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ARDROSSAN HARBOUR REDEVELOPMENT
PROOF OF CONCEPT REPORT

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1. EXECUTIVE SUMMARY

A new ferry is being introduced into the Ardrossan to Brodick ferry service. The new vessel, the MV Glen Sannox, is larger than the existing ferries that are currently in service and has different handling characteristics.

Ramboll, on behalf of Peel Ports Group and the wider stakeholders, have undertaken a Proof of Concept study to identify the optimum berth arrangement for the MV Glen Sannox in conjunction with landside infrastructure planning. The aim of the study was to identify a preferred berth option that considered the requirements of the project stakeholders and ferry service operations and which will then be put forward for Ministerial approval.

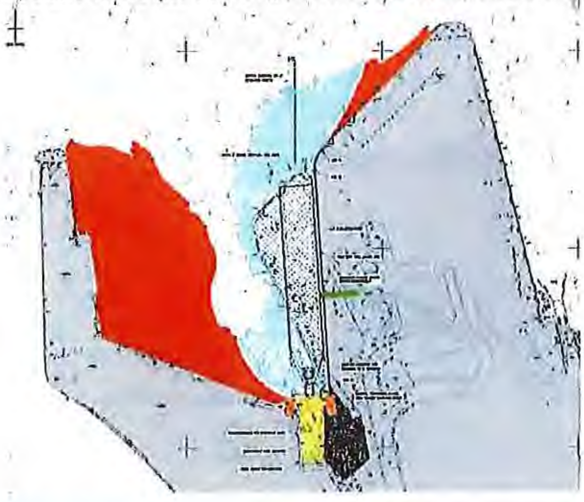
At the first stage of the Proof of Concept study 14 different berth configuration options were identified for Stakeholder consideration. These options were known as the Long List. A stakeholder workshop was held on the 12th February 2019 and the merits and dis-benefits of each option were discussed. Many options were discounted based initially on navigation as it was found that it was not viable to reliably navigate the Glen Sannox on to some of the new berth locations. The references for this reasoning were the vessel simulation undertaken previously of the Glen Sannox and the existing Arran Berth and Harbour Master and Pilot knowledge of the operating conditions within the harbour.

Three groups of options were selected at the workshop for further consideration including berth configurations that involved a re-alignment of the Arran Berth and also the option to locate the berth for the Glen Sannox on Winton Pier. A more detailed appraisal of the Winton Pier concluded that this arrangement was not viable due to geometrical constraints.

Subsequently, three favoured options, all re-alignments of the Arran Berth, were taken forward to more detailed appraisal to identify a preferred option:

Option 2

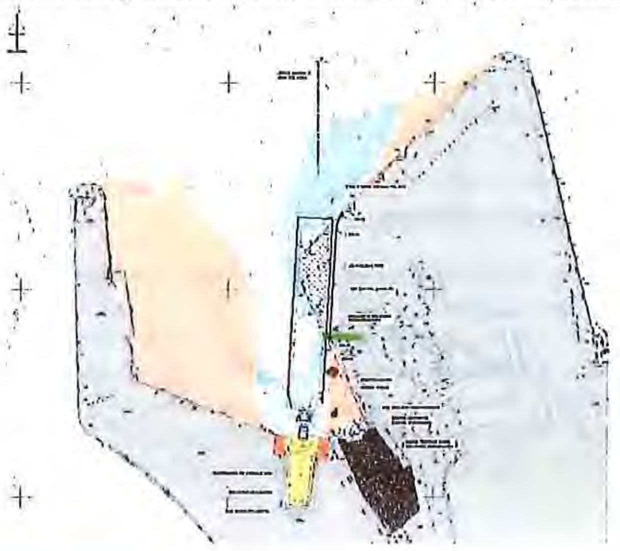
Option 2 involves an inland realignment of the Arran Berth and is a scheme that was previously developed by Ramboll on behalf of CMAL. This option is also included as the reference proposed scheme in the Transport Scotland Sponsor's Requirement Schedule (SRS). Of the three favoured options it results in the greatest loss of landside area.



Berth Option 2

Option 7

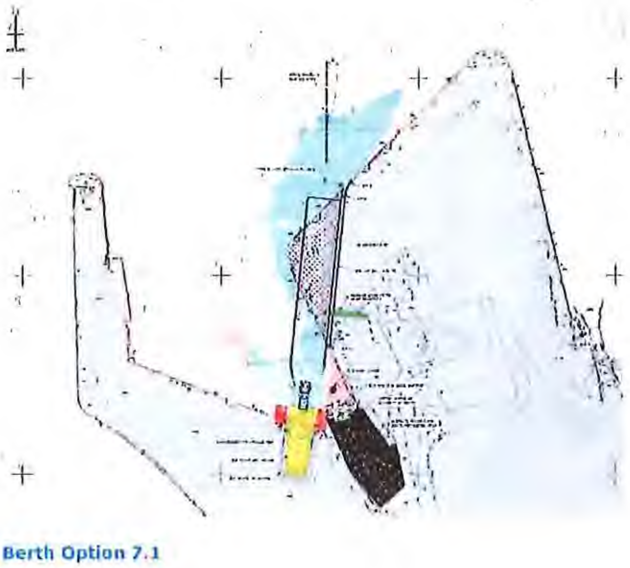
Option 7 is a scheme involving partial inland realignment of the Arran Berth. Of the three favoured options it results in the lowest loss of landside area.



Berth Option 7

Option 7.1

Option 7.1 is a scheme also involving partial inland realignment of the Arran Berth. The alignment lies between Option 7 and Option 2 and of the three favoured options it results in the greatest change in angle of the berth.



Berth Option 7.1

A review of environmental considerations of the three options has been undertaken by EnviroCentre Ltd working on behalf of Peel Ports Group. Environmental Impact Assessment (EIA) screening undertaken previously by EnviroCentre had confirmed that Option 2 would not require an EIA. EnviroCentre's review concluded that, if impact piling is not undertaken, then strong reasoning can be put forward that the development does not constitute EIA Development.

On behalf of Peel Ports Group, BDB Pitmans LLP (Parliamentary Agents) have undertaken a review of the potential need for a Harbour Revision Order (HRO) to implement each of the favoured options. Their review concluded that for any of the favoured options, it is not anticipated that an HRO would need to be applied for.

To inform selection of a recommended option the following studies have been carried out on the favoured options:

- Vessel simulation
- Ground conditions and construction methodology
- Wave modelling
- Mooring analysis
- Landside design interface
- Estimate of construction durations
- Estimate of construction costs

A high-level summary of the findings of each of the studies is as follows:

Vessel simulation
CalMac Masters, along with the Peel Ports Pilot utilised the Peel Ports simulators at Greenock Ocean Terminal to determine the viability of the favoured options and determine the likely operational envelopes.

The vessel simulation identified that Option 2 provides manoeuvring space to enable operations in a greater range of conditions. Option 2 was found to provide the most optimal configuration due to the increased manoeuvring space available coupled with the ideal mooring configuration. Option 7.1 was also found to have benefits. However, due to the berth length of Options 7 and 7.1, both configurations were found likely to impact on smaller vessels operating on the route including MV Caledonian Isles and MV Isle of Arran, potentially offsetting any benefits that may be experienced in improving the reliability of MV Glen Sannox.

Ground conditions and construction methodology
Ground conditions are relatively consistent across the three berth options. The presence of redundant buried quay walls and tie back structures are common across the options and add complexity and risk to the works.

Option 2 is set back from the existing perimeter quay wall for much of its length. This lowers the degree of interface with the existing quay wall and also gives the contractor a larger working area that is more removed from the sea therefore reducing risk. The increased quay wall length of Option 2 increases the risk of encountering unexpected ground conditions or buried structures. The alignment also passes in close proximity to the existing terminal building.

Option 7 passes through tie backs to the existing quay walls along virtually its entire length making construction whilst continuing to maintain the integrity of the existing quay wall very difficult and risky. It is anticipated that a temporary construction bund located on the outside of the existing quay wall would be required in order to safely execute the works.

Option 7.1 also passes through tie back structures but to a lesser extent than Option 7. A contractor could explore different construction methodologies including a construction bund or temporary connection of tie rods to the new quay wall piles to maintain stability before demolition of the existing quay wall.

Wave modelling
Wave modelling has been undertaken for Option 2, Option 7,1 and the existing condition. There was not found to be a major difference in the wave climate at either Option 2 and Option 7.1. The proposed new berth configurations were shown to be more exposed to the North-westerly storms due to their orientation. The proposed new berth configuration was shown to be less exposed to the South-westerly storms due to their location.

Mooring analysis
Mooring analysis of Option 7.1 (as the "middle" of the three options) was carried out using the software "Optimoor". Several mooring arrangements were analysed. Vessel excursions from these arrangements met with the BS and PIANC recommendations. The new Arran Berth configuration was found to be suitable for carrying out load/unload operations under regular weather conditions (including CALMAC recommendations) and, also, staying at quay during rough weather (storms) or at night.

Landside design interface
On behalf of Peel Ports Group Ironside Farrar Ltd developed landside masterplan layouts for each of the three favoured berth options. Ironside Farrar found that Option 2 retains the current general arrangement and offers best capacity, flexibility and future proofed layout for landside aspects of the port and ferry and terminal operations albeit at a cost to the extent of the operational area of the Pierhead. Based on landside facilities the masterplan layouts suggest Option 2 would best meet the requirements set out in the SRS with Option 7.1 offering a viable solution subject to relaxation of SRS requirements associated with on-site parking.

Estimate of berth construction durations

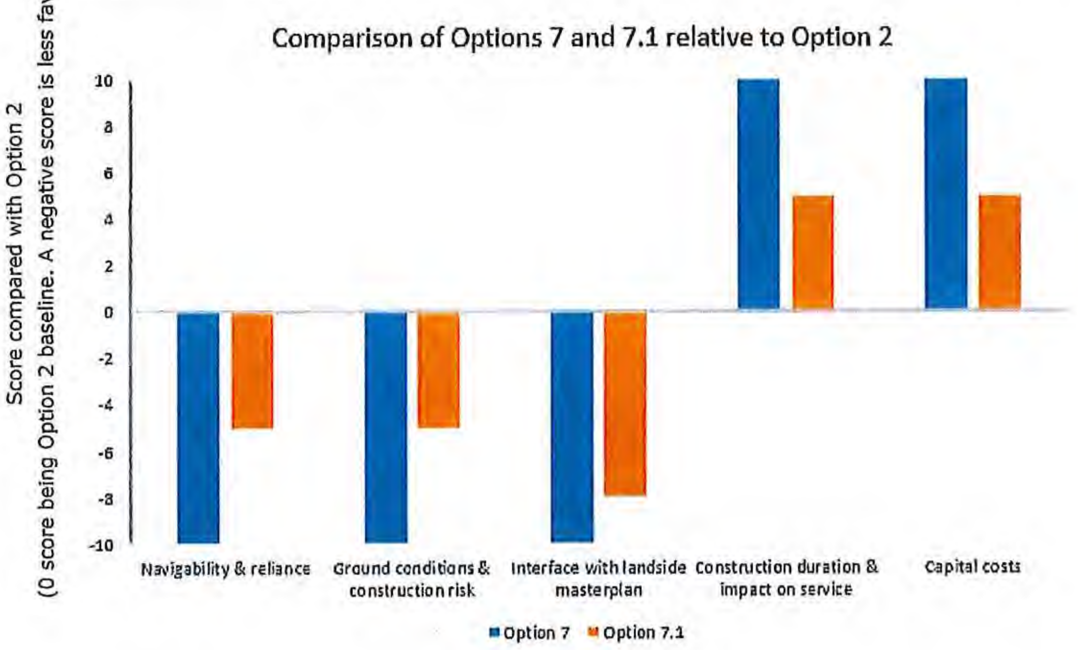
	Option 2	**Option 7**	**Option 7.1**
Estimated construction duration including allowance for risk	18 months	13 months	15 months
Estimated closure of Arran Berth including allowance for risk	16 months	13 months	14 months

Estimate of berth construction costs

	Option 2	Option 7	Option 7.1
Estimated total construction cost including 15% Optimism Bias	[redacted]	[redacted]	[redacted]
Peel Ports Group Funding marine works	[redacted]	[redacted]	[redacted]
Delta in Funding	[redacted]	[redacted]	[redacted]

Summary

A high-level summary of the comparison of Option 7 and 7.1 relative to Option 2 for the primary project considerations is as follows:



Conclusion

Option 2 has less interface with existing structures compared to the other two favoured options and was found to be preferable in terms of interface with the landside masterplan.

Option 2 has the longest estimated construction duration and has the potential for construction activities to still be taking place, and therefore the Arran Berth still in suspension, into a second summer season. Whilst this represents a greater short-term disruption to the public and the local community, Option 2 has been proven by vessel simulations carried out by CalMac Masters and the Peel Ports Pilot to provide a more resilient berth configuration which will allow enable operations in a greater range of conditions. Given the 50year design life of the berth structure the long-term benefits of Option 2 can be considered to outweigh the higher cost and the short-term construction programme disbenefits of this option. The conclusion of the study is therefore that Option 2 may be put forward for Ministerial approval.

2. INTRODUCTION

A new ferry is being introduced into the Ardrossan to Brodick ferry service. The new vessel, the MV Glen Sannox, is larger than the existing ferries that are currently in service and has different handling characteristics.

In 2017 Peel Ports Group and North Ayrshire Council jointly made a bid to Transport Scotland for Ardrossan to remain as the mainland port for the Brodick service. The bid was on the basis of limited changes being required to the harbour (primarily just a linkspan upgrade was anticipated). It is now known that more substantial adjustments to the harbour are required to suit the navigational requirements of the Glen Sannox. The principal requirements for the revised berthing are set out in the Marine Works Sponsors Requirement Schedule Rev 5 (SRS) prepared by Transport Scotland which materially changed the scope of the works from a harbour refurbishment project to a reconfiguration of both the landside and marine facilities of Ardrossan Harbour with a design life of 50 years.

Ramboll, on behalf of Peel Ports Group and the wider stakeholders, carried out a Proof of Concept study to identify the optimum berth arrangement for the MV Glen Sannox in conjunction with landside infrastructure planning. The aim of the study is to identify a preferred berth option that considers the requirements of the project stakeholders and ferry service operations which will then be put forward for Ministerial approval. Of particular operational importance to the new berth configuration is navigation of the vessel onto the berth and resilience of the ferry operations to bad weather when approaching from within the breakwaters, and while moored on the berth, although many other factors come into consideration.

A progress note published on 04th March 2019 reported on a wide selection of possible new berth options that were identified and appraised in the first part of the proof of concept phase. This report considers in more detail the favoured options that were identified for further consideration in the progress note. At this stage in the project the favoured options are still very much concept designs though where possible more developed elements of the design from berth design work previously undertaken by Ramboll have been taken into consideration.

Once the Scottish Transport Minister has accepted the recommended option the next stage will be to develop the berth and landside design in more detail, undertaken the license applications and procure the works ahead of construction.

This report focusses on a primary operating berth for the Glen Sannox. Any works or costs associated with upgrading a secondary berth are outside of the scope of this report.

3. PROJECT STAKEHOLDERS

Key stakeholders engaged in the project are:

Transport Scotland (TS) – Overseeing over-all project delivery and potential funding on behalf of the Scottish Government.
Ardrossan Harbour Company Ltd (AHCL) – Harbour Authority
Peel Ports Group (PPG) AHCL – Port (assets) owner and infrastructure operator
Caledonian MacBrayne (CalMaC) - Current ferry operator
Caledonian Maritime Assets Ltd (CMAL) - Ferry vessels owner
North Ayrshire Council (NAC) - Ardrossan facility stakeholder and local planning authority

Ironside Farrar Ltd (IFL) is appointed by PPG to undertake landside masterplanning of the port and to specify geotechnical investigations.

4. ARDROSSAN HARBOUR LAYOUT

The existing berths in Ardrossan Harbour are identified in Figure 1 and are commonly referred to as such for reference.

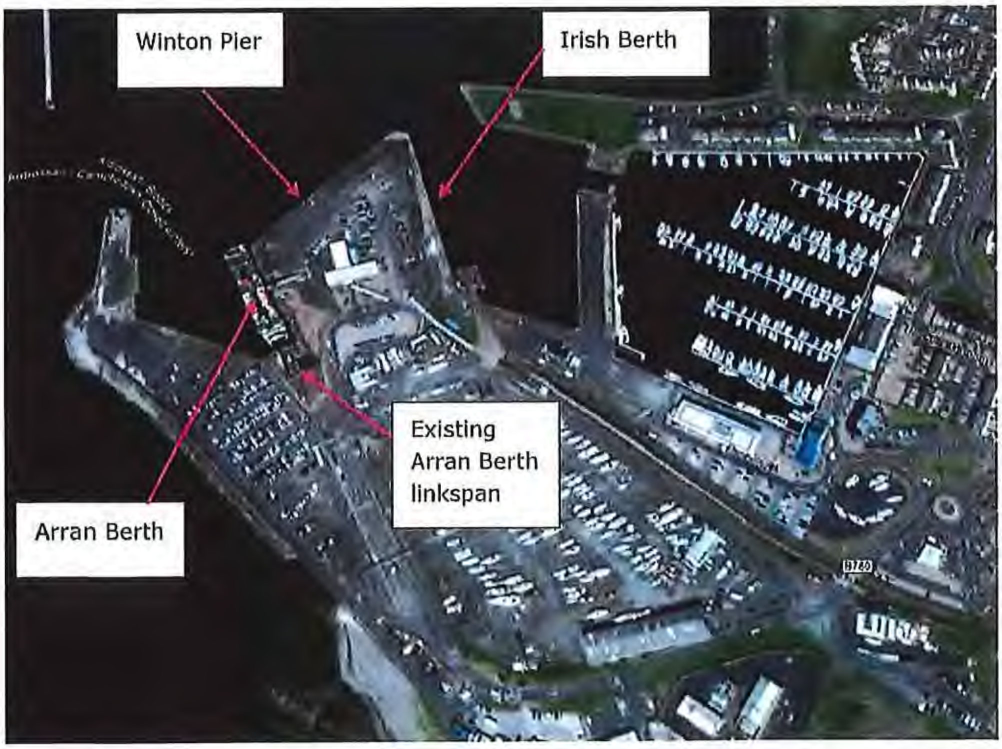


Figure 1 Ardrossan Harbour Layout

5. PRINCIPAL REQUIREMENTS

The principal requirements for the revised berthing are set out in the Marine Works Sponsors Requirement Schedule Rev 5 (SRS) prepared by Transport Scotland.

A summary of technical queries answered by TS in this period is as follows:

Table 1 Technical queries

TQ no.	Technical Query
TQ 001	Physical characteristics and operating parameters for Glen Sannox
TQ 002	Confirmation of linkspan specification (size)
TQ 003	Capability of thrusters on Glen Sannox
TQ 004	Vehicle handling arrangements on Glen Sannox
TQ 005	Outputs from previous vessel simulations
TQ 006	Design vessel for secondary berth
TQ 007	Proposed form of new linkspan
TQ 008	Mooring line specification
TQ 009	Limiting operational conditions
TQ 010	Mooring line arrangement for mooring analysis.
TQ 011	Discounting of Winton Pier options.

In line with the SRS and technical query responses, the following principal requirements for the new berth were identified:

- Two operational berths overall (one Primary Berth, and one Secondary Berth).
- Both berths have a linkspan.
- Only primary berth has a passenger access system.
- Primary berth is to be designed for both existing vessels (MV Caledonian Isles and MV Hebrides) and Glen Sannox. In addition to the primary existing design vessels the primary berth is to be designed for a number of secondary vessels as set out in the SRS.
- Secondary berth is to be designed for existing vessels only. Gangway access only.
- Base case for primary berth is a double lane linkspan. Costing of single lane linkspan to also be assessed.

5.1 Vessel details and requirements

The principal particulars of the primary design vessels as set out in the SRS are presented in Table 2.

Table 2 Design vessel particulars

	MV Glen Sannox	MV Caledonian Isles	MV Hebrides
Length (OA)	102.4m	94.0m	99.40m
Length (BP)	95.87m	85.20m	91.20m
Beam (excluding belting)	17.00m	15.80m	15.80m
Beam (including belting)	17.50m	16.32m	16.32m
Design Draught	3.70m	3.15m	3.30m
Normal operating draught	3.45m		
DWT (at design draught)	1,273t	735t	660t
DWT (at operating draught)	900t		
Gross Tonnage	7,040t	5,221t	5,506t
Displacement	4,773t	3,319t	3,493t
Lower belting from keel	6.78m	4.10m	5.10m
Upper belting from keel	10.18m	7.40m	8.50m

As defined in the SRS, to meet the operational requirements of the Glen Sannox a bed level of -4.7m below lowest astronomical tide (equivalent to a bed level of -4.9mCD) is required at, and on the approach to, the new berth.

The berth arrangement will need to allow for mooring of the primary design vessels during linkspan operation and also in their overnight positions (circa 6m pull back from the linkspan).

The following bunkering provisions are required (full details of the requirements are defined in the SRS):

- Fresh water
- MGO supplied via fuel tankers
- LNG storage and supply infrastructure (to be designed and supplied via CMAL). Details of the infrastructure and COMAH zone requirements are not available at this stage.
- Potential future provision for cold ironing. Allowance for ducts and draw pits only at this stage.
- Waste reception facilities

6. INDENTIFICATON OF FAVOURED OPTIONS

In the first part of the proof of concept study Ramboll held internal design critiques to identify possible berth configurations. The starting point for the optioneering was the original base case offer from Peel Ports. All berth options around the harbour were explored, not just options with the Primary Berth at the location of the Arran Berth as set out in the SRS. Four families of options were identified:

- Primary Berth at Arran Berth
- Primary Berth at Irish Berth
- Primary Berth at Winton Pier
- Primary Berth at Marina Pier

The Options were then further developed with input from IFL and PPG. The Long List options were scored via a scoring matrix. A berth options workshop with the stakeholders was held on

12th February 2019. Many of the of the long list options were discounted at the workshop leaving a short list of options. Further appraisal of the short listed identified three favoured options for more detailed consideration:

- Option 2
- Option 7
- Option 7.1

A drawing of each of these options can be found at Appendix 1.

Each of the short-list involves a reconfiguration of the Arran Berth. A progress note published on 4th March 2019 reports on the work undertaken and the options considered leading up to selection of the three favoured options.

The Secondary Berth to be used in association with Primary Berth Options 2, 7 or 7.1 will be the Irish Berth. Any works or costs associated with upgrading the Secondary Berth are outside of the scope of this report.

7. DETAILED STUDIES

The following detailed studies have been performed to appraise the favoured options.

7.1 Ground investigation

On behalf of PPG, IFL instructed Causeway Geotech Ltd (CGL) to carry out a ground investigation at Arran Berth. The ground investigation was designed by IFL to investigate:

- the locations and nature of the existing buried structures associated with the most recent and historical quay walls.
- strata and groundwater profiles, including depth to bedrock, and geotechnical parameters for design of future works.
- environmental risks.

The intrusive works were carried out on site in January 2019, and the laboratory testing and groundwater monitoring was completed in February 2019. The findings of the investigation are presented in CGL's factual report "Ardrossan Harbour, Brodick Berth – Ground Investigation, Report No: 18-1401a, dated 15th February 2019.

The ground investigation comprised the following scope of work:

- 14 no. cable percussive boreholes to a maximum depth of 13.5 metres below ground level (mbgl).
- 5 no. rotary core follow on boreholes from the cable percussive boreholes to a maximum depth of 24.5 mbgl.
- 9 no trial pits to a maximum depth of 3.6 mbgl.
- 13 no trial trenches to a maximum depth of 3.5 mbgl.
- 5 no. combined ground gas and groundwater monitoring wells up to 13.5 mbgl.
- geotechnical testing comprising classification testing, strength testing of soils, chemical testing, and rock core testing.
- environmental testing.

In addition to the intrusive works a ground penetrating radar (GPR) survey was undertaken by Scantech Ltd to investigate buried historic structures. The GPR survey report is presented in CGL's factual report.

The findings of the intrusive geotechnical ground investigation are summarised in Table 3.

Table 3 Summary of geotechnical ground conditions

Strata	Depth to Top of Stratum (mbgl)	Thickness Range (m)	Brief Description
Made Ground	0.0	3 to 8	Mainly granular material of sand and gravel including hardcore and concrete, with occasional layers of clay.
Superficial Deposits	3.0 to 8.0	5.5 to 10.5	Sandy silty fine to coarse gravel and cobbles, with occasional layers of firm or stiff sandy clay, and occasional boulders
Bedrock	5.5 to 10.5	10.5 to 24.5 (proven)	Generally very weak to weak, occasionally medium strong, sandstone, and weak to medium strong bands of conglomerate

The GPR survey was targeted at the locations of the trial trenches. Buried historic features including remnants of historic quay walls and features related to the existing quay wall were proven. A summary of the findings of the buried features encountered are presented on drawing no. 1620005121-RAM-XX-00-SK-CW-0011 "Buried Structure Plan" presented at Appendix 2.

The majority of the existing quay wall affected by the three new berth alignments is a tied sheet pile wall constructed in 1974 / 1975. The toe of the wall is concreted into a shallow rock trench therefore the wall cannot act as a cantilever and relies on the tie rods and also the fill behind for stability. Photographs taken during the 1974 construction indicate that it was likely that horizonal steel bracing was erected to support a waling beam which in turn supported the sheet piles during concreting of the toe and backfilling. It is not known whether the horizontal bracing is still present. Typical cross sections of the wall from record drawings and a photo during construction are shown below.

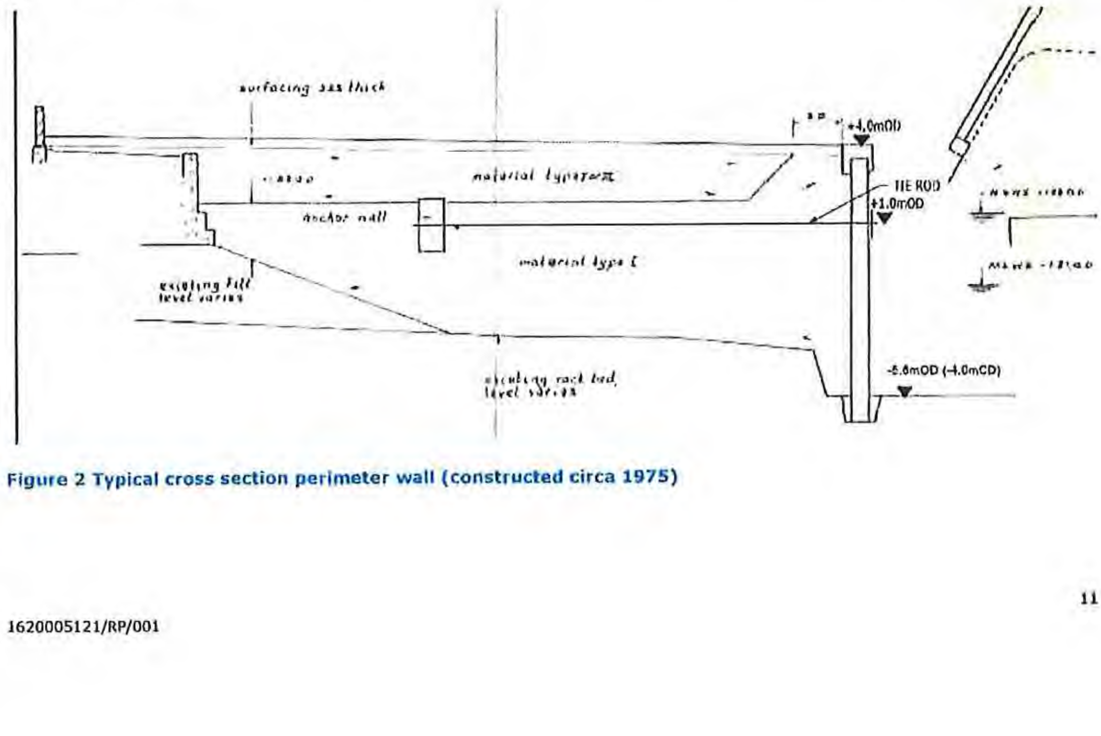


Figure 2 Typical cross section perimeter wall (constructed circa 1975)

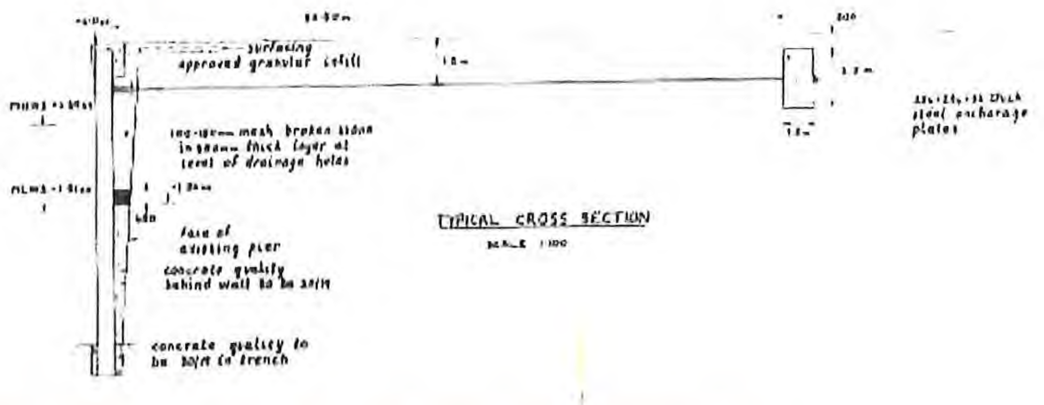


Figure 3 Typical cross section perimeter wall (extension wall constructed circa 1975)

Figure 4 Photograph during construction (dated 1975)

7.2 Vessel simulation

On the 20th March 2019 CalMac Masters, along with the Peel Ports Pilot utilised the Peel Ports simulators at Greenock Ocean Terminal (GOT) to determine the viability of the favoured options and determine the likely operational envelopes.

Simulator Assumptions

- The simulator at GOT reflects the expected performance of MV Glen Sannox
- Gusts in wind speeds experienced in the simulator represent an increase or decrease of three knots (CFL consider this as a minimum and in reality would expect gusts of around +10 knots)

- Swell conditions experienced on the simulator were not realistic, vessel motion when entering the harbour and alongside is considerably more pronounced.

Refer to Appendix 3 for a copy of the CalMac vessel simulation report.

7.3 Wave modelling

7.3.1 Numerical modelling strategy

On behalf of Ramboll, RPS Group has undertaken a detailed wave modelling study to evaluate the wave conditions within Ardrossan Harbour in the current situation and also for the layout of Option 2 and Option 7.1. Option 7 has not been modelled at this stage as it represents the smallest change from the existing situation.

A numerical modelling strategy based on a two-step numerical modelling approach was used in this study:

- Regional wave modelling (MIKE21 Spectral Waves).
- Wave disturbance modelling (MIKE21 Boussinesq Waves).

The Regional wave modelling was performed using the MIKE21 Spectral Waves (SW) Model (DHI). The Wave disturbance modelling was performed using the MIKE21 Boussinesq Waves (BW) Model (DHI). Both models have been developed by DHI and are broadly considered the state-of-the-art software in coastal engineering; the MIKE21 suite is globally used in the delivery of wave climate studies, among others. For this study, both models are used in a coupled mode so that results (wave climate) from the regional wave modelling feed the wave disturbance modelling.

7.3.2 Data sources

Several data sources have been used to undertake this wave modelling study. The main types and sources are described below:

- Bathymetric data: UK Hydrographic Office (detailed surveys), C-Map Norway (digital chart) and Aspect Surveys 2017 (detailed Ardrossan Harbour surveys).
- Wind and wave data: CFSR NCEP NOAA (hourly data set for the period 1979 to 2017).

7.3.3 Regional wave modelling

The first modelling task of the regional wave modelling was identifying the storm directions which were likely to result in the largest waves penetrating into the harbour towards the Arran Berth. A series of storms were generated from several return periods (1 in 0.5, 1 in 1,1 in 10, 1 in 50 and 1 in 100 year) for every 15 degrees from 135 to 330 degrees. These simulations were carried out with a 1 in 2 year return period water level. It was concluded that there were two main critical storm directions: 240° (Southwestern storms) and 285/300° (Northwestern storms). Due to the effects of refraction, the wave incidences in Ardrossan harbour were 215° (Southwestern) and 250/265° (Northwestern).

Secondly, a series of numerical models were undertaken for the several return periods from the two previously calculated storm directions.

7.3.4 Wave disturbance modelling

Since MIKE21 SW does not include wave-wave interaction, Boussinesq wave simulations were undertaken. MIKE21 BW models are based on a Flexible Mesh (FM) and are specially indicated for the analysis of port agitation and resonance. Wave climate applied at the model boundaries were taken from the previous regional wave modelling. Several storm wave models were carried out considering these return periods. Moreover, two different storm surge levels were considered depending on their storm direction (+4.0m CD for SW and +3.6m CD for NW).

Figure 5 SW wave model simulation for the 1 in 10 year return period storm from 285°

Simulations were carried out for the current harbour configuration and, also, for the Option 2 and Option 7.1 layouts. The main results from the wave modelling in Ardrossan Harbour are:

- Storm wave patterns.
- Significant wave heights spatial distribution.
- Spectral wave analysis (port resonance).

Main conclusions from the results of the wave modelling study are:

- There is not a major difference in the wave climate at either Option 2 and Option 7.1.
- The proposed new berth configuration will be more exposed to Northwest storms (285°N) due to their orientation.
- The proposed new berth configuration will be less exposed to Southwest storms (240°N) due to their location (a little further away from the harbour entrance).
- There is no evidence of experiencing significant long-period seiching (port resonance) in the Arran Berth for any berth configuration (existing, Option 2 and Option 7.1).

A more detailed description of this section is presented in wave study report that can be found at Appendix 4.

7.4 Mooring analysis

A mooring analysis for the MV Glen Sannox was carried out for the new Arran Berth configuration based on the Option 7.1 layout. Option 7.1 was selected as this option is the "middle" quay wall alignment of the favoured options and therefore can also be considered as reasonably representative of the three options.

This mooring analysis was undertaken through numerical modelling with Optimoor (TTI) following the main standards and codes in port engineering such as: BS 6349, PIANC guidelines, OCIMF and ROM. For this proof of concept study, up to seven (7) different scenarios were analysed through quasi-static mooring analysis with Optimoor.

7.4.1 Operational limits

According to the main codes, there are a series of operational limits and, also, maximum admissible vessel movements recommended depending on the type of vessel, the loading/unloading system and the type of berth operation.

A) Environmental operational limits

For this study, environmental operational limits for i) cargo transfer and ii) staying at quay berth operations, have been taken from PIANC (Container ships, RoRo ships and ferries) and, also, from the operator CALMAC.

B) Maximum admissible vessel movements

Each type of vessel has a different cargo handling system and, therefore, it presents a series of maximum admissible movements for safe working conditions. For this study, these values have been adopted from PIANC (Ferries, Ro-Ro with linkspan) and BS 6349 (Gas tankers).

7.4.2 Optimoor model description

Optimoor is the industry-standard software tool to perform mooring analysis, especially for berths used in the oil and gas industry due to the implementation of the OCIMF recommendations within the model. Optimoor takes input data for a design vessel and a particular berth and computes all the mooring forces generated by the wind, wave, current and other forces and by changes in draft, trim and tide.

Mooring analysis must take into consideration the characteristics and performance of three key elements:

- Fender system.
- Mooring system.
- Mooring lines and tails.

The fender system is usually formed by proprietary fenders which absorb part of the kinetic energy during the berthing of the vessel. The mooring system is formed by all the elements related to the mooring points of the lines and tails that includes: bollards, quick release hooks (QRH), fairleads, winches and bitts. Mooring lines link the vessel with the quay and are made of several different materials which range from the conventional steel wire to new synthetic materials. Tails are placed at the end of the mooring lines and are made of synthetic materials. All these elements (except the steel wire mooring lines) show a highly non-linear behaviour which turns the mooring analysis into a very complex series of differential equations only solved by computer programs. Moreover, the mooring analysis must also consider the interaction of the wave and the currents on the vessel hull. The hydrodynamic response of the vessel is also highly non-linear so that the mooring analysis gets even more complex. Optimoor software is able to solve these complex equations in a fast and reliable way to obtain the optimum mooring configuration at a berth.

7.4.3 Optimoor model set-up

The Optimoor model needs to be configured from several data points from the actual berth configuration (berthing and mooring systems), the design vessel specifications and maritime conditions. This is a list of the main Optimoor model input parameters and their source:

a) Water level (Admiralty Charts).
b) Wave (PIANC, RPS wave-study).
c) Wind (PIANC, RPS wave-study).
d) Swell (RPS wave-study).
e) Currents (PIANC).
f) Mooring lines and tails (CALMAC).
g) Deck configuration (FERGUSON marine).
h) Berth configuration (BS, PIANC, Ramboll and Trelleborg).
i) Maximum admissible vessel excursions (BS, PIANC).

7.4.4 Scenarios evaluated

Up to seven (7) different scenarios were analysed for this study depending on these factors:

a) Vessel position (A: next to the linkspan ramp, B: 6 metres offset from the linkspan ramp).
b) Condition (working conditions or safe mooring conditions).
c) Mooring arrangement (standard or heavy).
d) Link to shore (walkway, linkspan, ship gangway, LNG transfer system).
e) Maritime conditions (mainly wave and wind).
f) Maximum admissible vessel movements (surge, sway and heave).

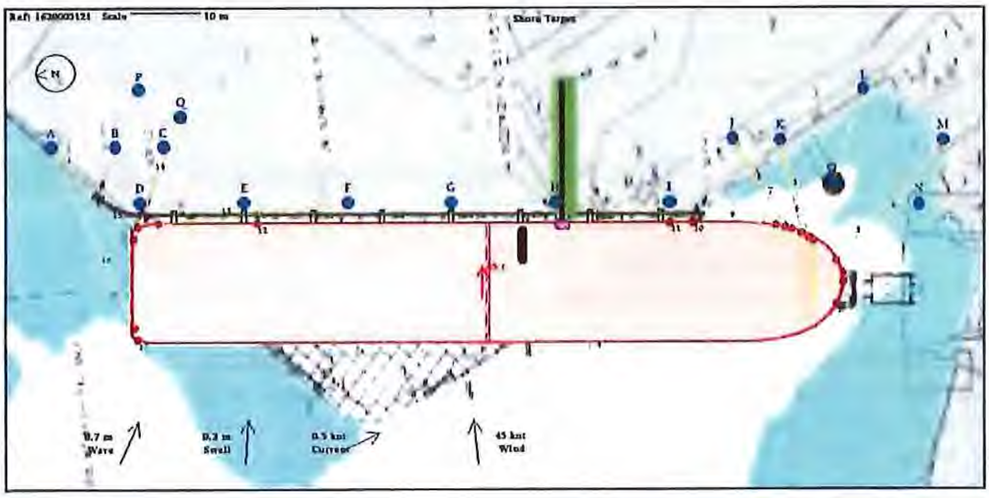


Figure 6 Optimoor simulation with the optimum mooring arrangement of the MV Glen Sannox at the Arran Berth (Position B)

7.4.5 Results

A series of results were obtained for each one of the scenarios analysed with the Optimoor model:

a) Optimum mooring arrangements.
b) Maximum vessel excursions.
c) Maximum loads in mooring lines.
d) Maximum forces in bollards.

7.4.6 Conclusions

Main conclusions from the mooring analysis are:

- Several mooring arrangements were analysed in order to identify the optimum mooring arrangements for the positions A and B which leads to the minimum vessel excursions and line loads.
- Vessel excursions from these arrangements meet with the BS and PAINC recommendations.
- New Arran Berth configuration is suitable for carrying out load/unload operations under regular weather conditions (including CALMAC recommendations) and, also, staying at quay during rough weather (storms) or at night.
- According to the BS standards, the new configuration of the Arran Berth is suitable for carrying out LNG fuelling operations (shore to ship) based on loading arms systems under regular weather conditions. Other LNG transfer systems such as truck to ship (TTS) based on hoses should be checked through their own specifications (safe working conditions).

7.5 Environmental Impact Assessment

On behalf of PPG, EnviroCentre Ltd has undertaken a review of the potential need for an Environmental Impact Assessment (EIA) to support the development. The findings of the appraisal are presented in Appendix 5.

An extract of EnviroCentre's conclusions is as follows:

Each option has been considered and the headline observations are as follows:

- Considering the construction works in isolation screening has confirmed Option 2 is not an EIA development;

- If no impact piling is proposed for Options 7 and 7.1, then strong reasoning can be put forward that the development does not constitute EIA Development. It is considered unlikely to be screened 'in';

- If impact piling in open water is proposed this increases the potential for Options 7 and 7.1 to become EIA developments, albeit the amount of piling is small and mitigation is available. The development would still not be expected to immediately be classed as an EIA development;

- Likewise, for Options 7 and 7.1, if infilling is also added into the construction sequence the development may not necessarily be classed as an EIA development. We would still be hopeful that a case could be made that the infilling was in a highly disturbed area;

- The most potentially contentious aspect is likely to be the associated dredging. If dredging is required and is of reasonable magnitude (10's of thousands of m^3) this may raise questions about the potential for impacts on the benthic communities and other marine life and there is no existing information we are aware of on the nature of the sea bed in the areas potentially to be dredged so while it could be possible to make a case that the area must be disturbed given its location, there is no data available to support this.

7.6 Harbour Revision Order

On behalf of PPG, BDB Pitmans LLP, (Parliamentary Agents, formally known as Bircham Dyson and Bell) have undertaken a review of the potential need for a Harbour Revision Order (HRO) to implement each of the favoured options. The executive summary of BDB Pitmans' appraisal is as follows:

- In line with our earlier advice note, we consider that the powers available to the Ardrossan Harbour Company Limited ("**AHCL**") under s. 23 of the Ardrossan Harbour Consolidation Act 1864 ("**the 1864 Act**") would appear to provide statutory authority for the construction and maintenance of each of the development options under consideration at Ardrossan Harbour ("**the Harbour**").

- Since s. 23 of the 1864 Act appears to provide statutory immunity in respect of actions in nuisance for any interference with public rights of navigation arising from the erection of new structures below high-water mark within the Harbour, we conclude that a Harbour Revision Order ("**HRO**") would not need to be applied for under the Harbours Act 1964 ("**the 1964 Act**") for any of the development Options under consideration, provided that AHCL is responsible for the execution and management of the works.

Therefore, for any of the favoured options, it is not anticipated that an HRO would need to be applied for.

7.7 Masterplanning – Landside Facilities

The Arran Berth is the primary berth for the Arran and Kintyre service. The new berth and linkspan will be designed to accommodate the primary design vessels and integrated with the landside works.

In parallel with the Proof of Concept marine engineering option appraisal, IFL have undertaken further development of the Landside Masterplan. This has included a series of masterplan level studies undertaken to ensure that the implications of berthing options were understood in terms of:

- Landside operational requirements for the port / all users.
- Integration of marine and landside facilities.
- Safe movement /accessibility (pedestrian/vehicular/service activity).
- Capacity and capability to meet operational requirements of the SRS.
- Masterplan general arrangements/layouts to inform costs and programming.

Landside arrangements have been developed for each of the short-listed options and masterplan input provided to the long-list options through the various stakeholder workshops and consultations. Refer to Appendix 6 for landside masterplan drawings.

Public consultation to update and engage with ferry users and stakeholders was organised by the Ardrossan Steering Group with events hosted at Brodick and Ardrossan 23rd/24th October 2018. Detail was outlined on the project objectives, indicative layouts and the arrangements for project delivery (24 Boards). Details of the engagement and engagement feedback are available on the NAC Website.

8. BERTH OPTION 2

8.1 Description

Option 2 involves realignment of the Arran Berth and is a scheme that was previously developed by Ramboll on behalf of CMAL. This option is also included as the reference proposed scheme in the SRS. Of the three favoured options it results in the greatest loss of landside area.

Figure 7 Illustration of Berth Option 2 - refer to Appendix 1 for full detail

The option comprises the following elements:

- New quay wall alignment behind the existing Arran Berth. At this stage it is proposed that the new quay wall will be formed from a rock socketed steel combi wall with rock anchors.
- Removal of the existing perimeter wall and lowering of existing levels seaward of the new quay wall line to form the berth.
- Dredging outside of the perimeter of the existing quay wall to achieve the required underkeel clearance on the approach to the berth.
- Removal of the existing linkspan and dolphins.
- Formation of a new piled linkspan recess.
- Filling and levelling of what remains of the existing linkspan recess.
- Installation of a new double lane linkspan (form of linkspan to be a linkspan supported by hydraulic rams of a similar design to the new linkspan at Brodick)

A drawing of Option 2 is presented at Appendix 1.

8.2 Construction methodology

Consideration of the construction methodology has been carried out to assess construction risks and to inform budget costing. Input from a marine contractor has been taken into account.

8.2.1 Geotechnical considerations

The ground conditions are relatively consistent across the site and are described in Section 7.1

A summary of the findings of the buried features encountered are presented on drawing no. 1620005121-RAM-XX-00-SK-CW-0011 "Buried Structure Plan" presented at Appendix 2. An extract is given in Figure 8 below.

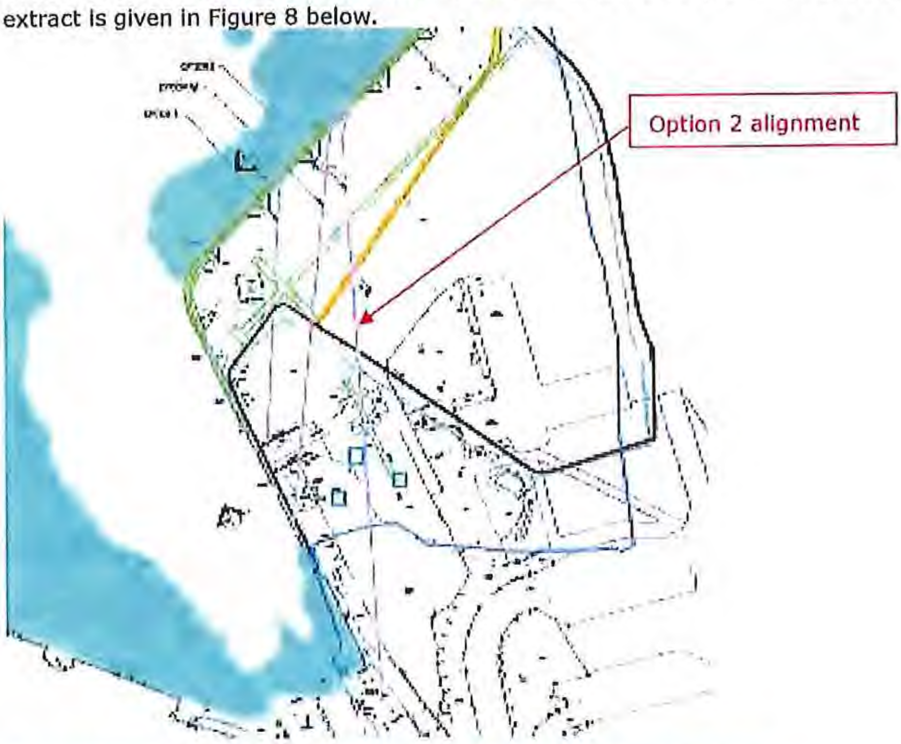


Figure 8 Extract from buried structure plan – refer to Appendix 2 for full detail

The new quay wall for Option 2 dissects 4 existing gravity former quay walls. Towards its centre and at its north end the new wall alignment crosses tie back structures for the current sheet pile perimeter wall.

8.2.2 Construction sequence

Over half of the length of Option 2 involves piling which is not constrained by the presence of existing tie rods. The new alignment crosses 4 existing quay walls therefore allowances for local removal of these quay walls at the crossing points will be made in the costing (assuming that all walls still exist even though the oldest / most inland wall was not encountered in the ground investigation). Engagement with the marine contractor confirmed that maintaining a level site during new quay wall construction would be a key aim to allow effective piling.

At the central zone and north end where the new wall crosses tie rods, a local construction bund could be constructed outside of the wall to support the existing wall enabling tie rods to be cut and the new wall installed through this region. Alternatively, due to the wider tie road spacings in these zones and the shorter lengths of existing quay wall affected, it should be possible to maintain temporary connectivity of the existing rods while the new wall is constructed as described below:

- Install piles with land-based plant working south to north or with 2 work fronts working out from the centre point. Existing gravity walls would need to be broken out locally to allow the piling line to pass through.
- In the central tie rod zone cut tie rods and re-connect tie rods to the new quay wall on a rolling front or, install a temporary tie-back structure seaward of the new quay wall alignment to allow temporary anchoring of the existing tie rods.
- At north end cut tie rods and re-connect tie rods to the new quay wall on a rolling front.
- Once the new quay wall has been formed, the existing perimeter wall can be broken down and the ground level reduced, working back towards the new quay wall line. It may be possible to have a staggered overlap of quay wall construction and demolition / ground level lowering.

Therefore, for Option 2, there are methods available to the contractor on how best to undertake the construction.

8.2.3 Construction risks

- Unknown buried structures.
- The exact form of the existing gravity structures.
- Stability of the existing perimeter wall while tie rods are cut and reconnected.
- Stability of the perimeter wall during demolition.
- Release of fines during excavation.
- Potential impacts on the terminal building.

8.2.4 Ferry service disruption during construction

The interfaces between the new works and the existing operation of the Arran Berth are as follows:

- The new quay wall alignment cuts through the passenger route from the terminal building to the existing berth. The works will involve heavy civil engineering and therefore would present measurable health and safety risks to the public.
- Use of the existing quay wall for berthing could not be considered once demolition of the quay wall / ground level lowering commences.
- New linkspan recess is on footprint of existing linkspan.

If construction of the new quay wall starts at its north end it is considered that the Arran Berth could remain open for ferry service during the first 2 months of the construction period. After this ferry services to the Arran Berth will need to be suspended until construction work is complete. Refer to Section 8.6 and Appendix 7 for more details on construction and berth suspension durations.

8.3 Vessel simulation

The vessel simulation found that:

- Option 2 provides manoeuvring space to enable operations in a greater range of conditions.
- Option 2 would be the preferred berth for the mooring layout and safe overnight berth.
- Based on the berthing trials completed, and with the knowledge of how the vessel is expected to operate as outlined in the vessel specification, it is anticipated that MV Glen

Sannox would feature an operational window of between 25-40 knots when operating to Option 2. This was CalMac's best estimate based on the information currently available.

- An analysis of likely service disruption for Option 2 with an operational window of between 25-40 knots, found disruption rates being experienced of up to 2% in summer and 14% in winter. This equates to around 61 sailings in summer and 193 sailings in winter (assuming MV Glen Sannox operates the same timetable as MV Caledonian Isles currently). The service disruption analysis of Option 2 suggests an improvement to the current service with a potential decrease in disruption rates of 7 percentage points in the summer and 19 percentage points in the winter. This would suggest that the number of sailings affected by disruption would likely decrease under Option 2 by 204 sailings in summer and 231 sailings in winter, when compared to the current rate of disruption. It should be noted that the potential disruption figures quoted are calculated based on the outcome of simulations and utilising an untested vessel. On this basis any disruption forecasts are indicative only. A chart prepared by CalMac showing the results of the disruption analysis is provided in Figure 9 below.

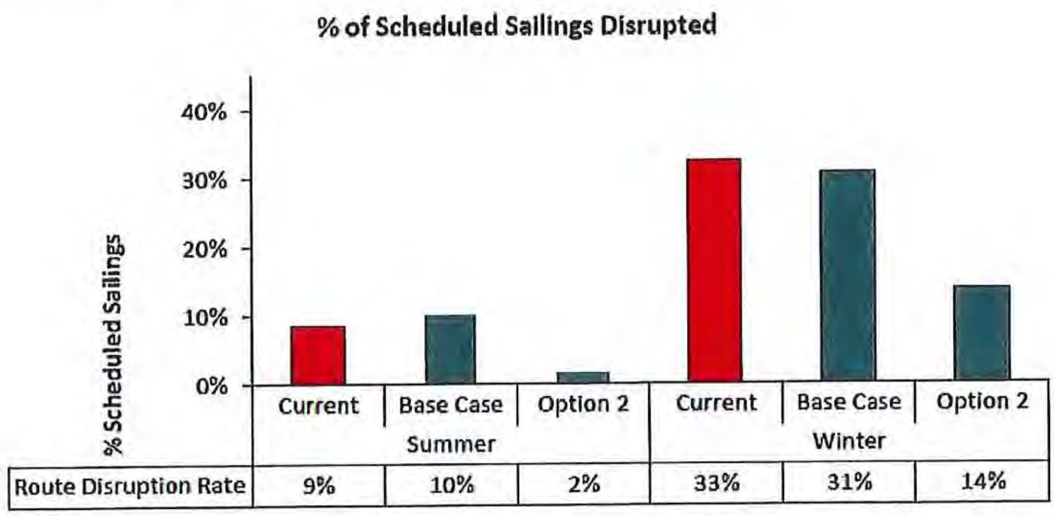


Figure 9 Indicative forecast disruption rates

Refer to Appendix 3 for a copy of the CalMac vessel simulation report.

8.4 Berth resilience

8.4.1 Wave modelling

A wave study for the Ardrossan Harbour based on the Option 2 layout was carried out. Also, a wave study based on the existing berth configuration was undertaken to check the evolution in the wave patterns and wave parameter values. Wave condition within the harbour and at Arran Berth were obtained from wave disturbance simulations. These numerical models were developed for storms coming from NW (285°) and SW (240°) which are able to induce the worst wave conditions (port agitation and resonance) within Ardrossan Harbour. Simulations were carried out for several storm return periods: 1 in 0.5, 1 in 1, 1 in 10, 1 in 50 and 1 in 100 years.

Main results of the wave study based on the Option 2 Arran Berth layout are:

a) Storm wave patterns

According to the results there are no significant differences in the storm wave patterns from the existing and Option 2 harbour configurations.

b) Significant wave-height and peak period values (incident waves)

Through the wave-height spatial distribution obtained, it is possible to identify the values of the highest significant wave-heights present at the Arran berth. These values are shown in the tables 4 and 5 depending on their storm directions (NW and SW).

Table 4 Maximum incident significant wave-heights obtained for SW storms

Maximum incident significant wave-heights obtained for SW storms (240°)				
Storm return period (years)	Existing berth		Option 2 berth	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1 in 0.5	1.2	7.5	1.0	6.9
1 in 1	1.3	7.5	1.1	7.5
1 in 10	1.9	8.5	1.5	9.6
1 in 50	2.2	8.8	1.9	9.6
1 in 100	2.3	8.8	1.9	9.6

Hs is significant wave height. Tp is peak wave period.

Table 5 Maximum incident significant wave-heights obtained for NW storms

Maximum incident significant wave-heights obtained for NW storms (285°)				
Storm return period (years)	Existing berth		Option 2 berth	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1 in 0.5	1.2	5.0	1.3	5.3
1 in 1	1.2	5.0	1.5	5.3
1 in 10	1.3	6.6	1.7	6.6
1 in 50	1.7	7.1	2.1	7.1
1 in 100	2.0	7.4	2.5	7.1

Hs is significant wave height. Tp is peak wave period.

According to these values, the existing berth configuration is more exposed to the SW storms than from the NW ones. However, berth configuration based on the Option 2 layout is more exposed to the NW storms than from the SW ones. This fact is due to the change in the berth location and orientation. On the one hand, because new berth design is a little more distanced from the harbour entrance, waves that enter into the harbour and reach the berth present slightly lower levels of wave energy. On the other hand, because new berth alignment is a little more oriented to the north, waves coming from the NW present slightly higher wave energy values. Considering the maximum wave-height values obtained independently of their storm direction, it can be stated that there are no significant differences between the existing and the new configuration based on the Option 2 layout.

It is important to highlight that this wave data is associated to the waves that present the highest wave-height values for the whole Arran Berth. These waves are located next to the quayside and are the sum of the incident and the reflected waves. Given that, RPS has considered a partial reflection coefficient of 0.9 for vertical structures such as the Arran berth, the values presented in the wave study report have to be divided by 1.9 in order to obtain the wave-height values associated to the incident waves. Incident waves act on the hull of the moored vessel and have, therefore, been considered in order to carry out the mooring analysis.

c) Spectral wave analysis

According to the wave peak values obtained through the spectral wave analysis, there is no evidence of any long-period seiching (port resonance) within the Arran Berth.

8.4.2 Mooring analysis

Mooring analyses are bespoke studies based on several very specific constraints and factors (see Section 7.1) such as berth configuration, vessel specifications and maritime conditions present in the study area. However, since many of these factors are common for all the new berth options, it has been considered to undertake only one mooring analysis for all the berth options at this time. This decision is aligned with the scope of works considered for this proof of concept study. Among the three layout options, it has been considered to select the Option 7.1 as it is the most representative of all the three options. Option 7.1 berth configuration represents an intermediate solution between Option 2 and Option 7 and, therefore, it can be considered as reasonably representative of all favoured options.

A detailed description with the main results and findings of this mooring analysis can be found in section 10.4.2. It is also worth noting that Option 2 has a quay wall with a long berthing face making the handling of mooring lines straightforward and giving flexibility when mooring different sized vessels.

8.5 Interface with landside masterplan

Option 2 realigns the Arran Berth and provides the reference scheme in the SRS. The realignment essentially pivots and realigns the quay based on the existing linkspan position and provides a new quay wall and linkspan for berthing.

The change introduces a number of implications for the scope/extent of landside works and these are illustrated within Option 2 Masterplan (refer to Appendix 6). The masterplan is based on the SRS Requirements prepared by Transport Scotland. The main elements and assumptions are as follows:

- Existing Terminal Building (retained in Base Case) is not retained
- New Terminal Building is located adjacent/on site of the existing building
- New PAS connects to MV Glen Sannox or other vessels
- Pierhead surfaces / pavement required repair/resurfacing post quay wall reconstruction and development of the LNG facility (CMAL)
- Irish Berth and linkspan to remain accessible and operational
- Developing simple general arrangement (marshalling/car parking) capable of safe operation that minimises pedestrian/vehicular conflicts and keeps control points to minimum whilst facilitating ready access/egress to ferry and facilities
- Strong connections to be provided between Terminal Building and Rail Station and thereafter Town Centre with a focus on active travel modes
- Access for HGV vehicles to LNG facility(assumed Winton Pier Area)
- Multi-modal transport interchange developed to the Building frontage providing for public transport / taxi's / cycle-pedestrian access / DDA parking / Pick-Up-Drop-Down Zone / Emergency Vehicles
- Public realm and place-making suitable /reflecting a public facility

- Car Park to meet 450 + spaces plus staff parking
- Marshalling to meet 150% largest vessel capacity (HGV's/Cars)
- Sea wall repairs completed to include assessment of issues of over-topping and long-term resilience

In developing the arrangement for the Option 2 Berth/Quay arrangements a number of options have been considered. These have included:

- Options based on revised circulation arrangements (one-way/two way circulation)
- Options based on revised parking and marshalling arrangements
- Options based on revised Terminal Building arrangements

General arrangements are at masterplan level (RIBA Stage 1/2). No detailed design has been undertaken but with various elements 'tested/validated' (Vehicle Tracking / Safe Access / DMRB-Road Design Guidelines / etc) to seek to ensure the layouts provide a foundation for design development. Parking and marshalling capacities are noted on drawings.

In summary the key benefits and dis-benefits of Option 2 in terms of landside works are as follows:

Table 6 Option 2 Landside Considerations

Option 2 Landside Benefits	**Dis-Benefits**
• Core elements layout as existing • Proven operational model • Meets SRS capacity requirements • Strong legibility • Safe operational management • Ready access/egress ferry (loading/unloading) • Marshalling & Car Park efficiencies • Safeguards Irish Berth Marshalling • Provides Construction Works Area • Secures flexibility/	• Loss of Land Area Pierhead • Limited Working Area (Marine/Landside) • Building Construction follows Quay Works
Conclusion: **Option 2 retains current general arrangement and offers best capacity, flexibility and future proofed layout for landside aspects of the port and ferry and terminal operations**	

A number of additional interfaces with marine works relate to working areas / construction phase activity and construction management of the marine and landside works. The key issues for option 2 are noted in tabular form below:

Table 7 Option 2 Landside Construction Phasing

Construction Phasing
• Scope of marine works suggests an extended closure of port/Arran Berth • Marine works prevent access to existing Terminal Building • Marine works require completion in advance of Terminal Building works • Construction compound anticipated Future Irish Berth marshalling area

8.6 Costs & Construction Programme

An estimation of berth construction costs and programme has been made in conjunction with Doig and Smith for berth Option 2. To inform this estimate we have had an initial engagement with a marine contractor to draw on their experience.

The berth construction duration is estimated to be in the order of **18 months** including an allowance for risk. Closure of the Arran berth to ferry traffic is expected to be required for around 16 months including an allowance for risk. A graphical representation of the construction periods and the estimated durations of closure of the existing berths is provided in Appendix 7.

In the cost estimate, allowances for inflation have been made to the mid-point in construction based on the RICS Tender Price Index, (TPI). Assuming a first quarter 2020 start on site, the price point is **fourth quarter 2020.**

With the ongoing uncertainty surrounding the UK leaving the European Union and the conditions on which this is achieved, the Royal Institution of Chartered Surveyors (RICS) is producing a range of estimates for inflation in addition to the TPI. This consists of an upper range "Upside" scenario, a "Central" scenario and a lower range "Downside" scenario. The percentage change for inflation for these scenarios as presented by the RICS is as follows:

Table 8 Percentage change for inflation

Scenario	Percentage Change, (Year on Year)		
	3Q18 to 3Q19	3Q19 to 3Q20	3Q20 to 3Q21
Upside	+4.8	+6	+7
Central	+3.2	+4	+6.5
Downside	-3.5	-2.6	+4.7

The cost estimate is for construction costs only and is projected on the TPI which equates approximately to the "Central" scenario. There are no allowances for management fees. A separate allowance for an Optimism Bias of 15% of construction cost in line with TS guidance has been made. Further detail of the basis of the costs is contained within the Doig and Smith cost estimate.

It should be noted that the status of the design is very high level at this stage and as such the cost estimates are very much budget estimates. We recommend that the budget estimates are updated as the design is developed in more detail.

A copy of the Doig and Smith cost estimates with full limitations and caveats to the estimates are presented at Appendix 8.

Table 9 Budget cost estimate for berth Option 2

Option 2			
Estimated Construction Cost, (Double Lane Linkspan)	£	[redacted]	Excluding VAT
Optimism Bias	£	[redacted]	Excluding VAT
Total Estimated Construction Cost, (Double Lane Linkspan)	£	[redacted]	**Excluding VAT**
Estimated Reduction for Single Lane Linkspan, (including reduction in Optimism Bias)	£	[redacted]	Excluding VAT
Total Estimated Construction Cost, (Single Lane Linkspan)	£	[redacted]	**Excluding VAT**
Estimated Construction Programme		18 months	

PPG funding – Marine works	[redacted]	
Delta in funding (double linkspan)	[redacted]	

9. BERTH OPTION 7

9.1 Description

Option 7 is a scheme involving partial realignment of the Arran Berth. Of the three favoured options it results in the lowest loss of landside area.

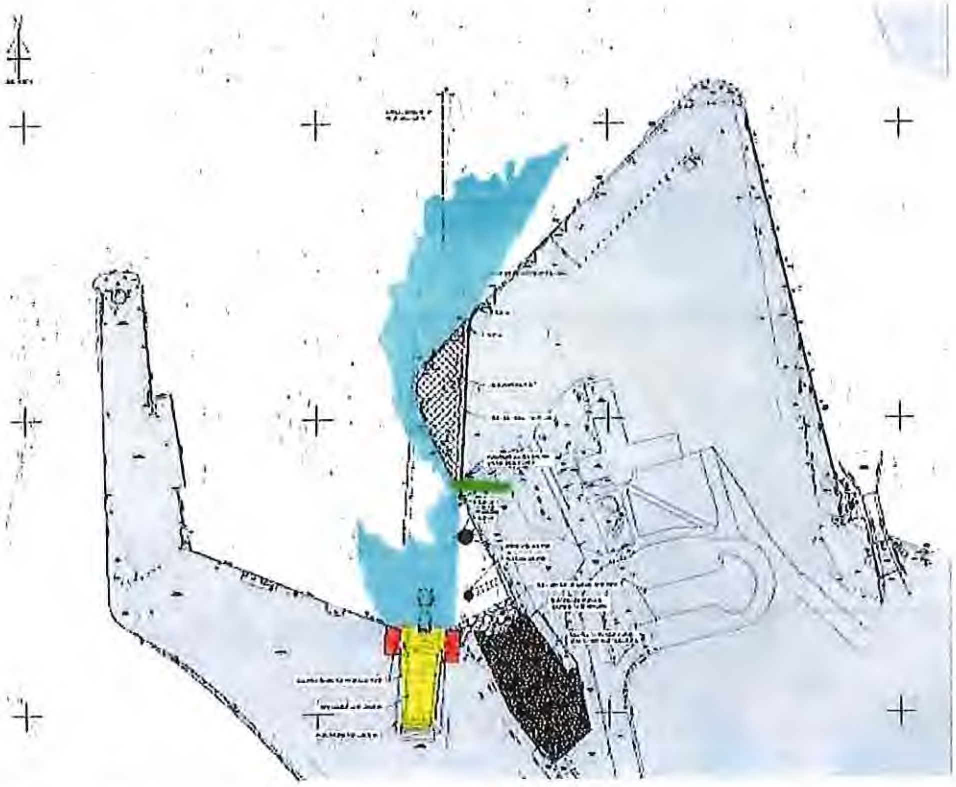


Figure 10 Illustration of Berth Option 7 – refer to Appendix 1 for full detail

The option comprises the following elements:

- New quay wall alignment behind the existing Arran Berth. At this stage it is proposed that the new quay wall will be formed from a rock socketed steel combi wall with rock anchors.
- Removal of the existing perimeter wall and lowering of existing levels seaward of the new quay wall line to form the berth.
- Dredging outside of the perimeter of the existing quay wall to achieve the required underkeel clearance on the approach to the berth.
- Removal of the existing linkspan and dolphins.
- Formation of a new piled linkspan recess.
- Filling and levelling of the existing linkspan recess including a revetment across the current opening to the recess.
- Installation of a new double lane linkspan (form of linkspan to a linkspan supported by hydraulic rams of a similar design to the new linkspan at Brodick).

A drawing of Option 7 is presented at Appendix 1.

9.2 Construction methodology

Consideration of the construction methodology has been carried out to assess construction risks and to inform budget costing. Input from a marine contractor has been taken into account.

9.2.1 Geotechnical considerations

The ground conditions are relatively consistent across the site and are described in Section 7.1.

A summary of the findings of the buried features encountered are presented on drawing no. 1620005121-RAM-XX-00-SK-CW-0011 "Buried Structure Plan" presented at Appendix 2. An extract is given in Figure 11 below.

Figure 11 Extract from buried structure plan - refer to Appendix 2 for full detail

Virtually the full length of the Option 7 alignment crosses existing perimeter wall tie rods and tie back structures. The alignment crosses the area where the tie rods are very congested at the knuckle in the quay wall making construction of the new quay whilst maintaining stability of the existing quay wall very challenging and risky. The alignment also crosses two redundant gravity quay walls.

9.2.2 Construction sequence

Two methodologies for Option 7 have been considered.

Method A (Figure 12 and 13).

- Construct lateral "bookend" piled walls to contain the end of the zone of excavation. Tie backs expected to be needed.
- Excavate behind existing quay wall and dismantle existing quay wall and tie backs to form a battered perimeter to the site along zone of construction. Risks: Complexity of lowering

fill without compromising stability of existing quay wall, bracing may be required to temporarily support the wall. Resilience of batter to wave attack during a storm.

- Construct new piled wall from landside plant. Risks – Piles would need to be installed from a crane. Working frames may need to be provided for access. Marine plant may be required. Stability of new quay wall before backfilling – bracing of piles may be required.

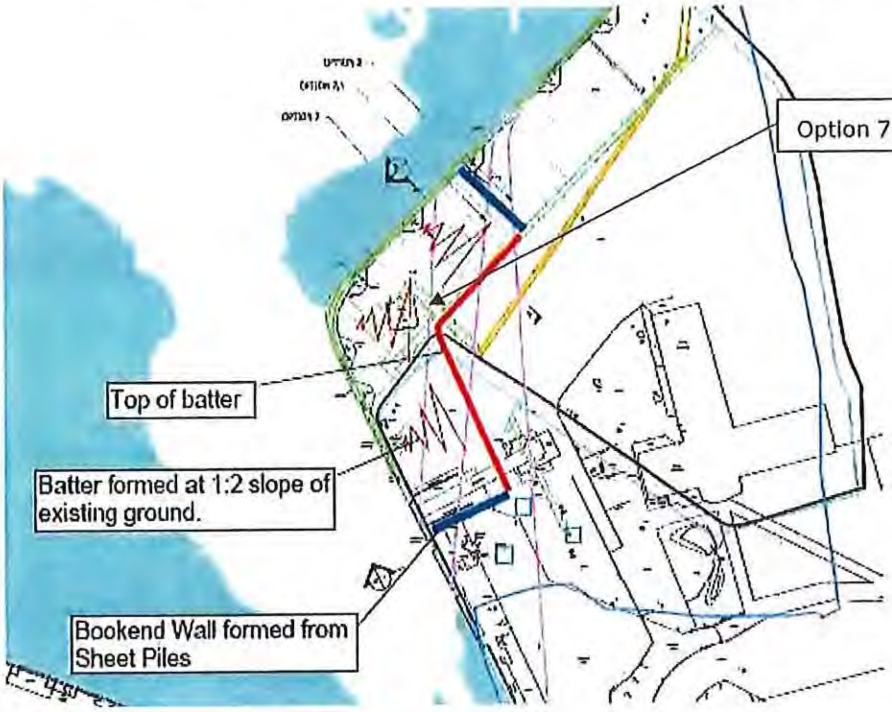


Figure 12 Construction Method A – Plan

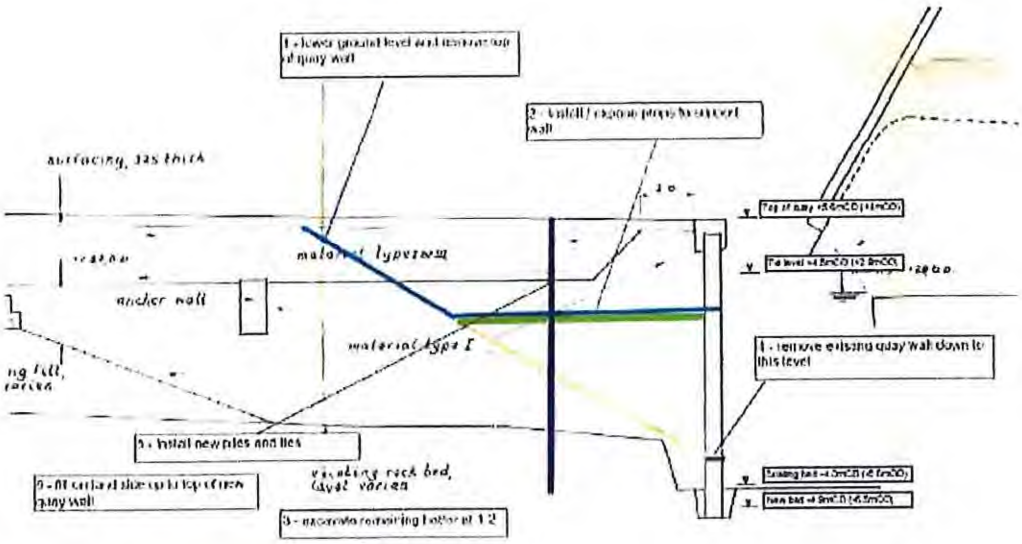


Figure 13 Construction Method A - Section

Method B (Figure 14 and 15).

- Install a construction bund around the perimeter of the zone of construction. Risks: Resilience of bund to wave attack during a storm.
- Cut tie backs. Remove tie back structures where they clash with alignment.
- Install new piles with land-based plant.
- Install new anchors.
- Remove bund, dismantle existing sheet piled wall and lower levels in front of new quay wall.

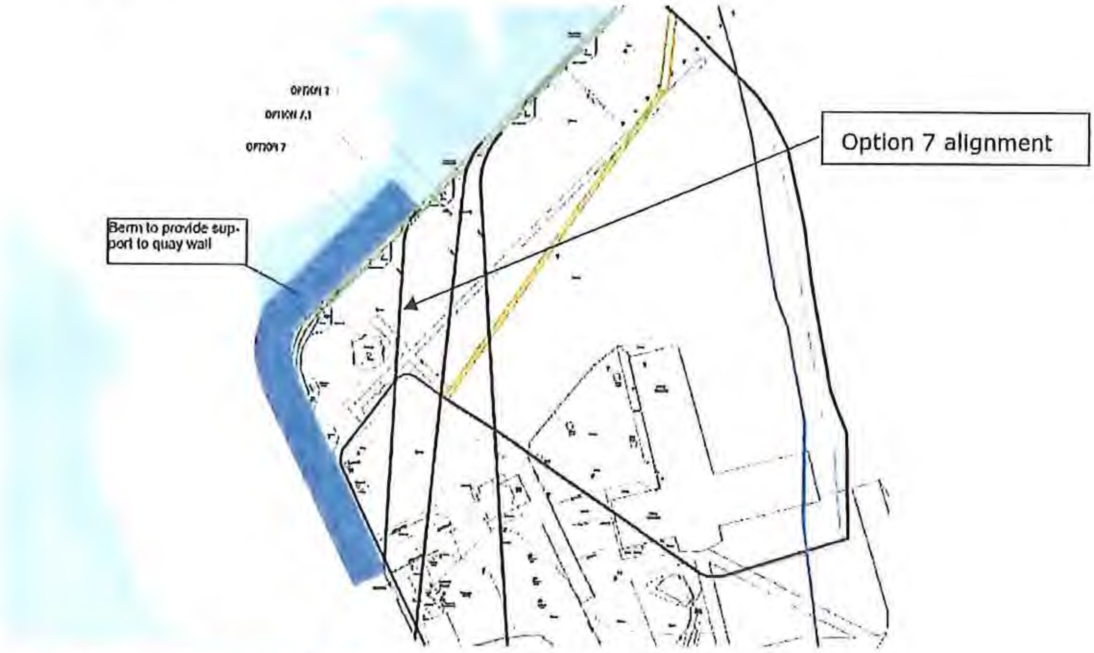


Figure 14 Construction Method B - Plan

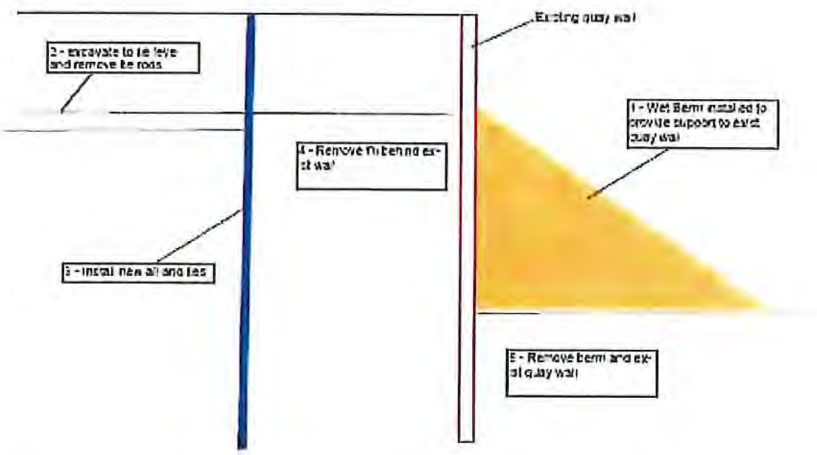


Figure 15 Construction Method B - Section

The source of bund material and route of disposal of bund material would need to be determined. There is potential to re-use material on site or to tie-in with other construction projects.

EnviroCentre Ltd have made an initial review of the environmental consideration of the two construction methodologies. They did not anticipate that the regulator would have a clear preference for one option or the other. Possibly method B might be perceived as better as the works are more contained, although this may be offset as it involves putting a temporary bund on the seabed (though much of this footprint would be subject to dredging in any case). EnviroCentre did not think there are likely to be significant effects from either of these construction approaches.

Method B gives a much more controlled and safer work site and has lower risks compared to Method A. Piling through a battered slope adds complexity and may not be feasible. The marine contractor we engaged with concurred that Method B would be the preferred approach for Option 7. We consider that potentially Method B (construction bund) is the only viable way of constructing Option 7 and therefore we have used this method as the basis of the costing and construction duration for this option.

9.2.3 Construction risks

Method B

- Source and disposal route for construction bund fill.
- Resilience of construction bund during storms.
- Release of fines from the bund / excavation.
- Unknown buried structures.
- The exact form of the existing gravity structures is unknown.
- Stability of the perimeter wall during demolition.

9.2.4 Ferry service disruption during construction

The interfaces between the new works and the existing operation of the Arran Berth are as follows:

- The new quay wall alignment commences at the point of the existing passenger gangway. The works will involve heavy civil engineering and therefore would present measurable health and safety risks to the public.
- Use of the existing quay wall for berthing could not be considered once demolition of the quay wall / ground level lowering commences.
- The construction of the new dolphins would prevent ferries using the existing linkspan.

The first activity in the new quay wall construction is placement of the temporary bund around the outside of the existing quay wall affected by the works. Ferry services to the Arran Berth must be suspended before bund placement commences and ferry services cannot be brought back online until the new quay wall is fully complete. On this basis it will be necessary to close ferry traffic to the Arran berth for the full duration of the construction of Option 7. Refer to Section 9.6 and Appendix 7 for more details on construction and berth suspension durations.

9.3 Vessel simulation

The vessel simulation found that:

- Option 7 offers less manoeuvring space than 2 and 7.1 which will ultimately impact the operational window of the vessels and reduce the reliability of the service.
- The impact of the open corner at the bow and of the swell conditions on the berth need to be considered further. CalMac were concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns.
- Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels and bow visor reducing the mooring deck and available spread of mooring leads and as such this may result in reduced service reliability and/or the vessels that can be deployed on the route.

Refer to Appendix 3 for a copy of the CalMac vessel simulation report.

9.4 Berth resilience

9.4.1 Wave modelling

A wave study for Ardrossan Harbour has been carried out for the existing layout, Option 2 and 7.1 layouts. According to the results obtained in the wave study (see Appendix 4), there are no significant differences for the new berth configurations compared with the current berth configuration: highest values of significant wave-height are very similar.

It is likely that the changes to the Option 7 berth wave climate compared to existing will be lower than for options 2 and 7.1 as the change in berth alignment is also lower. Considering the results obtained for the Option 2 and 7.1, it can be said that Option 7 is also more exposed to the NW storms than from SW ones.

9.4.2 Mooring analysis

Mooring analysis are bespoke studies based on several very specific constraints and factors (see Section 7.1) such as berth configuration, vessel specifications and maritime conditions present in the study area. However, since many of these factors are common for all the new berth options, it has been considered to undertake one only mooring analysis for all the berth options at this time. This decision is aligned with the scope of works considered for this proof of concept study. Among the three layout options, it has been considered to select the Option 7.1 as it is the most representative of all the three options. Option 7.1 berth configuration represents an intermediate solution between the Option 2 and Option 7 and, therefore, it can be considered as reasonably representative of all favoured options.

A detailed description with the main results and findings of this mooring analysis can be found in the section 10.4.2. Option 7 has the shortest berthing face giving less flexibility to accommodate different sized vessels. The lack of a continuous quay wall at the bow area makes the handling of bow mooring lines more difficult, necessitating the need for mooring dolphins or the means to pass mooring lines ashore to bollards on the quayside.

9.5 Interface with landside masterplan

Option 7 realigns the Arran Berth and creates a new marine/land connection for the double linkspan to the west of the current location within the existing car park. The re-location of the linkspan and the angle of the linkspan relative to the existing landside infrastructure requires additional modifications to access, parking and marshalling requirements.

The change introduces a number of implications for the scope/extent of landside works and these are illustrated within the Option 7 Masterplan (refer to Appendix 6). The masterplan is based on the SRS Requirements prepared by Transport Scotland. The main elements and assumptions are as follows:

- Existing Terminal Building (retained in Base Case) is not retained
- New Terminal Building is located adjacent/on site of the existing building
- New PAS (extended length over Option 2 subject to Building location) connects to MV Glen Sannox or other vessels
- Pierhead surfaces / pavement required repair/resurfacing post quay wall reconstruction and development of the LNG facility (CMAL)
- Irish Berth and linkspan to remain accessible and operational
- General arrangement (marshalling/car parking) and access to linkspan involves more movement with impact on controlled (pedestrian/vehicular) crossings on the front apron – fencing and control points required
- Strong connections to be provided between Terminal Building and Rail Station and thereafter Town Centre with a focus on active travel modes
- Access for HGV vehicles to LNG facility(assumed Winton Pier Area)
- Multi-modal transport interchange developed to the Building frontage providing for public transport / taxi's / cycle-pedestrian access / DDA parking / Pick-Up-Drop-Down Zone / Emergency Vehicles
- Public realm and place-making suitable /reflecting a public facility
- Car Park challenged to meet 450 + (efficient layout 400) spaces plus staff parking
- Marshalling to meet 150% largest vessel capacity (HGV's/Cars). Marshalling for Irish Berth more restricted than Option 2
- Sea wall repairs completed to include assessment of issues of over-topping and long-term resilience.

In developing the arrangement for the Option 2 Berth/Quay arrangements a number of options have been considered. These have included:

- Options based on revised circulation arrangements (one-way/two way circulation)
- Options based on revised parking and marshalling arrangements including marshalling to the sea wall and parking central to site
- Options based on revised Terminal Building arrangements – further assessment required relative to PAS and Rail Station access

General arrangements are at masterplan level (RIBA Stage 1/2). No detailed design has been undertaken but with various elements 'tested/validated' (Vehicle Tracking / Safe Access / DMRB-Road Design Guidelines / etc) to seek to ensure the layouts provide a foundation for design development. Parking and marshalling capacities are noted on drawings.

In summary the key benefits and dis-benefits of Option 7 in terms of landside works are as follows:

Table 10 Option 7 Landside Considerations

Option 7.0 Landside **Benefits**	**Dis-Benefits**
• Core elements layout as existing • Proven operational model • Good legibility • Building construction potentially less overlap with Quay Works	• Loss of Land Area Pierhead – less than Option 2 • Limited Working Area (Marine/Landside) • Challenge to meet SRS parking capacity req.

• Good access/egress ferry (loading/unloading) • Provides limited Irish Berth Marshalling • Provides Construction Works Area	• Safe operational management requires more on-site control/ user management • Car parking constrained and tight to sea wall • A little less optimised in layout than Option 2 or Option 7.1
Conclusion: **Option 7.0 for landside is more contrived and less flexible/ adaptable and has more limited capacity than Option 2 or Option 7.1. Subject to detailed design may not deliver SRS requirements for parking.**	

A number of additional interfaces with marine works relate to working areas / construction phase activity and construction management of the marine and landside works. The key issues for Option 7.0 are noted in tabular form below:

Table 11 Option 7 Landside Construction Phasing

Construction Phasing
• Scope of marine works suggests a less extended closure of port/Arran Berth • Marine works less restrictive of access to existing Terminal Building • Marine works and Terminal Building works require contract coordination • Construction compound anticipated future Irish Berth marshalling area

9.6 Costs & Construction Programme

An estimation of berth construction costs and programme has been made in conjunction with Doig and Smith for berth Option 7. To inform this estimate we have had an initial engagement with a marine contractor to draw on their experience.

The berth construction duration is estimated to be in the order of **13 months** including an allowance for risk. Closure of the Arran berth to ferry traffic is expected to be required for around 13 months including an allowance for risk. A graphical representation of the construction periods and the estimated durations of closure of the existing berths is provided in Appendix 7.

In the cost estimate allowances for inflation have been made to the mid-point in construction based on the RICS Tender Price Index, (TPI). Assuming a first quarter 2020 start on site, the price point is **third quarter 2020**.

With the ongoing uncertainty surrounding the UK leaving the European Union and the conditions on which this is achieved, the RICS is producing a range of estimates for inflation in addition to the TPI. This consists of an upper range "Upside" scenario, a "Central" scenario and a lower range "Downside" scenario. The percentage change for inflation for these scenarios as presented by the RICS is as follows:

Table 12 Percentage change for inflation

Scenario	Percentage Change, (Year on Year)		
	3Q18 to 3Q19	3Q19 to 3Q20	3Q20 to 3Q21
Upside	+4.8	+6	+7
Central	+3.2	+4	+6.5
Downside	-3.5	-2.6	+4.7

The cost estimate is for construction costs only and is projected on the TPI which equates approximately to the "Central" scenario. There are no allowances for management fees. A separate allowance for an Optimism Bias of 15% of construction cost in line with TS guidance has been made. Further detail of the basis of the costs is contained within the Doig and Smith cost estimate.

It should be noted that the status of the design is very high level at this stage and as such the cost estimates are very much budget estimates. We recommend that the budget estimates are updated as the design is developed in more detail.

A copy of the Doig and Smith cost estimates with full limitations and caveats to the estimates are presented at Appendix 8.

Table 13 Budget cost estimate for Berth Option 7

Option 7			
Estimated Construction Cost, (Double Lane Linkspan)	£	[redacted]	Excluding VAT
Optimism Bias	£		Excluding VAT
Total Estimated Construction Cost, (Double Lane Linkspan)	£		**Excluding VAT**
Estimated Reduction for Single Lane Linkspan, (including reduction in Optimism Bias)	£		Excluding VAT
Total Estimated Construction Cost, (Single Lane Linkspan)	£		**Excluding VAT**
Estimated Construction Programme		13 months	

PPG funding – Marine works	[redacted]	
Delta in funding (double linkspan)		

10. BERTH OPTION 7.1

10.1 Description

Option 7.1 is a scheme involving partial realignment of the Arran Berth. Of the three favoured options it results in the greatest change in the bearing of the berth.

Figure 16 Illustration of Berth Option 7.1 – refer to Appendix 1 for full detail

The option comprises the following elements:

- New quay wall alignment behind the existing Arran Berth. At this stage it is proposed that the new quay wall will be formed from a rock socketed steel combi wall with rock anchors.
- Removal of the existing perimeter wall and lowering of existing levels seaward of the new quay wall line to form the berth.
- Dredging outside of the perimeter of the existing quay wall to achieve the required underkeel clearance on the approach to the berth.
- Removal of the existing linkspan and dolphins.
- Formation of a new piled linkspan recess.
- Filling and levelling of the existing linkspan recess including a revetment across the current opening to the recess.
- Installation of a new double lane linkspan (form of linkspan to a linkspan supported by hydraulic rams of a similar design to the new linkspan at Brodick)

A drawing of Option 7.1 is presented at Appendix 1.

10.2 Construction methodology

Consideration of the construction methodology has been carried out to assess construction risks and to inform budget costing. Input from a marine contractor has been taken into account.

10.2.1 Geotechnical considerations

The ground conditions are relatively consistent across the site and are described in Section 7.1

A summary of the findings of the buried features encountered are presented on drawing no. 1620005121-RAM-XX-00-SK-CW-0011 "Buried Structure Plan" presented at Appendix 2. An extract is given in Figure 17 below.

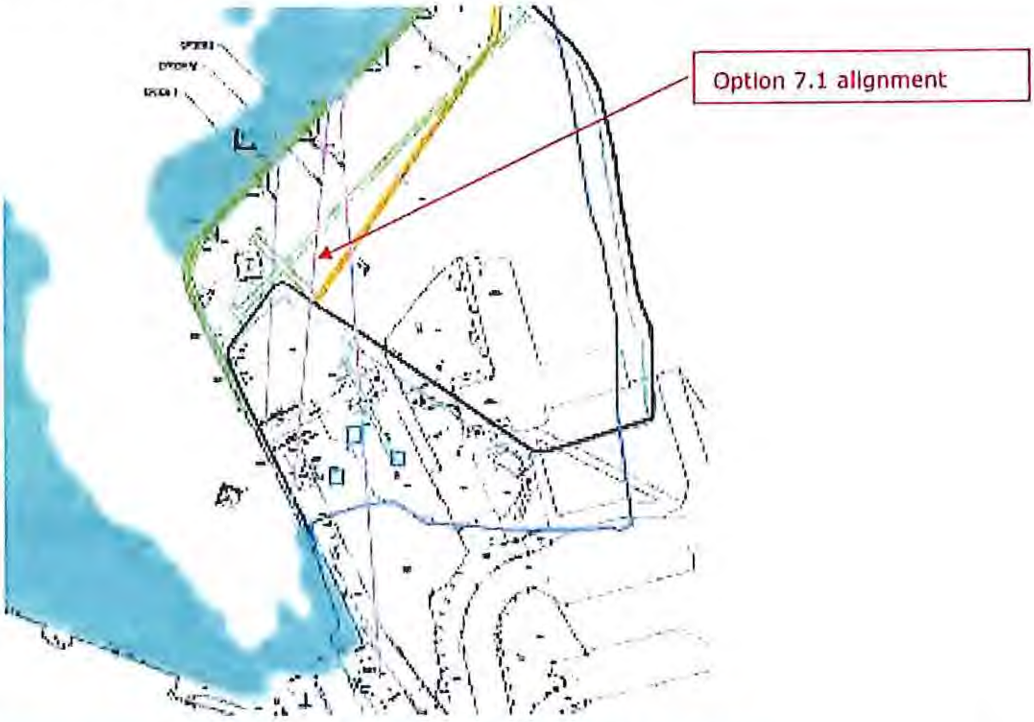


Figure 17 Extract from buried structure plan – refer to Appendix 2 for full detail

A significant proportion of Option 7.1 alignment crosses existing perimeter wall tie rods. The alignment also crosses two redundant gravity quay walls.

10.2.2 Construction sequence

Either a construction bund (as Option 7), or potentially to maintain temporary connectivity of the existing tie rods while the new quay wall is installed (as Option 2), could be applied to Option 7.1. The marine contractor agreed that at this stage it was not clear which method would be preferable. The budget estimate for Option 7.1 has been undertaken assuming a construction bund approach.

10.2.3 Construction risks

Method B

- Source and disposal route for construction bund fill.
- Resilience of construction bund during storms.
- Release of fines from the bund / excavation.
- Unknown buried structures.
- The exact form of the existing gravity structures is unknown.
- Stability of the perimeter wall during demolition.

10.2.4 Ferry service disruption during construction

The interfaces between the new works and the existing operation of the Arran Berth are as follows:

- The new quay wall alignment crosses the passenger route from the terminal building to the existing berth. The works will involve heavy civil engineering and therefore would present measurable health and safety risks to the public.
- Use of the existing quay wall for berthing could not be considered once demolition of the quay wall / ground level lowering commences.
- The construction of the mooring dolphin would prevent ferries using the existing linkspan.

If construction of the new quay wall starts at its north end we believe that the Arran Berth could remain open for ferry service during the first month of the construction period. After this ferry services to the Arran Berth will need to be suspended until construction work is complete. Refer to Section 10.6 and Appendix 7 for more details on construction and berth suspension durations.

10.3 Vessel simulation

The vessel simulation found that:

- Option 7.1 provides manoeuvring space to enable an increase in operational limits, however the impact of the open corner at the bow and the swell conditions on the berth need to be considered. CalMac were concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns.
- Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of vessel and bow visor reducing the mooring deck and available spread of mooring leads and this will result in reduced reliability of service and/or the vessels that can be deployed on the route.
- CalMac acknowledges that there is a sub-option of Option 7.1 which considers increasing the length of the berth removing the requirement for the dolphin. If this option is progressed then it is expected that this would improve the resilience of the option.

Refer to Appendix 3 for a copy of the CalMac vessel simulation report.

10.4 Berth resilience

10.4.1 Wave modelling

A wave study for the Ardrossan Harbour based on the Option 7.1 layout was carried out. Also, a wave study based on the existing berth configuration was undertaken to check the evolution in the wave patterns and wave parameter values. Wave condition within the harbour and at Arran Berth were obtained from wave disturbance simulations. These numerical models were developed for storms coming from NW (285°) and SW (240°) which are able to induce the worst wave conditions (port agitation and resonance) within Ardrossan Harbour. Simulations were carried out for several storm return periods: 1 in 0.5, 1 in 1, 1 in 10, 1 in 50 and 1 in 100 years.

Main results of the wave study based on the Option 7.1 Arran Berth layout are:

a) Storm wave patterns

According to the results, there are no significant differences in the storm wave patterns from the existing and Option 2 harbour configurations.

b) Significant wave-height and peak period values (incident waves)

Through the wave-height spatial distribution obtained, it is possible to identify the values of the highest significant wave-heights present in the Arran Berth. These values are shown in tables 14 and 15 depending on their storm directions (NW and SW).

Table 14 Maximum incident significant wave-heights obtained for SW storms

Maximum incident significant wave-heights obtained for SW storms (240°)				
Storm return period (years)	Existing berth		Option 7.1 berth	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1 in 0.5	1.2	7.5	1.2	7.4
1 in 1	1.3	7.5	1.3	7.4
1 in 10	1.9	8.5	1.6	8.5
1 in 50	2.2	8.8	1.8	9.0
1 in 100	2.3	8.8	1.9	9.0

Hs is significant wave height. Tp is peak wave period.

Table 15 Maximum incident significant wave-heights obtained for NW storms

Maximum incident significant wave-heights obtained for NW storms (285°)				
Storm return period (years)	Existing berth		Option 7.1 berth	
	Hs (m)	Tp (s)	Hs (m)	Tp (s)
1 in 0.5	1.2	5.0	1.6	4.9
1 in 1	1.2	5.0	1.8	5.4
1 in 10	1.3	6.6	2.1	6.1
1 in 50	1.7	7.1	2.3	6.1
1 in 100	2.0	7.4	2.4	6.8

Hs is significant wave height. Tp is peak wave period.

According to these values, new berth configuration (Option 7.1) is more exposed to the NW storms than from the SW ones. This effect was also registered for other new configurations (see section 8.4.1). This fact is a consequence of the change in the berth location and orientation. On the one hand, because new berth design is a little more distanced from the harbour entrance, waves that enter into the harbour and reach the berth present slightly lower levels of wave energy. On the other hand, because new berth alignment is a little more oriented to the north, waves coming from the NW present slightly higher wave energy values. Considering the maximum wave-height values obtained independently of their storm direction, it can be stated that there are no significant differences between the existing and the new configuration based on the Option 7.1 layout.

It is important to highlight that this wave data is associated to the waves that present the highest wave-height values for the whole Arran Berth. These waves are located next to the quayside and are the sum of the incident and the reflected waves. Given that, RPS has considered a partial reflection coefficient of 0.9 for vertical structures such as the Arran berth, the values presented in the wave study report have to be divided by 1.9 in order to obtain the wave-height values associated to the incident waves. Incident waves act on the hull of the moored vessel and, therefore, have been considered to carry out the mooring analysis.

c) Spectral wave analysis

According to the wave peak values obtained through the spectral wave analysis, there is no evidence of any long-period seiching (port resonance) within the Arran Berth.

10.4.2 Mooring analysis

A mooring analysis of the MV Glen Sannox moored at the Arran Berth (Option 7.1) was undertaken to assess the suitability of the vessel operations carried out by the new vessel in the new berth. This mooring analysis was carried out considering the main ports engineering related codes and standards, such as BS 6349, PIANC, OCIMF and ROM.

Whilst there are numerous potential approaches to the Arran Berth at Ardrossan Harbour, the approach adopted depends greatly on the wind direction. In the majority of the cases, ferries berth bow in at Ardrossan due to the strong westerly winds. This fact has been taken into consideration in this analysis so that Glen Sannox is moored at her port side and being linked to the linkspan ramp by her bow.

Two vessel positions have been considered according to the nature of the vessel operations being carried out; when the vessel is operating next to the linkspan ramp (Position A), and when the vessel is moored due to rough weather or staying at night (Position B). Both situations have been analysed from several scenarios (7) depending on different constraints and factors such as the maritime conditions. Whilst four scenarios (1, 2, 3 and 4) were analysed to for the Position A, three scenarios (5, 6 and 7) were analysed for the Position B. Mooring analysis was conducted for these scenarios. Both mooring arrangements leads to the lowest vessel excursion values with a balanced load in the mooring lines.

Maximum admissible vessel movements are set according to the kind of vessel operation carried out. Whilst in the Position A, Glen Sannox is undertaken load/unload operations (through the linkspan and passenger walkway), in the Position B she is staying at quay. Therefore, it has been considered that for the Position A, maximum vessel excursions are set by the PIANC recommendations (Ferries, Ro-ro with linkspan). For the Position B, it has been considered that LNG fuelling operations can be undertaken and, therefore, maximum vessel excursions are set by the BS 6349 recommendations.

Main results from mooring analysis about the vessel excursions are shown in the following table.

Table 16 Maximum vessel excursions experienced (Option 7.1 – Arran Berth)

Maximum vessel excursions experienced (Option 7.1 – Arran Berth)								
Scenario	Position	Description	Hs (m)	Wind (knots)	Mooring scheme	Surge	Sway	Heave
1	A	Vessel operation limit (CALMAC)	0.3	20	Standard	0.3	0.4	0.3

2		Amber alert (CALMAC)	0.3	30		0.4	0.4	0.3
3		Operational limit (PIANC)	0.3	43		0.5	0.4	0.3
4		Vessel at quay limit (PIANC)	0.7	43		0.5	0.9	0.7
5		Unable to operate (CALMAC)	0.7	45		0.5	0.9	0.7
6	B	1 in 0.5 yr return period (RPS)	0.8	54	Heavy	0.6	1.0	0.8
7		1 in 1 yr return period (RPS)	0.9	58		0.7	1.1	0.9

Hs is significant wave height.

The main results from the Optimoor simulations show that loading/unloading operations (position A) can be carried out meeting with the BS, PIANC and CALMAC recommendations (Scenarios 1, 2 and 3). Despite surge value observed in the Scenario 3 is slightly higher (1-10 cm) that recommended (0.4 m), since this surge movement is towards the ramp, it does not lead to an unsafe situation and, therefore, it can be considered valid. However, in case of worse maritime conditions (Scenario 4) vessel excursions (sway) values are incompatible with linkspan working conditions and walkway conditions should be also checked.

Staying at berth operations (position B) due to rough weather show vessel excursion values of up to 1 metre (Scenarios 5 and 6) and slightly higher for the 1 in 1 year return period (Scenario 7). According to the BS standard, LNG ship to shore transfer through a loading arms system can be undertaken up to 1 metre of surge and sway excursions (up to Scenario 6). These values should be thoroughly checked with the specifications of actual LNG transfer system installed in the Arran Berth.

According to the values of the loads in the mooring lines, they are all working in their safe working range, but from the Scenario 7 (49% of Ship Design MBL) they are getting close to the recommended values (55%).

Option 7.1 does not have a quay wall running the full length of the vessel giving slightly less flexibility to accommodate different sized vessels compared with Option 2. The lack of a continuous quay wall at the bow area makes the handling of bow mooring lines more difficult, necessitating the need for a mooring dolphin or the means to pass mooring lines ashore to bollards on the quayside.

10.5 Interface with landside masterplan.

Option 7.1 realigns the Arran Berth and creates a new marine/land connection for the double linkspan to the west of the current location within the existing car park and very similar in general layout as Option 7.0. The re-location of the linkspan and the angle of the linkspan relative to the existing landside infrastructure requires additional modifications to access, parking and marshalling requirements.

The change introduces a number of implications for the scope/extent of landside works and these are illustrated within Option 7.1 Masterplan. The masterplan is based on the SRS Requirements prepared by Transport Scotland. The main elements and assumptions are as follows:

- Existing Terminal Building (retained in Base Case) is not retained
- New Terminal Building is located adjacent/on site of the existing building

- New PAS (extended length over Option 2 subject to Building location) connects to MV Glen Sannox or other vessels
- Pierhead surfaces / pavement required repair/resurfacing post quay wall reconstruction and development of the LNG facility (CMAL)
- Irish Berth and linkspan to remain accessible and operational
- General arrangement (marshalling/car parking) and access to linkspan involves more movement with impact on controlled (pedestrian/vehicular) crossings on the front apron – fencing and control points required
- Strong connections to be provided between Terminal Building and Rail Station and thereafter Town Centre with a focus on active travel modes
- Access for HGV vehicles to LNG facility(assumed Winton Pier Area)
- Multi-modal transport interchange developed to the Building frontage providing for public transport / taxi's / cycle-pedestrian access / DDA parking / Pick-Up-Drop-Down Zone / Emergency Vehicles
- Public realm and place-making suitable /reflecting a public facility
- Car Park challenged to meet 450 + (efficient layout 420) spaces plus staff parking
- Marshalling to meet 150% largest vessel capacity (HGV's/Cars). Marshalling for Irish Berth more restricted than Option 2
- Sea wall repairs completed to include assessment of issues of over-topping and long-term resilience

In developing the arrangement for the Option 7.1 Berth/Quay arrangements a number of options have been considered. These have included:

- Options based on revised circulation arrangements (one-way/two way circulation)
- Options based on revised parking and marshalling arrangements including Marshalling to the sea wall and parking central to site
- Options for revised parking/marshalling to secure additional capacity
- Options based on revised Terminal Building arrangements – further assessment required relative to PAS and Rail Station access

General arrangements are at masterplan level (RIBA Stage 1/2). No detailed design has been undertaken but with various elements 'tested/validated' (Vehicle Tracking / Safe Access / DMRB-Road Design Guidelines / etc) to seek to ensure the layouts provide a foundation for design development. Parking and marshalling capacities are noted on drawings.

In summary the key benefits and dis-benefits of Option 7.1 in terms of landside works are as follows:

Table 17 Option 7.1 Landside Considerations

Option 7.1 Landside Benefits	**Dis-Benefits**
• Core elements layout as existing • Proven operational model • Good legibility • Building construction potentially less overlap with Quay Works • Good access/egress ferry (loading/unloading) • Provides limited Irish Berth Marshalling • Provides Construction Works Area	• Loss of Land Area Pierhead • Limited Working Area (Marine/Landside) • Challenge to meet SRS parking capacity req. • Safe operational management requires more on-site control/ user management • Car parking constrained and tight to sea wall • A little less optimised in layout than Option 2
Conclusion: **Option 7.1 is an enhancement on Option 7.0 but is more contrived and less flexible/ adaptable and has more limited capacity than Option 2. Subject to detailed design may not deliver SRS requirements for parking.**	

A number of additional interfaces with marine works relate to working areas / construction phase activity and construction management of the marine and landside works. The key issues for Option 7.1 are noted in tabular form below:

Table 18 Option 7.1 Landside Construction Phasing

Construction Phasing
• Scope of marine works suggests a less extended closure of port/Arran Berth • Marine works less restrictive of access to existing Terminal Building • Marine works and Terminal Building works require contract coordination • Construction compound anticipated Future Irish Berth marshalling area

10.6 Costs & Construction Programme

An estimation of berth construction costs and programme has been made by Doig and Smith on behalf of Ramboll for berth Option 2 and Option 7. To inform this estimate we have had an initial engagement with a marine contractor to draw on their experience.

The berth construction duration is estimated to be in the order of **15 months** including an allowance for risk. Closure of the Arran berth to ferry traffic is also expected to be required for around 14 months including an allowance for risk. A graphical representation of the construction periods and the estimated durations of closure of the existing berths is provided in Appendix 7.

In the cost estimate allowances for inflation have been made to the mid-point in construction based on the RICS Tender Price Index, (TPI). Assuming a first quarter 2020 start on site, the price point is **fourth quarter 2020.**

With the ongoing uncertainty surrounding the UK leaving the European Union and the conditions on which this is achieved, the RICS is producing a range of estimates for inflation in addition to the TPI. This consists of an upper range "Upside" scenario, a "Central" scenario and a lower range "Downside" scenario. The percentage change for inflation for these scenarios as presented by the RICS is as follows:

Table 19 Percentage change for inflation

Scenario	Percentage Change, (Year on Year)		
	3Q18 to 3Q19	3Q19 to 3Q20	3Q20 to 3Q21
Upside	+4.8	+6	+7
Central	+3.2	+4	+6.5
Downside	-3.5	-2.6	+4.7

The cost estimate is for construction costs only and is projected on the TPI which equates approximately to the "Central" scenario. There are no allowances for management fees. A separate allowance for an Optimism Bias of 15% of construction cost in line with TS guidance has been made. Further detail of the basis of the costs is contained within the Doig and Smith cost estimate.

It should be noted that the status of the design is very high level at this stage and as such the cost estimates are very much budget estimates. We recommend that the budget estimates are updated as the design is developed in more detail. A copy of the Doig and Smith cost estimates with full limitations and caveats to the estimates are presented at Appendix 8.

Table 20 Budget cost estimate for berth Option 7.1

Option 7.1			
Estimated Construction Cost, (Double Lane Linkspan)	£	[redacted]	Excluding VAT
Optimism Bias	£	[redacted]	Excluding VAT
Total Estimated Construction Cost, (Double Lane Linkspan)	£	[redacted]	**Excluding VAT**
Estimated Reduction for Single Lane Linkspan, (including reduction in Optimism Bias)	£	[redacted]	Excluding VAT
Total Estimated Construction Cost, (Single Lane Linkspan)	£	[redacted]	
Estimated Construction Programme		15 months	

PPG funding – Marine works	[redacted]
Delta in funding (double linkspan)	[redacted]

11. CONCLUSION

At the start of the Proof of Concept study, 14 Long List Options were identified as possible primary berth arrangements for the Glen Sannox. Following a workshop with the project stakeholders, from these 14 Long List Options, three favoured options were identified for more detailed assessment and comparison; Option 2, Option 7 and Option 7.1. All three were adjustments to the existing Arran Berth.

Taking Option 2 as the baseline scheme, Option 7 and 7.1 have been compared for the primary project considerations and scored against Option 2 based on the detailed studies undertaken (with the Option 2 score being zero and negative scores being less favourable). Both Option 7 and 7.1 have a less favourable overall score compared to Option 2.

Table 21 Comparison of Option 7 and 7.1 against Option 2

		Option 7	Option 7.1
Navigability and reliance	Commentary*	Narrowest operational limits of the 3 options considered. Concern with open corner at the bow and of the swell conditions. Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels. Bow mooring lines more difficult to handle.	Narrower operational limits. Concern with open corner at the bow and of the swell conditions. Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels. Bow mooring lines more difficult to handle. (though these issues could be overcome by filling in the bow area though at additional cost)
	Score#	-10	-5
Ground conditions and construction risk	Commentary*	Much higher risk due to number of existing wall tie rods affected. Relies on construction bund maintain stability of existing wall	Higher risk as works are closer to existing quay wall
	Score#	-10	-5
Interface with Landside Masterplan	Commentary*	Loss of pier head area Challenge to meet SRS parking capacity. More on site control required. Least optimised layout	Loss of pier head area Challenge to meet SRS parking capacity. More on site control required. Less optimised layout
	Score#	-10	-8
Construction Duration and impact on service	Commentary*	Construction period 5 months shorter Estimated to be 3 months less impact on Arran Berth use	Construction period 3 months shorter Estimated to be 2 months less impact on Arran Berth use
	Score#	10	5

Costs	Commentary*	Cheapest option though most expensive per metre	Cheaper than Option 2 though more expensive per metre
	Score#	10	5
	Total Score	**-10**	**-8**

**Option 2 as baseline (Zero Score). Scores in the range -10 to +10 from baseline (negative being less favourable)*
 # Commentary relative to Option 2

Option 2 was a scheme previously developed by Ramboll on behalf of CMAL and forms the reference scheme in the SRS. Whilst Option 2 represents the greatest overall investment it is interesting to note that on a per metre basis Option 2 is [redacted]m whilst Options 7 and 7.1 are [redacted]m and [redacted]/m respectively so, in terms of new berth length provided, Option 2 actually offers the greatest value linearly. All options carry high geotechnical risk due to the presence of buried structures however the alignment of Option 2 generally keeps the new quay wall construction away from the existing quay wall edge reducing the degree of interface and the gives the contractor a larger working area that is more removed from the sea therefore reducing risk. It is also noted however that the increased quay wall length of Option 2 increases the risk of encountering unexpected ground conditions or buried structures. The alignment also passes near the existing terminal building.

The assessment of the landside masterplan by IFL found that Option 2 retains current general arrangement and offers best capacity, flexibility and future proofed layout for landside aspects of the port and ferry and terminal operations.

Option 2 has the longest estimated construction duration and has the potential for construction activities to still be taking place, and therefore the Arran Berth still in suspension, into a second summer season. Whilst this represents a greater short-term disruption to the public and the local community, the conclusion from the simulation trials carried out is that Option 2 will allow the vessel to operate in the greatest range of conditions compared to options 7 and 7.1. Given the 50year design life of the berth structure the long-term benefits of Option 2 can be considered to outweigh the higher cost and the short-term construction programme disbenefits of this option. The conclusion of the study is therefore that Option 2 offers the most robust solution and relative best value and so may be put forward for Ministerial approval.

APPENDIX 1
FAVOURED BERTH OPTIONS DRAWINGS

Notes

1. DO NOT SCALE FROM THIS DRAWING.
2. ALL DIMENSIONS ARE IN METRES (m) UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METRES RELATIVE TO CHART DATUM UNLESS NOTED OTHERWISE. ORDNANCE DATUM IS 1.5m ABOVE CHART DATUM.
4. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.
5. BATHYMETRIC SURVEY BY ASPECT LAND & HYDROGRAPHIC SURVEYS JULY 2017.
6. CO-ORDINATES ARE TO LOCAL GRID. TOPOGRAPHICAL SURVEY BY L & M SURVEY SERVICES MAY 2017.

	EASTING	NORTHING
SDP-01	222369.155	642250.166
SDP-02	222365.763	642239.622
SDP-03	222372.206	642126.864

KEY:

- LANDSIDE AREA
- EXISTING QUAY SIDE REMOVED
- DREDGING TO -4.9m C.D. (-6.5m O.D.)
- BED LEVEL HIGHER THAN -4.9m C.D BUT NO DREDGING PROPOSED (INDICATED AROUND ARRAN BERTH ONLY)
- BACKFILL

Rev	Description	Date	By / Chk	App
P03	FOR COMMENT	[illegible] 2019	LH / LBB	LBB
P02	FOR COMMENT	[illegible] 2019	LH / LBB	LBB
P01	FOR COMMENT	[illegible] 2019	LH / LBB	LBB

FOR COMMENT

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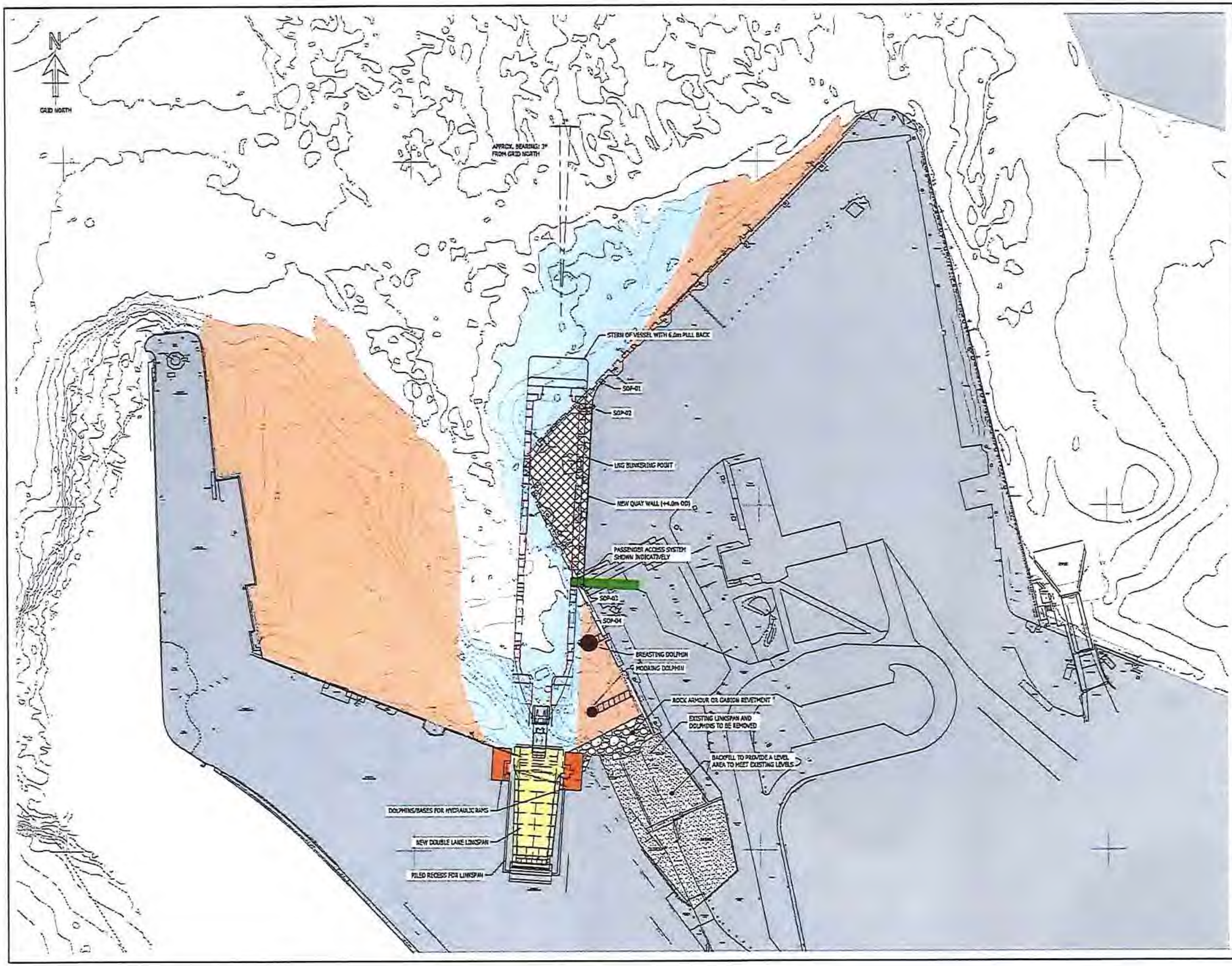
www.ramboll.co.uk

ARDROSSAN HARBOUR REDEVELOPMENT

BERTH OPTION 2

Scale	Date	Drawn	Checked
1:500	FEB 2019	LH	LBB

Drawing No.	Rev
1620005123-RAM-XX-00-SK-CW-0007	P03



Notes

1. DO NOT SCALE FROM THIS DRAWING.
2. ALL DIMENSIONS ARE IN METRES (m) UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METRES RELATIVE TO CHART DATUM UNLESS NOTED OTHERWISE. ORDNANCE DATUM IS 1.5m ABOVE CHART DATUM.
4. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.
5. BATHYMETRIC SURVEY BY ASPECT LAND & HYDROGRAPHIC SURVEYS JULY 2017.
6. CO-ORDINATES ARE TO LOCAL GRID. TOPOGRAPHICAL SURVEY BY L & M SURVEY SERVICES MAY 2017.

	EASTING	NORTHING
SOP-01	222355.057	642235.346
SOP-02	222352.161	642228.358
SOP-03	222349.235	642176.474

KEY:

- LANDSIDE AREA
- EXISTING QUAY SIDE REMOVED
- DREDGING TO -4.9m C.D. (-6.5m O.D.)
- BED LEVEL HIGHER THAN -4.9m C.D BUT NO DREDGING PROPOSED (INDICATED AROUND ARRAN BERTH ONLY)
- BACKFILL
- DOLPHIN AND ACCESS GANGWAY

Rev	Description	Date	By / Chk	App
P03	FOR COMMENT	25/02 2019	LH / LBB	LBB
P02	FOR COMMENT	18/02 2019	LH / LBB	LBB
P01	FOR COMMENT	20/02 2019	LH / LBB	LBB

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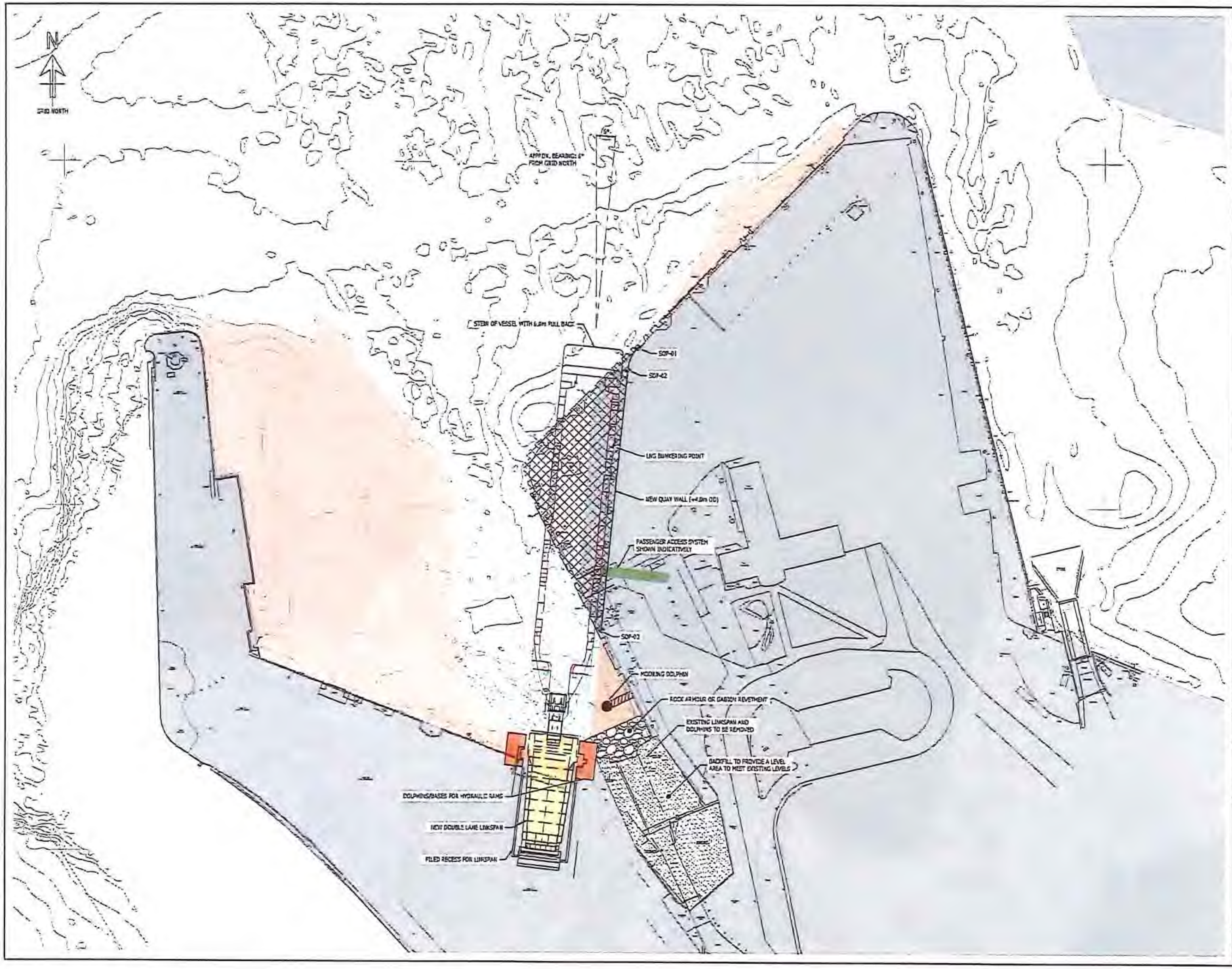
ARDROSSAN HARBOUR REDEVELOPMENT

BERTH OPTION 7

Scale:	Date:	Drawn:	Checked:
1:500	FEB 2019	LH	LBB

Drawing No.:	Rev:
1620005121-RAM-XX-00-SK-CW-0003	P03



Notes

1. DO NOT SCALE FROM THIS DRAWING.
2. ALL DIMENSIONS ARE IN METRES (m) UNLESS NOTED OTHERWISE.
3. ALL LEVELS IN METRES RELATIVE TO CHART DATUM UNLESS NOTED OTHERWISE. ORDNANCE DATUM IS 1.5m ABOVE CHART DATUM.
4. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL RELEVANT ARCHITECTS AND ENGINEERS DRAWINGS AND SPECIFICATIONS.
5. BATHYMETRIC SURVEY BY ASPECT LAND & HYDROGRAPHIC SURVEYS JULY 2017.
6. CO-ORDINATES ARE TO LOCAL GRID. TOPOGRAPHICAL SURVEY BY L & M SURVEY SERVICES MAY 2017.

	EASTING	NORTHING
SOP-01	222365.594	642246.534
SOP-02	222362.540	642240.144
SOP-03	222355.051	642164.595

KEY:

LANDSIDE AREA

EXISTING QUAY SIDE REMOVED

DREDGING TO -4.5m C.D. (-6.5m O.D.)

BED LEVEL HIGHER THAN -4.5m C.D BUT NO DREDGING PROPOSED (INDICATED AROUND ARRAN BERTH ONLY)

BACKFILL

DOLPHIN AND ACCESS GANGWAY

Rev	Description	Date	By / Chk	App
P03	FOR COMMENT	[illegible] 2019	LH / [illegible]	LBB
P02	FOR COMMENT	[illegible] 2019	LH / [illegible]	LBB
P01	FOR COMMENT	[illegible]	LH / [illegible]	LBB

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ARDROSSAN HARBOUR REDEVELOPMENT

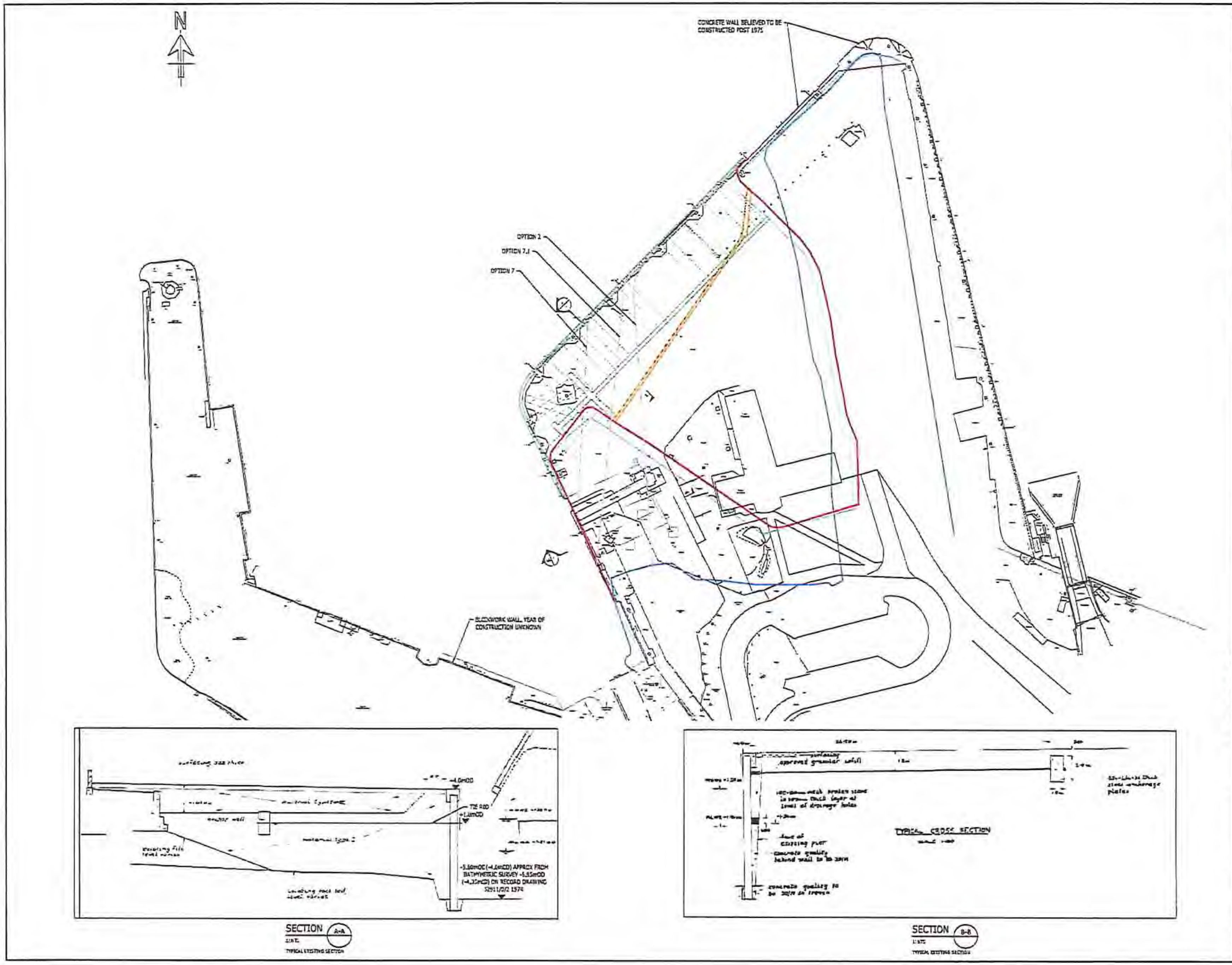
BERTH OPTION 7.1

Scale	Date	Drawn	Checked
1:500	FEB 2019	LH	LBB

Drawing No.: 1620005121-RAM-XX-00-SK-CW-0010 | Rev: P03

ARDROSSAN HARBOUR REDEVELOPMENT
PROOF OF CONCEPT REPORT

APPENDIX 2
BURIED STRUCTURES PLAN



Notes

1. EXISTING STRUCTURE LOCATIONS BASED ON DRAWINGS PROVIDED BY IRONSIDE FARRAR.
2. EXISTING STRUCTURE DETAILS FROM RECORD DRAWING 52911/8 (1974) AND 52911/21 (1975).
3. ORDNANCE DATUM IS 1.6m ABOVE CHART DATUM.
4. GROUND INVESTIGATION, REFER TO THE FACTUAL GROUND INVESTIGATION REPORT "ARDROSSAN HARBOUR, BRODICK BERTH - GROUND INVESTIGATION, REPORT NO: 18-1431A, DATED 15TH FEBRUARY 2019, BY CAUSEWAY GEOTECH LTD

KEY:

1855 Pier Outline MASONRY WALL. NOT IDENTIFIED IN THE GROUND INVESTIGATION

1895 Pier Outline CONSTRUCTED OF SANDSTONE BLOCKS. IDENTIFIED IN TT09.

1963 Pier Outline CONSTRUCTED OF CONCRETE. IDENTIFIED IN TT04, TT05, AND TT09.

1963 - 1974 Pier Outline BURIED STEPPED CONCRETE WALL. IDENTIFIED IN TT04, AND TT05.

1974 Pier Outline SHEET PILED WALL TIED BACK WITH ANCHOR RODS TO A CONCRETE ANCHOR BEAM. IDENTIFIED IN TT04-BB, TT05-BB, TT09A-BB AND TT09-BB.

Rev	Description	Date	By / Chk	App
P03	FOR INFORMATION	2019	LH / RH	LBB
P02	FOR INFORMATION	11/02 2019	HL / AMD	JC
P01	FOR INFORMATION	2019	HL / AMD	JC

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ARDROSSAN HARBOUR REDEVELOPMENT

BURIED STRUCTURE PLAN

Scale	Date	Drawn	Checked
1:500	FEB 2019	LH	LBB

Drawing No.	Rev
1620005121-RAM-XX-00-SK-CW-0011	P03

APPENDIX 3
CALMAC VESSEL SIMULATION REPORT

Caledonian MacBrayne
Hebridean & Clyde Ferries

Ardrossan Shortlist Options Operators Assessment and Simulation Outcomes

4 April 2019

Contents

Caledonian MacBrayne
CalMac Ferries Ltd., Ferry Terminal Gourock PA19 1QP
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1. Introduction and Purpose

1.1 This report presents the findings from an operational assessment of each of the short list options under consideration by Peel Ports to improve the resilience and reliability of Ardrossan port. The report will also detail the outcome of the simulations carried out of operating to each of the options being considered and the potential operational envelopes and resulting service disruption.

1.2 This report will serve as an adjunct to the wider assessment being carried out by Peel Ports considering the technical and financial implications of each of the options. This is a further iteration of previous papers assessing the operational impacts and envelopes of options identified in 2017 and 2018.

2. Background

2.1 Ramboll, on behalf of Peel Ports Group, are undertaking a Proof of Concept study to identify the optimum berth arrangement for the MV Glen Sannox. Of particular importance to the new berth configuration is navigation of the vessel onto the berth and resilience of the ferry operations to bad weather. The first stage of that study identified numerous possible berth options. The favoured options remaining at the end of the exercise are options 2 (the option identified as preferred and presented to the Taskforce), 7 and 7.1. These options will be subject to detailed studies including mooring analysis, wave modelling, assessment of construction costs and duration, assessment of ground conditions and simulator testing to establish operational windows.

3. Simulations Overview

3.1 CalMac were invited to attend Peel Ports simulators at Greenock Ocean Terminal (GOT) on 20 March 2019. The CalMac Masters, along with Peel Ports Pilot utilised the simulator to determine the viability of the short listed options and determine the likely operational envelopes

3.2 Simulator Assumptions

- The simulator at GOT reflects the expected performance of MV Glen Sannox
- Gusts in wind speeds experienced in the simulator represent an increase or decrease of three knots (CFL consider this as a minimum and in reality would expect gusts of around +10 knots)
- Swell conditions experienced on the simulator were not realistic, vessel motion when entering the harbour and alongside is considerably more movement.

4. Options Identification and Analysis

4.1 An overview of the options under consideration can be found in Table 1. These options are the short listed options progressed from the Proof of Concept study:

Scope of Works		
Option	**Arran Berth Works**	**Irish Berth Works**
Option 2	• Replacement linkspan • Large cut-out of existing quay wall • Dredging at turning circle	• Refurbishment of suspended deck • Refurbishment of linkspan
Option 7	• Replacement linkspan (set in) • Cut off corner to quay wall • Breasting dolphin construction • Dredging at turning circle	• Refurbishment of suspended deck • Refurbishment of linkspan

Scope of Works		
Option	**Arran Berth Works**	**Irish Berth Works**
Option 7.1	• Replacement linkspan (set in) • Large cut off corner to quay wall • Breasting dolphin construction • Dredging at turning circle	• Refurbishment of suspended deck • Refurbishment of linkspan

Table 1 – Short-List Options Overview

4.2 A full analysis of the options can be found in Appendix 1 with an excerpt of the conclusions of each option included below.

4.2.1 Option 2

- Option 2 provides manoeuvring space to enable operations in a greater range of conditions.
- Option 2 would be the preferred berth for the mooring layout and safe overnight berth.

4.2.2 Option 7

- Option 7 offers less manoeuvring space than 2 and 7.1 which will ultimately impact the operational window of the vessels and reduce the reliability of the service.
- The impact of the open corner at the bow and of the swell conditions on the berth need to be considered further. CalMac are concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns.
- Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels and bow visor reducing the mooring deck and available spread of mooring leads and as such this may result in reduced service reliability and/or the vessels that can be deployed on the route.

4.2.3 Option 7.1

- This option provides manoeuvring space to enable an increase in operational limits, however the impact of the open corner at the bow and the swell conditions on the berth need to be considered. CalMac are concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns.
- Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of vessel and bow visor reducing the mooring deck and available spread of mooring leads and this will result in reduced reliability of service and/or the vessels that can be deployed on the route.
- CalMac understands that there is a sub-option which considers increasing the length of the berth removing the requirement for the dolphin. If this option is progressed then this it is expected that this would improve the resilience of the option.

5. Operational Envelopes

5.1 When defining operational windows it must be remembered that wind speed is used as a proxy to account for a reality factor and take into consideration situations that would likely be experienced in practice but could not be simulated. This is to allow a quantitative assessment to be carried out of the likely impacts on service. For the purposes of defining an operational window for MV Glen Sannox it was assumed that the vessel will operate as demonstrated in the simulator.

5.2 It is difficult to determine operational windows in simulations, particularly in the current circumstances of an unconfirmed and un-trialled vessel (other simulations such as in the aviation industry are far more advanced and based upon existing and long serving aircraft). Therefore, based on the simulations completed within the time available, broad conclusions have been drawn using the information available and knowledge of the Masters on the route.

5.3 The conclusion from the simulation trials carried out is that Option 2 will allow the vessel to operate in an increased range of conditions compared to options 7 and 7.1. Successful simulated berthings were completed in SW winds of up to 35 knots, NW of up to 30 knots, SE winds of up to 30 knots and easterly winds of up to 30 knots (currently the Irish Berth is utilised in easterly winds over 25 knots on MV Caledonian Isles, less on MV Isle of Arran). Although unsuccessful berthings were experienced in NW winds of 40 knots, if the vessel performs as set out in the specification, it is thought that berthing in NW winds of 40 could be achieved.

5.4 Based on the berthing trials completed, and with the knowledge of how the vessel is expected to operate as outlined in the vessel specification, it is anticipated that MV Glen Sannox would feature an operational window of between 25-40 knots when operating to Option 2. This is CalMac's best estimate based on the information currently available.

5.5 Furthermore, the inclusion of a dolphin in options 7 and 7.1 present concerns from a number of perspectives. Dolphins will result in the vessel experiencing additional movement in the bow when on the berth, which may reduce the operational window and ability to undertake cargo operations. It is difficult to estimate operational limits for options 7 and 7.1 due to the unknown impacts of the wave climate at the berth as a result of the inclusion of dolphins.

5.6 However, as option 7.1 provides a similar space to manoeuvre on to the berth, if this option is modified to provide a full berth then it is expected that this would provide a similar operational envelope to that of option 2.

6. Analysis of Service Disruption

6.1 For the purposes of quantifying the impact on service disruption only option 2 has been considered as it's not possible to determine operational windows for options 7 and 7.1 due to the unknown impacts of the dolphin (as outlined in section 5.5). However, the qualitative analysis of each of the options in section 5 will allow for a comparison.

6.2 Analysis has been undertaken to determine the effect that the proposed operational window would have on the disruption rates experienced on the route. The findings of this analysis can be found in Chart 1.

6.3 It is difficult to differentiate between cancellations and delays when forecasting potential disruption rates based on an operational window. For this reason, the figures being quoted in the analysis of service disruption consists of both cancellations and delays. This is to enable high level but direct comparisons to be drawn with MV Glen Sannox operating in each of the infrastructure options.

6.4 The current levels of disruption for the route are also outlined in Chart 1. This is to allow for comparison between the forecasted disruption rates of each of the options.

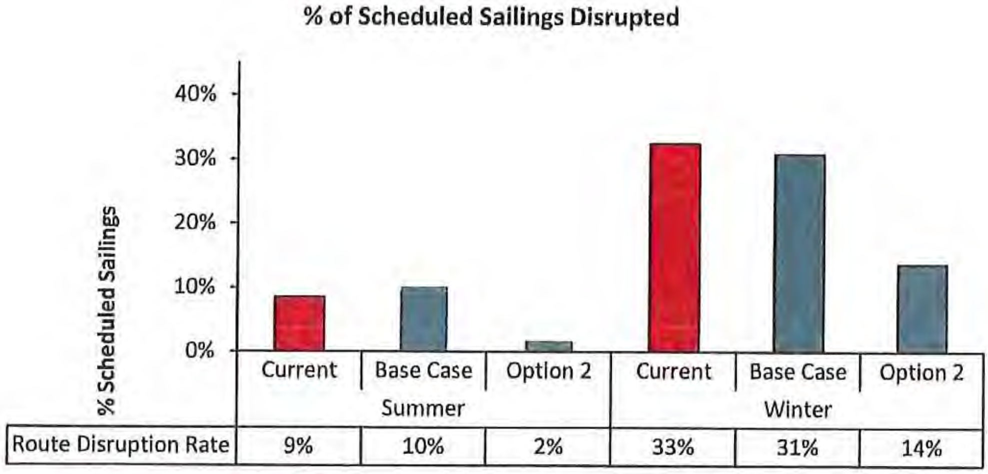

Chart 1 – Forecast Disruption Rates

6.5 It is evident from the analysis that Option 2, which would result in an operational window of between 25-40 knots, would see a disruption rate being experienced of up to 2% in summer and 14% in winter. This equates to around 61 sailings in summer and 193 sailings in winter (assuming MV Glen Sannox operates the same timetable as MV Caledonian Isles currently).

6.6 When comparing the disruption expected with Option 2 against the Base Case Option (an application of a 20 knot limit), suggests that option 2 would see a decrease in disruption rates of 8 percentage points in the summer and 17 percentage points in the winter. Furthermore, as well as demonstrating an improvement over the Base Case, Option 2 also suggests an improvement to the current service with a potential decrease in disruption rates of 7 percentage points in the summer and 19 percentage points in the winter. This would suggest that the number of sailings affected by disruption would likely decrease under Option 2 by 204 sailings in summer and 231 sailings in winter, when compared to the current rate of disruption. It should be noted that the potential disruption figures quoted are calculated based on the outcome of simulations and utilising an untested vessel. On this basis any disruption forecasts are indicative only.

6.7 Lastly, although this report is mainly concerned with MV Glen Sannox, it is apparent that the other vessels which operate to the route will benefit from the increased space presented by Option 2. It is expected that increasing the manoeuvring space will also benefit MV Caledonian Isles which is intended to operate as the secondary vessel on the route. Although MV Caledonian Isles is able to operate in higher wind speeds, opportunities have been limited due to the limited space within the harbour. However, it is expected with Option 2 that the vessel will be able to operate in greater wind speeds on a more consistent basis.

6.8 A summary of the analysis can be found in Table 1.

			% Sailings Affected		No. of Sailings Affected	
			Primary Vessel	Secondary Vessel	Primary Vessel	Secondary Vessel
Summer	Current	Rate	8.0%	9.0%	162	103
	Base Case	Rate	12.7%	8.0%	258	91
		Delta*	4.7%	-1.0%	96	-12
	Option 2	Rate	1.9%	1.9%	39	22
		Delta*	-6.1%	-7.1%	-123	-81
Winter	Current	Rate	24.0%	41.0%	216	208
	Base Case	Rate	37.7%	24.0%	340	122
		Delta*	13.7%	-17.0%	124	-86
	Option 2	Rate	13.7%	13.7%	124	69
		Delta*	-10.3%	-27.3%	-92	-139

*Delta from current service

Table 1-Summary of Disruption Rates and Sailings Affected Compared to Operational Envelope

6.9 As noted in section 5.1, wind speed has been used as a proxy to assist in quantifying the impact of the alternative berth layouts. In reality the actual disruption experienced depends on a range of factors including swell, gust and sea state. Therefore, the analysis above presents an indicative representation of expected disruption.

6.10 It is important to note that this analysis assumes that the Irish Berth will be available to all vessels deployed on the service. If this assumption proves false and the Irish Berth is unavailable then the disruption rates would increase. A best estimate is that this would be in the region of 5% of scheduled sailings.

7. Conclusion

7.1 It is evident that the short-listed options under consideration by Peel Ports will vary with the extent to which they will affect the reliability of the new MV Glen Sannox. Whilst Option 2 provides the most optimal configuration due to the increased manoeuvring space available coupled with the ideal mooring configuration, it must be recognised that Option 7.1 is not without its benefits. However, due to the berth length of Options 7 and 7.1, both of these configurations will likely impact on smaller vessels operating to the route including MV Caledonian Isles and MV Isle of Arran, potentially offsetting any benefits that may be experienced in improving the reliability of MV Glen Sannox.

Caledonian MacBrayne
Hebridean & Clyde Ferries

8. Appendix 1 – Options Analysis

Option	Advantages	Disadvantages	Simulator Findings	Conclusion
Option 2 	• Provides sufficient manoeuvring space enabling operations in a greater range of conditions. • This option provides the most space for berthing/unberthing in easterlies and is an increase on the status quo. Therefore this option should increase the operational window for easterly winds and somewhat reduce the requirement for using the Irish berth. • The entire vessel length is supported on the berth and provides a good spread of moorings for an overnight berthing and cargo operations.	• While this option provides the greatest benefit when berthing in easterlies the vessel will still have a lower operational envelope (approximately 30 knots) than for other wind directions. This is due to the alignment of the berth (approximately north/south) resulting in an easterly wind being perpendicular to the berth blowing the vessel off so the vessel power and available moorings will determine the limit. Therefore, there is a continued requirement to utilise the Irish Berth in periods of stronger easterly winds.	Berthing / Unberthing: 35kt SW ✓ | 40kt SW ✓ 30kt NW ✓ | 40 kt W ✓ 30kt SE ✓ | 30kt E ✓ 30kt E ✓ | **Berthing** • SW 35kts + gusts - Successful • NW 30kts + gusts – Successful • SE 30kts +gusts - Successful • E 30kts +gusts - Successful holding vessel with own power and use of moorings. **Unberthing** • SW 40kts +gusts - Successful • NW 40kts +gusts - Successful using top Winton knuckle. • E 30kts + gusts - Successful however more set of vessel expected. • E 30kts + gusts - Successful however more set of vessel expected.	• Option 2 provides sufficient manoeuvring space enabling operations in a greater range of conditions. • Option 2 would be the preferred berth for the mooring layout and safe overnight berth
Option 7 	• This option provides more space than currently available for berthing and unberthing in most wind directions	• Offers less manoeuvring space than other options • During easterly winds the vessel will be more restricted than in option 2 and 7.1 and as such have a lower operational limit. This is due to berthing and unberthing in an off berth wind with less manoeuvring space, as such this would result in more frequent requirement to utilise the Irish berth and more cancellations if Irish Berth is not available for MV Glen Sannox	Berthing / Unberthing: 35kt SW ✓ | 30kt E × 30kt NW (1) × | 30kt NW (2) ✓ | 35kt NW (3) × | 35kt NW (4) × | 35kt W × |	• Option 7 offers less manoeuvring space than options 2 and 7.1 which will ultimately impact the operational window of the vessels and reduce the reliability of the service. • The impact of the open corner at the bow and of the swell conditions on the berth need to be considered further. CalMac are concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns.

Option	Advantages	Disadvantages	Simulator Findings	Conclusion
		• This option would see the mid and aft section of the vessel resting on the berth with the bow section unsupported. This may result in the vessel not being able to maintain position on the berth due to sea/ swell conditions and therefore being unable to land ramp for cargo operations. • Vessel deployment options during relief or overhaul may be reduced as smaller vessels i.e. MV Caledonian Isles and Isle of Arran may be less resilient due to length and bow visor design which proves difficult to provide for an easy mooring arrangement with very long leads and limited access for mooring gangs.	**Berthing** • 35 knots SW – successful • 30 knots NW – unsuccessful, heavy contact with bow on Winton Pier knuckle • 30 knots NW reattempted – successful however vessel landed heavy on port quarter • 35 knots NW – unsuccessful stern did not lift up due to slowed speed (wind remained on the port quarter, setting the vessel on to lighthouse) • 35 knots NW – re - attempted speed maintained to get stern up into the wind, however heavy contact with port quarter on Winton knuckle. • 35 knots W – unsuccessful - heavy contact with winton knuckle and unable to check the vessel's swing. **Unberthing** • 30 knots easterly winds with gusts – unsuccessful – while the vessel unberthed, this wouldn't be replicated in reality as too risky due to requirement to utilise all of vessel power to get in a safe position	• Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels and bow visor reducing the mooring deck and available spread of mooring leads and as such this may result in reduced service reliability and/or the vessels that can be deployed on the route.
Option 7.1 	• The position of the Winton Knuckle provides sufficient manoeuvring space for berthing and unberthing in most wind directions.	• While this option provides an increase in manoeuvring space for berthing/unberthing in easterlies, the representative increase in operational limits is less than is expected in option 2. • This option would see the mid and aft section of the vessel resting on the berth with the bow section unsupported. This may result in the vessel not being able to maintain position on the berth due to sea/ swell conditions and therefore being unable to land ramp for cargo operations. • Vessel deployment options during relief or overhaul may be reduced as smaller vessels i.e. MV Caledonian Isles and Isle of Arran may be less resilient due to length and bow visor design which proves difficult to provide for an easy mooring arrangement with very long leads and limited access for mooring gangs.	Berthing | | Unberthing | 35kt SW | ✓ | | 35kt NW | ✗ | | **Berthing** ○ 35 knots south westerly winds with gusts – successful ○ 35 knots north westerly winds with gusts – successful although vessel landed heavy with port quarter. **Unberthing** ○ Not trialled due to being content with departures from this alignment (similar to option 2)	• This option provides sufficient manoeuvring space enabling an increase in operational limits, however the impact of the open corner at the bow and the swell conditions on the berth need to be considered. CalMac are concerned that this will impact the ability to hold the vessel alongside the berth and to conduct cargo operations, as such this may reduce the operational window and present reliability concerns. • Smaller vessels like MV Caledonian Isles and Isle of Arran maybe negatively impacted due to length of these vessels and bow visor reducing the mooring deck and available spread of mooring leads and as such this may result in reduced service reliability and/or the vessels that can be deployed on the route. • CalMac understands that there is a sub-option which considers increasing the length of the berth removing the requirement for the dolphin. If this option is progressed then this would improve the resilience of the option.

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ARDROSSAN HARBOUR REDEVELOPMENT
PROOF OF CONCEPT REPORT

APPENDIX 4
WAVE STUDY REPORT