Marine Directorate Licensing Operations Team (MD-LOT)
Marine Scotland
By email

Our ref 676693/EC/007
Telephone 0141 341 5040
E-mail [redacted]

7 July 2023

Attn: Marine Directorate Licensing Operations Team (MD-LOT)

Ardersier Port – Marine License MS-00009963 (Capital Dredging)
Request for a Screening Opinion

Introduction

We write on behalf of our clients, Ardersier Port (Scotland) Ltd (APSL), to formally request a screening opinion under The Marine Works (Environmental Impact Assessment) (Scotland) Regulations 2017 (MW EIA Regulations). This request follows on from recent correspondence and discussions regarding the proposed alterations to the site's capital dredging licence. In particular, the email from MD-LOT dated 26/05/2023, which requests under Regulation 10(2) of the MW EIA Regulations, further information on certain points of the proposed changes to be provided.

Background to the Request for A Screening Opinion

As you will be aware, APSL are committed to upgrading their existing facilities to create a state-of-the-art port facility offering services to a wide range of industries which include off-shore wind, marine decommissioning, waste to energy etc (Refer to Plate 1, Appendix A for the current site Masterplan).

In order to support the marshalling and installation of key components of the off-shore wind farm industry the depth of the approach channel and berthing pocket need deepened to -12.9m CD. The proposed depth of the channel has been calculated based on a robust scan of vessels and their operating drafts which are typically used for this purpose by the offshore wind sector. These elements would include foundations and wind turbine generators which would be transported to and assembled at Ardersier port on a range of heavy lift vessels and semi-submersibles such that they can be efficiently installed by specialist construction vessels at the offshore wind sites.

Information Requested

For ease, the information requested under a specific MW EIA Regulation is presented in a blue box with the response provided below it.

10 2(b)(i)
- List all changes that are proposed, including all material and temporal changes. A request to MD-LOT dated 7 March 2023 outlines the consideration of the removal of conditions concerning dredging during hours of darkness. This must be included in the information provided.

- The changes proposed in this screening request are as follows;

1) A temporal extension to the Marine Capital Dredging License (as per our email dated 29 March 2023). We can confirm the temporal extension request would be for a period of 2 years i.e. Marine Licence Expiry Date being September 2025;
2) Request to remove the night dredging restrictions (as per our email dated 8th May 2023); and
3) Request to change the dredge area and volume (as per our letter Ref 676693/CCAS/005, dated 19th May 2023). This request relates to the proposals to:
   i) Increase the dredge depth from the approved -6.5m CD to -12.9m CD; and
   ii) Increase the associated dredging volume from the approved quantity of 4,600,000 wet tonnes (wt) (comprising 4,000,000 wt for beneficial reuse and 600,000 wt to form the permanent dredge spoil storage bund) to 8,600,000 wet tonnes (increasing the volume identified for beneficial reuse by 4,000,000 wt to 8,000,000 wt). *

*Note: The proposals are to re-use the additional dredge material on site in the works to upgrade the quay.

10 2(b)(ii)
- Detail the correct amount of dredge material licensed under MS-00009936 (being 4,600,000) and state how much of this has already been dredged.
- Provide a realistic, worst-case timeframe for dredging the additional material without the requirement for additional variations to the licence. Considering the substantial additional amount of dredging required, we query whether an additional year is sufficient and includes enough contingency.
- Provide details of the vessel(s) proposed to carry out the dredge and the methodology of the vessel(s) e.g. Trailing Suction Hopper, Plough Dredger. We understand there have been changes to the vessels used throughout the project and seek clarification on the vessels and dredging methods used going forward.

- The correct amount of dredge material licensed under the current capital dredging licence is confirmed under the response to Regulation 10 2 (b)i. Of this amount 1,080,000 wt has been dredged since dredging operations began in March/April 2022. This leaves circa 3,520,000 wt to be dredged under the current capital dredging licence (i.e. without the requested increase in volume).

- As noted above we have taken on board your advice and are requesting an extension to September 2025. This extension is based on the assumption that a summer dredging campaign in 2024 utilising a cutter suction dredger will be approved with the winter dredging period in 2023/2024 and 2024/2025 using the smaller dredger that is currently operational. This would leave Summer 2025 period as a contingency should this be required.

- It is proposed to use the following vessels for dredging purposes:

  1) 2024 Summer Campaign will use a cutter suction dredger similar to the one proposed and assessed in the 2018 EIAR. Currently the exact vessel is still to be contracted and will be confirmed once the updates to the current capital dredging licence are approved; and
  2) The 2023 / 2024 and 2024/2025 winter dredge campaigns will use the smaller cutter suction dredger that is currently operational at the port.

10 2(b)(iii)

- Provide a description of the location of the proposed dredge, with particular regard to the environmental sensitivity of geographical areas likely to be affected. We ask that you provide full consideration of impacts on all the nearby designated sites and other sensitive and priority species. If any mitigation to negate the impact is proposed, these should be clearly laid out.

The attached drawing (ARUP ref no 294067-ARUP-XX-XX-DR-CG-002001 P01, Appendix A) shows the area that is proposed to be dredged to the new depth of -12.9 CD. Also attached is an Ecological Assessment (Appendix B) that considers the environmental sensitivity of the geographical areas likely to be affected by the proposals. It also considers the impacts on all the nearby designated sites and other sensitive and priority species as well as the mitigation measures to negate any identified impacts.

10 2(c)

- Provide a comprehensive assessment of the potential environmental impacts from the proposal and the resulting likely significant effects. This must include, but is not limited to, the designated sites affected by the proposal and the effect on the qualifying interests of these sites, and potential impacts on other habitats and species present. Take into account:

  (a) the magnitude and spatial extent of the impact (for example geographical area and size of the population likely to be affected);
  (b) the nature of the impact;
  (c) the transboundary nature of the impact;
  (d) the intensity and complexity of the impact;
  (e) the probability of the impact;
  (f) the expected onset, duration, frequency and reversibility of the impact;
  (g) the cumulation of the impact with the impact of other existing and/or approved works;
  (h) the possibility of effectively reducing the impact.

- Consider potential impacts of species where mitigation measures are in place as part of conditions for licence MS-00009936. In particular, the removal of conditions regarding dredging during hours of darkness.

As noted in the response to the question under Regulation 10 2(b)(iii), an Ecological Assessment report is attached which addresses this request. It includes consideration of potential impacts of species where mitigation measures are in place as part of conditions for licence MS-0009936 which include the proposals to remove the conditions regarding dredging during the hours of darkness.

Additional Information

Please also find attached the Spit Stability Geotechnical Assessment (Appendix C) undertaken by Arup for the proposed revised dredge. An updated Coastal Processes Assessment (Appendix D) is also attached which considers the potential impacts of the revised dredge design on coastal processes. This assessment is an update to the 2018 Coastal Processes Assessment which informed the 2018 EIAR.

We trust the above is in order however please do not hesitate to contact us should you require any further information.

Yours sincerely
for EnviroCentre Ltd

(issued electronically)

Emma Cormack
Principal Consultant

Campbell Stewart
Associate Director

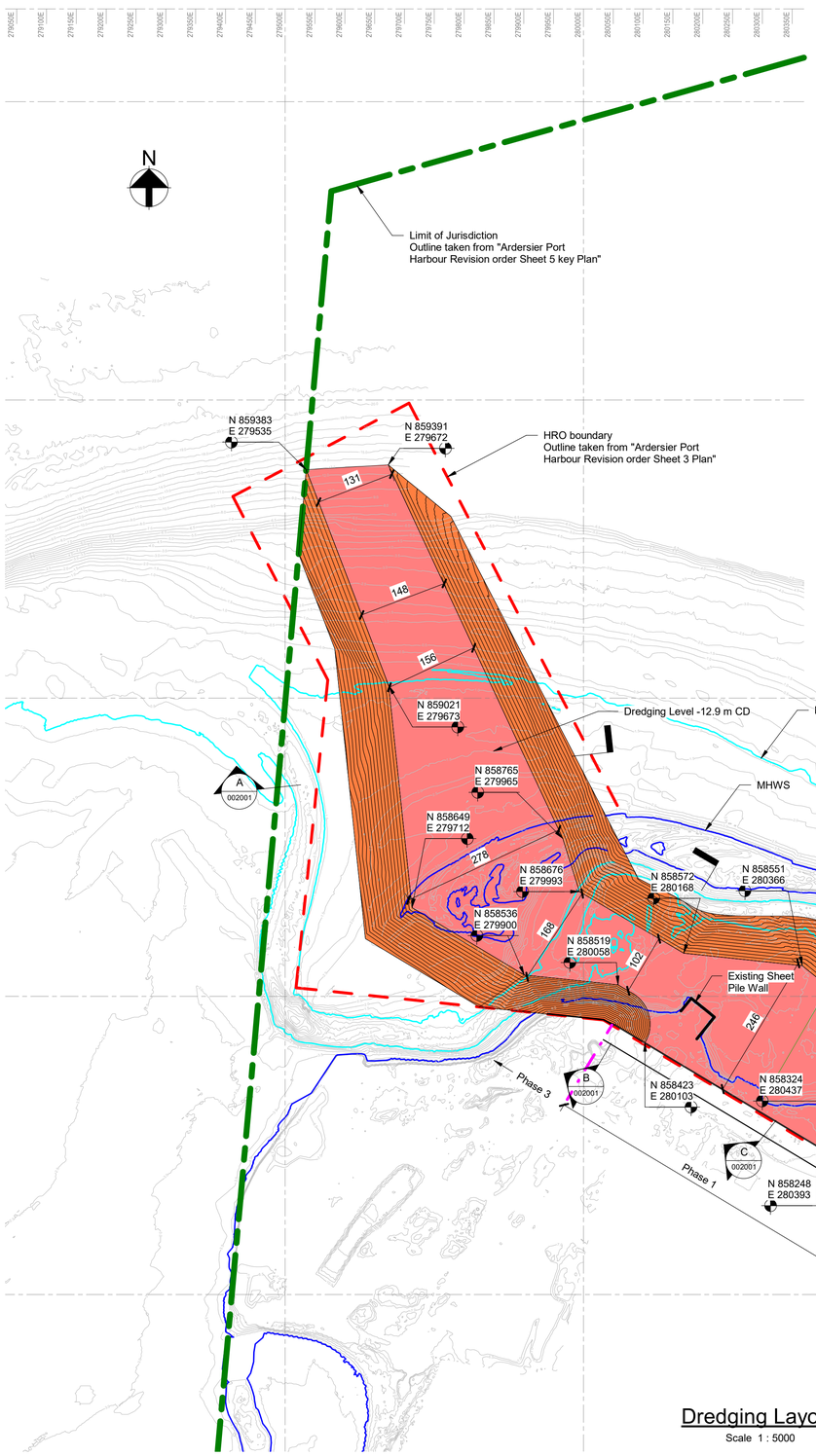
Enc: Ardersier Port Masterplan
ARUP Drawing 294067-ARUP-XX-XX-DR-CG-002001 P01
Ecological Assessment, (Report Ref 13543, Dated 07/07/2023)
Ardersier Port, Spit Stability: Geotechnical Assessment, Arup, Reference: 294067-ARUP-Z1-XX-RP-CG-000001 July 2023
Coastal Processes Assessment Report 13546, July 2023

CC: Steve Regan, Ardersier Port (Scotland) Ltd
Gregor Ogilvie, Ardersier Port (Scotland) Ltd

A DRAWINGS

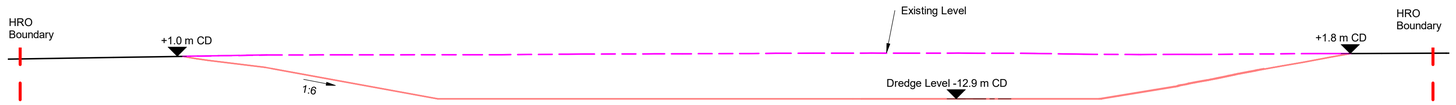
Plate 1: Masterplan

A1



Dredging Layout

Scale 1 : 5000



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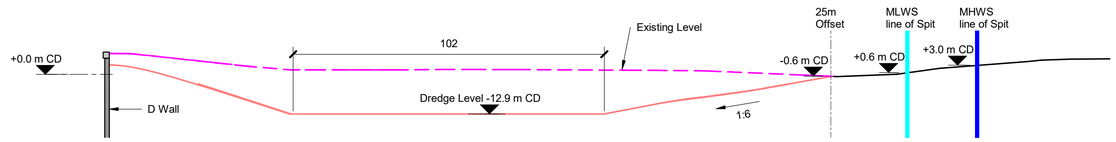

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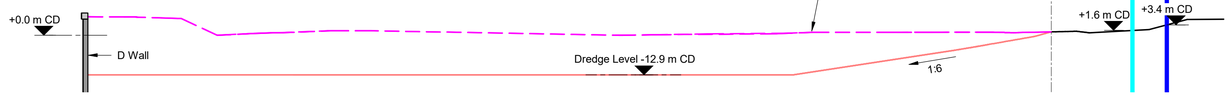

C Section C

1 : 1000

Legend

- Dredge Slope 1:6
- Spit Reinstatement area

Not for Construction

Notes:

1. All levels are in m above Chart Datum (mCD).
2. Coordinates are shwon to OS National Grid.

Issue	Date	
P01	12/05/2023	First Issue

ARUP

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Client: Ardersier Port

Project Title: Ardersier Port

Drawing Title: Phase 1
Proposed Dredging Layout

Scale at A1	As indicated	By / Chkd / Appd	JDW/AR/PST
Role	Civil - Geotechnical		
Status	S2 - Suitable for Information -		
Arup Job No	294067-00	Rev	P01
ID	294067-ARUP-XX-XX-DR-CG-002001		

15/05/2023 16:07:59

Do not scale

B ECOLOGICAL ASSESSMENT

Ardersier Deeper Dredge
Ecological Assessment

July 2023

CONTROL SHEET

Client: Ardersier Port Ltd
Project Title: Ardersier Deeper Dredge
Report Title: Ecological Assessment
Document number: 13543
Project number: 676693

Issue Record

Issue	Status	Author	Reviewer	Approver	Issue Date
1	Final	MM	GN	EC	07/07/2023
2					

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EXECUTIVE SUMMARY

Envirocentre was commissioned by Ardersier Port to undertake an Ecological Appraisal of the proposed amendments to dredging being conducted under marine licence MS-00009936, to inform Environmental Impact Assessment (EIA) Screening, requested by Marine Scotland.

Since the 2018 impact assessment was undertaken and marine licence was granted for dredging, further investigative works have revealed that a change in the volume and depth of dredge are required. There is also a change in the footprint of the area to be dredged.

The aim of this study is to assess the impacts and significance of any subsequent effects the proposed dredging amendments will have on ecological receptors.

The impacts in relation to night-time dredging were assessed as part of the 2018 EIA and it is not considered that the proposed dredge amendments will affect the original assessment. The proposed dredge amendments won't alter the parameters of the modelling (eg noise generated by the vessel will not be different). Assuming that animals will flee as soon as they hear the noise from the dredging, and expected disturbance from modelling is highly localised to the dredge site, with individuals present within the wider Moray Firth unlikely to be impacted. There is only considered to be a risk to marine mammals if they are in close proximity to the dredge vessel when dredging is commencing. The modelling also shows that there is no difference to disturbance distances regardless if the activity continues for 8 hours or 24 (as long as they do not remain stationary).

As long as mitigation is employed, as it currently is, it is not anticipated that dredging activities at night-time would have any greater impact on marine mammals that day-time dredging has. By allowing night- time dredging, the total number of days dredging may occur over will be reduced as greater volumes would be removed within a 24hr period with longer operational hours.

The impacts from night-time dredging are not predicted to affect the conservation status of any of the populations of marine mammals present within the Moray Firth and are not significant.

The loss of additional sub-tidal habitat will be permanent. No Annex I or Priority Marine Feature habitats are considered to be present within the dredge footprint[1]. The habitat is also not considered to be key habitat for any protected or notable species. It is considered that the birds have access to alternative roosting and nesting habitat and the loss of the island will not impact on the conservation status of the wider populations. There will be an overall reduction of habitat available for roosting within the development area and so the effects will be significant at a site level.

Additional mitigation will be required in order to compensate for the proposed loss of bird nesting and roosting habitat. The existing Habitat Management Plan which sets out compensatory and enhancement actions for the site will be updated to reflect the loss of the island.

[1] According to habitat maps available through the Marine Scotland National Marine Plan Interactive Map available at: https://marinescotland.atkinsgeospatial.com/nmpi/ (accessed 06/07/2023).

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1 INTRODUCTION

1.1 Terms of Reference

Envirocentre was commissioned by Ardersier Port to undertake an Ecological Appraisal of the proposed amendments to dredging being conducted under marine licence MS-00009936, to inform Environmental Impact Assessment (EIA) Screening, requested by Marine Scotland[2].

1.2 Scope of Report

The aim of this study is to assess the impacts and significance of any subsequent effects the proposed dredging amendments will have on ecological receptors. The objectives are as follows:

- Review the existing EIA and other relevant assessments pertaining to the works.
- Describe the potential impacts of the proposed dredging amendments.
- Identify the ecological features which could be impacted by the proposed amendments.
- Assess any additional impacts to IEFs not already covered within the existing EIA.
- Recommend any additional mitigation required to avoid or minimise impacts.

1.3 Project Background

Dredging works are required to facilitate the creation of a new port facility granted planning permission in principle in 2019 (planning reference 18/04552/PIP). An Environmental Impact Assessment[3] was undertaken in 2018 to inform the planning application. The EIA considered impacts arising from works, including impacts dredging would have in relation to marine mammals and the qualifying features of designated sites, amongst other ecological receptors and found that with mitigation, no significant impacts were predicted.

Since the 2018 impact assessment was undertaken and marine licence was granted for dredging, further investigative works have revealed that a change in the volume and depth of dredge are required. There is also a change in the footprint of the area to be dredged.

The requirement for night-time dredging was anticipated and the significance of impacts arising from dredging were assessed on the basis of 24 hour operation in 2018. Despite no significant effects being identified with mitigation, Marine Scotland placed a condition on the licence that works could not take place outside of daylight hours, in order to protect qualifying features of the Moray Firth Special Area of Conservation (bottlenose dolphin, *Tursiops truncates*). Ardesier Port are seeking for the condition to be removed in order to maximise the time available to complete dredging.

As well as the marine license for dredging, the project has a derogation licence for the disturbance European Protected Species (EPS) (MS EPS 06/2019/0) and works are being undertaken in accordance with a Marine Mammal Protection Plan[4].

At present dredged material is being transported onshore via a floating pipe. It is then stockpiled with a view to repurposing. No at sea disposal is anticipated. Associated water from the dredging process is

[2]Request via email subject *00009936 -Ardersier Port Limited (per Envirocentre Ltd) - Capital Dredging and Deposit Variation – Notification That Further Information Is Required for Screening* sent 26th May 2023.
[3]Ardersier Port (2018) *Ardersier - Environmental Impact Assessment Report Volume 2*
[4] EnviroCentre (2018) *Ardersier Port Marine Mammal Protection Plan*.

directed through settlement ponds to help reduce the suspended solid content prior to discharge of the water back into the harbour.

1.4 Report Usage

The information and recommendations contained within this report have been prepared in the specific context stated above and should not be utilised in any other context without prior written permission from EnviroCentre Limited.

If this report is to be submitted for regulatory approval more than 12 months following the report date, it is recommended that it is referred to EnviroCentre Limited for review to ensure that any relevant changes in data, best practice, guidance or legislation in the intervening period are integrated into an updated version of the report.

Whilst the Client has a right to use the information as appropriate, EnviroCentre Limited retains ownership of the copyright and intellectual content of this report. Any distribution of this report should be managed to avoid compromising the validity of the information or legal responsibilities held by both the Client and EnviroCentre Limited (including those of third party copyright). EnviroCentre Limited does not accept liability to any third party for the contents of this report unless written agreement is secured in advance, stating the intended use of the information.

EnviroCentre Limited accepts no liability for use of the report for purposes other than those for which it was originally provided, or where EnviroCentre Limited has confirmed it is appropriate for the new context.

2 EIA REVIEW

Table 2-1 below sets out the impacts predicted in 2018 to occur in relation to the dredging campaign currently consented and underway. It also sets out how those impacts are likely to change in relation to the proposed amendments (increased dredge area and deeper dredge, night-time working was already assumed within the impact assessment).

Table 2-1: Dredging impacts review

Current Impacts Assessed	Receptor	Current Mitigation	Significance of Impact	Likely Changes with Proposed Amendments	Additional Mitigation Required
Increased underwater noise.	-Moray Firth SAC (bottlenose dolphins) -Dornoch Firth and Morrich More SAC (harbour seals, *Phoca vitulina*) -River Moriston SAC (Atlantic salmon, *Salmo salar*) -Atlantic salmon and sea trout (*Salmo trutta)* -Harbour porpoise (*Phocoena phocoena*) -Seals (grey seal (*Halichoerus grypus*) and harbour seal) -Dolphinids (Bottlenose dolphin, Common dolphin (*Delphinus delphis*))	Marine Mammal Protection Plan in place inclusive of MMO protocol. Visual searches within 500m mitigation zone prior to dredge commencing. Dredging to commence in daylight hours and sea states conducive to conducting searches (less than sea state 4).	Not significant for any of the receptors	No change	None
Increased airborne noise	-Inner Moray Firth SPA (non-breeding birds) -Moray Firth SPA (non-breeding and breeding birds)	Regular monitoring of roost locations. Buffer to be maintained between any known roost sites and proposed works as all times.	Not significant for any of the receptors	No change	None

Increased visual disturbance through vessel movements.	-Inner Moray Firth SPA (non-breeding birds) -Moray Firth SPA (non-breeding and breeding birds)	Regular monitoring of roost locations. Buffer to be maintained between any known roost sites and proposed works as all times.	Not significant for any of the receptors	No change	None
Temporary localised increase in sediment suspension around dredge location.	-Moray Firth SAC (bottlenose dolphins) -Dornoch Firth and Morrich More SAC (harbour seals, *Phoca vitulina*) -River Moriston SAC (Atlantic salmon, *Salmo salar*) -Inner Moray Firth SPA (non-breeding birds) -Moray Firth SPA (non-breeding and breeding birds) -Atlantic salmon and sea trout (*Salmo trutta)* -Harbour porpoise (*Phocoena phocoena*) -Seals (grey seal (*Halichoerus grypus*) and harbour seal) -Dolphinids (Bottlenose dolphin, Common dolphin (*Delphinus delphis*))	Cutter suction dredger used to minimise sediment suspension.	Not significant for any of the receptors	No change	None

Minor and localised alterations to coastal processes.	-Moray Firth SAC (subtidal sandbanks) -Whiteness Head SSSI (coast geomorphology, sand dunes, shingle, sand flats, saltmarsh)	N/A	Not significant for any of the receptors	Updates to the coastal morphology model are being undertaken to assess if there are significant changes. A geotechnical assessment has been conducted in relation to the the spit (forming part of the Whiteness Head SSSI) and it is considered that the dredging to date and proposed phase 1 dredging will not undermine stability[5].	Unknown at present

[5] Arup (2023) *Ardersier Port, Spit Stability: Geotechnical Assessment.*

Loss of small areas of habitat within the Whiteness Head Site of Special Scientific Interest (SSSI) (<3%) and Inner Moray Firth Special Protection Area (SPA) (0.1%) and Moray Firth SAC.	-Moray Firth SAC -Moray Firth SPA -Inner Moray Firth SPA -Whiteness Head SSSI	Habitat enhancement plan to be implemented.	Not significant for any of the receptors.	Additional dredge area is outwith the designated sites so no additional habitat will be lost. The island to be formed during creation of the dredge channel, which would provide predator free roosting and nesting opportunities for birds will now be lost. This was to be mitigation for loss of habitat within the SPA	Habitat Enhancement Plan to be revised and alternatives for roosting bird provision sought through enhancement of other areas of the site.
Increased risk of pollution events occurring in the event of a fuel leak and spill	-All features.	-Good practice pollution prevention measures set out within Construction Environment Management Plan (CEMP) -Adherence to CEMP audited during weekly Ecological Clerk of Work (ECoW) visits.	Not significant	No change	None

3 ASSESSMENT OF ADDITIONAL IMPACTS

3.1 Habitat Loss

The key difference in the proposed dredging amendment and the existing dredge plan is that the footprint of the dredge area will be larger (additional 10.11ha). The loss of additional sub-tidal habitat will be permanent. No Annex I or Priority Marine Feature habitats are considered to be present within the dredge footprint[6]. The habitat is also not considered to be key habitat for any protected or notable species.

As well as sub-tidal habitat loss, the new dredge area will result in the loss of the western end of the spit. This is comprised of open dune habitat and intertidal mud and sand. Whilst not within the Inner Moray SPA or Moray SPA, the seabird and wader species which are designated features of the sites may utilise the end of the spit for roosting. Under current plans the end of the spit was to be retained, providing an island, protected from land predators such as foxes, which could be utilised by nesting or roosting birds. The creation of this island was part of mitigation for loss of SPA habitat elsewhere within the site.

It is considered that the birds have access to alternative roosting and nesting habitat and the loss of the island will not impact on the conservation status of the wider populations. There will be an overall reduction of habitat available for roosting within the development area and so the effects will be significant at a site level.

3.2 Night-time dredging

The impacts in relation to night-time dredging were assessed as part of the 2018 EIA and it is not considered that the proposed dredge amendments will affect the original assessment. Due to concerns raised by Marine Scotland and the inclusion of the condition preventing night-time work in order to protect bottlenose dolphin within the Moray SAC, the impacts of this on bottlenose dolphin (and other marine mammals) are further provided here.

The main impact predicted to arise from the current and proposed dredging, in relation to marine mammals, is the generation of underwater noise. High levels of underwater noise have the potential to cause injury to marine mammals via temporary or permanent threshold shifts (TTS or PTS) in hearing. In extreme circumstances, loud noises generated in close proximity to individuals can cause death due to pressure changes. In lower levels, noise can cause disturbance and changes in behaviour through masking (where man-made noise drowns out natural noises, affecting communication between individuals, ability to hunt and/or navigate) or displacement from habitats. Underwater noise modelling undertaken to inform the 2018 EIA included modelling of noise which would be generated by dredging using a cutter suction dredger. The proposed dredge amendments won't alter the parameters of the modelling (eg noise generated by the vessel will not be different) Figure 3-1 below shows the results of the modelling with regards to distances for PTS and TTS thresholds for different hearing groups. It is assumed that marine mammals will swim away from any noises which are causing them disturbance or are harmful, the shorter exposure periods for the modelling are therefore the most likely to be experienced.

[6] According to habitat maps available through the Marine Scotland National Marine Plan Interactive Map available at: https://marinescotland.atkinsgeospatial.com/nmpi/ (accessed 06/07/2023).

Assuming that animals will flee as soon as they hear the noise from the dredging, the PTS range for any species is a maximum of 3m from the source of the noise. The TTS limits are all within 230m (within 2m for all species when excluding harbour porpoise) when assuming animals will flee from the noise source. The expected disturbance is therefore highly localised to the dredge site, with individuals present within the wider Moray Firth unlikely to be impacted. There is only considered to be a risk to marine mammals if they are in close proximity to the dredge vessel when dredging is commencing. The modelling also shows that there is no difference to the TTS and PTS threshold distances regardless if the activity continues for 8 hours or 24 (as long as they do not remain stationary).

Dredging NMFS (2018) - SEL_{cum} (8 hours)	PTS criteria		TTS criteria	
	Fleeing	Stationary	Fleeing	Stationary
Low Frequency (LF) Cetaceans	< 1 m	34 m	2 m	370 m
Mid Frequency (MF) Cetaceans	< 1 m	20 m	2 m	220 m
High Frequency (HF) Cetaceans	3 m	330 m	230 m	2.8 km
Phocid Pinnipeds (PW)	< 1 m	22 m	2 m	240 m

Table 5 Summary of the impact ranges for auditory injury using criteria from NMFS (2018) for dredging (non-impulsive) noise over 8 hours

Dredging NMFS (2018) - SEL_{cum} (12 hours)	PTS criteria		TTS criteria	
	Fleeing	Stationary	Fleeing	Stationary
Low Frequency (LF) Cetaceans	< 1 m	42 m	2 m	460 m
Mid Frequency (MF) Cetaceans	< 1 m	25 m	2 m	280 m
High Frequency (HF) Cetaceans	3 m	400 m	230 m	3.3 km
Phocid Pinnipeds (PW)	< 1 m	27 m	2 m	300 m

Table 6 Summary of the impact ranges for auditory injury using criteria from NMFS (2018) for dredging (non-impulsive) noise over 12 hours

Dredging NMFS (2018) - SEL_{cum} (24 hours)	PTS criteria		TTS criteria	
	Fleeing	Stationary	Fleeing	Stationary
Low Frequency (LF) Cetaceans	< 1 m	61 m	2 m	640 m
Mid Frequency (MF) Cetaceans	< 1 m	36 m	2 m	390 m
High Frequency (HF) Cetaceans	3 m	570 m	230 m	4.3 km
Phocid Pinnipeds (PW)	< 1 m	39 m	2 m	420 m

Table 7 Summary of the impact ranges for auditory injury using criteria from NMFS (2018) for dredging (non-impulsive) noise over 24 hours

Figure 3-1: Underwater noise modelling results in relation to dredging.

In order to avoid and minimise the risk of injury and disturbance to marine mammals, a Marine Mammal Protection Plan is in place. The main mitigation in relation to underwater noise is to employ a Marine Mammal Observation (MMO) Protocol. Prior to dredging commencing, a dedicated MMO will undertake a visual search of waters within 500m of the dredge vessel for 30min prior to dredging commencing. No works will begin until 20 min after any marine mammals are observed leaving the mitigation zone. The visual searches will be conducted in daylight hours only, in suitable conditions (sea state less than 4). Whilst the searches prior to the activity commencing are required to be done in periods with good visibility, it is considered that dredging may continue into the night, or periods of reduced visibility (due to weather conditions etc) as long as there is no break in activity. This is in line with Joint Nature Conservation Committee guidance on reducing noise impacts to marine mammals in relation to impact piling[7]; "*A distinction should be made here between piling which commences during times of good visibility (and subject to the above provisions) and continues into a period of poor visibility/ night-time, and piling that commences during times of poor visibility (including night-time conditions). Assuming that the operations are continuous the first scenario would not need additional mitigation*."

As long as mitigation is employed, as it currently is, it is not anticipated that dredging activities at nigh-time would have any greater impact on marine mammals that day-time dredging. By allowing night-

[7] Available at: https://data.jncc.gov.uk/data/31662b6a-19ed-4918-9fab-8fbcff752046/JNCC-CNCB-Piling-protocol-August2010-Web.pdf (Accessed 06/07/023)

time dredging, the total number of days dredging may occur over will be reduced as greater volumes would be removed within a 24hr period with longer operational hours.

The impacts from night-time dredging are not predicted to affect the conservation status of any of the populations of marine mammals present within the Moray Firth and are not significant.

3.3 Cumulative Impacts

No significant cumulative impacts were identified within the original EIA and given the highly localised nature of the additional impacts identified for the proposed dredge amendments, it is considered that this is still likely to be the case.

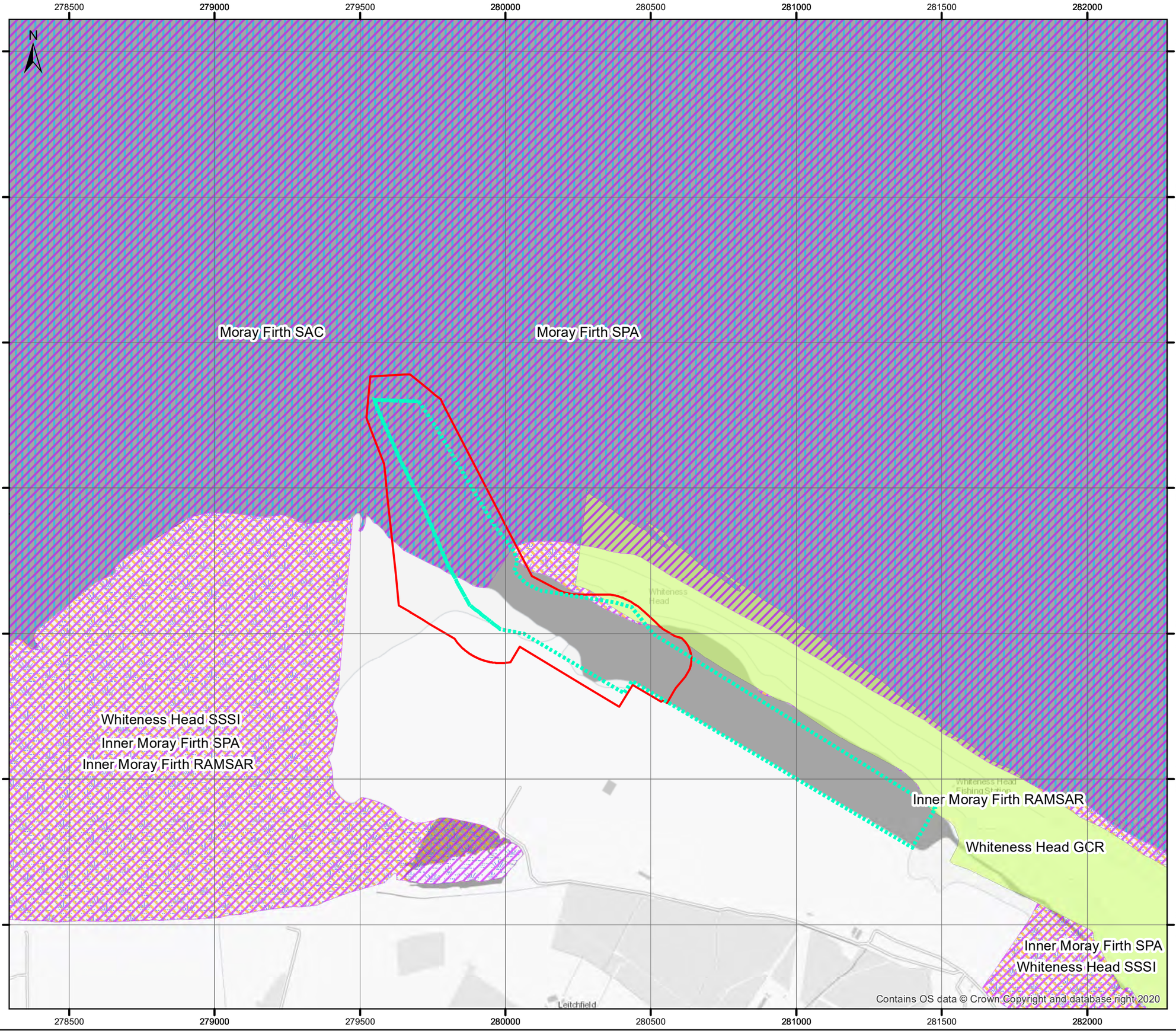
4 MITIGATION

Additional mitigation will be required in order to compensate for the proposed loss of bird nesting and roosting habitat. The existing Habitat Management Plan which sets out compensatory and enhancement actions for the site will be updated to reflect the loss of the island. Stakeholders within the Habitat Management Group, have discussed the possibility of re-storing the natural hydrology of the lagoon situated to the west of the development area. This would involve re-connecting it to the sea and allowing it to flood. It may be possible to create a similar island within this area, however further hydrological investigation is required to assess the feasibility.

It is considered that the existing protocols set out within the MMPP will be sufficient to avoid and minimise the risk associated with underwater noise generation from dredging.

APPENDICES

A DREDGE AREA AND DESIGNATED SITES



Legend

- Dredge Boundary 2018
- Dredge Outline 2023

Designation

- GCR
- RAMSAR
- SAC
- SPA
- SSSI

Do not scale this map

Client
Ardersier Port (Scotland) Ltd

Project
Ardersier Port

Title
Dredge Extent and Designated Sites

Status
FINAL

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MN	EC	CCAS

Scale
1:12,500 @A3
0 62.5 125 250 375 Metres

Rev	Date	Amendment	Initials
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C SPIT STABILITY ASSESSMENT

ARUP

Ardersier Port

Ardersier Port

Spit Stability: Geotechnical Assessment

Reference: 294067-ARUP-Z1-XX-RP-CG-000001

Issue 02 | 5 July 2023

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		Signature			

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Figure 5.7. Plaxis, Incremental displacements for C-Phi reduction stage. A) Overview image B) Zoomed in

1. Introduction

Ardersier Port is proposing to redevelop its existing land into a new port facility. A major element of the scheme is the utilisation of the existing natural spit as a breakwater for the port. The spit will protect the proposed quay from the North Sea and provide the required conditions for safe utilisation of the quay by vessels.

Current proposals for Ardersier Port involve additional dredging works to increase the depth and width of the main channel and create berth pockets. The dredging works will be undertaken in two phases: Phase 1 involves a dredge level of -12.9mCD; and Phase 2 involves a proposed dredge level of -16.5mCD.

This report presents an assessment of the geotechnical stability of the spit following dredging down to the Phase 1 dredge level of -12.9mCD. The available ground investigation information has been reviewed to derive a site-specific ground model which has been used to assess the geotechnical stability of the proposed dredge slope. This has been compared against existing submerged slopes in the area, as well as published case history data, to provide additional verification of the proposed geometry. The Phase 2 dredge profile will be assessed as part of a later study.

The proposed Phase 1 dredge profiles have been developed with particular regard for the future stability of the spit. The following measures have been adopted to minimise the risk of disturbance to this natural structure:

- the use of 1v:6h for the submerged slope angle of any dredged slope in natural materials; and
- a 25m buffer has been adopted between the edge of the spit (taken as Mean Low Water Springs) and the start of any submerged slope within the dredge. This provides additional space, in case of any unforeseen slope movement, without impact on the spit.

The geotechnical stability of these slopes has been assessed and the conclusion from this work is that the design is suitable and safeguards the overall stability of the spit. This is detailed further in the report.

The impact of scour from the operation of vessels in the port is an important aspect of the long-term stability of the dredged slopes. The assessment of vessel scour is in progress and will be incorporated in the design when the study has been completed. In addition, work associated with global sediment transport is being undertaken by others and will also be reported separately.

2. Development of the Phase 1 dredging profiles

2.1 Basis of design

The design work presented in this report is based on information available at the time of writing. A ground investigation for the proposed new quay wall construction has been completed and has been used to inform this assessment. A further investigation is ongoing on the spit itself and, while some draft logs and preliminary laboratory tests are available, some information is outstanding. The outstanding information includes logs for a number of boreholes, as well as the results of laboratory classification and strength tests. It is noted, however, that the information collected to date suggests that the ground conditions in the area of the spit are similar to the rest of the site. It is therefore considered therefore that an interim assessment of the geotechnical stability of the spits can be carried out through holistic use of the data that is available.

This report presents the work undertaken to assess the geotechnical stability of the spit proposed for the dredging works proposed as part of Phase 1 of the port works. This involves a proposed dredge level of -12.9mCD. A complementary assessment of scour associated with vessel operations is ongoing and will be reported separately. Work associated with sediment transport is being undertaken by others and will also be reported separately.

This report will need to be reviewed, and potentially updated, following completion of the ground investigation works, and finalisation of associated reporting.

Works associated with subsequent phases of the proposed port development works (Phase 2 and 3) are not part of the scope of this report and will be covered by later submissions.

2.2 Dredge profile

The Phase 1 dredging profiles have been developed based on the bathymetric survey information provided by Ardersier Port (drawing No. 2022_004_A_P_DW_100 Rev P02). The proposed maximum dredge level is -12.9mCD through the navigation channel area up to the eastern end of Phase 1 quay.

The dredge profiles pay particular regard to the future slope stability of the spit. A series of criteria have been used when considering the layout in order to minimise the risk of disturbance to this natural structure. This includes:

- The use of 1v:6h for the submerged slope angle of any dredged slope which is compliant with the range of typical underwater slopes presented BS6349-1-3:2012. This is considered to be a safe estimate based upon observed slope angles within the existing bathymetry in the area together with slope stability calculations using assumed material parameters.
- A 25m buffer between the edge of the spit (taken as Mean Low Water Springs) and the start of any submerged slope within the dredge. This provides a margin of safety for the spit in the following ways:
    1. to allow for any slumping in dredge slope profiles due to local variations or planes of weakness in the strength of the underlying material. Slope slumps to a reduced gradient of 1v:8h could be accommodated by the 25m buffer without disturbance of the spit.
    2. to provide a margin to prevent the existing spit being undermined by scour holes due to vessel disturbance. A scour hole of up to 4m could be accommodated by the 25m buffer zone provided.
    3. as per point 2 to allow for the potential for local over-dredge at the toe of any dredged slopes in close proximity to the spit. Normal over dredge tolerances are likely to be of the order of 1.0m and could, therefore, be comfortably accommodated by the proposed buffer zone.
    4. In areas of away from the proposed spit, 1v:6h dredge slopes have also been adopted, although this is considered to be conservative and will be reviewed in the future stages of the design.

In later sections of this report, geotechnical analysis will be presented to demonstrate the overall stability of the slopes defined with a 1:6 gradient, formed with the naturally occurring soils on-site.

Additional considerations will be presented in the following sections on important themes reported by BS6349-1-3:2021, these being:

- Local experience – interrogation of the bathymetric survey;
- Static liquification assessment;
- Geotechnical slope stability assessment;

2.3 Plan and Typical Cross Section of Phase 1 Concept Dredge Solution

The dredge plan and typical cross sections are given on drawing number 294067-ARUP-XX-XX-SK-CG-000002. Three cross sections are provided for illustrative purposes below. Figure 2.1, Figure 2.2 and Figure 2.3 represent the navigation channel, port entrance and main harbour basin respectively. These figures illustrate the general use of shallow dredge slopes adopted together with the buffer zones in close proximity to the spit.

Figure 2.1: Typical Cross Section for The Navigation Channel.

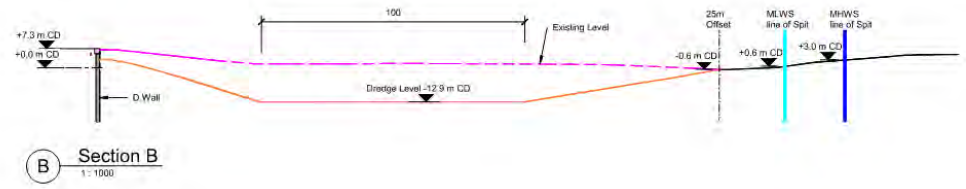

Figure 2.2: Typical Cross Section for The Port Entrance.

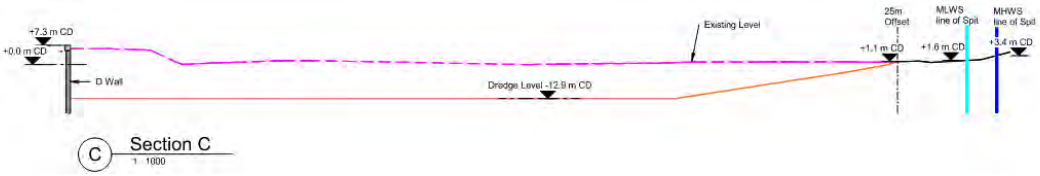

Figure 2.3: Typical Cross Section for The Harbour Basin.

3. Local experience: Bathymetric survey

A bathymetry survey was undertaken by Aspect Surveys in 2018. An excerpt of this survey is presented in Figure 3.1, focusing on the spit. As outlined in BS6349, this information is important to provide evidence of the slope geometries which exist in similar ground and water conditions.

Using the elevation contours, gradients were calculated around the spit area (Figure 3.1). As an approximate guide, the observations of the measurements can be made:

- slope angles vary across the area, ranging from 1:2.6 to 1:12.
- 16 of the 26 values are steeper than or equal to 1:6, 10 are less steep than 1:6;
- the numerical mean of the slope angles calculated is 1:5.7; and
- the median value of the slope angles calculated is 1:5.4.

The review of the existing slopes indicates that a slope of 1:6 is within the range of angles observed at the site, it is a significantly lower angle than the steepest slopes observed and is on the safer side of the average values observed.

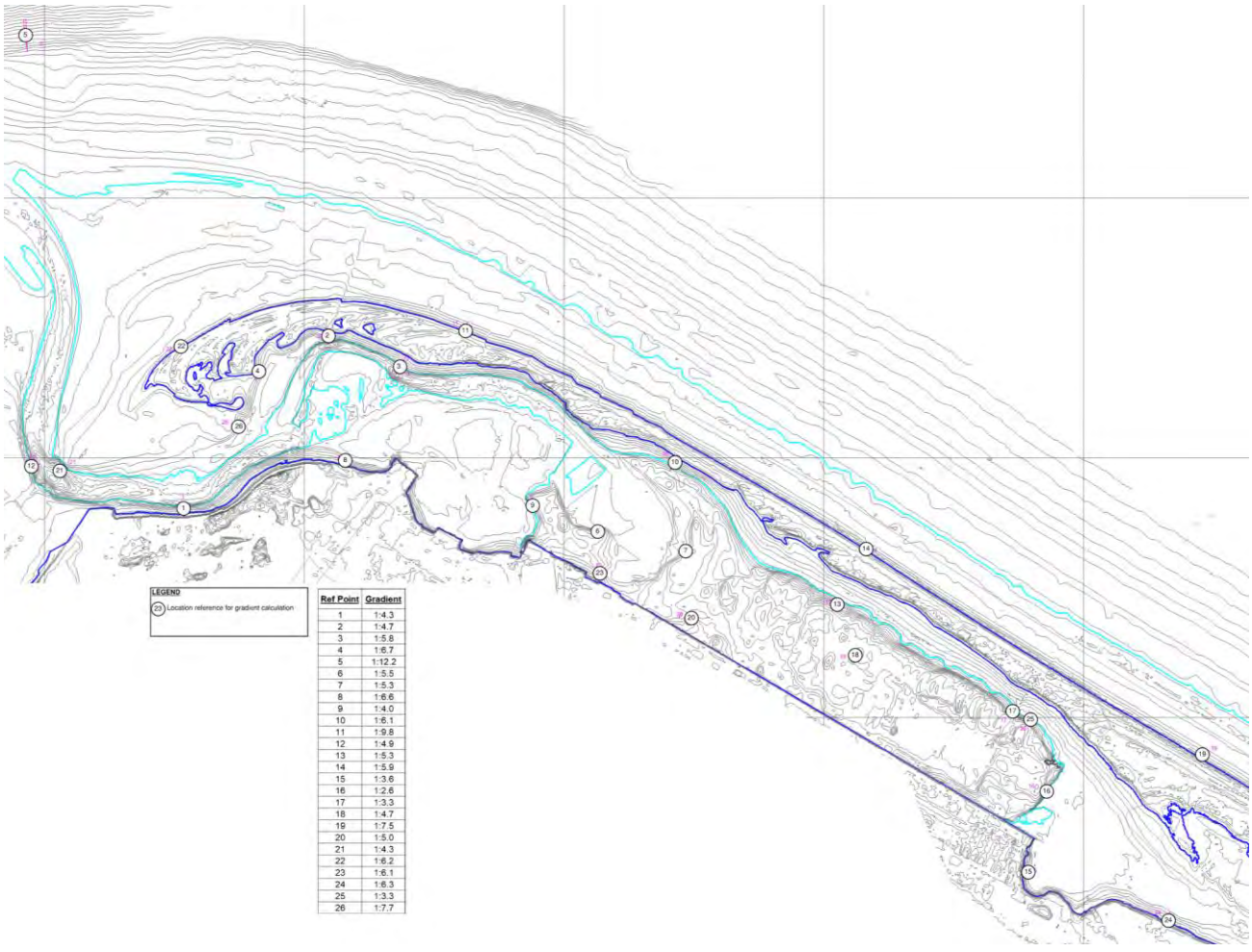

Figure 3.1: Bathymetry survey, with gradient annotations

4. Ground Conditions

4.1 Ground Investigation Information

Two phases of ground investigation have been planned for the site as part of Phase 1 of the project. The first phase of ground investigation works was located on the quay side of the port. The site works are complete and reporting is in the process of being finalised. A second phase of investigation works on the spit is currently in progress. Further phases of investigation works will be undertaken for Phase 2 and 3 of the project. This report is based on the information available at the time of writing and the findings will need to be reviewed following completion of the planned intrusive investigation works and associated laboratory testing and reporting.

4.1.1 Quay side investigation information

A ground investigation was undertaken by Solmek for the Phase 1 works between 21st November 2022 and 19th January 2023. This comprised 15 cable percussive boreholes and 23 CPT's along the length of the quay wall and anchor pile wall to depths of up to 50m. The investigation included the installation of groundwater monitoring, tidal monitoring and insitu permeability testing together with a programme of laboratory testing.

The consolidated borehole logs and CPT data can be found in the following report issued by Solmek via email dated 10 March 2023. Subject: RE: Solmek – Factual Report.

- Phase 2: Site Investigation. Quay Wall Phase 1, Ardersier Port, Inverness. Ardersier Port (Scotland) Ltd. S221111 – Interim Report.

Preliminary field measurement data, in-situ test results and laboratory test results received by email from Solmek on the following dates:

- 31st March 2023, Subject: RE: Quay Wall Geotechnical Design Parameters. Document References:
  - 23-07232.pdf
  - 23-07234.pdf
  - 23-07237.pdf
  - 23-07241.pdf
  - 1742 – SSBX BHAW03 06.00 B-A B – 37315-473556.pdf
  - 1742 – SSBX BHAW03 36.00 A B – 37315-473551.pdf
  - 1742 – SSBX BHAW04 18.00 A B – 37315-478357.pdf
  - 1742 – SSBX BHAW05 24.00 A B – 37315-473532.pdf
  - 1742 – SSBX BHAW05 37.50 A B – 37315-473565.pdf
  - 1742 – SSBX BHFW09 28.50 B B – 37315-473537.pdf
  - 1742 – SSBX BHFW09 38.20 B-A B – 37315-473533.pdf
  - 1742 – SSBX BHFW09 38.20 B-A B – 37316-473533.pdf
  - Ardersier Data Logs Jan to Mar 2023.zip
  - Ardersier Falling Head Test Results.pdf
  - S221111 – Ardersier Port – Schedule S221111_2-additional max-mins.pdf
  - S221111 – Ardersier Port – Schedule S221111_4_additional max-min and PSD.pdf
  - 23-07232_DETS_31032023_V4.ags
  - 23-07234_DETS_31032023_V4.ags
  - 23-07237_DETS_31032023_V4.ags
  - 23-07241_DETS_31032023_V4.ags
  - S221111 – Ardersier Port – Schedule S221111_2 PRELIM 2023-03-31T15-03-18.ags
  - S221111 – Ardersier Port – Schedule S221111_4 PRELIM 2023-03-31T15-07-37.ags
- 6th April 2023, Subject: RE: Quay Wall Geotechnical Design Parameters. Document References:
  - 1742 – SSBX BHFW03 07.50 A B – 37360-478361.PDF
  - 1742 – SSBX BHFW03 24.00 B-A B – 37360-478374.PDF
  - 1742 – SSBX BHFW04 43.50 B-A B – 37360-473525.PDF
  - 1742 – SSBX BHFW05 31.50 B B – 37316-473539.PDF
  - 1742 – SSBX BHFW05 49.50 B B – 37316-473536.PDF
  - 1742 – SSBX BHFW06 22.00 A B – 37316-473554.PDF

    - 1742 – SSBX BHFW06 40.00 A B – 37316-473593.PDF
    - 1742 – SSBX BHFW07 07.00 B-A B – 37316-473524.PDF
    - 1742 – SSBX BHFW07 33.25 B B – 37316-473570.PDF
    - 1742 – SSBX BHFW10 04.50 B-A B – 37316-473585.PDF
    - 1742 – SSBX BHFW10 27.00 B-A B – 37316-473550.PDF
    - S221111 – Ardersier Port – Schedule S221111_2 PRELIM_V2 2023-03-31T15-03-18.AGS
    - S221111 – Ardersier Port – Schedule S221111_2_PRELIM_V2.pdf
    - S221111 – Ardersier Port – Schedule S221111_3 PRELIM_V2 2023-03-14T10-54-45.AGS
    - S221111 – Ardersier Port – Schedule S221111_3 PRELIM_V2 GEO-37316 01.PDF – Max Min.pdf
    - S221111 – Ardersier Port – Schedule S221111_4 PRELIM_V2 2023-04-03T09-39-59.AGS
    - S221111 – Ardersier Port – Schedule S221111_4_Prelim_V2.pdf
- 28th April 2023, Subject: RE: Quay Wall Geotechnical Design Parameters. Document References:
    - BHAW06 Draft.pdf
    - BHFW11 Draft.pdf
    - S221111 – Ardersier Port – Schedule S221111_1 2023-04-26T12-33-14.AGS
    - S221111 – Ardersier Port – Schedule S221111_1 GEO-37166 01.PDF
    - S221111 Geotech Report.pdf
    - S221111.ags
- 15th May 2023, Subject: FW: Ardersier. Document References:
    - 22-26895 Jan Feb.pdf
    - 22-26895_DETS_03012023_V4.AGS
    - 23-07232.pdf
    - 23-07232_DETS_31032023_V4.AGS
    - 23-07234.pdf
    - 23-07234_DETS_31032023_V4.AGS
    - 23-07237.pdf
    - 23-07237_DETS_31032023_V4.AGS
    - 23-07241.pdf
    - 23-07241_DETS_31032023_V4.AGS
    - 23-10134.PDF
    - 23-10134_DETS_03052023_V4.AGS
    - 23-10182.PDF
    - 23-10182_DETS_04052023_V4.AGS
    - S221111 - Ardersier Port - Schedule S221111_0 GEO_Combined.pdf
    - S221111 - Ardersier Port - Schedule S221111_1 2023-04-26T12-33-14.AGS
    - S221111 - Ardersier Port - Schedule S221111_1 GEO-37166 01.PDF
    - S221111 - Ardersier Port - Schedule S221111_2 2023-05-19T17-24-27.AGS
    - S221111 - Ardersier Port - Schedule S221111_2 GEO-37315 02.PDF
    - S221111 - Ardersier Port - Schedule S221111_3 2023-05-16T14-53-42.AGS
    - S221111 - Ardersier Port - Schedule S221111_3 GEO-37316 02.PDF
    - S221111 - Ardersier Port - Schedule S221111_4 2023-05-19T17-30-44.AGS
    - S221111 - Ardersier Port - Schedule S221111_4 GEO-37360 02.PDF
    - S221111 Geotech Report Sch 5.pdf
    - S221111 Geotech Report.pdf
    - S221111 Sch 5.ags
    - S221111.ags

4.1.2 Spit investigation works

Ground investigation works are currently in progress by Solmek on the spit. The aim is to confirm the ground conditions at the spit and undertake in-situ and laboratory testing to provide material properties to enable detailed design of the submerged slopes to be formed as part of the dredging works. The scope of the proposed works comprises nine boreholes, five of which are planned as part of the current works and four to be completed at a later date, in advance of Phase 2 of the main port works. The investigation works include cable percussion boreholes with associated sampling and insitu and laboratory testing.

This report is based on the draft information received from Solmek by email to date. The information received is listed below.

- 7th June 2023, Subject: Fwd: Spit BH Log - BHSP09
  - BH-SP09 Log typed.pdf
- 16th June 2023, Subject: RE: Ardersier
  - BH-SP08 Log typed.pdf
  - Spit BHSP08 Schedule.xlsm
- 27th June 2023, Subject: Ardersier Spit Boreholes
  - BH-SP08 Log typed.pdf
  - BH-SP09 Log typed.pdf
  - S230503 Geotech Report SP08 & 09.pdf
  - S230503 SP08 & 09.ags
- 30th June 2023, Subject: RE: Ardersier Boreholes
  - BH-SP06 Log typed.pdf
  - BHSP07 Log typed.pdf
  - S230503 Geotech Report.pdf
  - S230503.ags
  - Spit BHSP07 Schedule 4.xlsm

A summary of the current understanding of the ground conditions is provided in the following section.

4.2 Ground model

The "Whiteness Head", situated on the north side of the quay, is a shingle spit complex formed by active westerly longshore drift processes. It is understood that the shallower layers of the spit comprise coastal erosion deposits resulting from longshore drift action.

A ground investigation has been undertaken on the quay side of the port and ground investigation works are in progress on the spit itself. Preliminary information indicates that the upper strata of the spit is formed by sandy gravel and it extends from ground surface to approximately -1.5mCD. Below this, the strata comprise fine sands with locally increasing silt content at depth. Below -1.5mCD, the conditions are reasonably consistent between the Holocene deposit identified on the quay side and the spit.

The Holocene strata predominantly comprise silty sands, however, a layer of clayey silt has been typically encountered between approximately -30m CD and -40mCD in the CPTs on the quay side but not encountered in the boreholes. It is considered that, in reality, this stratum is likely to comprise silty or very silty sand and the clay classification is spurious and due to the penetration rate of the CPT's.

Available information does not confirm the level of rockhead at the site, however, recent investigation works suggests that it is at least greater than 50m below ground level. The rockhead has been shown to be sufficiently deep that it is not a significant factor in the stability of the spit.

A schematic geological cross-section through the proposed port is shown in Figure 4.1.

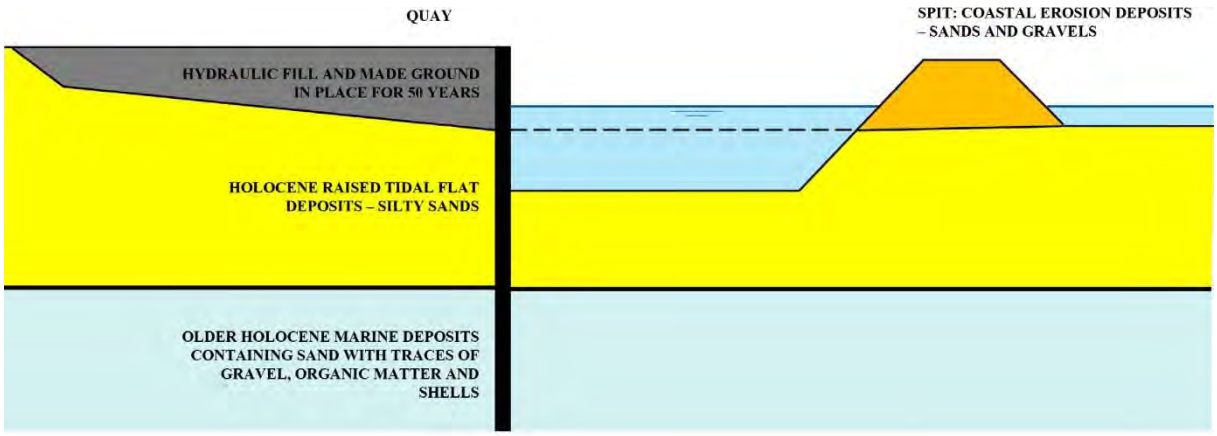

Figure 4.1: indicative geological cross section through Ardersier Port.

The material properties for the subsequent slope stability assessments have been derived from CPT and SPT data and laboratory testing. The CPTs are located 'landside' i.e. south-west of the main quay wall, however, the ground investigation information available at the time of writing indicates that the conditions are consistent across the site. The adoption of parameters based on testing from the quay side of the port is, therefore, considered appropriate for the spit stability assessment.

Pertinent results from the ground investigation are included below.

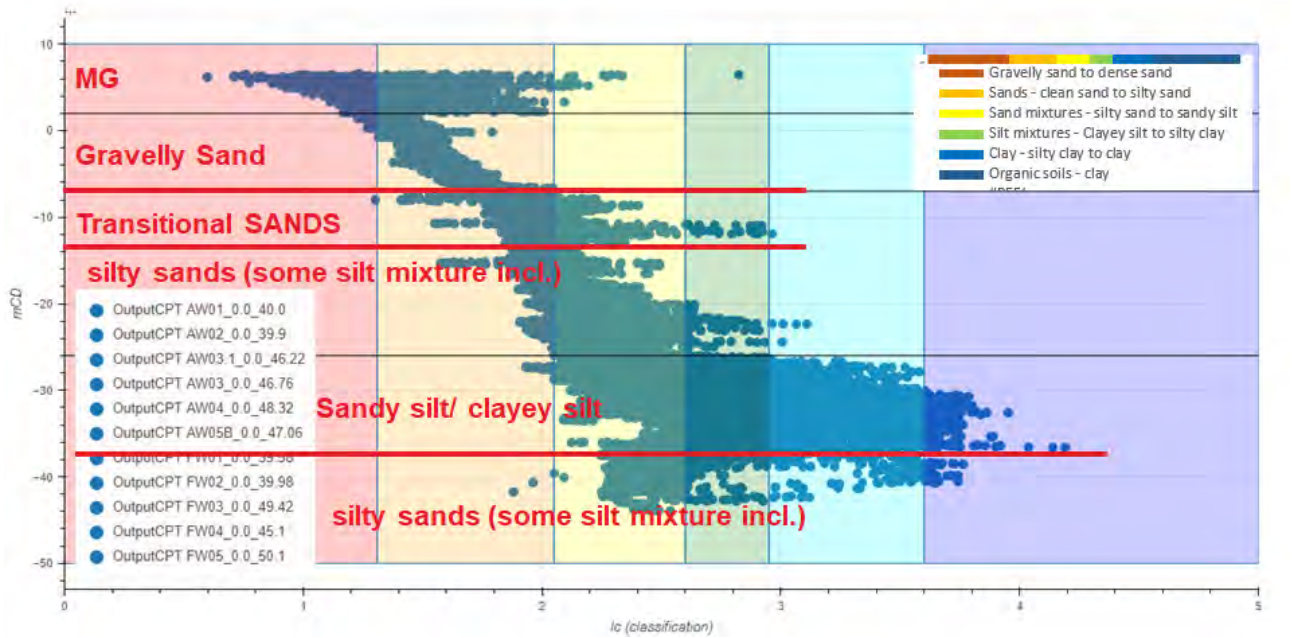

Figure 4.2. Soil Classification based on CPT's.

Figure 4.2 indicates the soil behaviour type index against reduced level calculated using the Robertson [10] method which accounts for overburden, as described in Robertson & Cabal [9]. The plot is based on CPT's and indicates the strata pertinent to the stability of the spit are gravelly sands/sands overlying transitional sands and silty sands.

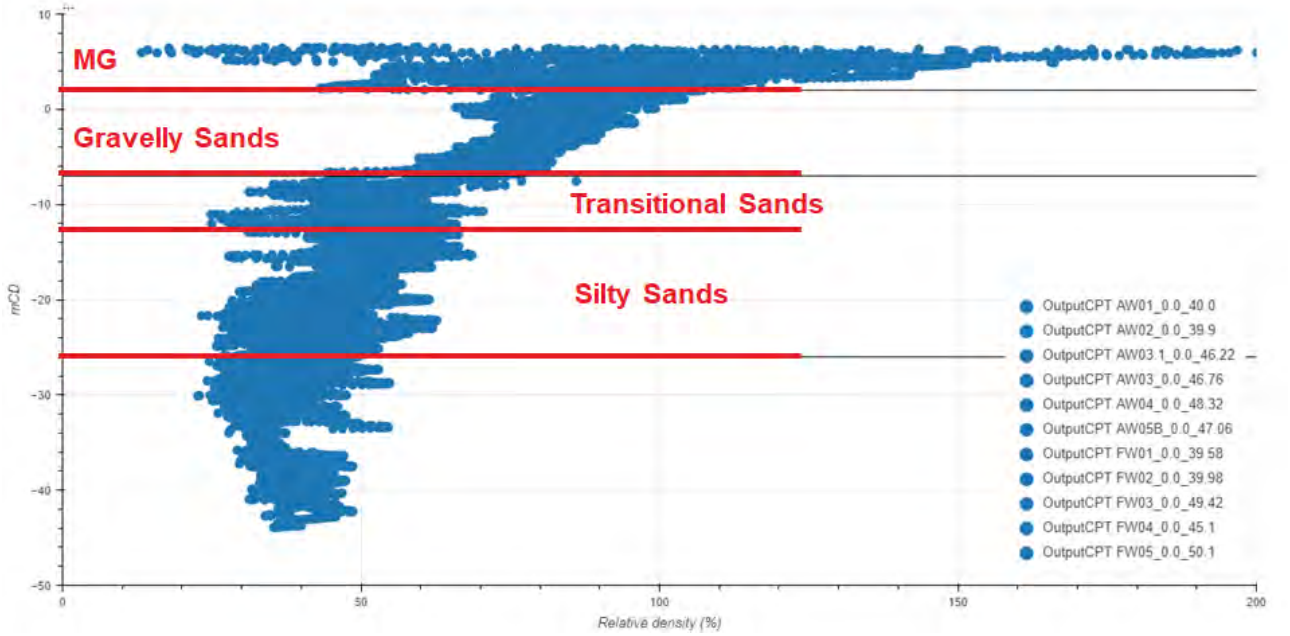

Figure 4.3. Relative Density based on CPT's.

Figure 4.3 shows relative density data for the strata at the site based on CPT results. The data indicates relative densities as follows:

- Gravelly sands: generally 65% to 85% with a reducing trend with depth;
- Transitional sands: between 40% and 60% with no clear trend with depth; and
- Silty sands: generally 35% to 60% with a reducing trend with depth.

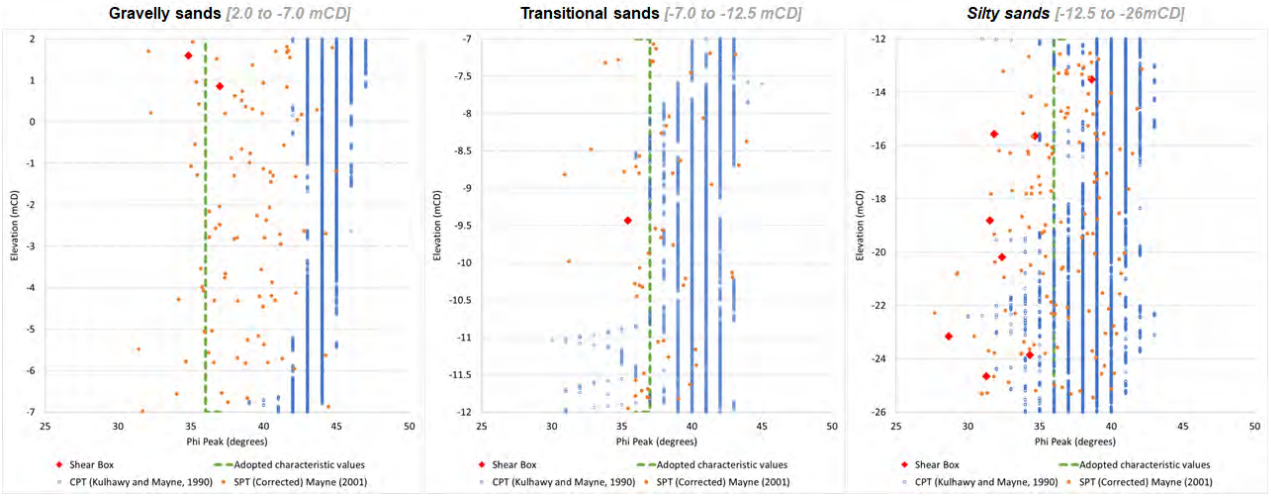

Figure 4.4. Strength (friction angle) data based on CPT's, SPT's and shear box tests.

Available soil shear strength data is plotted in terms of friction angle, from CPT's, SPT's and shear box tests, against elevation in Figure 4.4. The friction angles based on CPTs were calculated using the method described by Kulhawy and Mayne [12]. The friction angles based on SPTs were calculated using the Mayne [13] method using depth corrections outlined in BS EN ISO 22476-3:2005+A1:2011.

The plots indicate a greater degree of spread from the SPT and shear box results compared to the CPT results. The shear box and SPT results generally form a lower bound to the CPT data. This may be due to difficulty in achieving relative densities which are consistent with the material insitu in the shear box tests or an imbalance of water pressures in the boreholes when undertaking SPTs. Most reliance has been placed on the CPT data.

For the gravelly Sands, the CPT's consistently indicate higher friction angles than the SPT and shear box results. A characteristic friction angle of 36º was selected, predominantly based on the SPT data.

In the case of transitional Sands, the CPT's generally indicate higher friction angles than the SPT and shear box results. A characteristic friction angle of 37º was selected based on the CPT and SPT data.

The shear strengths based on shear box results in the silty sands are consistently lower than the general SPT and CPT data. A characteristic friction angle of 36º was selected, predominantly based on the CPT and SPT data.

Based on a review of the available ground investigation information, a summary of the adopted ground model and characteristic shear strength parameters is shown in Table 4.1.

Table 4.1. Material properties adopted for OASYS Slope analyses

Stratum	Unit weight (kN/m^3)	Friction angle (º)	Cohesion (kPa)	Top level (mCD)	Bottom level (mCD)
Gravelly sands	20	36	0	n/a	-7
Transitional sands	20	37	0	-7	-12.5
Silty sands	20	36	0	-12.5	-26

Conservatively, in-line with BS6349-1-3:2012, no cohesion is assumed for the slope analyses.

5. Spit slope stability assessment

As noted previously, the Spit is a natural geomorphological feature resulting from ongoing coastal processes. Its geometry and composition have evolved over recent geological time and will continue to do so over the life of the port. As a result, the physical interaction between the proposed dredging, port operations and the stability of the spit need to be assessed. The following section provide a description of the geotechnical slope stability analyses undertaken. Impacts of scour due to vessel movements and sediment transportation are not within the scope of this report and will be covered elsewhere.

5.1 Flow slide slope instability assessment

Static liquefaction potential, as mentioned in BS6349-1-3:2021 in section 15.2.3, needs to be assessed and, where necessary, remediated on marine structures. The assessment can also be used as an indicator of how mobile the material is and susceptible to transportation. Static liquefaction can be assessed via a number of approaches which have to be considered holistically.

For this study, firstly the Particle Size Distribution (PSD) lab results were assessed from two boreholes performed on the spit with samples down to -16.5mCD (approximately 3.5m below the proposed dredge level). This exercise was used to assess the level of sand/silt content, which affects the susceptibility of the material to static liquefaction. Based on the Solmek PSD results, 17No. PSD curves, shown in Figure 5.1, ten of the samples indicate the material to be 'particularly' susceptible to liquefaction. The PSD data suggest that the material is less susceptible at shallow depth within the sandy gravel but becomes more susceptible with depth.

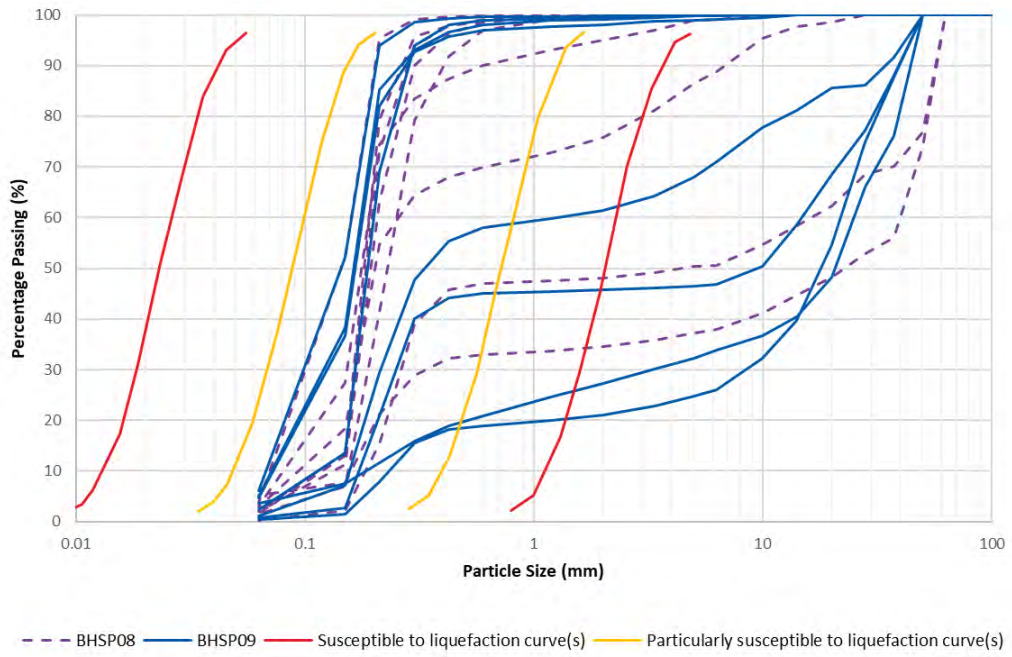

Figure 5.1. PSD grading curves, with susceptibility to liquefaction curves overlaying liquefaction curves from the Japanese Geotechnical Society (1998)

Static liquefaction can also be investigated using SPT and CPT results. SPT N values and CPT tip resistance can be correlated to contractive/dilative behaviours of materials. Flow slide slope instability is a behaviour linked to contractive soils.

Olson and Stark (2003) propose that the first step of liquefaction analysis for sloping ground is determining whether the soils in question are contractive on shearing, i.e. susceptible to liquefaction (flow slide) failure. Based on back-analysis of liquefaction failure case studies, a relationship between corrected SPT blow count

(N_{60}) and in-situ effective stress has been proposed by Olson and Stark (2003) to identify contractive soils susceptible to liquification. SPT data collected from the ground investigation has been plotted against this relationship and is presented in Figure 5.2. Similarly, Olson and Stark (2003) identified a relationship between CPT tip resistance and in-situ effective stress to identify contractive soils susceptible to liquification. The CPT data collected on the site has been plotted on Figure 5.3.

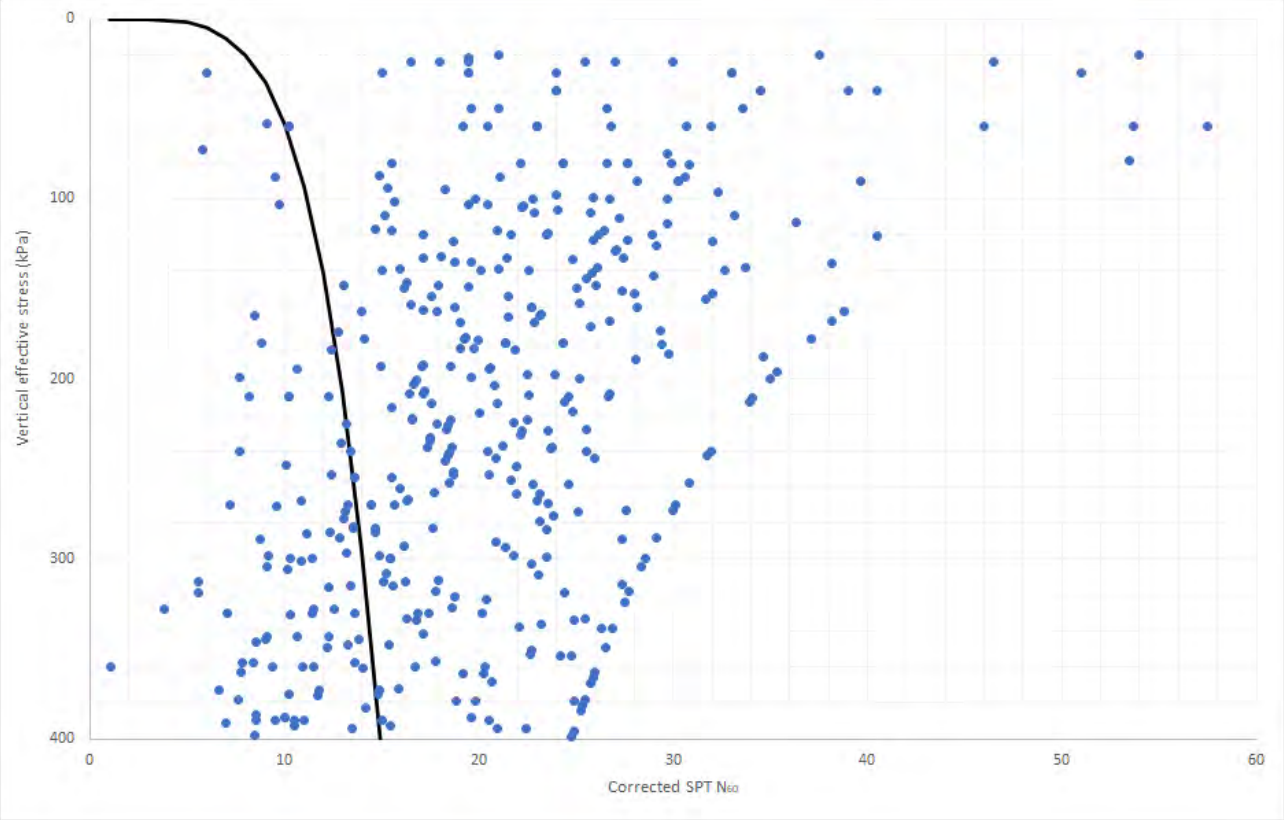

Figure 5.2. SPT N versus vertical effective stress – with Olson and Stark's [1] 'behaviour' curve

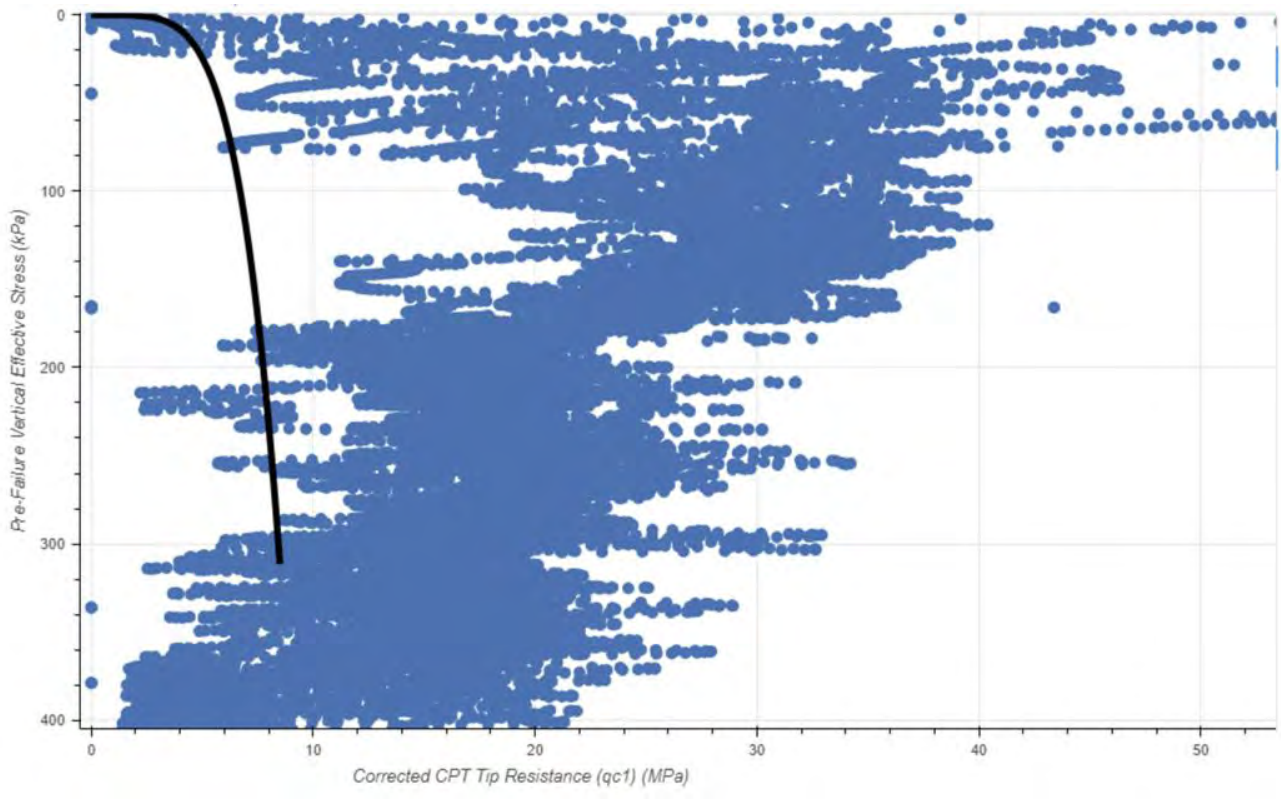

Figure 5.3. CPT tip resistance versus vertical effective stress – with Olson and Stark's [1] 'behaviour' curve

From the SPT data in Figure 5.2, only a small number of data points are within the liquefiable (contractive) region. The majority of the points indicate the ground to be in a dilative state. A similar conclusion can be drawn from the CPT data (Figure 5.3). The majority of the points indicate dilative behaviour, however, liquifiable (contractive) behaviour is indicated to be more likely at vertical effective stresses of greater than 300kPa (equating to levels lower than approximately -21mCD*). This level is beneath the dredge level and is, therefore, not relevant to the stability of the spit slope.

*assuming constant unit weight of 20kN/m^3, ground level at +6.0mCD (spit level) and groundwater level at +3mCD:

3*20 = 60kPa,

300-60 = 240kPa,

240kPa / (20-10) = 24m,

3+24=27m,

+6mCD – 27m = -21mCD

Additionally, Stoutjesdijk et al. (1994) reports 100 case studies where flow-slides occurred on shoreline structures, such as dykes. The geometry of the structures was typically similar to the ground profile across the spit and, therefore, provides useful data for comparison. Figure 5.4a shows slope height versus average slope angle, with design lines for the relative density of the material. From the CPT data shown in Figure 4.3, the in-situ relative density (Dr) over the levels applicable to the spit slope (+6mCD down to -12.9mCD) are generally greater than 40% (Dr>0.4) and mostly significantly greater than this. It can be seen that there are no flow slides recorded for slopes that had 1 in 6 slope angles and slope height of between 15m and 18m for relative densities of greater than 40%.

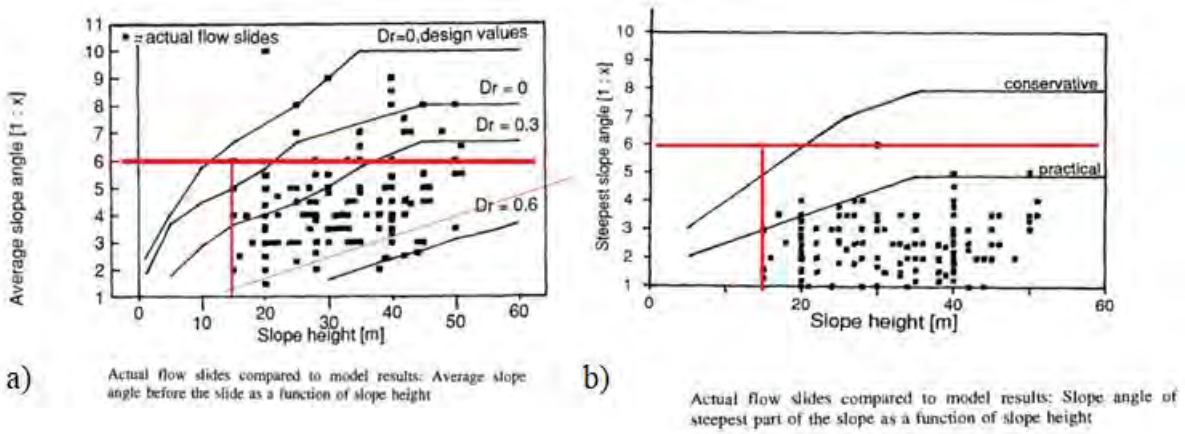

Figure 5.4. Flow slide case studies [4]. a) Average slope angle b) Steepest slope angle

Based on the case studies reported above, and the results of the static liquefaction potential, it is considered that the risk of flow-slide is low and that the proposed slope design angles are appropriate.

5.2 Slope stability assessment

An assessment to evaluate the slope stability of the gradient chosen (1v:6h) was performed using limit equilibrium and numerical methods and is presented in this section of the report. The assumptions and methodology used will be introduced before presenting the results.

5.2.1 Model geometry

Figure 5.5 shows a plan view of the dredge drawing (294067-ARUP-XX-XX-DR-CG-002001). Cut sections A, B and C have been used for verification of the slope stability.

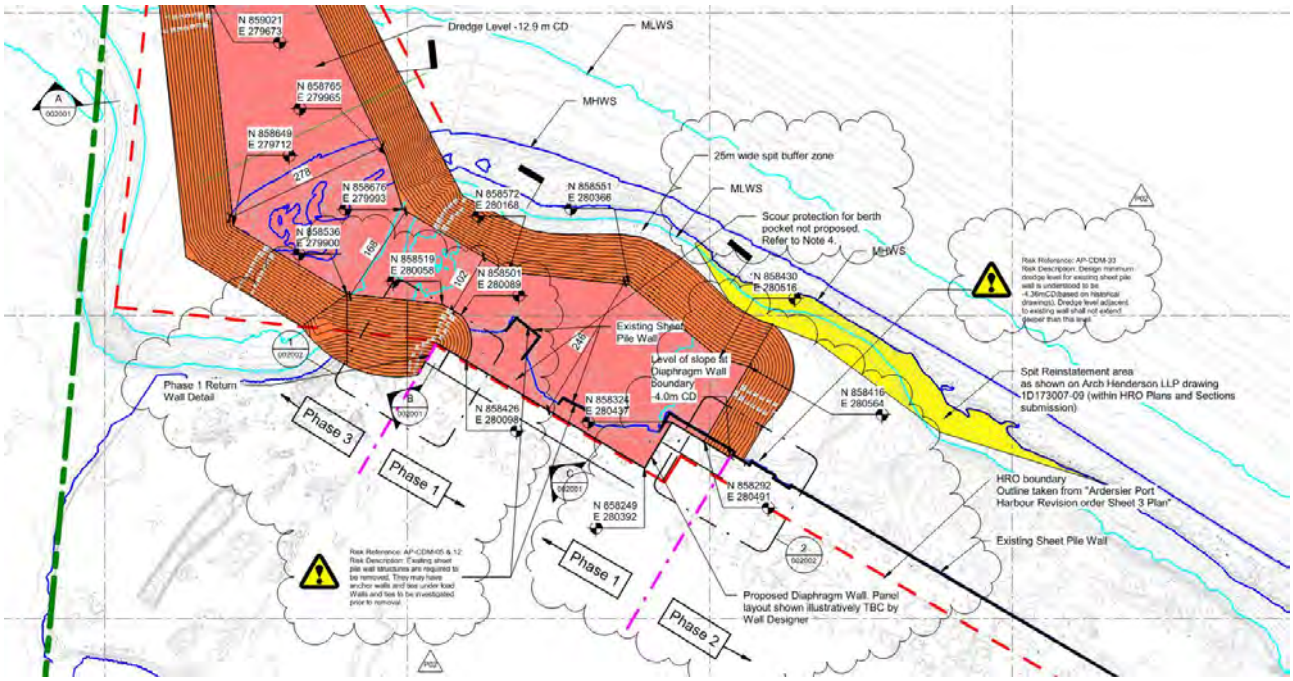

Figure 5.5. Plan view of the proposed dredging works

Orange regions of Figure 5.5 show slopes with an angle of 1:6.

The assumption of an over-dredge allowance of 1m has been adopted for the slope analyses herein, which is consistent with experience from similar projects. An additional allowance was considered for the potential effects of scour, where an additional 2m localized lowering of the toe of the slope has been assumed.

The slope analyses considered two cases (Figure 5.6), those being:

- Case A: The over-dredge + scour occur at the same angle as the main slope (1:6); and
- Case B: The over-dredge + scour with increased slope angle of 1:5.

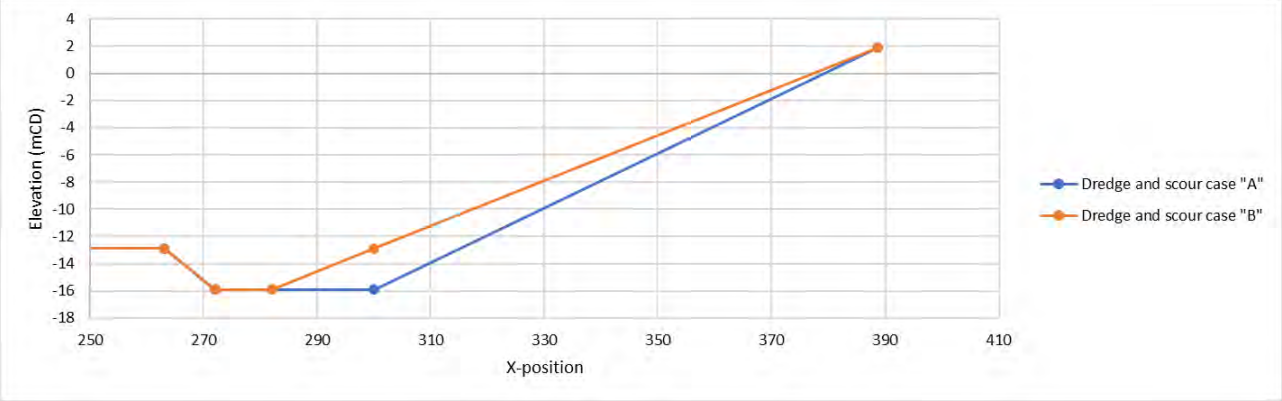

Figure 5.6. Dredge / scour cases visually depicted.

5.2.2 Methodology

OASYS Slope (limit equilibrium method) has been used primarily for slope analyses, with an additional study using Plaxis finite element analysis software to validate its results.

5.2.2.1 OASYS Slope

OASYS Slope (V22) is a limit equilibrium method (LEM) software, which has been used to check the factor of safety / over-design factor (ODF) of circular slip failures. Bishop's method, with variably inclined interslice forces, has been used to derive the ODF.

A minimum slip weight equating to 1.5m^3 of material has been adopted (i.e. 30kN/m), and the two most extreme water scenarios have been checked – those being the Lowest and Highest Astronomical Tide (+0.2mCD and +4.8mCD, respectively).

5.2.2.2 Plaxis 2D

Plaxis 2D (V22), a finite element analysis software, has also been used in conjunction to verify the slope stability. The Plaxis model has been used to ensure that non-circular or complex slip failures are not of concern. The Plaxis model was initialised as flat, with subsequent stages digging down to the proposed slope profile. Subsequently, a C-Phi reduction (safety phase) was used to determine the critical slip geometry and ODF.

5.2.3 Material properties

Material properties for this slope assessment have been presented in Section 4.2. Partial factors have been applied to the material strength properties, as prescribed by the BS EN 1997-1:2004+A1:2013 (EC7) for approach DA1C2 that is considered the most critical for slope stability.

5.2.4 Load information

The spit is not anticipated to undergo any active loading, and if it were, this would be sufficiently far away from the proposed slopes to be ignored. On this basis, verification using EC7 DA1C1 is not required.

5.2.5 Results

This section summarises the OASYS Slope and Plaxis results.

5.2.5.1 OASYS Slope Results

Table 5.1 presents the DA1 C2 results for the 1:6 slope angle models assuming the Case A geometry (Figure 5.6) allowing for over-dredge and scour.

Table 5.1. OASYS Slope, Design Approach 1 Combination 2 results

Section	Overdesign factor (DA1 C2)	
	LAT	HAT
A	2.898	3.506
B	3.515	3.515
C	2.961	3.509

Sections A and C gave very similar results and were both considered to represent critical sections. The ODF was generally lower for the LAT case. This was because the water level generally intersected the ground surface on the slope and led to localised critical slip surfaces near the crest of the slope. In the case of Section B, the ODF was the same in the LAT and HAT cases because the slope was submerged in both cases.

Section A was analysed for Case B (Figure 5.6) with a revised geometry to incorporate an allowance for over-dredge and scour. The revised geometry results in a slope gradient of 1v:5h (a 20% steepening of the slope angle).

Comparing the ODF's (DA1 C2) for the LAT scenario, for the critical section A (as in Table 5.1), there is a reduction of ODF from 2.898 to 2.482.

5.2.5.2 Plaxis Results

Section C has been used for the Plaxis analysis in order to investigate the presence of failure mechanisms that might not be captured by a limit equilibrium analysis. Sections A and C were found to give very similar results in the OASYS Slope analyses reported above. The LAT scenario was considered.

Using characteristic soil properties and a C-Phi reduction in Plaxis, the safety phase obtains an implied factor of safety of 3.606.

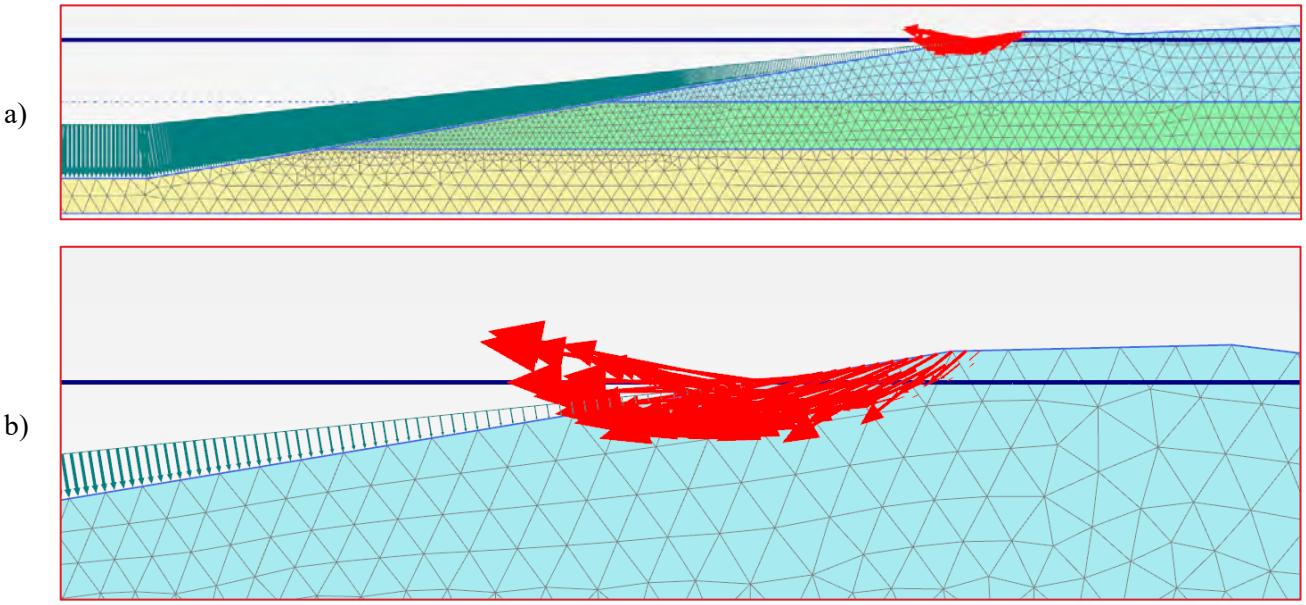

Figure 5.7. Plaxis, Incremental displacements for C-Phi reduction stage. A) Overview image B) Zoomed in

The result of the C-Phi reduction in Plaxis equates to factoring down the tangent of the friction angle by 3.606. This indicates a friction angle of 11.4º once factored. Using this back-calculated friction angle in the slope analyses confirms that the slip identified in Plaxis is in good agreement, with an ODF of approximately unity. Therefore, OASYS Slope analyses and Plaxis indicate consistent critical failure mechanisms and ODF values.

In cases where the LAT is below the ground surface, i.e. where the spit is exposed above water level, both the OASYS Slope and Plaxis analyses indicate the critical failure mechanism to be located around the water level, in the intertidal zone. The ODF against failures lower down the slope is greater and similar to the ODF for the HAT case.

5.2.6 Slope stability results discussion

BS6349-1-3:2012 details typical slope angles for still and active water conditions. The port is considered as an active water condition, whilst analysis presented above consider a still ground water condition. In order to apply the results of this study to the active water conditions, a comparison of the still and active water typical side slopes, reported in BS6349-1-3:2012, is presented in Table 5.2 .

Table 5.2. Excerpt from BS6349:2012 [3] with additional interpretation regarding the ODF required to for active waters conditions.

Material type	Typical side slope: Still water*	Typical side slope: Active water*	Safe slope angle ratio (active conditions: still conditions)
Coarse sand	20º (1:2.75)	10 º (1:5.67)	2.06:1
Fine sand	15 º (1:3.7)	5 º (1:11.4)	3.06:1

*From Table 1 of BS6349-1-3:2012)

Table 5.2 also shows the "safe slope angle ratio", defined as the ratio of safe slope angle for active conditions to the angle for still conditions for the cases presented in BS6349-1-3:2012. This factor could then be applied to the safe angles determined for still conditions at the site to estimate a reasonable slope angle for active conditions.

OASYS Slope analyses were undertaken to derive the slope angle which would provide an ODF of 1.0 in still conditions (Table 5.3). The table also shows the equivalent slope angle that would be considered stable assuming active conditions for fine sand and coarse sand.

Table 5.3. Deriving active water slope angles using BS6349

Slope section	ODF (DA1 C2, slope angle 1:2)	Approximate estimated slope gradient for ODF = 1.0 in still conditions at LAT	Required slope gradients for COARSE SAND in active water conditions (conversion factor= 2.06)	Required slope gradients for FINE SAND in active water conditions (conversion factor= 3.06)
A	0.969	1:2.1	1:4.3	1:6.4
B	1.157	1:1.9	1:3.9	1:5.8
C	1.141	1:1.9	1:3.9	1:5.8

Whilst for section B and C the 1:6 slope gradient selected for the dredged slopes is shallower than the required ones both for fine and coarse sand (Table 5.3), for section A the gradient 1:6 is shallower than the angle required for coarse sand, but it is steeper than the angle required for fine sand. Despite this, 1:6 is believed to be a reasonable basis for the design even for active water at all the sections analysed as the material on site is indicated to be variable and a combination of fine sand and some coarser sands (Figure 5.1).

These stable slope angles tie in with the observed slope angles measured within the bathometric data for the site, refer to Section 3. Finally, it is noted that the adoption of a buffer zone of 25m allows the slope angle to ravel back to 1 in 8 before the material within the spit would be affected. This slope is much shallower than any of those determined in the table above and shows that this is an appropriate step to allow for potential variation in materials.

6. Conclusions

Ardersier Port is proposing to redevelop its existing land into a new port facility. A major element of the scheme is the utilisation of the existing natural spit as breakwater for the port to protect the proposed quay from the North Sea and provide the required conditions for safe utilisation of the quay by vessels.

Current proposals for Ardersier Port involve additional dredging works to increase the depth and width of the main channel. Work presented in this report demonstrates that the proposed dredge profiles on the south side of the spit have adequate geotechnical stability based on the information available to date.

Several considerations were highlighted throughout the document and are summarised below:

- Dredge profiles have been developed for Phase 1 and a slope of 1v:6h has been selected, leaving a 25m buffer between the edge of the spit (taken as Mean Low Water Springs) and the start of any submerged slope within the dredge profile. The geotechnical stability of these slopes has been assessed and the conclusion from this work is that the design is suitable and safeguards the overall stability of the spit.
- A review of existing submerged slope angles on, and in close proximity to, the site was carried out using the bathymetry survey. The bathymetry survey indicated a range of maximum slope angles exist within the area of the spit. Within the range of angles recorded it can be seen that a number of slopes are steeper than the proposed dredge slope angle of 1 in 6. This provides observational data that the chosen slope angle is appropriate.
- Based on preliminary results of ground investigations performed on the Spit (borehole factual reports and particle size distributions) it is believed that the material underlying the superficial material on the spit are the same Holocene deposits that were identified on the quay area investigations. A holistic review of all the data collected to date has therefore been undertaken to develop a ground model and geotechnical material parameters for the assessment of the stability of the spit.
- The potential for flow-slide instability of the spit was assessed. It was concluded that the risk of that this failure mechanism occurs for the proposed dredged slopes is low. This is based on the outcome of the case studies analysed considering the proposed slope height and angle together with a site-specific liquefaction potential assessment performed using the available SPT and CPT data.
- Limit equilibrium geotechnical analysis of the spit slope has shown that the dredge slope gradient of 1v:6h will be a stable configuration both for active and still water conditions. These analyses were based on the ground conditions encountered on site and supplemented by investigation and engineering properties derived from laboratory and field testing on similar material on the quay side.
- The impact of scour on the slope due to vessel movements is an important consideration and is in the process of being assessed. This will be reported separately. In addition, work associated with global sediment transport is being undertaken by others and will also be reported separately.

7. References

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D COASTAL PROCESSES ASSESSMENT

Ardersier Port
Coastal Processes Assessment

July 2023

CONTROL SHEET

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Report Title:	Coastal Processes Assessment
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1 INTRODUCTION

1.1 Terms of Reference

EnviroCentre have been commissioned by Ardersier Port (Scotland) Ltd. to provide supporting information in relation to coastal processes for the proposed variation to the existing capital dredge licence MS-00009936 for Ardersier Port.

1.2 Scope of Report

This report provides an update to the previous 2018 assessment to reflect the observed changes in the baseline conditions and projected effects of the proposed capital dredge variation.

Additional coastal modelling of hydrodynamics, waves and sediment transport are underway. These have been delayed due to the availability updated bathymetry datasets. This report will be updated to include the modelling results in due course.

1.3 Report Usage

The information and recommendations contained within this report have been prepared in the specific context stated above and should not be utilised in any other context without prior written permission from EnviroCentre Limited (EnviroCentre).

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2 OVERVIEW OF PORT DEVELOPMENT

2.1 Dredging Activity to Date

Ardersier Port was originally developed to service the off-shore oil and gas industry in 1972. Initial construction of the yard area saw the formation of the navigation channel and harbour with the dredged material being pumped ashore for land reclamation purposes to create the main yard area. Subsequent maintenance dredging operations were carried out at typically 18-24 month intervals up until 2001. No further dredging took place until 2022, when the present harbour and navigation dredging operations commenced.

The original navigation channel width was nominally 100 m with the dredge depth taking account of the particular vessels using the channel. Admiralty Chart 1077 indicates a dredge depth to -4.7 m Chart Datum (CD).

A dredging licence was consented as part of plans to re-open Ardersier Port in 2014, which included a navigation channel width of 120 m and a dredge to -8.5 mCD. The planned dredging did not take place at that time and a subsequent dredging licence was consented in 2018 which included a navigation channel width of 120 m and a dredge to -6.5 mCD. Dredging of the harbour and navigation channel commenced under this consent in 2022.

2.2 Proposed Dredge Activity

The variation to the existing consented dredge activity is provided in ARUP Drawing 294067-ARUP-XX-XX-DR-CG-002001 P01, where the proposed increase to the dredge is as follows:

1. Depth from the approved -6.5 mCD to -12.9 mCD; and
2. Increased dredge amount from the approved 5,000,000 wet tonnes (wt) by 3,600,000 wt to 8,600,000 wt, with all of the increase being brought to land for beneficial reuse.

The proposal increases the presently consented dredge depth in 2018 by 6.4 m and the previously consented dredge depth in 2014 by 4.4 m. The navigation channel width now varies (130 – 150 m at the outer approach, 150 – 278 in the mid-channel and 102 – 168 m in the inner harbour approach), compared to the previously consented 120 m width (dimensions from ARUP Drawing 294067-ARUP-XX-XX-DR-CG-002001 P01).

3 OVERVIEW OF BASELINE COASTAL CONDITIONS

3.1 Previous Studies

Assessment and modelling were undertaken in support of reinstating the navigation channel and harbour as part of an Environmental Impact Assessment for a capital dredge licence issued by Marine Scotland in 2014, however no dredging was undertaken through this licence. Subsequent to this, the coastal processes were assessed and modelled again in 2018 in support of reinstating the navigation channel and harbour as part of an Environmental Impact Assessment Report in support of the present dredge licence that was consented.

Previous investigations undertaken into the coastal processes around Whiteness Head that are relevant to the proposed dredge activities include:

- Geological Conservation Review: Whiteness Head, J.D. Hansom © JNCC 1980–2007. Volume 28: Coastal Geomorphology of Great Britain, Chapter 6: Gravel and 'shingle' beaches – GCR site reports (GCR ID: 1442) (http://www.jncc.gov.uk/page-2731).
- Port of Ardersier: Whiteness Head Coastal Assessment, May 2013. EnviroCentre Report No 5474 to Port of Ardersier.
- Coastal Processes Assessment, September 2018. EnviroCentre Report No 8364 to Ardersier Port Ltd.

The coastline at Whiteness Head is also included in the National Coastal Change Assessment (NCCA) led by the Scottish Government (Hansom, Rennie & Fitton, 2017; The Scottish Government, 2017).

The 2018 coastal assessment built upon the 2013 assessment through continued assessment of bathymetry change in the period between assessments and adoption of more detailed sediment modelling techniques.

The following sections summarise the key findings of the 2018 assessment, with updated commentary in relation to the existing dredging operations underway. These will be subject to additional refinement as updated datasets that have been collected through the Sediment Transport Monitoring Plan (STMP) that forms part of the existing consented dredging activity, and subsequent modelling update results become available.

3.2 Bathymetry

The wider bathymetry of the Moray Firth as shown in Figure 3.1 highlights the presence of a number of important features to the local hydrodynamic regime, including the channels around the sand bank in the middle of the firth and the narrows between Fort George and Chanonry Point.

The local bathymetry within the harbour and navigation channel is presently undergoing active change as dredging operations continue. An updated bathymetric survey is available for the dredge areas and a wider bathymetry survey update is presently underway and will be provided in a subsequent report including updated model scenario runs.

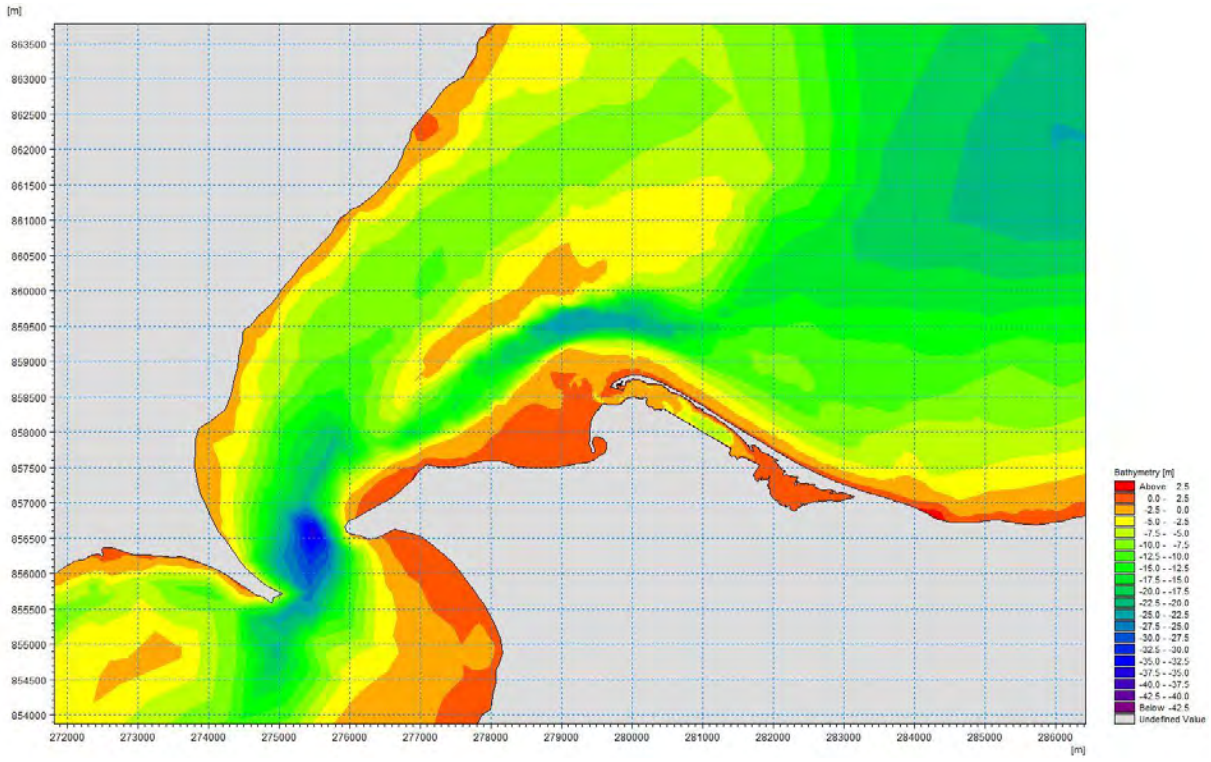


Figure 3.1: Wider Moray Firth Bathymetry in Vicinity of Whiteness Head

3.3 Sediment

Several phases of sediment sampling have been undertaken over recent years in the vicinity of Ardersier Port. The site investigations to date have found that Whiteness Sands, spit and associated channel are essentially formed in mobile sand deposits. Four sand types can be identified based on lognormal particle size populations. The spatial distributions of the following sand fractions at the time of survey (2013) are shown in Figure 3.2:

- **Medium-coarse sand** – Mode 0.355mm. Normally present forming a secondary bimodal grain population with a dominant medium-fine sand. Indicative of bedload transport.
- **Medium sand** – Mode 0.250mm. Normally present forming a bimodal grain population with a dominant medium-fine sand. Indicative of bedload transport.
- **Medium-fine well-sorted sand** - Mode 0.180mm. Almost ubiquitous outside the zone immediately offshore from the spit. The sand population most easily set in motion by flowing water, typically moving as near-bed suspension.
- **Fine sand** – Mode 0.150 – 0.125mm. Dominates the seabed offshore from the spit, typically unimodal. Indicative of suspended load transport processes.

Gravel deposits are present to the surface of the spit, predominantly along and above the high water mark, and are present in lower quantities within the immediate vicinity of the spit. Sediment within the immediate vicinity of the dredging activity is generally associated with present day processes, however, chart annotations of seabed conditions highlight adjacent areas of drift deposit exposure. These annotations indicate there are two eroding Holocene or Pleistocene deposits in the area, the foreshore and offshore area to the east of the spit, and the Fort George narrows area. In these two zones recent deposits are probably thin or absent, with erosion providing an important source of gravel to be reworked by present day processes.

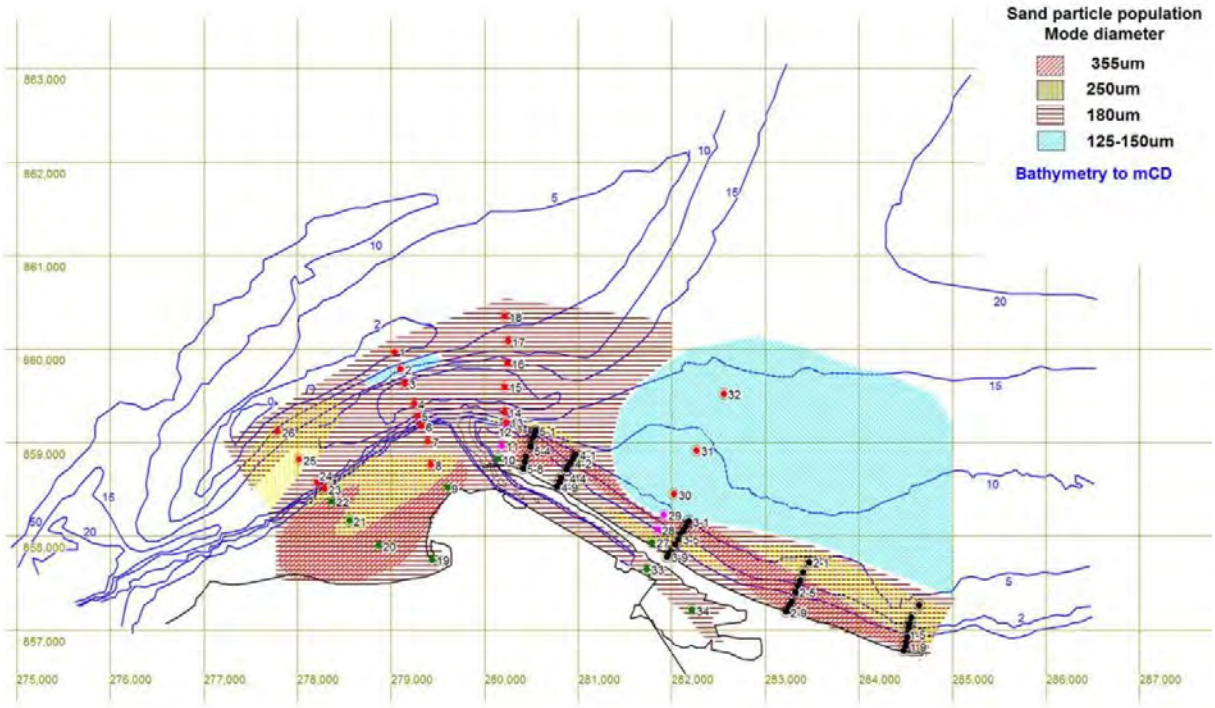


Figure 3.2: Distribution of Sand Particle Populations and Grab Sample Locations (2013)

3.4 Tidal Regime – Levels and Currents

Tidal levels at Ardersier Port (formerly McDermott Base) as presented within the Admiralty Tide Tables show a maximum astronomical tidal range of 4.6 m, and a mean tidal range of 3.3m during spring tides and 1.6m during neap tides (Table 3.1). More extreme event offshore water levels nearby from SEPA predictions include a 1 in 200 year return period event of 3.51mAOD (Table 3.2).

Table 3.1: Tidal Water Levels – Ardersier Port

Tide Condition	Chart Datum (mCD)*	Ordnance Datum (mOD)
Highest Astronomical Tide (HAT)	4.8	+2.66
Mean High Water Spring (MHWS)	4.2	+2.06
Mean High Water Neap (MHWN)	3.3	+1.16
Mean Sea Level (MSL)	2.5	+0.36
Mean Low Water Neap (MLWN)	1.7	-0.44
Mean Low Water Spring (MLWS)	0.9	-1.24
Lowest Astronomical Tide (LAT)	0.2	-1.94

*Chart Datum correction for Ordnance Datum is -2.14m (relative to OD at Newlyn)

Table 3.2: Ardersier Port Extreme Sea Levels (SEPA Dataset)

Return Period (Years)	Water Level (mCD)	Water Level (mAOD)
2	5.05	2.91
5	5.14	3.00
10	5.21	3.07
50	5.36	3.22
100	5.43	3.29
200	5.49	3.35
1000	5.65	3.51

Hydrodynamic modelling highlights the main tidal streams within the vicinity of Ardersier Port. These are summarised as follows:

- **Flood Tide** (Figure 3.3 shows the modelled tidal current at mid-flood during a spring tide).

  During the flood tide the main tidal stream passes from east to west, aligned with the spit closer to shore, flowing round the head of the spit into the harbour inlet, and spreading across Whiteness Sands from the north-east. Modelled maximum current velocities at mid-flood during a spring tide occur in the main channel off the northern edge of Whiteness Sands (1m/s), and within the former dredged channel adjacent to the spit head (0.85m/s).

- **Ebb Tide** (Figure 3.4 shows the modelled tidal current at mid-ebb during a spring tide).

  During the ebb tide, the main tidal stream reverses, passing generally from west to east, draining towards the north-eastern edge of Whiteness Sands, and flowing out of the harbour inlet round the head of the spit. Modelled maximum current velocities at mid-ebb during a spring tide again occur in the main channel off the northern edge of Whiteness Sands (1m/s), and within the former dredged channel adjacent to the spit head (0.70m/s).

- Either side of low water the tidal stream into and out of the harbour inlet aligns with the former dredged channel, meandering from east to west and then north to south on the ebb tide, reversing on the flood tide. Peak current velocities fall towards low and high water. A consistent pattern of tidal stream orientation is observed during neap tidal cycles, with velocities of a lower order during all phases of a neap tide.

Comparison of modelled peak flood and ebb spring tidal currents has been undertaken to examine residual current patterns within the vicinity of the development site (Figure 3.5). This analysis highlights a dominant residual peak flood current extending from east to west around the head of the spit across the north-eastern tip of Whiteness Sands, and also south into the harbour inlet. Further offshore to the north-west of the spit head a dominant residual peak ebb current is observed within deeper waters. Localised residual ebb current dominance is observed along the northern edge of Whiteness Sands, and in central areas of the sands. Along the southern shoreline of Whiteness Sands a slight residual flood current is apparent. Elsewhere model results indicate negligible differential between the flood and ebb phase.

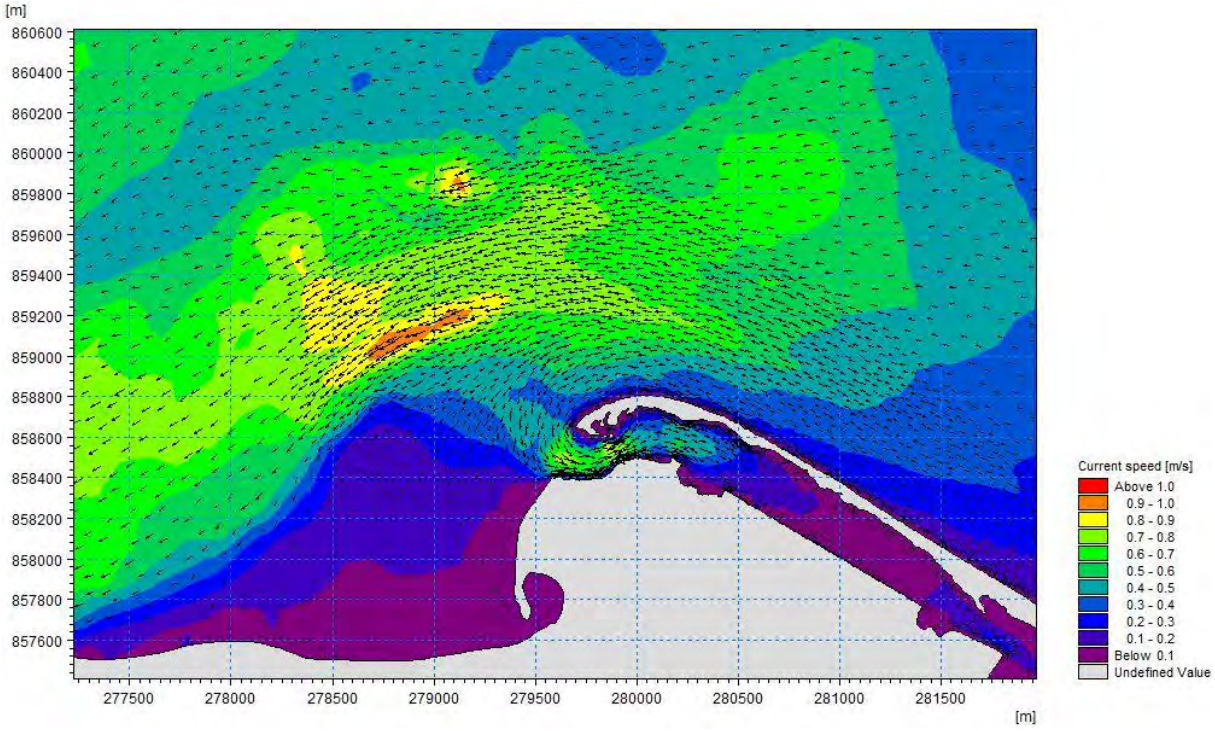


Figure 3.3: Modelled Mid-Flood Spring Tide – Current Speed and Direction (Vector Arrows)

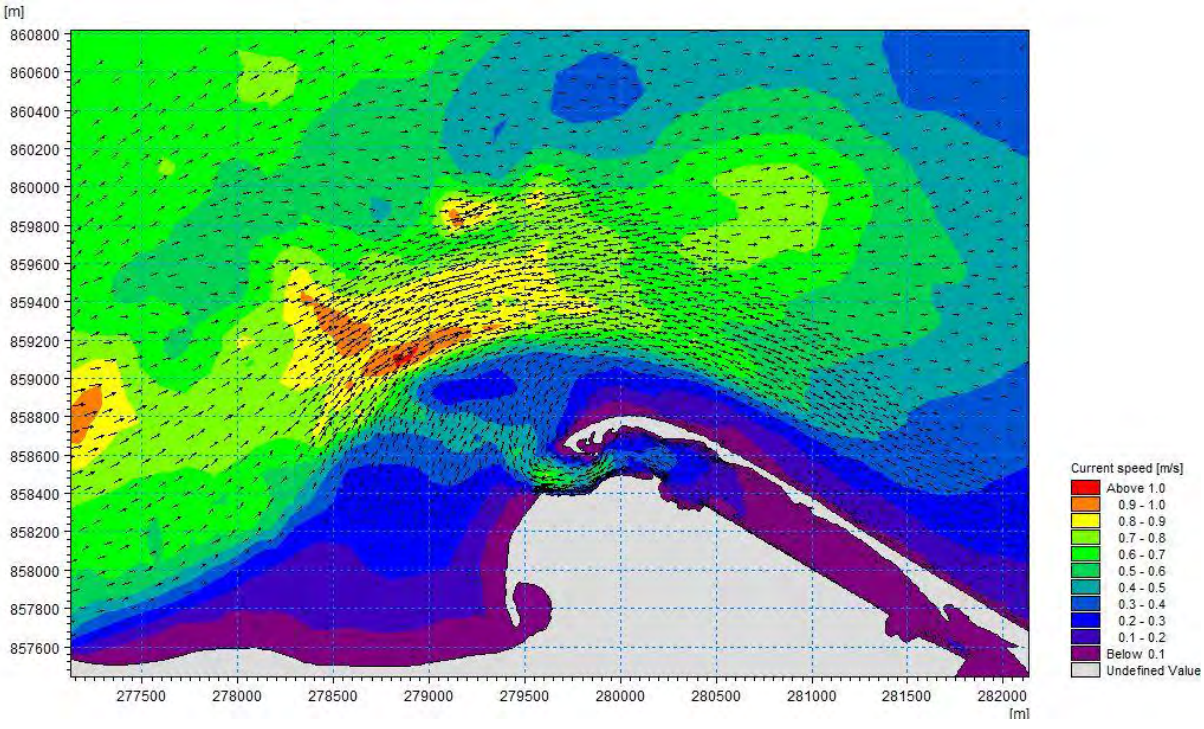


Figure 3.4: Modelled Mid-Ebb Spring Tide – Current Speed and Direction (Vector Arrows)

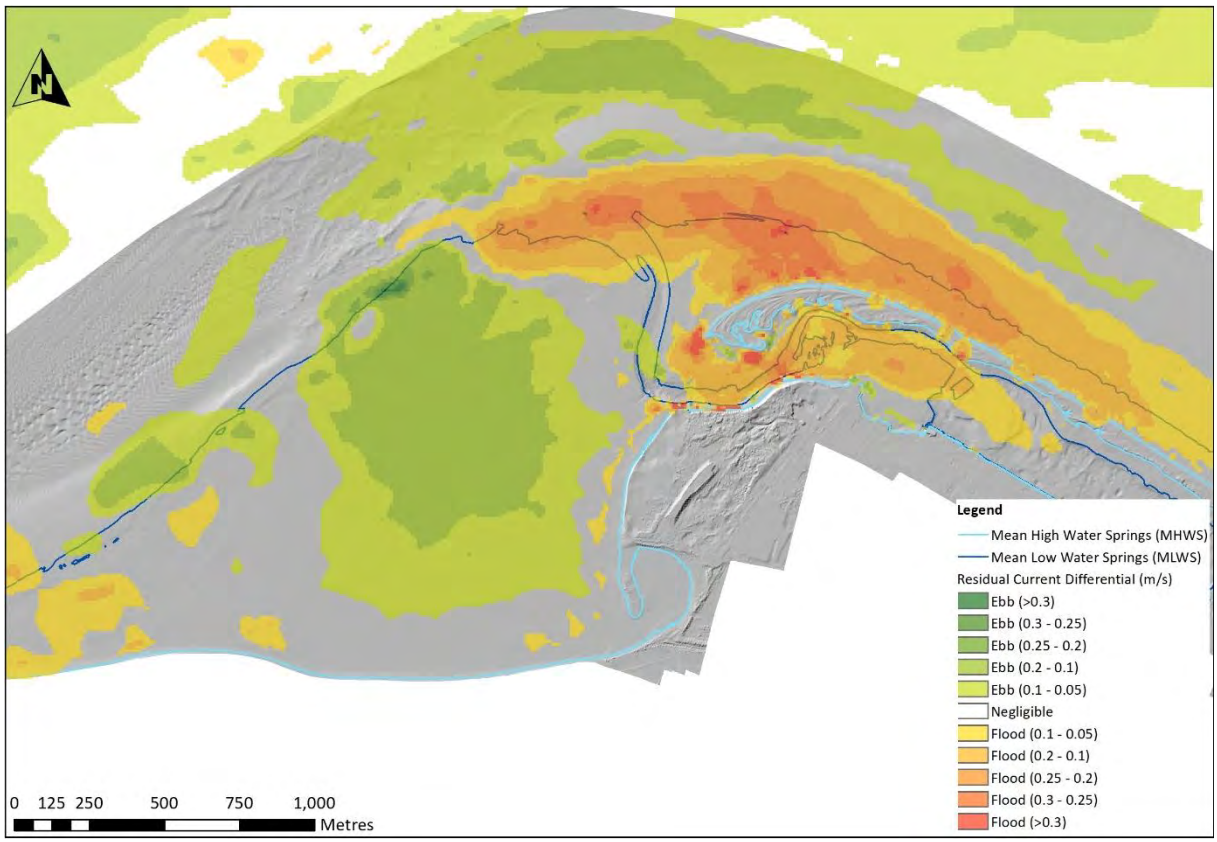


Figure 3.5: Residual Modelled Peak Spring Flood and Ebb Tidal Current Differential

3.5 Wave Climate

In the Moray Firth the prevailing wind direction is from the southwest, whilst the offshore wave direction is predominantly from the northeast. Offshore wind and wave data available from the Met Office from the period March 2000 – March 2007, for an area in the Outer Moray Firth situated over 20km offshore from Ardersier Port, has been analysed and the offshore wind rose and wave rose are presented in Figure 3.6.

The nearshore wave climate in the vicinity of the Ardersier Port has been examined by transformation of offshore wave conditions using Mike 21 FM SW (Flexible Mesh Spectral Wave Model) software. The nearshore wave climate has been modelled for a 6 month period using offshore Met Office Data (January – June 2003), with results extracted from the model at 4 points immediately offshore of the spit eastern frontage at approximately 10m depth of water (see Figure 3.7). The results are plotted as nearshore wave rose plots for points 1 to 4 in Figure 3.8 and indicate that significant wave height is typically less than 2m in the nearshore environment, with modelled significant wave heights generally slightly greater than half the offshore wave height.

The model results indicate that wave heights are greatest along the exposed eastern frontage of the spit, reducing around the head of the spit and into the more sheltered waters of Whiteness Sands.

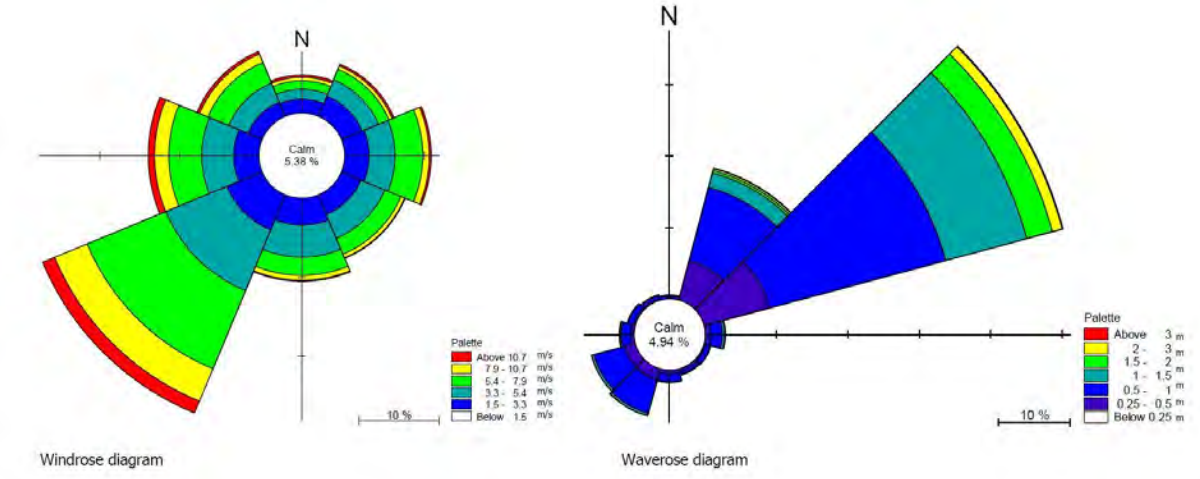


Figure 3.6: Offshore Wind Rose and Wave Rose (Met Office Data)

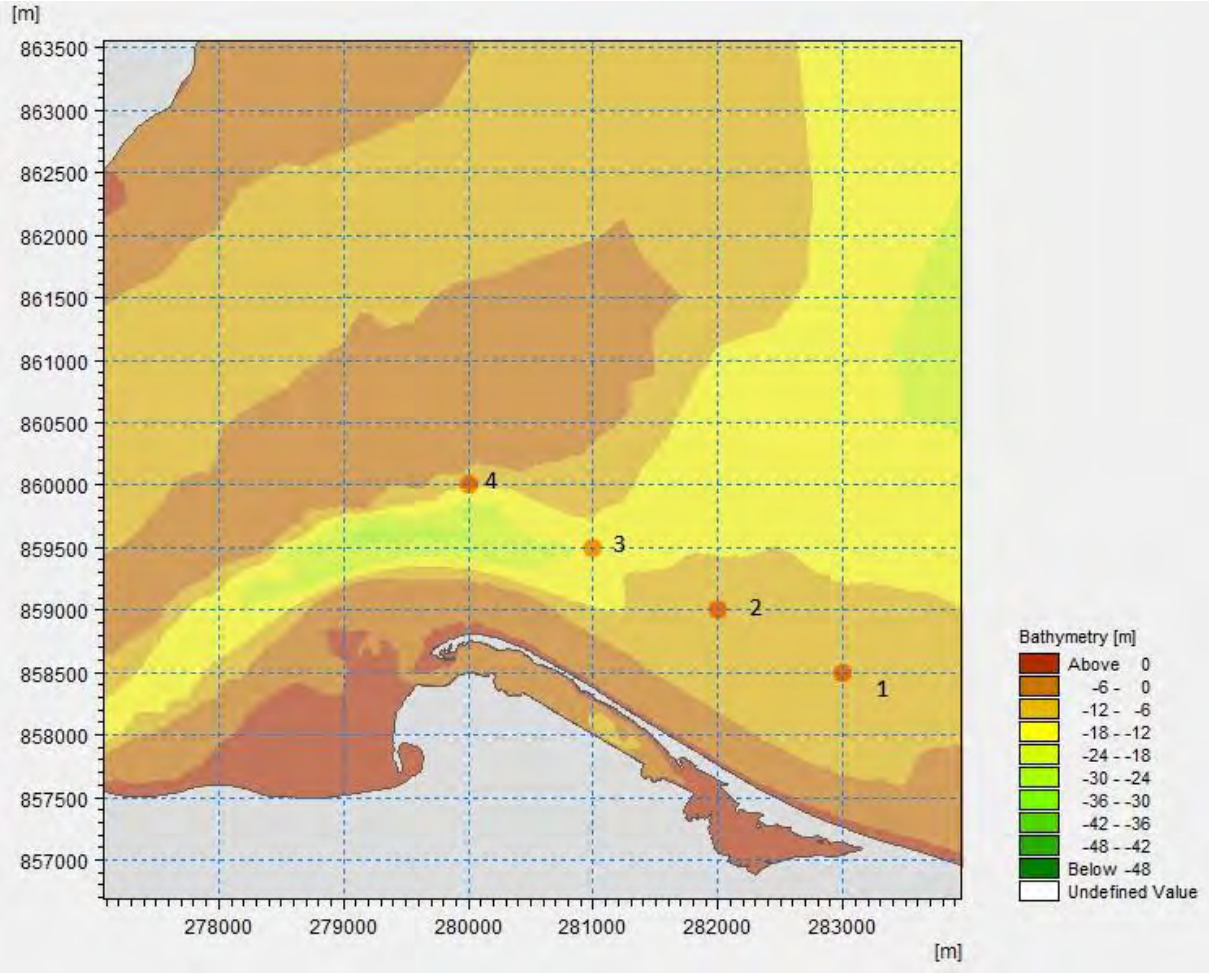
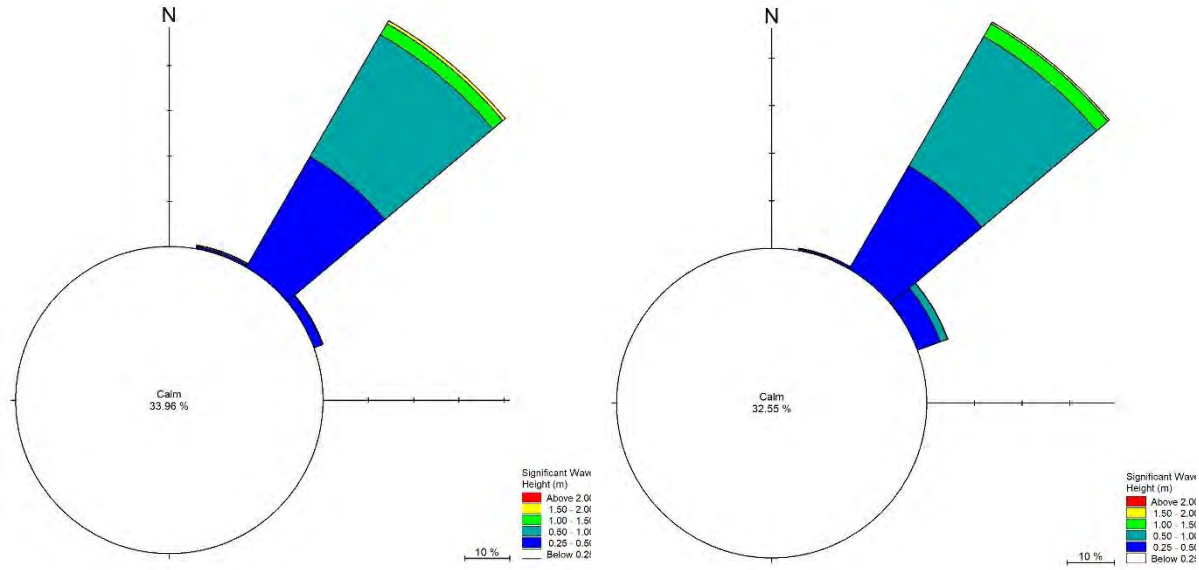
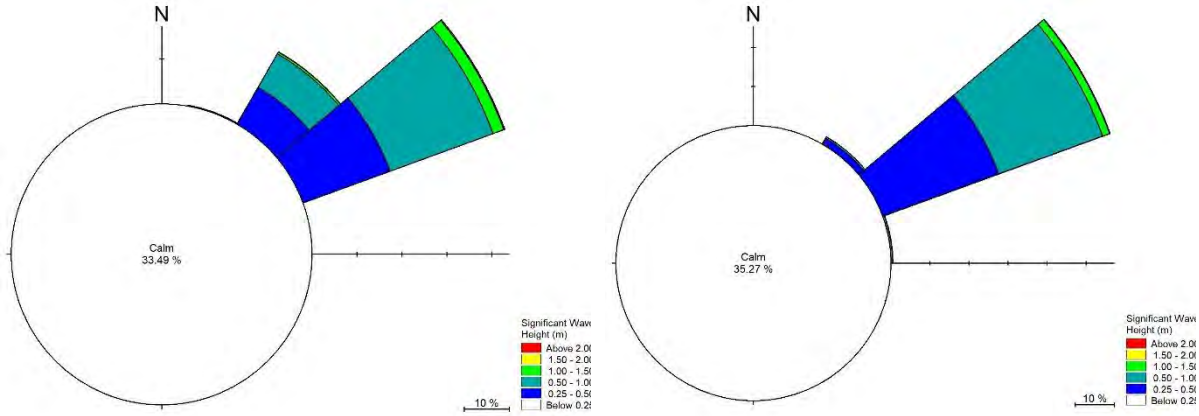


Figure 3.7: Nearshore Wave Climate Result Extraction Locations



Point 1 (283000,858500) Point 2 (282000,859000)



Point 3 (281000,859500) Point 4 (280000,860000)

Figure 3.8: Wave Roses for Nearshore Waves @ Points 1-4 (Jan–Jun 03, 2018 Bathy)

4 CONCEPTUAL MODEL OF COASTAL PROCESSES

A conceptual understanding of sediment transport and coastal morphology within the local coastal system was developed through review of observed and historic changes, supplemented by hydraulic modelling, and is visualised in Figure 4.1.

The conceptual model includes the longshore transport of sand and gravel along the eastern shore of Whiteness Head spit resulting in continued spit extension to the north-west, with recurves to the south-west. A continuity of this north-western transport pathway is highlighted, both offshore to the deeper waters of the main channel, and further west to the north-eastern intertidal and subtidal margin of Whiteness Sands.

The model includes the offshore movement of sand from the northern margin of Whiteness Sands, and a returning eastern transport pathway further offshore. This eastern pathway is considered to also contribute sediment to the tidal inlet, and the southern coastline of Whiteness Sands. Central areas of Whiteness Sands are considered to be generally stable within the local context of Whiteness Head.

This local coastal system has been subject to modification in the form of dredging for the McDermott Construction Yard from the early 1970's until around 2001. This site history remains an influence on present day processes, particularly on the extent and direction of spit head recurve, and on the volume of water exchanged within the tidal inlet. These have resultant localised impacts on currents and associated sediment transport processes, while the wider scale processes continue uninterrupted.

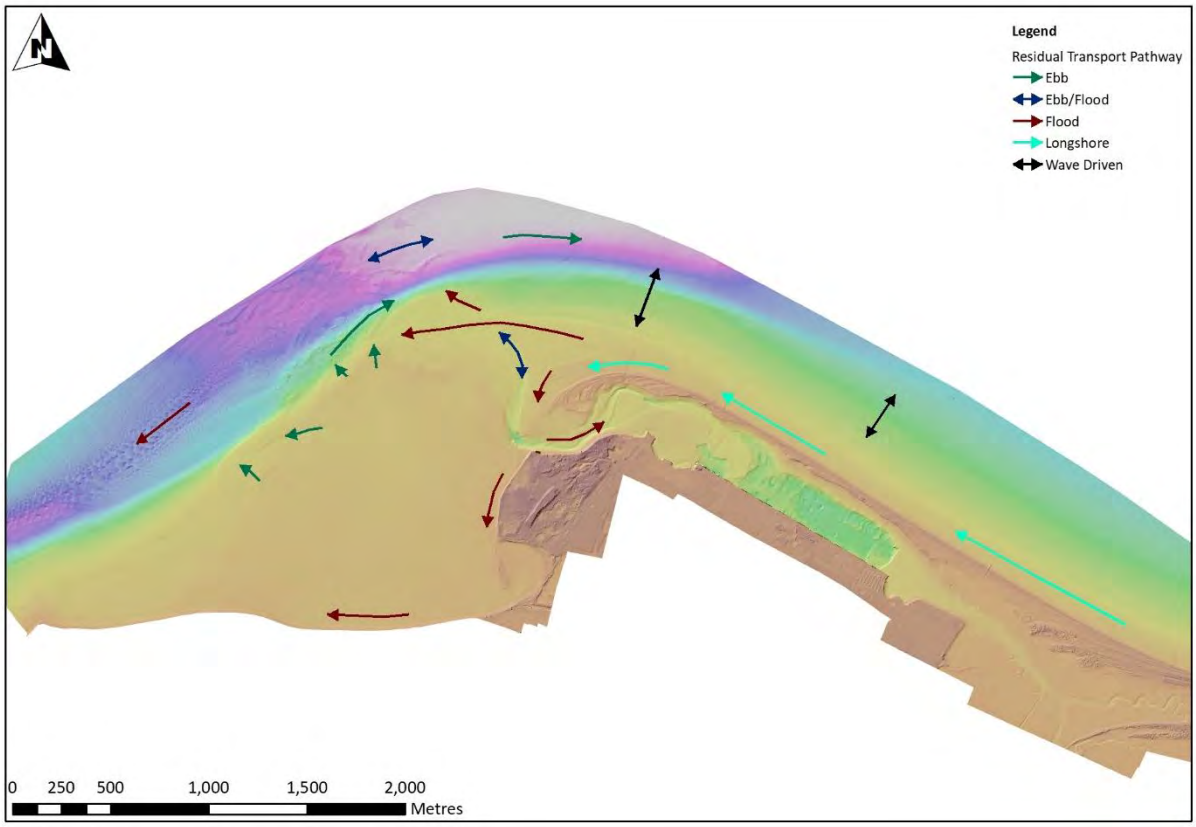


Figure 4.1: Conceptual Model of Sediment Transport Pathways (2018)

5 IMPACT ASSESSMENT

5.1 Coastal Processes

The pre-dredge 2018 (baseline) conditions have been compared with the consented 2018 dredge activity and the impacts on the coastal processes identified in the following sections. The proposed variation to the dredge activity extends across a similar, but slightly wider and deeper footprint. The model updates to quantify the spatial extent and magnitude of the changes is underway as the updated bathymetry becomes available, and the outputs from these model runs will be used to update this report when available.

5.1.1 Tides and Currents

A comparison of the modelling results with and without the consented 2018 dredge extent has been undertaken. This comparison highlights that there will be no significant impact on tidal levels, except to increase low water tidal range within the dredge zone. This is particularly evident where deposition has occurred in the harbour.

Hydrodynamic modelling results allow comparison of both flood and ebb tidal currents during a spring tidal cycle, with and without the consented 2018 dredge extent.

Comparison of the model results for the mid flood spring tidal currents indicates that there would be localised reductions in tidal velocity (up to 0.5 m/s) within the immediate vicinity of the navigation channel, and within the present alignment of the former navigation channel (up to 0.8 m/s) which will remain in situ post dredge. Further outside the immediate vicinity of the proposed dredge zone, comparison of modelling results indicates there would be no significant impact on tidal velocities during the flood tide.

Similarly, on the ebb tide comparison of modelling results indicates reductions in current velocity (up to 0.4 m/s) within, and immediately adjacent to, the navigation channel, and within the former dredged channel (up to 0.6 m/s). Again, outside the immediate vicinity of the proposed dredge zone comparison of modelling results indicates there would be no significant impact on tidal velocities during the ebb tide.

Whilst the modelling results indicate that the proposed dredging will produce localised changes in current velocities. It is considered that these variations are insignificant in terms of the wider hydrodynamic regime of the Moray Firth, with post development velocities of a similar nature to those observed elsewhere.

5.1.2 Waves

Modelling results show that during a typical winter period storm from the north-east the proposed dredging results in a slight increase in significant wave height within the dredge zone and immediate vicinity. Waves would be able to penetrate further into the harbour through the reinstated navigation channel. Elsewhere, outside the immediate vicinity of the proposed dredge zone the modelling indicates that the proposed development will have no significant impact on wave climate.

5.1.3 Sand Transport (Coastal Morphology)

Sand transport patterns and pathways have been modelled following completion of the 2018 consented dredging works. Model runs simulating 18 months of sand transport under post-dredge conditions have been carried out, for the whole of the model extent (Figure 5.1), and also looking specifically and transport pathways from the east of the navigation channel (Figure 5.2) and from the west of the navigation channel (Figure 5.3). The result plots (Figure 5.1 to Figure 5.3) show residual bed level change at the end of the 18 month run period. These model results will be updated for the proposed variation to the dredge activity and the report will be updated when these are available.

The results of these model runs indicate that the longshore transport of sand along the eastern face of the spit will continue unaffected by the 2018 consented dredging. The modelling highlights that whilst the north-western intertidal and subtidal build out of the spit will continue to the east of the dredged navigation channel, the channel will act as a trap to the further westward transport of sediment.

To the west of the new channel the model runs indicate that the remaining intertidal and subtidal head of the spit will be subject to ongoing erosion, with sand predominantly being transported further west into the present location of the former dredged navigation channel, and across the north-eastern fringe of Whiteness Sands, in line with present day processes. A smaller amount of sand is shown to move east into the new navigation channel immediately to the north of the remaining terrestrial spit head, which will remain as an island post dredging. Further south within the former dredged channel, the post-development lower energy conditions are predicted to result in increased deposition, particularly to the south-western lee of the remaining terrestrial spit head.

Further west across central parts of Whiteness Sands the model runs show limited movement, consistent with observed data and the conceptual understanding of transport in this area. The model runs indicate that present day processes will continue relatively unaffected by the development across Whiteness Sands. The model highlights the continued easterly subtidal transport pathway from the northern margin of Whiteness Sands, and a circulation of material into the remaining former dredged navigation channel.

Due to the large volume of sediment currently available within the local coastal system, it is considered that the removal of the proposed dredge budget to land will not be significant in terms of the wider system. Observed trends, model results and the conceptual understanding of local sediment transport processes all indicate that potential impacts to sediment transport and coastal morphology will be localised in extent. It is considered that the longshore feed of sediment along the spit will continue, with change limited to the footprint and immediate vicinity of the dredge channel, and the north-eastern fringe of Whiteness Sands.

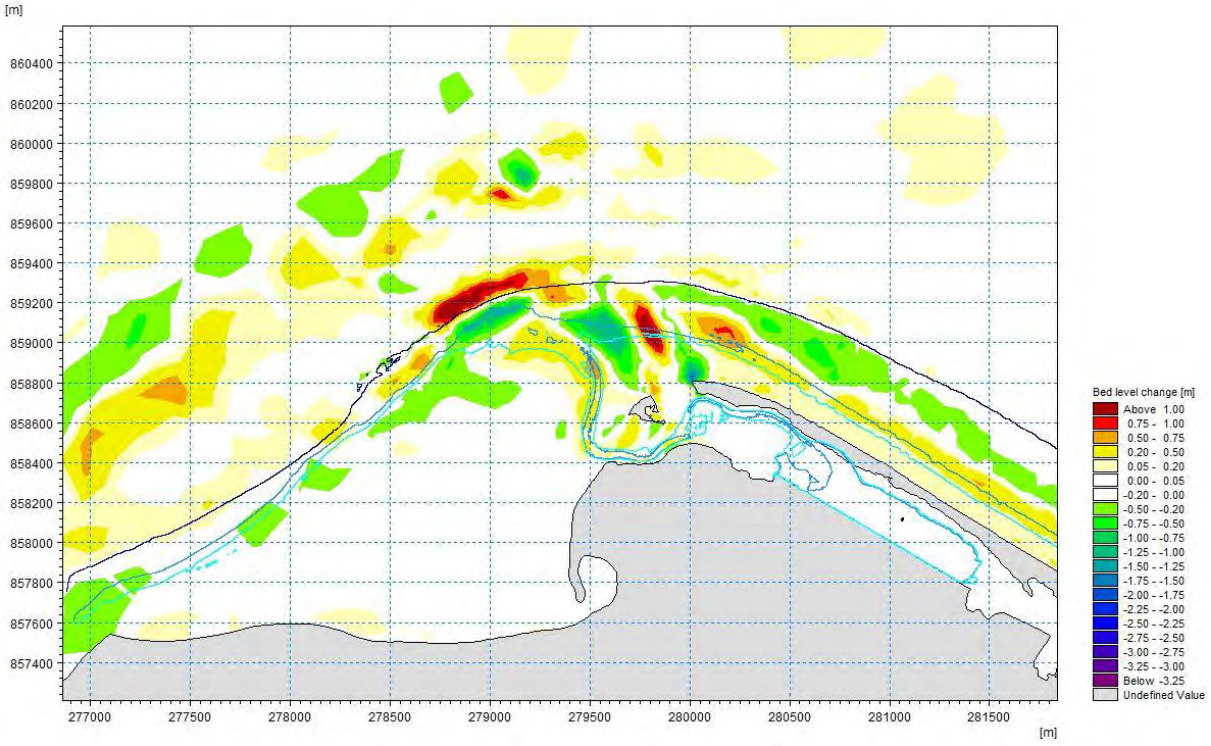


Figure 5.1: Sand Transport – Residual Bed Level Change (18 month run, 2018 bathy post-dredge)

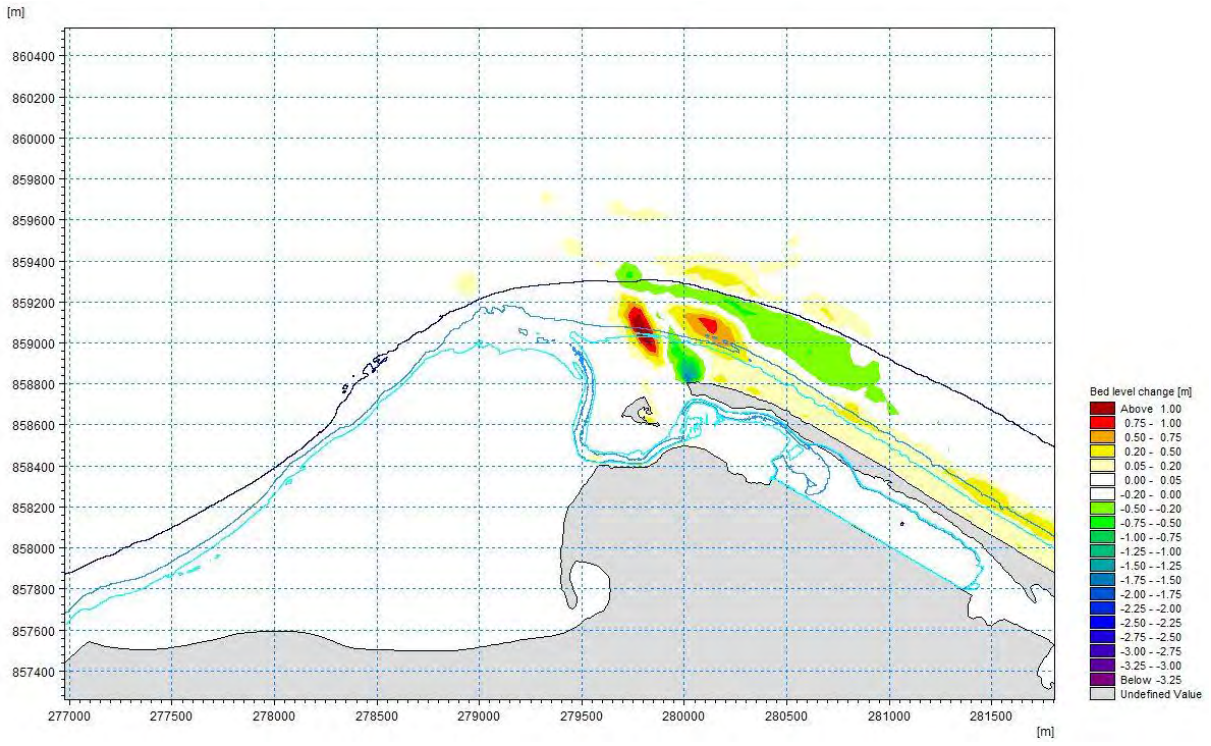


Figure 5.2: Sand Transport East of Navigation Channel – Residual Bed Level Change (18 month run, 2018 bathy post-dredge)

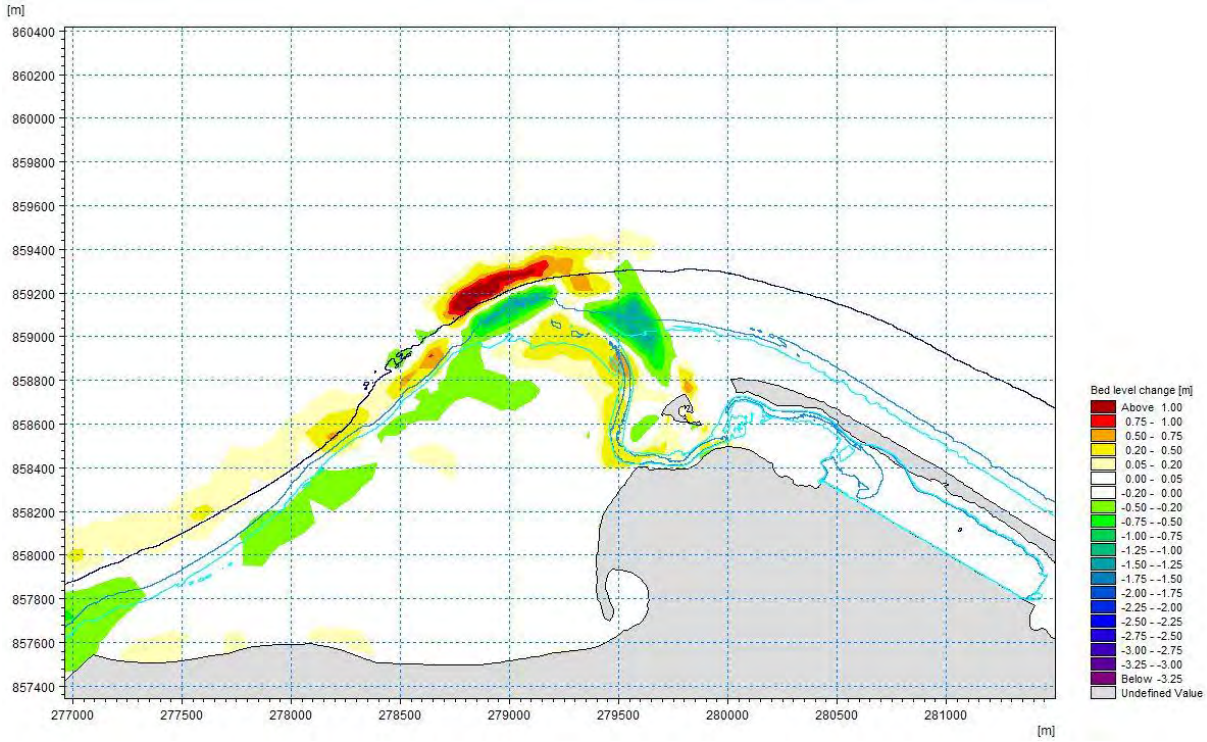


Figure 5.3: Sand Transport West of Navigation Channel – Residual Bed Level Change (18 month run, 2018 bathy post-dredge)

5.2 Impact on Designations

The predicted zone of impact to coastal processes from the proposed development in relation to designated sites is identified in Figure 5.4. These impacts relate primarily to the dredging activities to reinstate the navigation channel and harbour. The extents shown are based on the conceptual understanding and supported by hydraulic modelling. Comments in relation to the extent of the impact on the designated sites, and relative proportions of designation impacted, are provided in Table 5.1. The areas of the designated sites potentially impacted are small.

The findings of this assessment remain consistent with those of the NCCA report, Cell 3 – Cairnbulg Point to Duncansby Head, for Whiteness Head (Site 34) as presented below.

'Currently the site has planning permissions for both a new town development (postponed after 2006) and a renewables fabrication yard, which has yet to advance due to the Port of Ardersier going into administration. The past, recent and anticipated changes do not present a risk or threat to the nature conservation designation interest of the site.'(Hansom et al., 2017)

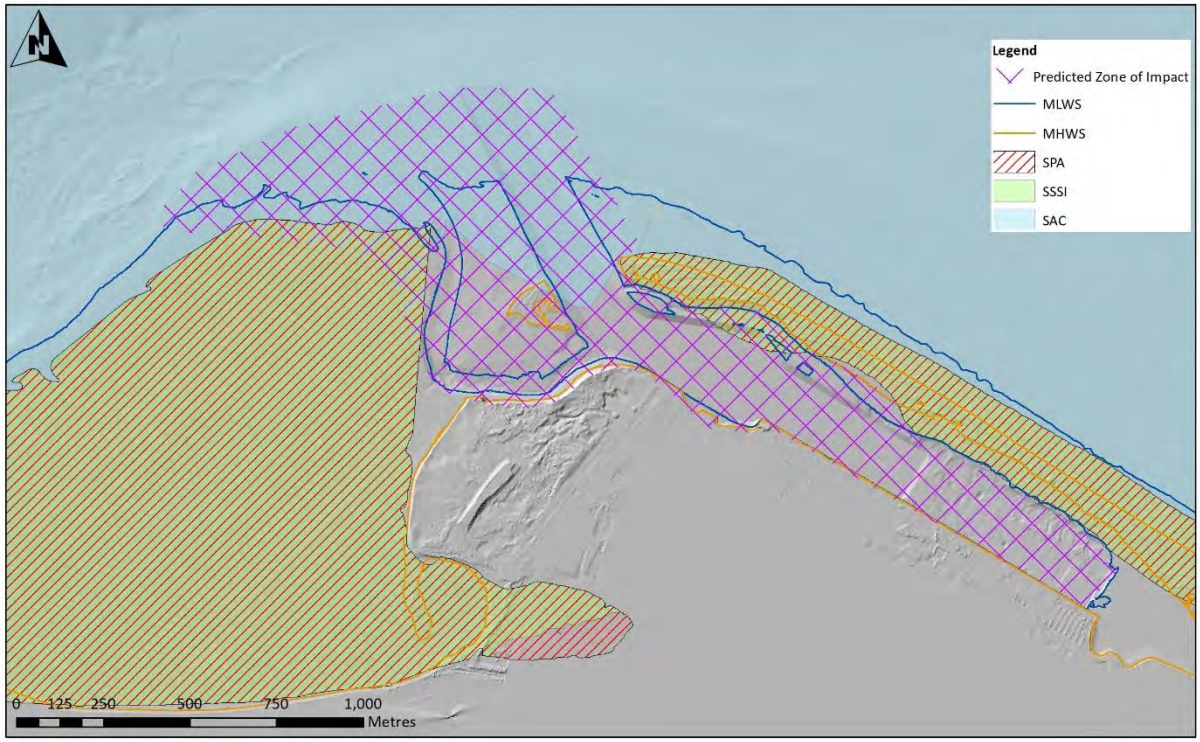


Figure 5.4: Predicted Zone of Impact in Relation to Designated Sites

Table 5.1: Zone of Impact Extents in Relation to Designated Sites

Designated Site	Comment	Area of Site Impacted
Whiteness Head SSSI	Spit: Predominantly outside designated boundary, but includes present spit head and future development area.	<3%
	Sands: Small area limited to north-eastern extent of intertidal sands.	
Inner Moray Firth SPA	Impact zone limited to Whiteness Head and Whiteness Sands. Comments as per SSSI above.	0.1%
Moray Firth SAC	Intertidal and subtidal zone around dredge channel and immediately to the west.	<0.1%

6 SUMMARY OF IMPACTS

In general terms, the proposed variation represents an increase in depth and width to the navigation channel as previously assessed in 2013 and 2018, while the relative positioning remains similar. The key findings of the effect of the 2018 assessment have been reviewed in relation to the proposed variation as summarised in Table 6.1.

Table 6.1: Review of coastal processes impacts (2018) to expected 2023 variation change

Coastal Process	2018 Assessment Findings	2023 Proposed Variation Conditions
Tides	No significant impact on tidal levels.	No Change.
	Low water tidal range will increase within dredge zone.	No Change.
	Localised reductions in tidal velocities within the immediate vicinity of dredge zone.	Further reduction due to increased depth and width of dredge zone.
	No significant impact on tidal velocities outside the immediate vicinity of dredge zone.	No change.
	Variations in tidal velocities considered insignificant in terms of the wider hydrodynamic regime of the Moray Firth.	No change.
Waves	Slight increase in significant wave height within the dredge zone and waves able to penetrate into the harbour via the dredge channel.	Further slight increases in wave height in dredge zone and penetration into harbour.
	No significant impact on wave climate outside the immediate vicinity of the dredge zone.	No change.
Sand Transport (Coastal Morphology)	Longshore transport of sand along spit from east will continue unaffected by the dredge.	No change.
	Intertidal and subtidal build up of the spit will continue to the east of the navigation channel.	No change.
	The navigation channel dredge zone will act as a trap to onward westward sediment transport along spit, with material being deposited.	No change to process, trapping effect to be greater.
	Immediately west of the navigation channel dredge zone, the remaining intertidal and subtidal head of the spit will be subject to ongoing erosion, with material being transported predominantly west into the former dredged channel and the north-eastern fringe of Whiteness Sands, with some material moving south and east into the navigation channel.	Process will remain similar. Increase in area of subtidal bed exposed to erosion.
	Further west across the central parts of Whiteness Sands will remain relatively unaffected.	No change.
	The proposed material removal by dredging is not considered significant in terms of the wider system due to the large volume of sediment currently available within the local coastal system.	No change.
	Impacts to sediment transport and coastal morphology will be localised in extent, with areas of change limited to the footprint and immediate vicinity of the dredge channel and the north-eastern fringe of Whiteness Sands	No change.
Impact on Designated Sites	Areas potentially impacted assessed as being small. Whiteness Head SSSI (<3%); Inner Moray Firth SPA (0.1%); and Moray Firth SAC (<0.1%)	Areas of impact to increase marginally, but not expected to change overall assessment.

This updated assessment of the 2018 coastal processes assessment findings, in the context of a now proposed deeper and wider dredge within the same corridor, finds similar impacts would be anticipated. Where changes have been identified, these are predominantly within the immediate vicinity of the dredge zone, becoming less beyond this zone. Where changes are expected, these are anticipated to be of a similar but slightly greater magnitude than previously assessed in 2018.

The overall impact of the proposed deeper dredge on the local conditions is not expected to significantly change the overall findings of the 2018 assessment.

It is however recognised that the present day conditions (e.g. local bathymetry) will have changed over the period since the pre-dredge 2018 modelling (based on 2017 bathymetry survey) was undertaken. The models are being updated with the most recent bathymetry as it becomes available and these results will be used to update this report and provide a quantification to these expected changes in terms of both magnitude and extents.