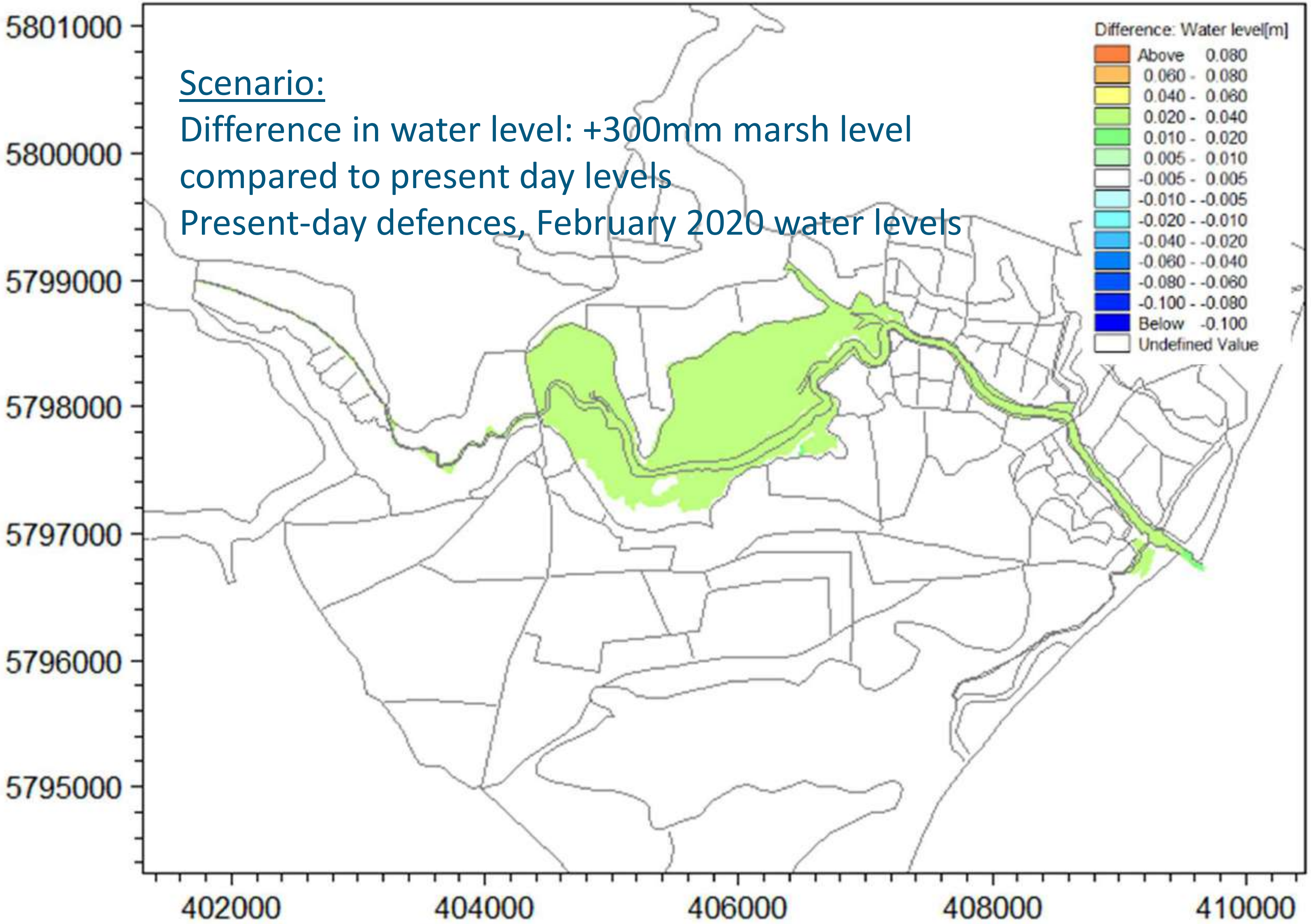


Royal HaskoningDHV

Sensitivity of water level to marsh level



Sensitivity of water level to marsh level



Royal HaskoningDHV

Sensitivity of flow rate to marsh level

Scenario:

Present-day defences

Present-day marsh levels

Feb 2020 water levels

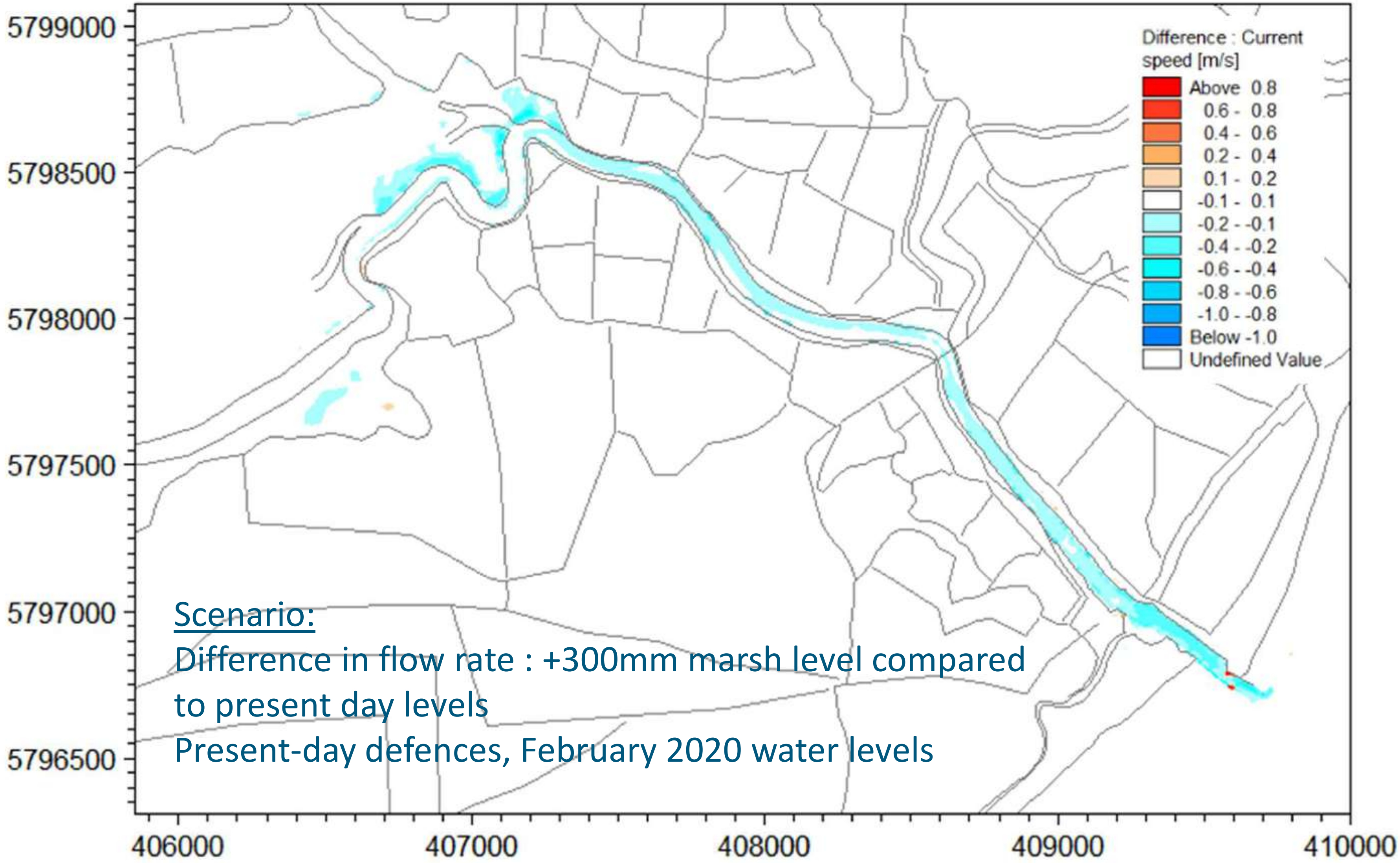
Royal HaskoningDHV

Sensitivity of flow rate to marsh level

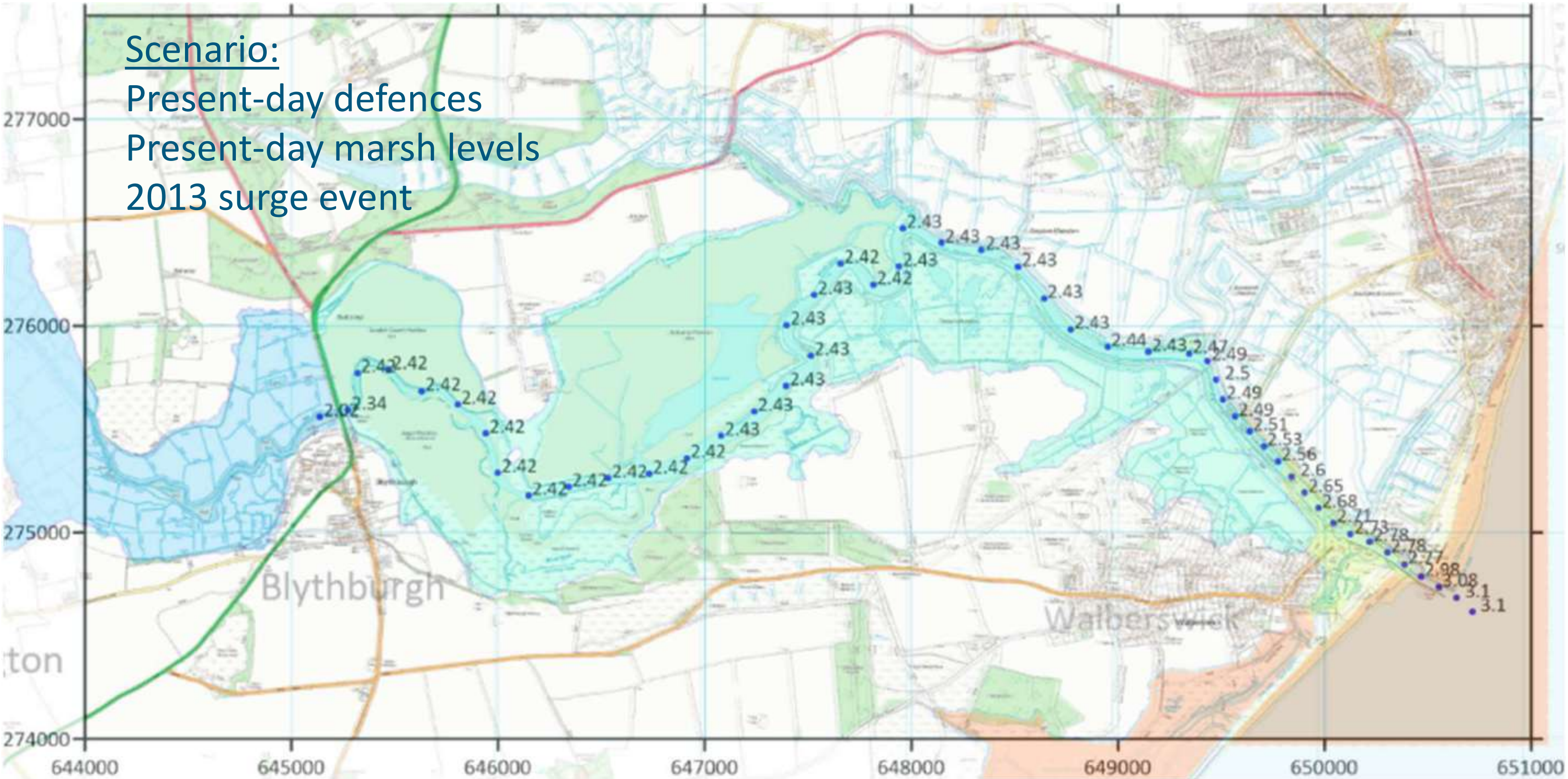
<u>Scenario:</u>
Present-day defences
Marsh levels +300mm
Feb 2020 water levels

Royal HaskoningDHV

Sensitivity of flow rate to marsh level

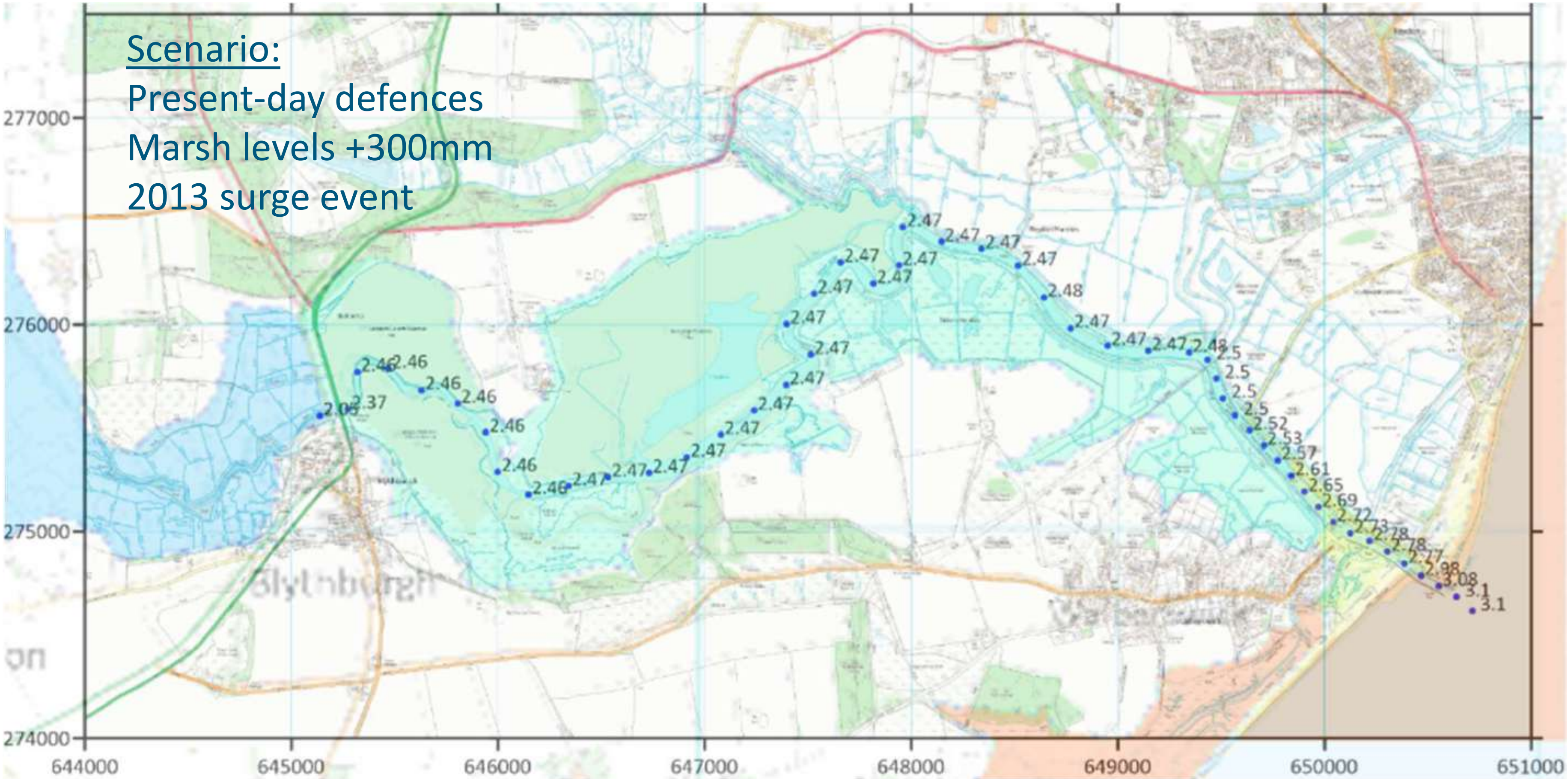


Sensitivity of water level to marsh level



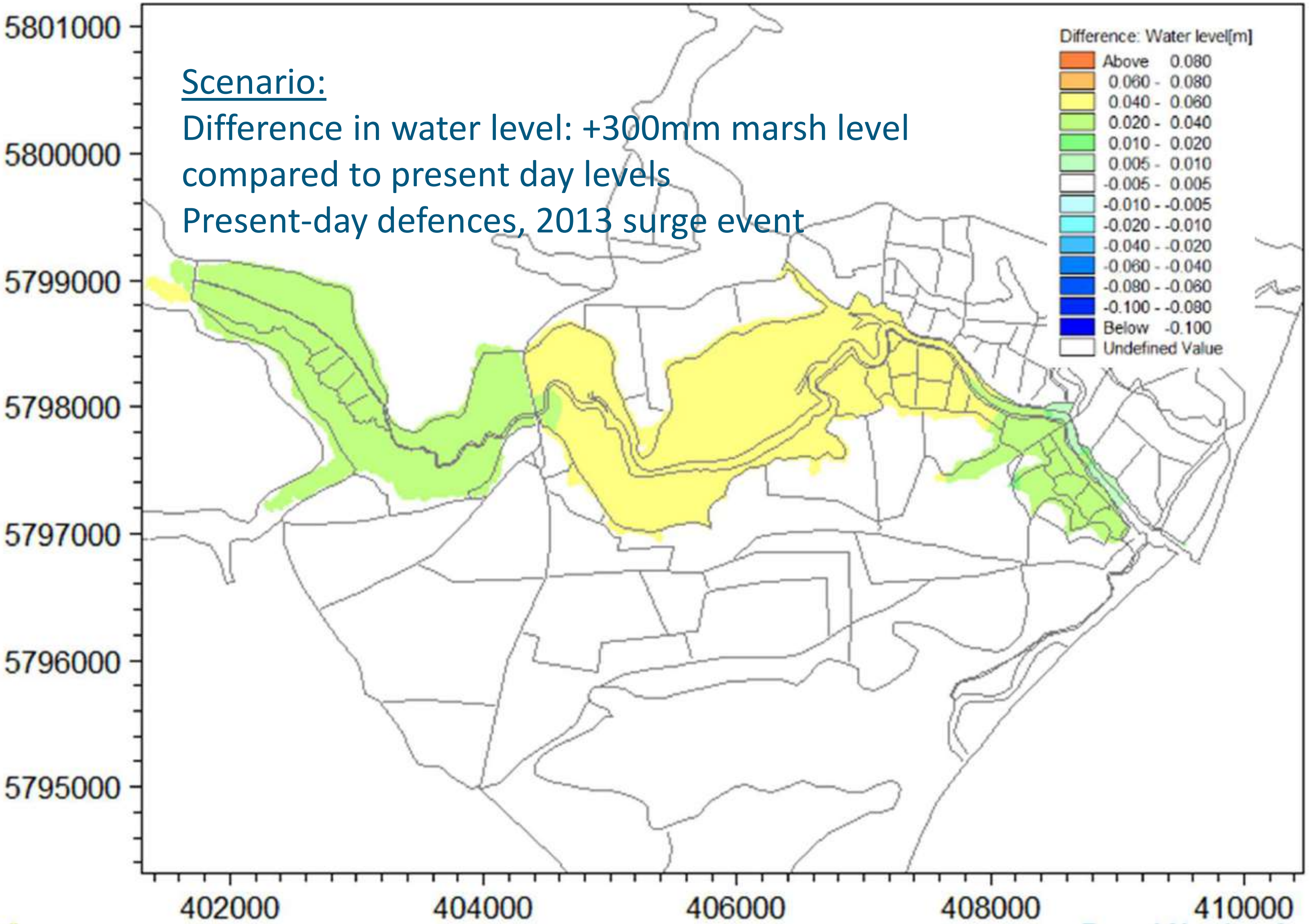
Royal HaskoningDHV

Sensitivity of water level to marsh level



Royal HaskoningDHV

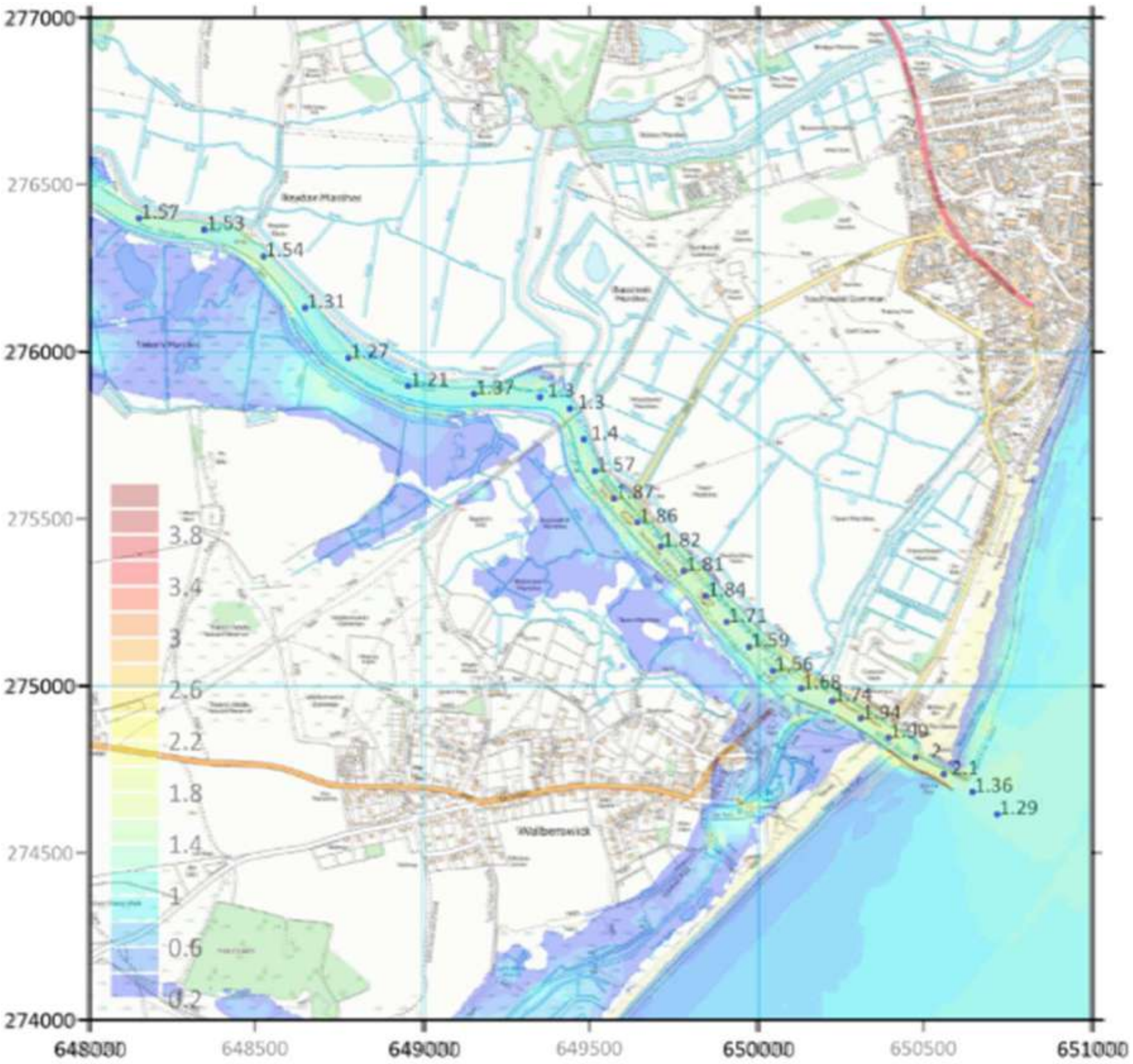
Sensitivity of water level to marsh level



Royal HaskoningDHV

Sensitivity of flow rate to marsh level

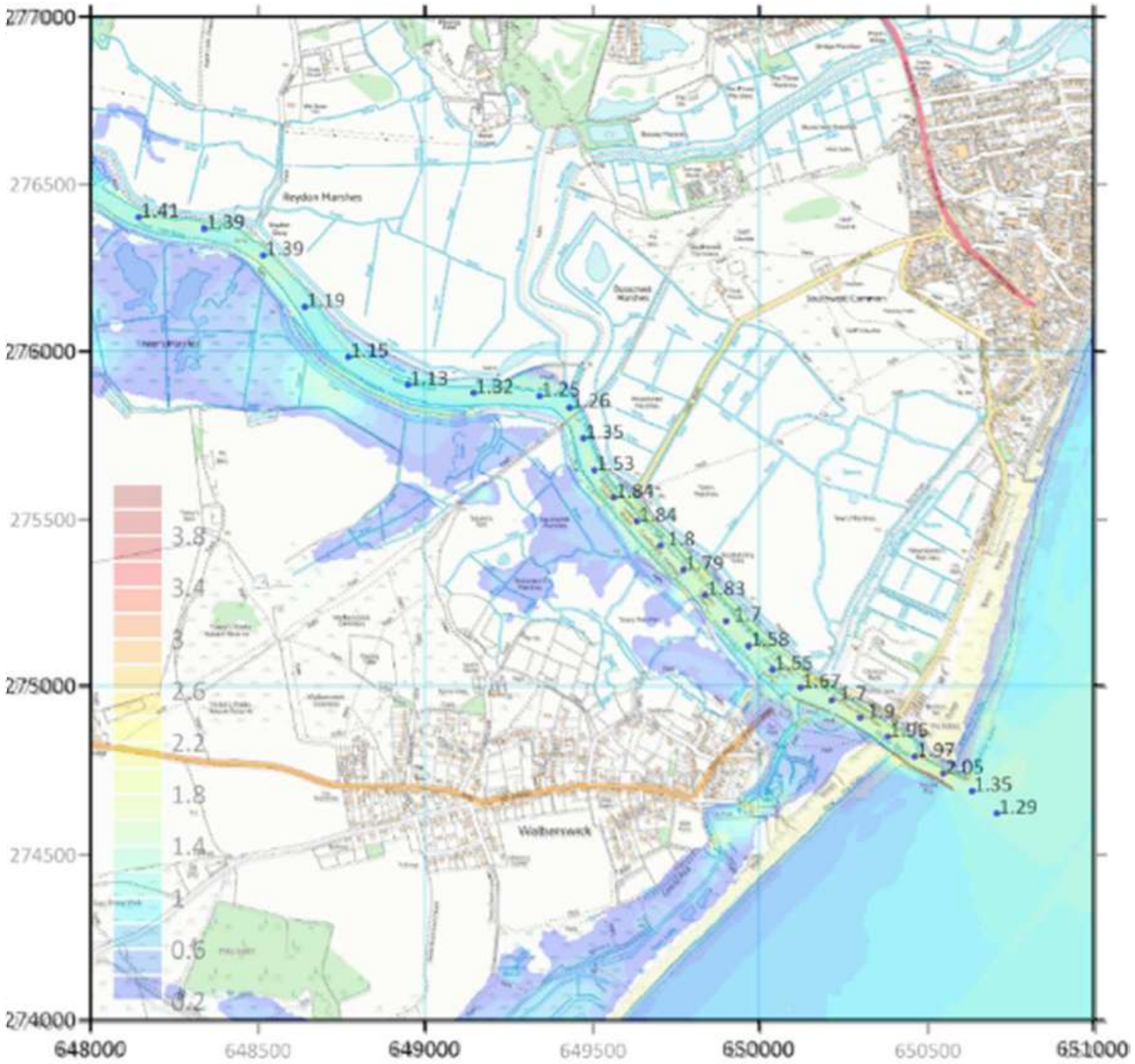
Scenario:
Present-day defences
Present-day marsh levels
2013 surge event



Royal HaskoningDHV

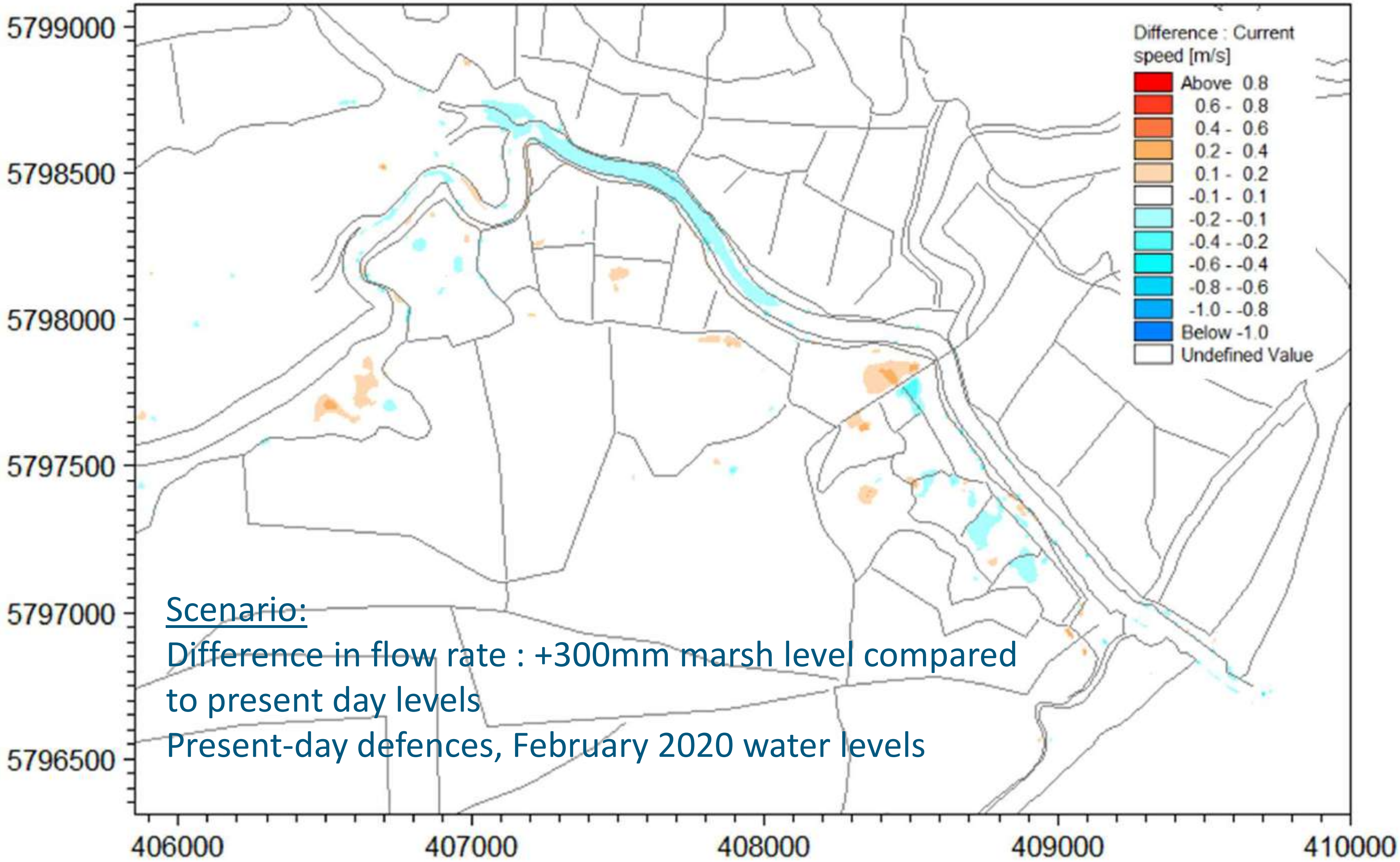
Sensitivity of flow rate to marsh level

<u>Scenario:</u>
Present-day defences
Marsh levels +300mm
2013 surge event



Royal HaskoningDHV

Sensitivity of flow rate to marsh level



Royal HaskoningDHV

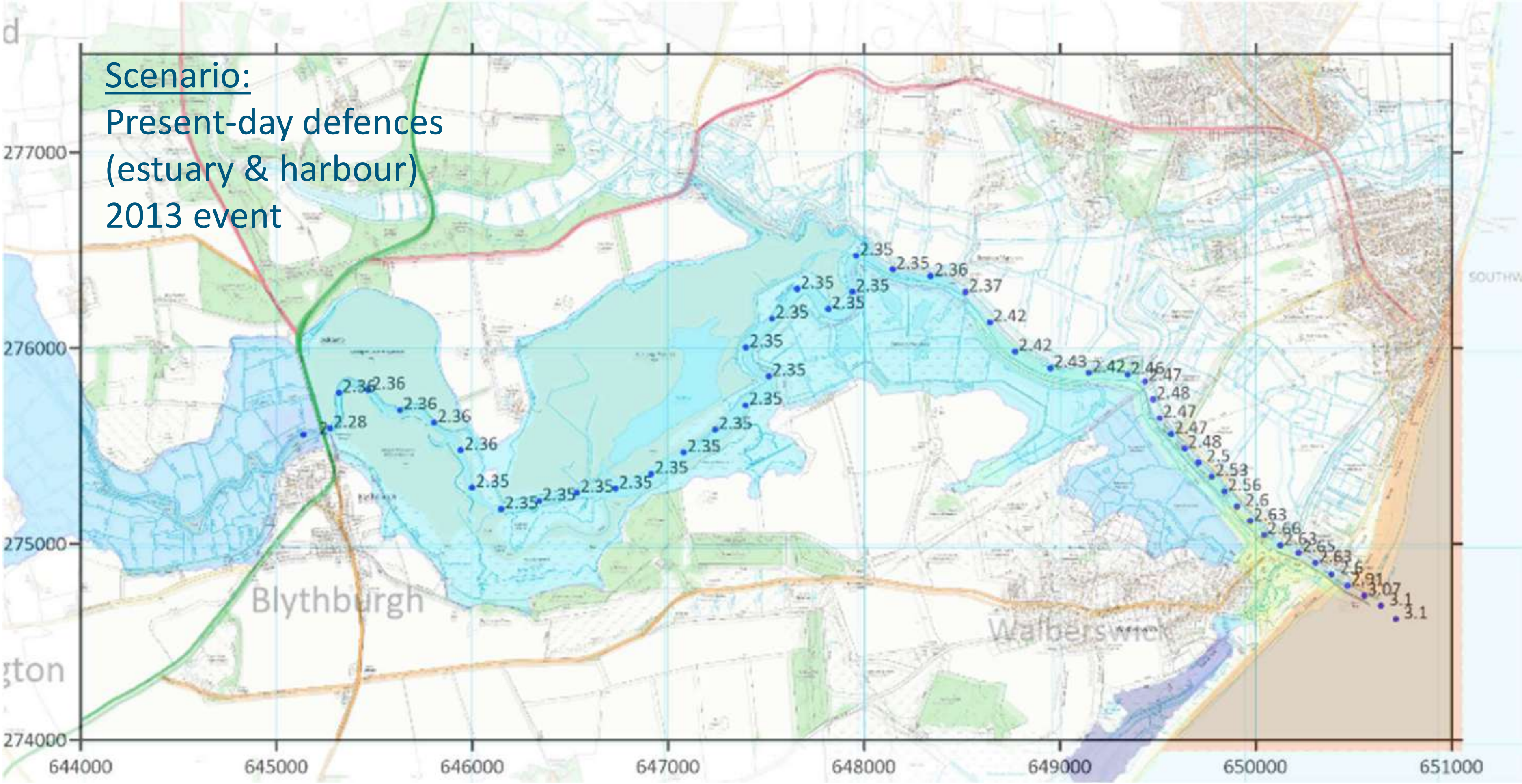
Sensitivity to marsh sedimentation (water levels, flow rates)

- **Results: Higher marsh levels reduce flooding and flow rates**
  - With flooding (e.g. 2013 conditions):
    - Higher marsh levels have less impact on water levels and flow rates
  - Without flooding (e.g. Feb 2020 conditions):
    - Water levels slightly higher for higher marsh levels
    - Flow rates are reduced
- Further tests needed to confirm how much sedimentation offsets sea level rise

Sensitivity to width of entrance channel

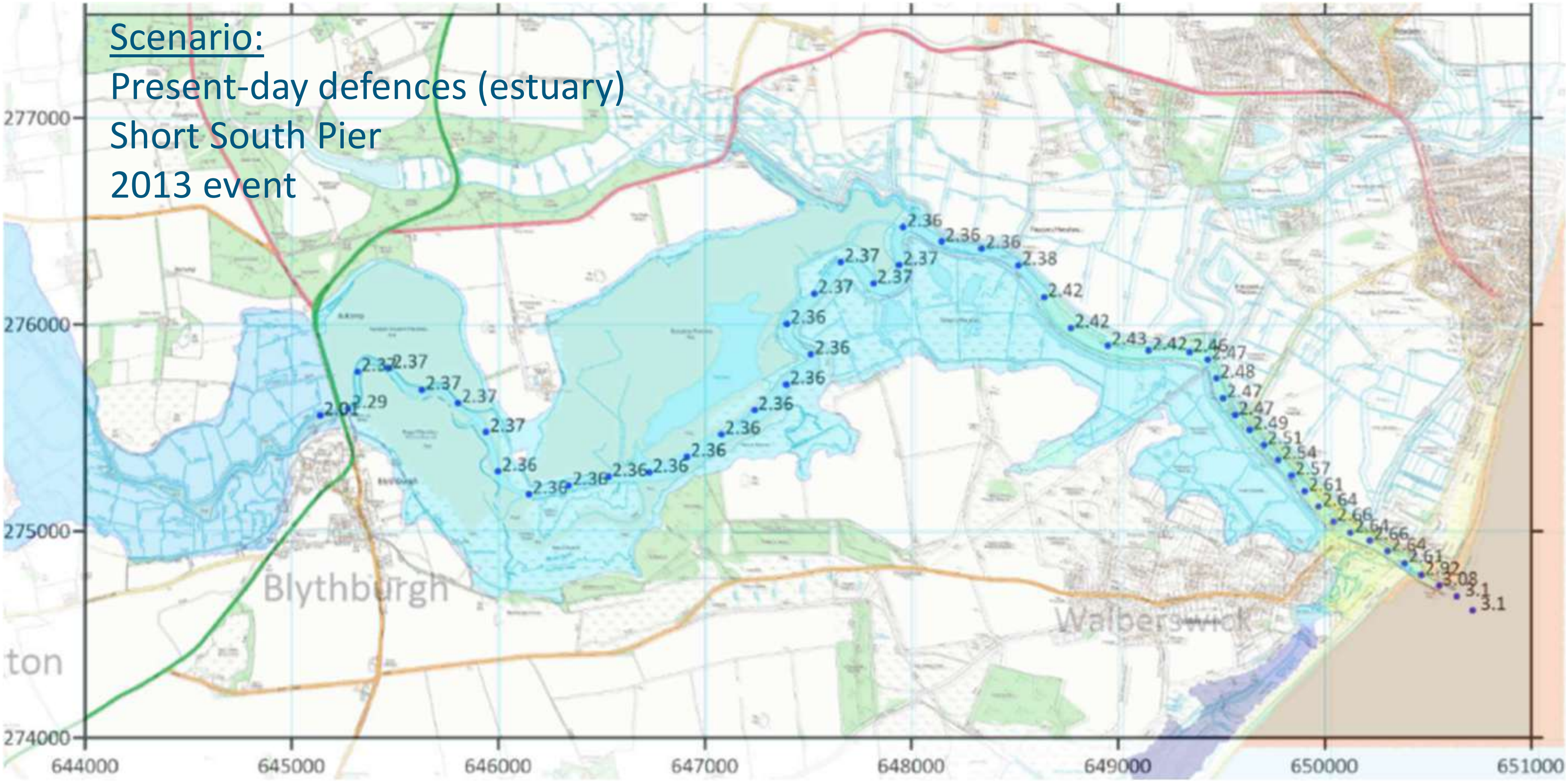
- Previous model results for wider entrance:
  - Lower water levels upstream than with existing harbour entrance
  - Results and input conditions checked; different assumptions had been applied
  - **Revised model results - little difference between short pier and existing entrance**
- Tidal model for solid South Pier:
  - **Upstream water levels / flow rates lower than for present-day conditions**
  - **Higher flow rates within the entrance channel (navigation impacts)**
- Wave model for solid South Pier:
  - **More wave disturbance within channel (all wave directions)**
  - **Worse for waves from North East (benefit of 'windows' in South Pier)**

Sensitivity of water level to channel width



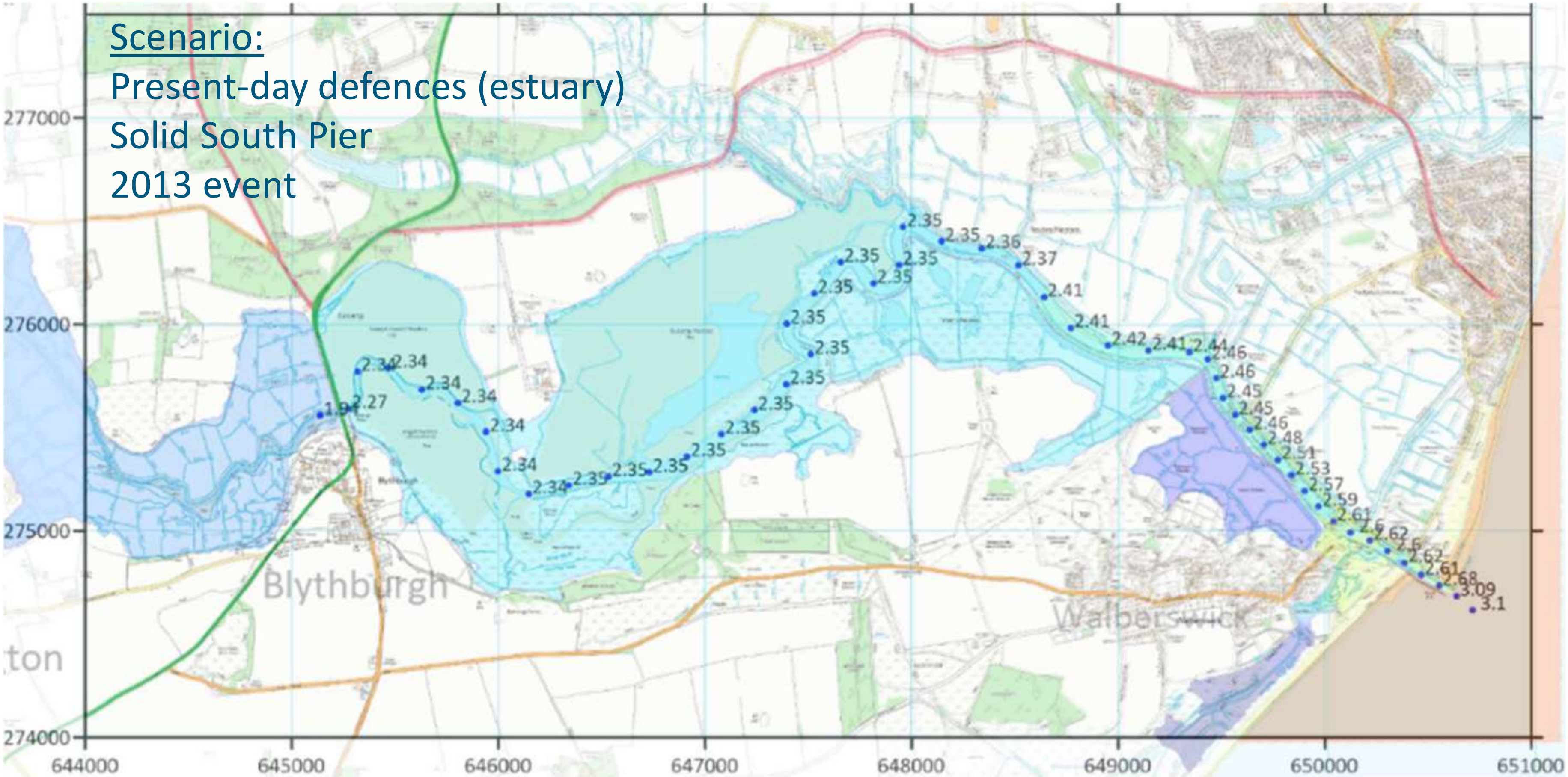
Royal HaskoningDHV

Sensitivity of water level to channel width



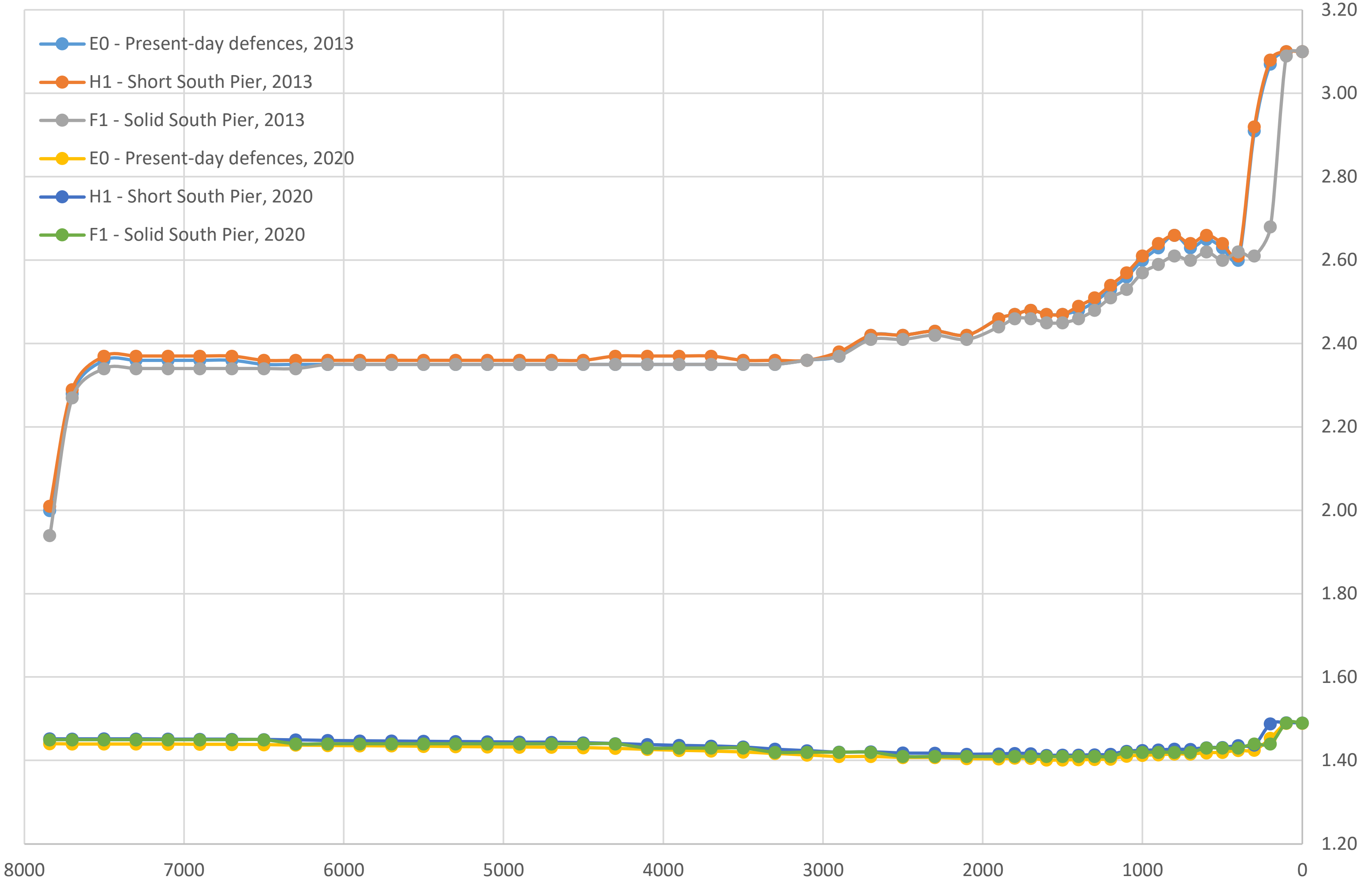
Royal HaskoningDHV

Sensitivity of water level to channel width



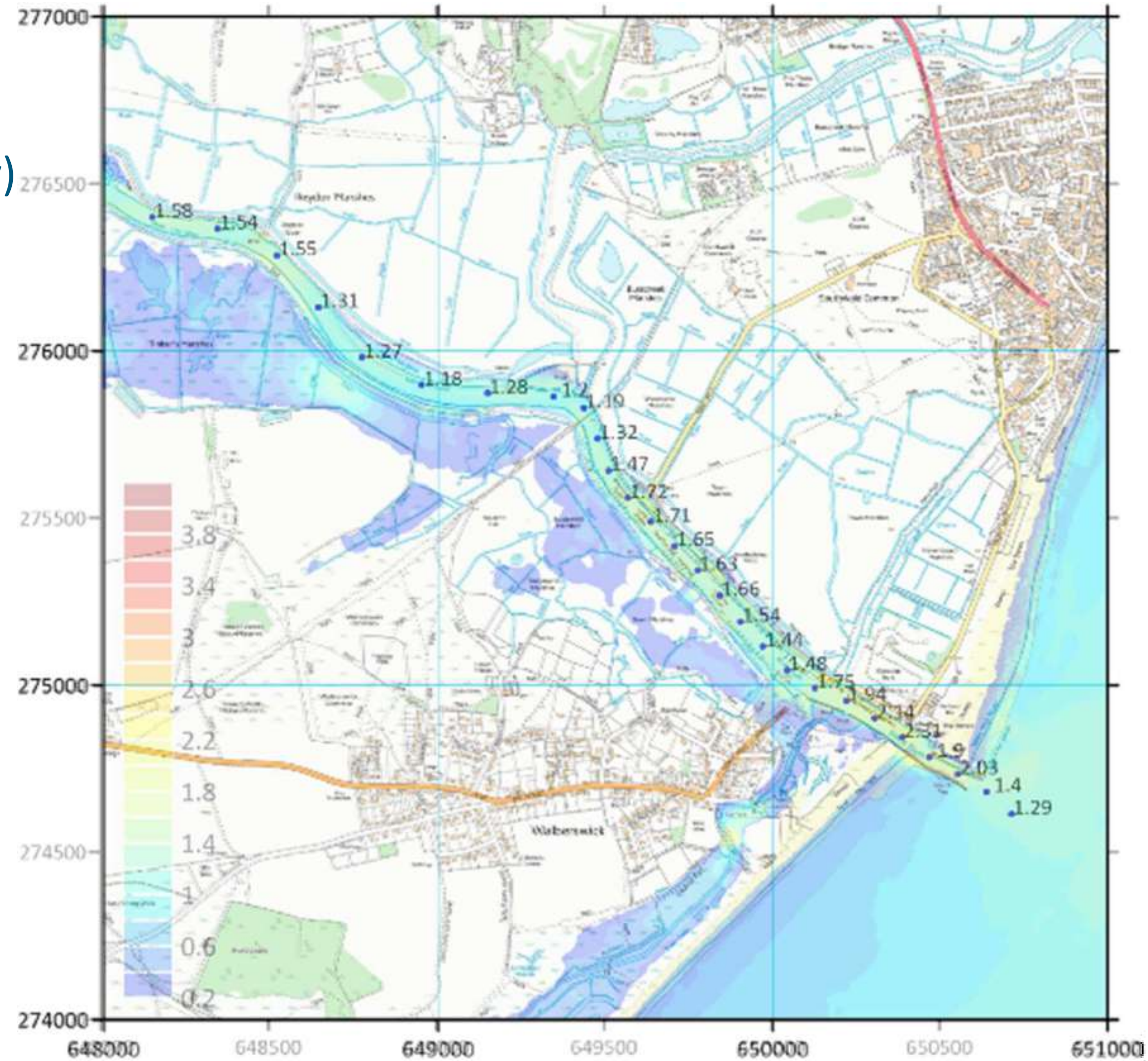
Royal HaskoningDHV

Comparison – variation in water level along channel



Sensitivity of flow rate to channel width

Scenario:
Present-day defences
(harbour entrance & estuary)
2013 event



Royal HaskoningDHV

Sensitivity of flow rate to channel width

Scenario:
Present-day defences (estuary)
Short South Pier
2013 event

Royal HaskoningDHV

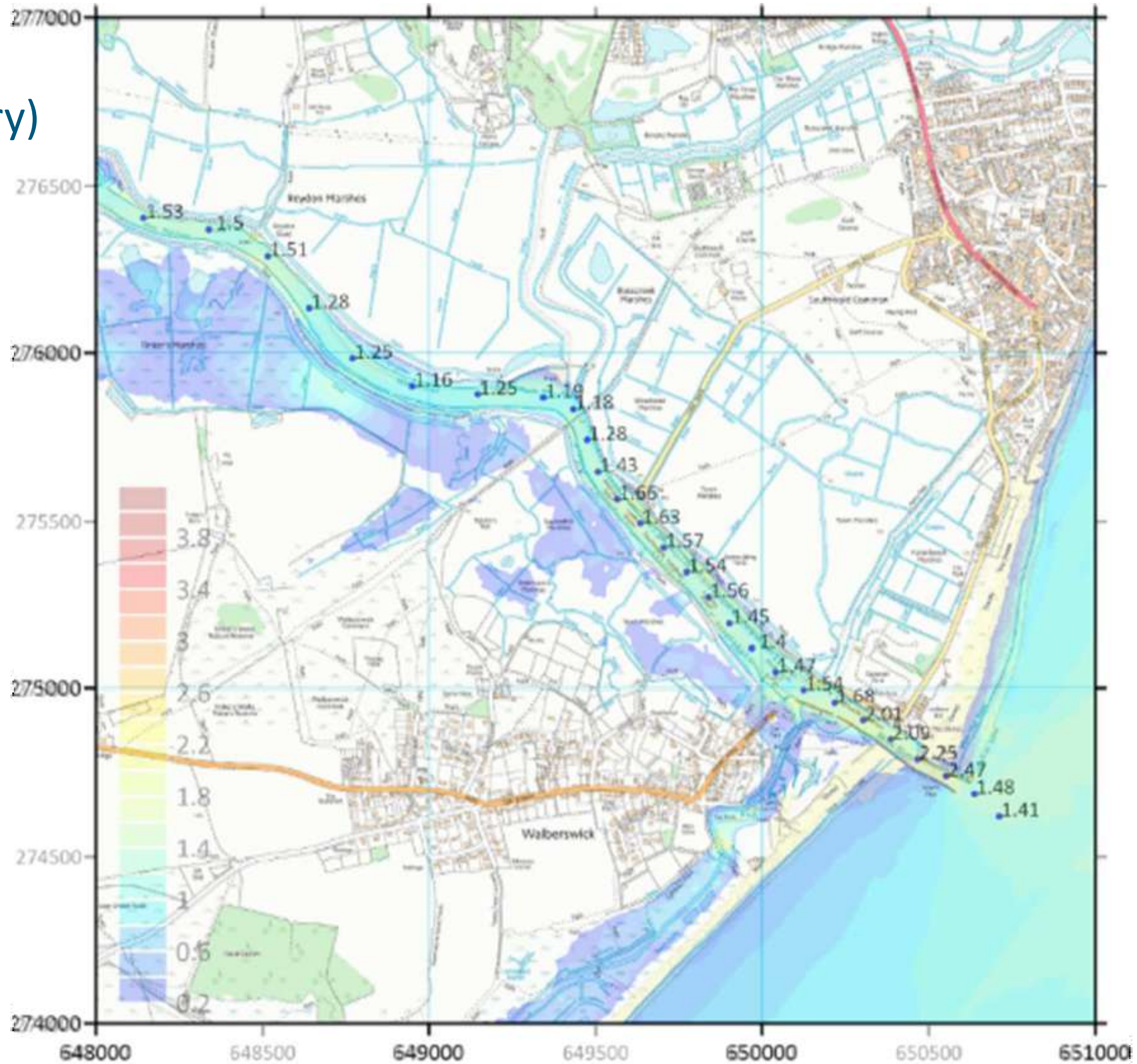
Sensitivity of flow rate to channel width

<u>Scenario:</u>

Present-day defences (estuary)

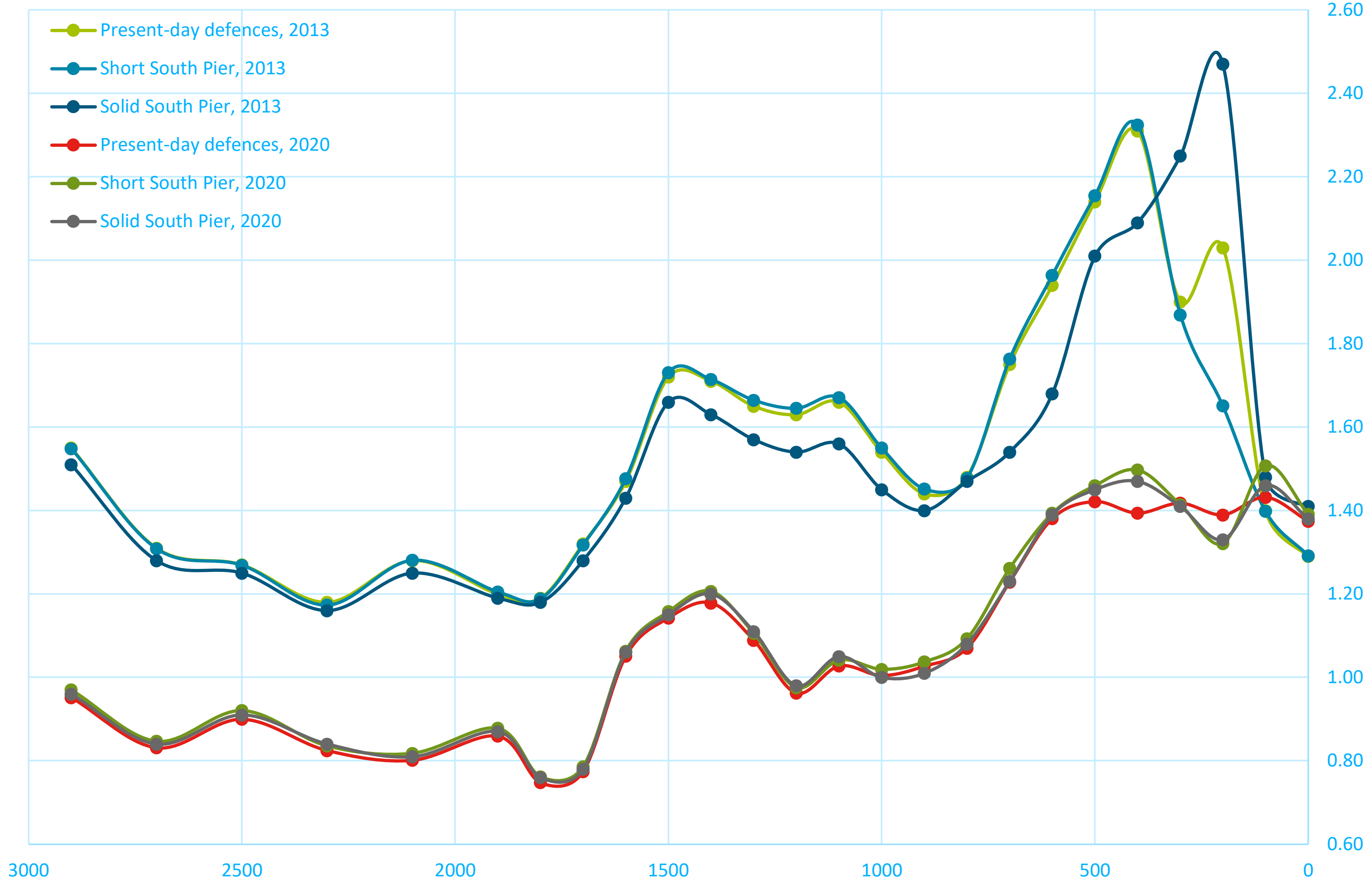
Solid South Pier

2013 event



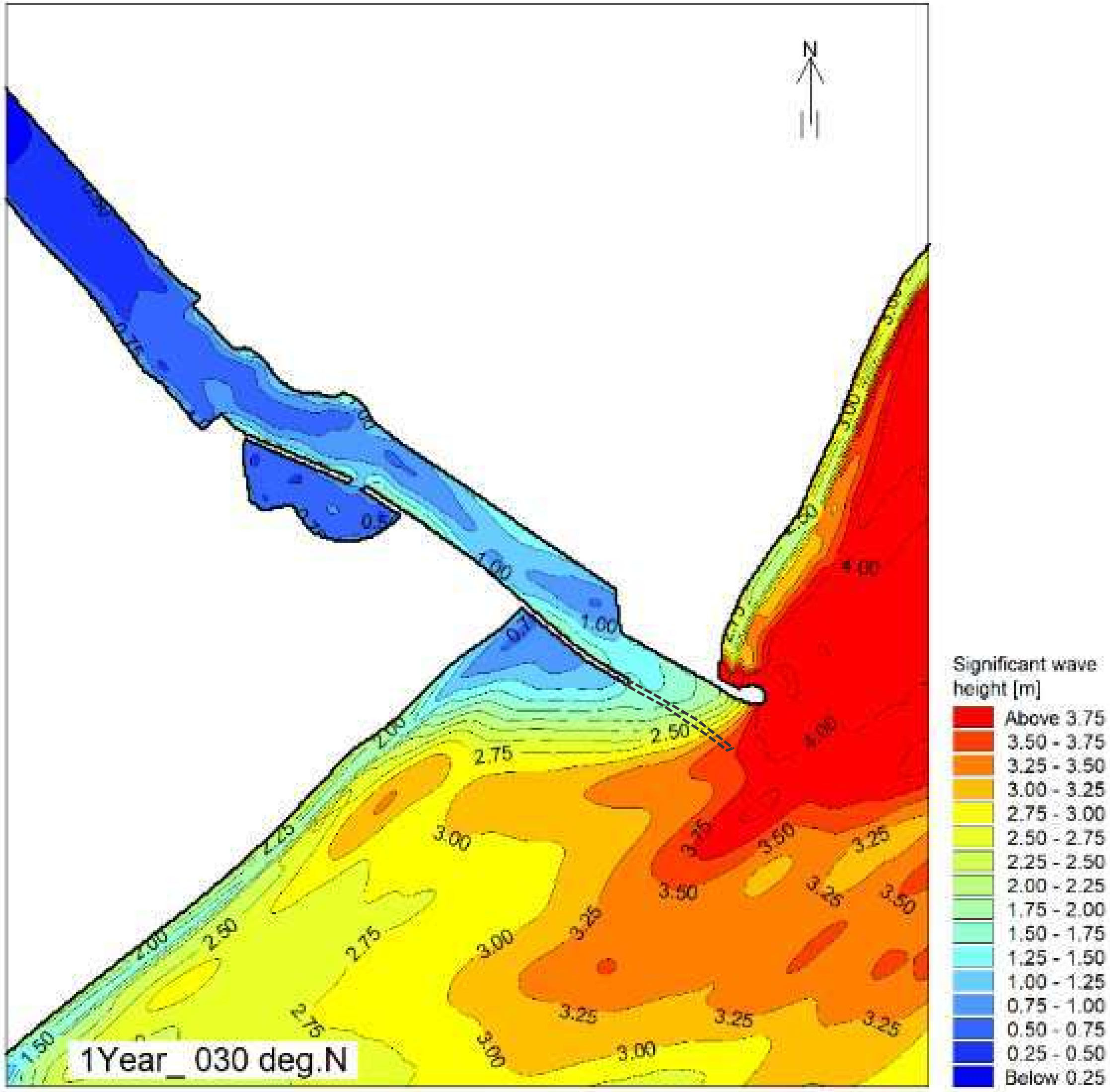
Royal HaskoningDHV

Comparison – variation in flow rate along channel



Sensitivity of wave conditions to channel form

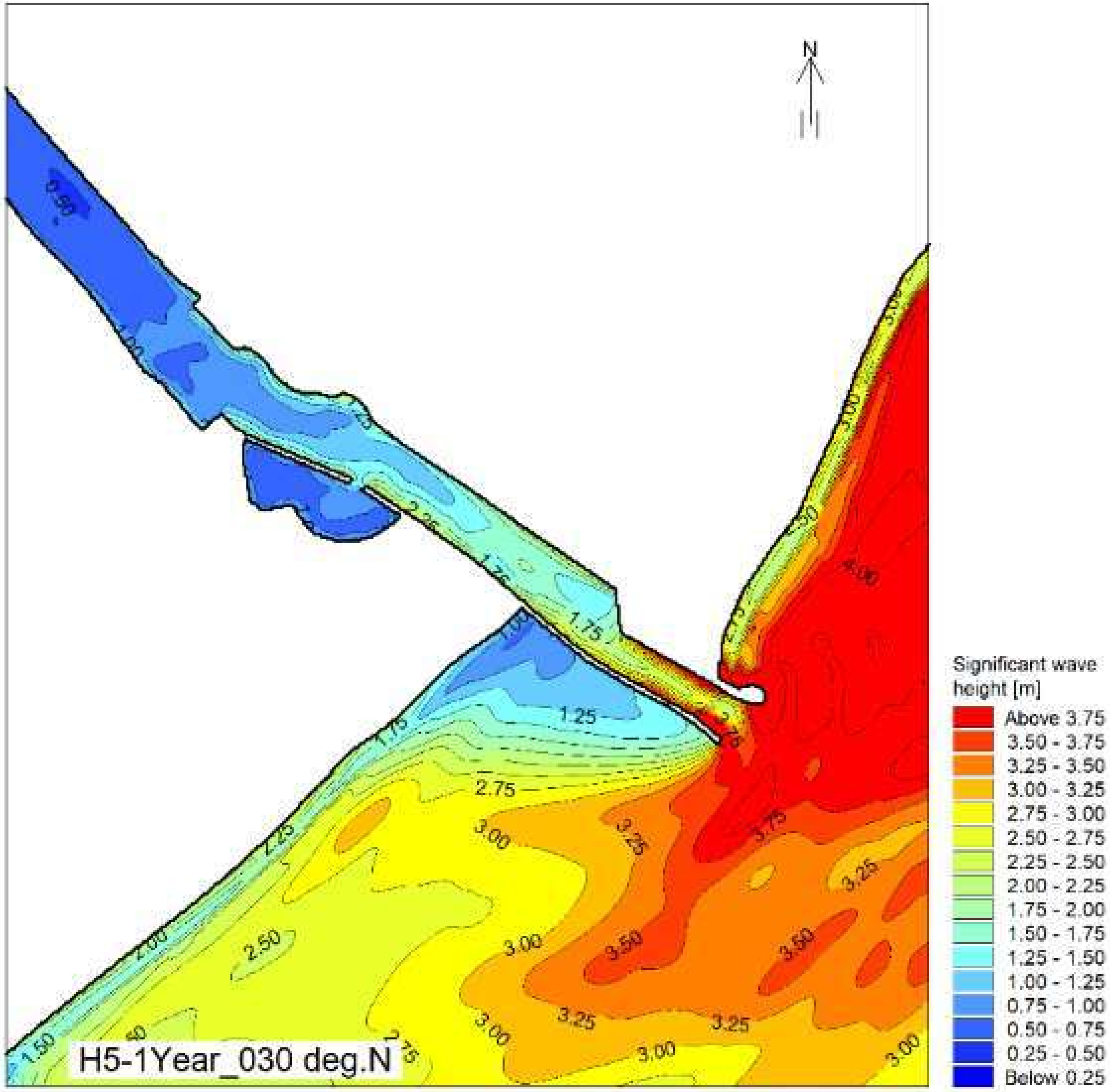
Scenario:
Present-day harbour entrance
1-year return period wave conditions
Waves from 30 deg



Royal HaskoningDHV

Sensitivity of wave conditions to channel form

Scenario:
Solid South Pier
1-year return period
wave conditions
Waves from 30 deg

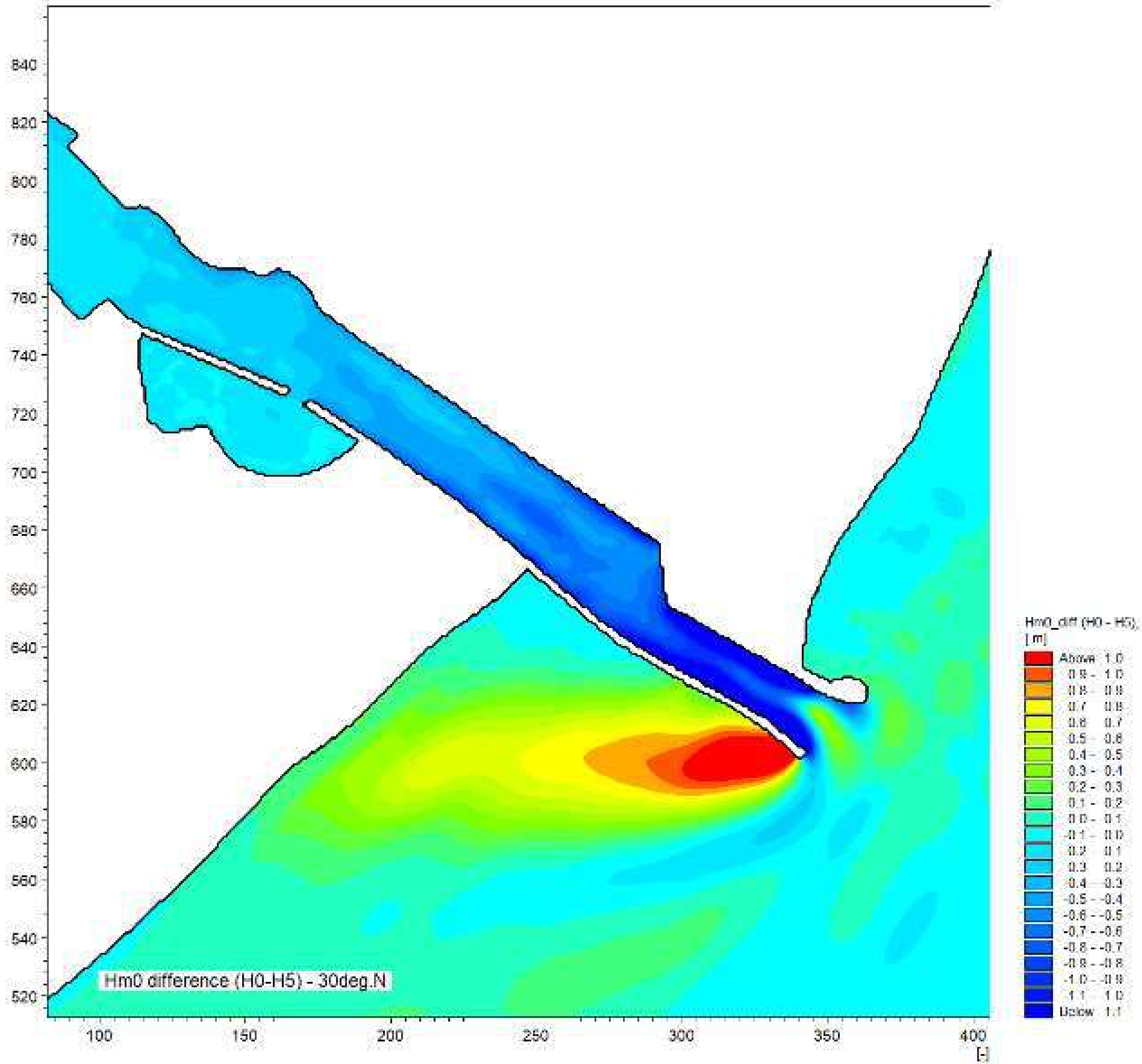


Royal HaskoningDHV

Sensitivity of wave conditions to channel form

<u>Scenario:</u>
Difference in wave height for present-day entrance channel compared to a solid South Pier

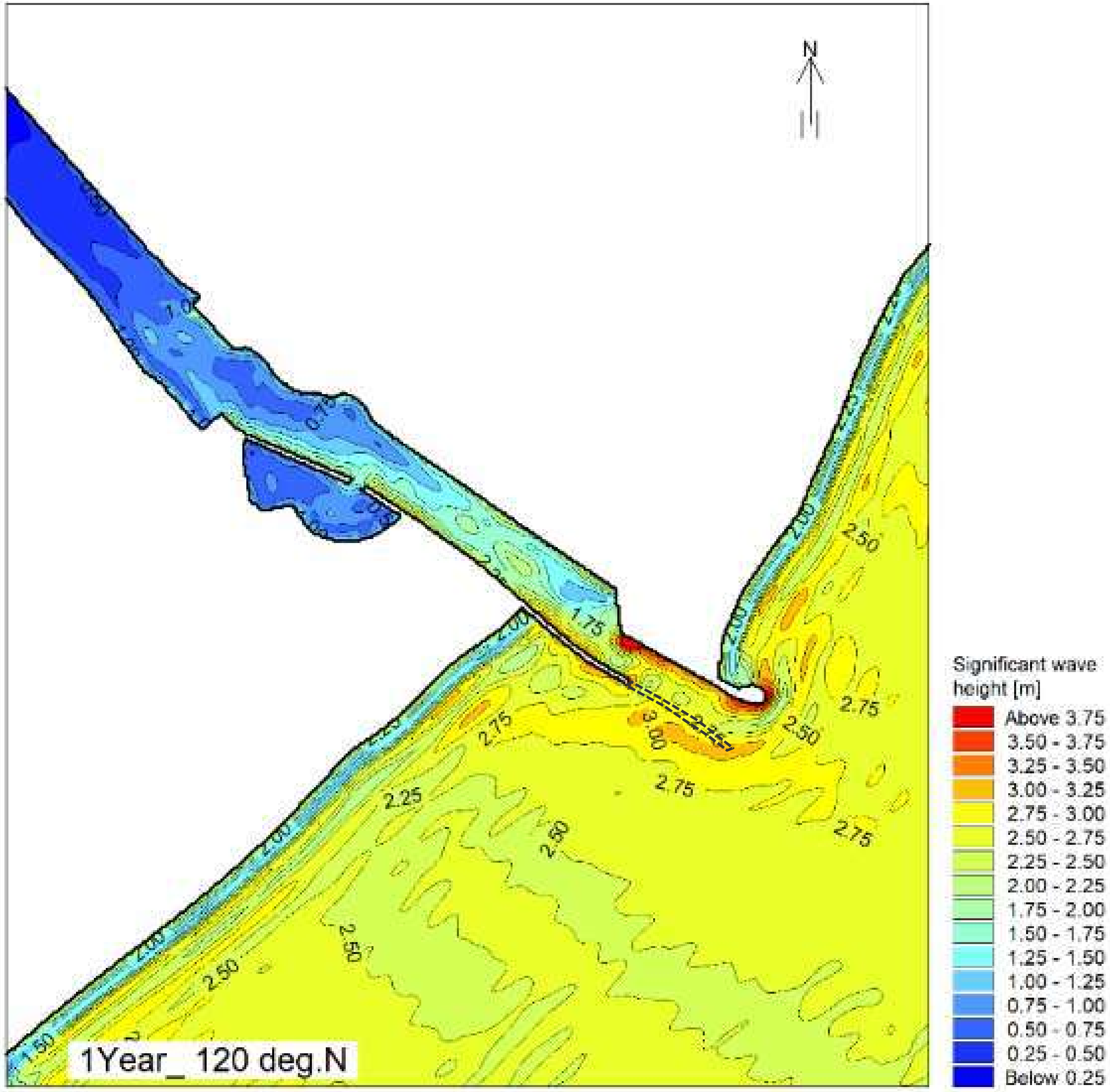
1-year return period wave conditions
Waves from 30 deg



Royal HaskoningDHV

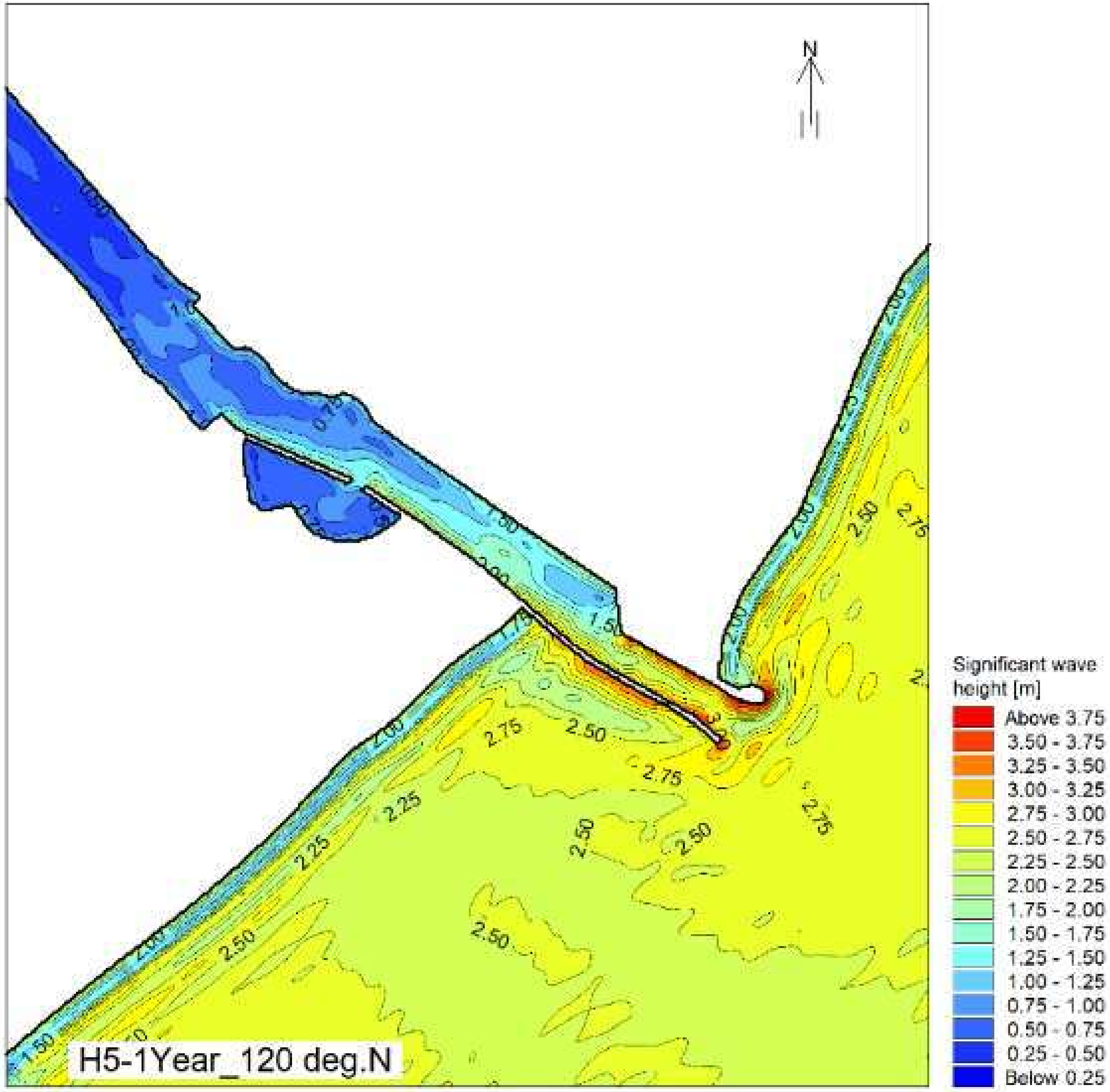
Sensitivity of wave conditions to channel form

<u>Scenario:</u>
Present-day harbour entrance
1-year return period wave conditions
Waves from 120 deg



Sensitivity of wave conditions to channel form

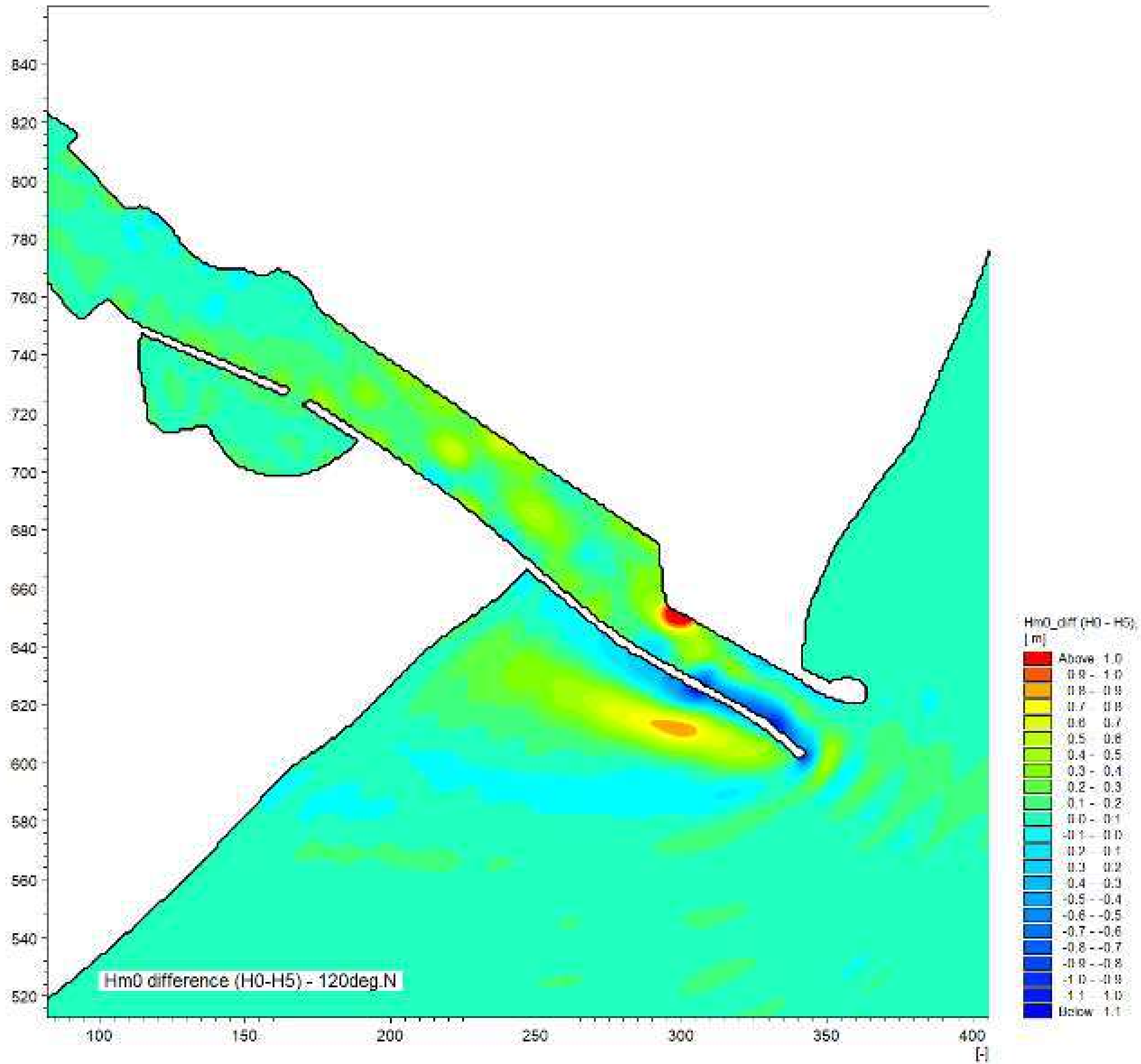
<u>Scenario:</u>
Solid South Pier
1-year return period wave conditions
Waves from 120 deg



Sensitivity of wave conditions to channel form

<u>Scenario:</u>
Difference in wave height for present-day entrance channel compared to a solid South Pier

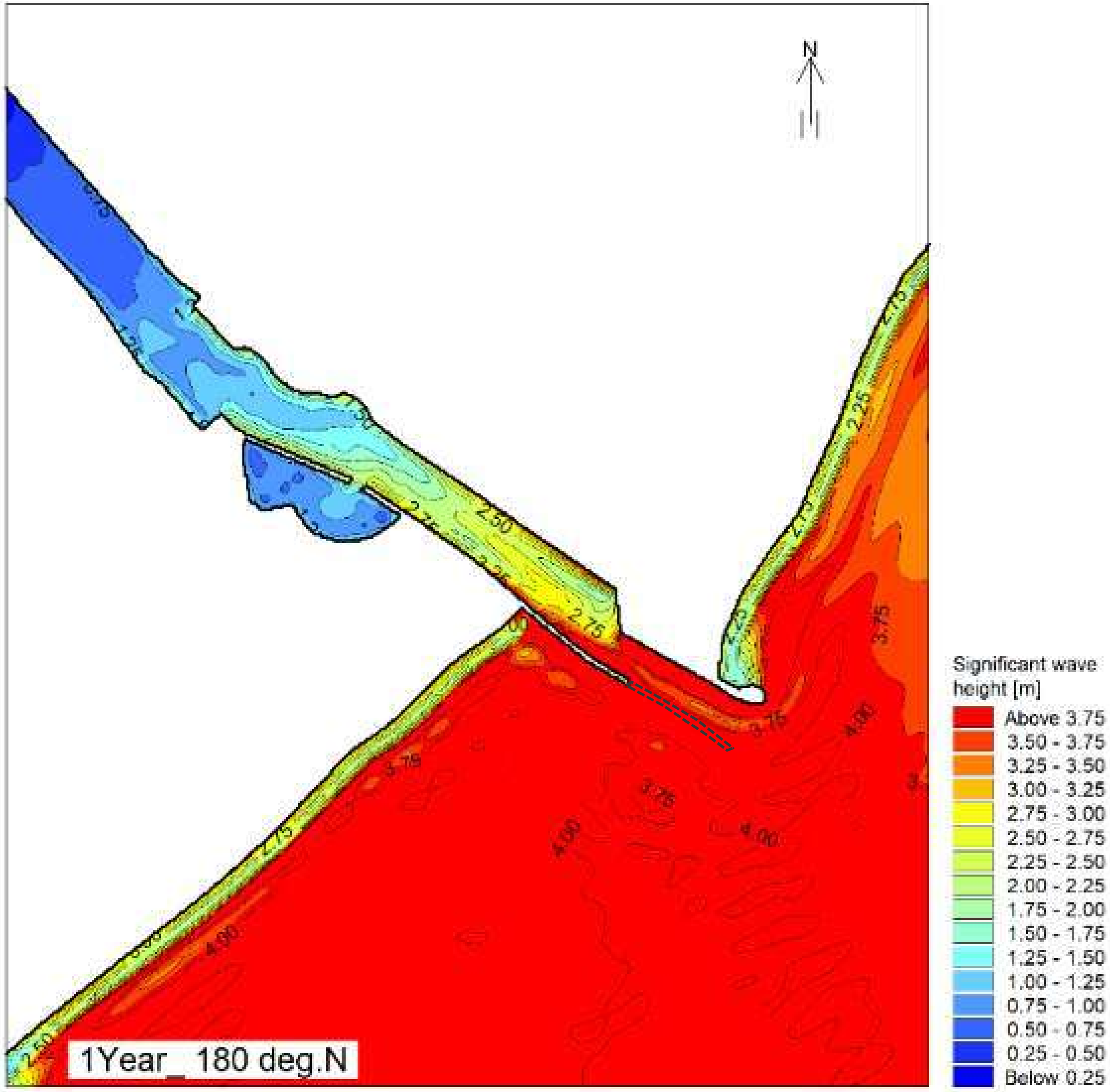
1-year return period wave conditions
Waves from 120 deg



Royal HaskoningDHV

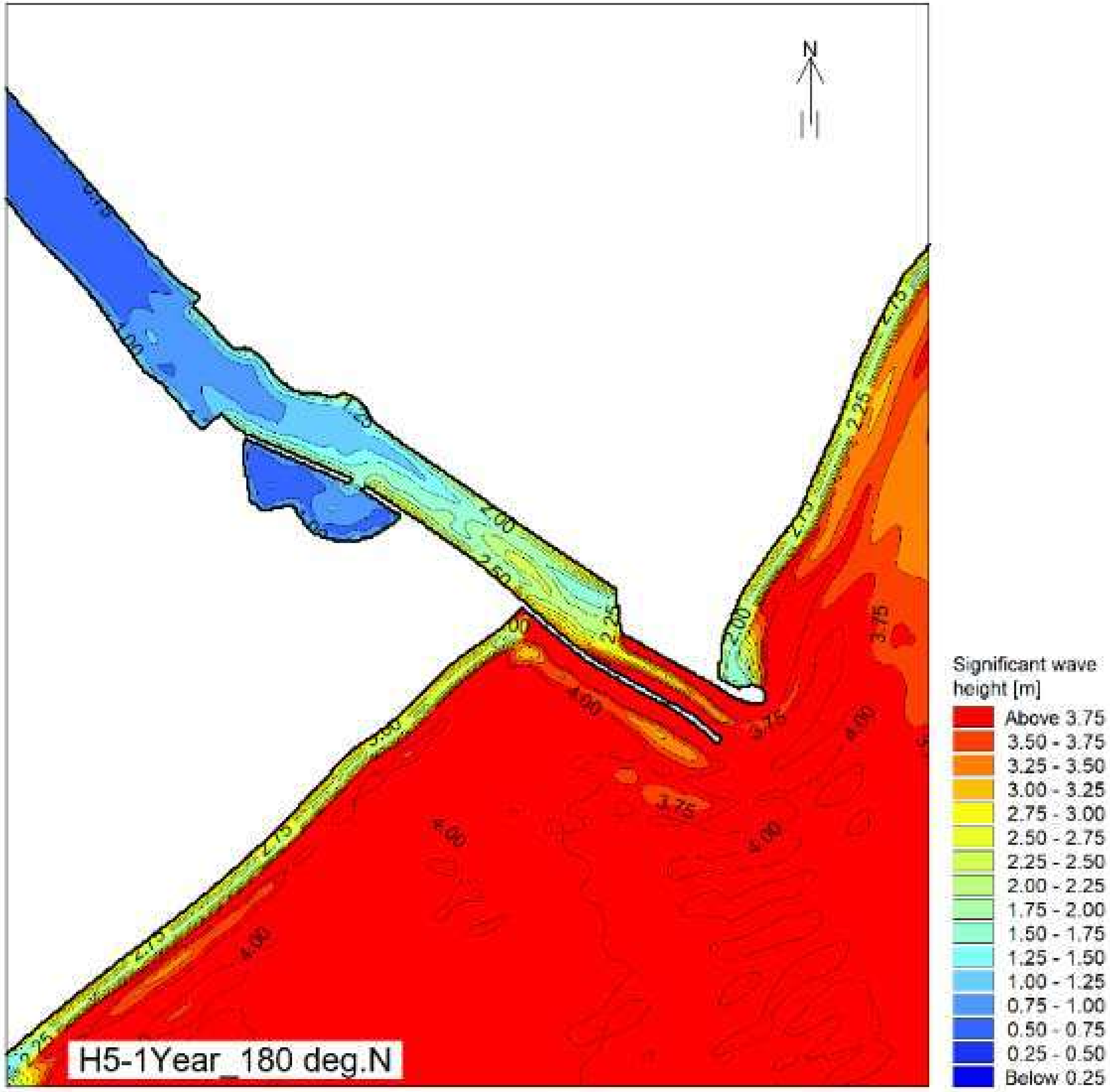
Sensitivity of wave conditions to channel form

Scenario:
Present-day harbour entrance
1-year return period wave conditions
Waves from 180 deg



Sensitivity of wave conditions to channel form

<u>Scenario:</u>
Solid South Pier
1-year return period
wave conditions
Waves from 180 deg

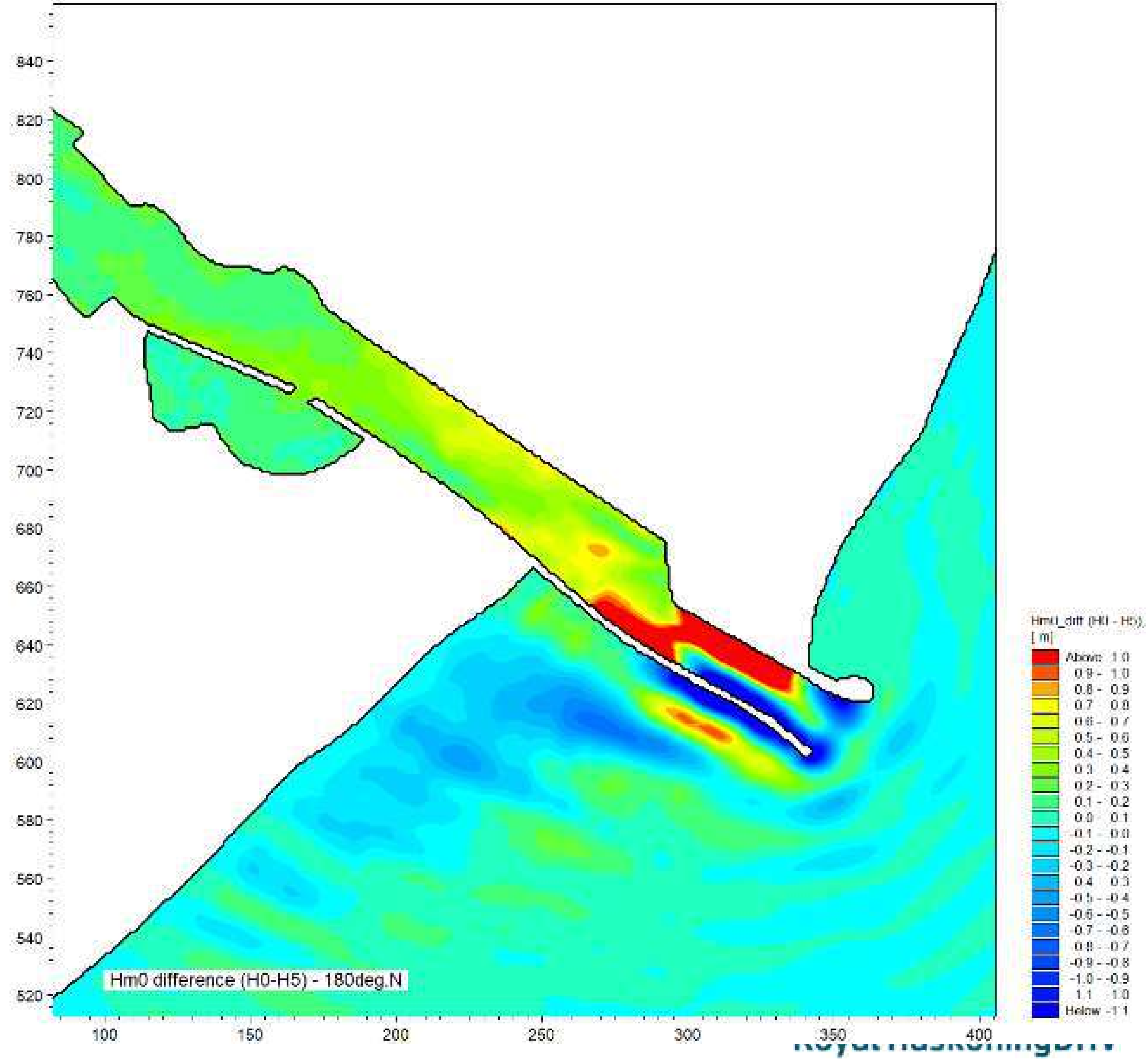


Royal HaskoningDHV

Sensitivity of wave conditions to channel form

<u>Scenario:</u>
Difference in wave height for present-day entrance channel compared to a solid South Pier

1-year return period wave conditions
Waves from 180 deg



Sensitivity to width of entrance channel

- Conclusions:
  - **Little difference in conditions comparing a short pier to the existing harbour entrance**
  - For a more constrained entrance channel:
    - **Upstream water levels / flow rates lower**
    - **Higher flow rates within entrance channel**
    - **More wave disturbance within channel**
    - **Higher waves within harbour due to waves from North East**
- Objectives for new harbour structures:
  - Maintain conditions for navigation
  - Address impacts of increasing tidal prism

Discussion – benefit of 'windows' in South Pier

Option to narrow the entrance channel?

- Proposed ‘pinch point’ with flap valves:
  - Technically possible, could reduce upstream water levels
  - Constraints:
    - Impacts on navigation, from increased flows in entrance channel, and from the narrowed section itself
    - Scour risk due to high flows
    - Substantial structure needed, high cost
    - Operational concerns for large flap valves in marine environment

Maintaining transmission through South Pier

- Options considered:
  1. Concrete frame structure (as existing)
  2. Piled channels through breakwater – rejected
  3. Sections of breakwater with a lower crest level to allow overtopping– rejected
  4. Box culverts through breakwater
     - Optimise position, level, alignment
     - Align to minimise wave penetration
     - Modelling - compare with present conditions
     - Culverts at inner end of breakwater:
       - Could help drain a surge event
       - Risk of scour
       - Increase in flow into harbour
- ***Discussion of options***

Tidal barrier options

- Tidal barrier across channel, upstream of Lifeboat Station
- Reduce tidal flood risk to estuary & Blackshore
- Substantial structure, high cost
- No need for works to estuary embankments
- Works still required to:
  - Harbour entrance structures
  - Seaward defences (embankments, dunes)
  - Blackshore (depending on operational conditions)
- Significant operational and maintenance requirements
- Risk of flooding upstream if there are high fluvial flows when barrier is closed

Royal HaskoningDHV

Tidal barrier options

- Radial barrier:
  - Similar to Thames Barrage
  - Rotates up from channel bed into closed position
  - Cost £50-70 million
  - To be included in Investment Plan, combined with works to harbour structures and possibly works to the Blackshore
- Vertical lifting gate (rejected):
  - Could be lower cost than radial barrier
  - Not best practice due to visual impact and safety concerns, therefore rejected

Tidal barrier options

- Rising gate (rejected):
  - Higher cost that than radial barrier
  - Slow to operate, increased risk of fluvial flooding
- Floating barrier (rejected):
  - River and tidal currents can make deployment of a floating barrier very difficult
  - The barrier itself can generate disruptive flows that interfere with its operation
  - Will take up space in the channel when not in use
  - Risk that fluvial flows / water pressure from upstream will unseat the barge
  - Cannot be opened / closed on a rising tide, increasing the risk of fluvial flooding


Flood Risk to Blackshore

- We have completed an initial review of the issues and possible options
- ***Discuss your aims and constraints***
- We will then develop and price the options
- To be included in the Investment Plan


Royal HaskoningDHV

Flood Risk to Blackshore

- We have completed an initial review of the issues and possible options
- ***Discuss your aims and constraints***
- We will then develop and price the options
- To be included in the Investment Plan

Spillway option

- Scope extended to consider spillway option:
  - Embankments protect against ‘normal’ events
  - Reinforced spillway(s) - overtopping happens at a known location on extreme events
  - Reduces risk of embankment failure
- Review a range of spillway dimensions:
  - Performance (flood extent & depth in marshes, likely impact on water levels)
  - Cost sensitivity (embankment height)
- Discuss results at next meeting
- Tidal model to assess water levels and flow rates for preferred arrangement
- Include in Investment Plan

Next steps

- Next meeting:
  - Flood risk to Blackshore
  - Spillway option
- Further work on those issues
- Develop Investment Plan
  - Finalise cost estimates (harbour structures, estuary defences, Blackshore)
  - Confirm timelines
  - Monitoring & maintenance
- Meeting to share draft Investment Plan
- Reporting
- Cost-benefit analysis
- ***Anything else?***

Response to questions and comments

- Further information to be provided on the impact of sedimentation on flood risk and flow rate, to include model animations.
- We will contact Archer and Marcus directly for information about the benefits of the windows through the South Pier.
- Option to constrict harbour entrance (with flap valves) may need to be considered further e.g. if spillway option doesn't work.
- Options to address flood risk to consider full length of harbour, not just Blackshore. Resilience options to be considered.
- Previous option to construct sill at Bailey Bridge to be checked.

Southwold Harbour Study

Stakeholder Workshop 5

1st April 2021

Agenda

Welcome & Agenda	11.30
Aims & objectives for this meeting	11.35
Sensitivity to marsh level (tidal prism)	11.40
Spillway option to reduce flood risk	12.10
Next Steps	12.50
FINISH	13.00

Aims and Objectives of this Workshop

- Address issues raised after last meeting
- Input into development of spillway option
- Review the next steps

Your comments on sensitivity to marsh sedimentation

- *"the assumption that sea level will rise but marsh levels won't increase gives us the worst-case scenario for the future harbour conditions…this is factually incorrect"*
- *"Flooding is the biggest risk to the future of the Harbour and … is currently being made* ***worse*** *by increasing sedimentation. Since the 1950s the tidal prism has been reducing leading to increased flooding risk in the harbour."*
- *"The breaching of the embankments / walls after the 1953 floods increased the floodplain again preventing silting up at the harbour entrance but this is now declining due to silt deposition in the marshes."*

Further review of marsh sedimentation issues

- Issues to be addressed:
  - Assumed sedimentation
  - Impact of sedimentation on flood levels
  - Impact of sedimentation on flows
- What we have modelled:
  - Marsh levels +300mm, +600mm
  - Present day defences, Do Nothing, Raised embankments
  - Feb 2020, Dec 2013 water levels

Impact of sedimentation on water levels and flows

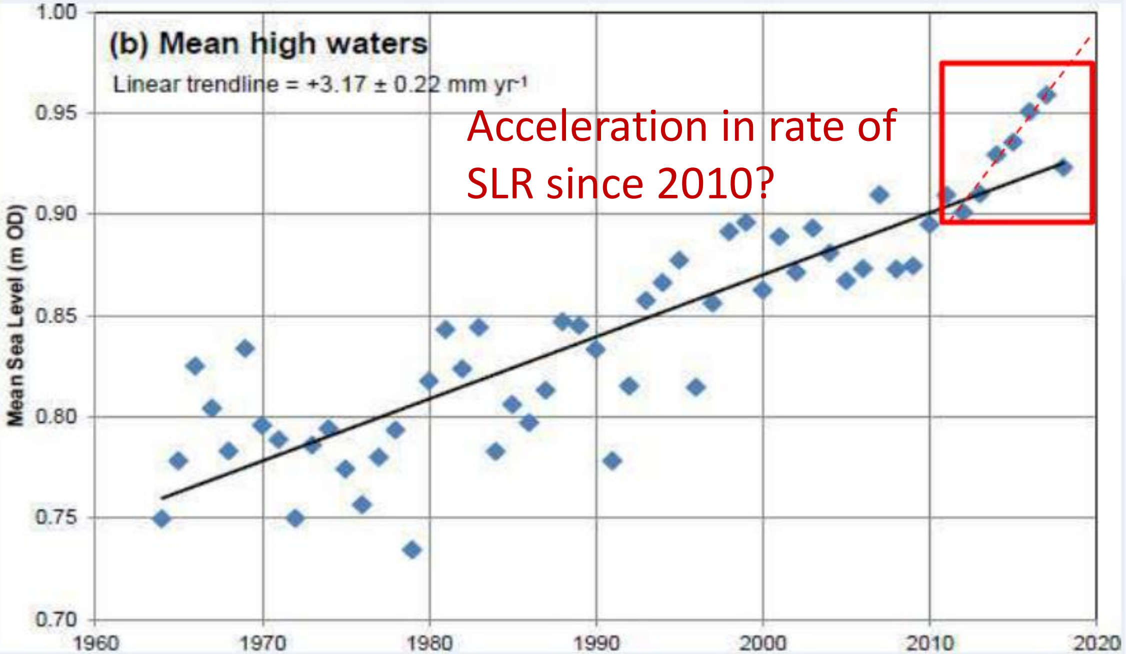
- An increase in marsh levels doesn't push peak flood levels up by the same volume
- By locally pushing up water levels, the volume of the tide entering the estuary is reduced, which can reduce peak flood levels again
- Net impact on peak flood levels is not simple to predict, depends on:
  - dimensions of the estuary
  - ratio between depth, width and length of channels and floodplains
  - tide and surge levels
  - influence of the dynamics and inertia of the water
- Processes are captured by the modelling software, modelling shows what the impacts are for Southwold
- **Animation – illustration of flow in the estuary**

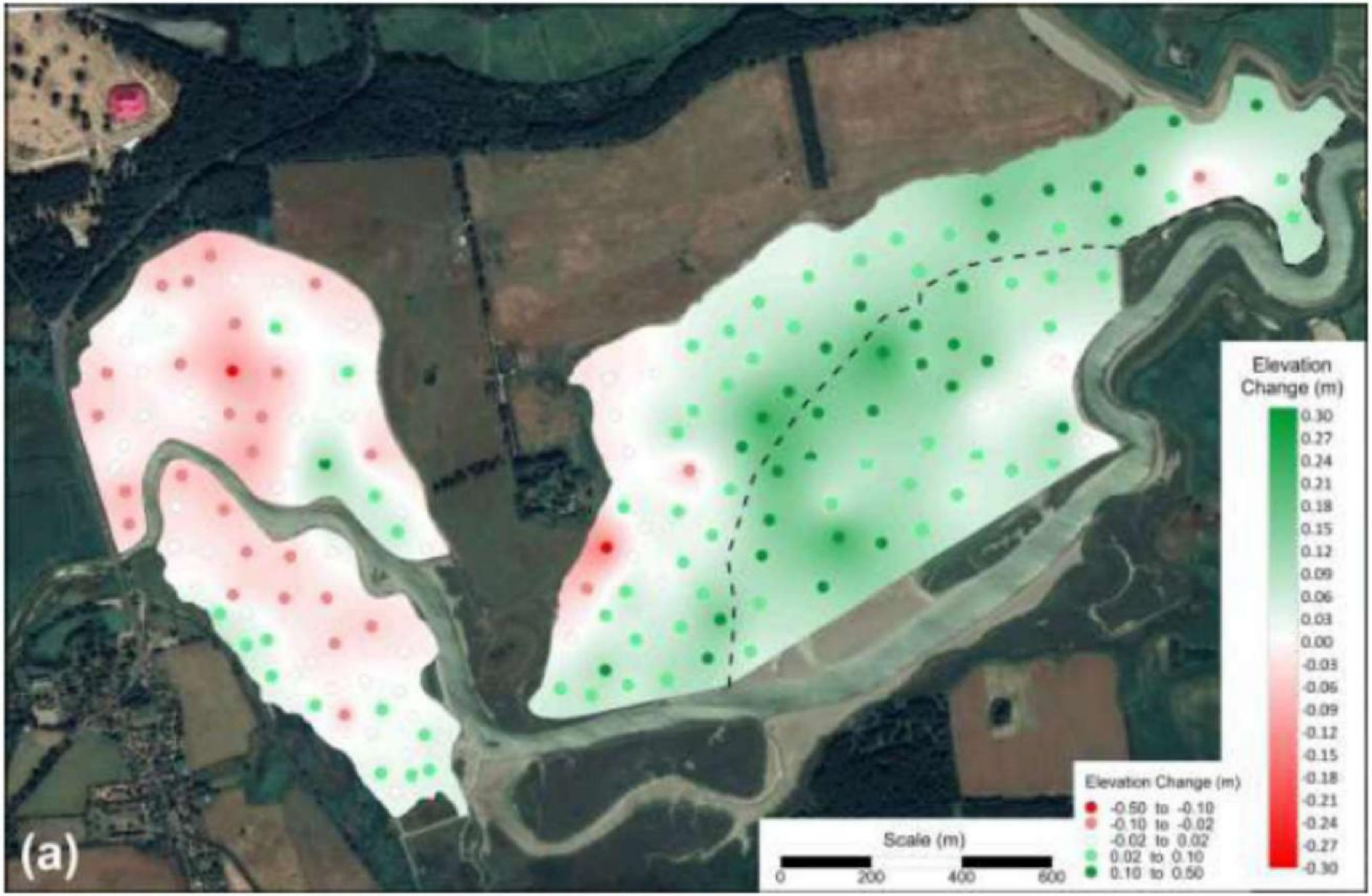
Assumptions for future marsh levels

- Sedimentation study (Pye, 2019):
  - Average sedimentation (1943-2019) = 6 mm/yr
  - Average sedimentation (2008-2019) = 3 mm/yr (marsh levels have reduced in places)
  - Average SLR (1964-2018) = 3 mm/yr
  - Projected SLR (2019-2069) = 3 - 10 mm/yr
  - UKCP Scenario RCP4.5 (50%) = 6 mm/yr

Assumptions for future marsh levels

		Sandpit Covert Marsh (n=39)	Angel Marshes (n=36)	Bulcamp Old Marshes (n=59)	Bulcamp New Marshes (n=36)	Bulcamp Old and New Marshes (n=95)	All marshes (n=170)
Sedimentation rate 1943-2019 (mm/yr)	Max	15.47	9.29	18.82	17.63	18.82	18.82
	Min	1.13	0.80	0.89	4.61	0.89	0.80
	Mean	5.41	4.58	6.18	9.85	7.57	6.44
	Median	**4.26**	**4.36**	**5.00**	**9.16**	**7.82**	**5.57**
	Stdev	3.36	1.97	4.23	2.74	4.12	3.81
Sedimentation rate 2008-2019 (mm/yr)	Max	11.82	5.45	21.18	22.64	22.64	22.64
	Min	-10.82	-5.73	-13.09	-1.55	-13.09	-13.09
	Mean	-1.46	-0.04	5.82	9.14	7.08	3.61
	Median	**-1.45**	**0.27**	**5.91**	**9.05**	**7.91**	**3.00**
	Stdev	4.16	2.81	5.66	5.41	5.77	6.29
Sedimentation rate 2008-2019 (number of data points)	>+1 mm/yr	8	17	49	34	83	108
	-1 to +1 mm/yr	10	4	5	1	6	20
	<-1 m/yr	21	15	5	1	6	42
Sedimentation rate required to keep pace with MSL rise 1964-2018 (mm/yr)		3.08	3.08	3.08	3.08	3.08	3.08




Elevation Change (m)
0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0.00
-0.03
-0.06
-0.09
-0.12
-0.15
-0.18
-0.21
-0.24
-0.27
-0.30
Elevation Change (m)
-0.50 to -0.10
-0.10 to -0.02
-0.02 to 0.02
0.02 to 0.10
0.10 to 0.50
Scale (m)
0
200
400
600
(a)

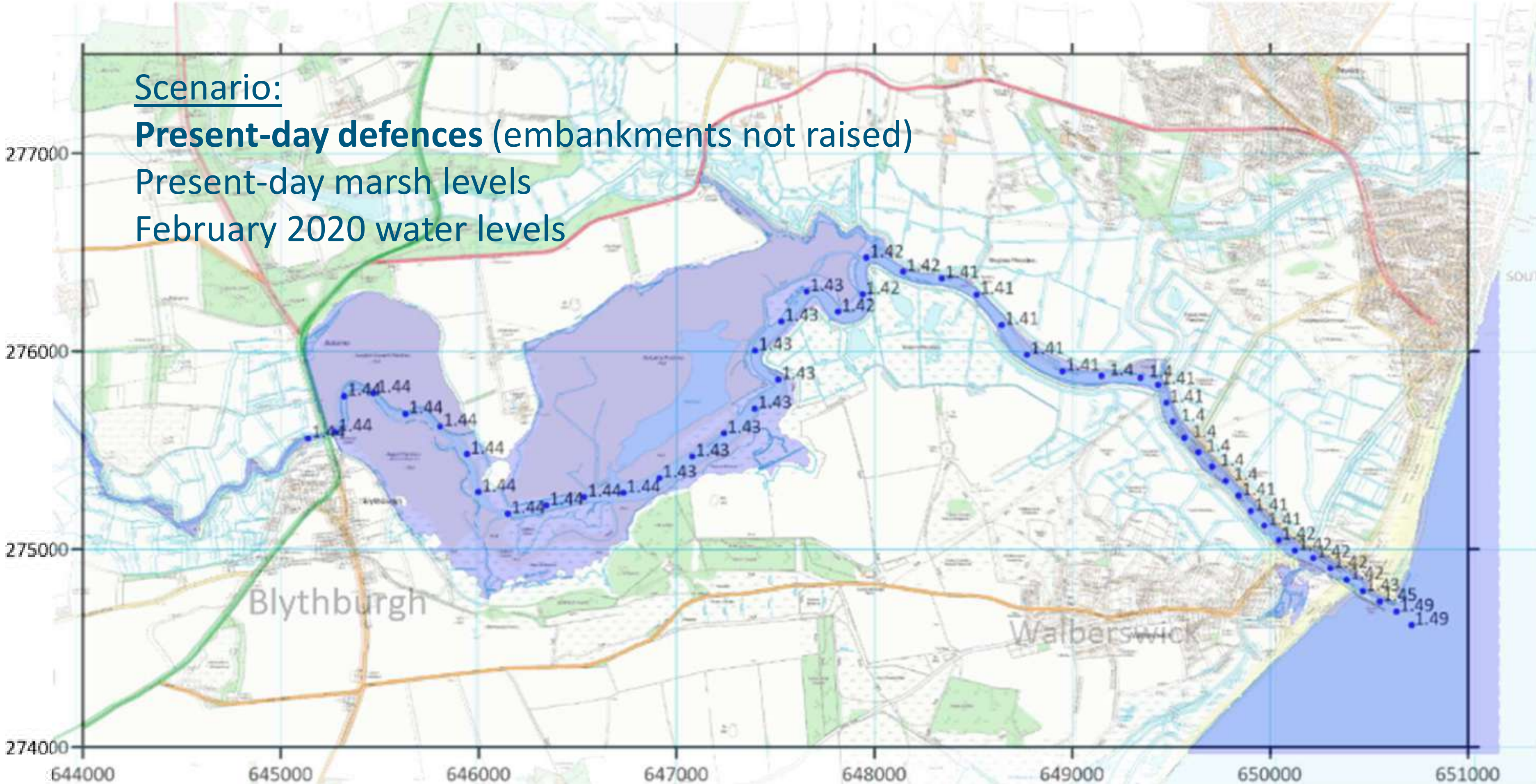
Assumptions for future marsh levels

- Sedimentation study (Pye, 2019):
  - Average sedimentation (1943-2019) = 6 mm/yr
  - Average sedimentation (2008-2019) = 3 mm/yr (marsh levels have reduced in places)
  - Average SLR (1964-2018) = 3 mm/yr
  - Projected SLR (2019-2069) = 3 - 10 mm/yr
  - UKCP Scenario RCP4.5 (50%) = 6 mm/yr
- Historically, tidal prism has been reducing since 1953 breaches
- Future sedimentation could keep pace with SLR, but from recent data:
  - Sedimentation may be slowing
  - SLR may be accelerating

Impact of marsh level on water levels

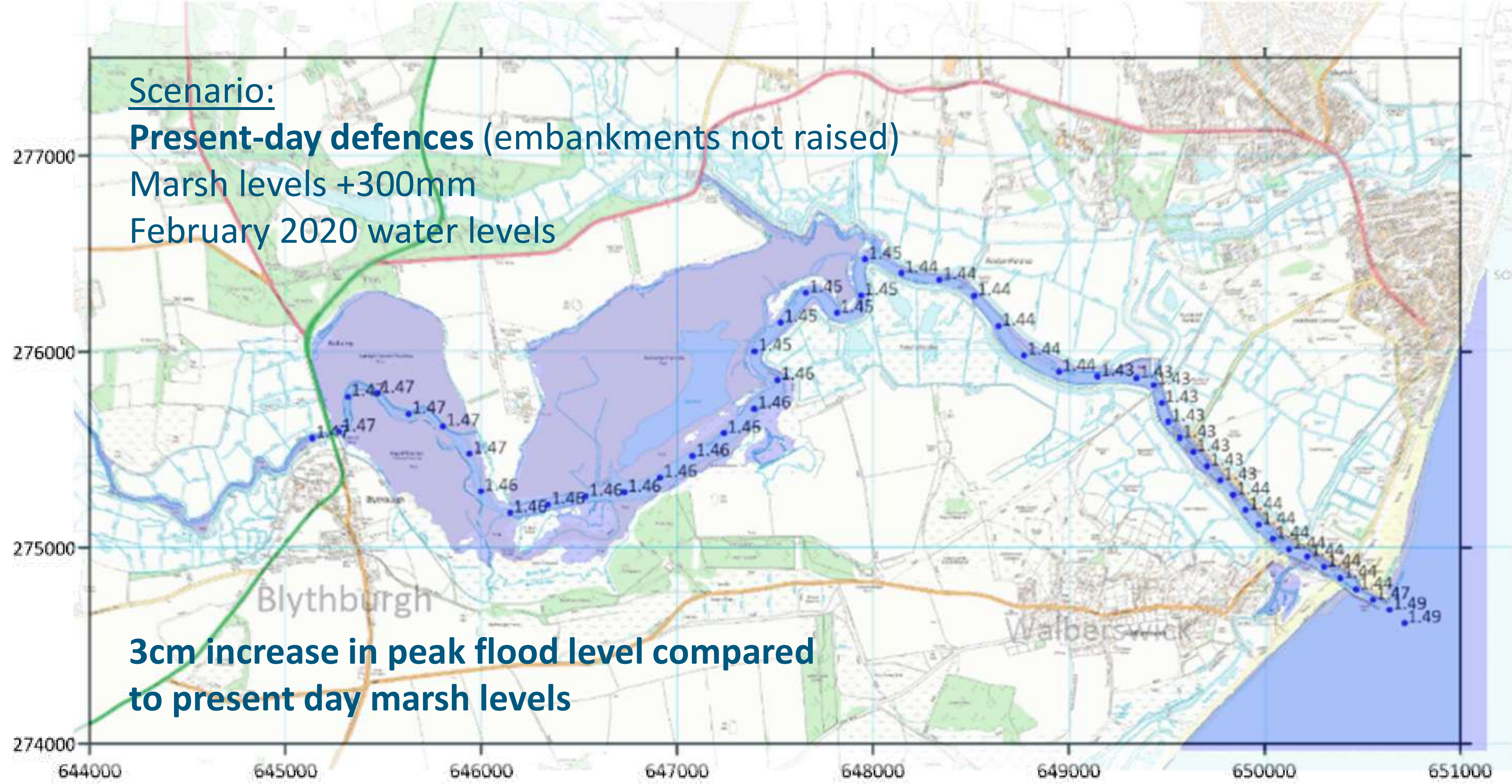
- What we have modelled:
  - Marsh levels +300mm, +600mm
  - Present day defences, Do Nothing, Raised embankments
  - Feb 2020, Dec 2013 water levels
- Historic sedimentation rate (6 mm/yr):
  - Breached marshes 300mm higher by 2070
  - Peak flood levels in harbour:
    - +3cm (Feb 2020 conditions)
    - +4cm (Dec 2013, raised embankments)
- Increase in sedimentation rate (12 mm/yr):
  - Breached marshes 600mm higher by 2070
  - Peak flood levels in harbour:
    - +5cm (Feb 2020 conditions)
    - +7cm (Dec 2013, raised embankments)
- **Impact on peak flood levels order of magnitude less than increase in marsh levels, not sensitive to tidal conditions**

Sensitivity of peak flood level in harbour to marsh level



Royal HaskoningDHV

Sensitivity of peak flood level in harbour to marsh level



Scenario:
Present-day defences (embankments not raised)
Marsh levels +300mm
February 2020 water levels

3cm increase in peak flood level compared to present day marsh levels

Royal HaskoningDHV

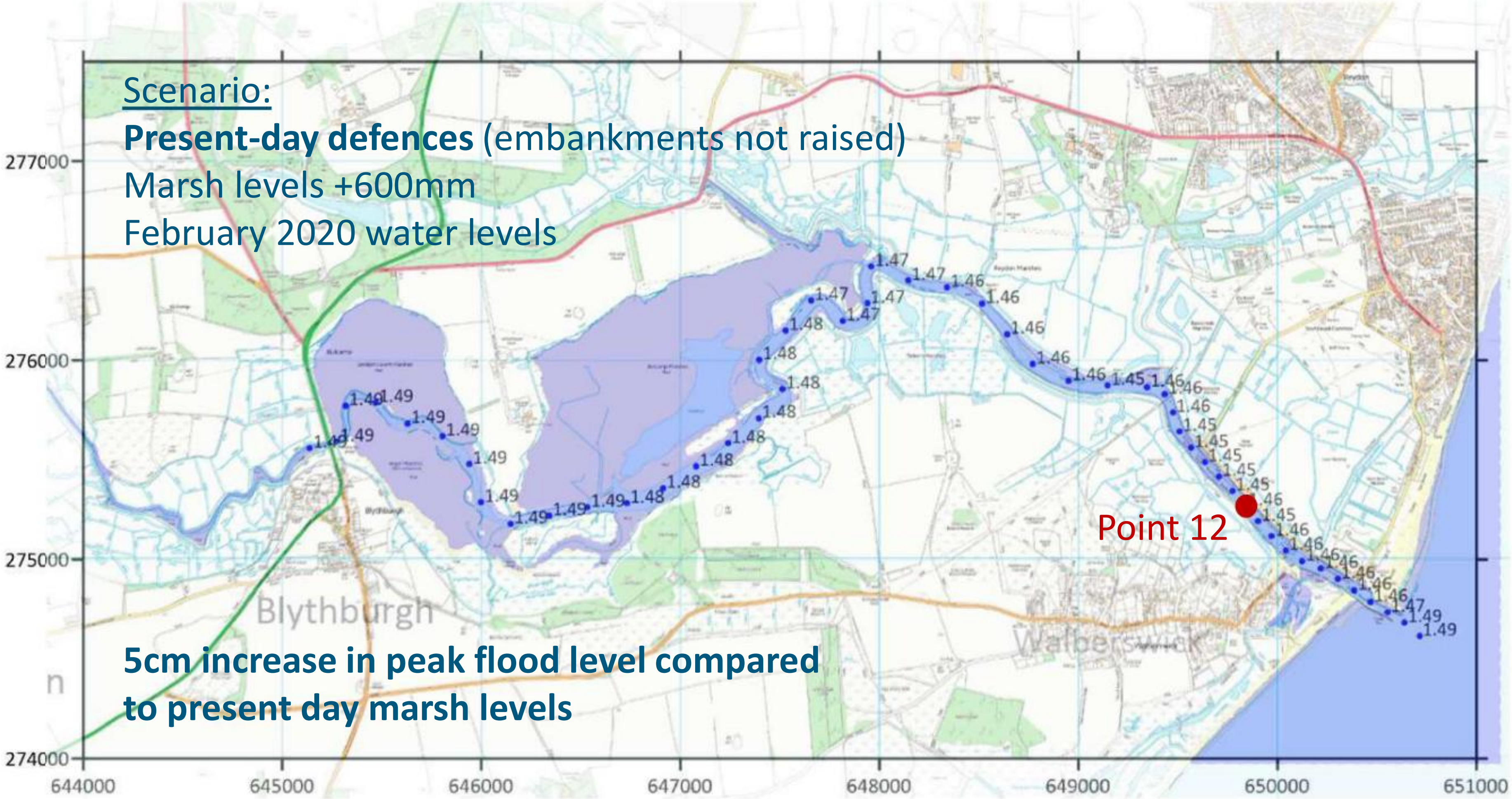
Sensitivity of peak flood level in harbour to marsh level

<u>Scenario:</u>

Present-day defences (embankments not raised)

Marsh levels +600mm

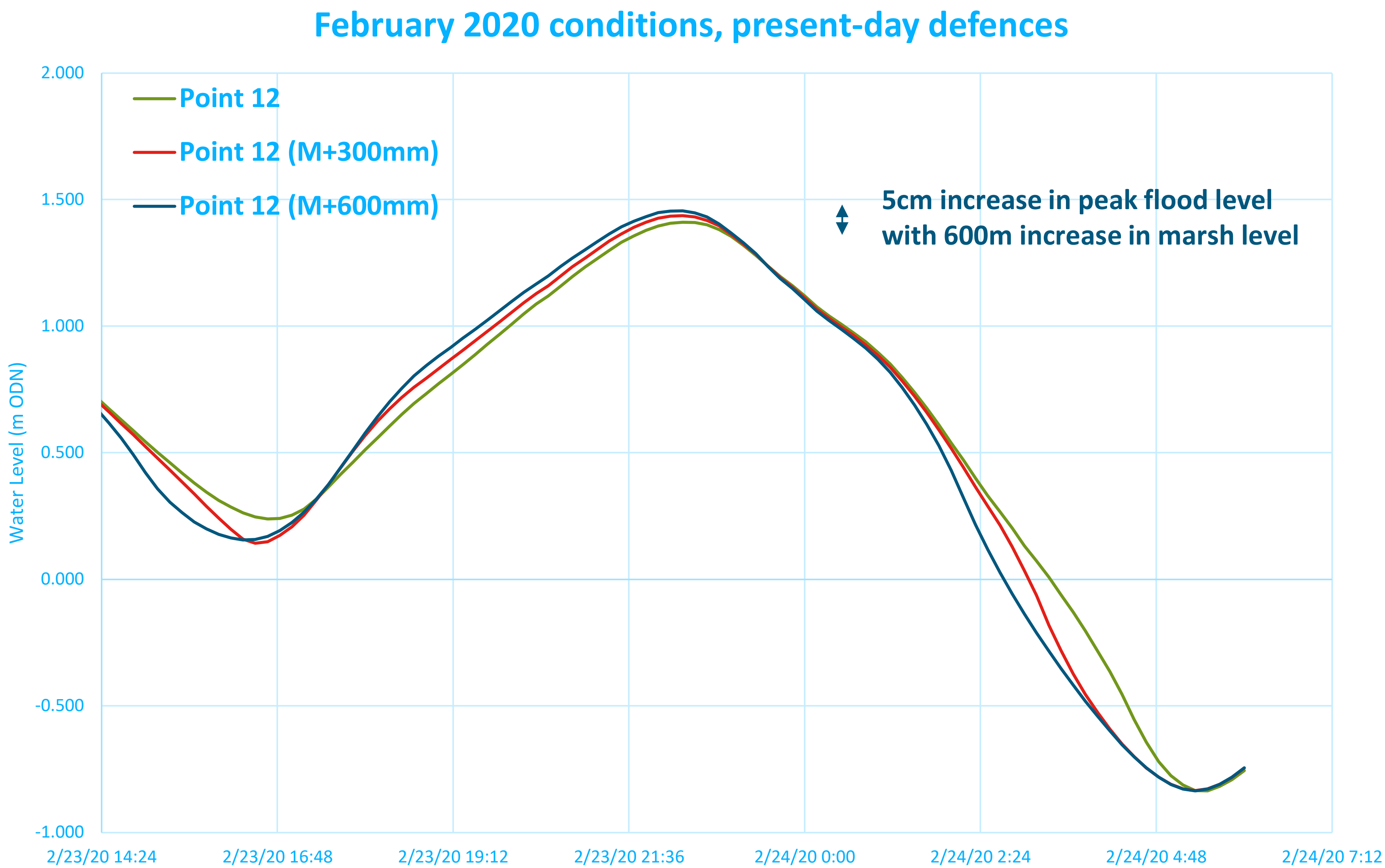
February 2020 water levels



5cm increase in peak flood level compared to present day marsh levels

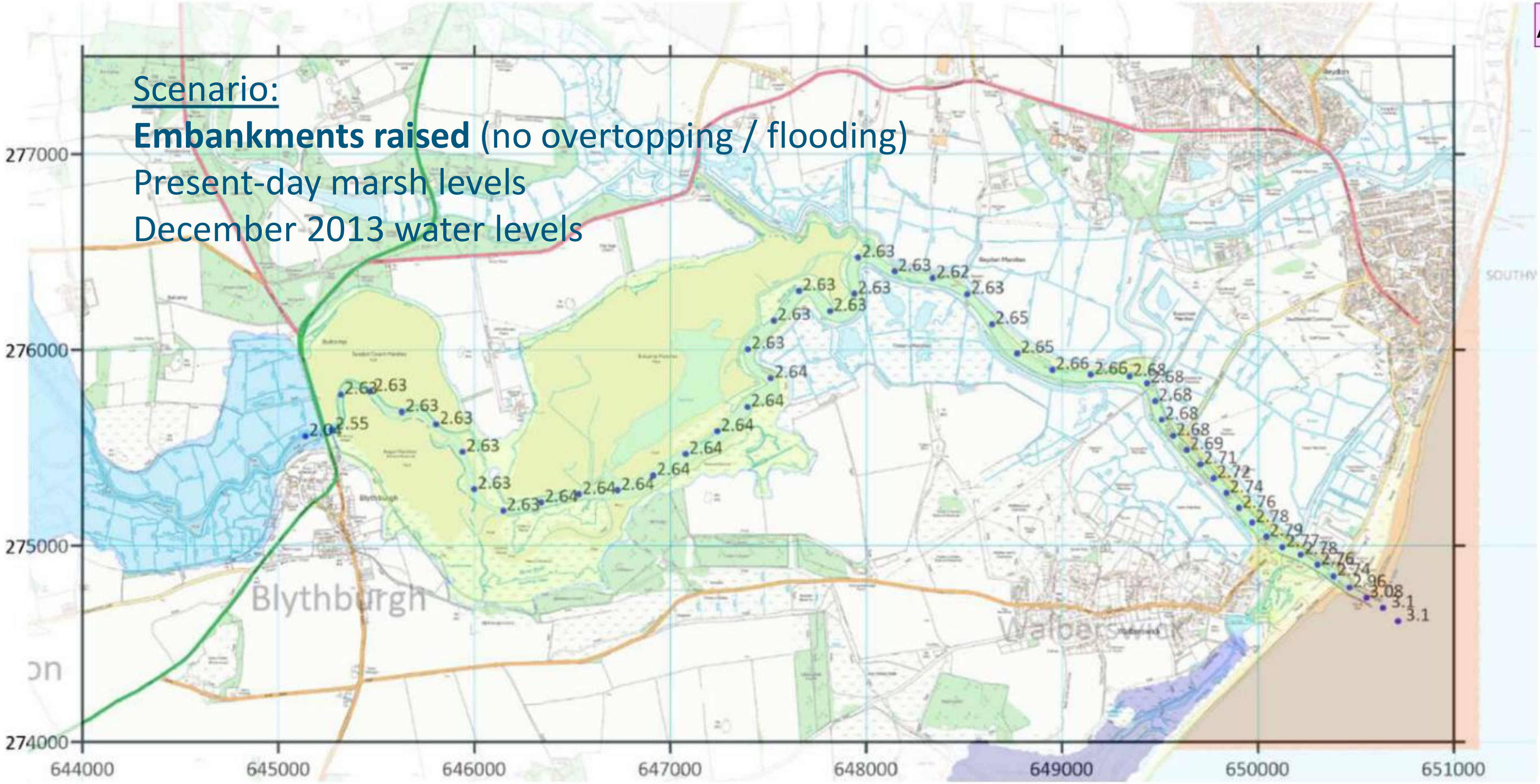
Royal HaskoningDHV

Sensitivity of peak flood level in harbour to marsh level



Sensitivity of peak flood level in harbour to marsh level

AS18



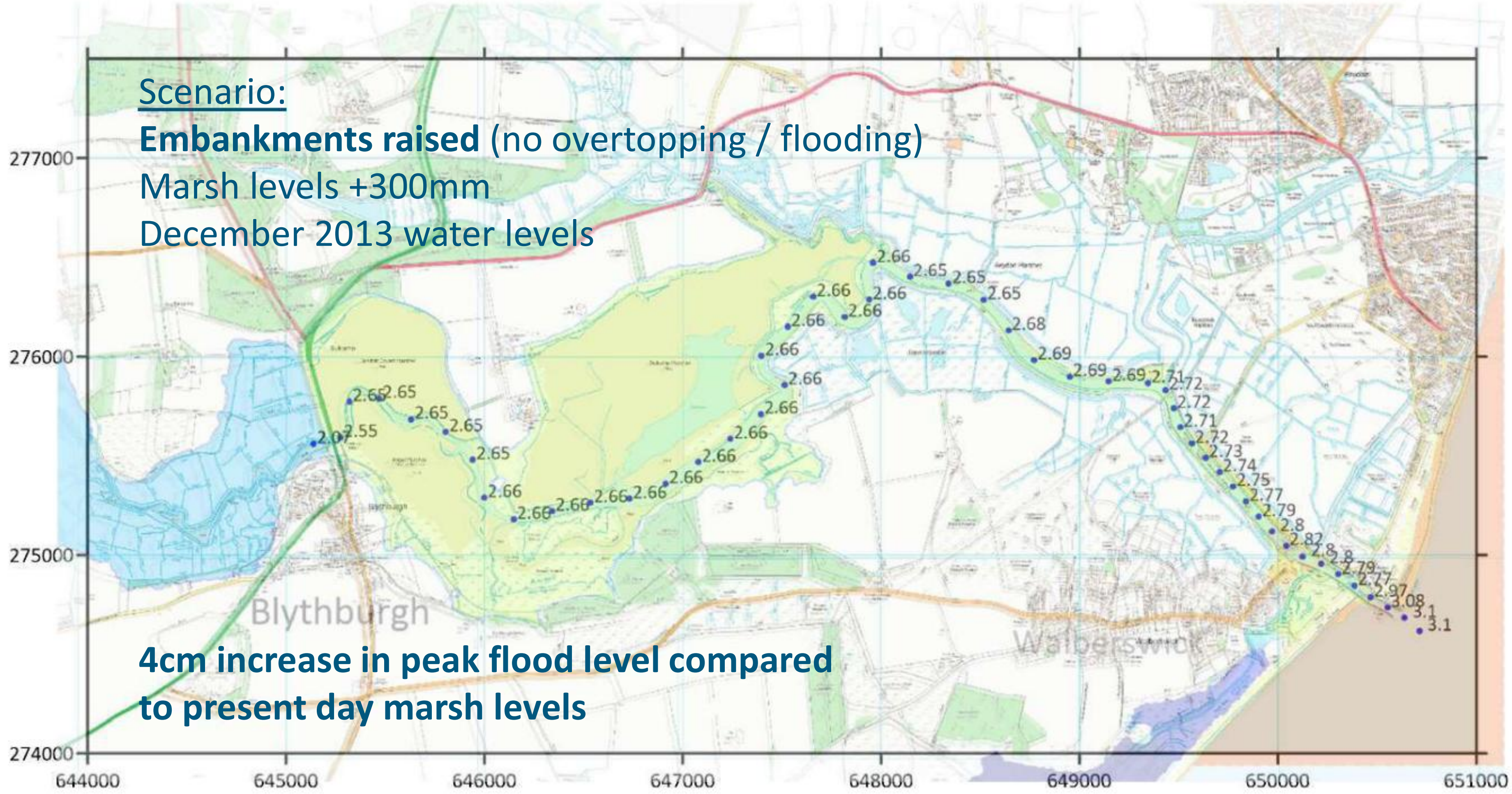
Royal HaskoningDHV

AS18 Correct figure to be added

Amy Savage, 30/03/2021

Sensitivity of peak flood level in harbour to marsh level

AS19



Royal HaskoningDHV

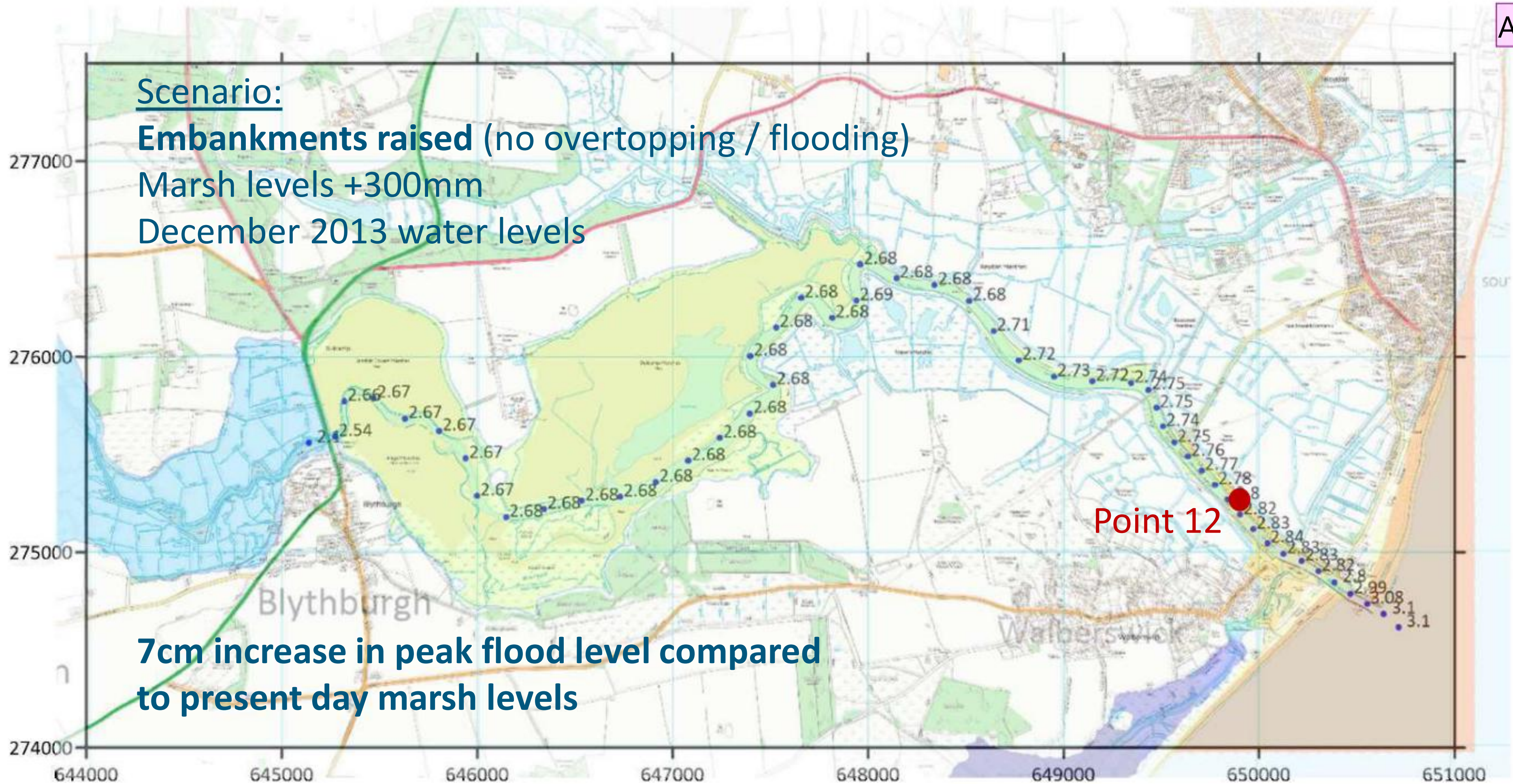
Slide 17

AS19 Correct figure to be added

Amy Savage, 30/03/2021

Sensitivity of peak flood level in harbour to marsh level

AS20



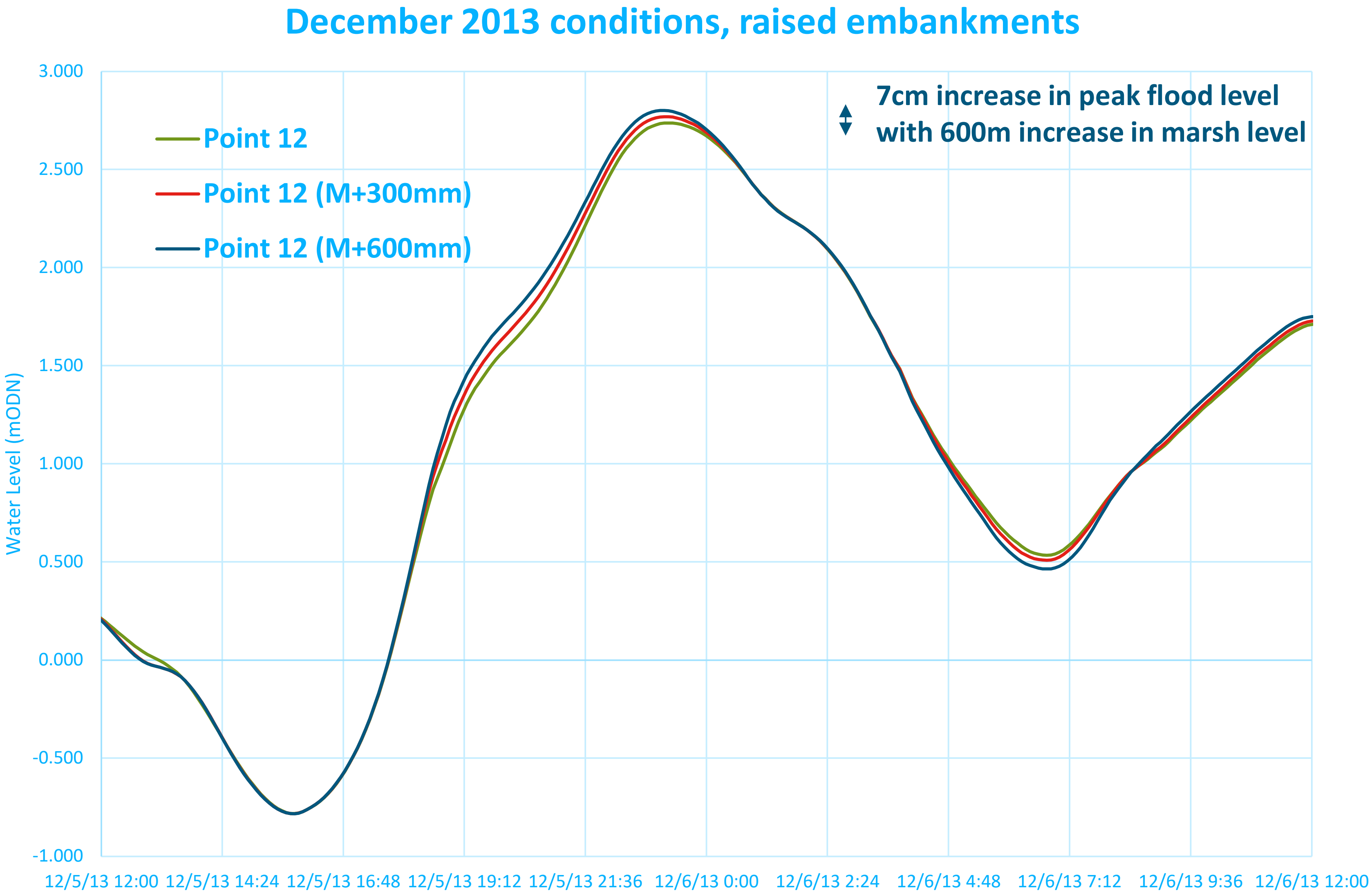
Royal HaskoningDHV

Slide 18

AS20 Correct figure to be added

Amy Savage, 30/03/2021

Sensitivity of peak flood level in harbour to marsh level



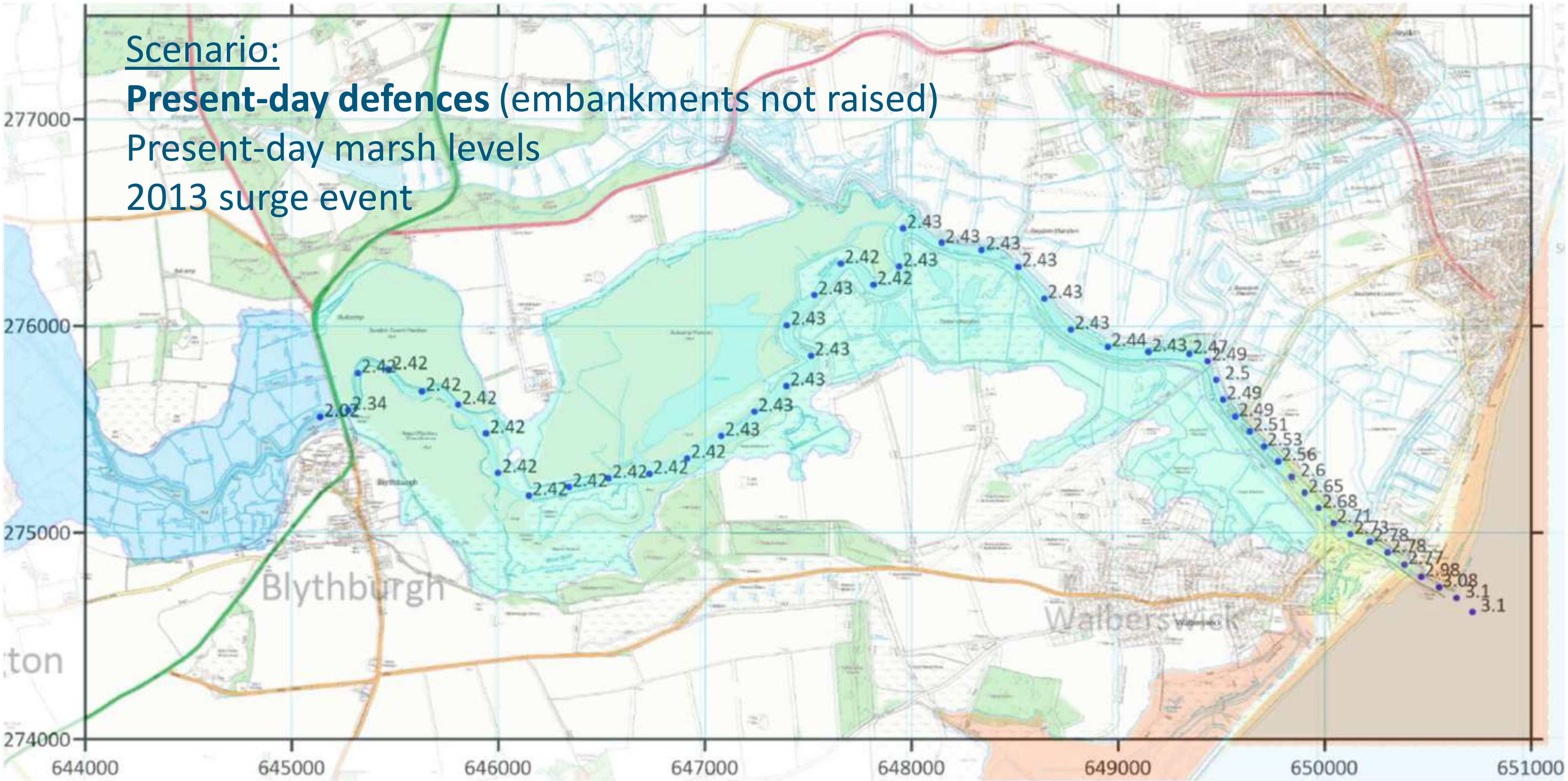
Sensitivity of water level to marsh level

<u>Scenario:</u>

Present-day defences (embankments not raised)

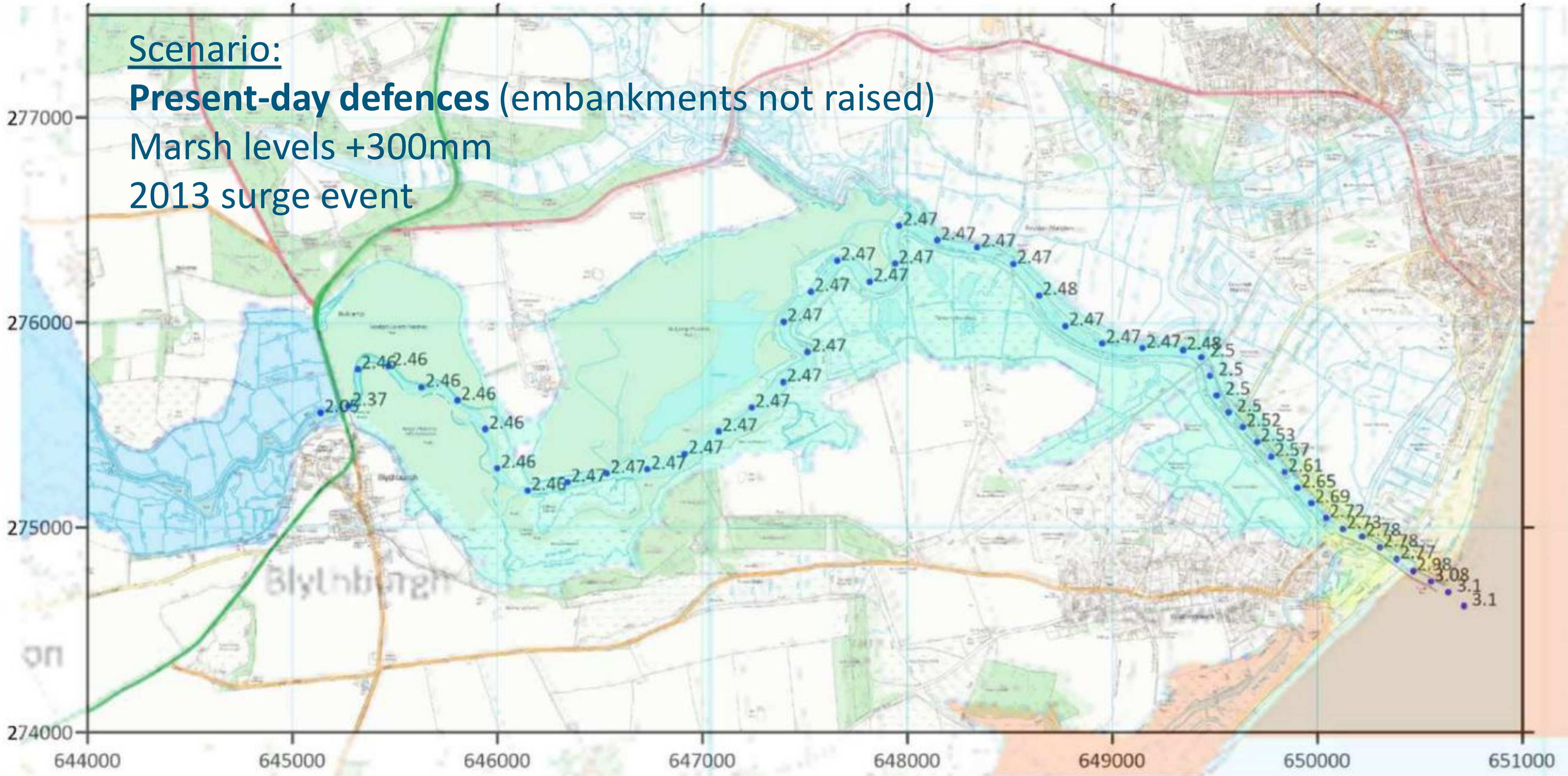
Present-day marsh levels

2013 surge event



Royal HaskoningDHV

Sensitivity of water level to marsh level

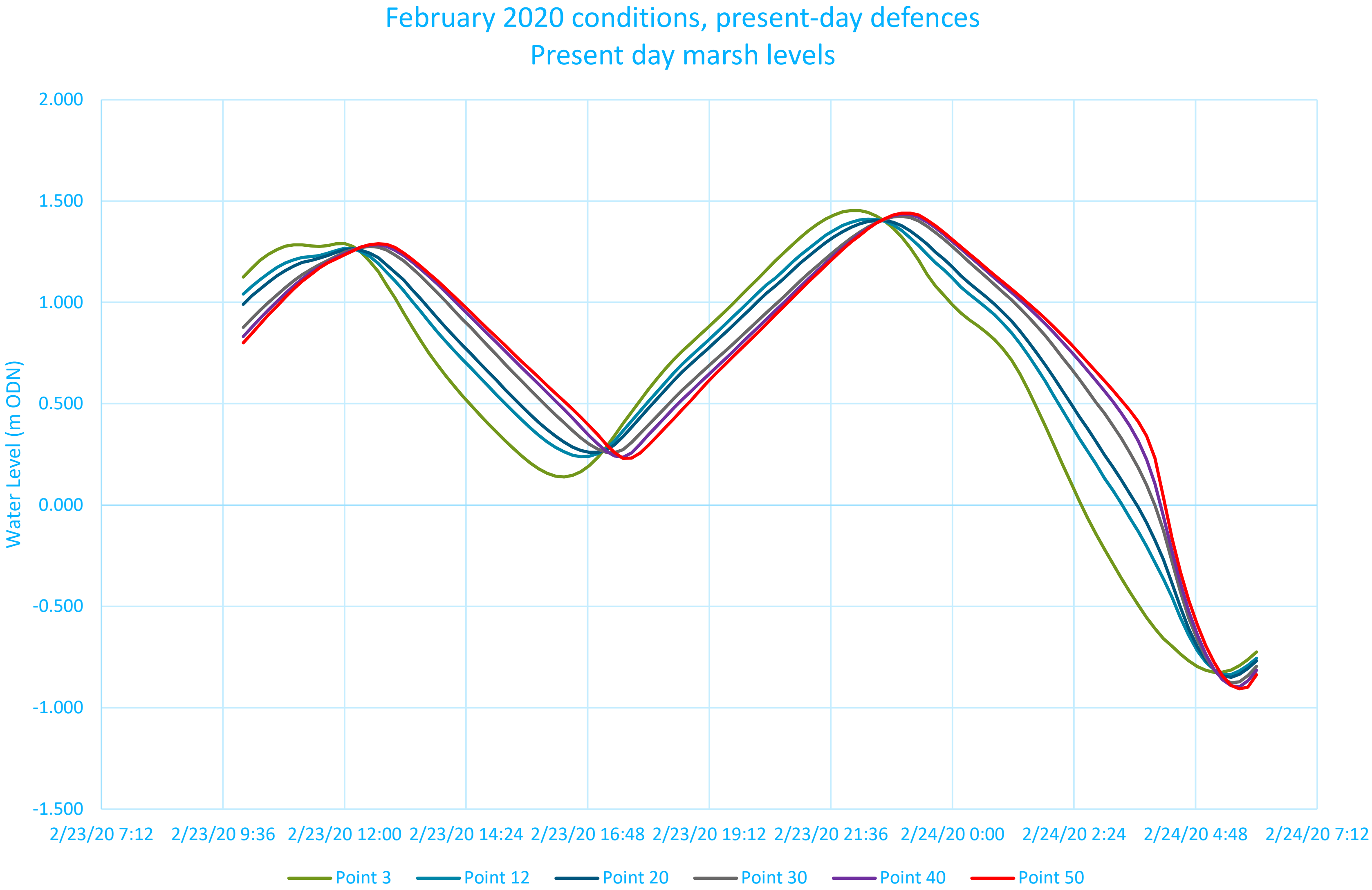


Royal HaskoningDHV

Impact of marsh level on peak flood levels

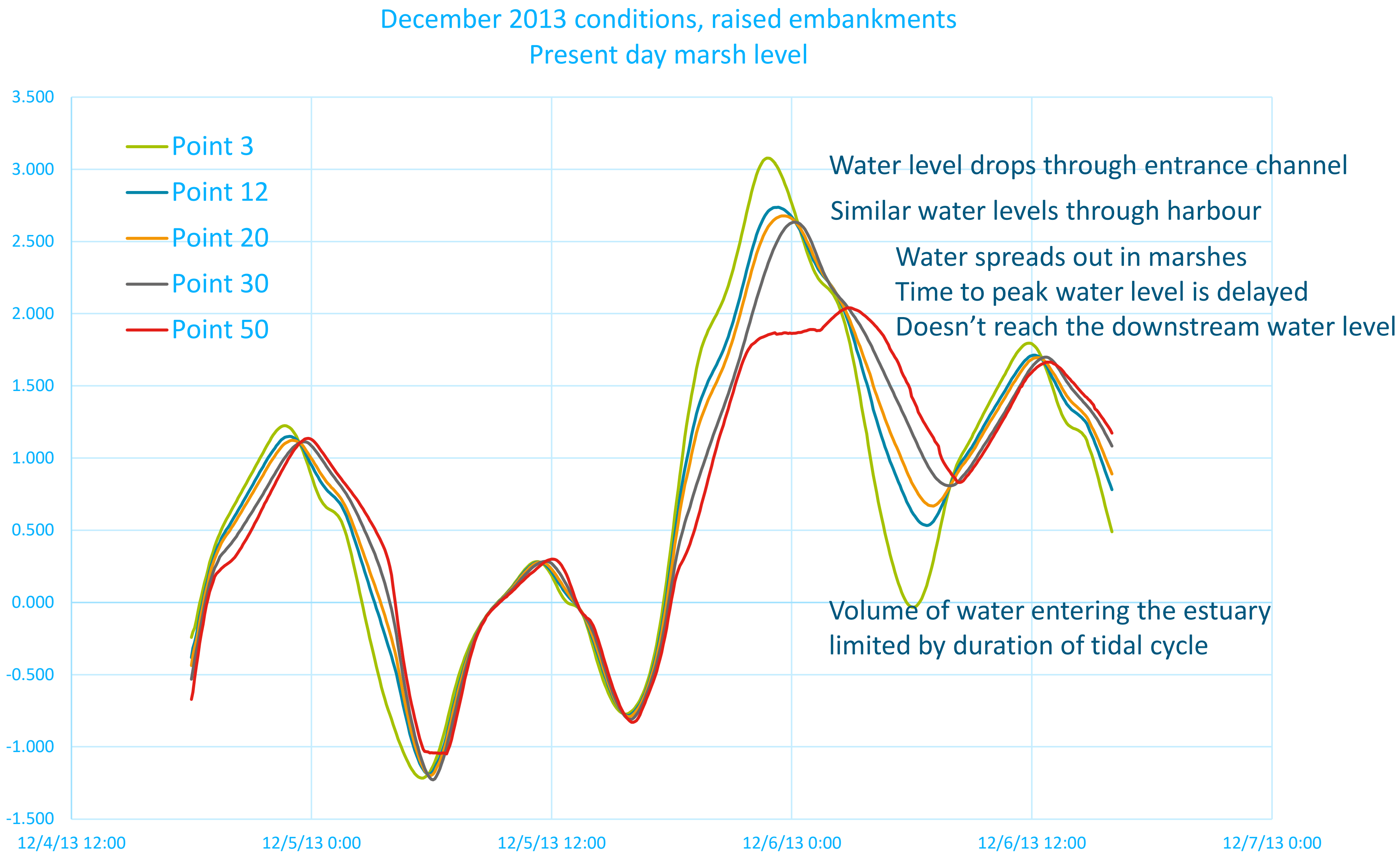
- What we have modelled:
  - Marsh levels +300mm, +600mm
  - Present day defences, Do Nothing, Raised embankments
  - Feb 2020, Dec 2013 water levels
- Historic sedimentation rate (6 mm/yr):
  - Breached marshes 300mm higher by 2070
  - Peak flood levels in harbour:
    - +3cm (Feb 2020 conditions)
    - +4cm (Dec 2013, raised embankments)
- Increase in sedimentation rate (12 mm/yr):
  - Breached marshes 600mm higher by 2070
  - Peak flood levels in harbour:
    - +5cm (Feb 2020 conditions)
    - +7cm (Dec 2013, raised embankments)
- **Impact on peak flood levels is ~10% of increase in marsh levels, not sensitive to flood conditions**

Estuary hydrodynamics



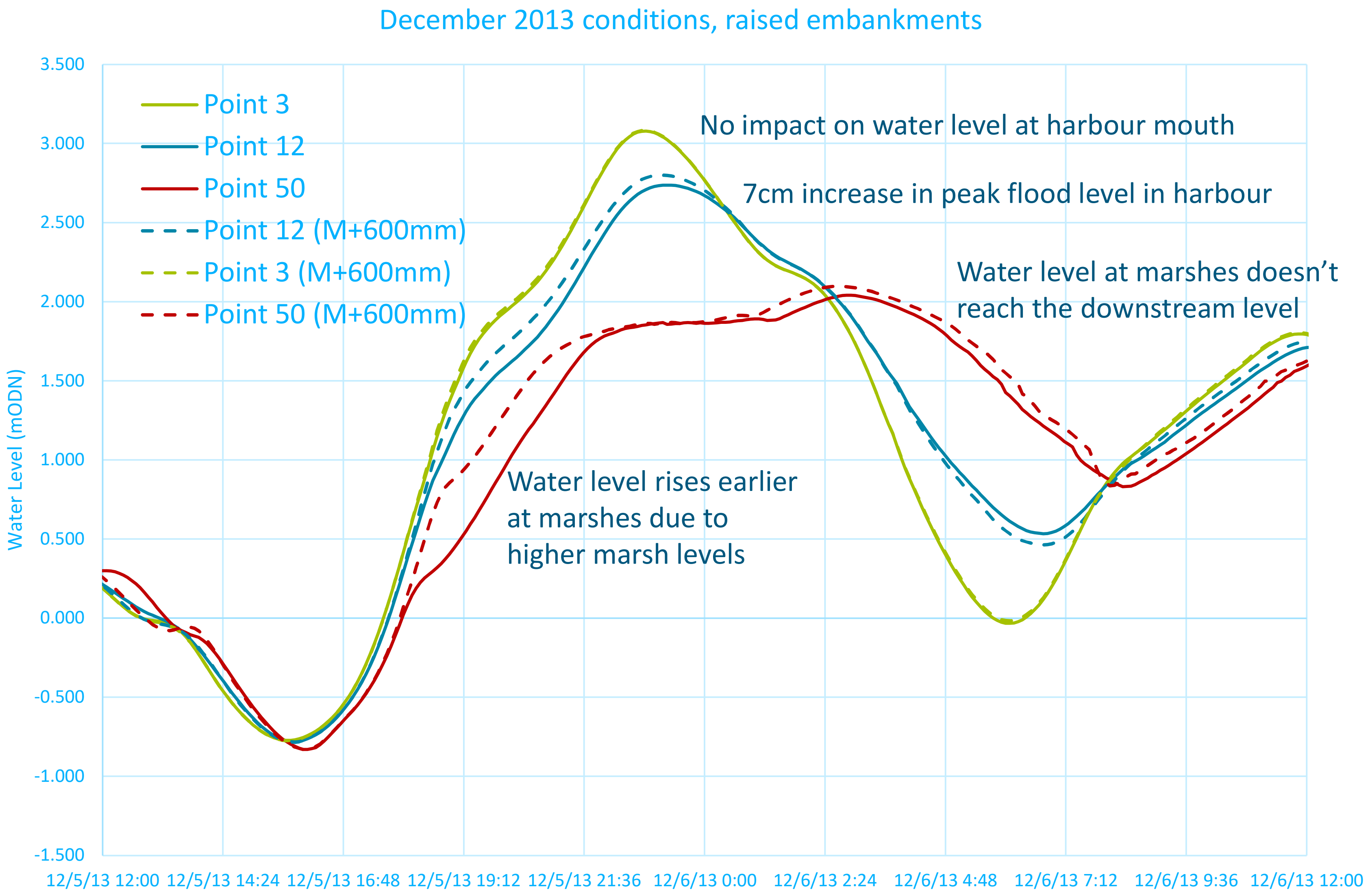
Royal HaskoningDHV

Estuary hydrodynamics



Royal HaskoningDHV

Sensitivity of water level to marsh level



Royal HaskoningDHV

Impact of marsh level on flow rate

- Flow rate in entrance channel is important for navigation and risk of scour to structures
- For historic sedimentation rate (6 mm/yr):
  - Marsh level 300mm higher by 2070
  - Maximum flow rates in entrance channel:
    - -14% (Feb 2020 conditions)
    - -3% (Dec 2013, raised embankments)
  - Flow rates for marsh level 600mm higher
    - -35% (Feb 2020 conditions)
    - -6% (Dec 2013, raised embankments)
- For higher marsh levels, less water fills the estuary in a tidal cycle, which reduces flow rates
- **Marsh sedimentation could benefit the entrance structures, but with risk of siltation of the channel**

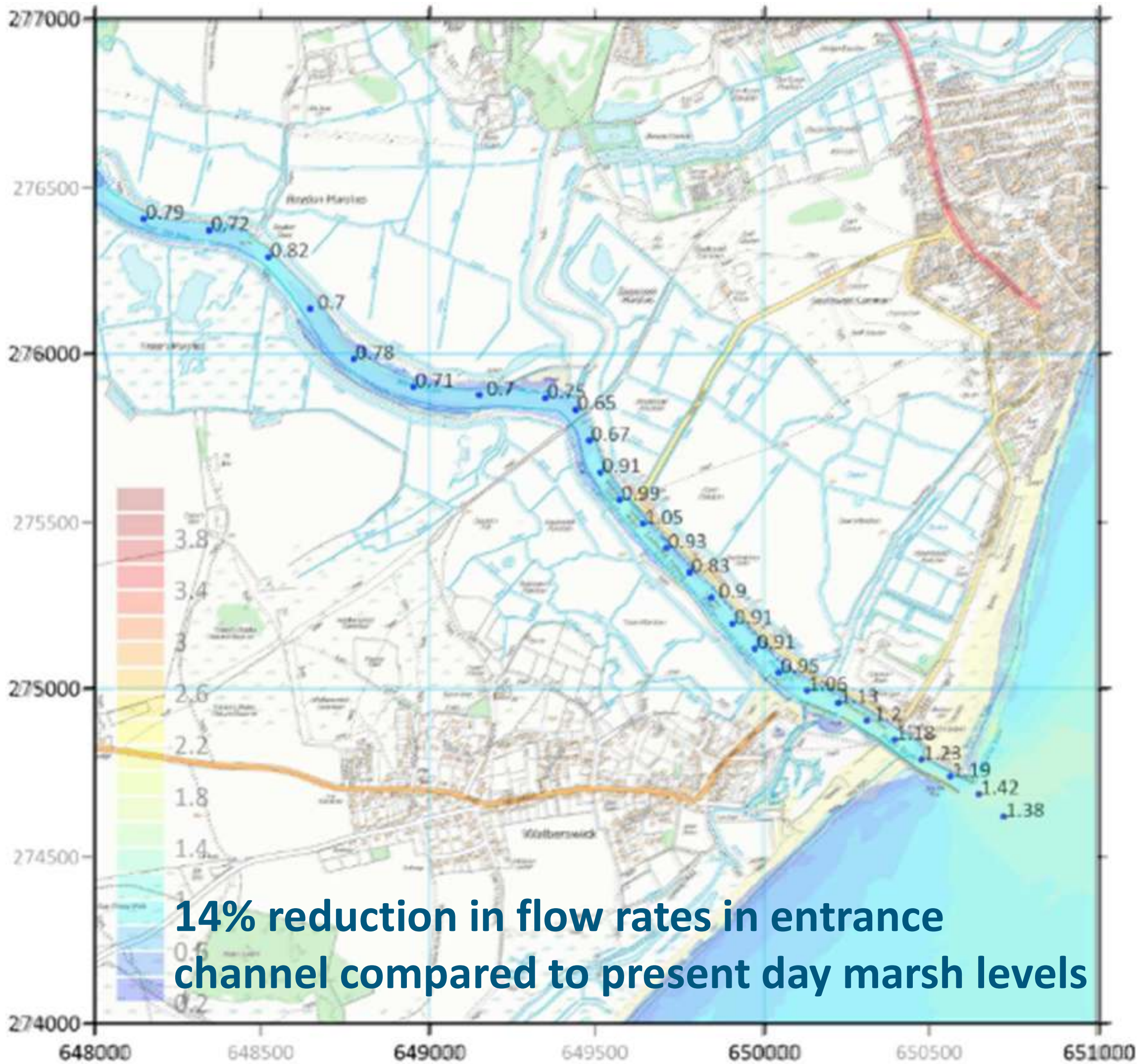
Sensitivity of flow rate to marsh level

<u>Scenario:</u>
Present-day defences
Present-day marsh levels
Feb 2020 water levels

Royal HaskoningDHV

Sensitivity of flow rate to marsh level

<u>Scenario:</u>
Present-day defences
Marsh levels +300mm
Feb 2020 water levels



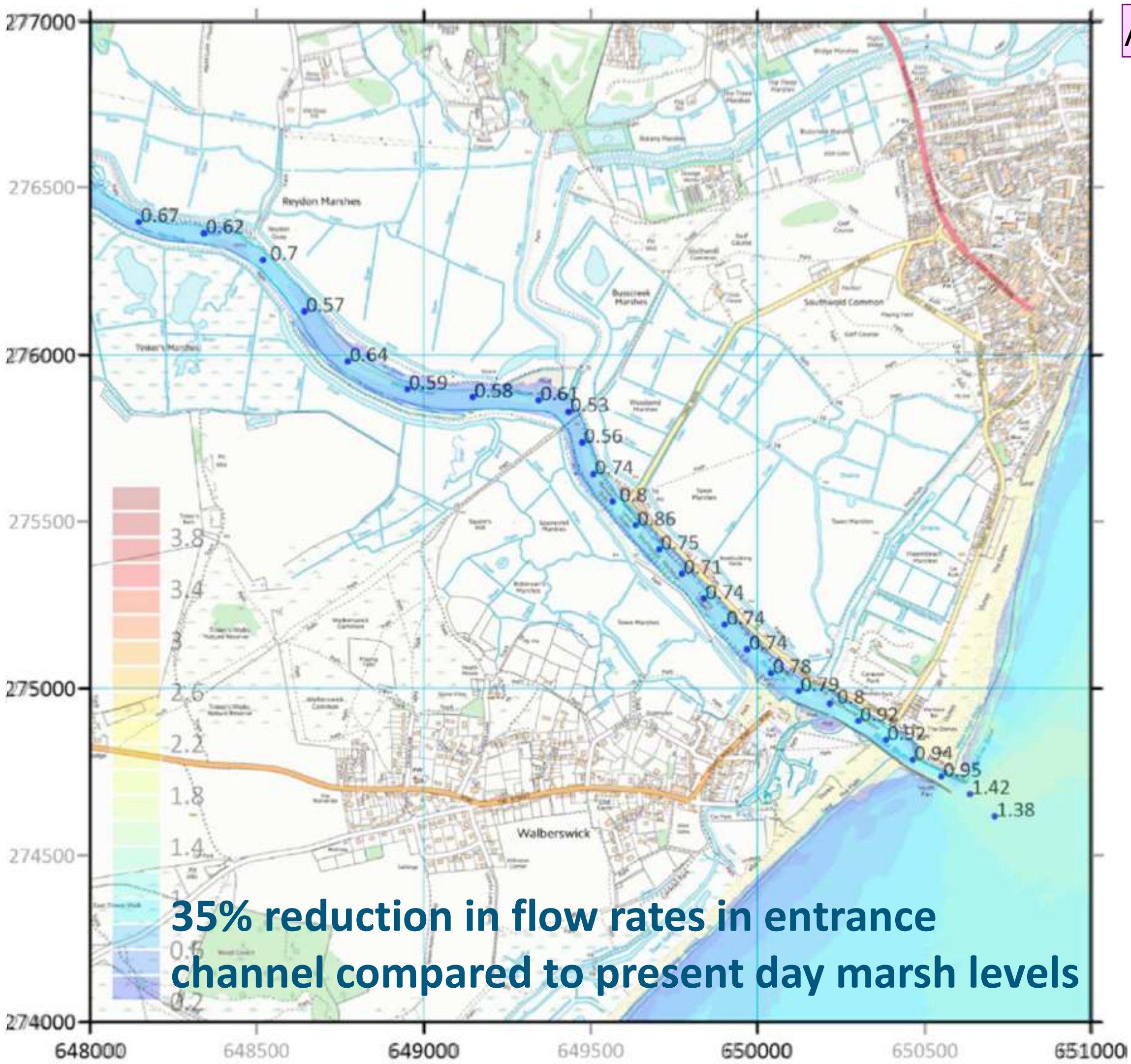
14% reduction in flow rates in entrance channel compared to present day marsh levels

Royal HaskoningDHV

AS22

Sensitivity of flow rate to marsh level

<u>Scenario:</u>
Present-day defences
Marsh levels +600mm
Feb 2020 water levels



35% reduction in flow rates in entrance channel compared to present day marsh levels

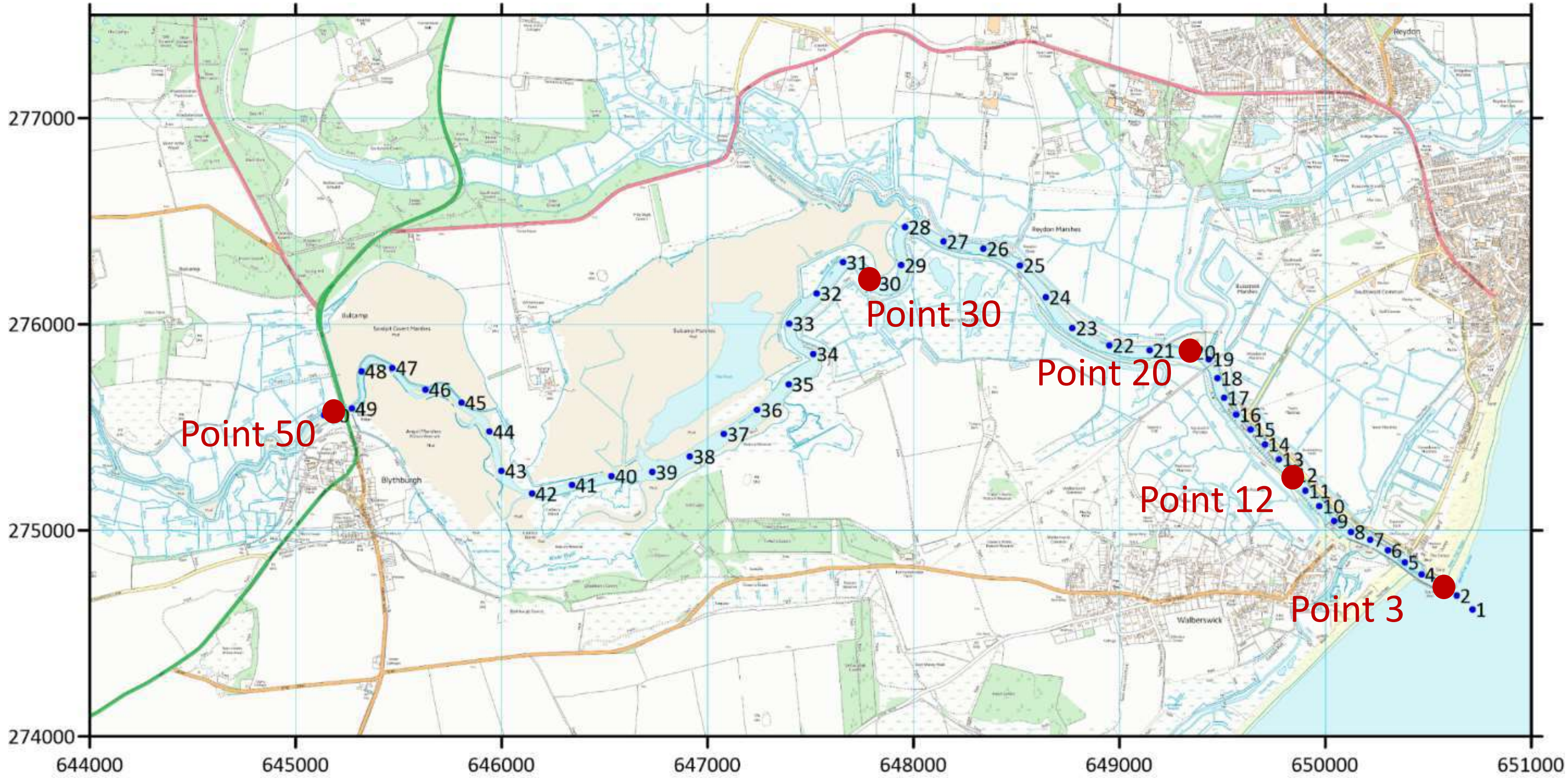
Royal HaskoningDHV

Slide 29

AS22 Add resluts for Dec 2013 conditions, raised embankemtns

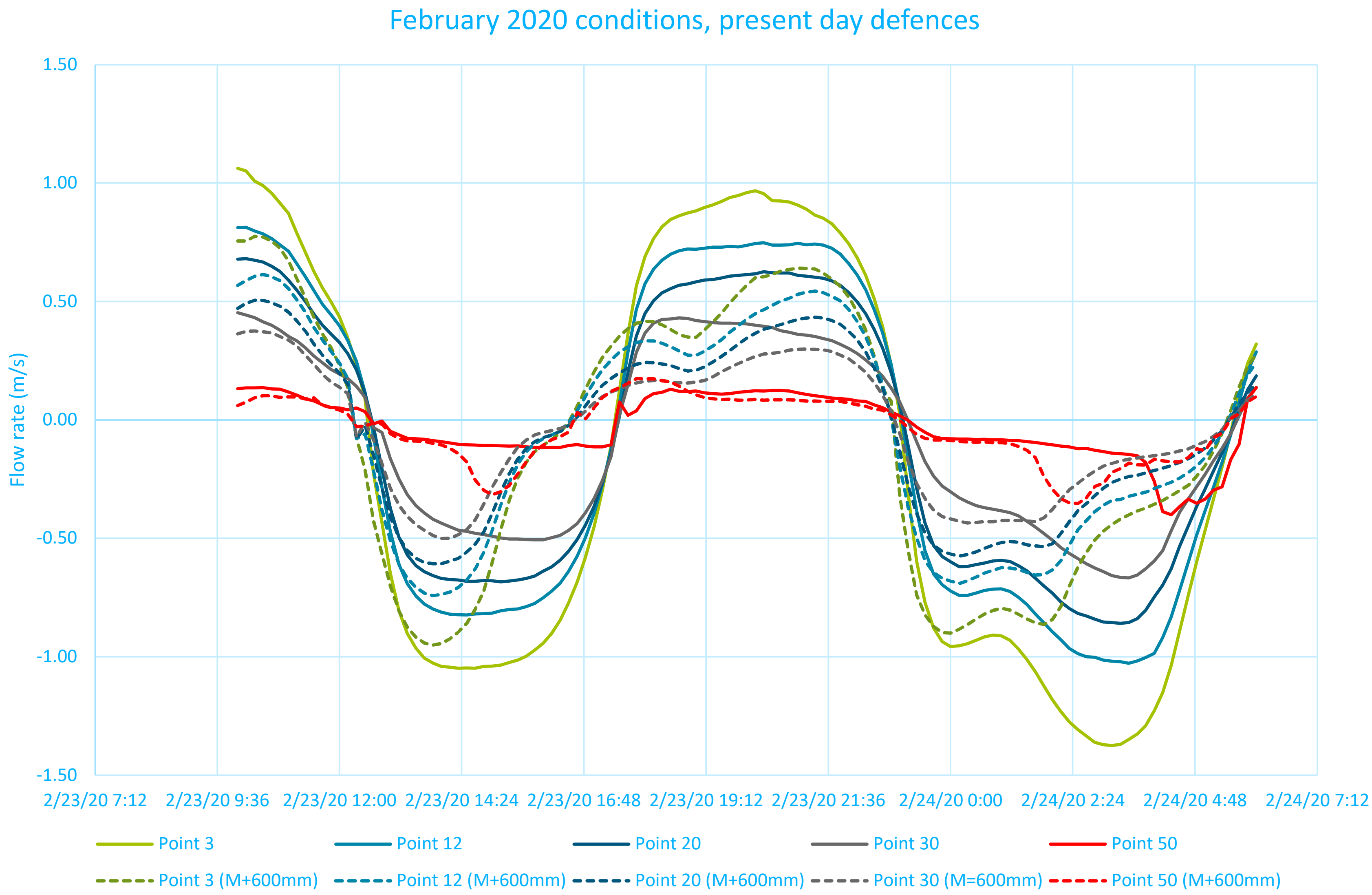
Amy Savage, 30/03/2021

Sensitivity of flow rate to marsh level



Royal HaskoningDHV

Sensitivity of flow rate to marsh level



Royal HaskoningDHV

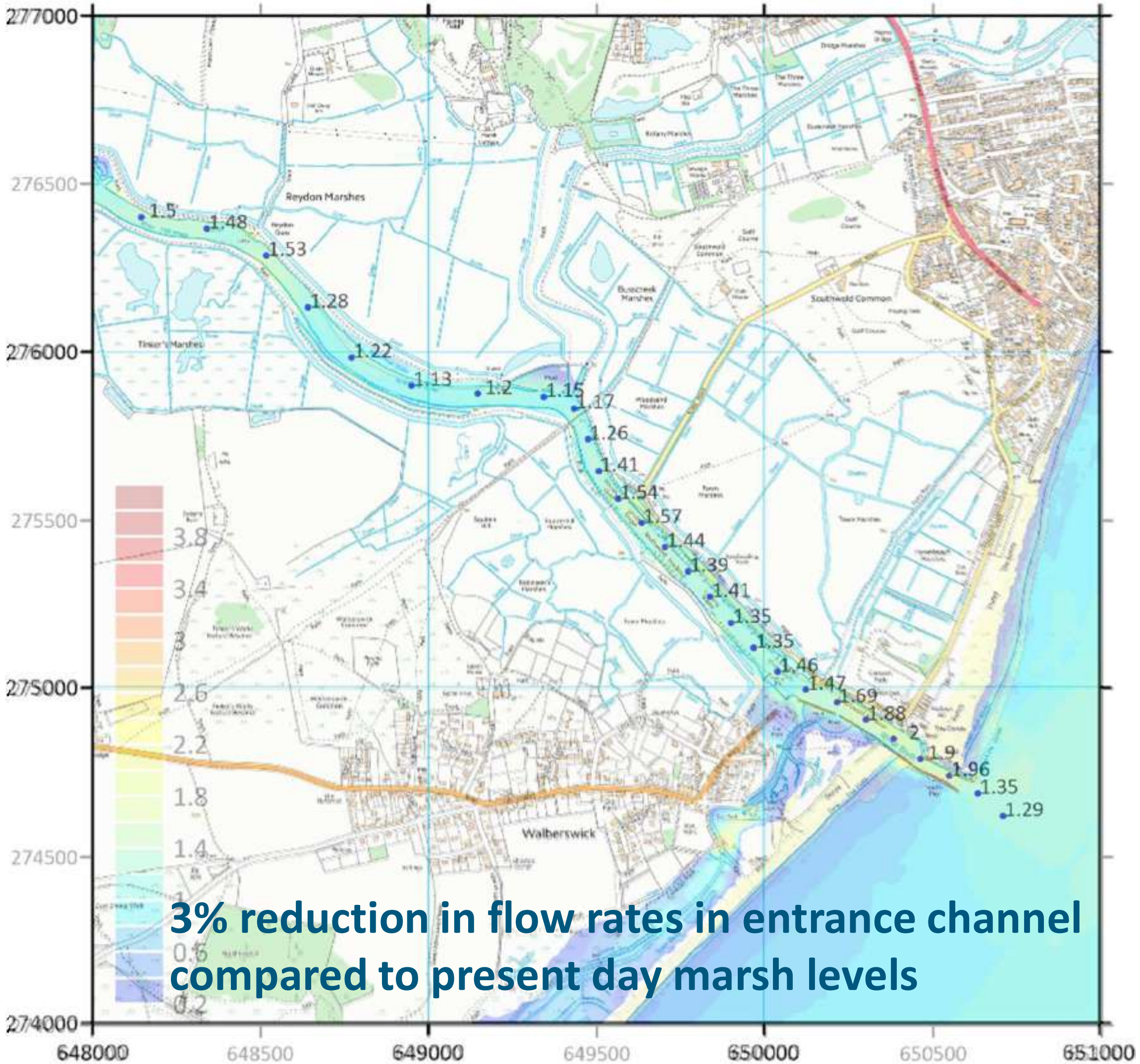
Sensitivity of flow rate to marsh level

Scenario:
Raised embankments
Present day marsh levels
Dec 2013 water levels

Royal HaskoningDHV

Sensitivity of flow rate to marsh level

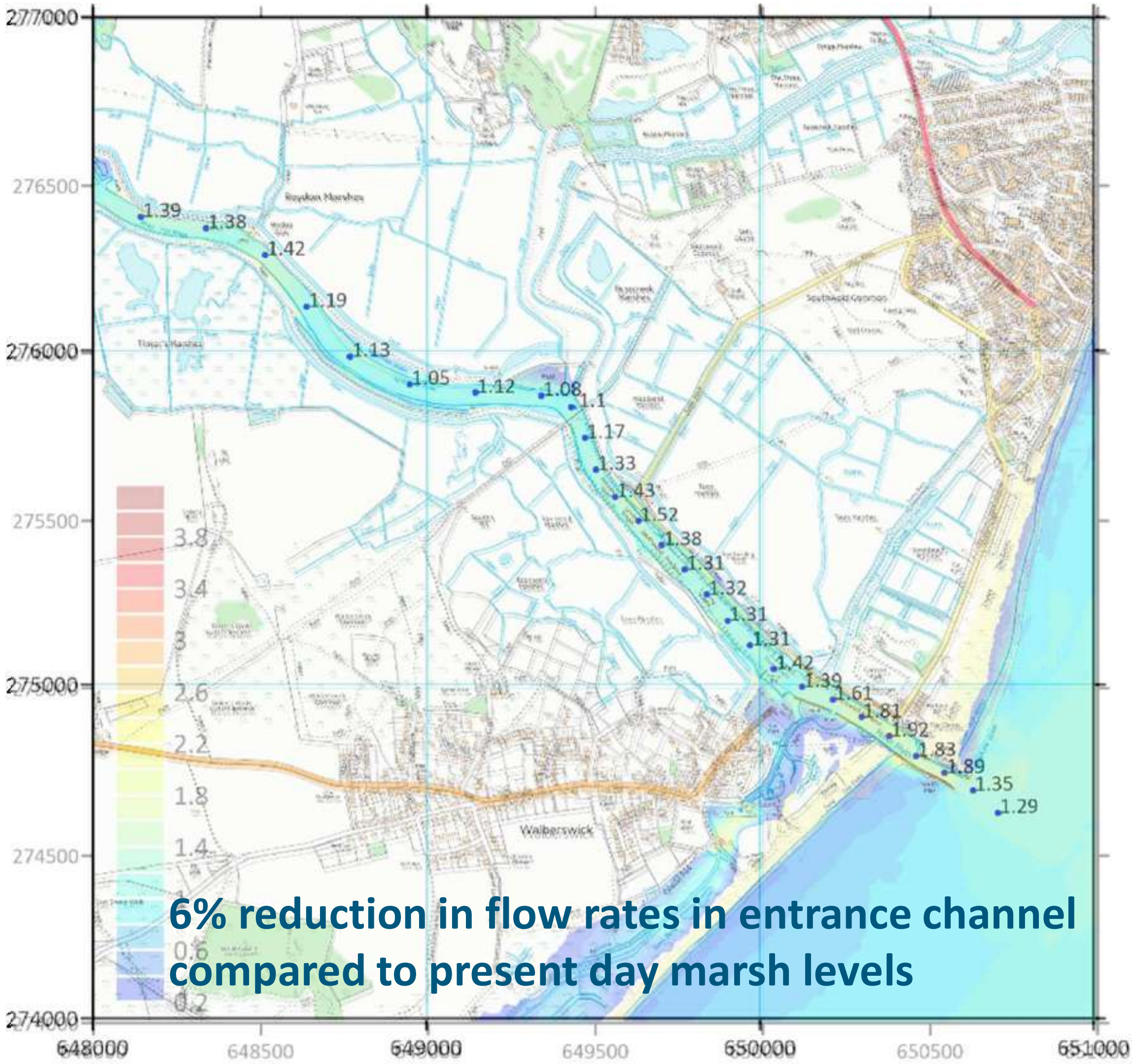
Scenario:
Raised embankments
Marsh levels +300mm
Dec 2013 water levels



Royal HaskoningDHV

Sensitivity of flow rate to marsh level

<u>Scenario:</u>
Raised embankments
Marsh levels +600mm
Dec 2013 water levels



Summary - impact of marsh sedimentation

- We are considering the potential range in future marsh levels
- Without sedimentation:
  - SLR will increase the tidal prism
  - Higher flow rates in entrance channel
    (keeps channel clear but may increase scour)
  - Worst-case for design of structures
- With sedimentation:
  - Peak flood levels in the harbour increase slightly
  - Upstream flood extents reduce slightly
  - Flow rates reduce, risk of siltation of entrance channel
  - Reduction in flow rate likely to be offset by SLR
- Additional checks needed for combined impacts of sedimentation and SLR

Discussion of spillway option

- Aims for this session:
  - Introduce the spillway option
  - Recap of overall results of modelling
  - Benefits / constraints of spillway option
  - Potential locations and dimensions
  - Next steps for assessment of this option
- Discussion:
  - Share your thoughts on this option e.g. type of spillway, location, size
  - Feedback on proposals for modelling

Spillway option

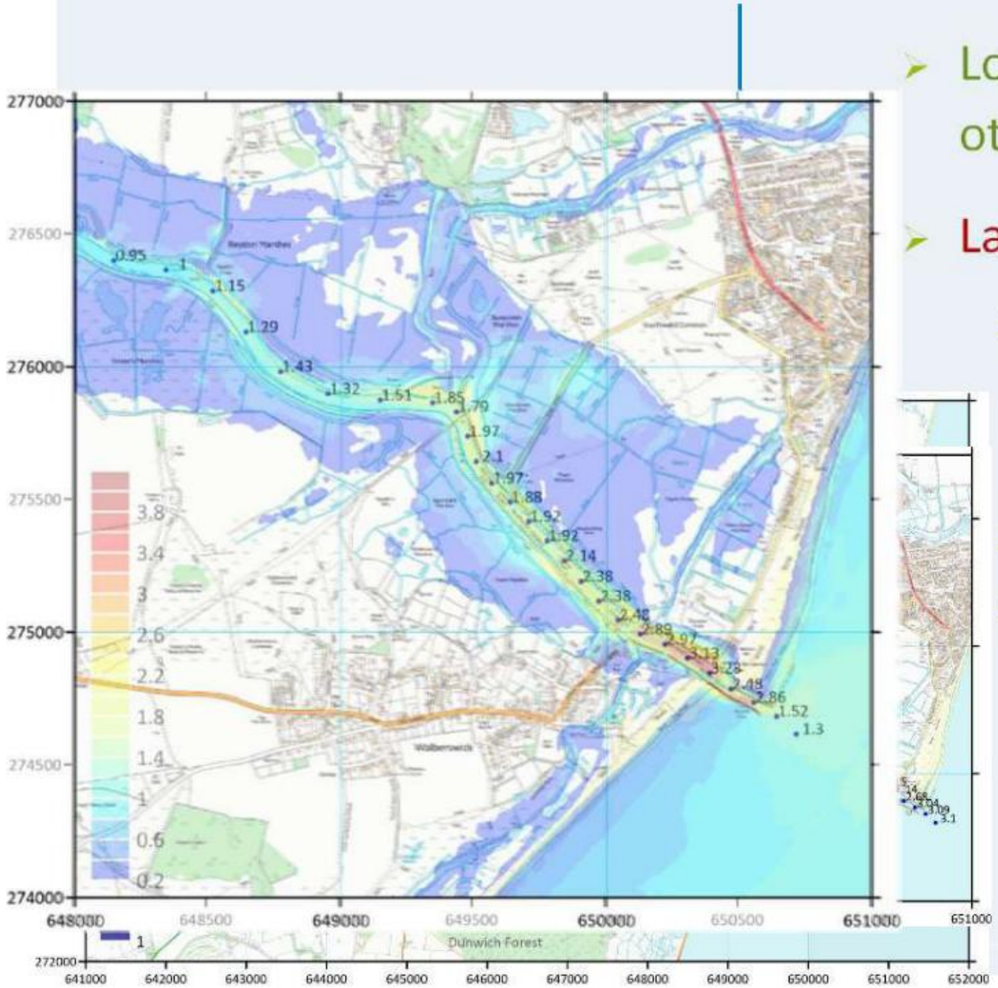
- What is a spillway?
  - Embankments protect against 'normal' events
  - Reinforced spillway(s) - overtopping happens at a known location on extreme events
  - Reduces peak flood levels and risk of embankment failure upstream
  - Controlled sluice gate or passive spillway (to be discussed further)

Spillway option

- What is a spillway?
  - Embankments protect against ‘normal’ events
  - Reinforced spillway(s) - overtopping happens at a known location on extreme events
  - Reduces peak flood levels and risk of embankment failure upstream
  - Controlled sluice gate or passive spillway (to be discussed further)
- Include in design of raised embankments as ‘Safety valve’ **OR**
- Variation on ‘SMP’ scenario for estuary management
  - This is the scenario we are considering here

Do Nothing (undefended)

- Flood risk to Walberswick and Southwold
- Lower peak flood levels in harbour than other options (due to flooding elsewhere)
- Larger tidal prism
  - Flow rates in entrance channel +60% compared to present day (Dec 2013 conditions)
  - Impact on navigation conditions
  - Risk of erosion of channel bed, undermining of structures



Royal HaskoningDHV

Overview of modelling results: Do Nothing

SMP review of 'unconstrained' scenario:

"The integrity of [the harbour entrance structures] is strongly influenced by the tidal prism of the estuary…in the absence of control at the mouth, there would be an immediate response in the coast."

"Abandoning defence of the marshes … would create a large increase in tidal volume. This would impose considerable pressure on the structures at the mouth of the estuary."

"if the defences within the inner estuary are abandoned, the most significant influence on the tidal prism would be the flooding of the Reydon Marshes. This would increase flow rates by some 50% within the harbour reach…Abandoning Tinkers Marsh would have a similar but smaller effect. Similarly, inclusion of Robinson's Marsh would have less impact but would still increase flow at the harbour mouth."

■ Raised embankments

- No flood risk to wider estuary
- Increased peak flood levels in harbour (+200mm for Dec 2013 conditions)
- Smaller tidal prism
  - Lower flow rates in entrance channel
  - Less impact for navigation
  - Greater risk of siltation of channel

Royal HaskoningDHV

- SMP policy scenario
  (raise North banks, realign some South banks)
  - SMP policy aims to minimise future increases in tidal prism and associated risk to harbour entrance

PREFERRED POLICY TO IMPLEMENT PLAN:	
From present day	Maintain the North Pier and the entrance to the harbour. Maintain defences along the northern side of the Harbour reach. Maintain Robinson's Marsh defences and Walberswick Dunes. Examine options for management of South Pier and Walberswick Quay in line with requirements to maintain the entrance to the harbour. Maintain the integrity of the Denes whilst allowing the dunes to adjust naturally.
Medium term	Maintain the North Pier and defences along the northern side of the Harbour reach. Allow failure of Robinson's Marsh defences and construct local retired defences. Maintain the integrity of the Denes whilst allowing the dunes to adjust naturally.
Long term	Maintain the North Pier and defences along the northern side of the Harbour reach. Maintain new defences to the south of the harbour mouth. Maintain the integrity of the Denes but allowing the dunes to adjust naturally.

Royal HaskoningDHV

- Modelling results for SMP scenario:
  - Addresses flood risk issues in wider estuary
  - Compared to 'Do Nothing':
    - Higher peak flood levels in harbour
    - Reduced tidal prism / flow rates
  - Compared to raised embankments:
    - Lower peak flood levels in harbour
    - Increased tidal prism / flow rates
  - Habitat impacts from flooding of marshes
  - Visual impact of permanently flooded marshes

Royal HaskoningDHV

Benefits and constraints of a spillway

- Estuary options don't address all issues
  - Flood risk to Blackshore only solved with an expensive tidal barrier?
- Spillway is a 'managed alternative' to SMP scenario
  - Controlled flooding of marshes, when peak flood levels need to be reduced on a surge tide
  - May reduce peak flood levels and address other constraints
- Spillways don't work on the open coast, can work on rivers
  - Too close to the sea, will 'suck in' water
  - More effective further inland

AS27

  - Drop in water level at Blackshore in 2013 after breach - suggests a spillway it could work here
  - Spill needs to happen at the right time to reduce peak flood levels
  - Modelling needed to determine if / how well a spillway could work

Royal HaskoningDHV

AS27 Lidar data showing ground levels

Amy Savage, 30/03/2021

Benefits and constraints of a spillway

- Compared to the SMP scenario:
  - Less frequent flooding of marshes
  - Reduced flood risk to Blackshore / Harbour – choose when sluice is opened for most benefit
  - Smaller tidal prism, lower flow rates
- Other issues:
  - Will there be enough reduction in peak flood level? (may not work so close to the sea)
  - Frequency & depth of flooding of marshes
  - Controlled sluice vs passive spillway

Controlled sluice

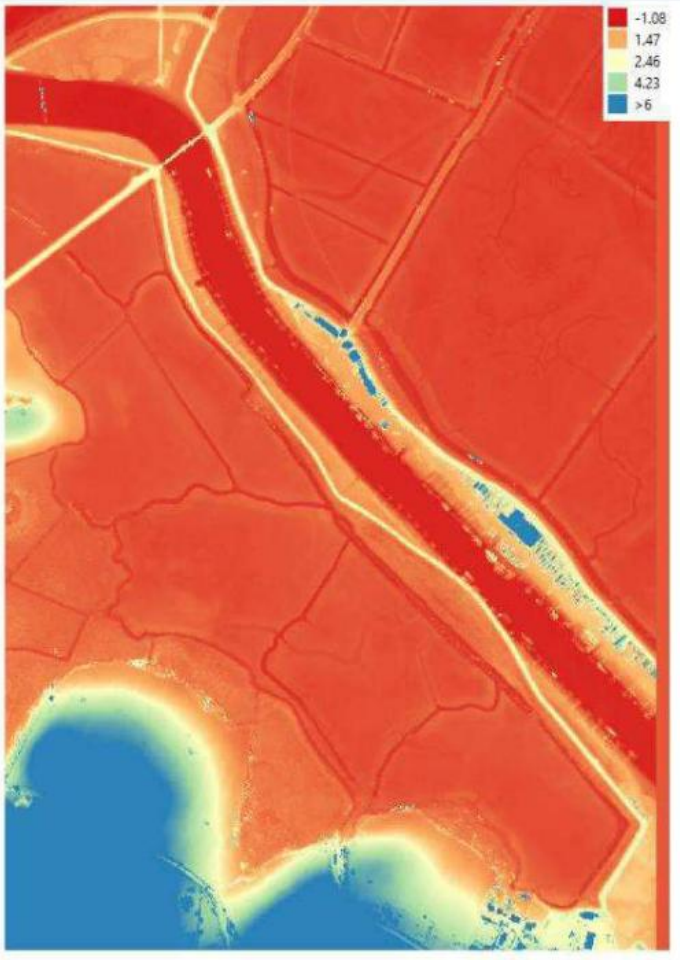
- Automatically controlled sluice gate
- Low sill level
- Greater width more effective, but increases costs
- Benefits
  - Greater impact on water levels than passive spillway
  - Able to optimise performance - open the sluice to give the greatest reduction in peak water levels
  - Direct drainage of flood water
- Constraints
  - May need to raise embankment levels in places
  - High cost
  - Operational requirements
  - Failure risk
- If a controlled sluice is not effective, it's unlikely that a passive spillway would work

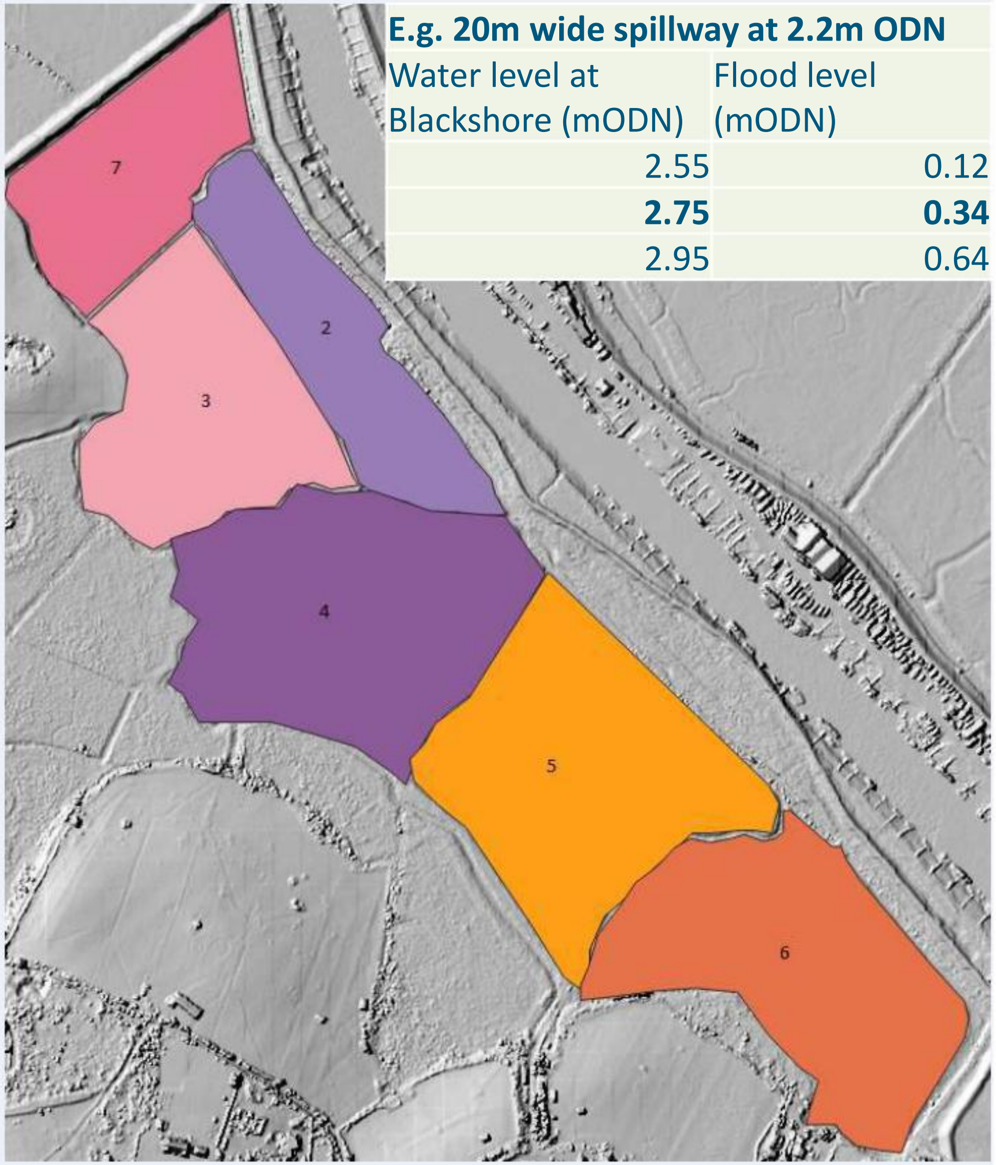
Passive spillway

- Not controlled by a gate, always open
- Higher sill level
  - Can't flood too often
  - Won't influence peak flood levels if too low
- Wider than a controlled sluice
- Benefits
  - Lower cost
  - Less operational requirements
  - Less visual impact than closed sluice gate
- Constraints
  - More frequent flooding of marshes
  - Need to pump out flood water
  - More embankment raising may be needed

Spillway location and dimensions

- Less effective closer to the sea
- Upstream of Blackshore would be less effective for peak flood levels
- Opposite Blackshore properties
  - Observed drop in water level here when embankments breached in 2013
  - Best location for reduction in flood risk to properties, less benefit to harbour downstream
- Maximum flood level on marshes is +1m ODN (risk of flooding to Walberswick properties)
- Initial analysis shows this is possible





E.g. 20m wide spillway at 2.2m ODN	
Water level at Blackshore (mODN)	Flood level (mODN)
2.55	0.12
2.75	**0.34**
2.95	0.64

Next steps to assess spillway option

- Initial assessment – could a spillway work?
- Tidal model to assess water levels, flow rates
  - Input conditions – scenario most likely to work
  - Most effective arrangement - wide, controlled sluice opposite Blackshore
  - Sluice opened ahead of peak of 'steep' surge tide
  - Depending on results, review passive spillway option, sensitivity to SLR and marsh level

Next steps

- Cost estimate for various spillway options, complete cost estimates for all options
- Next meeting - discuss modelling results & costs
- If spillway option is possible and preferred, further analysis would be needed to optimise
- Cost / benefit analysis likely to be needed to conclude on a preferred option

Next steps – further modelling

- Requests for additional modelling runs:
  - Embankment height for 0m / 1m flood depth
  - Range of SLR scenarios, impact on flood levels

- Tidal model considers a range of input conditions
  - Water levels from 1.4m to 3.6m, cover the range of future SLR scenarios
  - Modelling of spillway option will include an additional water level
  - We will interpret the results to answer your questions

Summary of questions & comments

- **As well as flooding, is the main risk from sea level rise the increase in flows at the harbour mouth that would endanger channel structures?** *Confirmed.*
- **Is navigation an issue in a 2013 flood event?** *The flow rates on an extreme event are more relevant for longer-term erosion or siltation of the channel rather than navigation. Flow rates during 'normal' conditions (now and in the future) have been modelled to assess navigation impacts.*
- **How much have banks been raised in the 'raised embankments' scenario?** *For this option it is assumed that the embankments are raised as much as is necessary to prevent overtopping / flooding. For comparison, slides have been added showing model results for the 2013 event conditions with present-day embankment levels.*
- **Would flood water need to be pumped out from marshes? Currently drains via Walbersick Sluice.** *Drainage requirements would need to be assessed in the spillway design. Depends on the capacity of the sluice and how long it is acceptable for the marshes to be under water.*
- **What effect would a spillway have on flow rates?** *Whilst the tidal prism would be increased, the spillway would mean the timing of the outflow could be controlled, managing flow rates. Flow rates will be assessed by the modelling.*
- **Concerns raised over potential costs and timescales of a wider cost benefit analysis. This could make decisions more difficult if wider issues are included.** *Benefits may need to be assessed as well as costs in order to justify funding.*
- **Comment on potential benefit of a tidal barrier or narrowed entrance, e.g. with flap valves as per previous discussions.** *A tidal barrier option will be included in the Investment Plan.*
- **Request made after meeting for modelling of a narrowed entrance with flap valves to discharge the ebb tide.** *This proposed additional scope will need to be discussed with the Council.*