



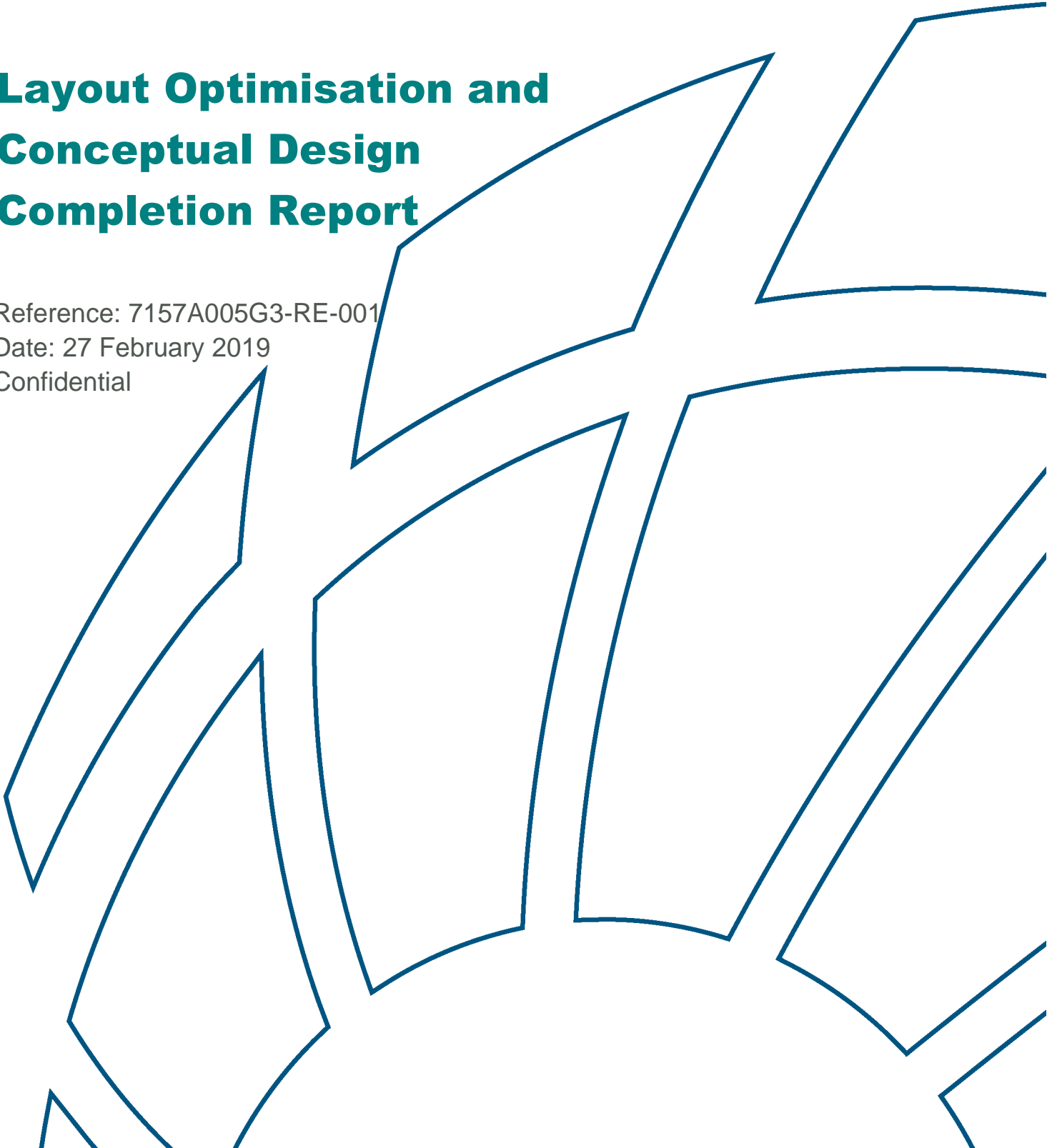
Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10-CT19

Layout Optimisation and Conceptual Design Completion Report

Reference: 7157A005G3-RE-001

Date: 27 February 2019

Confidential





Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10-CT19

Layout Optimisation and Conceptual Design Completion Report

Prepared under the Management of:

Name: *Goh Kun Kee*

Position: *Senior Contracts Manager, Maritime Structures, Asia Pacific*

Signature:

A handwritten signature in blue ink, appearing to read "Goh Kun Kee", written over a light blue grid background.

Reviewed and Approved by:

Name: *Ir. Sridhar Krishnan*

Position: *Director | Head of Maritime Structures, Critical Infrastructure, Asia Pacific*

Signature:

A handwritten signature in blue ink, appearing to read "K. Sridhar", written over a light blue grid background.

Reference: 7157A005G3-RE-001 Rev 0

Date: 27 February 2019

Filename: [7157A005G3-RE-001 R0 Westports Expansion - Layout Optimisation and Conceptual Design Completion Report](#)

456 Alexandra Road, 15-01 Fragrance Empire Building, Singapore 119962

Tel: (65) 6517 6800 Fax: (65) 6254 7677

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1 Introduction

This report presents the process and outcome of the layout optimisation exercise for the proposed expansion of Westports Malaysia. It also presents the phasing plan for the proposed expansion, and budgetary construction cost estimates.

2 Layout Optimisation Exercise

The layout optimisation exercise was performed in a stepwise manner, as follows:

Step 1 Establish terminal expansion requirements, based on the following parameters:

- Total target cargo-handling capacity at the expanded port facility;
- Mix of direct and transshipment cargoes to be handled at the expanded port facility; and
- Size of vessels expected to call at the expanded port facility.

These parameters were used to determine the required quay length and yard area.

Step 2 Review existing site conditions, specifically:

- Wave regime;
- Current regime;
- Sedimentation rates and pattern;
- Geotechnical conditions;
- Navigation corridors;
- Port boundary limits; and
- Port operations.

Step 3 Evaluate the initial layout, based on the following:

- Terminal expansion requirements established in Step 1; and
- Existing site conditions reviewed in Step 2.

This evaluation showed that the initial layout projects into the existing current flow path, causing eddies to be formed along the main face. It also showed that the initial layout has the potential to cause significant sedimentation problems.

Step 4 Develop alternative layout options, based on the following considerations:

- Efficiency of use of quay length;

- Efficiency of use of reclaimed area;
- Impact on existing current flow path;
- Sedimentation risk; and
- Impact on existing navigation corridors.

The alternative layout options were ranked based on the above considerations, and were presented to HSS Integrated Sdn Bhd and the Senior Management of Westports Malaysia Sdn Bhd in a series of Layout Option Workshops. Copies of the presentations made at these workshops are included in **Appendix A** for reference.

Step 5 Select preferred layout option and refine.

The “Crooked Finger” option was selected as the preferred option at the end of Step 4. This layout was further refined based on Capital and Operating Expenditure (CAPEX and OPEX) considerations.

Figure 2-1 shows the final layout. Salient features of this layout are summarised in **Table 2-1**.

Table 2-1 Salient Features of Final Layout

Feature	Detail
Number of Container Berths	8
Total Quay Length (m)	4,800
Total Yard Area (ha)	260
Maximum Depth at Chart Datum	Berths 1 – 4: 15.0m Berths 5 – 8: 18.0m
Type of Quay Structure	Reinforced-concrete deck supported on driven prestressed spun concrete piles, with a series of access bridges connecting the quay and the yard area.

Figures 2-2, 2-3 and 2-4 show 3D-rendered images of the final layout.

3 Phasing Plan

Figure 3-1 shows the phasing plan for the proposed expansion of Westports Malaysia. Salient features of this plan are as follows:

- Dredging Works
 - Dredging of the South Channel is proposed to be carried out in two phases, Phase 1A and Phase 2.
 - Dredging at Selat Lumut is proposed to be carried out as part of Phase 2.
 - A part of the dredged material from Phase 1A dredging of the South Channel will be placed in the Phase 1A containment area, and the remainder will be disposed off-site.
 - Similarly, a part of the dredged material from Phase 2 dredging of the South Channel will be placed in the Phase 2 containment area, and the remainder will be disposed off-site.
 - All the dredged material from Selat Lumut will be placed in the Phase 2 containment area.
- Land Reclamation, Ground Improvement and Shore Protection Works
 - Land reclamation, ground improvement and shore protection works will be carried out in three phases, Phase 1A, Phase 1B and Phase 2.
 - Land reclamation will be carried out using sand from offshore borrow areas.
 - Ground improvement works will consist of the installation of prefabricated vertical drains and the subsequent placement of preload/surcharge fill to accelerate consolidation and reduce post-construction settlements to acceptable limits.
 - Shore protection works will consist of the placement of rock revetment on slopes to protect them from erosion.
- Container Berths and Yard Areas
 - Container berths and associated yard areas will be built in three or more phases, depending on demand.

Figures

**Figure 2-2 3D-Rendered Image of Final Layout
- View from Top**

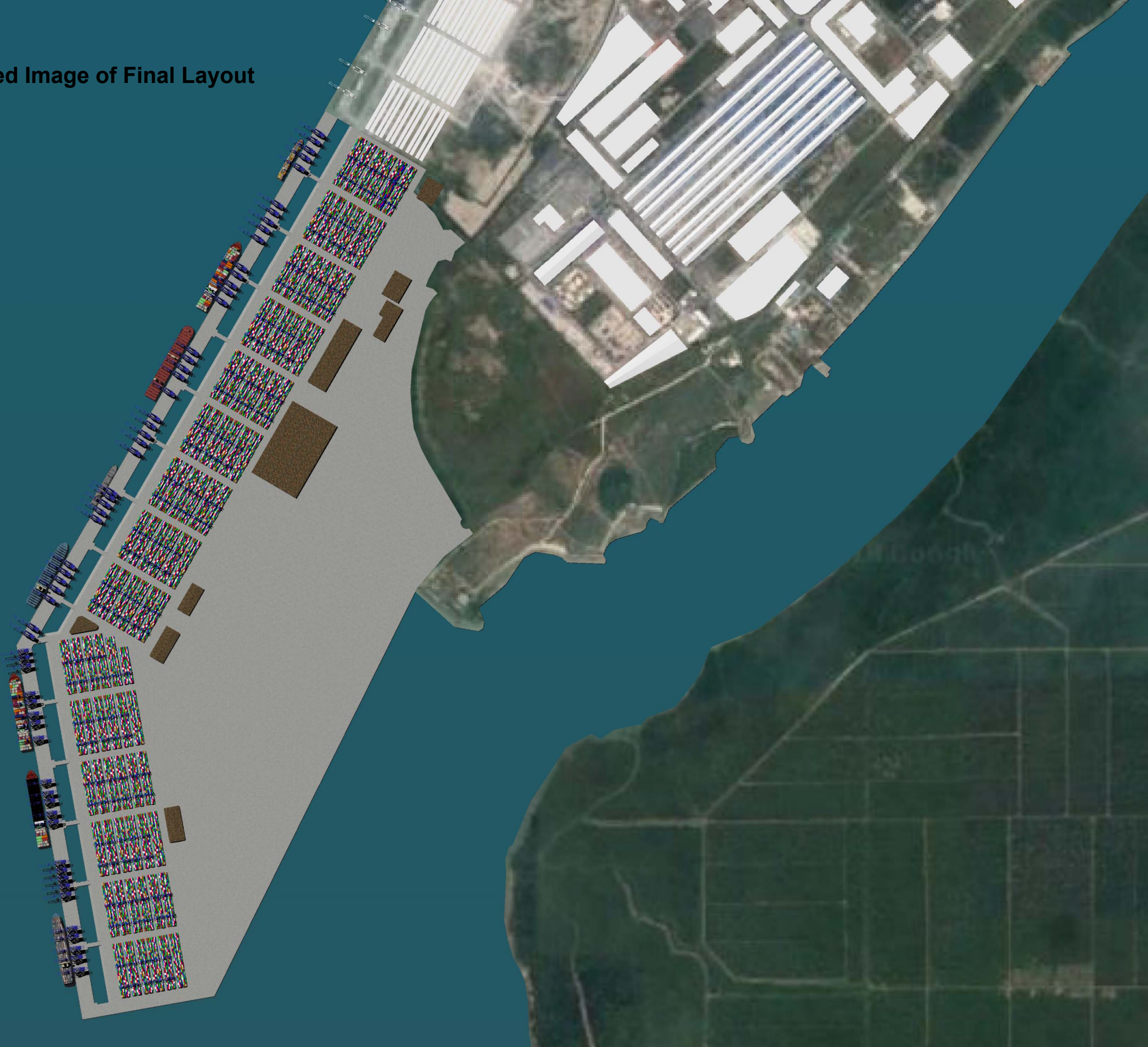


Figure 2-3 3D-Rendered Image of Final Layout - View from South East

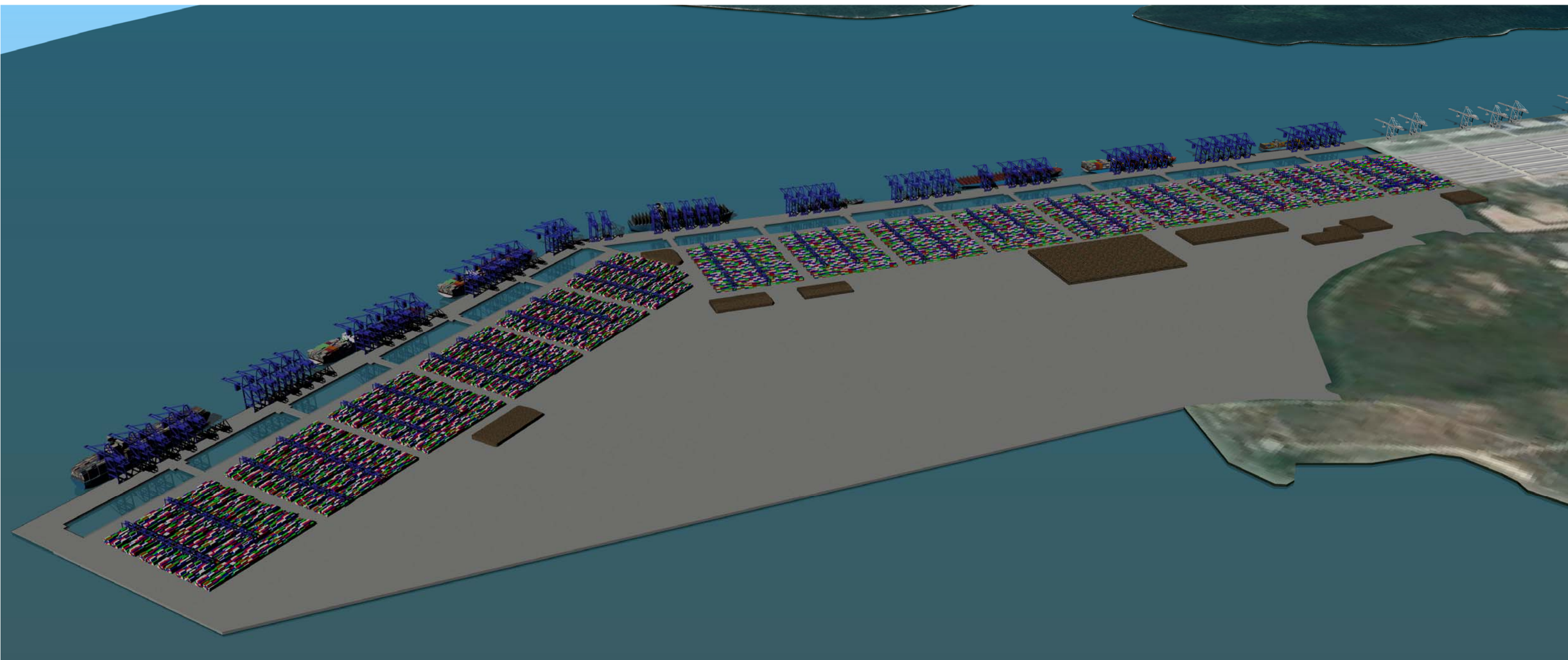


Figure 2-4 3D-Rendered Image of Final Layout - View from South West

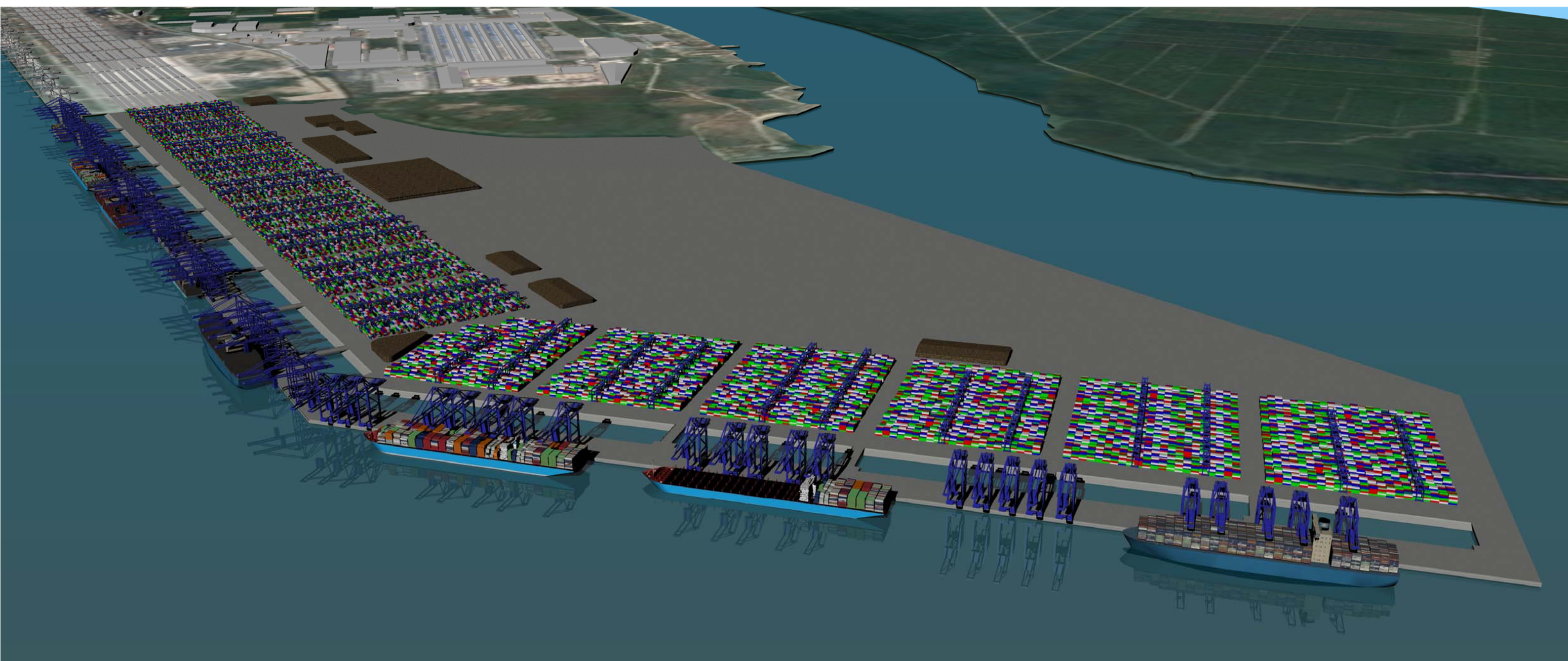
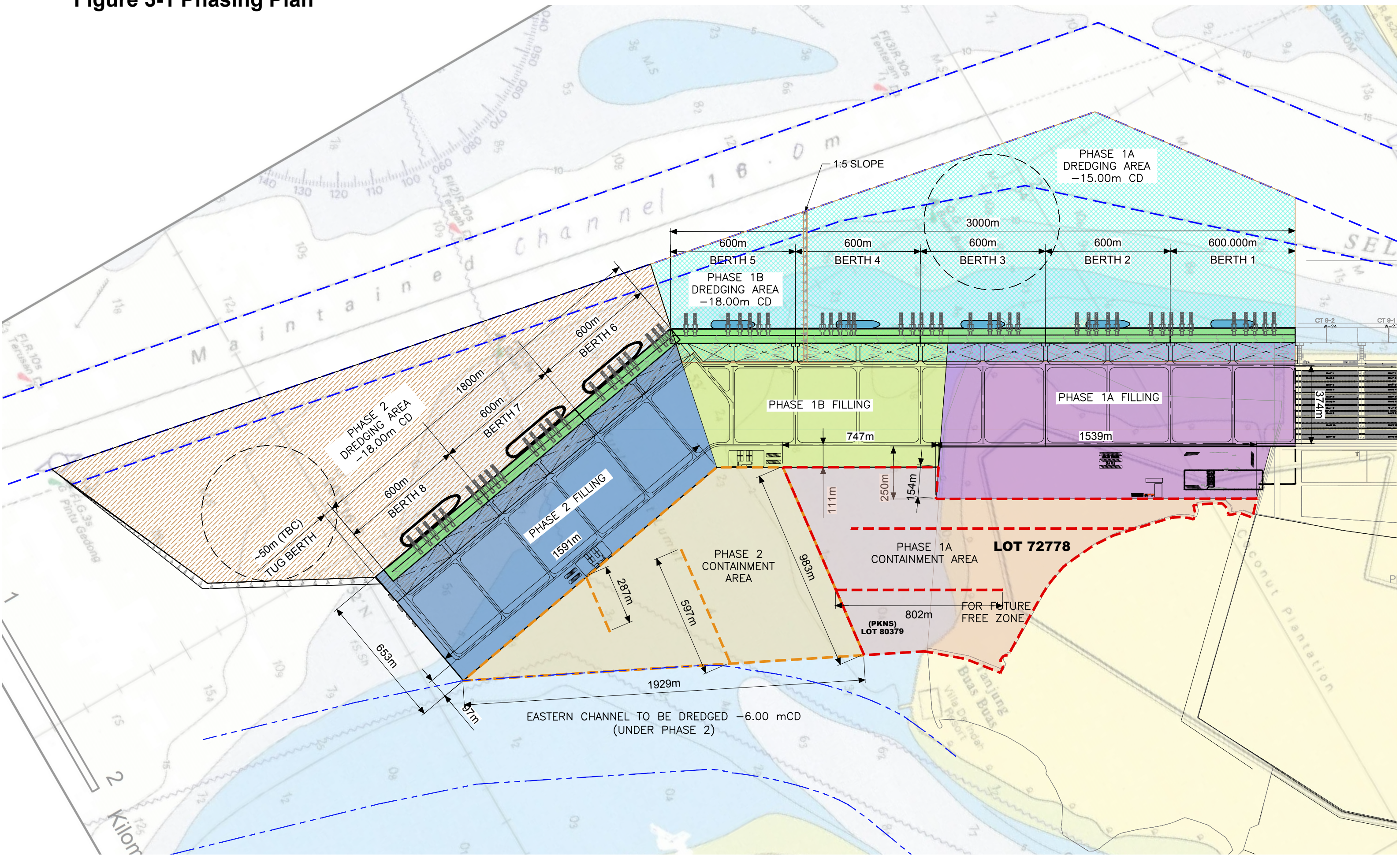


Figure 3-1 Phasing Plan



Appendix A

Layout Option Workshop Presentations

1st Layout Option Workshop

Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10 - CT19

Layout Option Workshop

Date: 30 May 2018



Agenda

1	Sizing for Terminal Expansion
2	Existing Conditions
3	Evaluation of Current Layout
4	Approach for Developing the Alternative Layout Option
	(i) DEFINE Design Criteria and Weighting
	(ii) DEVELOP Options based on Layout Forms and Variations
	(iii) RANK Options based on Design Criteria
	(iv) RECOMMEND Preferred Option
5	Next Steps
6	Q & A
7	Appendix



Sizing for Terminal Expansion

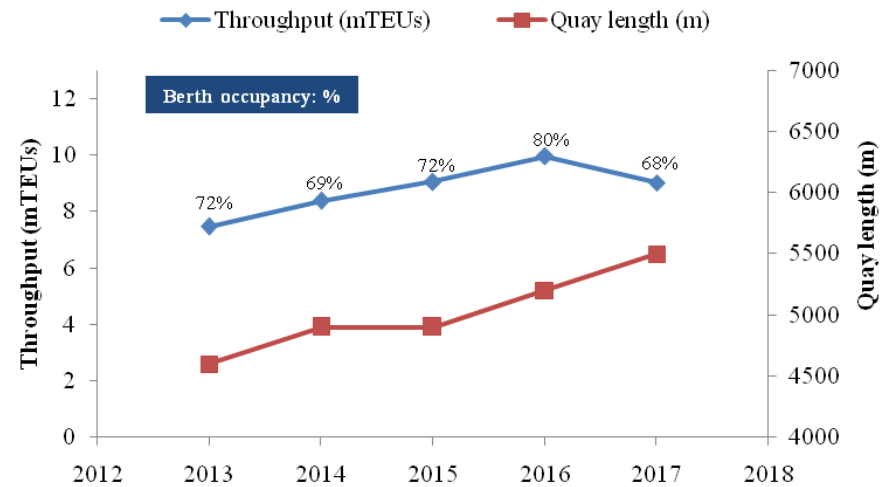
Quay Productivity of Westports

- Recent historic quay annual productivity varies between 2,030 to 2,309 TEUs/m
- Some scope in upwards berth utilization stretch
- Expected that TEUs exchange per vessel continue to increase, quay productivity expected to increase
- Quay productivity of **2,500 TEUs/meter** is appropriate for future planning.

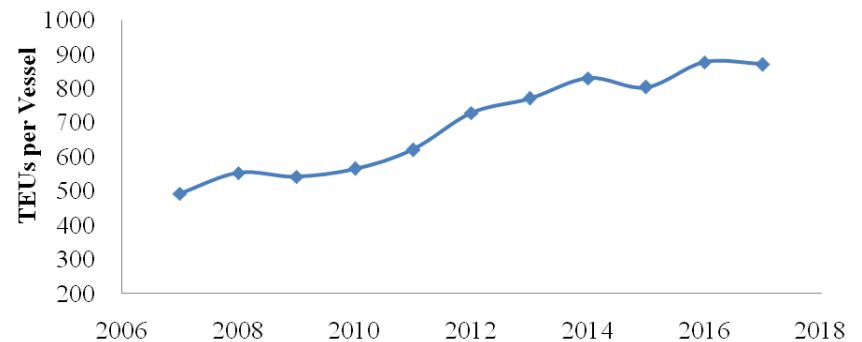
Maximum Quay Productivity (TEUs/m)

2013	2014	2015	2016	2017
2,030	2,228	2,309	2,153	2,171

Throughput, Quay Length and Berth Occupancy



TEUs Exchange per Vessel of Westports



Terminal Area Productivity of Westports

Terminal productivity of Westports:

- Terminal area: 187 hectares
- Ground slots: 46,922
- Average transit time: **8.0 days.**

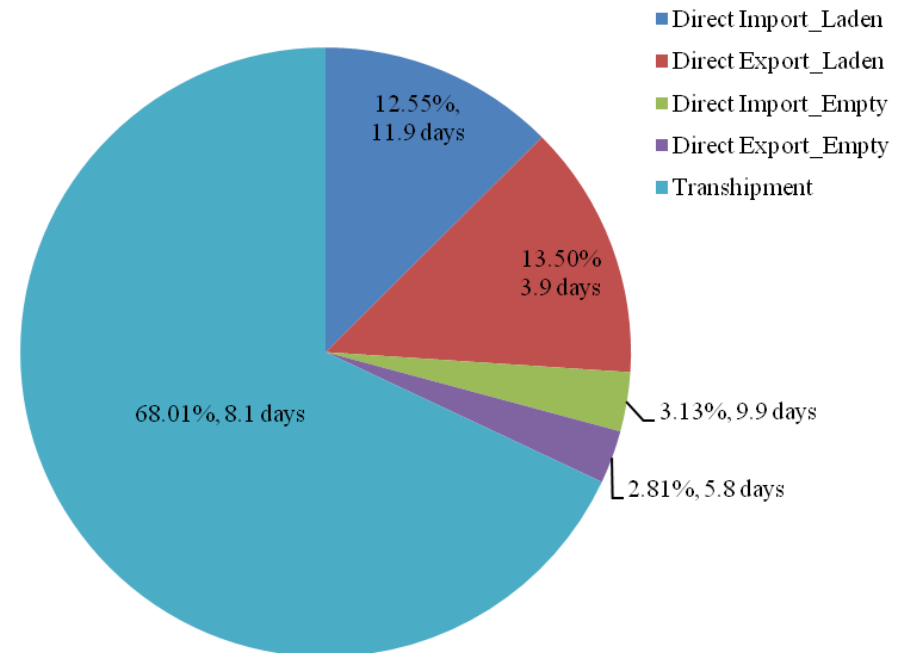
Planning parameters:

- Max stacking height (laden): 1 over 5
- Max stacking height (empty): 1 over 6
- Ratio of average to max height: 0.85
- Reserve capacity safety factor: 1.1

Terminal area productivity: 60,858 TEUs/Ha

- **60,000 TEUs/Ha** for planning assuming current mix of cargo
- **80,000 TEUs/Ha** for planning assuming Westports II to handle 90% transshipment

Throughput Share and Transit Time by Cargo Type of Westports



Quay Length and Terminal Area Requirement for Expansion

- **Scenarios** for Expansion Capacity Planning:
 - Plan I: 15 million TEUs
 - Plan II: 20 million TEUs
 - **Plan III: 20 million TEUs (90% transshipment)**
- After discussion on working level workshop, **Plan III** meets most of the requirement (target capacity with reduced land requirement)
- The requirements are **tentative and subject to changes in:**
 - Finalised forecast of cargo mix (direct vs transshipment)
 - Trend analysis of vessel size
 - Design of handling system

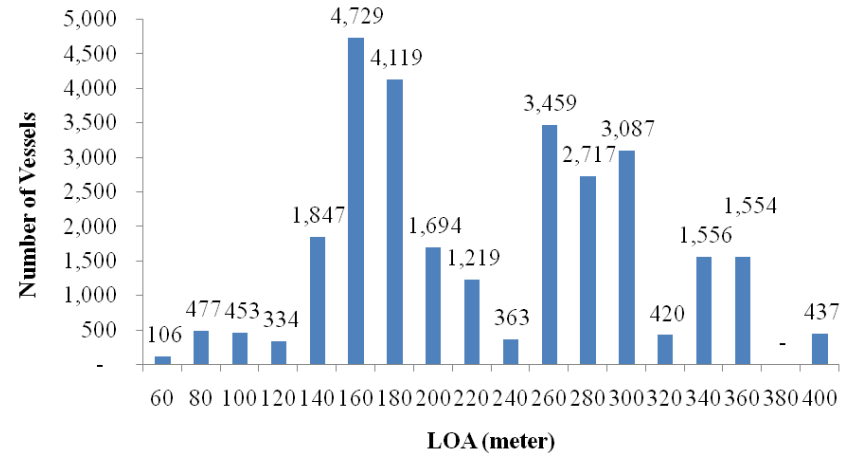
Quay Length and Terminal Area Requirements for Expansion

Capacity Plans	Capacity (m TEUs)	Quay Length (m)	Terminal Area (Ha)
I	15	6,000	250
II	20	8,000	330
III	20	8,000	250

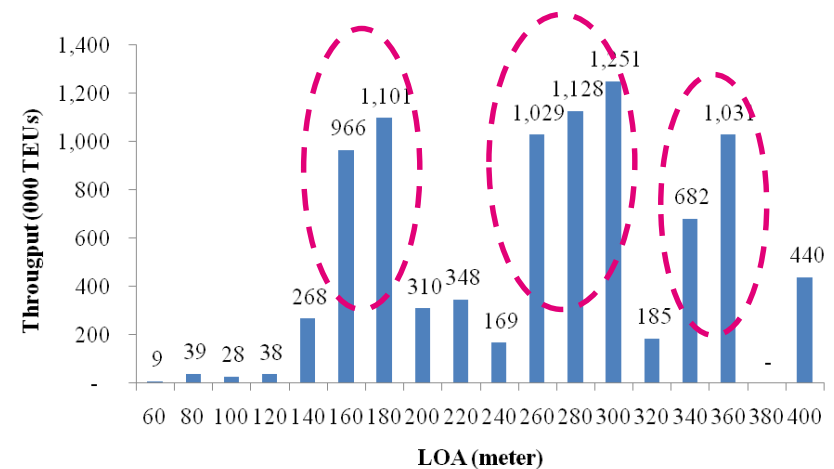
Planning of Berth Scale

- Analysis of vessel calls show that the following vessel groups dominate the throughput in Westports:
 - LOA 160~180m
 - LOA 260~300m
 - LOA 340~360m
- Expanded terminals should provide flexibility in accommodating largest vessels
- Nominal 400m long berths are suggested

Number of Vessel by Vessel Size (2017)



Throughput by Vessel Size (2017)



Design Module Block

Meeting the Capacity

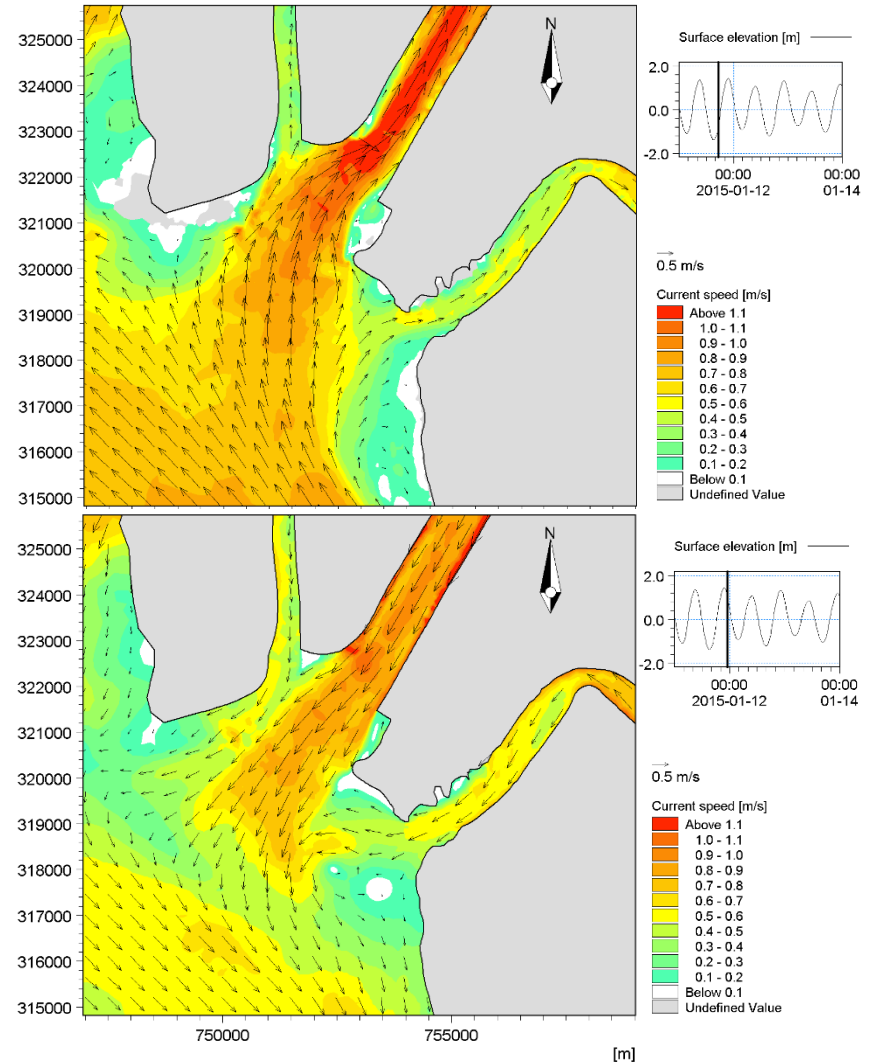
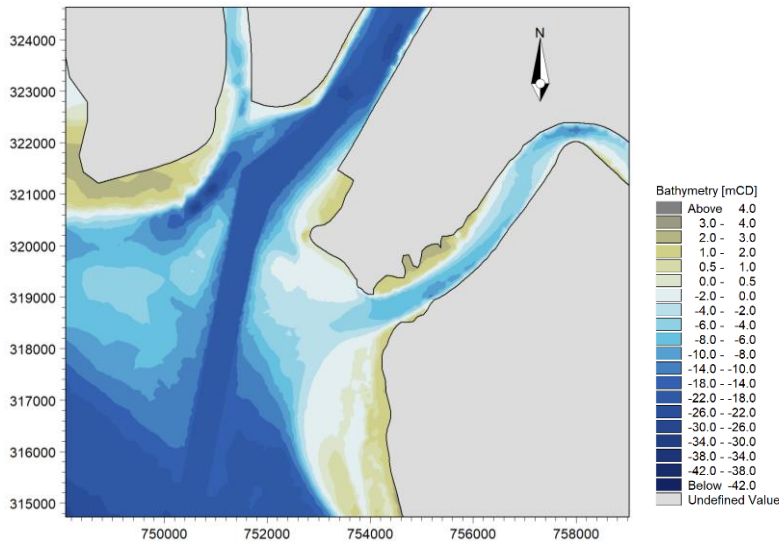
- Based on target capacity hence defining the total quay length and terminal area required
- Assign a typical berth length, calculate the number of berth required
- Calculate the required area and length behind each berth

Existing Capacity	Additional Capacity	Quay Length	Terminal Area	Berth Length	No. of Berth	Back up Area Per Berth	Length Behind Berth
(million TEUs)	(million TEUs)	(m)	(Ha)	(m)	(nos)	(Ha)	(m)
15	15M @ 70% Transhipment	6,000	250	400	15	17	425
15	20M @ 70% Transhipment	8,000	330	400	20	17	425
15	20M @ 90% Transhipment	8,000	250	400	20	12.5	315

Existing Conditions

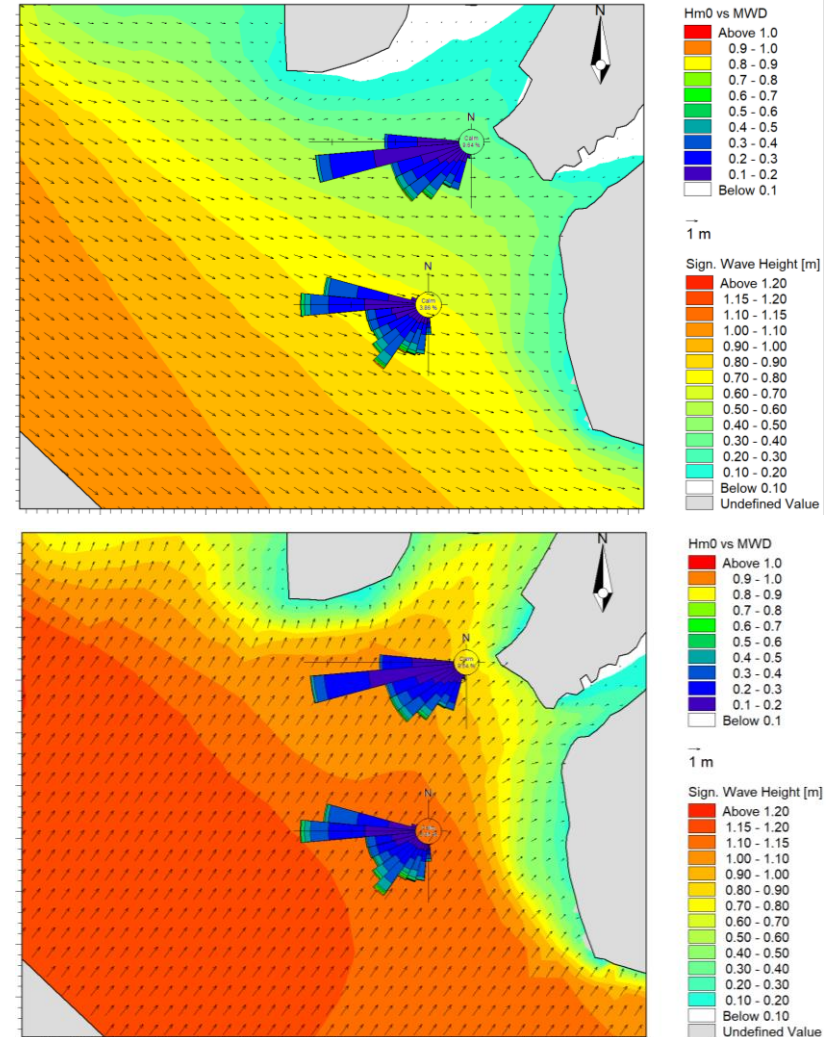
Current Regime

- Complex flow field
- Strong ebb and flood currents
- Current speeds exceeding 1 m/s (around 2 knots)



Wave Regime

- Wave climate is mild, however offshore wave heights can exceed 1m
- Existing berths have minimal wave exposure
- Outer areas are exposed to waves and mainly propagated from S-SW direction
- High waves could cause operational downtime – coupled with tidal range moorings may not effectively restrict vessel motions.

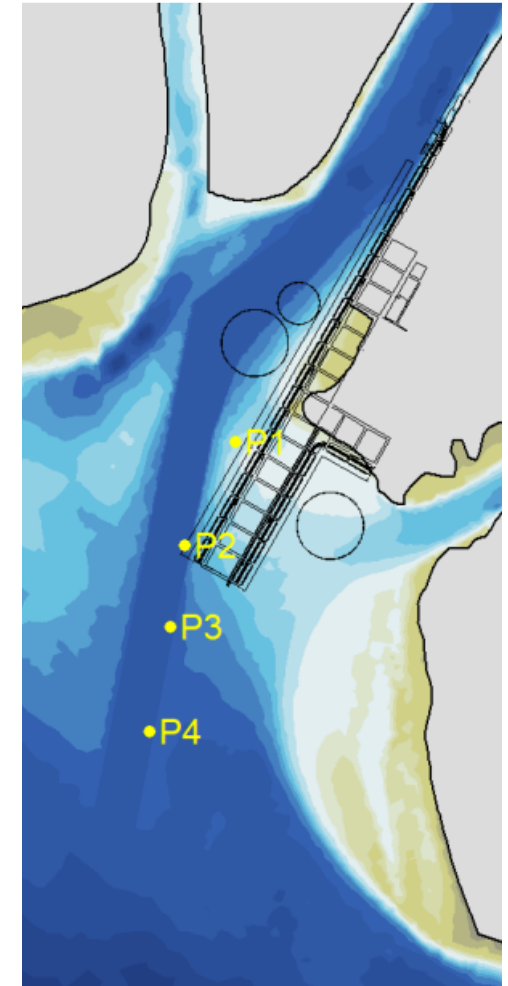


Wave Regime

- PRELIMINARY wave assessment of wave environment:

Exceedance of wave height (m)	P1 (%)	P2 (%)	P3 (%)	P4 (%)
1	0.0	0.1	0.3	0.3
0.75	0.3	0.7	0.9	1.1
0.5	2.0	4.8	6.7	8.9

- Target based on vessel motions, notably surge < 0.4m
- Limiting wave heights likely to be in order of 0.75m
- Exceedance approximately 1% of time (3-4 days / year)
- Acceptable to extend to SW, but greater efficiency of operations if berths are sheltered.



Other Expansion Constraints

Maintain Navigation Corridor

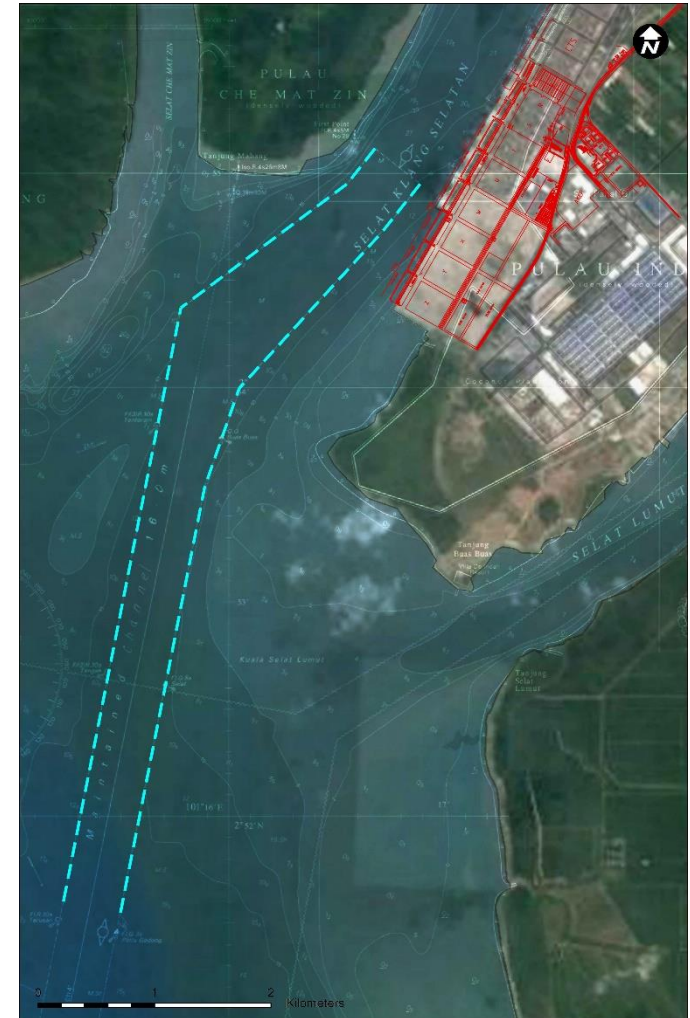
- North West of Westports - South Channel (Selat Kelang Selatan)
- South East of Westports - Selat Lumut

Port Operation

- Strong tidal current along South Channel
- Allow waterspace for Turning Circle
- Allow water depth for Vessel Mooring

Engineering/Geotechnical

- Reclamation Size
- Quay Design
- Maintenance dredging



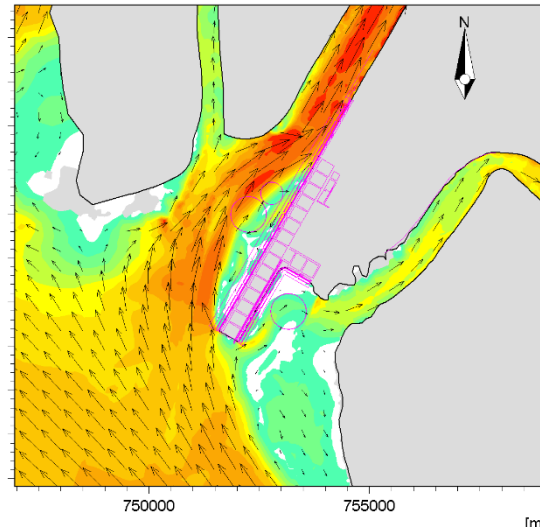


Evaluation of Current Layout

Views on Initial Layout

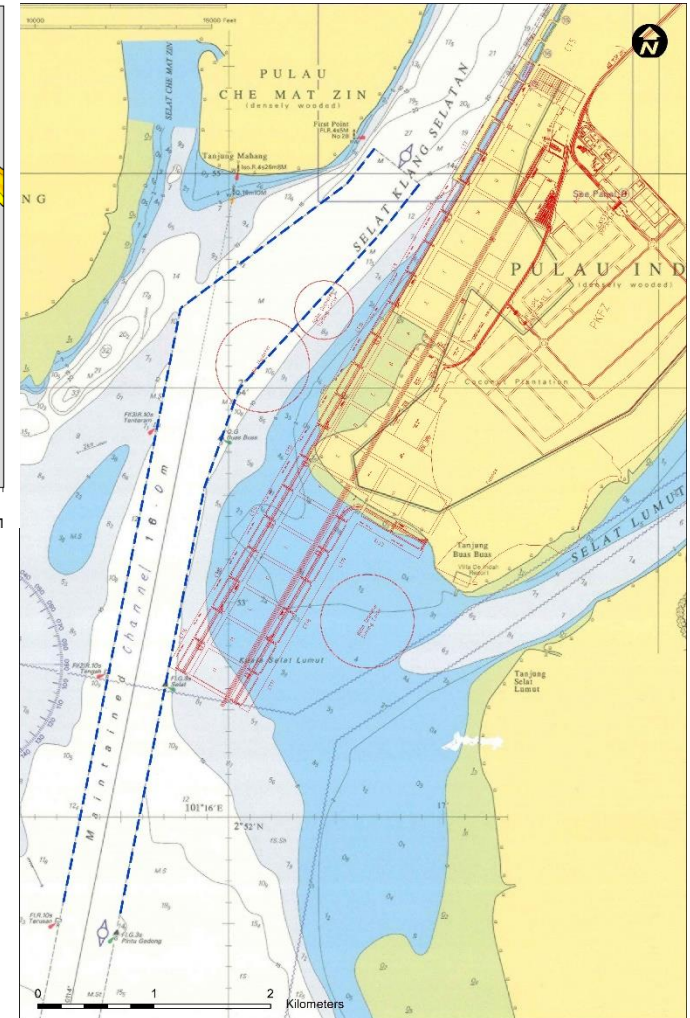
Hydrodynamic

- Projection into the stream creates eddies along the main face
- Major deposition in the “L” shaped basin



Proposed Alternate Design Principal

- Based on design parameter reflecting operational features & achievable efficiency
- Avoid “Corner” creating eddies
- Modified elongated shape to “stubby” shape





Alternative Layout Options

Define Design Criteria and Weighting

Design Criteria	Description	Assessment Measure	Weighting
Quay Connectivity	Efficiency on the use of quay length; i.e. alignment and connection with terminal back up area	Continuous quay is preferred	1 2 3 4 5
Usage of Reclamation Area	Efficiency on use of reclaimed area; i.e. ratio for reclaimed land vs terminal back up area	Higher ratio is preferred	1 2 3 4 5
Southwest Projection	Extent of intrusion, impacting marine traffic and hydrodynamics	Least projection is preferred	1 2 3 4 5
Impact on Existing Users	Review impact on South Channel and Selat Lumut	Number of berths on western face	1 2 3 4 5

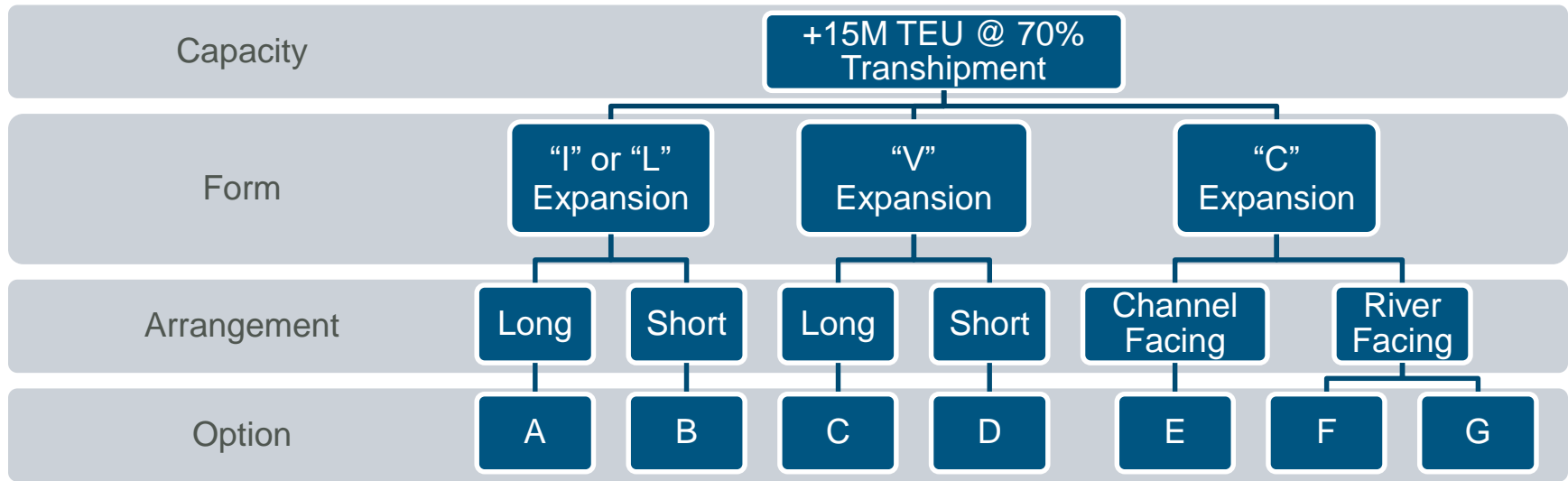
Note: At present no weighting has been given to these criteria – to be reviewed.



Expansion for +15M TEUs (Terminal Area 250 ha)

Layout Forms and Variations

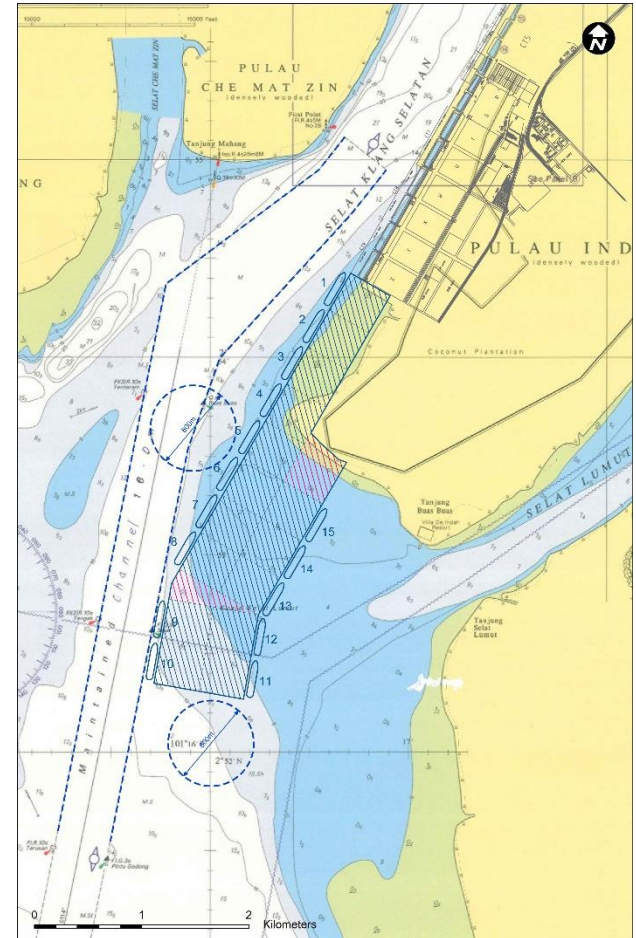
- **Continue Finger Pier** – Option “I” and Option “L”
- **Develop Non Parallel Piers** – Option “V”
- **Develop Indented berths** – Option “C”
- Possible hybrid of different forms to be developed



Option A – “I” Long





Design Criteria	Score
Quay Connectivity	●
Reclamation Area	●
Southwest Projection	◐
Impact on Existing Users	◑

Efficient but obtrusive

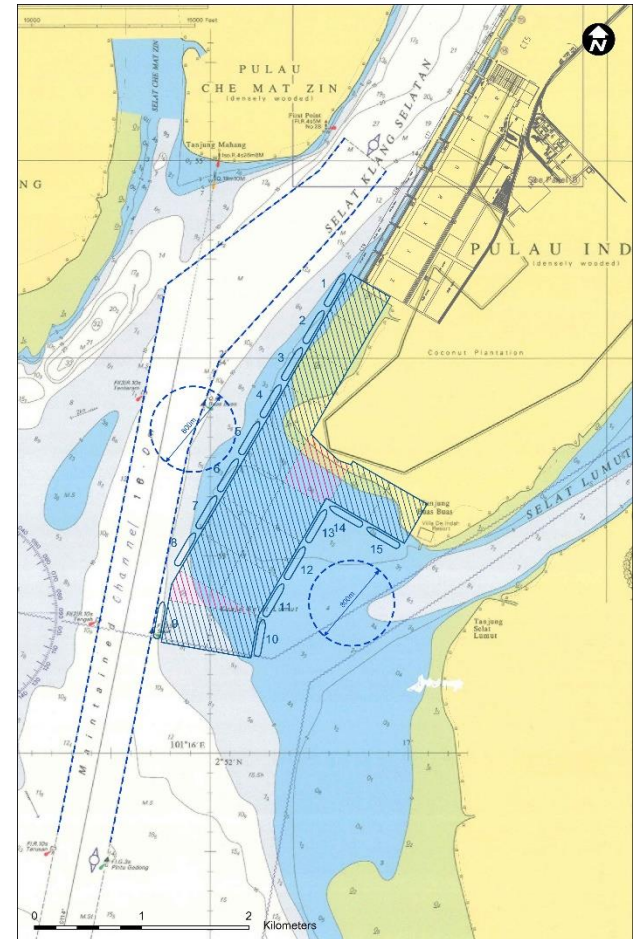


250 ha (terminal area) + 40 ha

Option B – “L” Long

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Compact, but less efficient

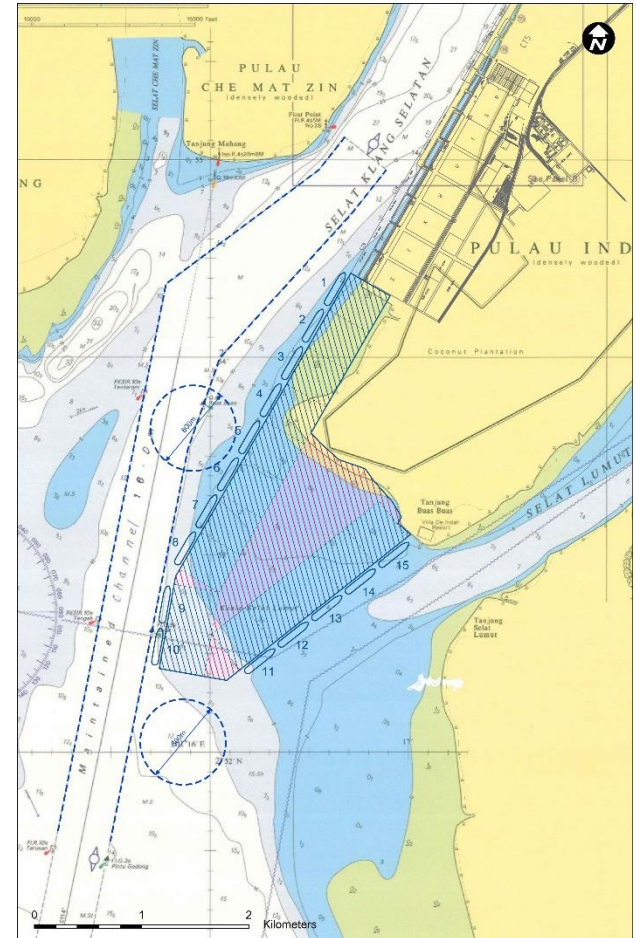


250 ha (terminal area) + 31 ha

Option C – “V” Long

Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◒

Creates additional back-up land (at a cost)

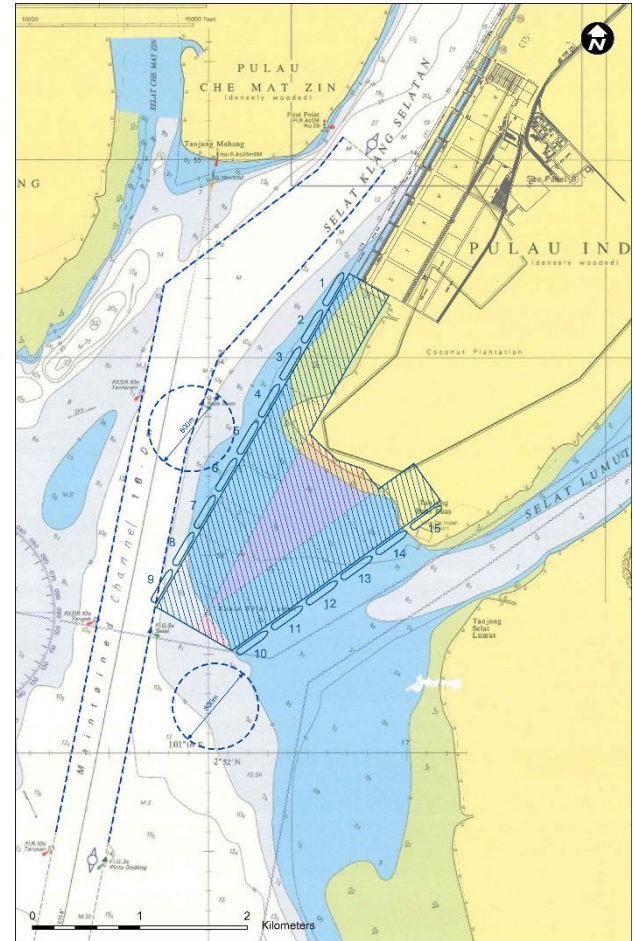


250 ha (terminal area) + 127 ha

Option D – “V” Short





Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◑

Less additional reclamation

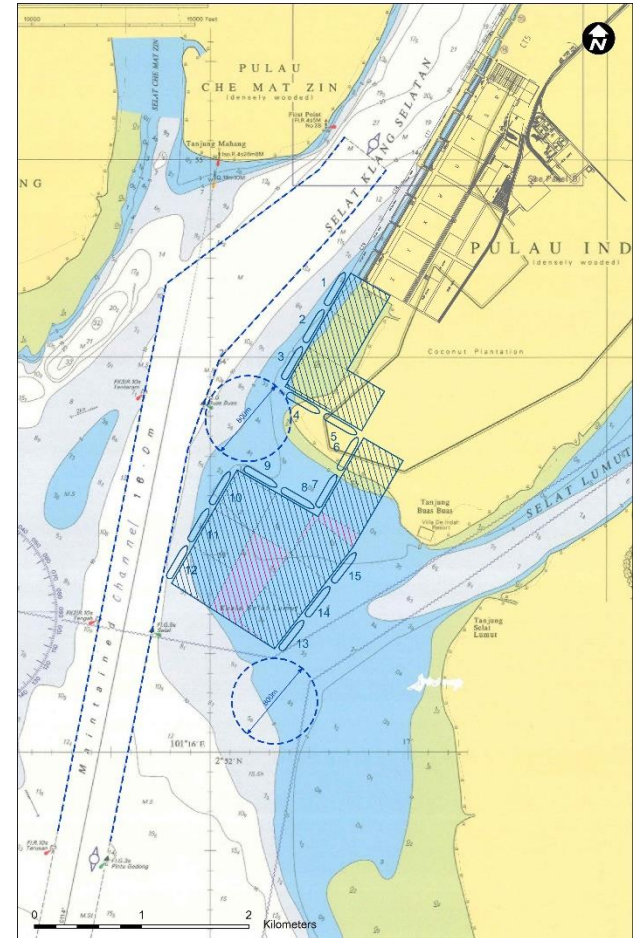


250 ha (terminal area) + 73 ha

Option E - "C" Channel Facing


Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Reduces extension South, at cost of less efficient berth orientation

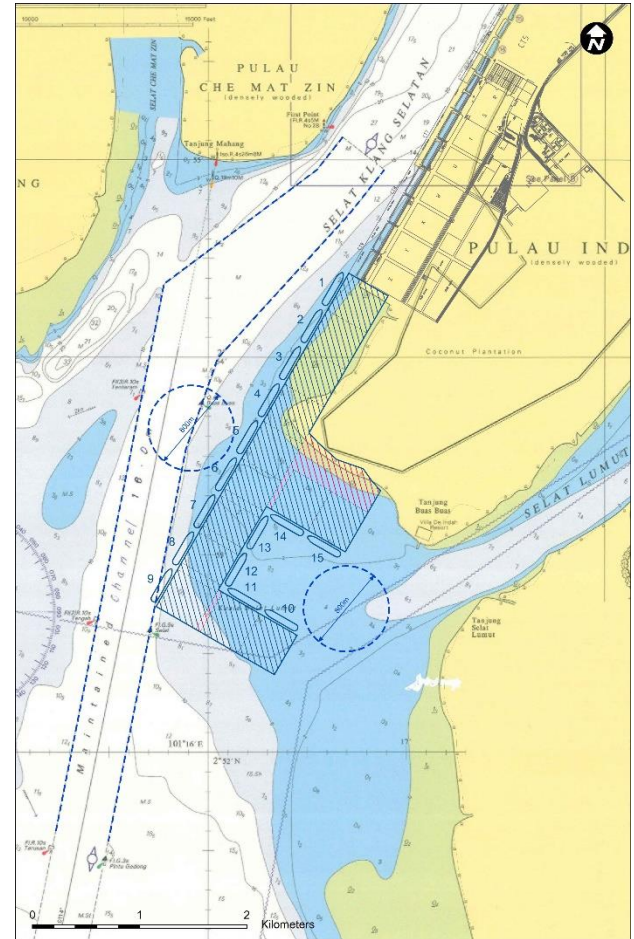


250 ha (terminal area)

Option F – “C” River Facing





Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Reduces extension South, S basin subject to siltation?

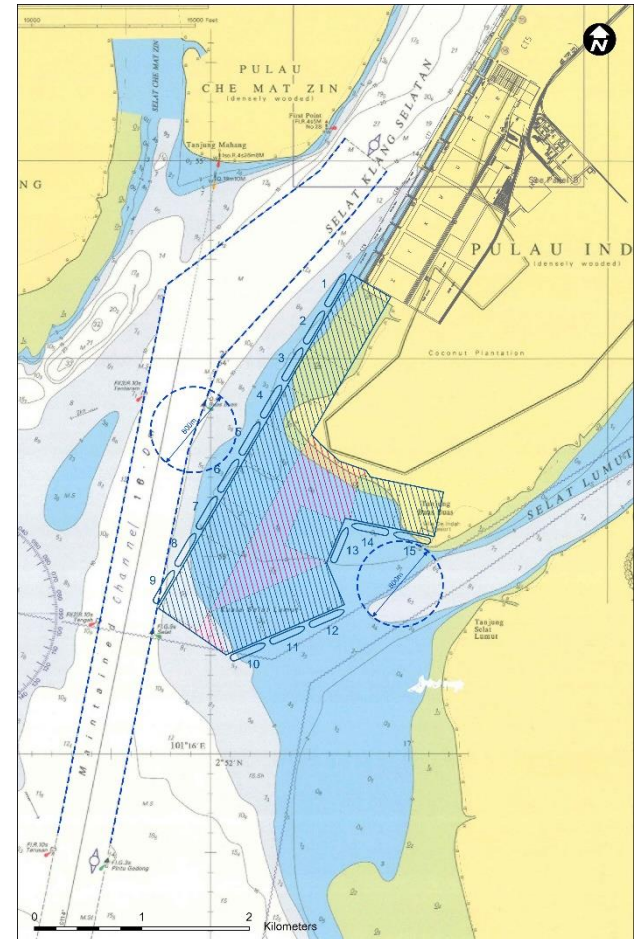


250 ha (terminal area) + 8 ha

Option G – Combined “V” & “C”

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

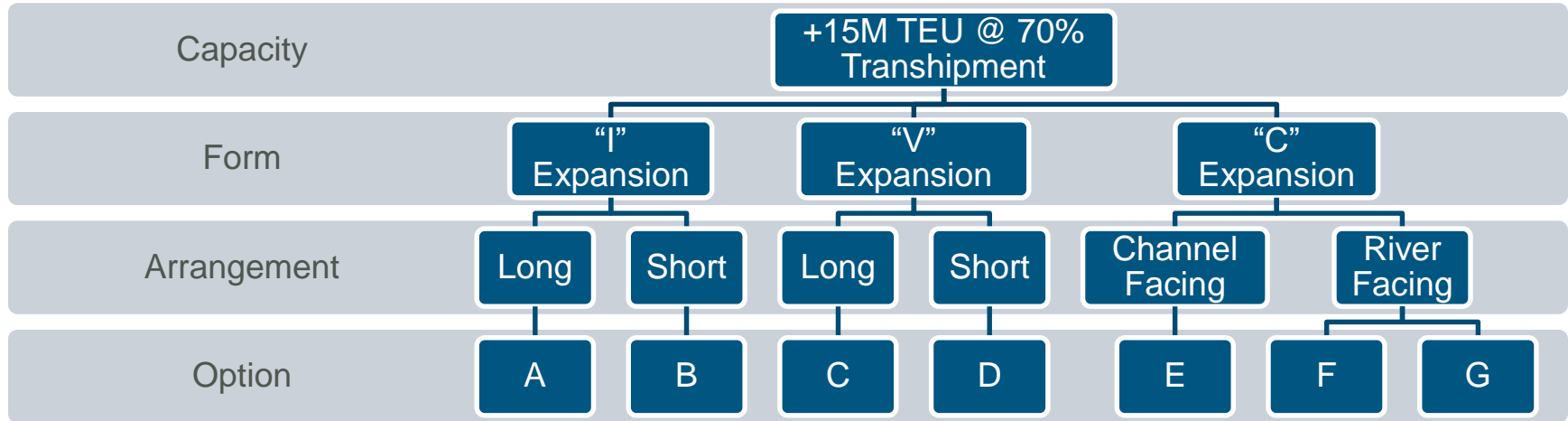
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250 ha (terminal area) + 71 ha

Ranking

Legend: ● Best ◐ > Ave' ◑ < Ave' ◒ Least



Qualitative Ranking

Criteria	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Quay Length	●	◐	●	●	◑	◑	◑
Reclamation Area	●	●	◐	◐	◐	◐	◐
Southwest Projection	◑	◑	◑	◑	◐	◑	◐
Impact on Existing Users	◑	◐	◑	◑	●	◐	●

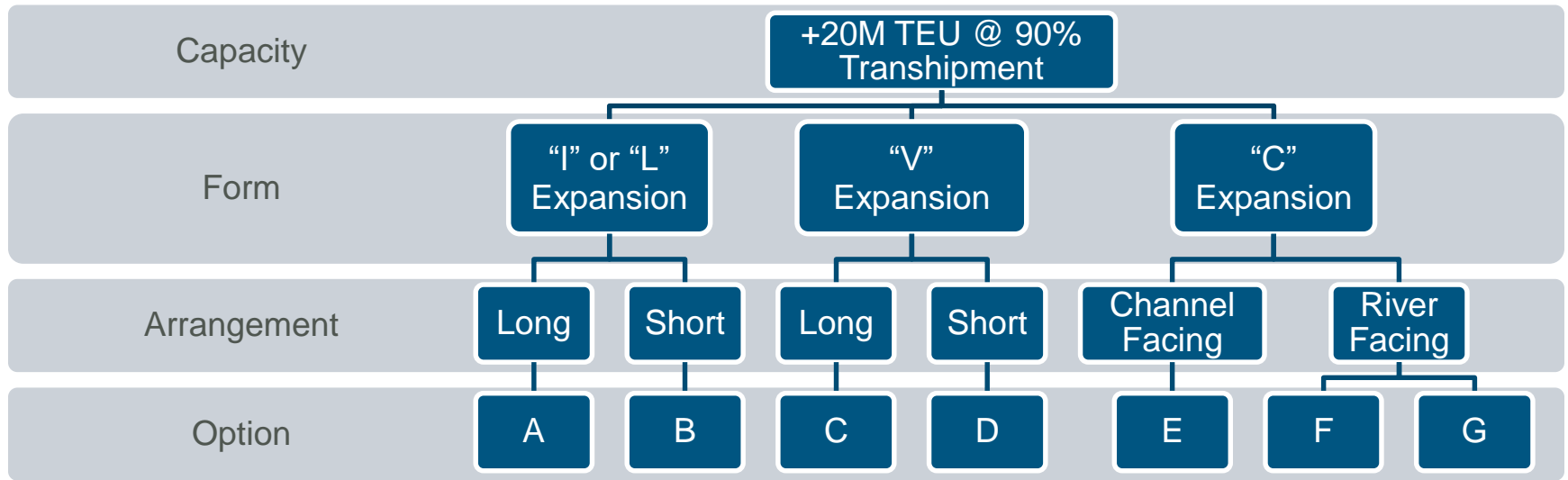
Options with “V” shape or basins appear to rank strongly as they set berths away from marine activity, and require less southern projection, but basins may be subject to siltation.



Expansion for +20M TEUs (Terminal Area 250 ha)

Layout Forms and Variations

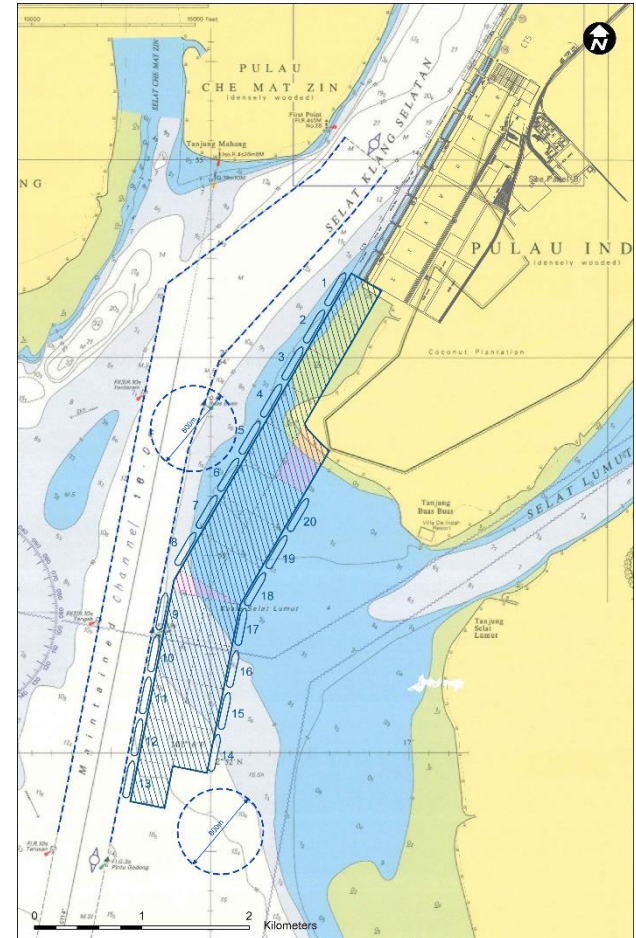
- **Continue Finger Pier** – Option “I” and Option “L”
- **Develop Non Parallel Piers** – Option “V”
- **Develop Indented berths** – Option “C”
- Possible hybrid of different forms to be developed



Option A – “I” Long





Design Criteria	Score
Quay Connectivity	●
Reclamation Area	●
Southwest Projection	◐
Impact on Existing Users	◐

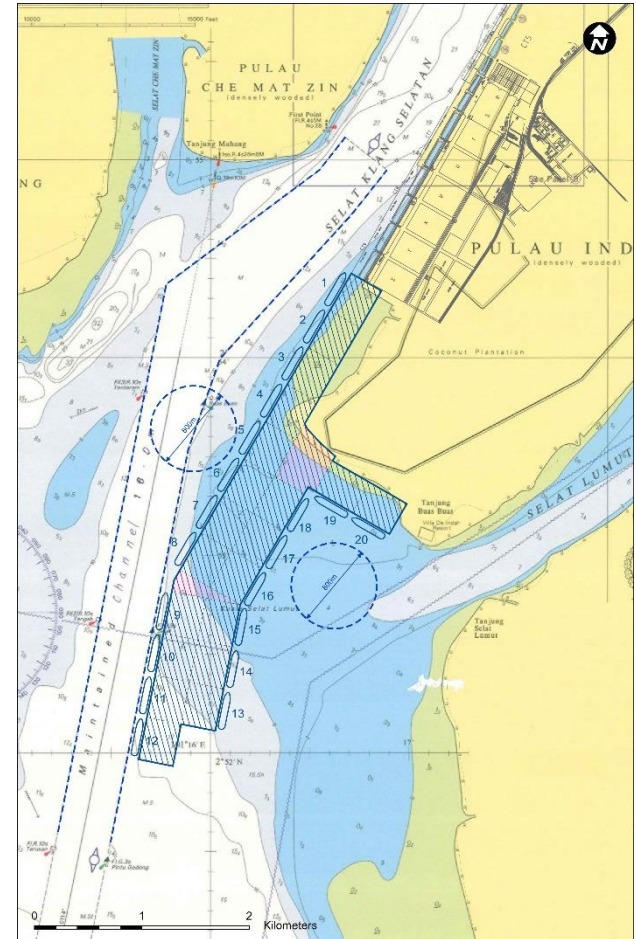
Ultra extreme extension with multiple berths on western face



250 ha (terminal area) + 50 ha

Option B – “L” Long

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	
<p style="text-align: center;">More compact, but still significant extension</p>	

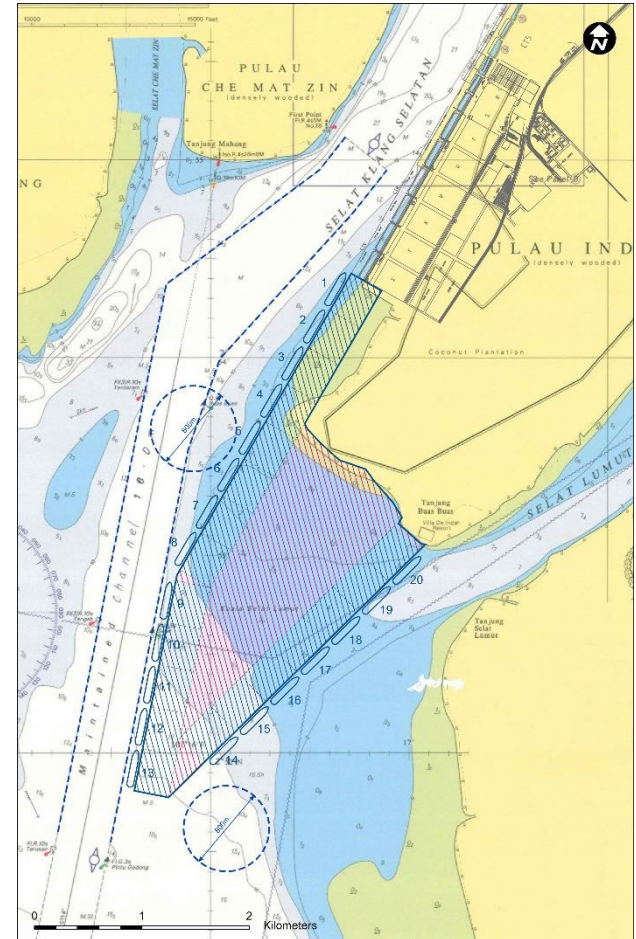


250 ha (terminal area) + 55 ha

Option C – “V” Long

Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◑

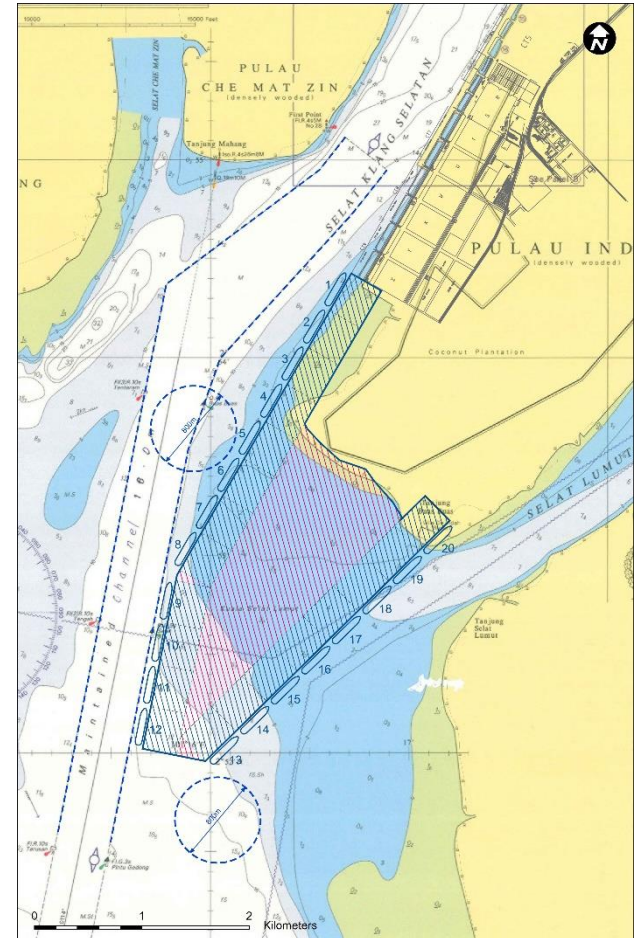
Creates additional back-up land, major dredging needed for east access



250 ha (terminal area) + 266 ha





Option D – “V” Short

Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◑
<p style="text-align: center; background-color: #4F7942; color: white; padding: 10px; border-radius: 15px;">Less additional reclamation</p>	

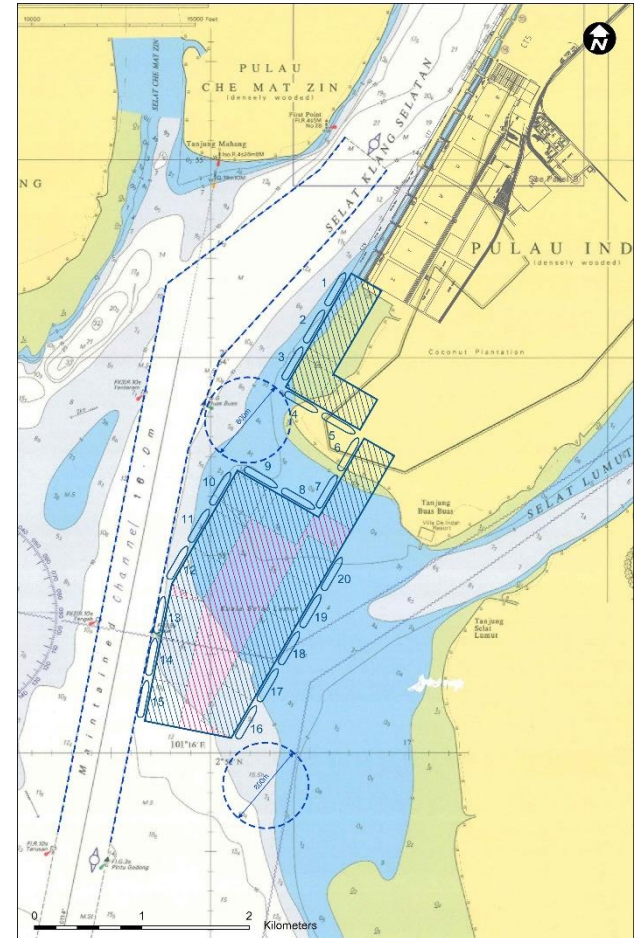


250 ha (terminal area) + 248 ha

Option E - "C" Channel Facing





Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Reduces extension South, at cost of less efficient berth orientation

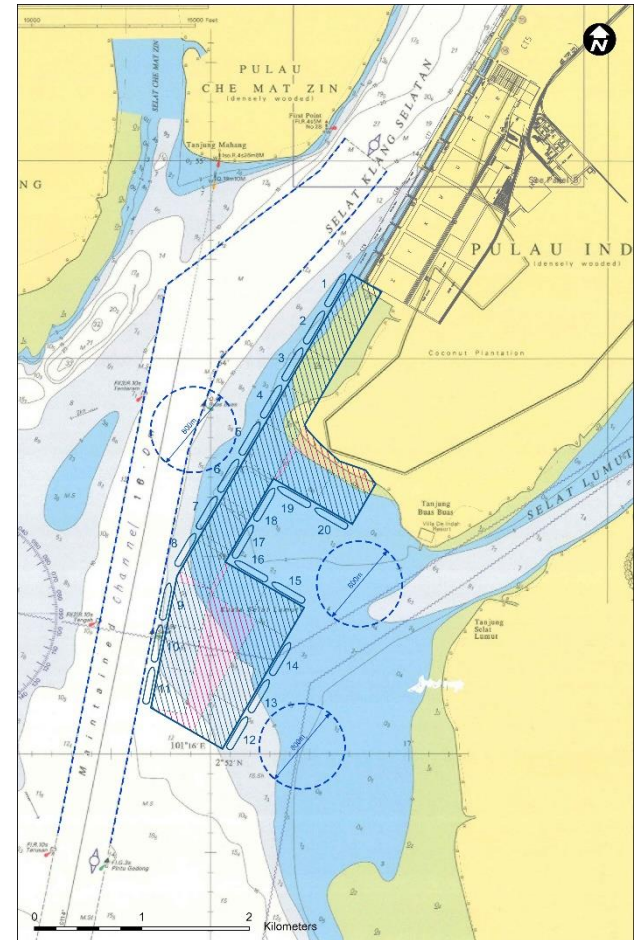


250 ha (terminal area) + 85 ha

Option F – “C” River Facing





Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Inefficient berth utilisation on east face

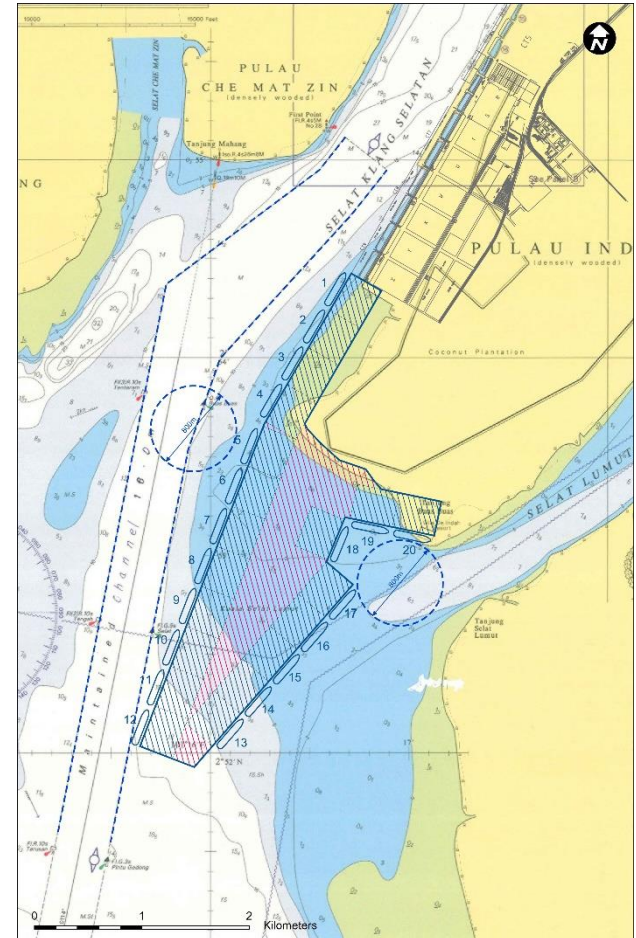


250 ha (terminal area) + 59 ha

Option G – Combined “V” & “C”

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

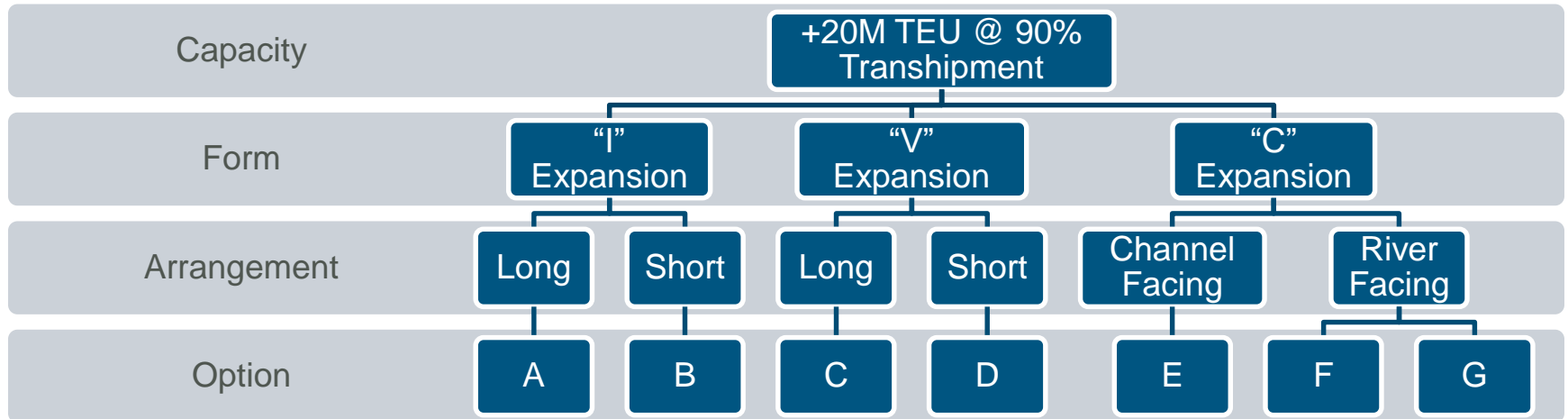
Hybrid does not capture additional value



250 ha (terminal area) + 144 ha

Ranking

Legend: ● Best ◐ > Ave' ◑ < Ave' ◒ Least



Qualitative Ranking

Criteria	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Quay Length	●	◐	●	●	◑	◑	◑
Reclamation Area	●	●	◐	◐	◐	◐	◐
Southwest Projection	◑	◑	◑	◑	◑	◑	◑
Impact on Existing Users	◑	◑	◑	◑	◐	◑	◐

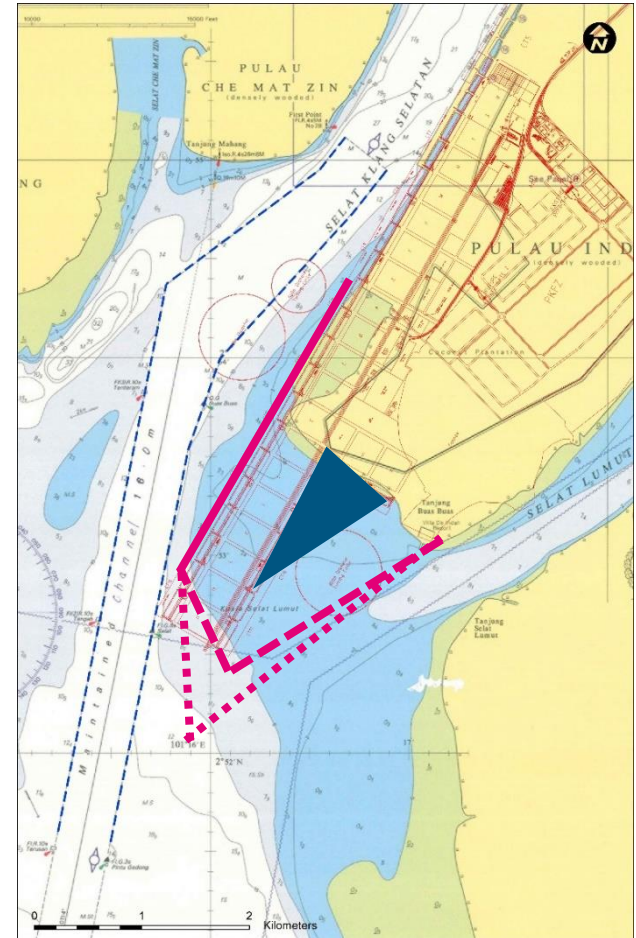
No clear favourite, as extent of projection challenges layout within constrained space.

Commentary

- All the options see significant southward extension
- Challenges are met fitting in an additional 8,000m of quayside required to meet +20M TEU capacity
- Options with berths away from the main “Southern Channel” appear to be favoured
- Basins / Berths concentrated to the east impact existing operations the least.
- Wave exposure is not extreme, but sheltered berths will always be more efficient.
- Designs will be taken forward that maximise eastern berthing space.

Design Direction?

- Maximise berths away from the main “Southern Channel”
- Southern projection reduced as far as possible
- Navigation corridor through Selat Lumut is maintained
- Continuous quay length – further optimisation required
- Use central area for contained sediment disposal?
- Essentially, extension and filling on existing SW tip of Pulau Indah



Next Steps & Decisions to be made

Next Steps

- **Design Development & testing**

for this we need:

Developing the Options

- **Focus on designs extending the SW corner of Pulau Indah (“V” expansion)?**

Sizing the Options

- **Design for 15M (70% transshipment) or 20M TEU additional (70 or 90% transshipment) ?**

Q & A

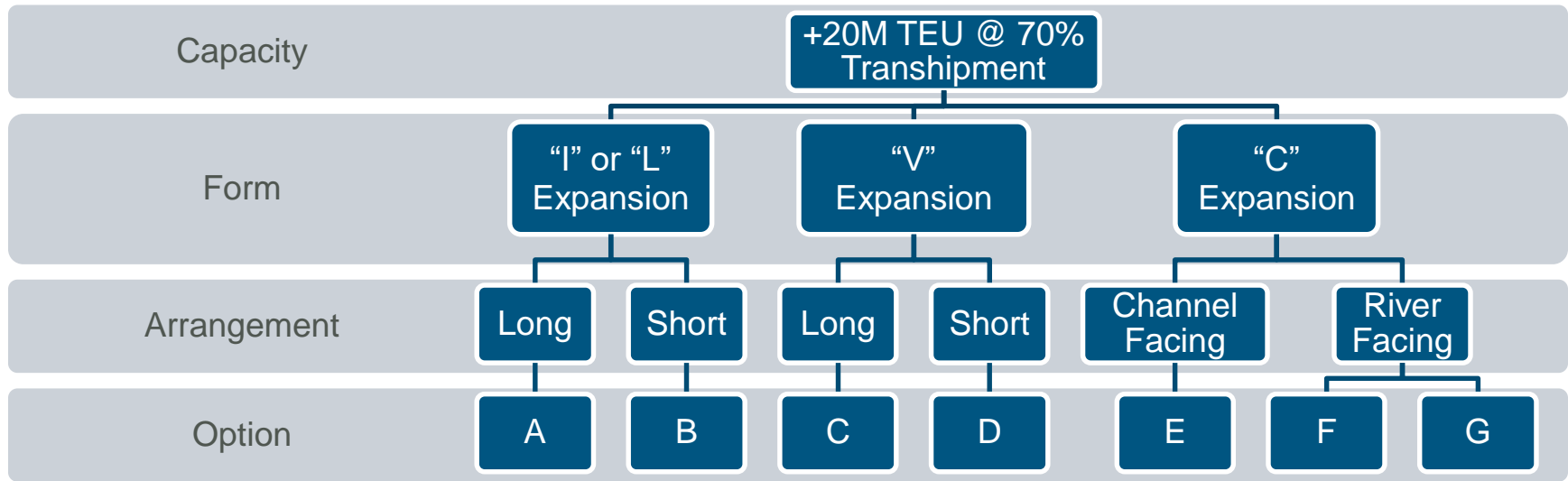
Appendix



Expansion for +20M TEUs (Terminal Area 330 ha)

Layout Forms and Variations

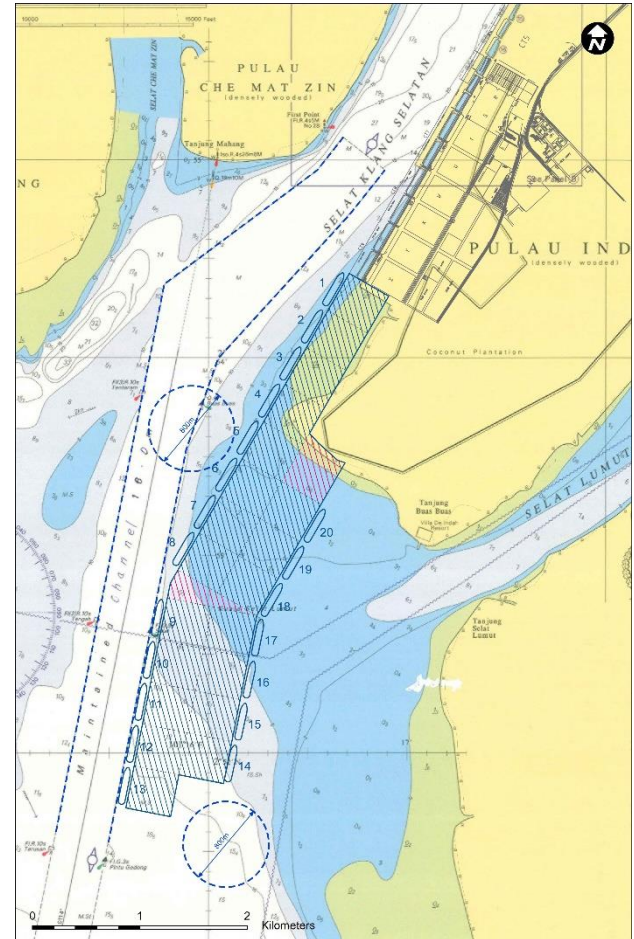
- **Continue Finger Pier** – Option “I” and Option “L”
- **Develop Non Parallel Piers** – Option “V”
- **Develop Indented berths** – Option “C”
- Possible hybrid of different forms to be developed



Option A – “I” Long





Design Criteria	Score
Quay Connectivity	●
Reclamation Area	●
Southwest Projection	◐
Impact on Existing Users	◐

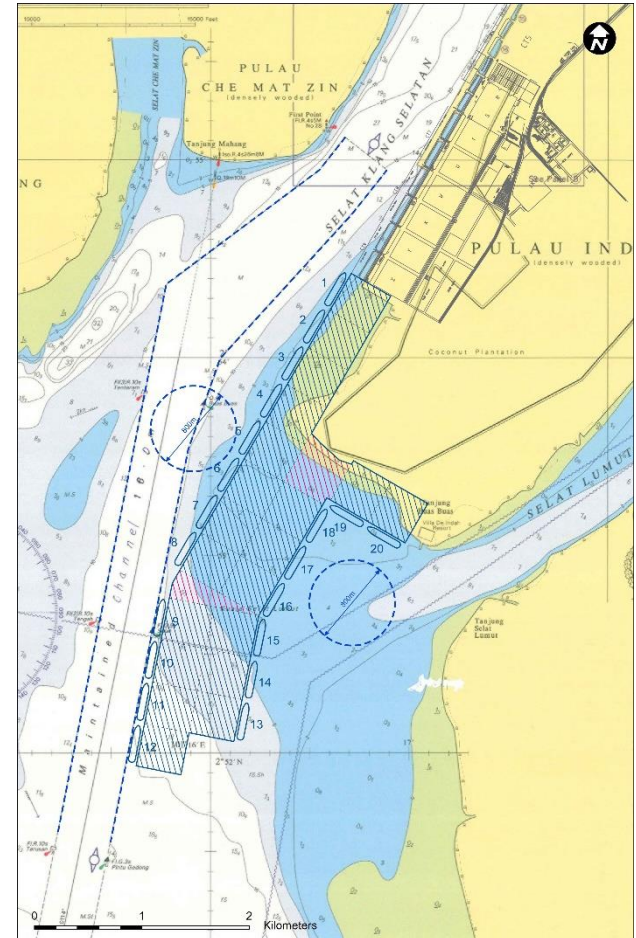
Extreme extension with multiple berths on western face



330 ha (terminal area) + 44 ha

Option B – “L” Long

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	
<div style="background-color: #4a695d; color: white; padding: 10px; border-radius: 15px; text-align: center;"> <p>More compact, but significant extension</p> </div>	

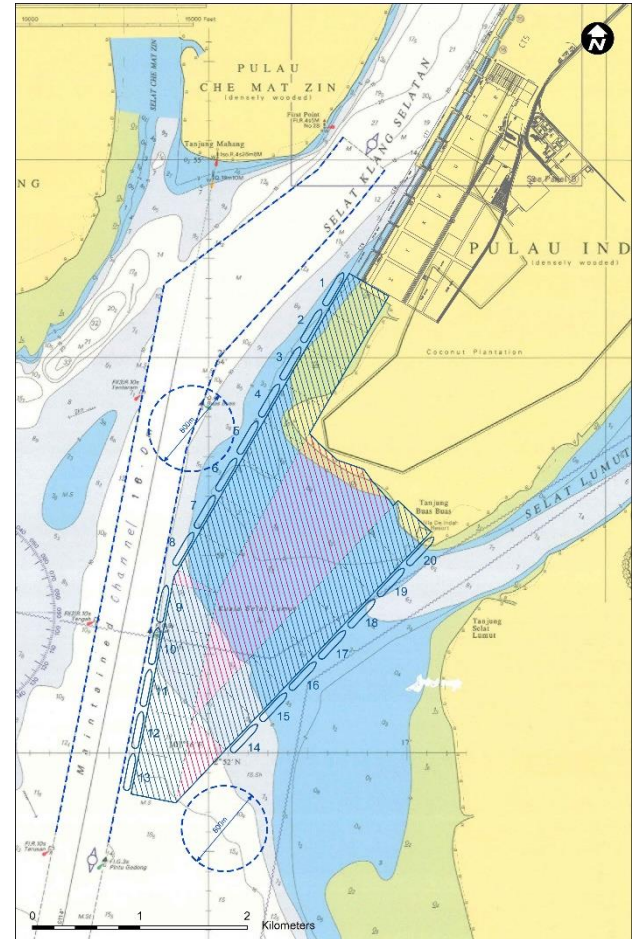


330 ha (terminal area) + 35 ha

Option C – “V” Long

Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◑

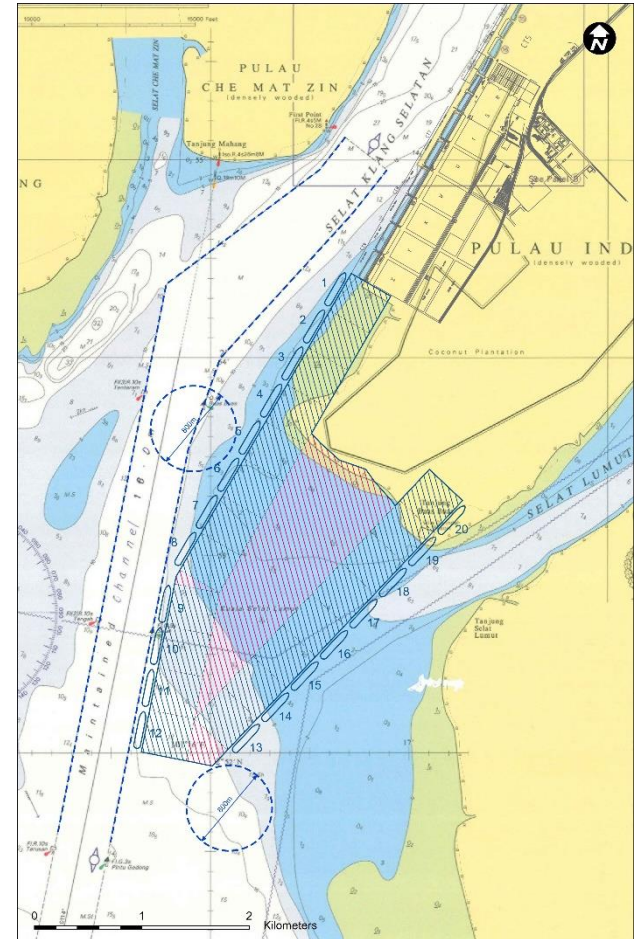
Creates additional back-up land, major dredging needed for east access



330 ha (terminal area) + 200 ha





Option D – “V” Short

Design Criteria	Score
Quay Connectivity	●
Reclamation Area	◐
Southwest Projection	◑
Impact on Existing Users	◑
<div style="background-color: #556b2f; color: white; padding: 10px; text-align: center; border-radius: 15px;"> <p>Less additional reclamation</p> </div>	

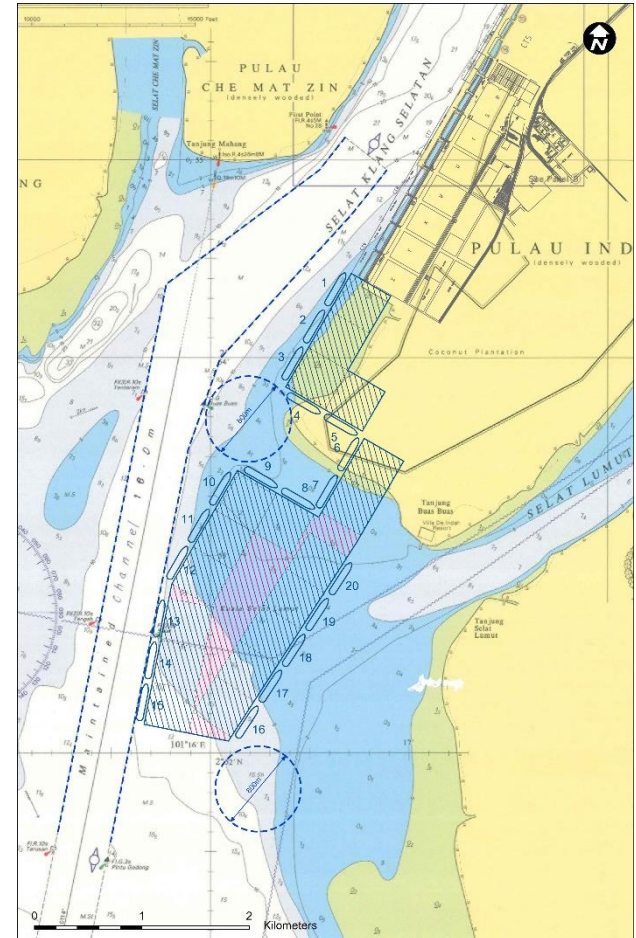


330 ha (terminal area) + 178 ha

Option E - "C" Channel Facing





Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Reduces extension South, at cost of less efficient berth orientation

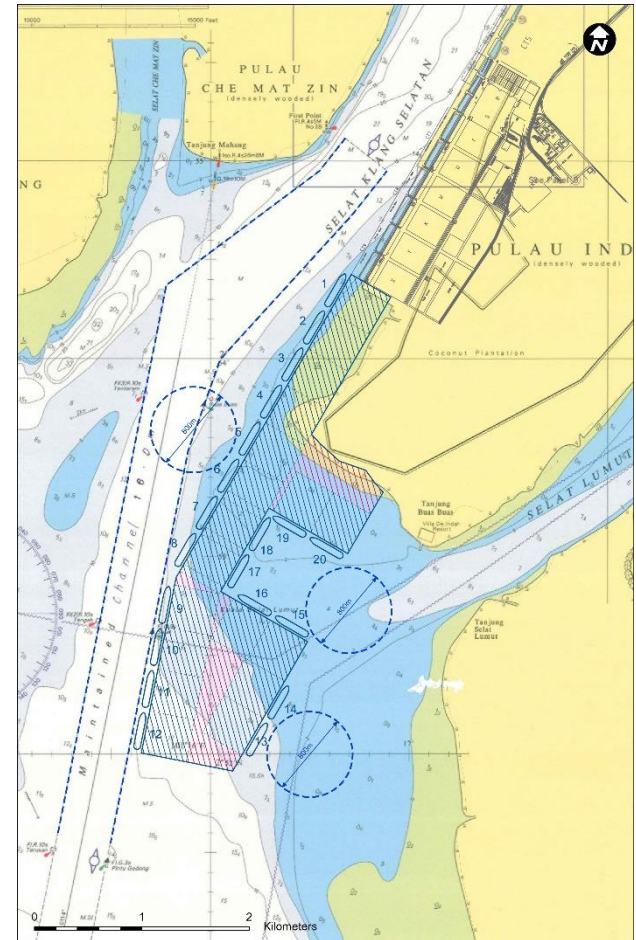


330 ha (terminal area) + 24 ha

Option F – “C” River Facing





Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

Inefficient berth utilisation on east face

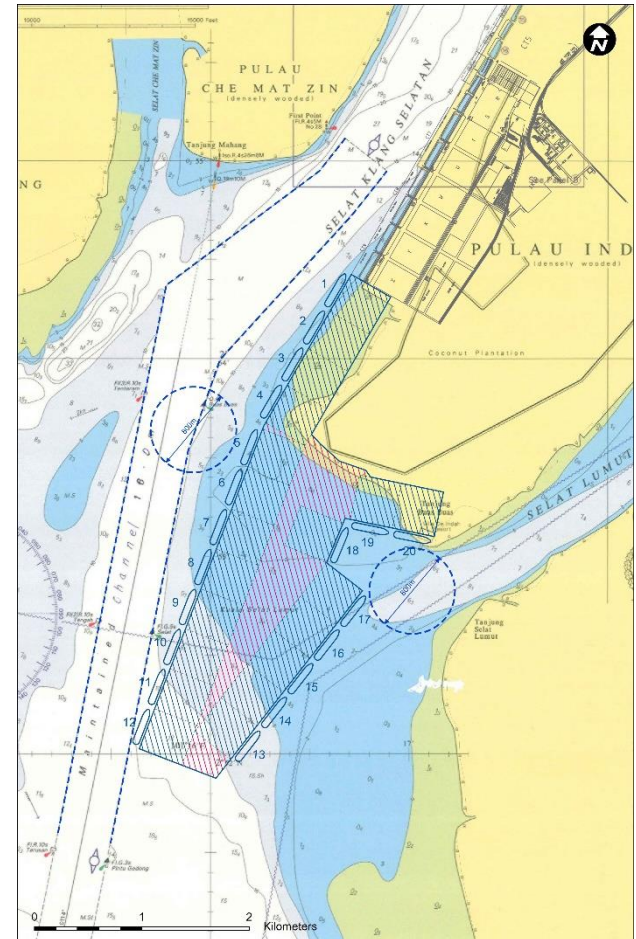


330 ha (terminal area) + 44 ha

Option G – Combined “V” & “C”

Design Criteria	Score
Quay Connectivity	
Reclamation Area	
Southwest Projection	
Impact on Existing Users	

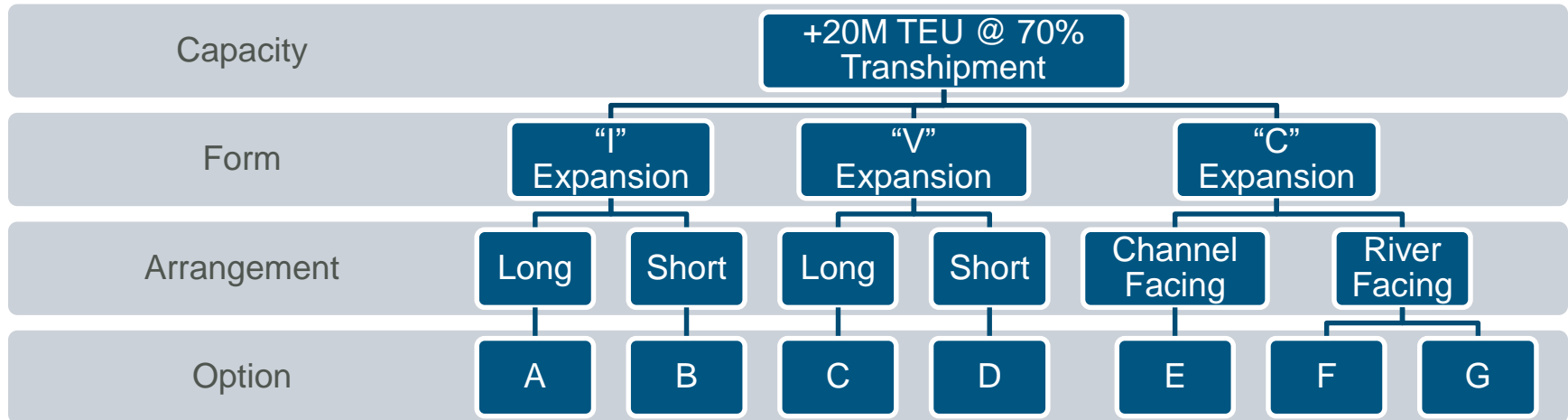
Hybrid does not capture additional value



330 ha (terminal area) + 102 ha

Ranking

Legend: ● Best ◐ > Ave' ◑ < Ave' ◒ Least



Qualitative Ranking

Criteria	Option A	Option B	Option C	Option D	Option E	Option F	Option G
Quay Length	●	◐	●	●	◑	◑	◑
Reclamation Area	●	●	◐	◐	◐	◐	◐
Southwest Projection	◑	◑	◑	◑	◑	◑	◑
Impact on Existing Users	◑	◑	◑	◑	◐	◑	◐

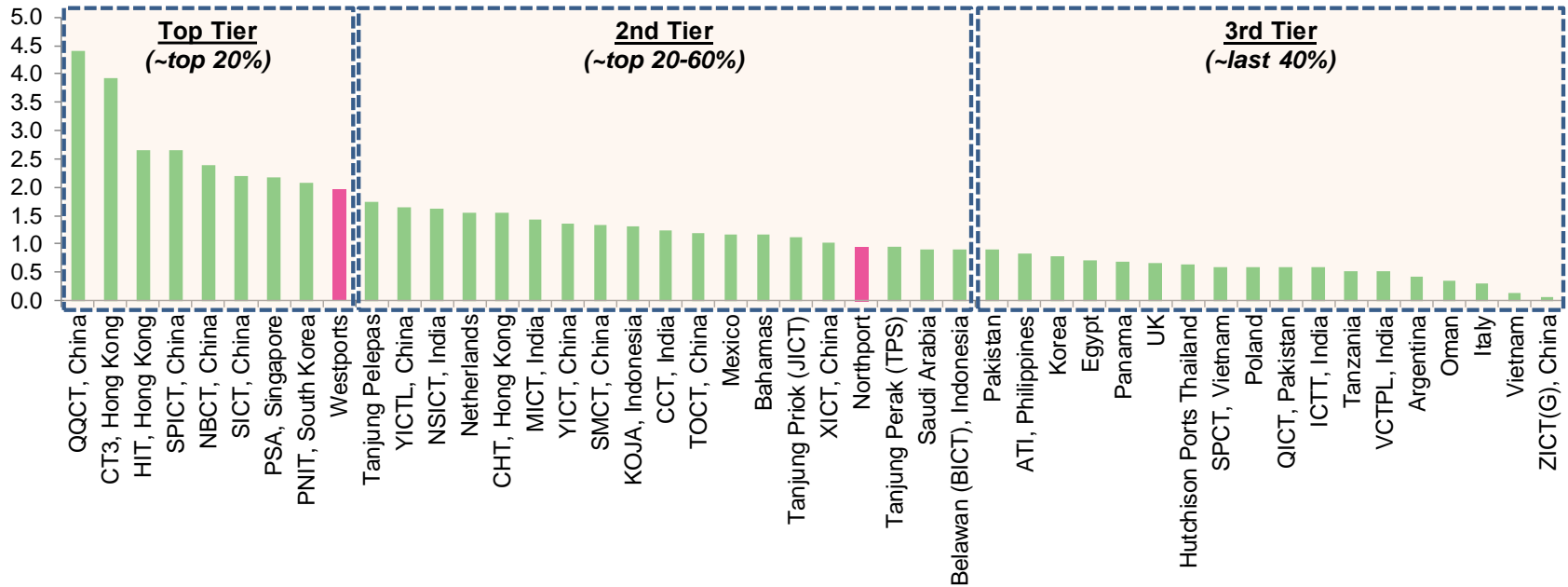
Options with a focus on berths being developed on the eastern berths appear to rank most strongly.

Operations Benchmark

Quay Performance Benchmark

- Quay length productivity much depends on the vessel sizes handled, which is decided by positioning of the port

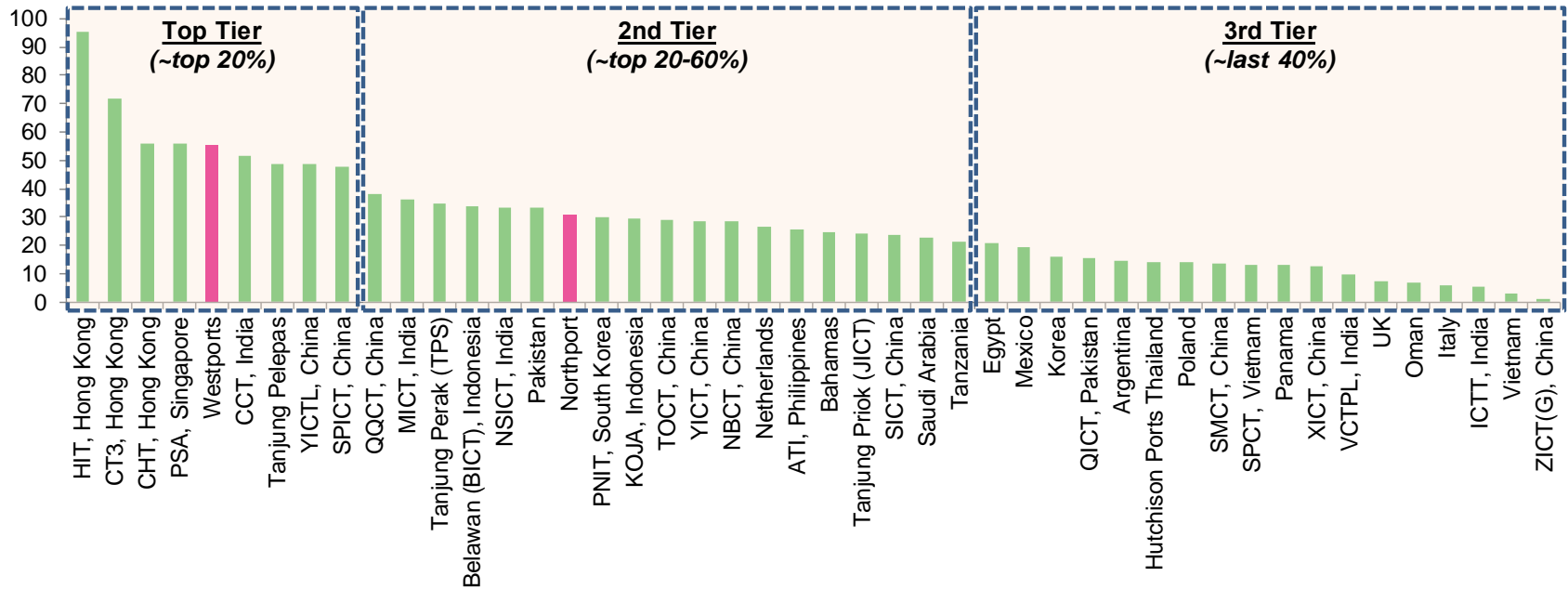
Throughput per Length of Quay ('000 TEU/m)



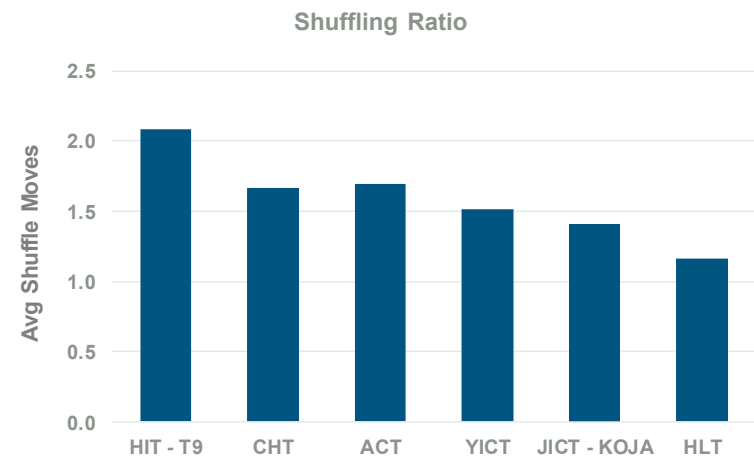
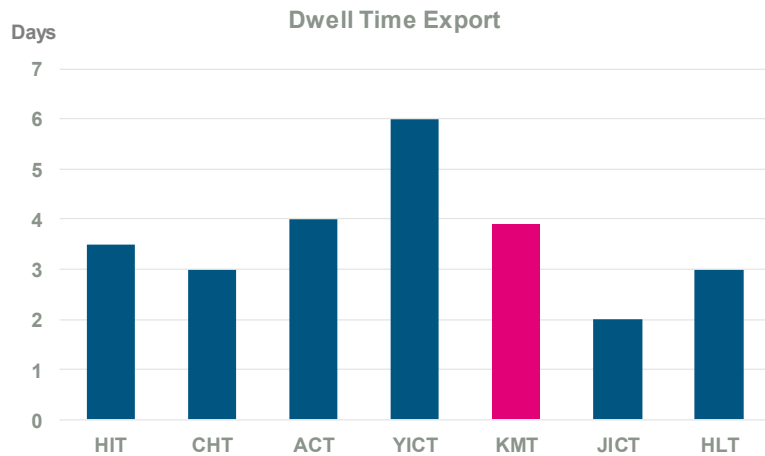
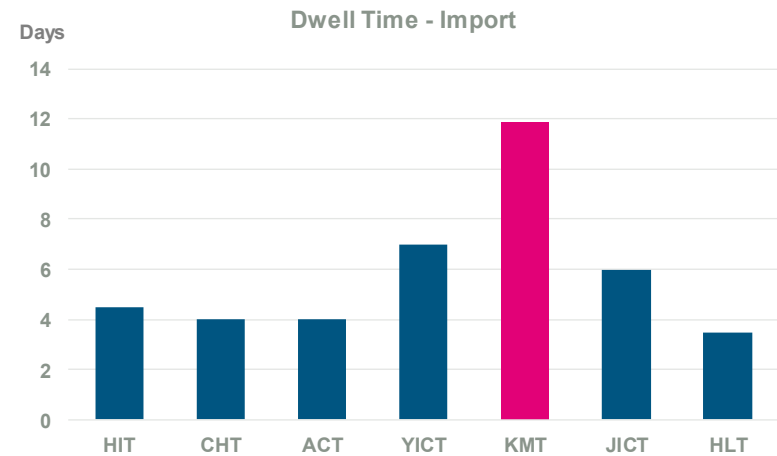
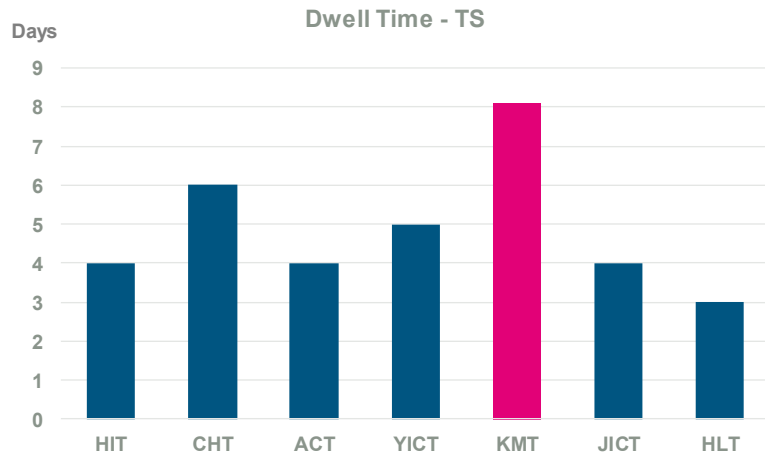
Yard Performance Benchmark

- Terminal area productivity depends on factors like dwell time, mix of transshipment and direct cargo, and trade-off between land cost and operational efficiency
- Quay and yard performance are inter-linked – higher quayside productivity associates with higher yard performance

Throughput per Terminal Area ('000 TEU/Ha)



Operation KPIs



2nd Layout Option Workshop

Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10 - CT19

2nd Layout Option Workshop

Date: 25 Jun 2018



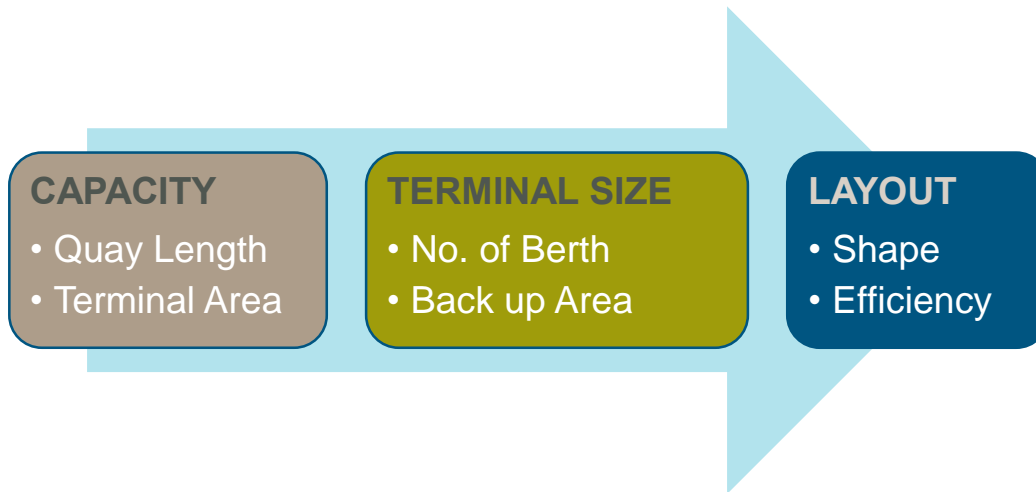
Agenda

1	Option Development
2	CAPEX & Income Assessment
3	Phased Expansion Approach
4	Future Growth
6	Automation Review
5	Q & A

Option Development

Recap

- Initial developments of options has been established:



- Significant constraints of development up to 20 berths were identified (based on the existing channel to the west, and shallow water to the east)
- The “I” or “V” shape reclamation layout were found to be generally preferred, as designs with basins did not offer particular benefits & risked additional sedimentation
- Questions raised re: potential economic returns for different phases of expansion.

Key Constraints

Channel

- Seek to avoid reclamation close to the channel

Land

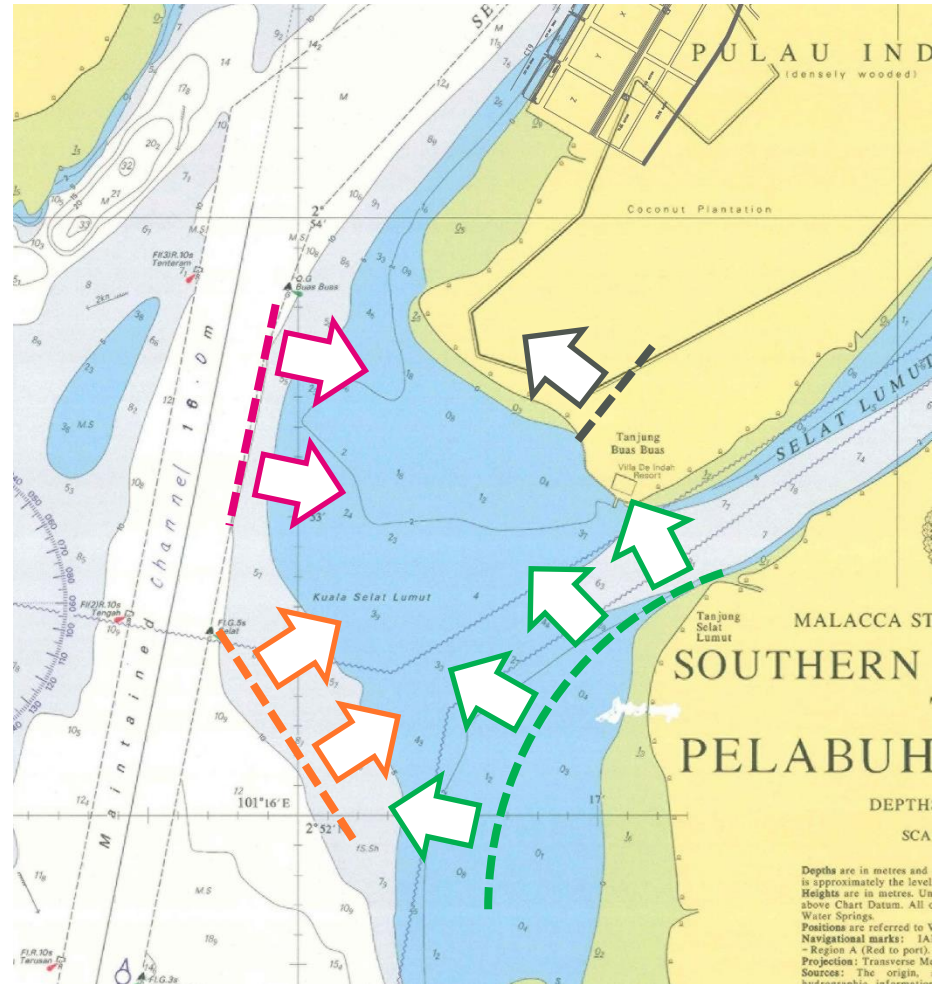
- Existing land ownership does not include the SE tip of Pulau Indah

Dredging

- Access to eastern berths require major dredge if close to Pulau Carey

Currents

- Limit impact on natural tidal flow patterns



Constraints is driven by quay length 15M TEU = 6,000m, 20M TEU = 8,000m

Existing Proposal

- **CANNOT** meet constraints

15M TEU

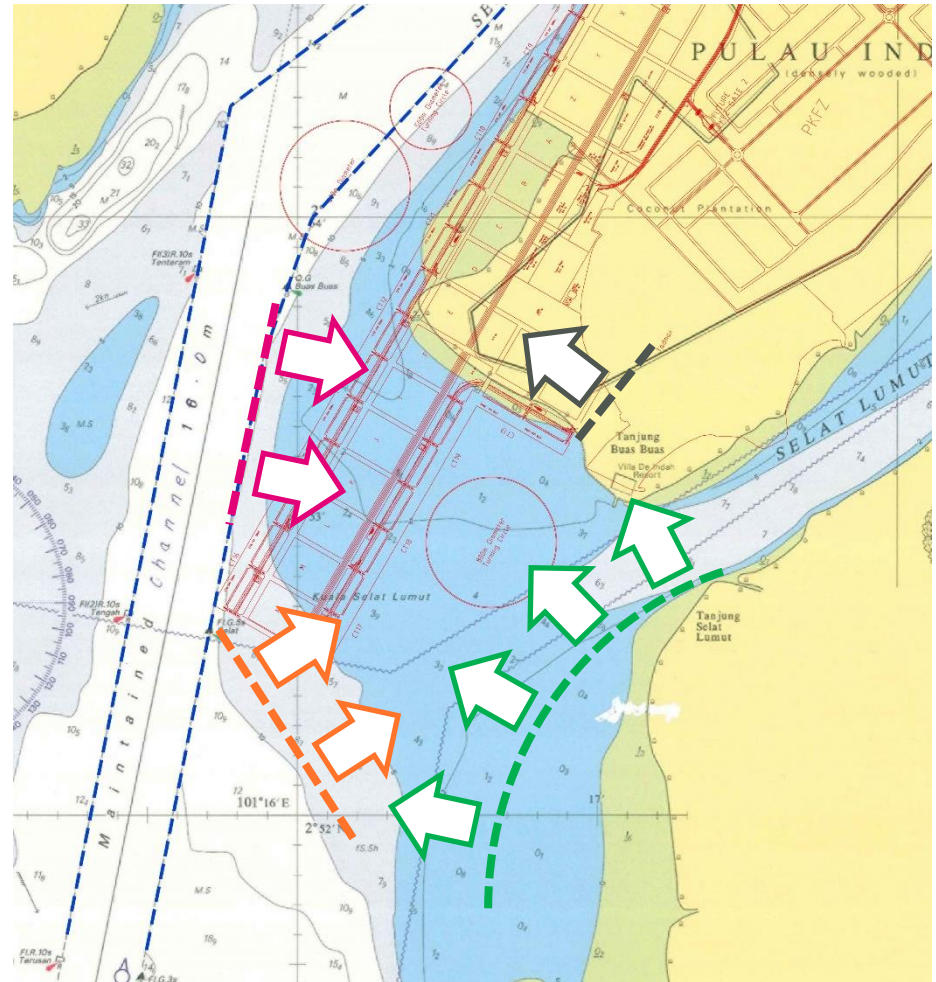
- Options **CAN** be developed which fit within existing constraints

20M TEU

- Options **CANNOT** be developed which fit within existing constraints

Up to 17M TEU

- Options **CAN** (geometrically) be developed to fit within existing constraints (for 70% & 90% trans')



Designed Capacity 17M – further assessment adopts as basis for analysis

Parameters

- The planned capacity and percentage of transshipment dictate the quay length and total terminal area behind berth required.

Additional Capacity	Quay Length	Length Behind Berth
(million TEUs)	(m)	(m)
17M @ 90% Transshipment	6,800	315
17M @ 70% Transshipment		375

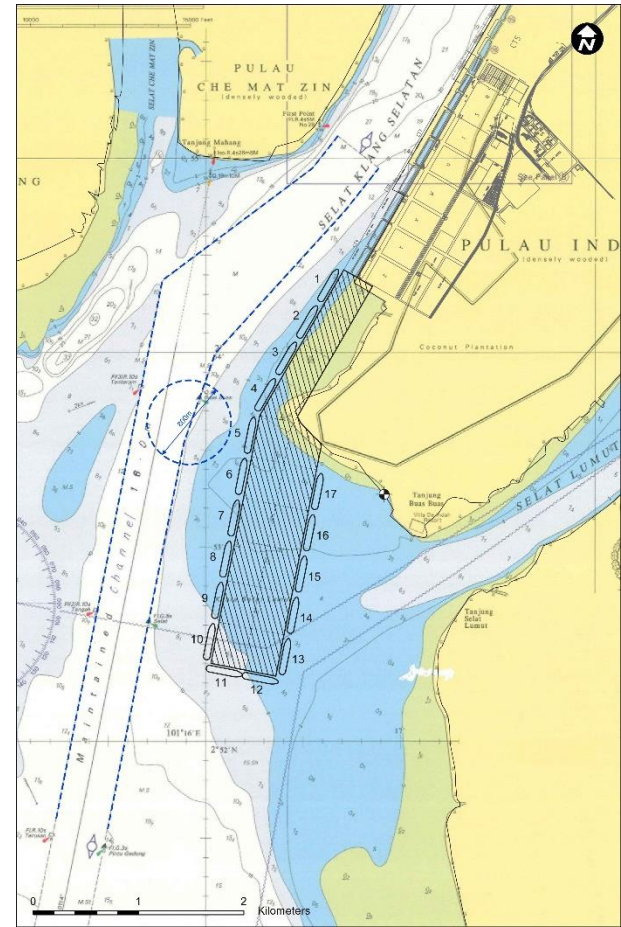
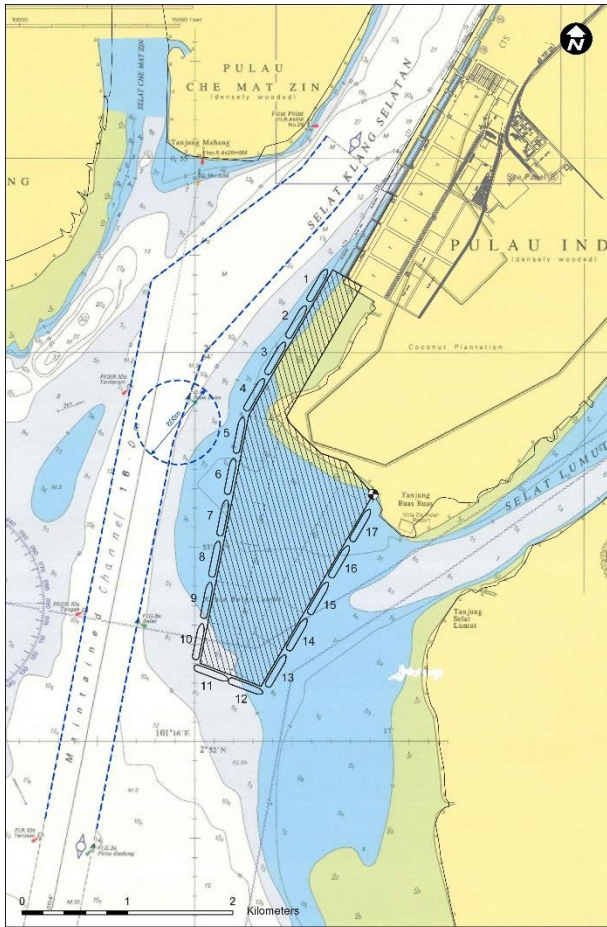


Layout Option – 17M TEU

A

(90% Transshipment)

B

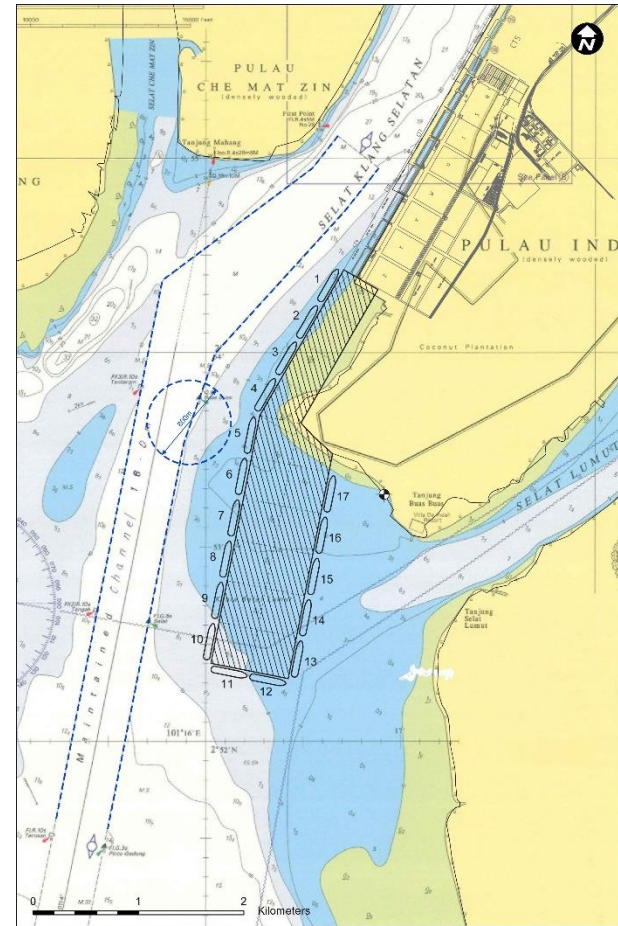
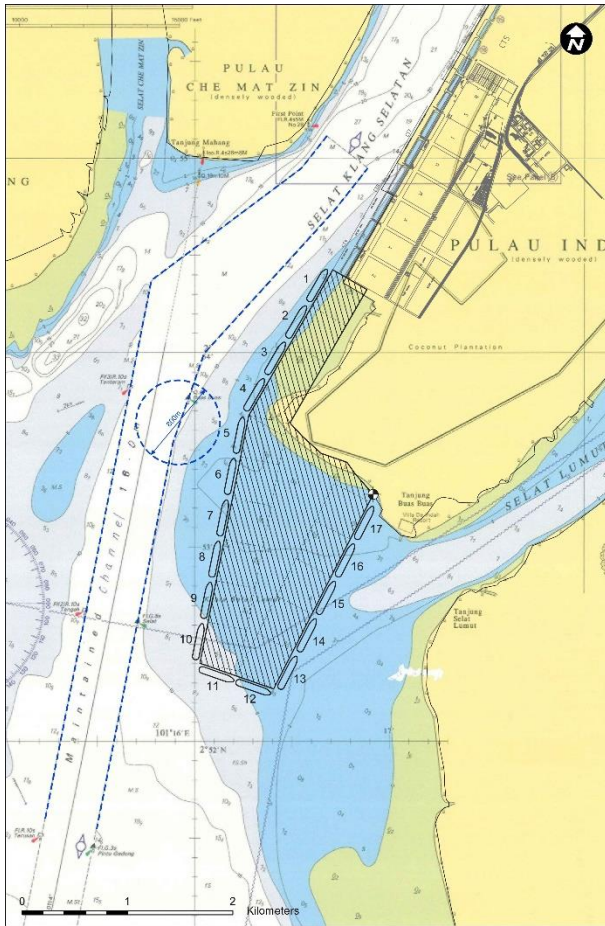


Layout Option – 17M TEU

A

(70% Transshipment)

B



CAPEX & Income Assessment

CAPEX

For preliminary review on CAPEX the major components include:

1. Civil Engineering Works

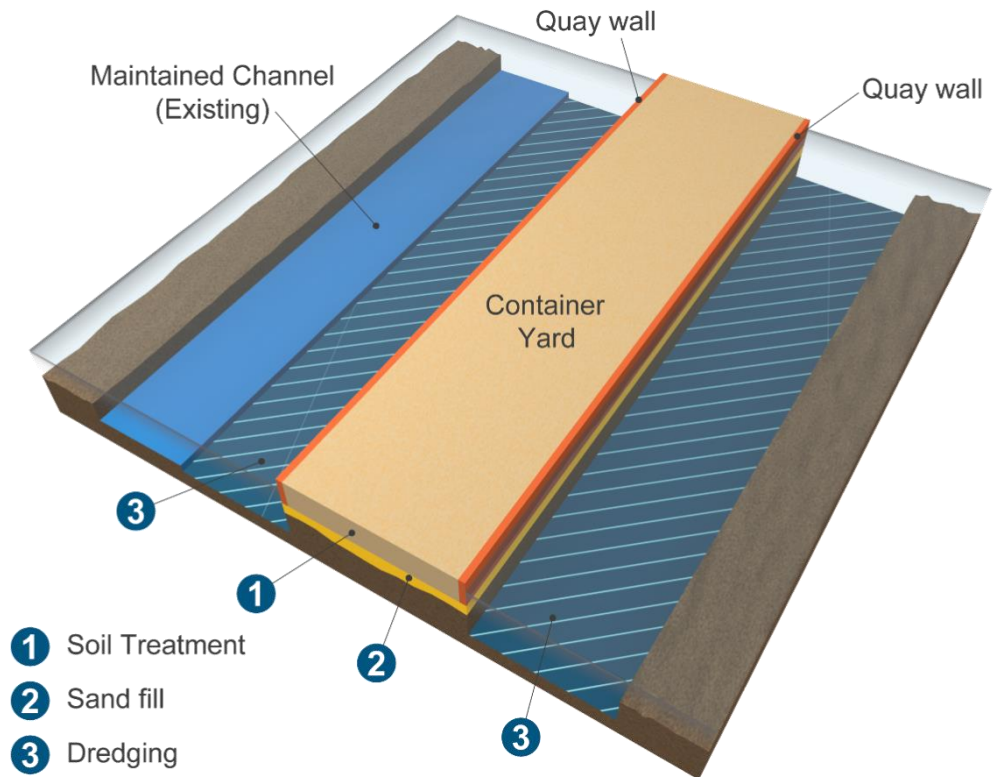
- Soil Treatment
- Sand Filling

2. Terminal Construction

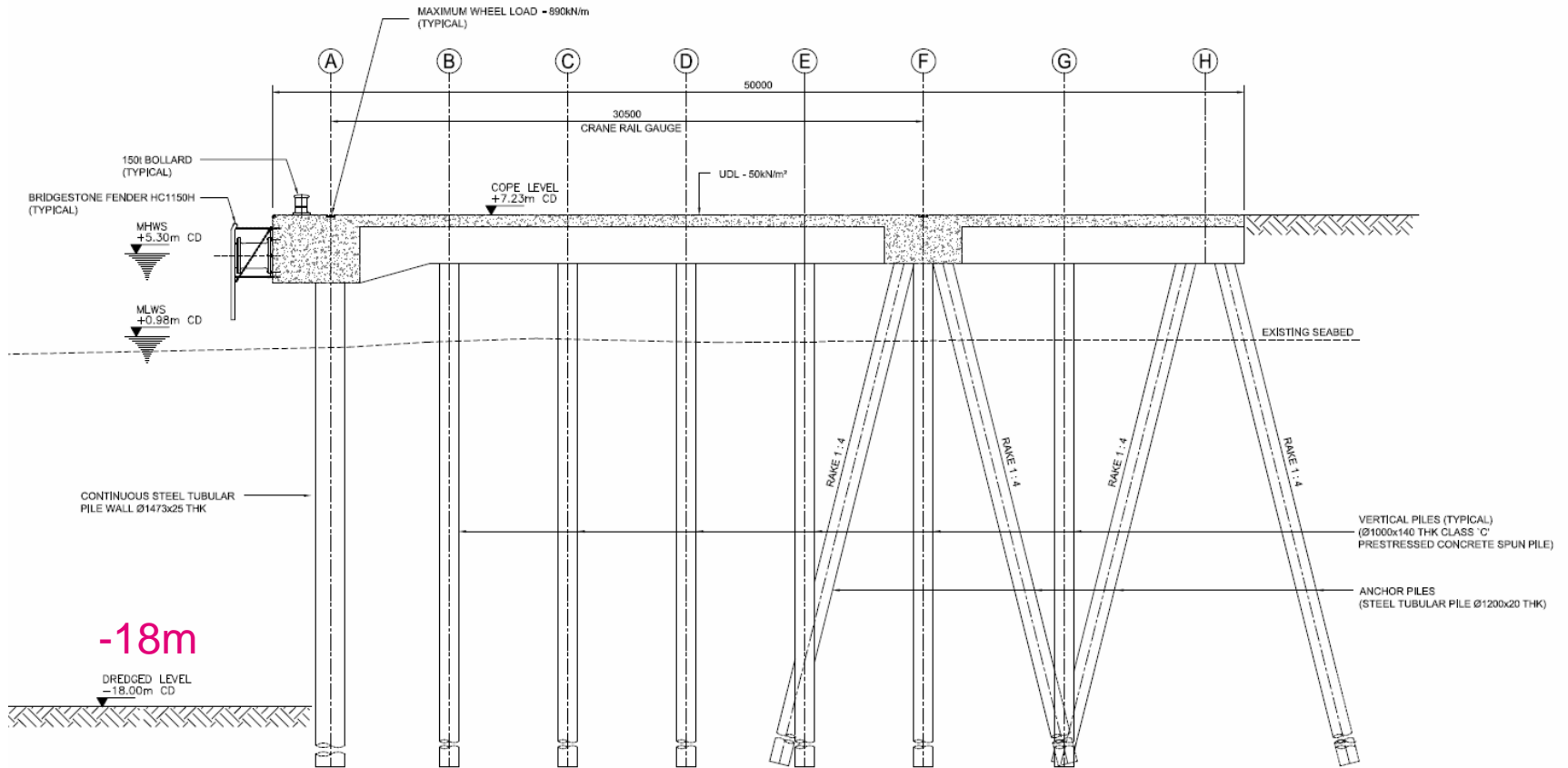
- Quay Wall & Apron
- Road, Pavement, Drains
- Equipment

3. Navigation

- Dredging



PRELIMINARY Deck Designs



TYPICAL CROSS SECTION OF QUAYWALL AND APRON STRUCTURE

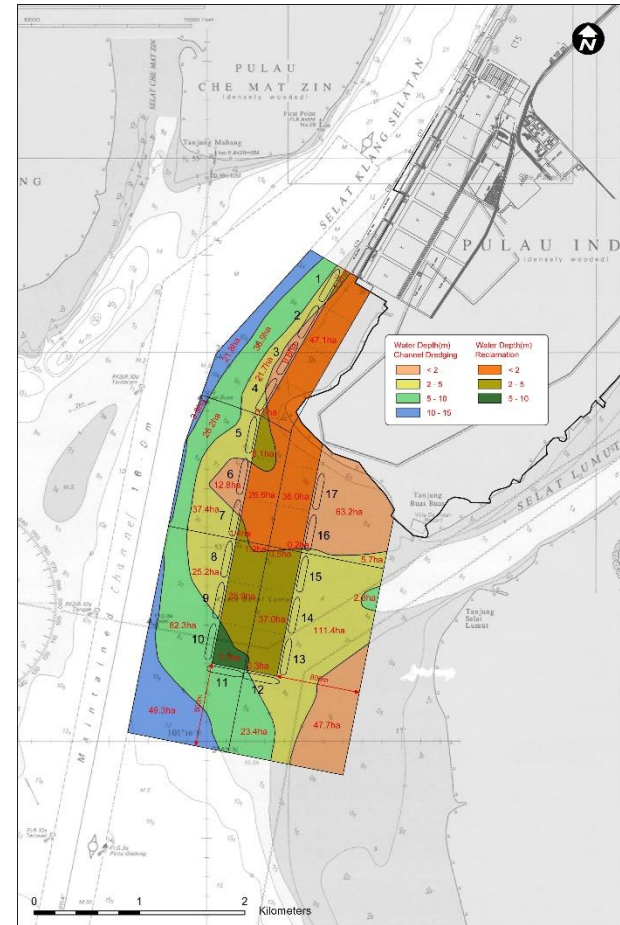
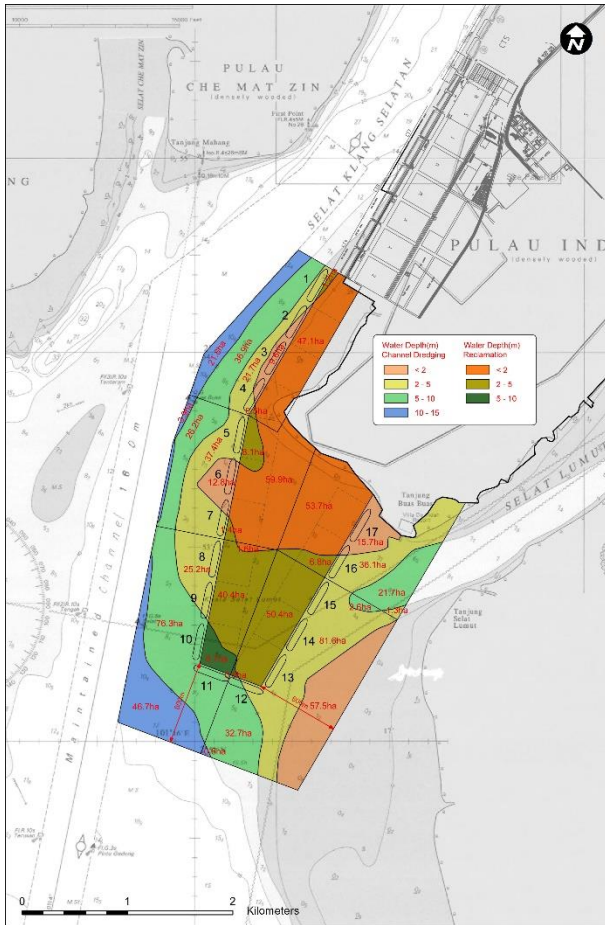
(SCALE 1:150)

Per Unit Assessment

(A)

(90% Transshipment)

(B)

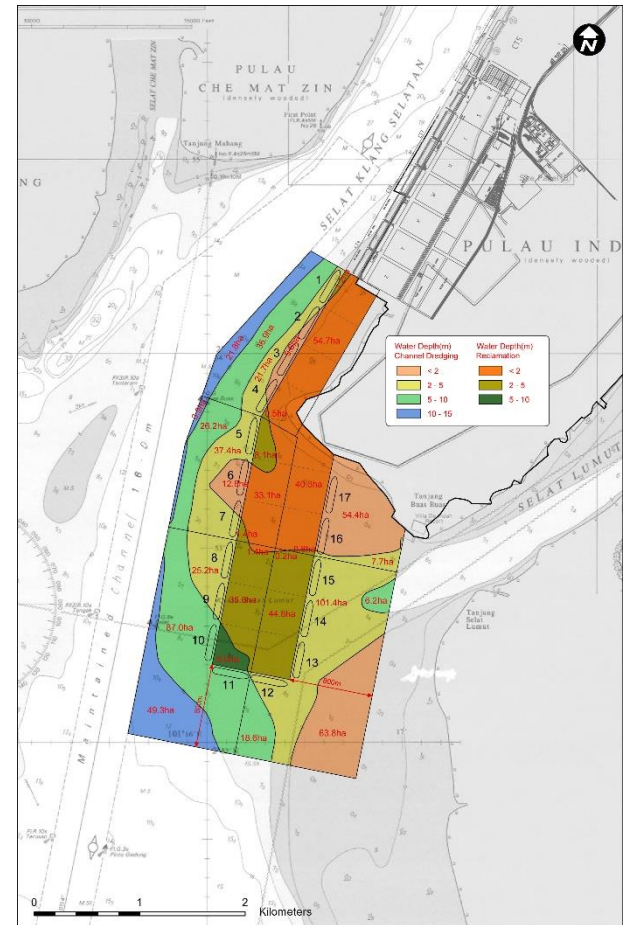


Per Unit Assessment

A

(70% Transshipment)

B



Income

Approach

- *Discounted Cash Flow* (DCF) based on Operating Profit (EBITDA)
- Operating profit per 400m berth, *cumulative* and *per berth* basis

Assumptions

Asset Life	30 years
Utilisation	New berth will be ready when existing berths reach 85% utilisation
Operating Margin	Up to 54% based on past 5 years (Westports financial report)
WACC	8% (2018, Hong Leong Investment Bank)
Tariff	<ol style="list-style-type: none"> 1) Current split between OD & TS 2) Along with inflation (2.5% p.a., IMF)
Scenarios	<ol style="list-style-type: none"> 1) 70%-90% transshipment 2) - 10% EBITDA margin (i.e. 44%)



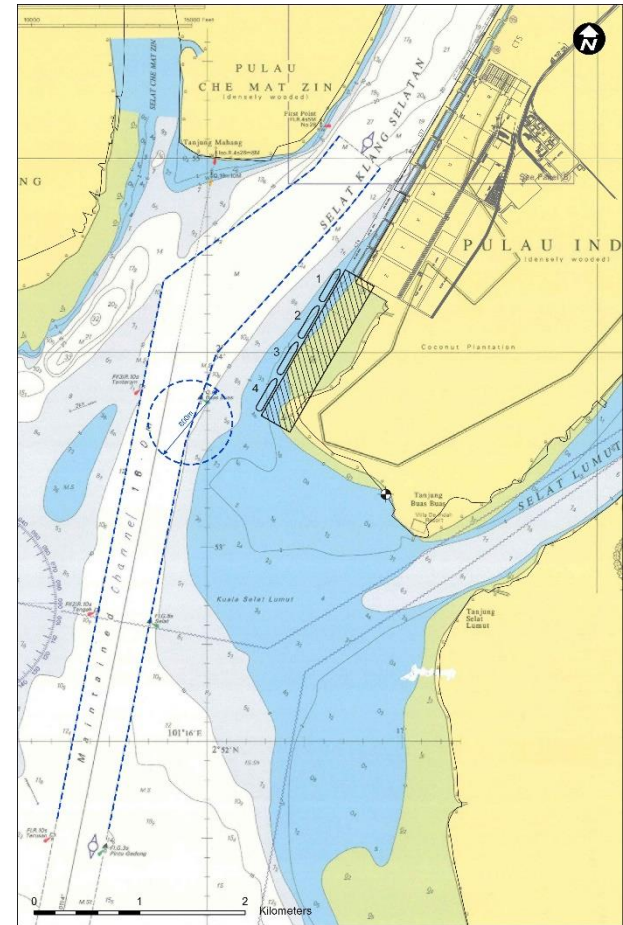
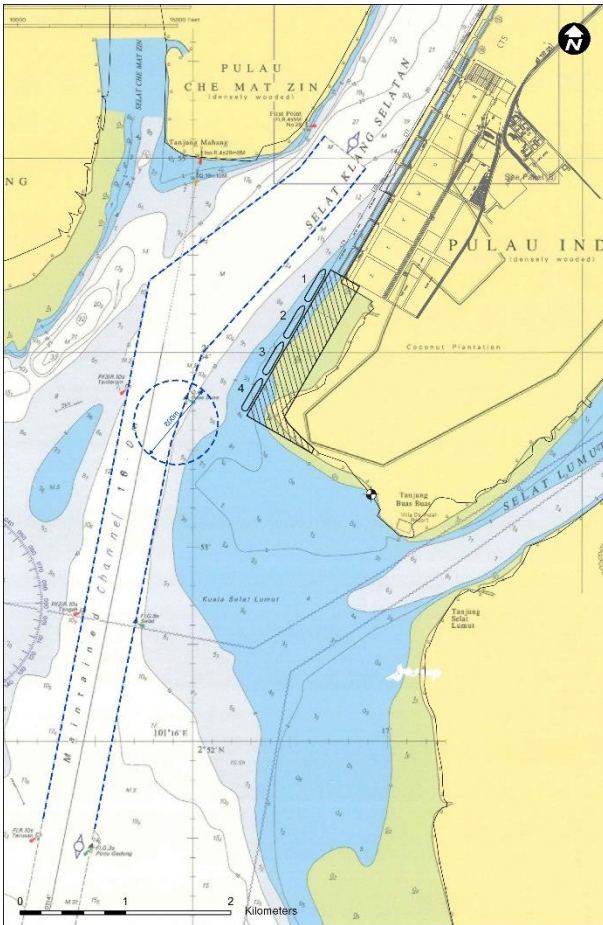
Phased Expansion Approach

PHASE ONE – 4 berths

A

(90% Transshipment)

B

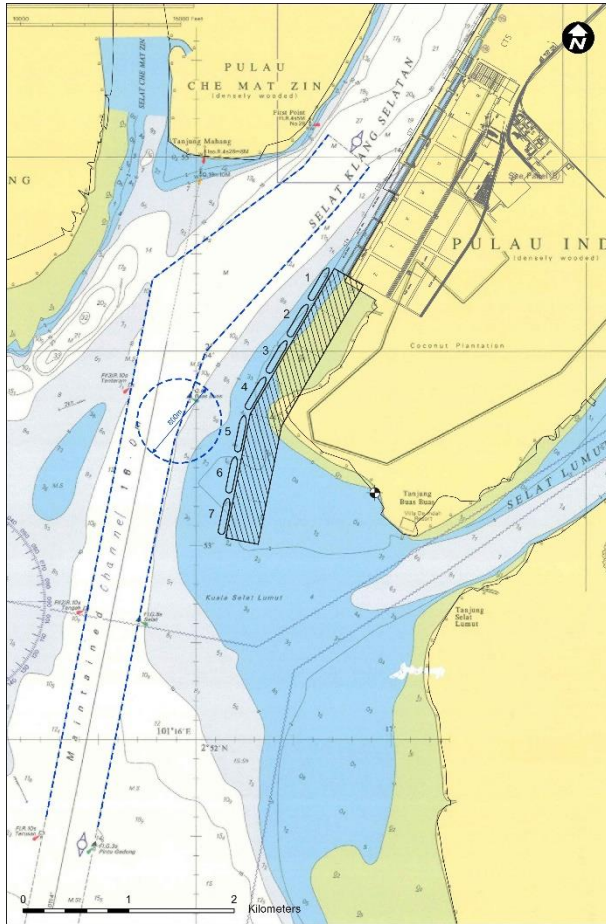
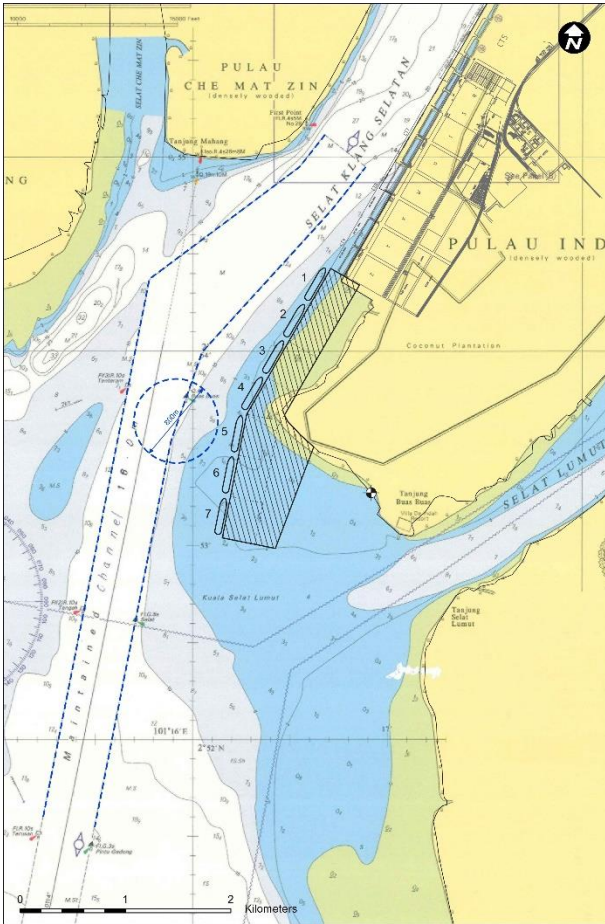


PHASE TWO – 7 berths

A

(90% Transshipment)

B

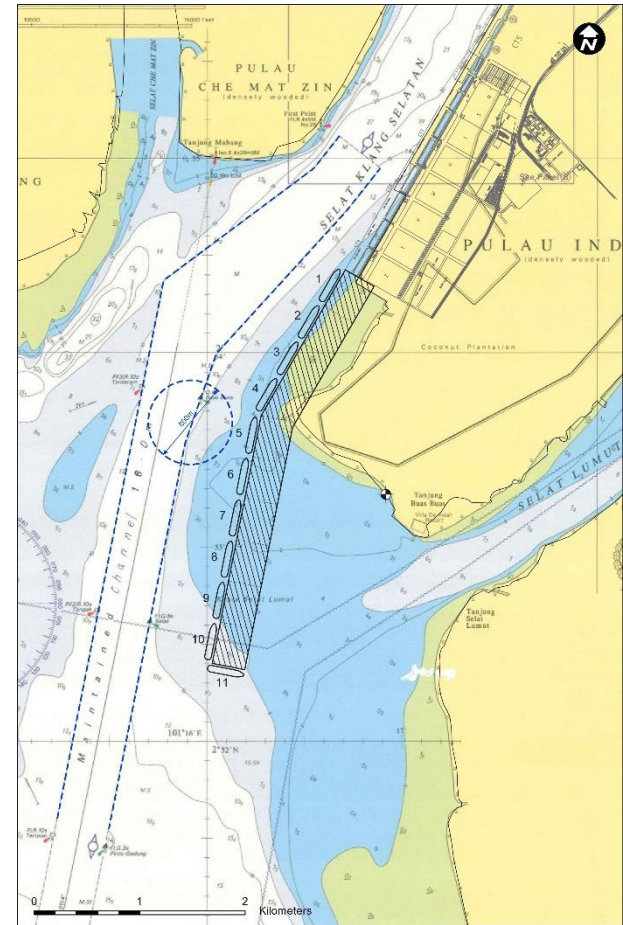
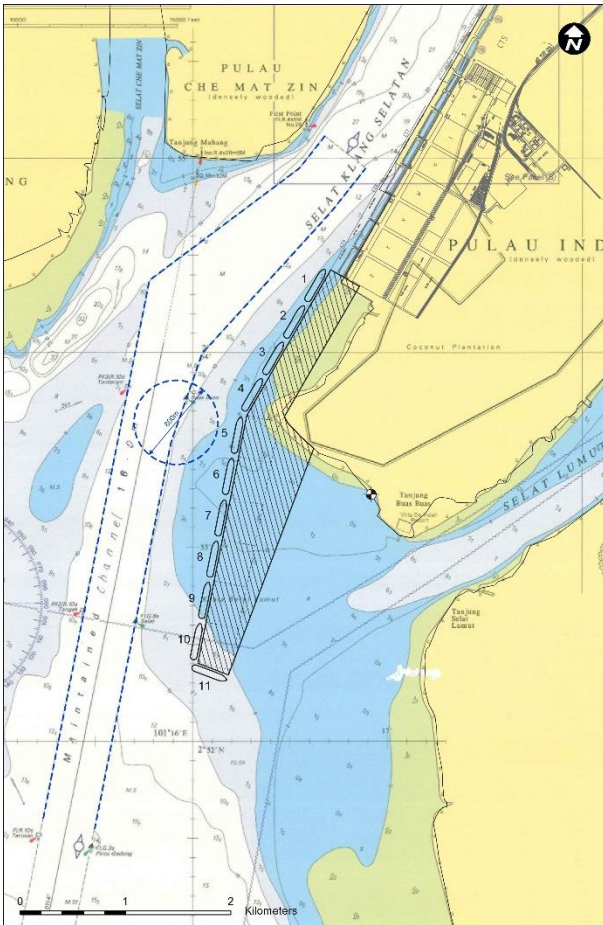


PHASE THREE – 11 berths

A

(90% Transshipment)

B

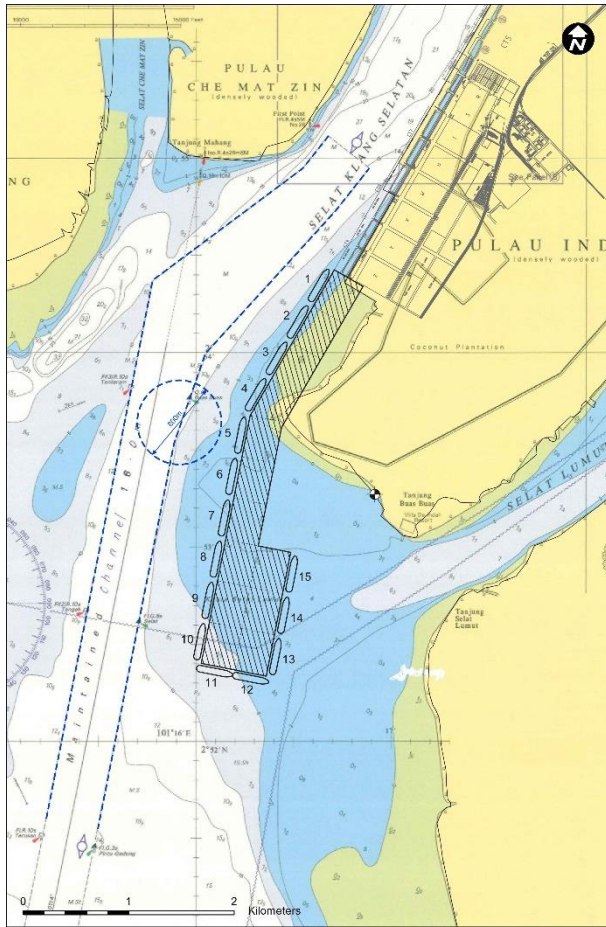
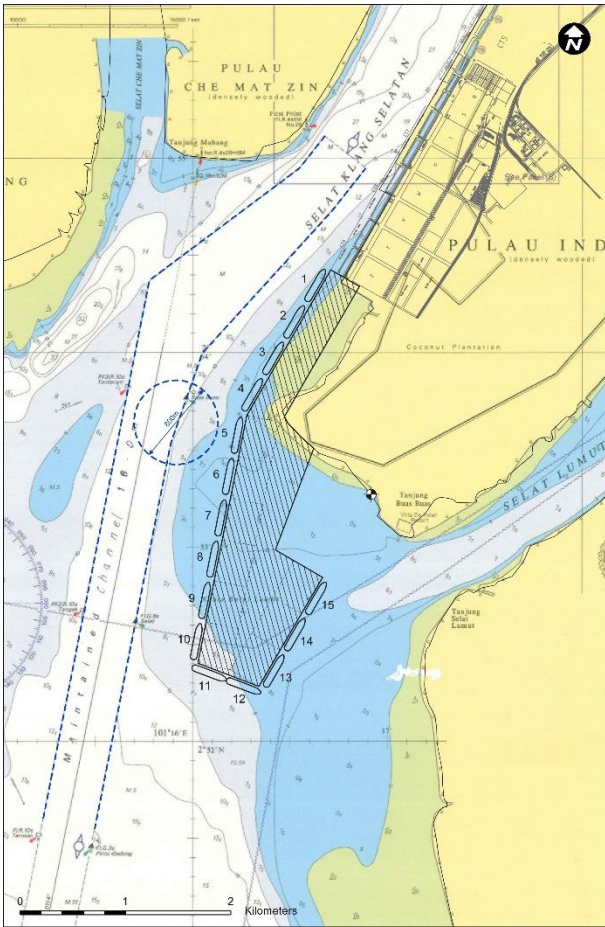


PHASE FOUR – 15 berths

A

(90% Transshipment)

B

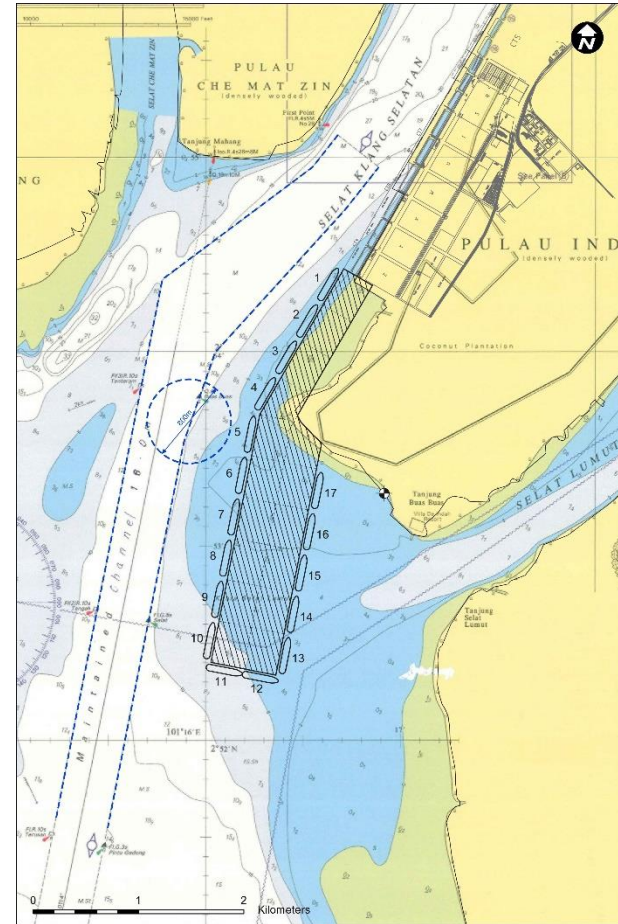
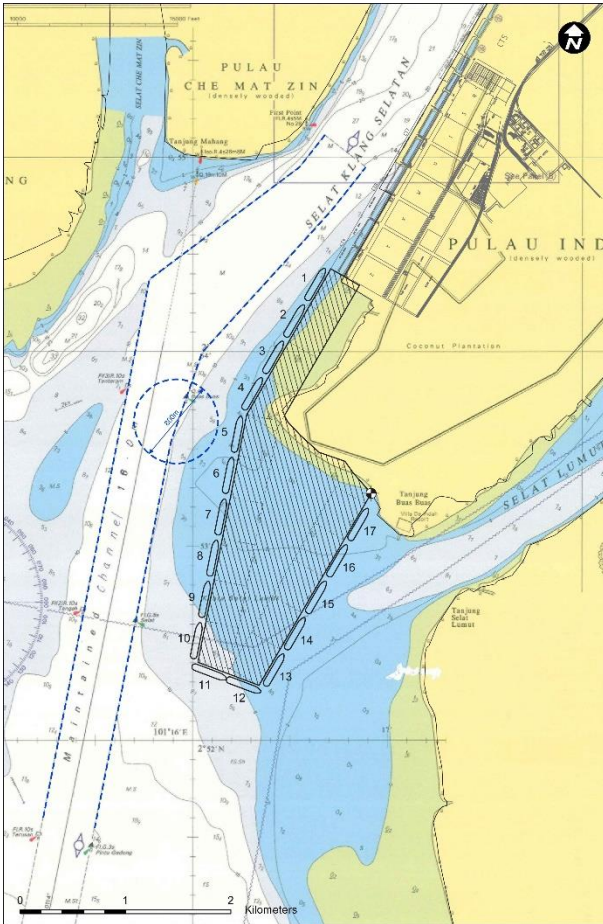


PHASE FIVE – 17 berths

A

(90% Transshipment)

B



Recommendation

Berths

- 17 (400m) to fit constraints

Geometry

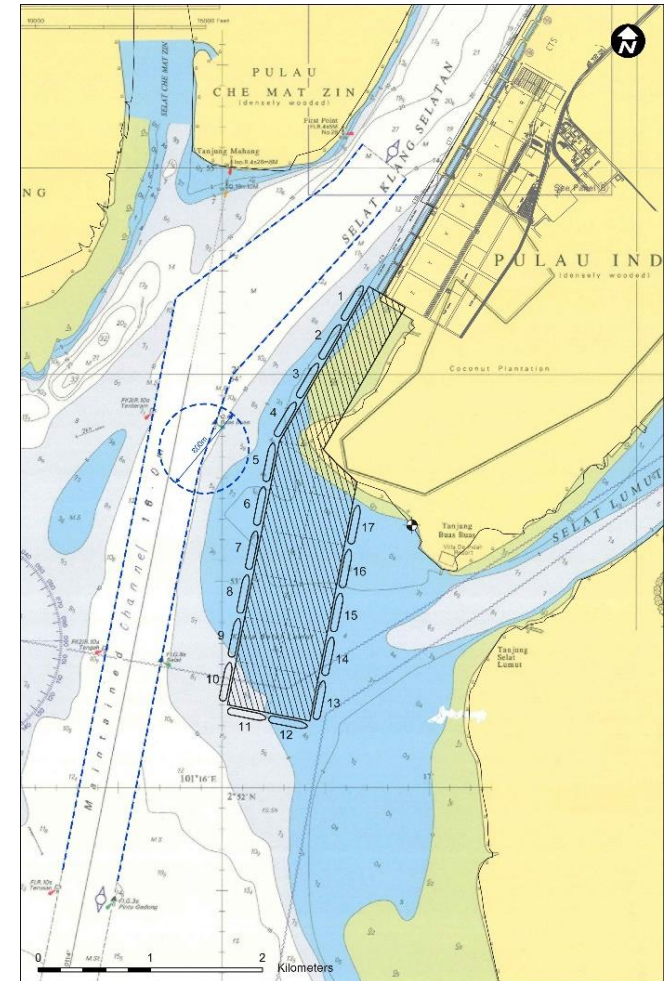
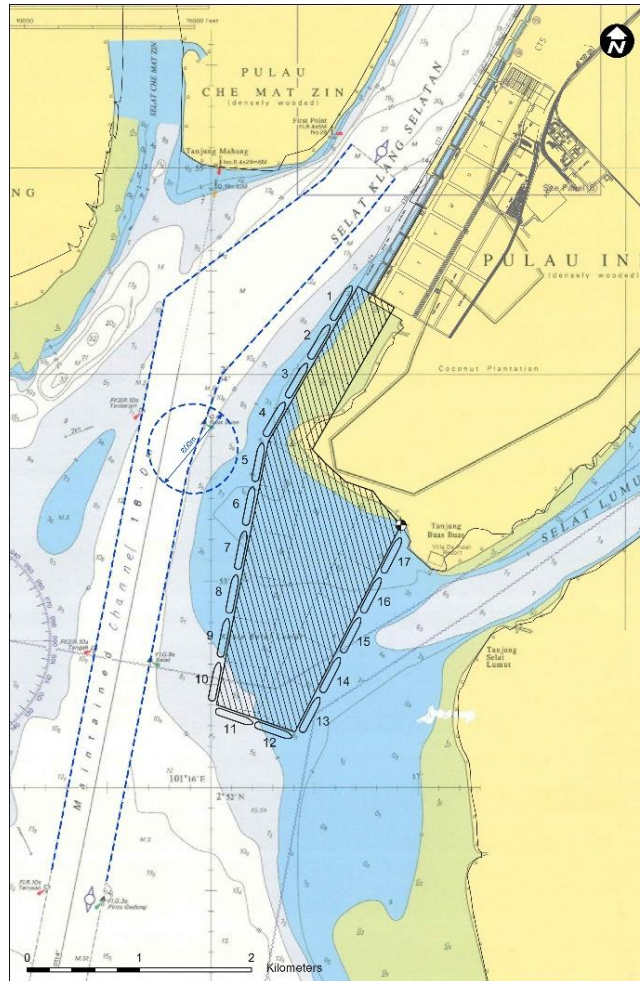
- Simple “finger”, “V” or parallel

Terminal size

- 375m – to cater for 70% to 90% transhipment: total costs similar.




Differentiator

- Sediment build up by E Berths



Automation Review

Terminal Automation

Quay	Yard	Horizontal Transport
<ul style="list-style-type: none"> - Fully automated QC not available - Exploration of remote control 	<ul style="list-style-type: none"> - Automated Stacking Crane (ASC) - C-RMG 	<ul style="list-style-type: none"> - Automated Guided Vehicle (AGV) - Lift AGV - Straddle Carrier
		
<ul style="list-style-type: none"> - n.a. 	<ul style="list-style-type: none"> - Rotterdam (Euromax) - Hamburg (CTA, CTB) - LA (TraPac) - Norfolk (APMT) 	<ul style="list-style-type: none"> - Rotterdam (Euromax) - Hamburg (CTA) - Brisbane (Patrick) - Antwerp (DPW)

Automation Cost – CAPEX

Equipment

- An ASC costs about US\$1 million more than an electrified RTG
- RMG requires rail construction, thus involves additional costs
- IT investment is in a range of US\$1-1.3 million, depending on the choice of TOS

Civil works

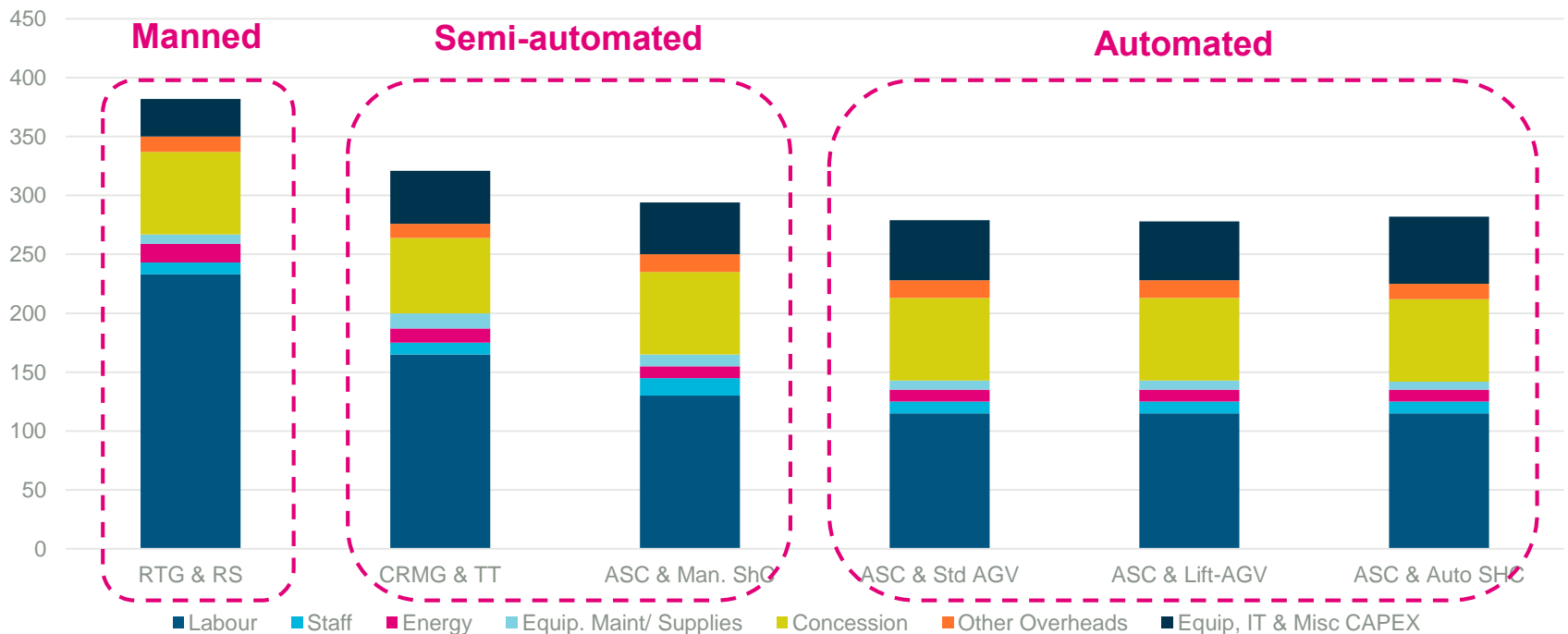
- Accommodate terminal infrastructure for the automation implementation
 - 10-15% more per sqm of yard pavement
 - 15-20% more per m of quay wall

Equipment	Cost per Unit (US\$)
Quay Equipment	
Quay Crane (QC)	8,000,000
Mobile Harbour Crane (MHC)	5,000,000
Yard Equipment	
RMG	3,000,000 + 12,000/m (rail work)
ASC	2,500,000
RTG	1,500,000
Reach Stacker	400,000
Horizontal Transport	
AGV	500,000
Forklift Truck	300,000
Straddle Carrier	250,000
Port Tractor Vehicle	40,000

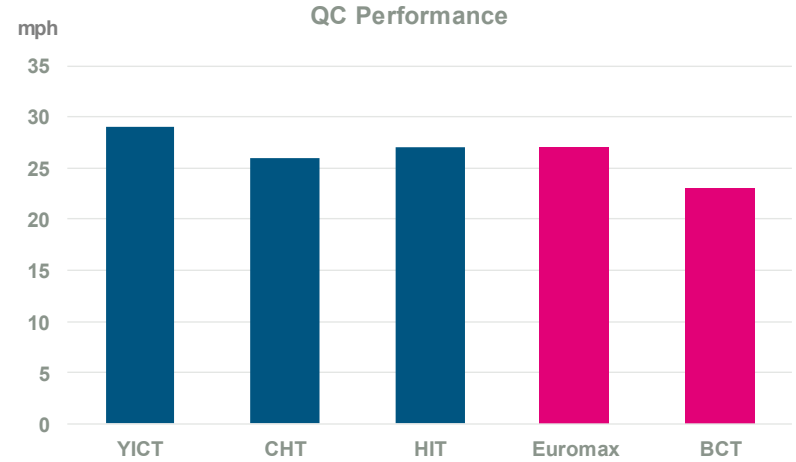
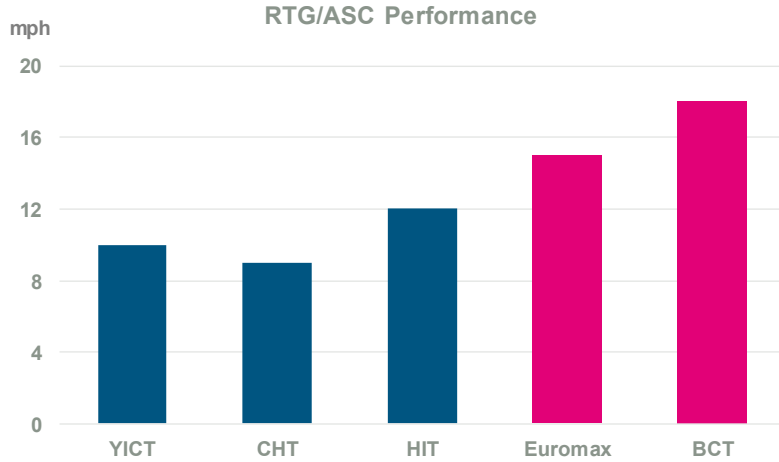
Automation Cost – OPEX

- Labour cost is key cost component, which accounts for 40-60% of the total costs per TEU
- Manned operations requires double of labour cost (~US\$230/ container) than full automation
- Power & fuel perspective, eRTG (e-mode) of 2-3 kwh/TLC vs ASC of 1-3 kwh/TLC

Total Costs per Container (US\$)



Automation Productivity



Performance	RTG	RMG	ASC
Lifting Height	1-over-5 TEU	1-over-5 TEU	1-over-5 TEU
Hoisting Speed	20-40 m/min	20-80 m/min	40-70 m/min
Trolley Speed	70 m/min	up to 180 m/min	60 m/min
Gantry Speed	135 m/min	up to 240 m/min	240 m/min
TEU/ha	1,100	1,350	1,250-1,400

Q & A

3rd Layout Option Workshop

Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10 - CT19

3rd Layout Option Workshop

Date: 30 Aug 2018



Agenda

1	Review of Option Development Process
2	Shortlisting
3	Sedimentation Review
4	Quay Design & Phasing
5	Costing Update
6	Automation Issues/Options
7	Tasks Ahead

Review of Option Development Process

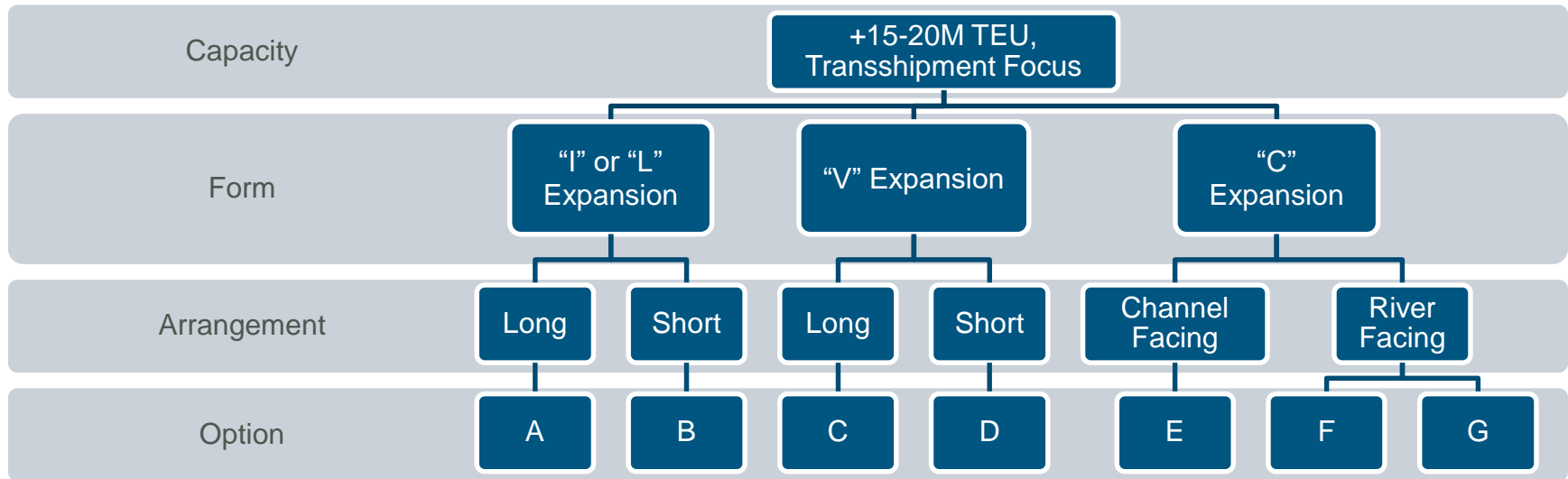
Capacity Requirement Established

- Initial developments of capacity requirement has been established:

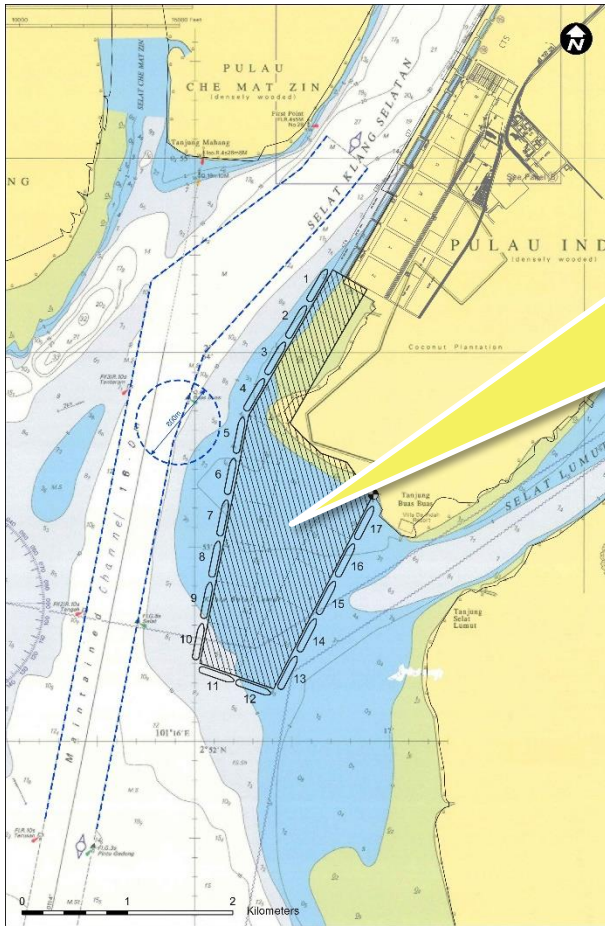


Existing Capacity	Additional Capacity	Quay Length	Terminal Area	Berth Length	No. of Berth	Back up Area Per Berth	Length Behind Berth
(million TEUs)	(million TEUs)	(m)	(Ha)	(m)	(nos)	(Ha)	(m)
15	15 - 20M @ 70 - 90% Transhipment	6,000 – 8,000m	250 - 330	400	15 - 20	12.5 - 17	315 - 425

Broad Option Assessment

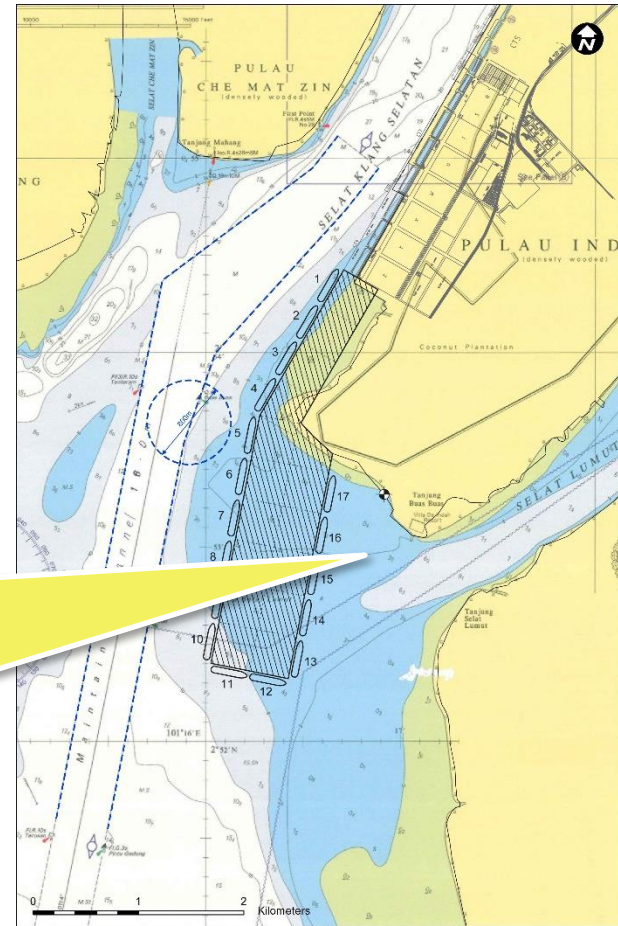


Two key Geometries Preferred

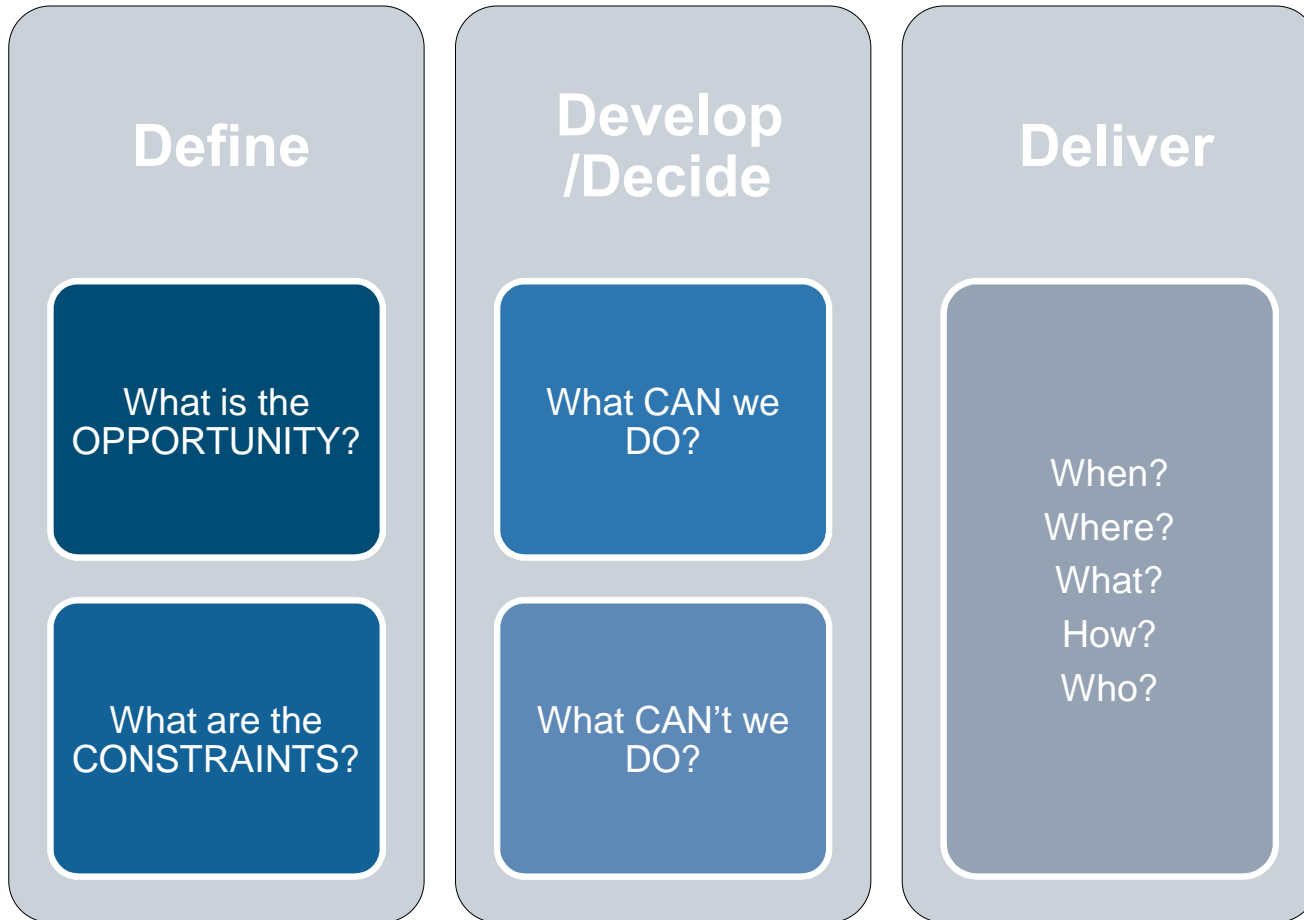


Is the land created of value – given impact on terminal separation?

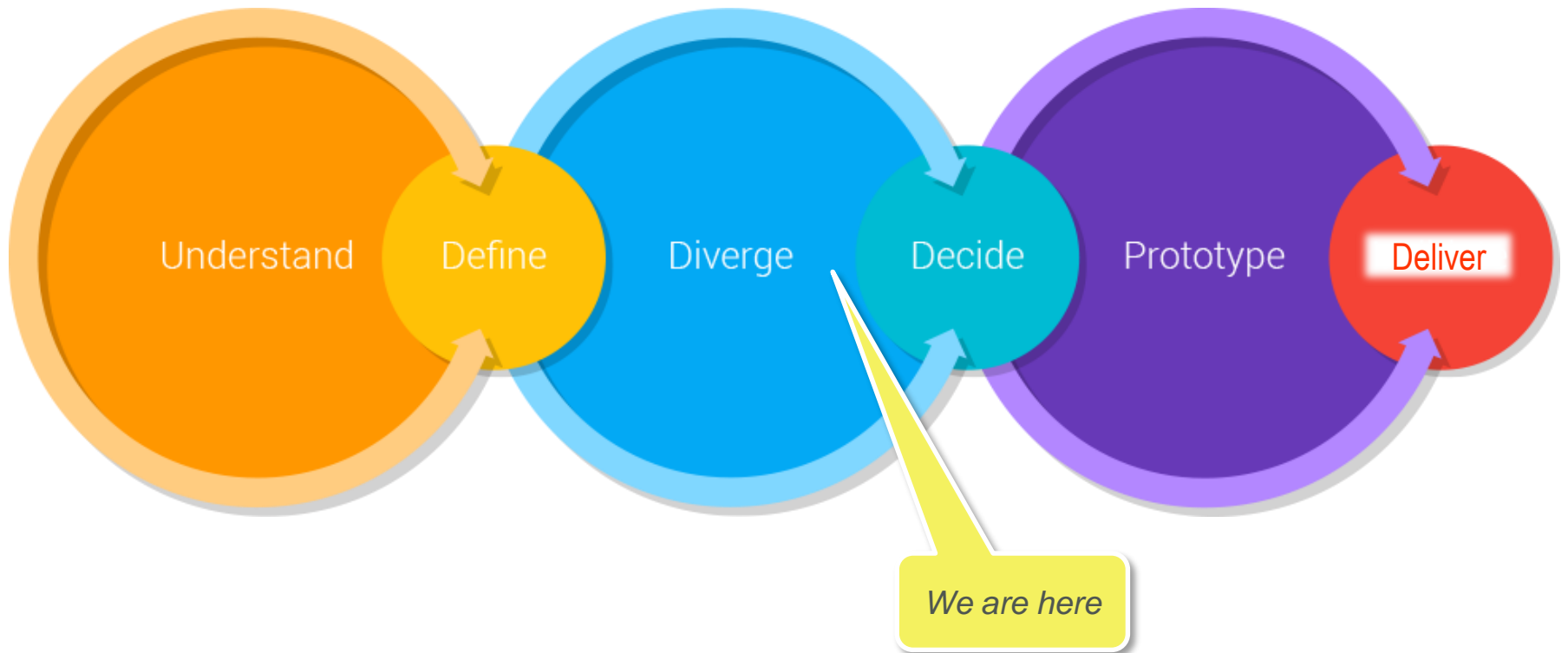
Does this design create significant sedimentation to the east (or west)?



Design Development Process Followed

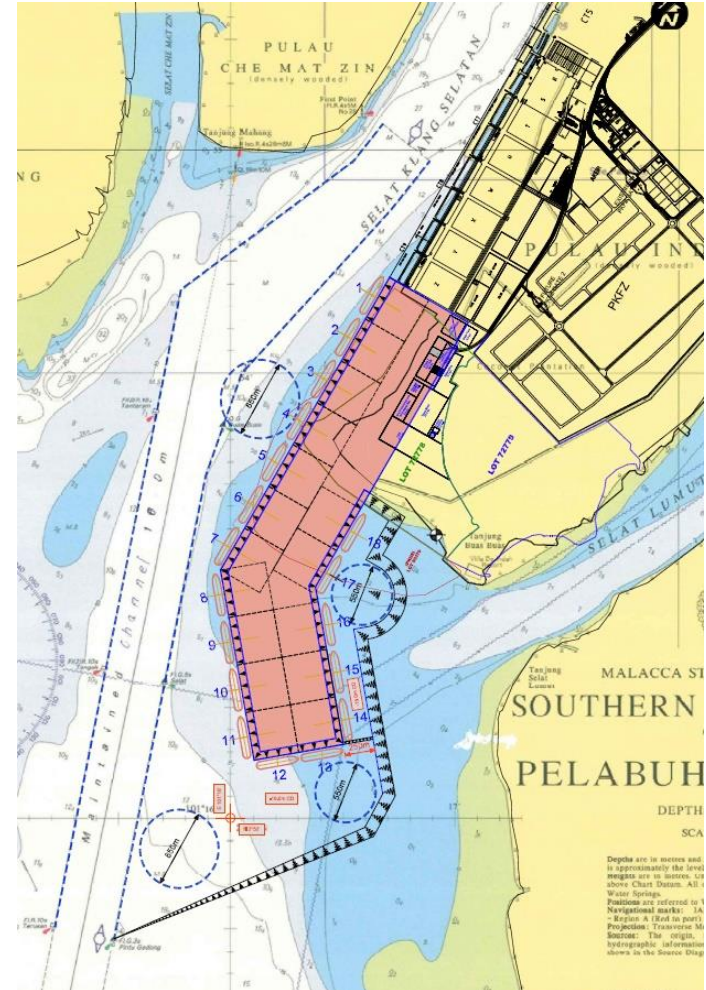
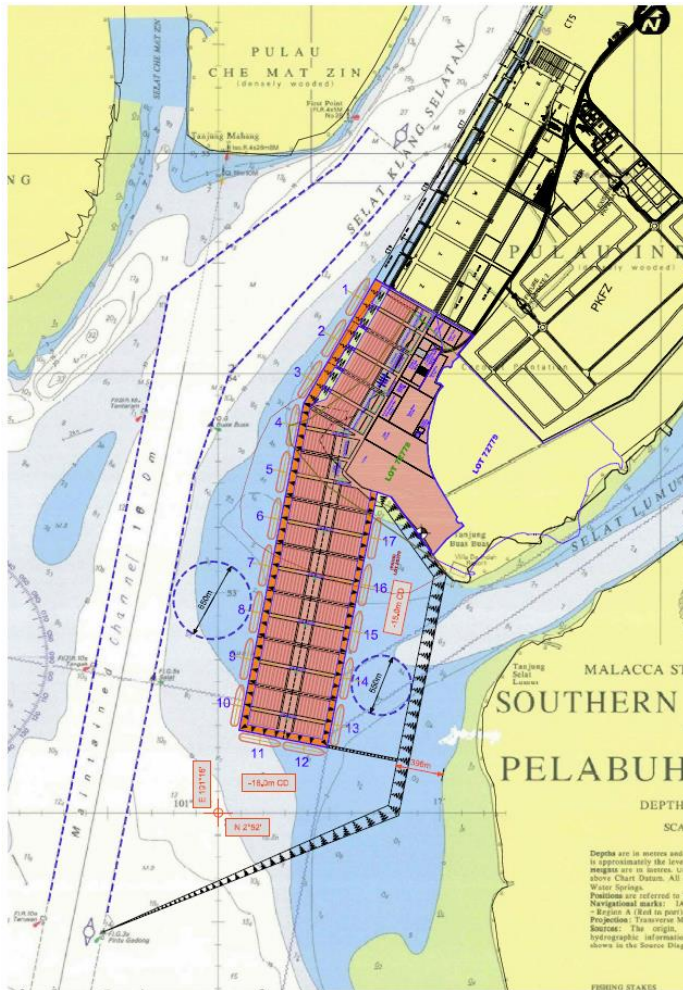


Rapid Prototyping with Feedback



Shortlisting

"Straight Finger" & "Crooked Finger" Options



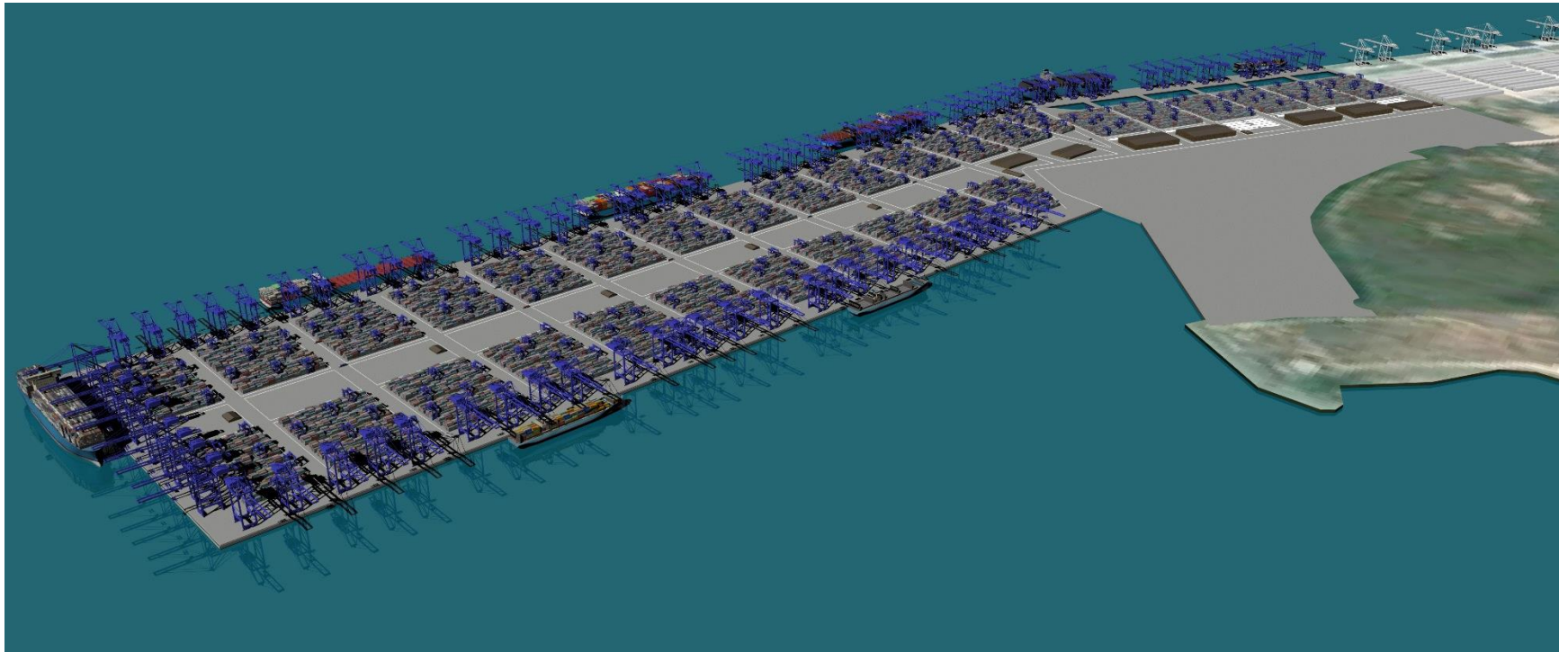
"Straight Finger" Option



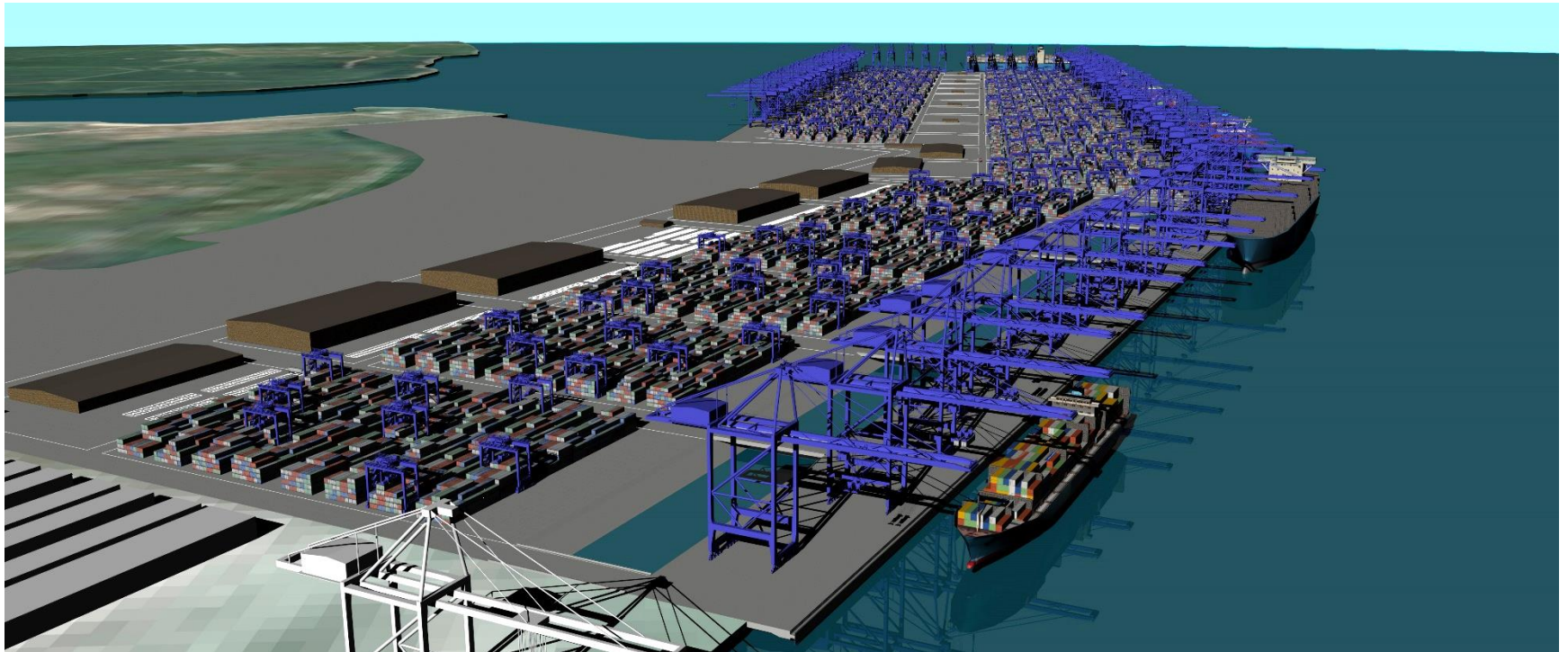
"Straight Finger" Option



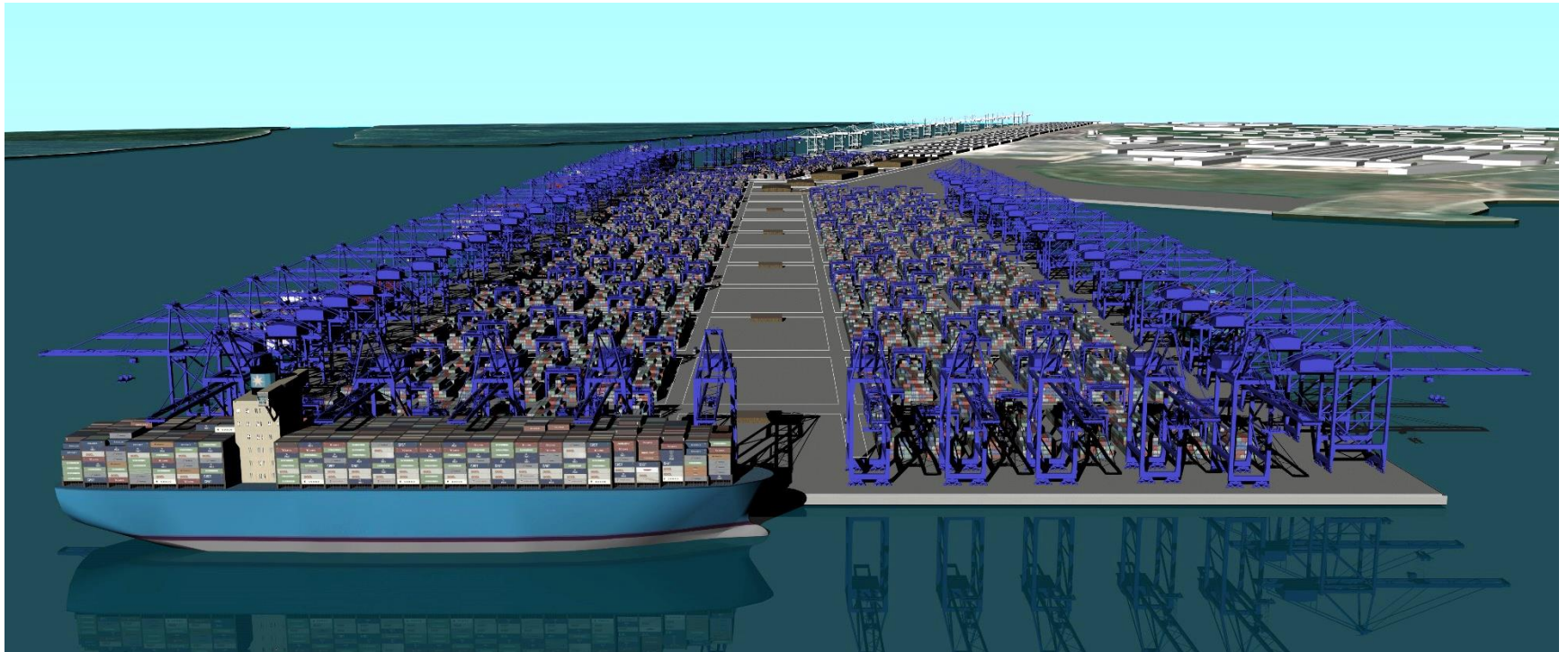
"Straight Finger" Option



"Straight Finger" Option



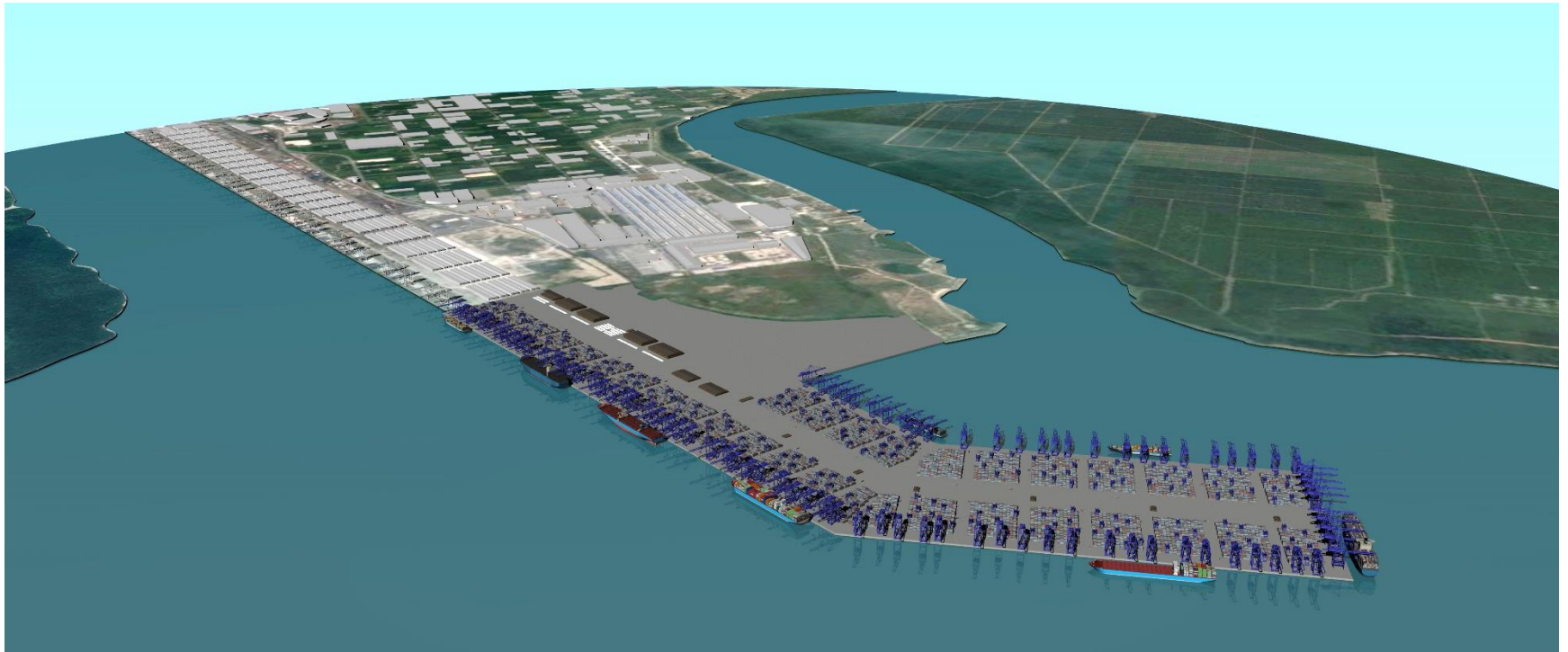
"Straight Finger" Option



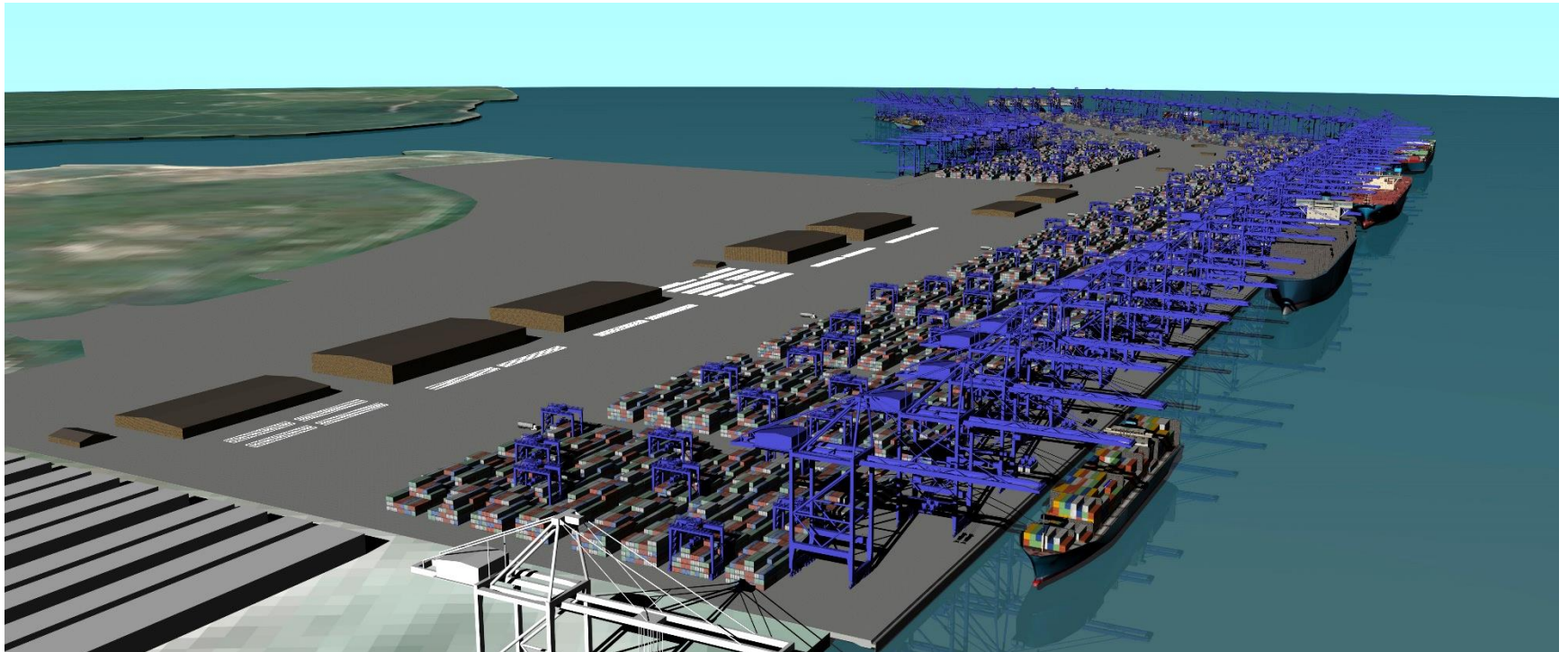
“Crooked Finger” Option



“Crooked Finger” Option

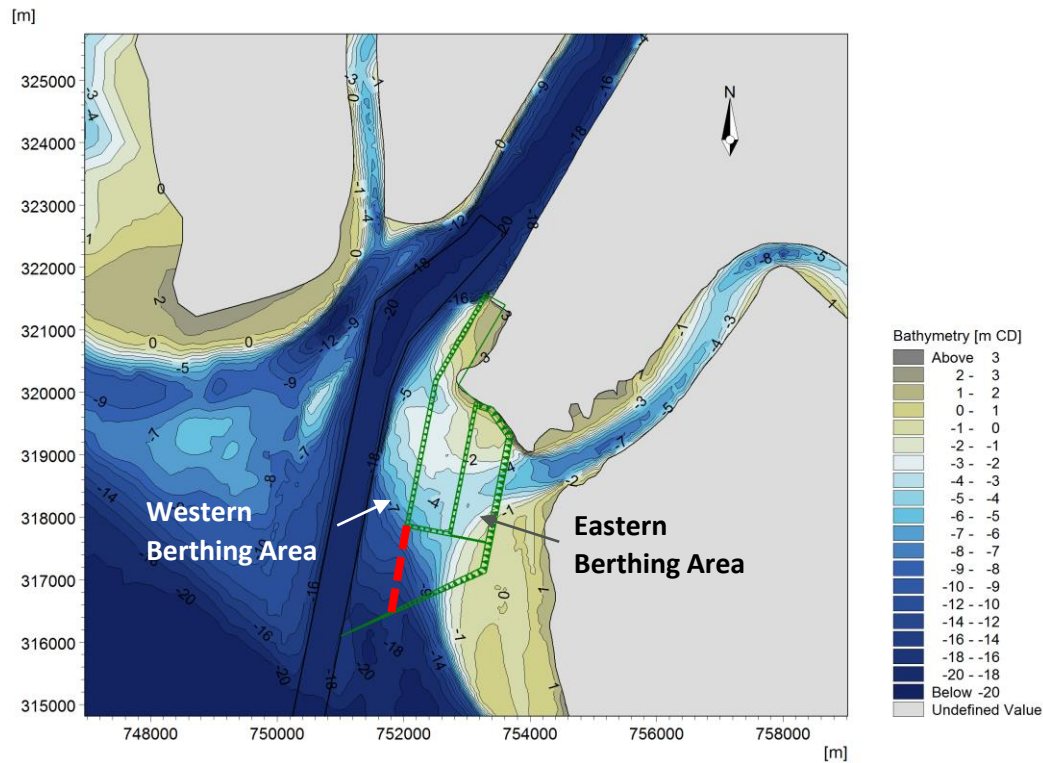


“Crooked Finger” Option

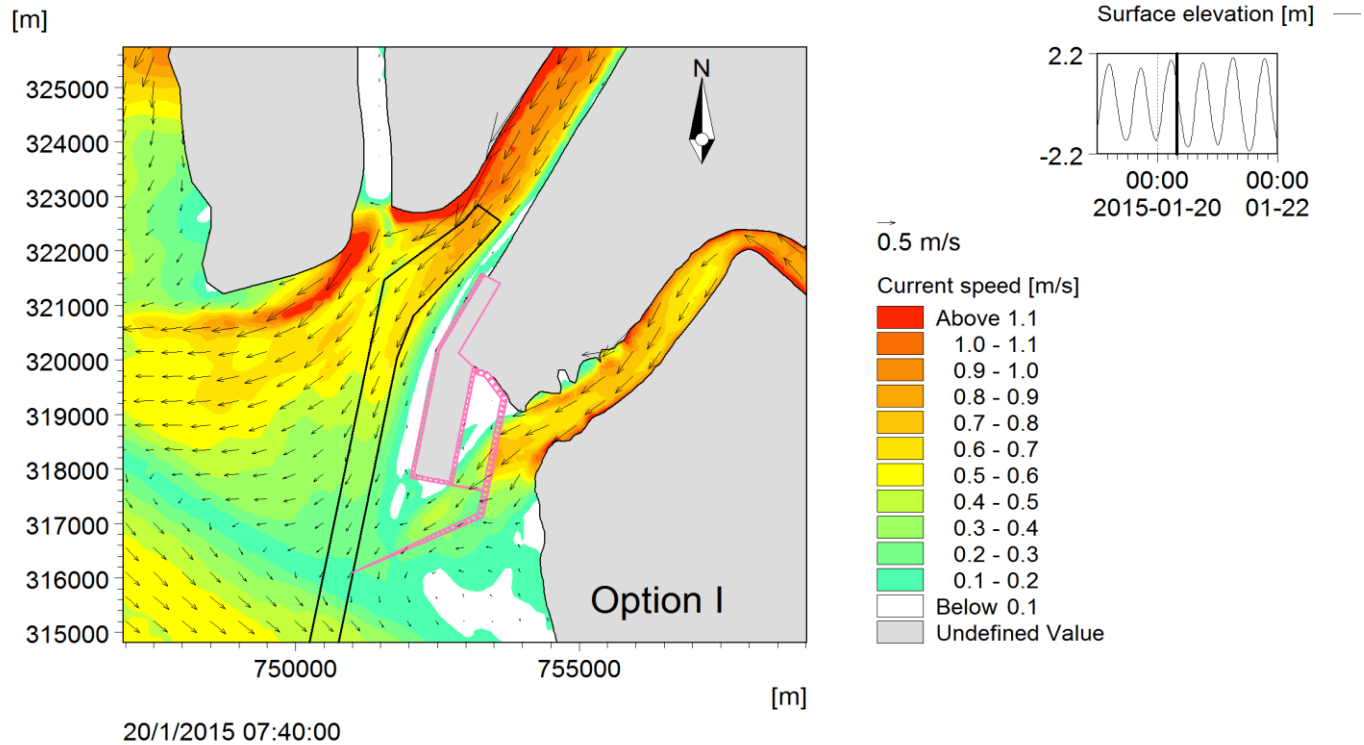


Sedimentation Review

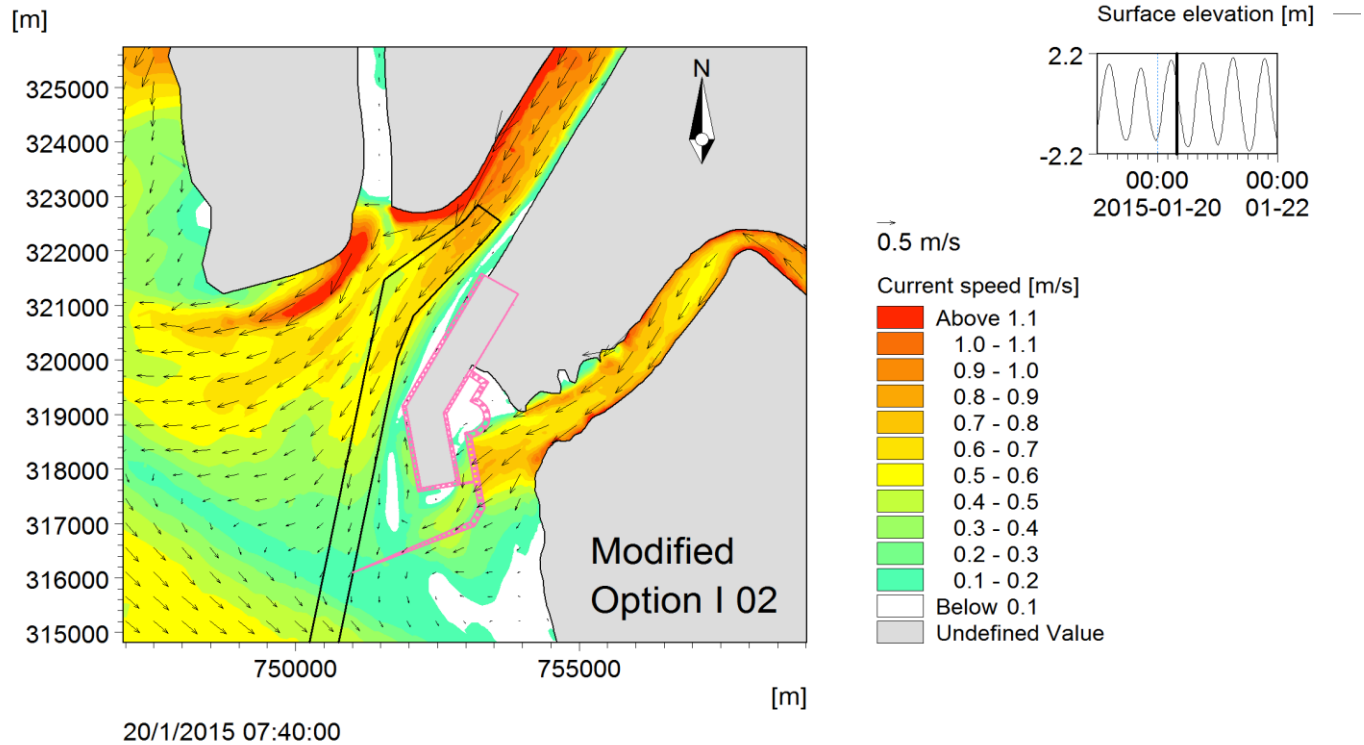
West and East Berthing Areas



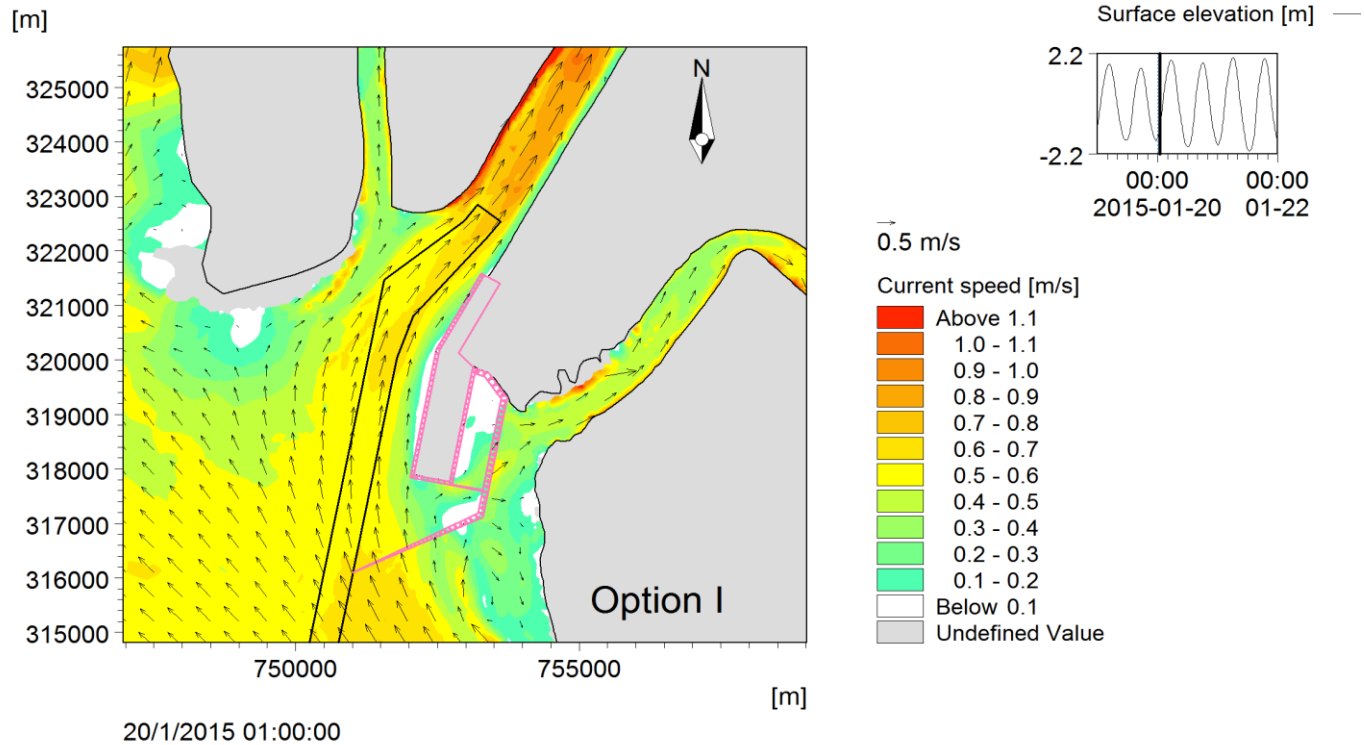
Current Speed at ebb tide (Straight Finger)



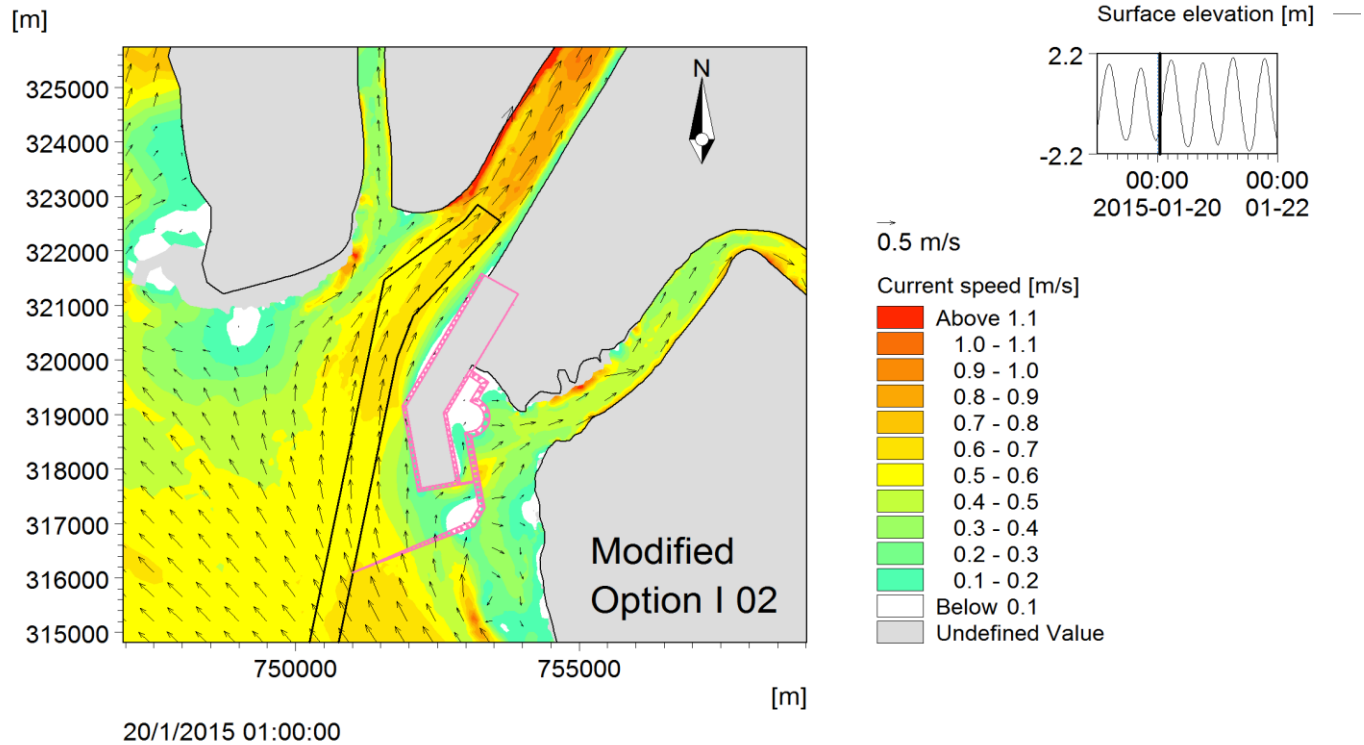
Current Speed at ebb tide (Crooked Finger)



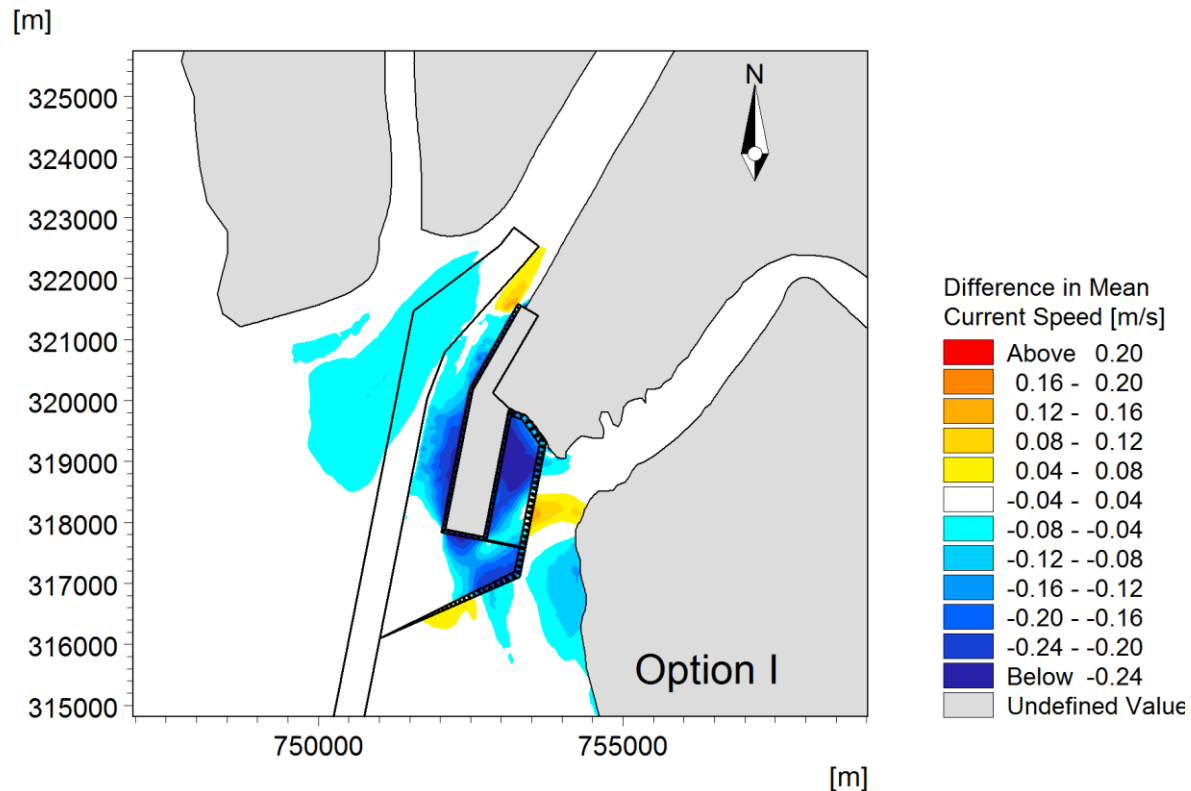
Current Speed at flood tide (Straight Finger)



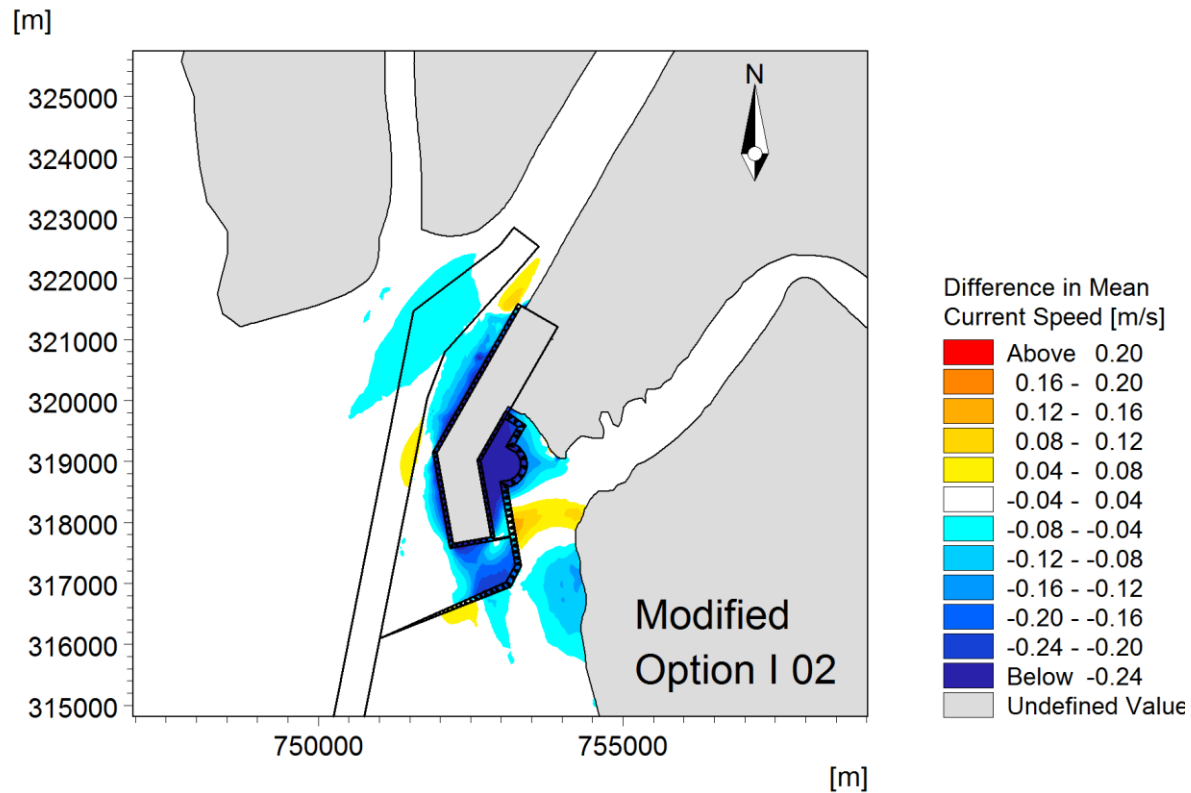
Current Speed at flood tide (Crooked Finger)



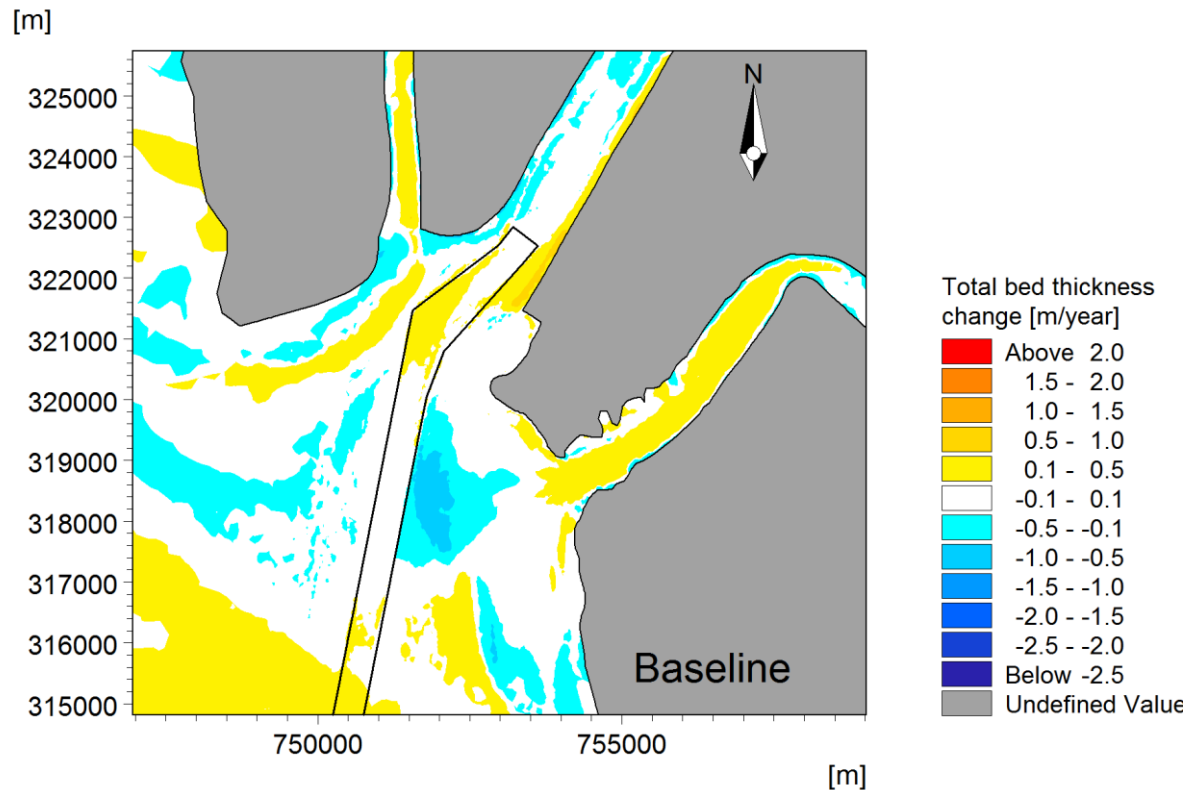
Difference in Mean Current Speed (Straight Finger)



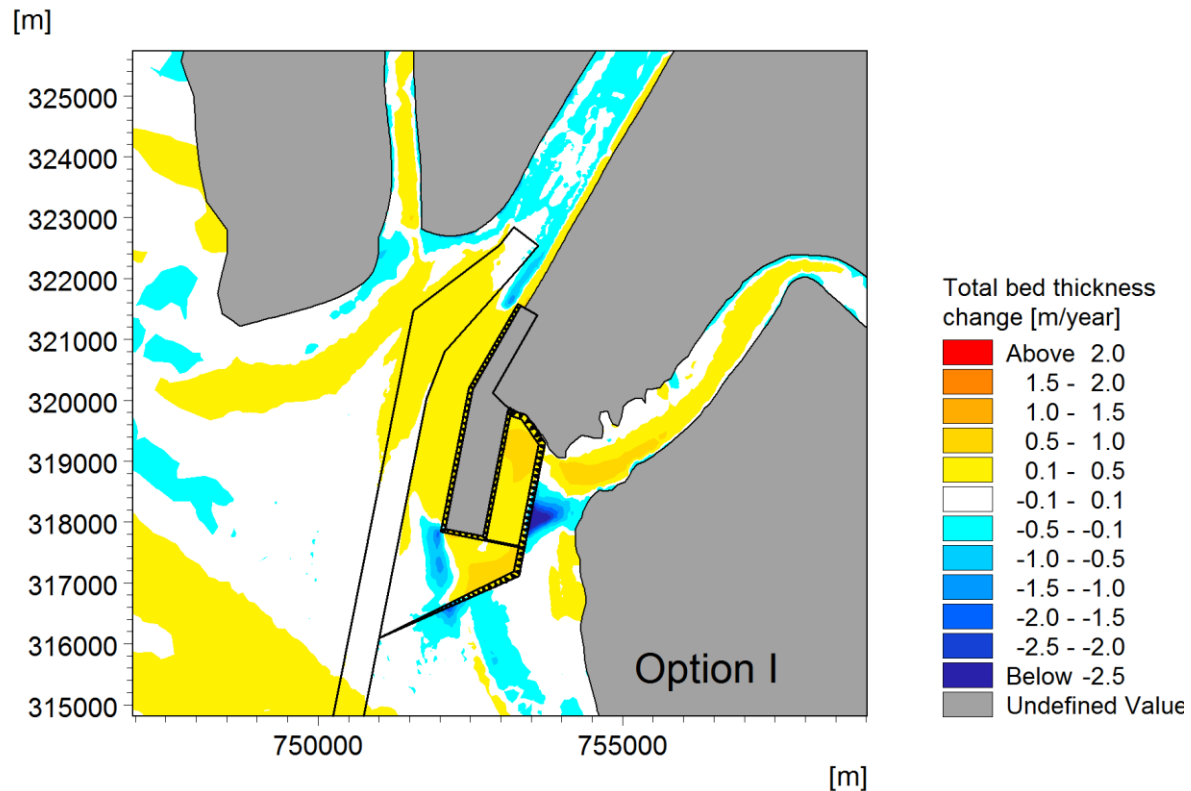
Difference in Mean Current Speed (Crooked Finger)



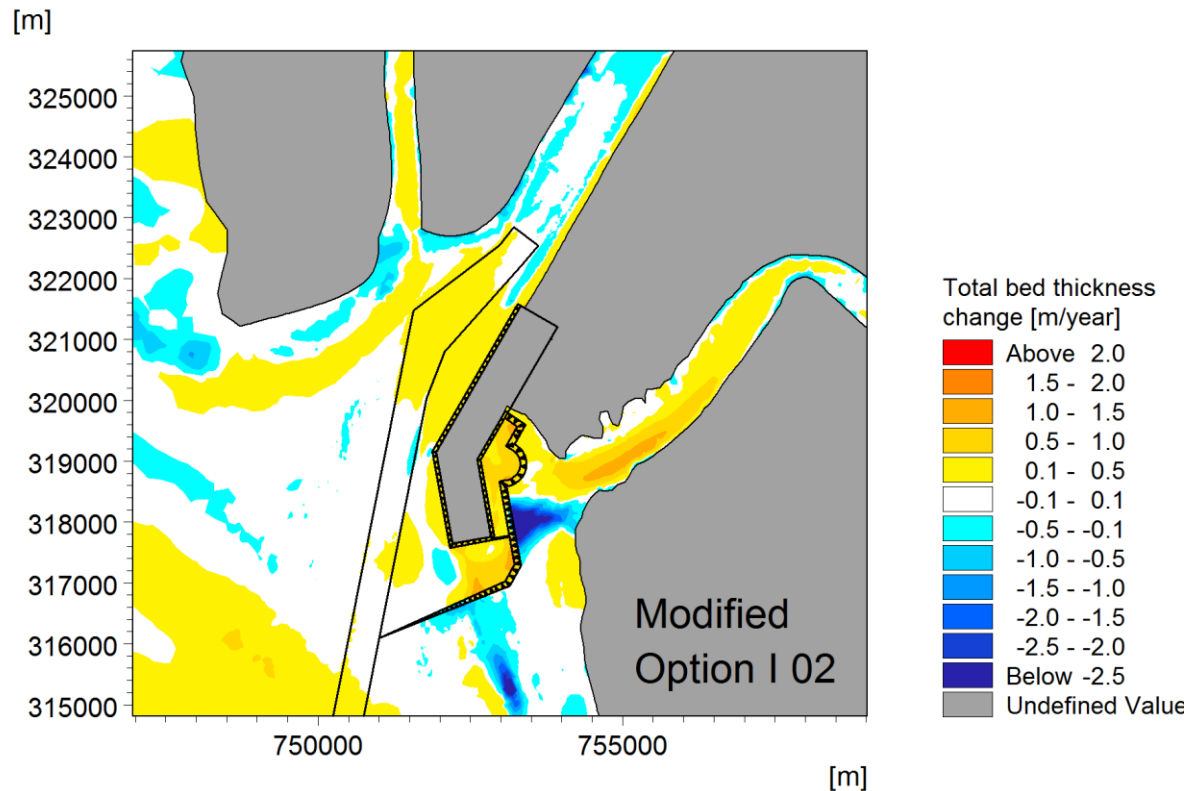
Bed Level Change (Baseline)



Bed Level Change (Straight Finger)



Bed Level Change (Crooked Finger)



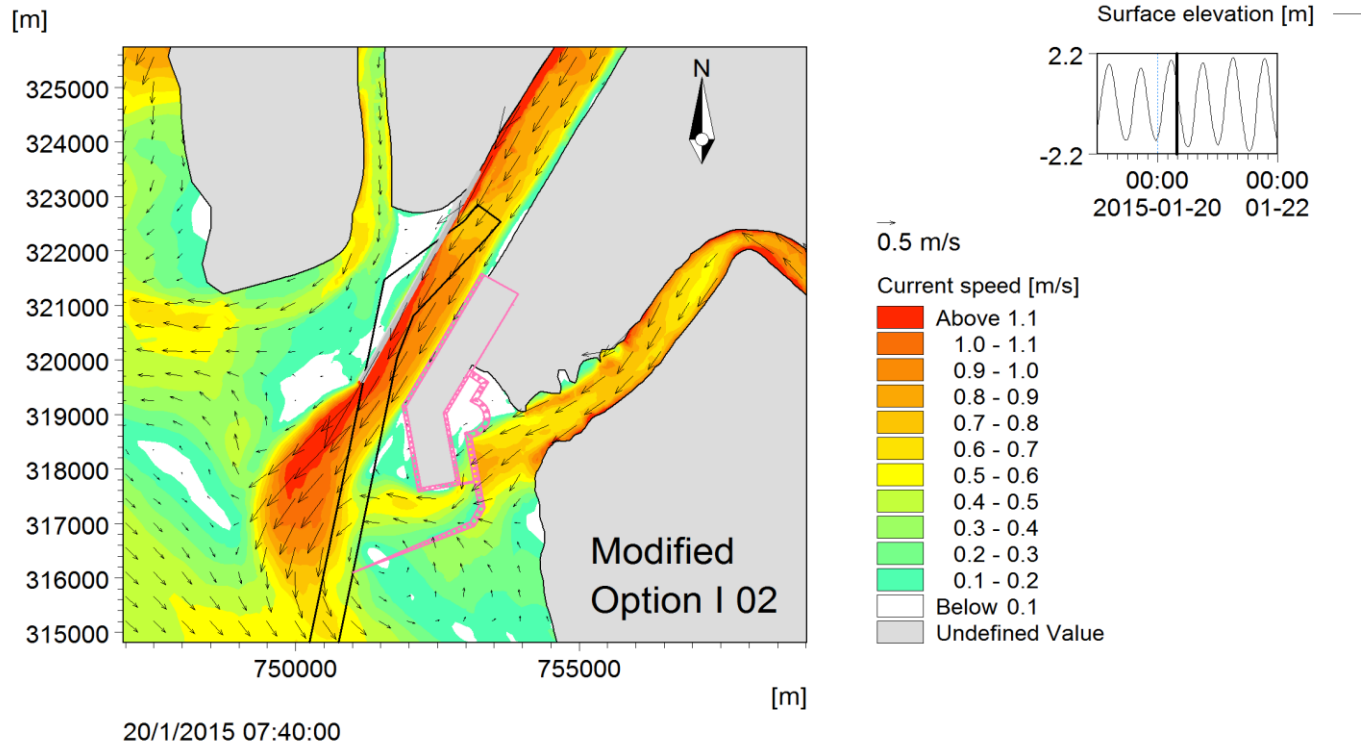
Sedimentation Volume at West and East Berthing Areas*

Modelled Options	West Berthing Area (1,000 m ³ /yr)	East Berthing Area (1,000 m ³ /yr)
Straight Finger	600 – 1,000	1,200 – 2,000
Crooked Finger	350 – 650	800 – 1,300

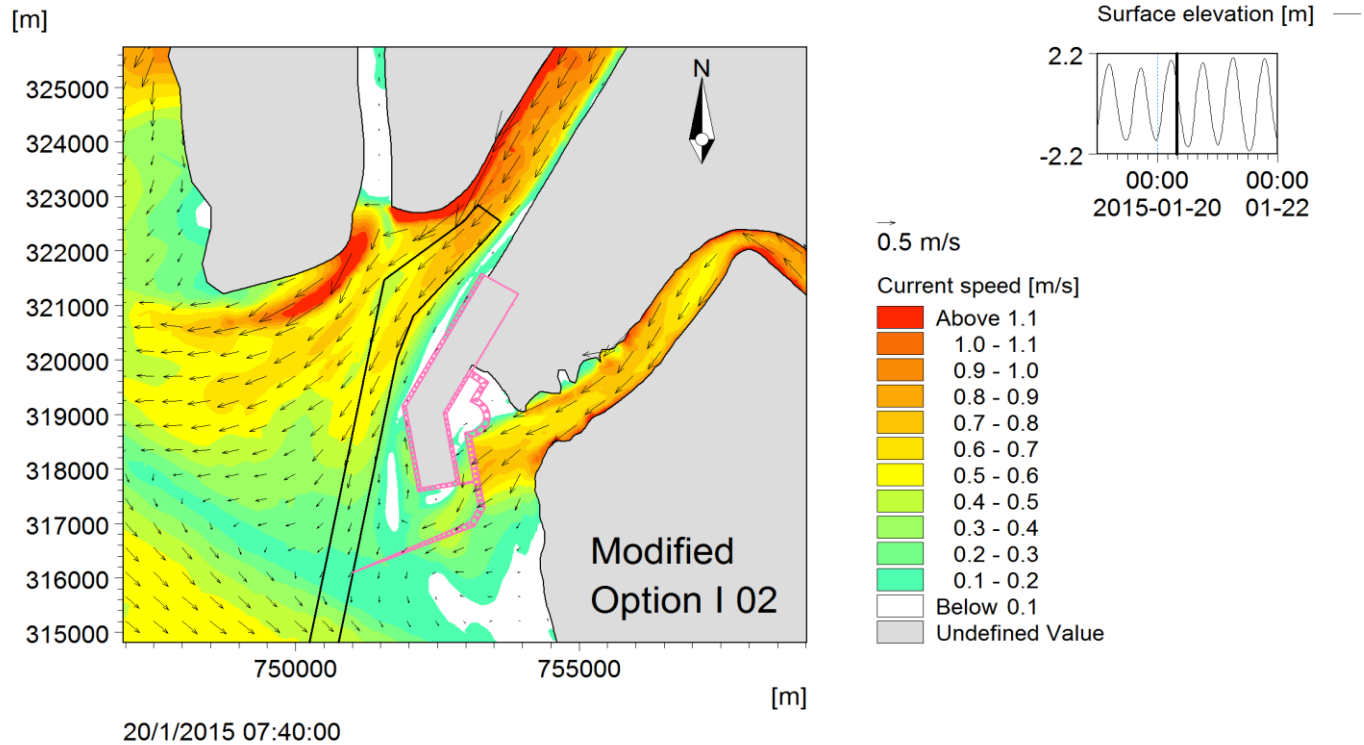
** We have not received the LPK data yet to verify the model*

Evaluation of changes in the channel

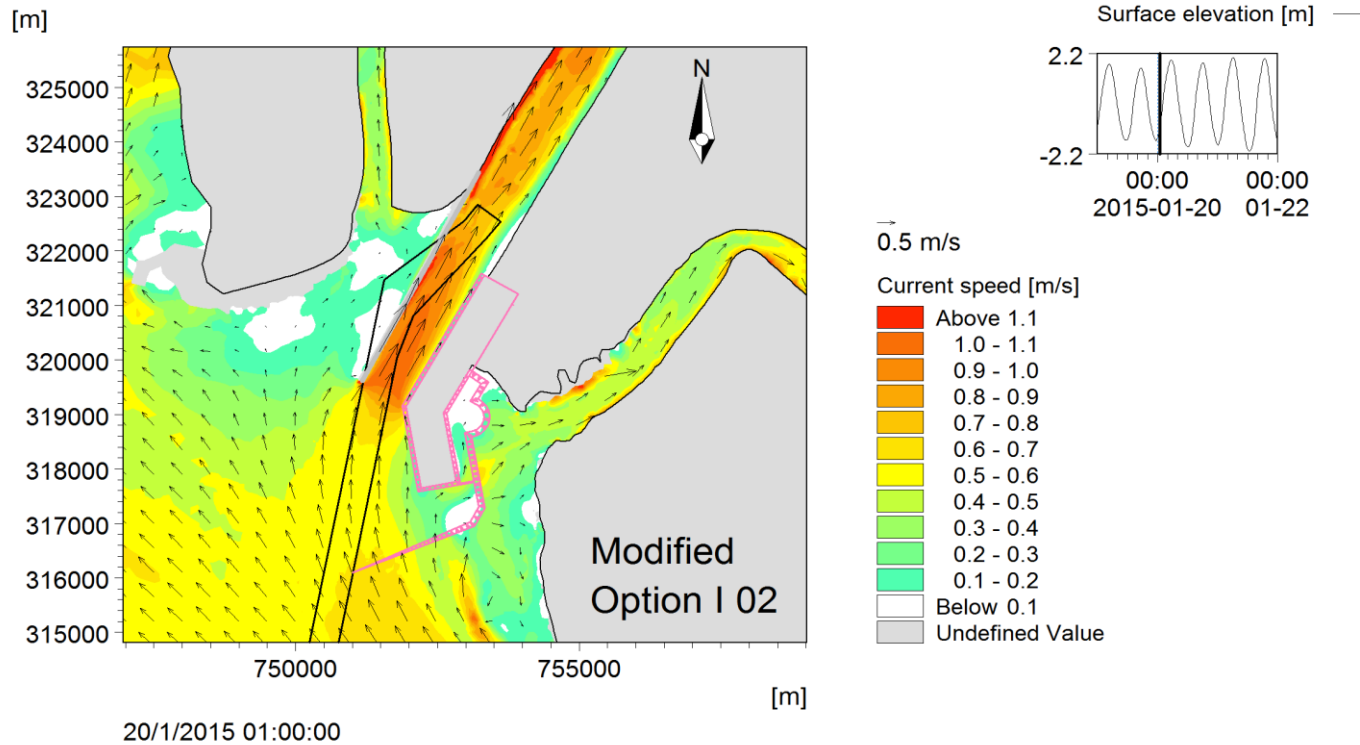
Current Speed at ebb tide (Crooked Finger with wall)



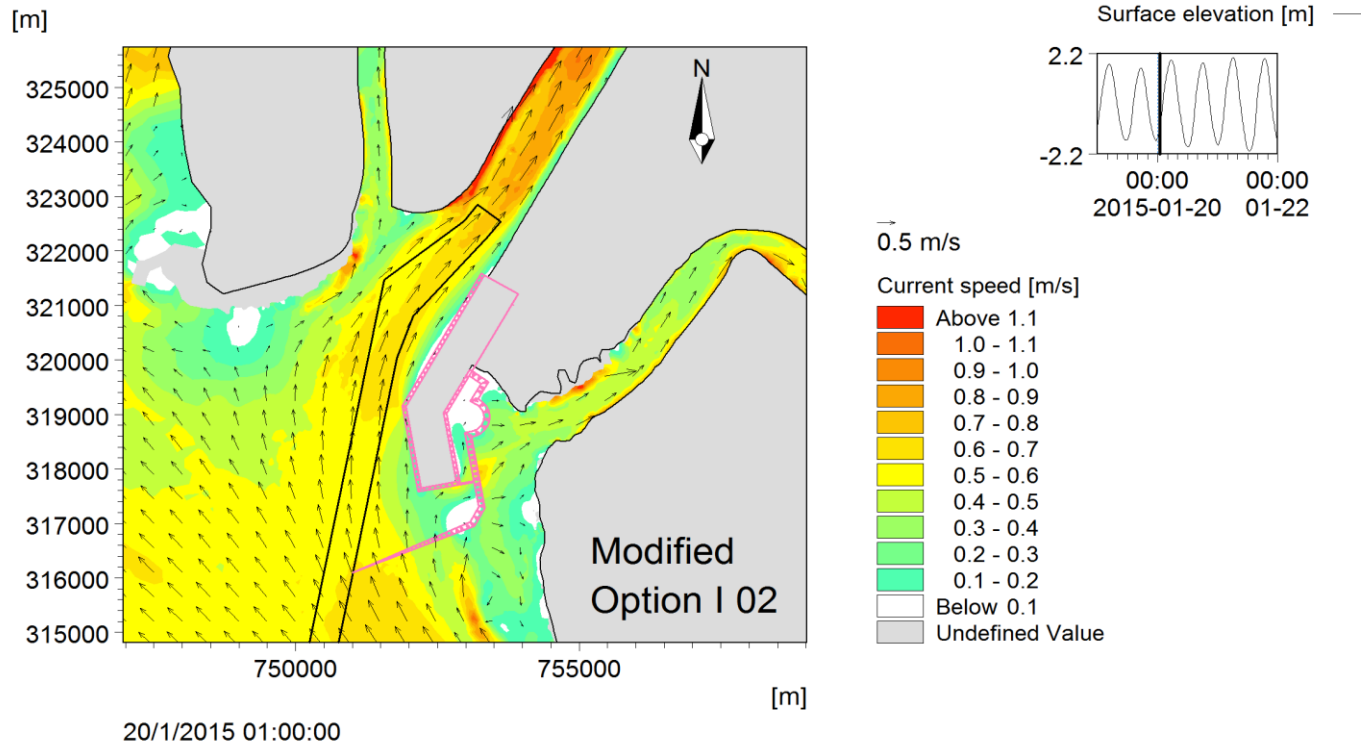
Current Speed at ebb tide (Crooked Finger)



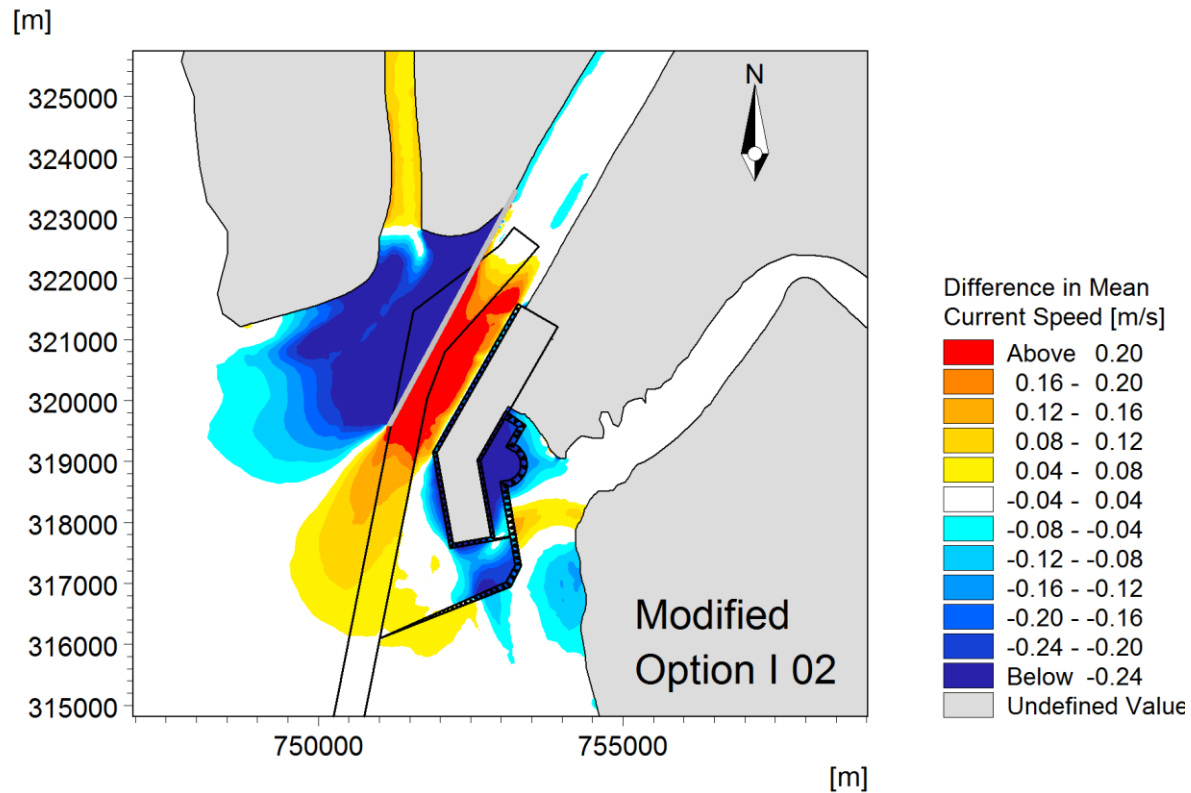
Current Speed at flood tide (Crooked Finger with wall)



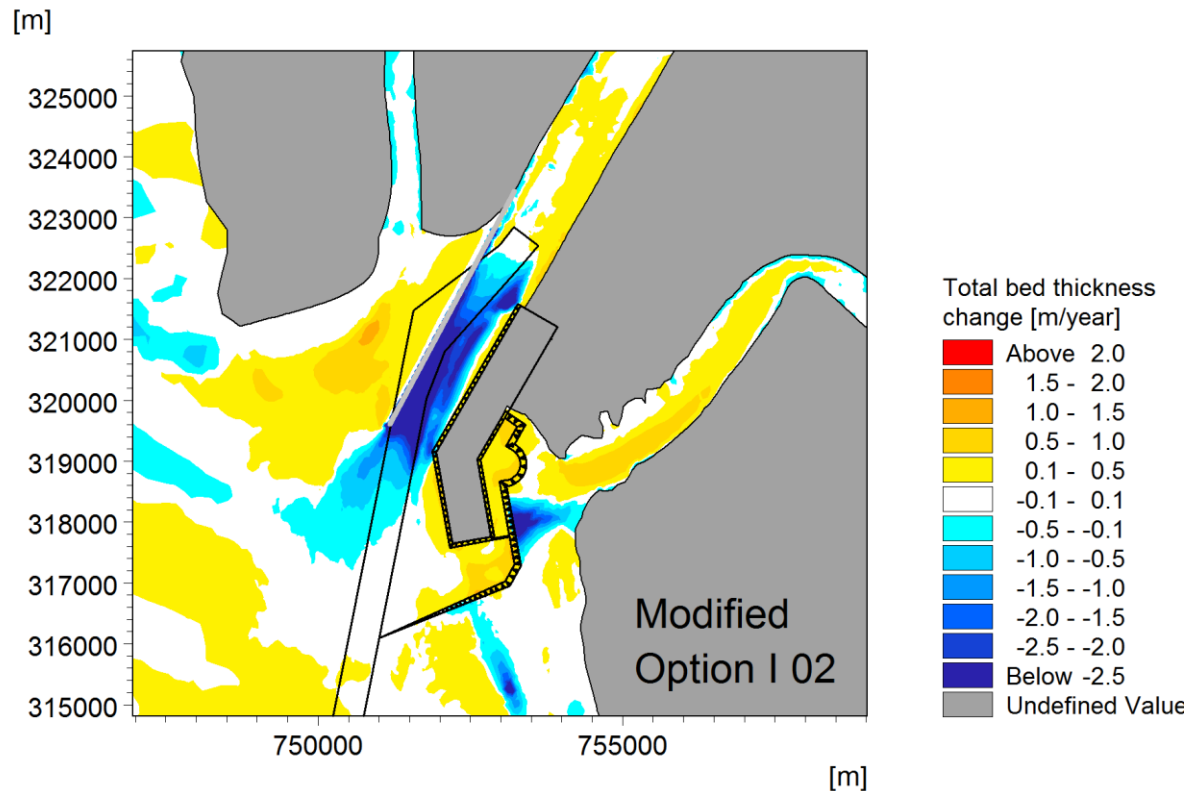
Current Speed at flood tide (Crooked Finger)



Difference in Mean Current Speed (Crooked Finger +/- wall)



Bed Level Change (Crooked Finger +/- wall)



Sedimentation Volume at West and East Berthing Areas*

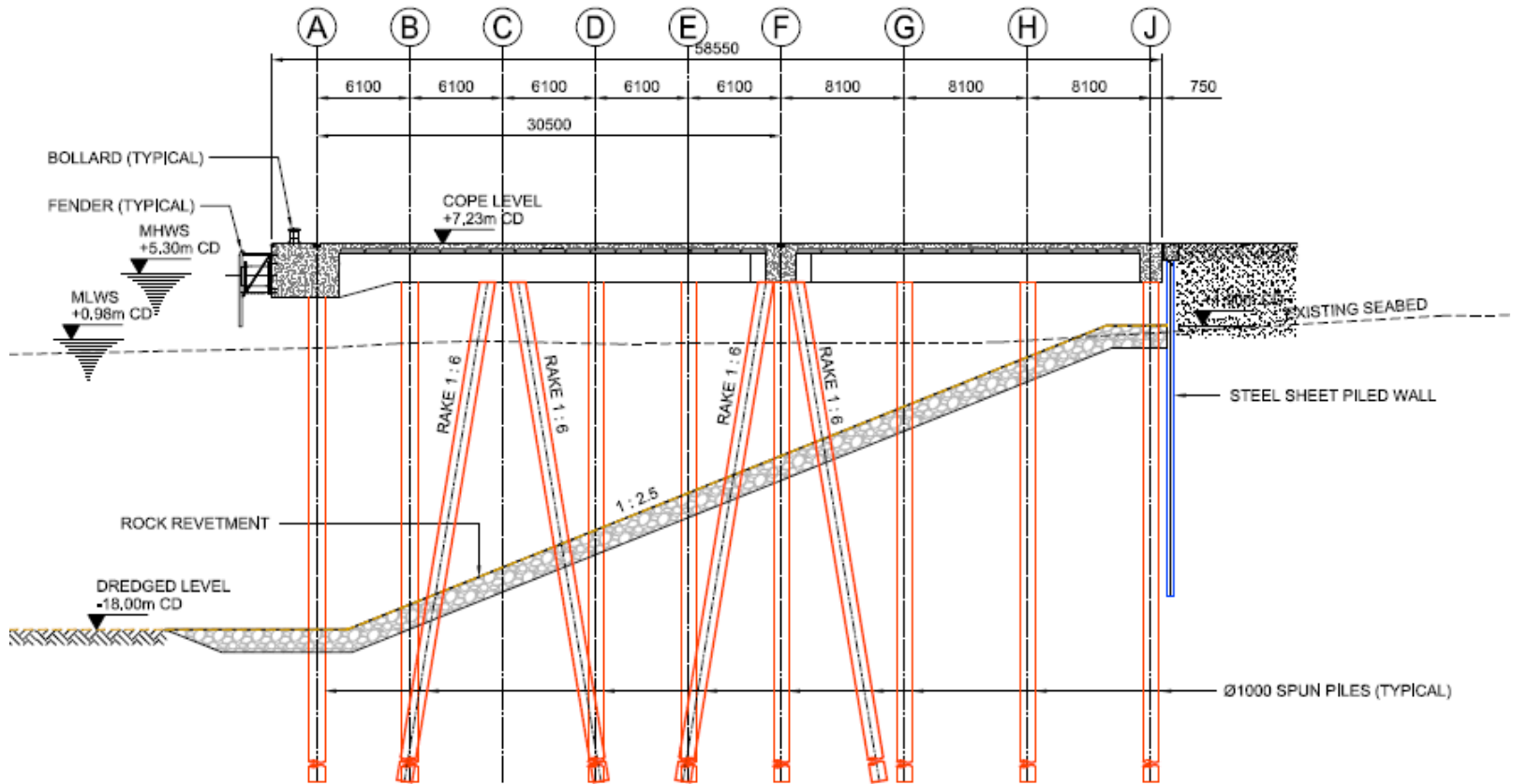
Modelled Options	West Berthing Area (1,000 m ³ /yr)	East Berthing Area (1,000 m ³ /yr)
Straight Finger	600 – 1,000	1,200 – 2,000
Crooked Finger	350 – 650	800 – 1,300
Straight Finger (wall)	450 – 750	1,100 – 1,800
Crooked Finger (wall)	250 – 450	850 – 1,500

* We have not received the LPK data yet to verify the model



Quay Design & Phasing

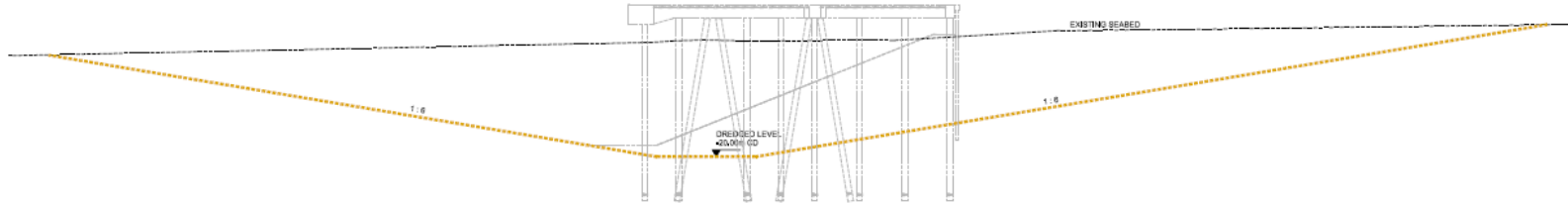
Preliminary Jetty Design



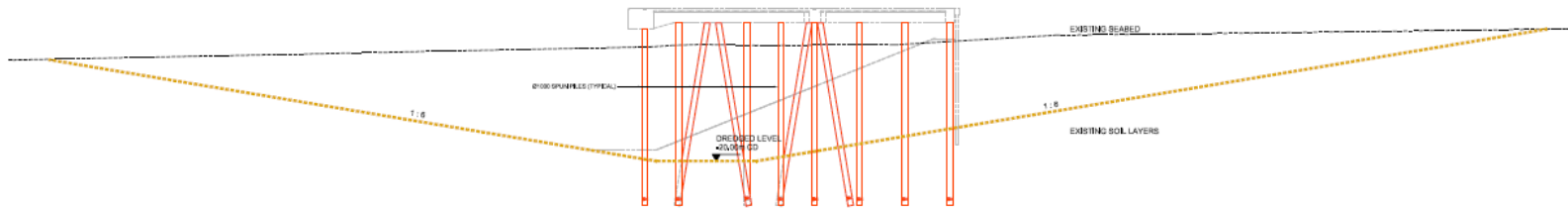
TYPICAL CROSS SECTION OF CONTAINER WHARF

(SCALE 1:150)

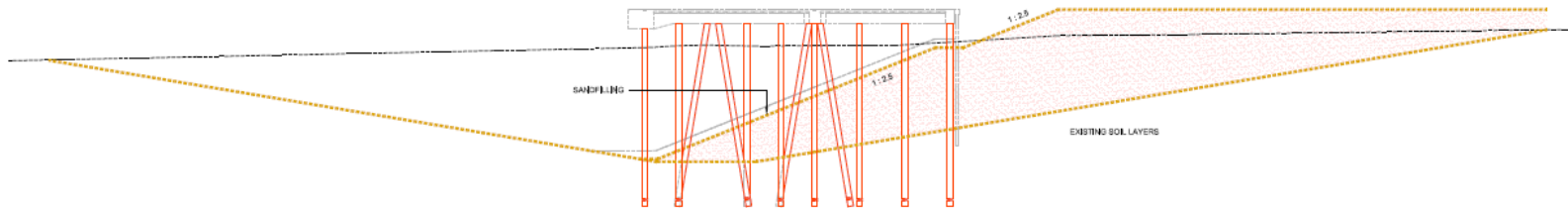
Construction Sequence



STAGE 1 - DREDGING

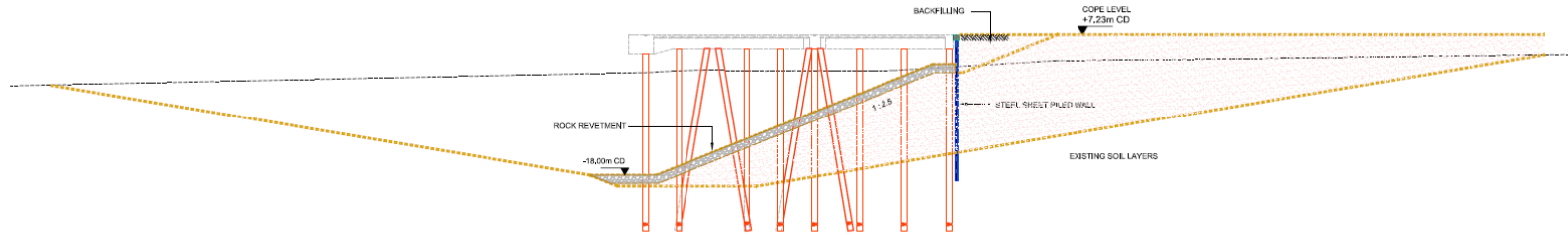


STAGE 2 - PILING

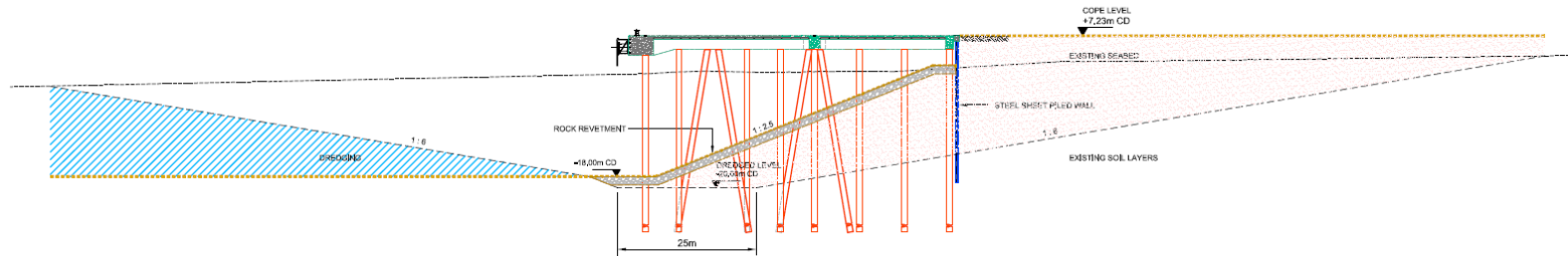


STAGE 3 - SANDFILLING TO FORM SLOPE FOR ROCK REVETMENT

Construction Sequence



STAGE 4 - CONSTRUCTION OF
a) SHEET PILED WALL
b) BACKFILLING BEHIND SHEET PILED WALL
c) ROCK REVETMENT

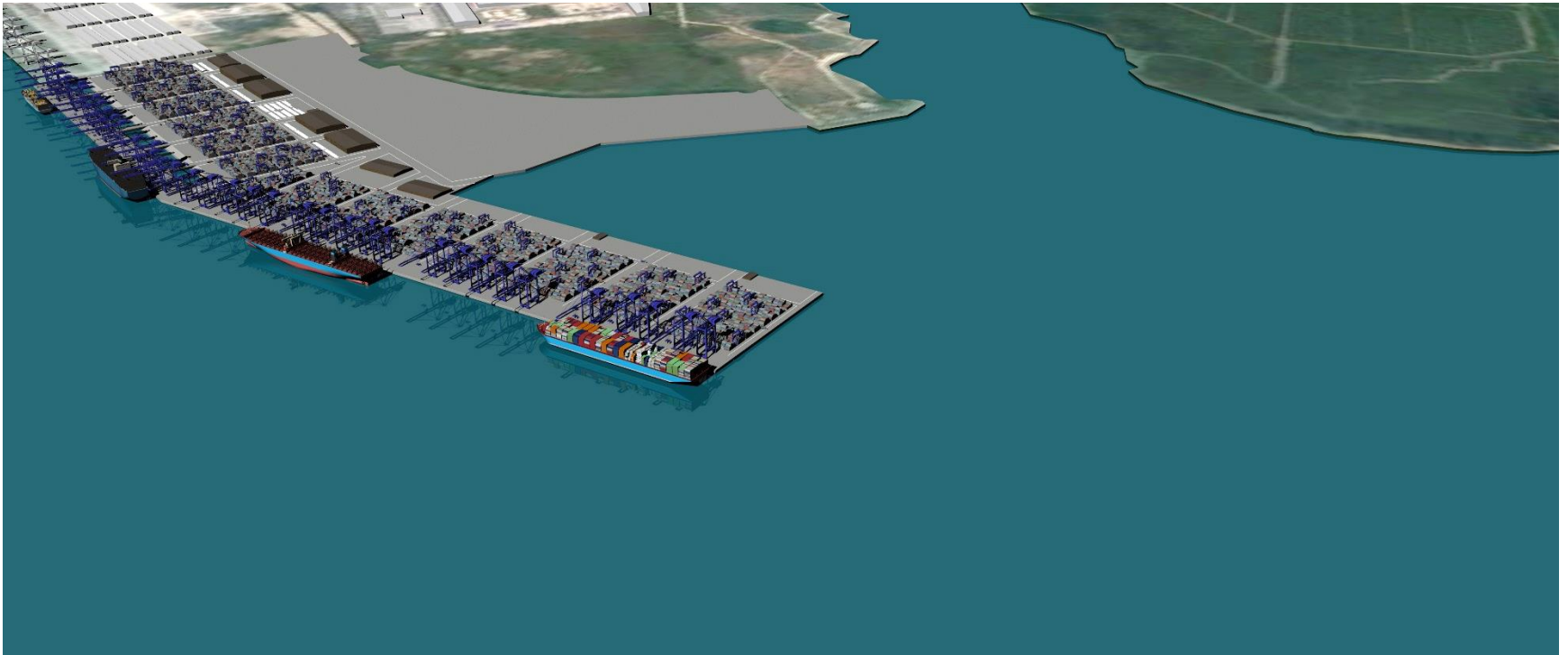


STAGE 5 - CONSTRUCTION OF WHARF STRUCTURE AND DREDGING WORKS

Phase 1



Phase 2



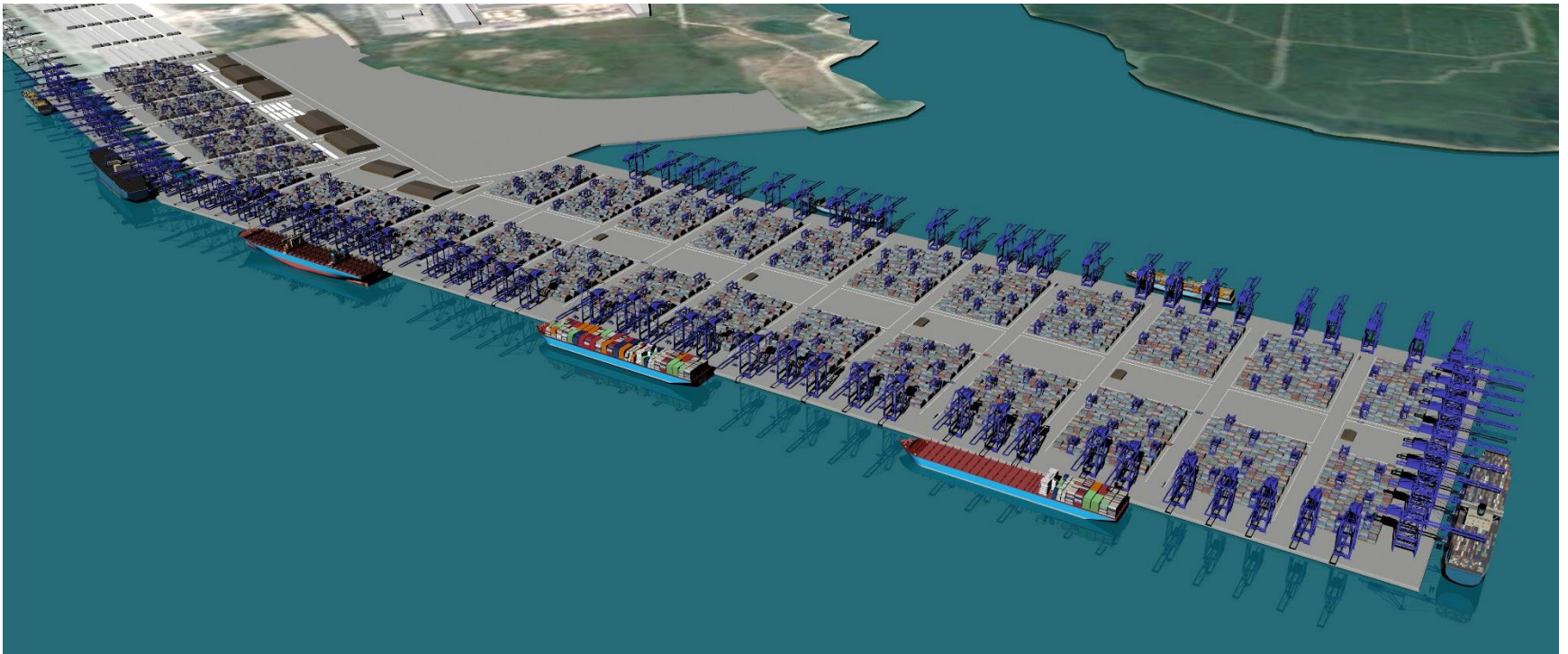
Phase 3



Phase 4



Phase 5



Costing Update

CAPEX

For preliminary review on CAPEX the major components include:

1. Civil Engineering Works

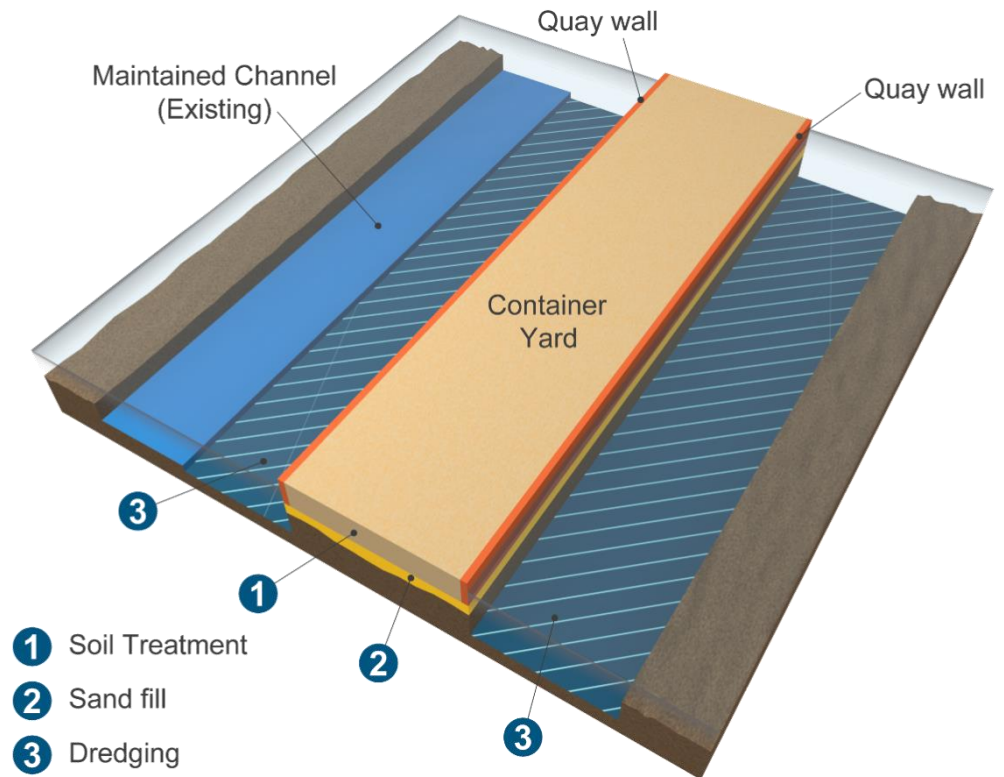
- Soil Treatment
- Sand Filling

2. Terminal Construction

- Quay Wall & Apron
- Road, Pavement, Drains
- Equipment

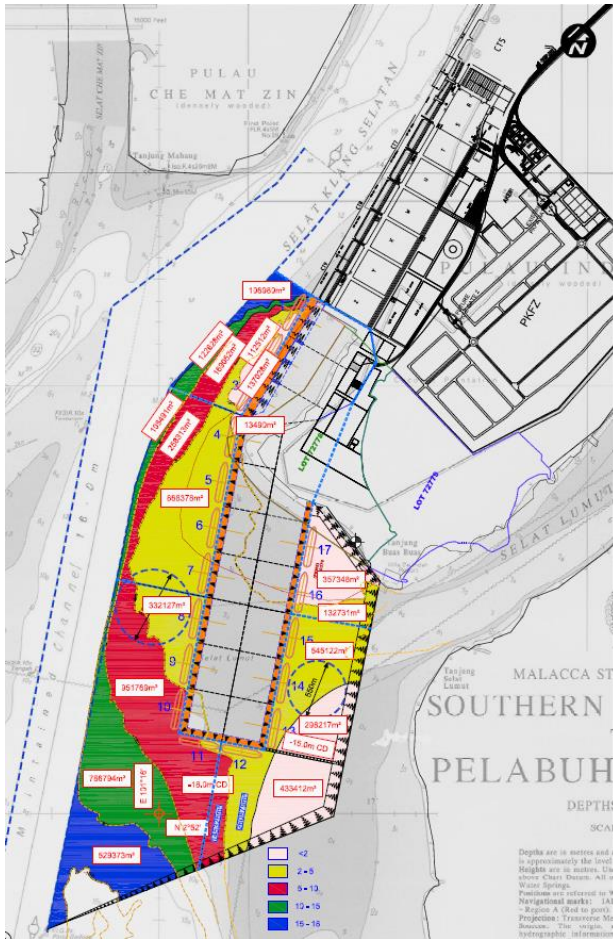
3. Navigation

- Dredging

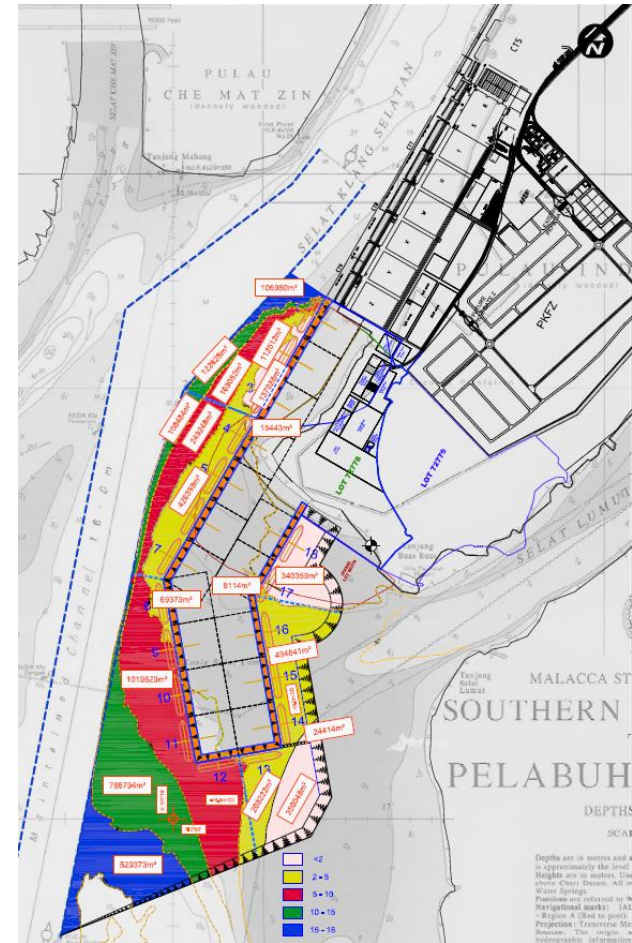


CAPEX – Dredging Estimate

Straight Finger

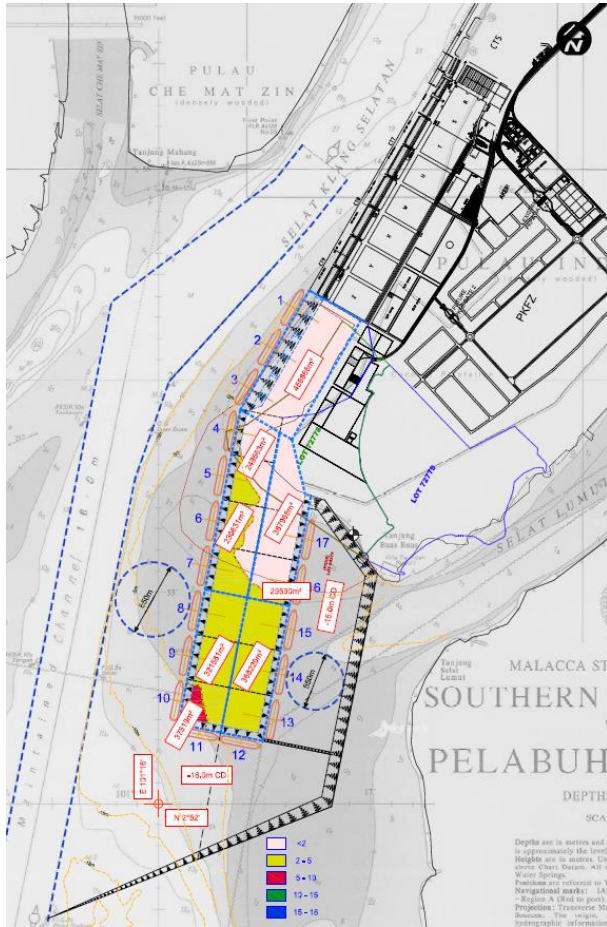


Crooked Finger

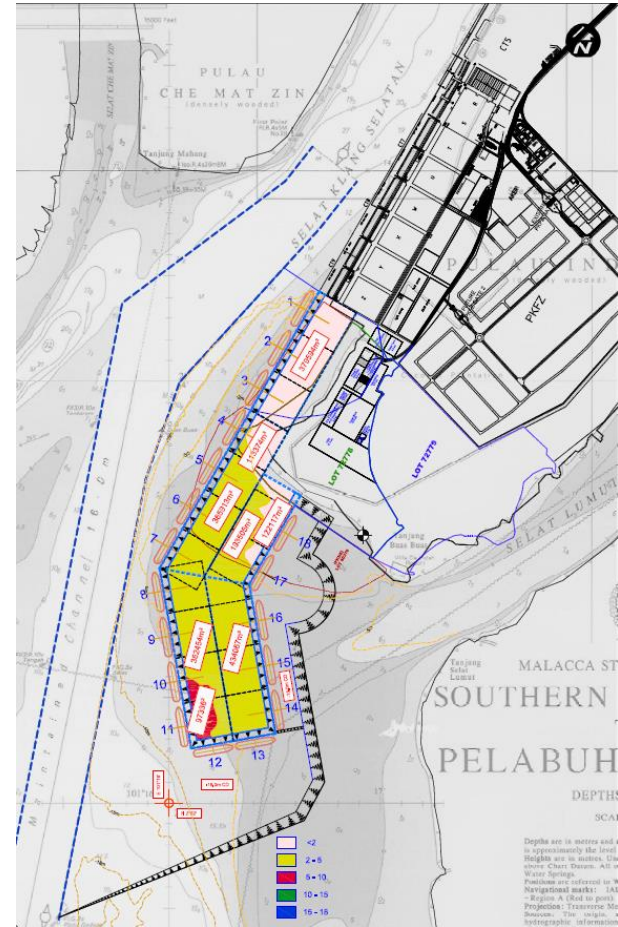


CAPEX – Reclamation Estimate

Straight Finger



Crooked Finger



Income (as previously)

Approach

- *Discounted Cash Flow* (DCF) based on Operating Profit (EBITDA)
- Operating profit per 400m berth, *cumulative* and *per berth* basis

Assumptions

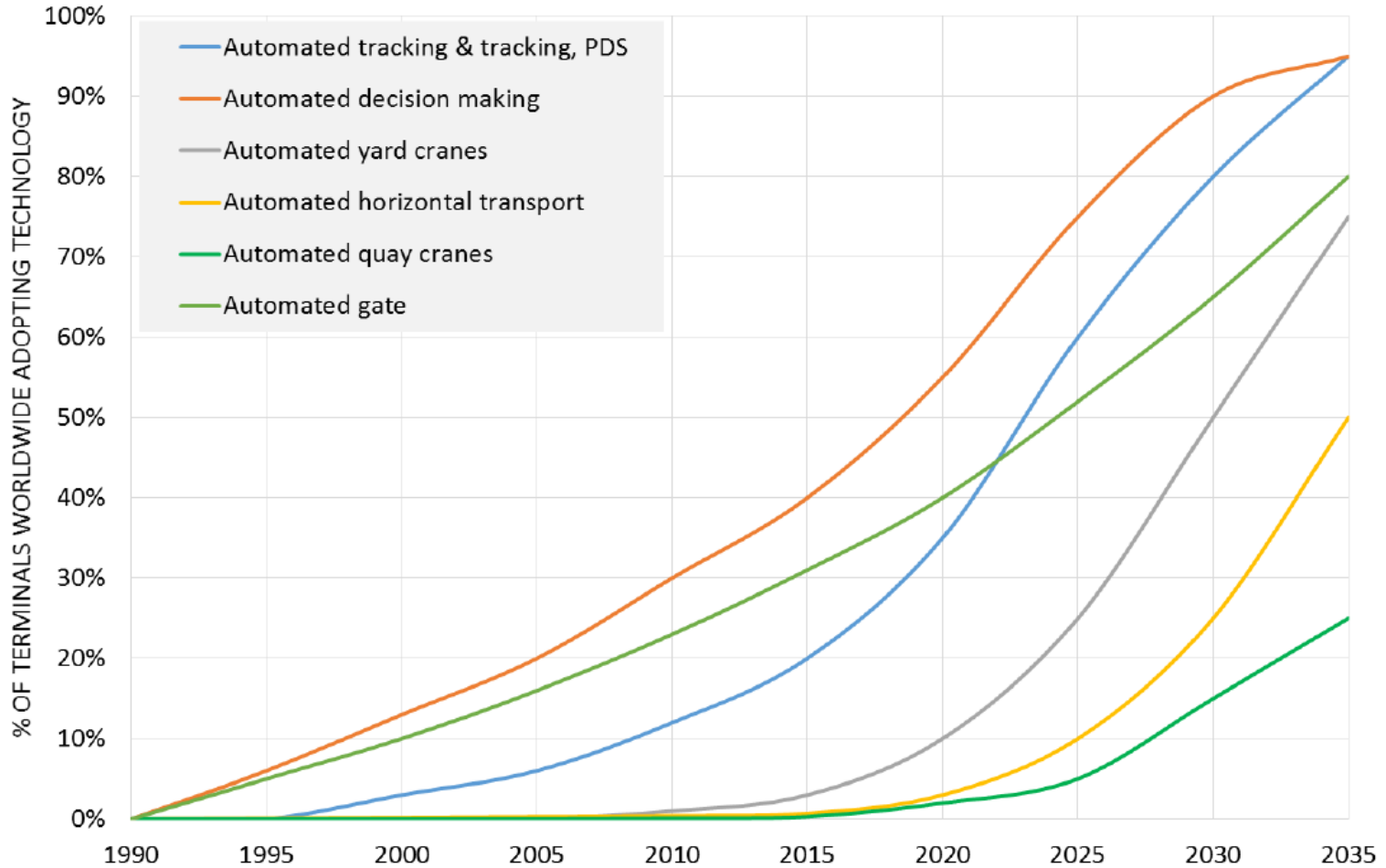
Asset Life	30 years
Utilisation	New berth will be ready when existing berths reach 85% utilisation
Operating Margin	Up to 54% based on past 5 years (Westports financial report)
WACC	8% (2018, Hong Leong Investment Bank)
Tariff	1) Current split between OD & TS 2) Along with inflation (2.5% p.a., IMF)
Scenarios	1) 70%-90% transshipment 2) - 10% EBITDA margin (i.e. 44%)

Automation Issues / Options

Scope



Terminal Automation Trend



Yard Automation – ASC



Yard Automation – Straddle Carrier

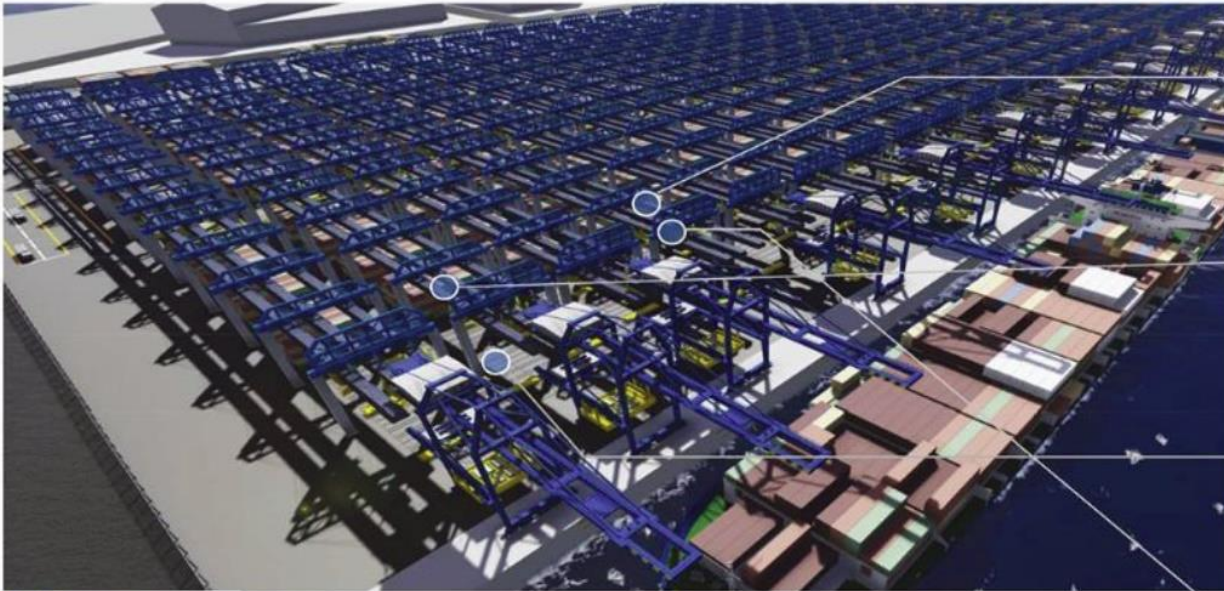


Automated Horizontal Transfer



Overhead Shuttle System Proposal

System Composition



Hardware

1. 40ft Overhead Shuttle

- High-speed hoist/trolley for 40ft
- Container pickup/release



2. 20/40ft Overhead Shuttle

- High-speed hoist/trolley for 20/40ft
- Container pickup/release



3. Flatcar

- Horz./Perpendicular move
- QC-Yard transport



4. Overhead Shuttle Rail

Software

1. Design/Operation Simulator

- Terminal design, evaluation



2. Operation/Monitoring System

- Realtime 3D monitoring



3. CO2 emission monitoring system

- CO2 emission forecast, monitoring

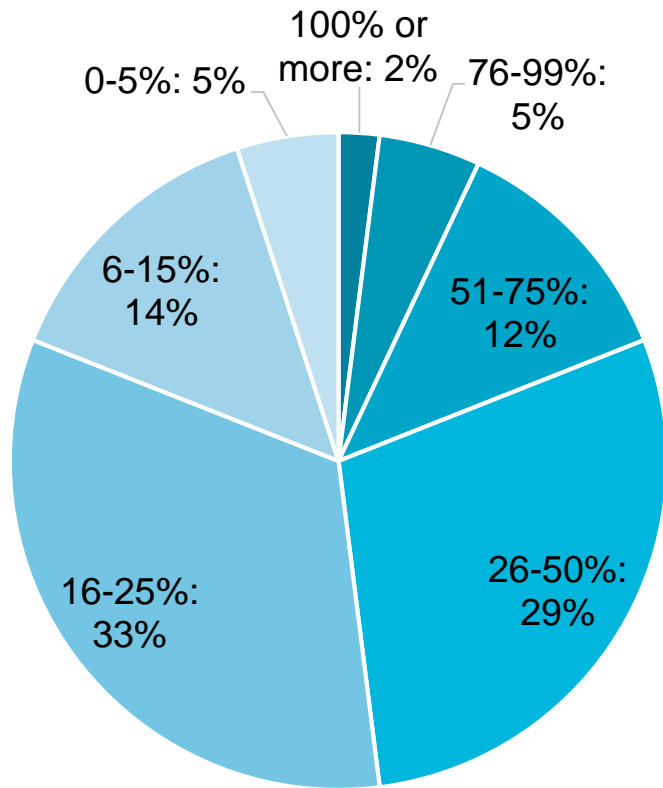


4. Overhead Shuttle Rail

- 하부레일 : 플랫폼 이동 경로 가능
- 상부레일 : 서플 이동 경로 가능



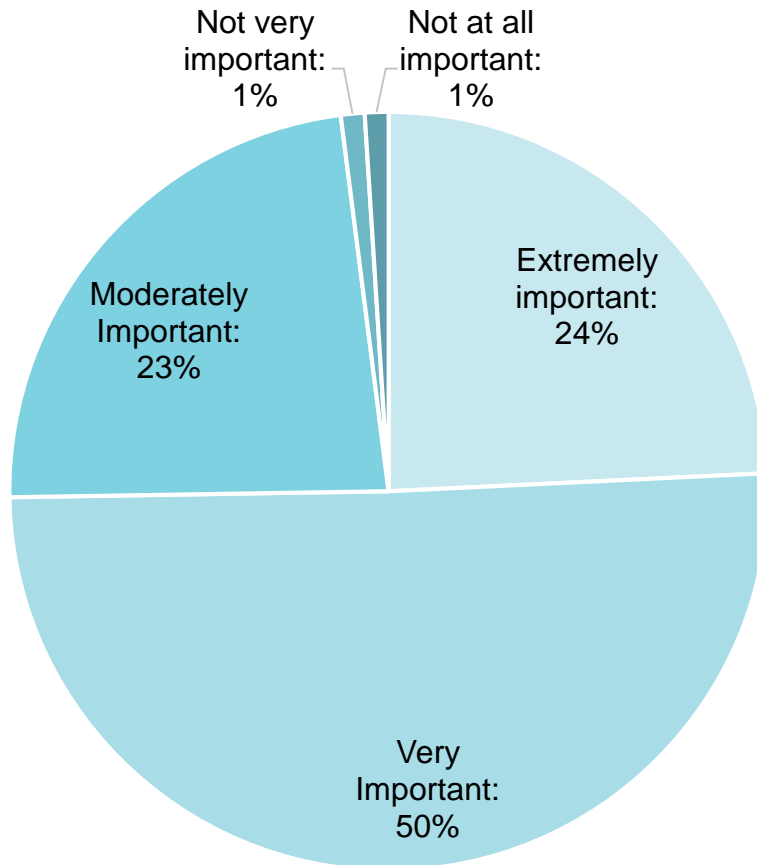
Automation – Reduction in Operating Cost?



- Labour cost is key cost component, which accounts for 40-60% of the total costs per TEU (US)
- Manned operations requires double of labour cost than full automation
- Power & fuel perspective, eRTG (e-mode) of 2-3 kwh/TLC vs ASC of 1-3 kwh/TLC

Source: TechValidate 2018 survey of 78 current users of Navis

Automation – Secure Competitiveness?



- An ASC costs about US\$1 million more than an electrified RTG
- RMG requires rail construction, thus involves additional costs
- IT investment is in a range of US\$1-1.3 million, depending on the choice of TOS

Source: TechValidate 2018 survey of 78 current users of Navis

Automation – Benefits?



Source: TechValidate 2018 survey of 78 current users of Navis

Remote Control Centre – Thailand (LCB Terminal D)



Remote Control Trend

- Remote control QC and RTG have been made available to the market
- QC and RTG with remote control function cost higher than traditional QC and RTG, but much less than ASC
 - Traditional RTG – USD ~1.7 mil
 - **RC RTG – USD ~2 mil** (+17% vs traditional RTG)
 - ASC – USD ~3 mil (+76% vs traditional RTG)
- Labour – one driver for traditional RTG vs one staff for **4-8** RC-RTGs
- Productivity – expect higher MPH (allegedly 20% by HIT) but at **limited level** given standardised process
- Safety and better working environment
- Remote control top priority for greenfield terminals and also preferred option for brownfield where conversion is possible

Conclusions & Recommendation

Conclusions:

- This is a fast evolving & growing field
- Few suppliers have significant installations with long track record
- WestPorts are in position to be a powerful customer
- There is no need at this stage to pick technologies/application types

Recommendations

- Keep options open

To Do List

Key Tasks & Decisions

Decisions by Client:

- Agreement to Adopt “Crooked Finger” Option as basis for design

Tasks by Study Team

- Dredging development / refinement
- Navigation Simulation
- Marine Traffic Assessment

Q & A

4th Layout Option Workshop

Port Planning Consultancy for the Conceptual Master Plan of the Proposed Westports Expansion CT10 - CT19

4th Layout Option Workshop

Date: 30 Oct 2018



Agenda

1	Review of Option Development Process
2	Sedimentation Review
3	Final Layout Option
4	Quay Phasing
5	Overall port development CAPEX
6	Tasks Ahead

Review of Option Development Process

Capacity Requirement Established

- Initial developments of capacity requirement has been established:



Existing Capacity	Additional Capacity	Quay Length	Terminal Area	Berth Length	No. of Berth	Back up Area Per Berth	Length Behind Berth
(million TEUs)	(million TEUs)	(m)	(Ha)	(m)	(nos)	(Ha)	(m)
15	15 - 20M @ 70 - 90% Transhipment	6,000 – 8,000m	250 - 330	400	15 - 20	12.5 - 17	315 - 425

Key Constraints

Channel

- Seek to avoid reclamation close to the channel

Land

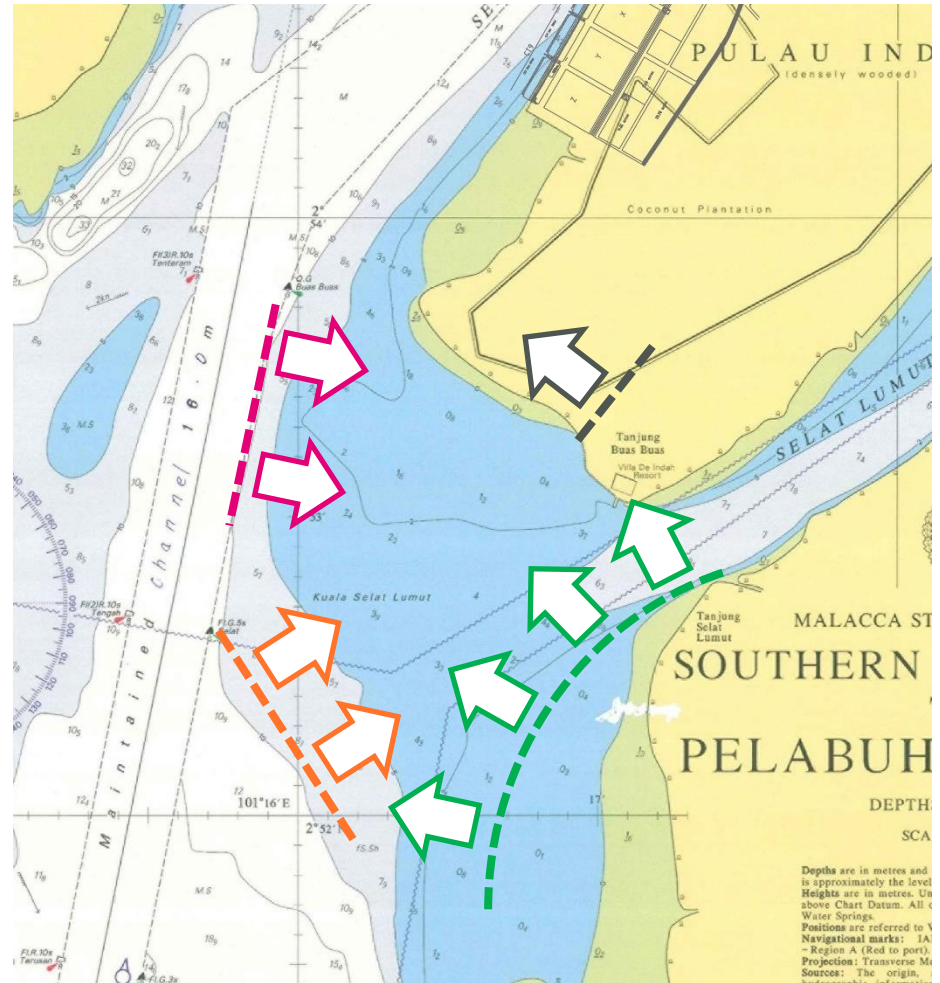
- Existing land ownership does not include the SE tip of Pulau Indah

Dredging

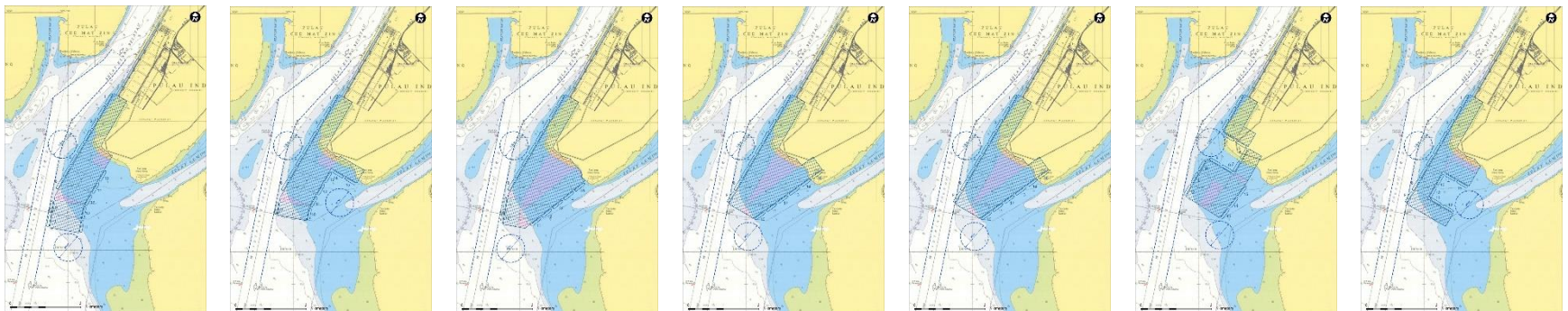
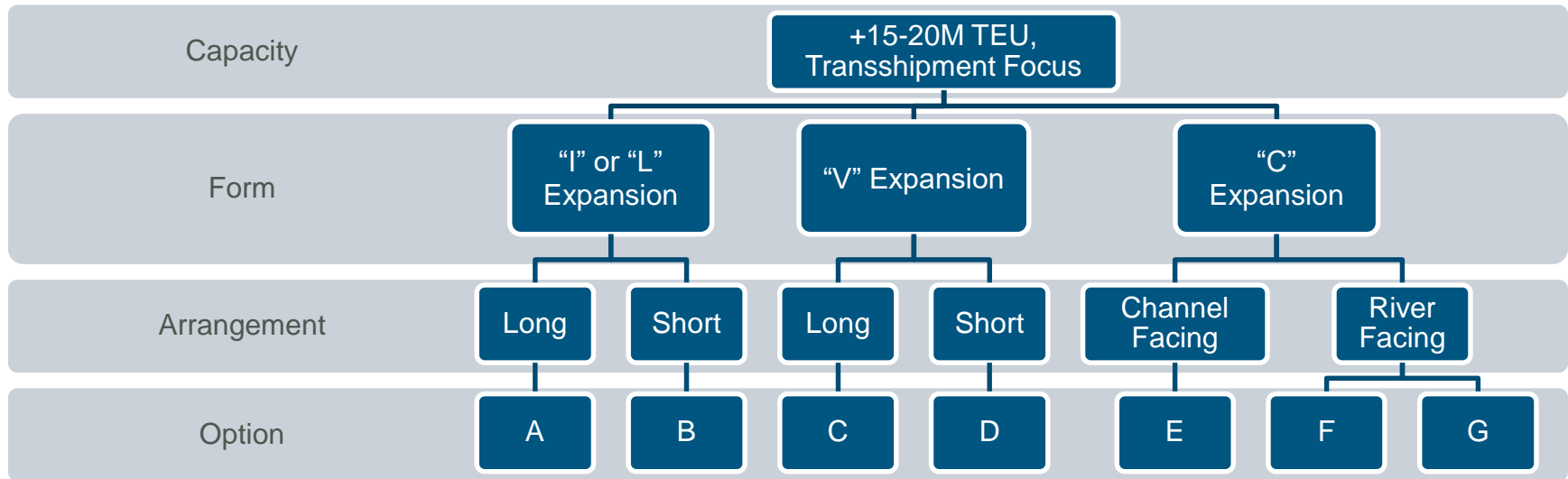
- Access to eastern berths require major dredge if close to Pulau Carey

Currents

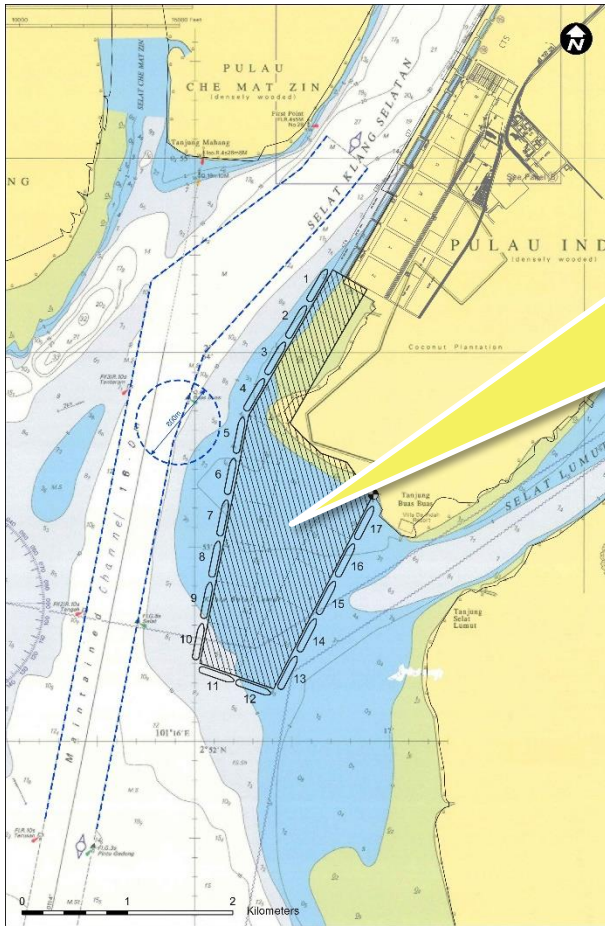
- Limit impact on natural tidal flow patterns



Broad Option Assessment

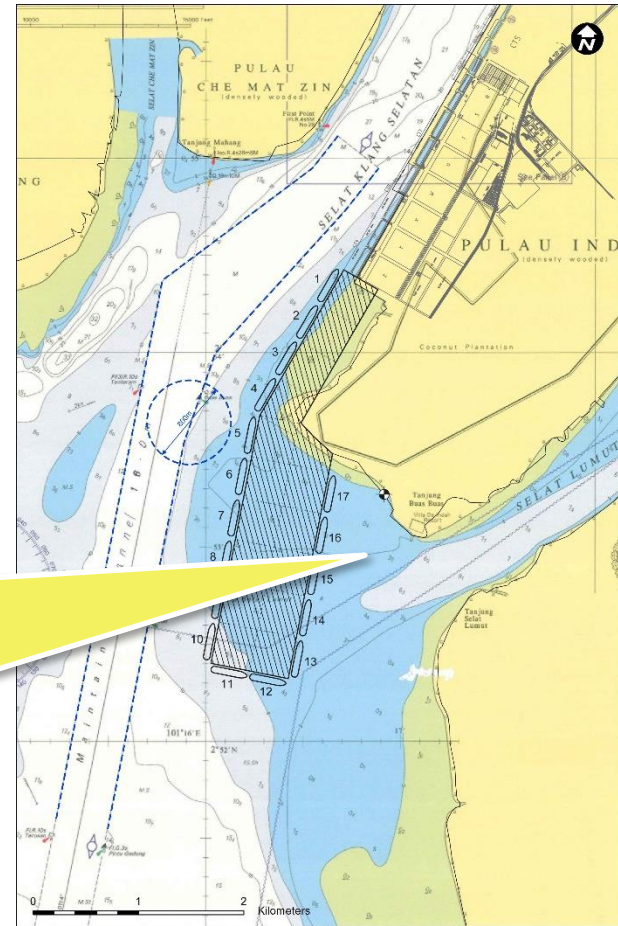


Two key Geometries Preferred

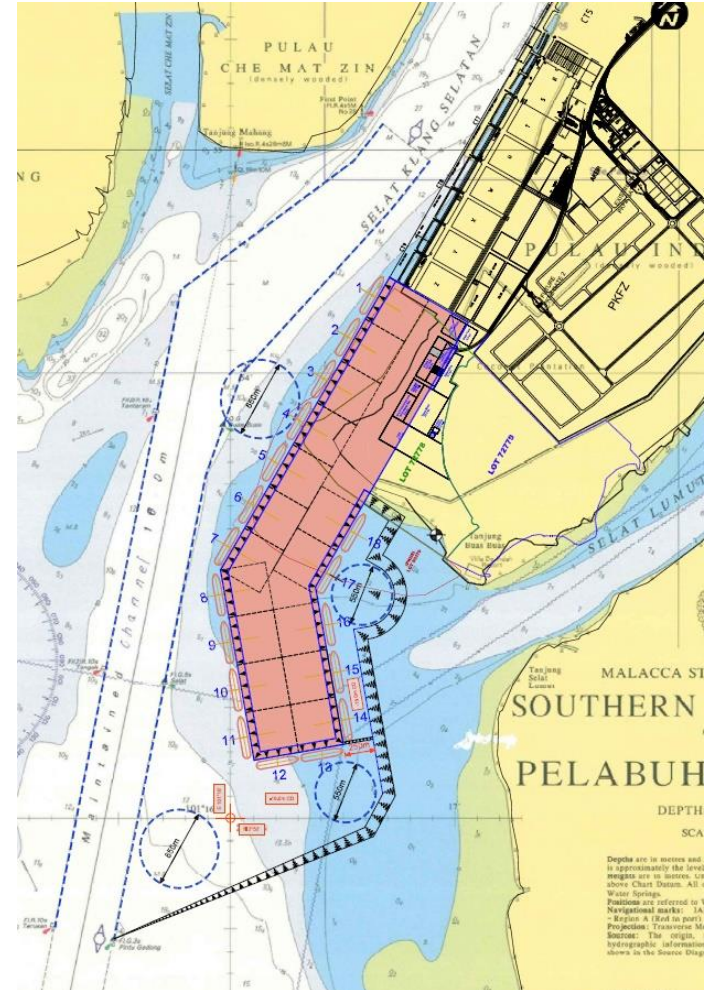
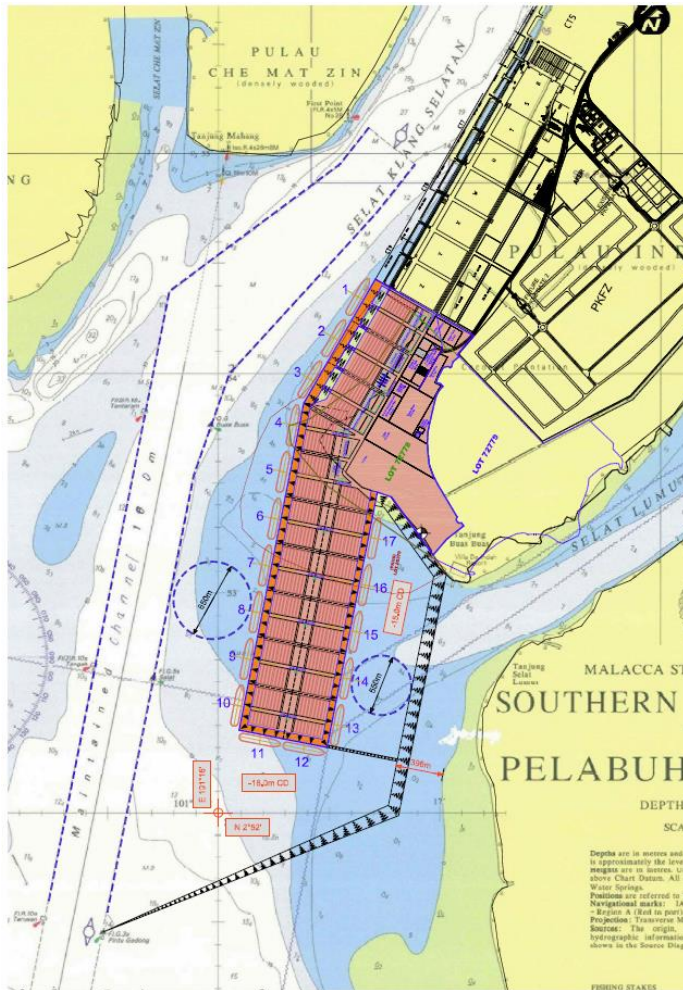


Is the land created of value – given impact on terminal separation?

Does this design create significant sedimentation to the east (or west)?



"Straight Finger" & "Crooked Finger" Options



Two Options “Crooked Finger” (CF) and “V”

Update:

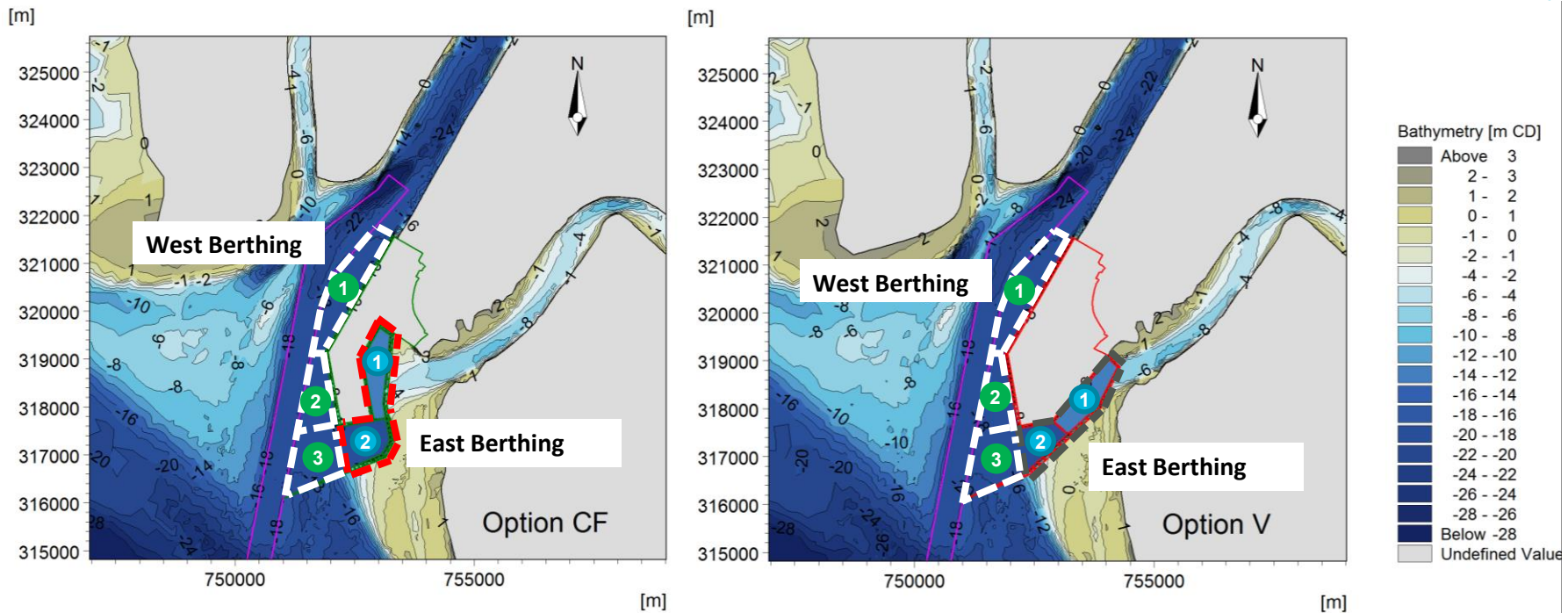
- Review of multiple options and layouts, and broad ranking (1st Workshop, 30.05.2018)
- Development of “Finger” and “V” layouts; preliminary costing (2nd Workshop, 25.06.2018)
- Optimisation of “Finger” layout to “Crooked Finger” to reduce sedimentation along western berths, quay design and costing update (3rd Workshop, 30.08.2016)

During the 3rd workshop concerns were expressed re: magnitude of potential sedimentation along the Eastern berths and whether crooked finger would “lock in” maintenance dredging costs that a “V” shape would avoid. The decision was made to:

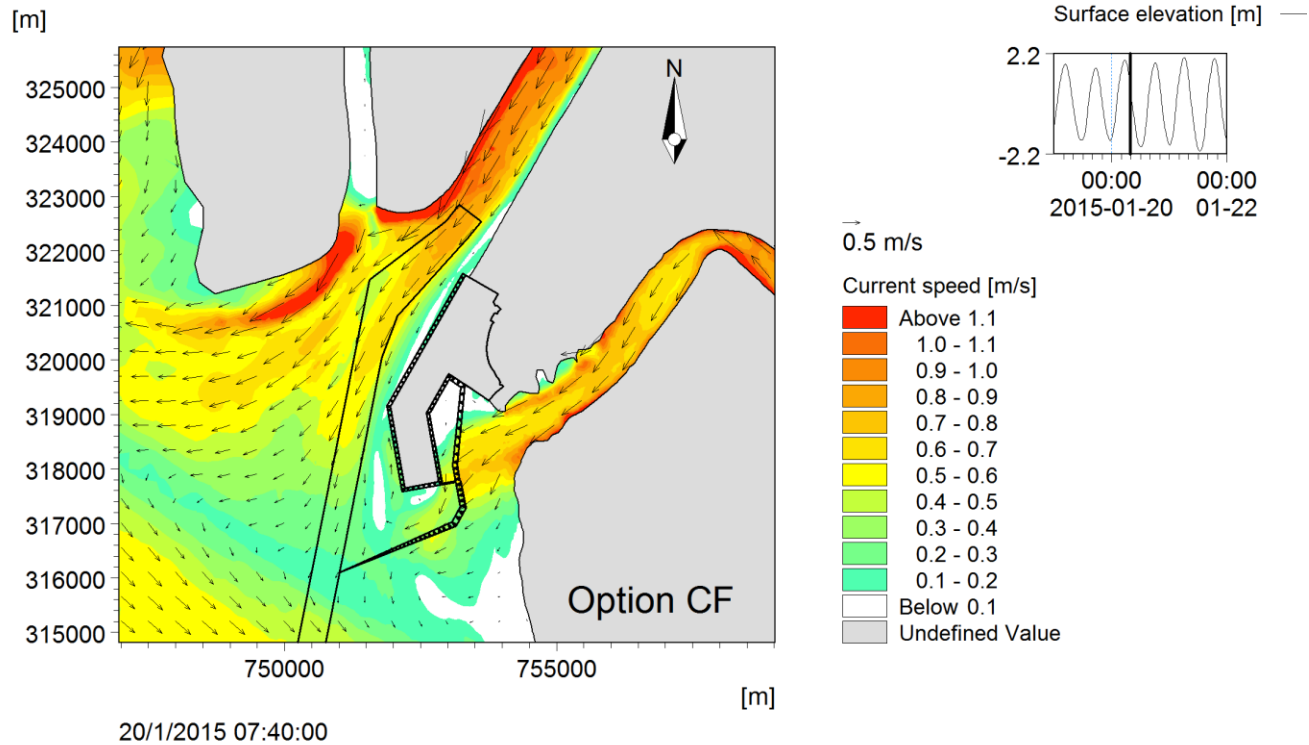
- Conduct hydraulic modelling for the CF and a V option (*enclosing the whole southern edge of Pulau Indah*)
- Identify broad range of sedimentation, and any differences

Sedimentation Review

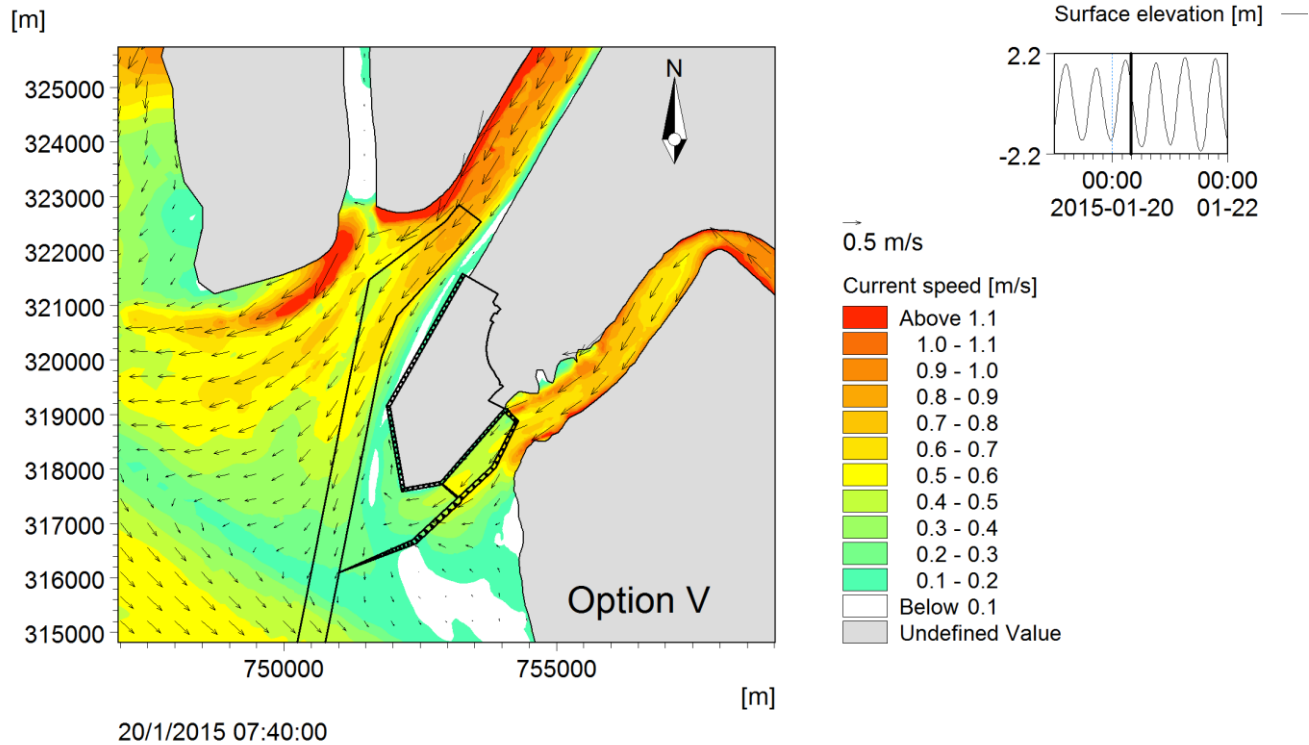
West Berthing and East Berthing Area



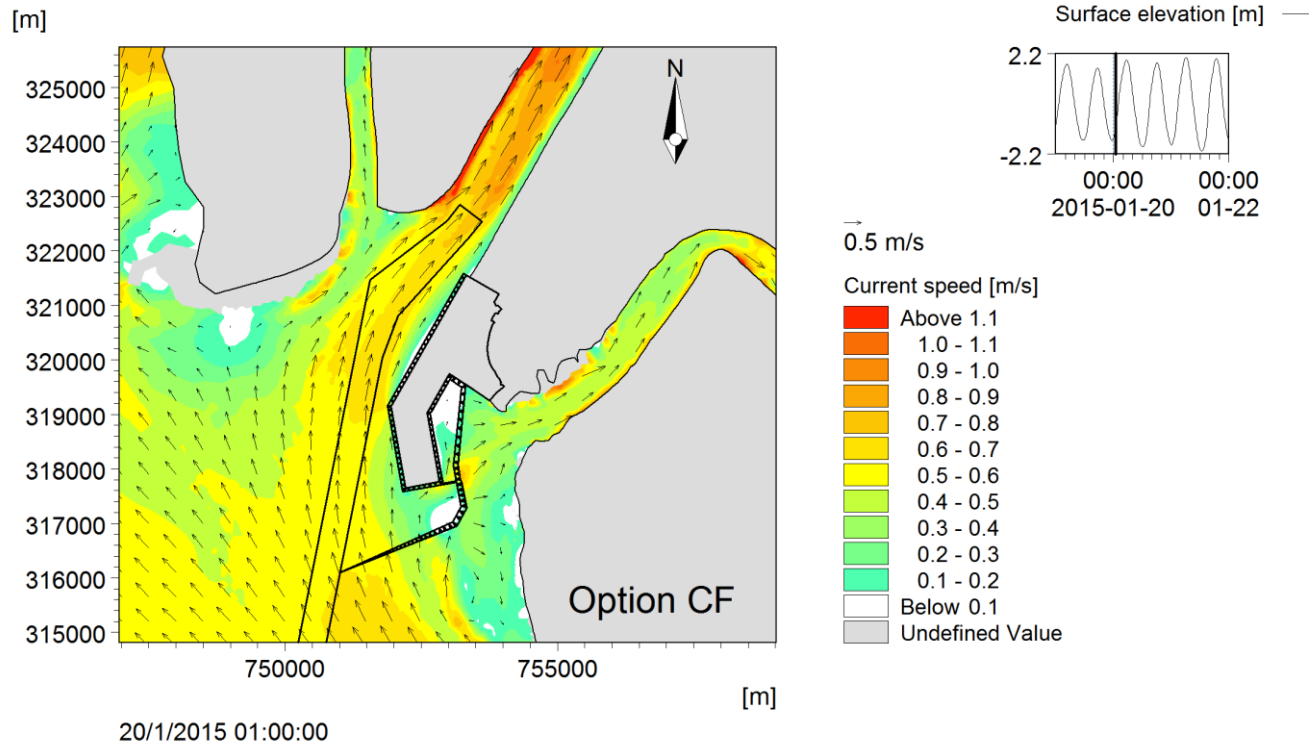
Current Speed at ebb tide (Option CF)



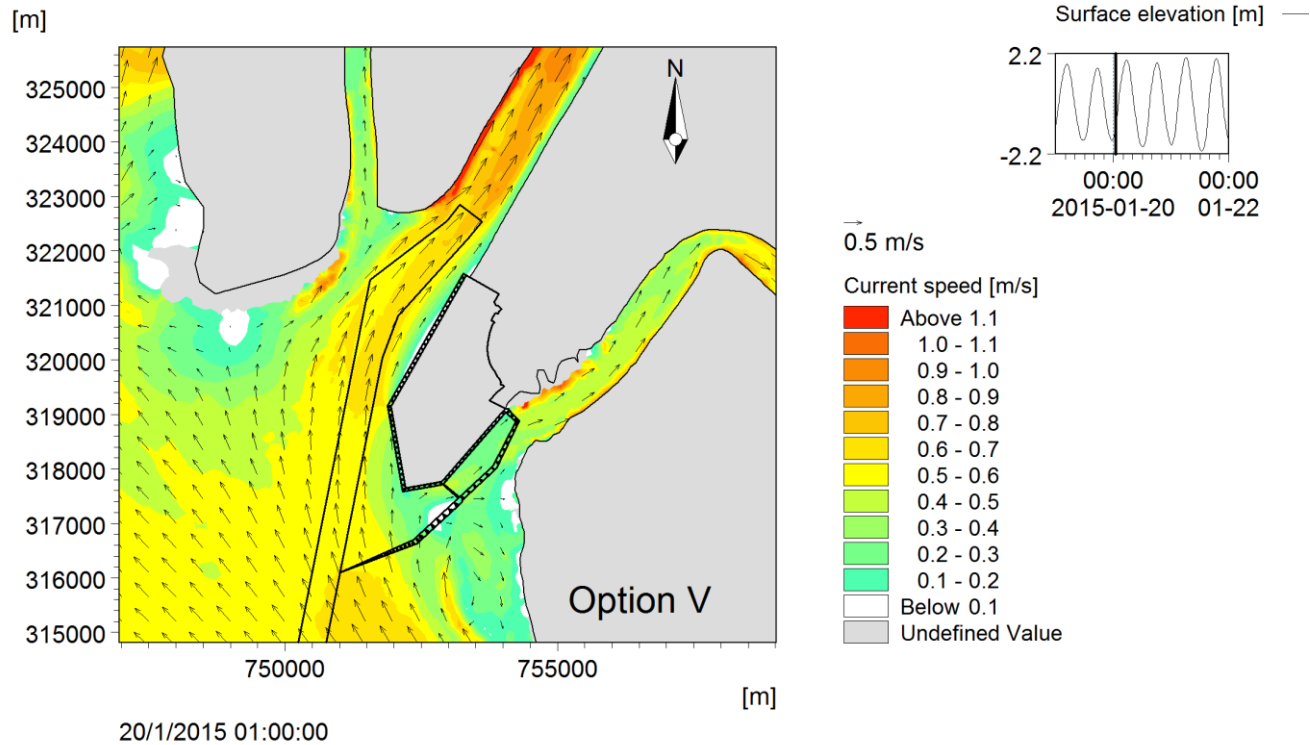
Current Speed at ebb tide (Option V)



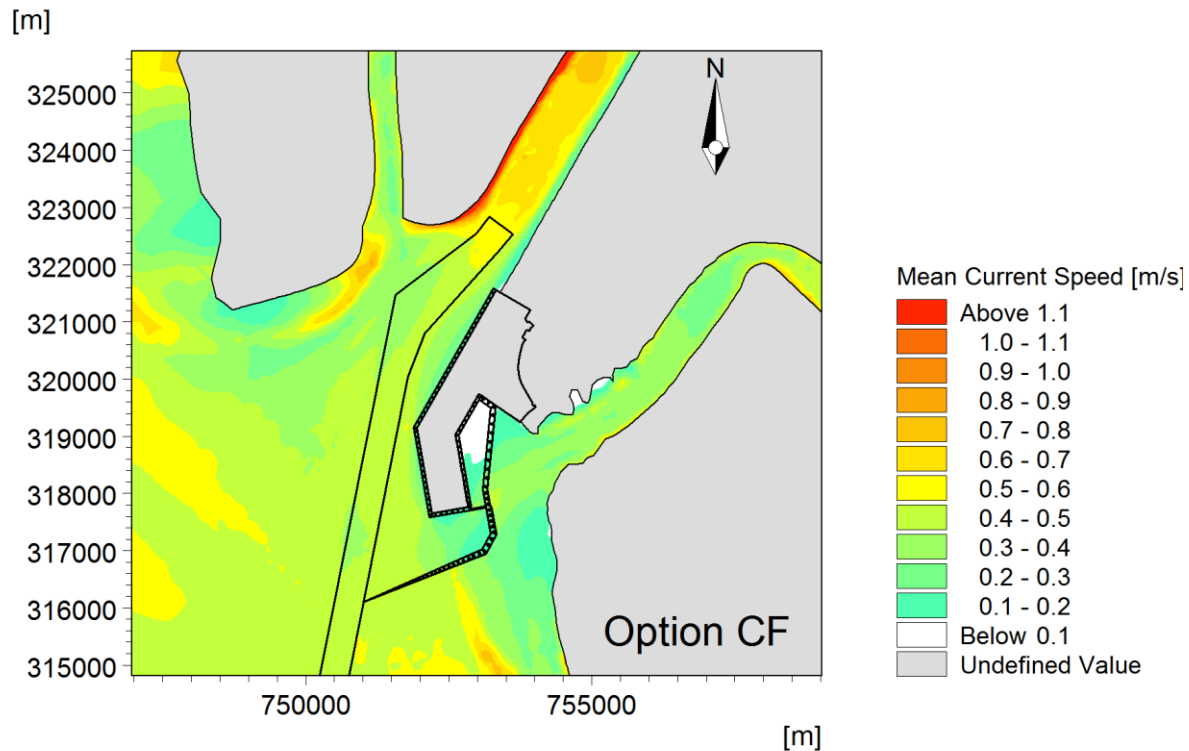
Current Speed at flood tide (Option CF)



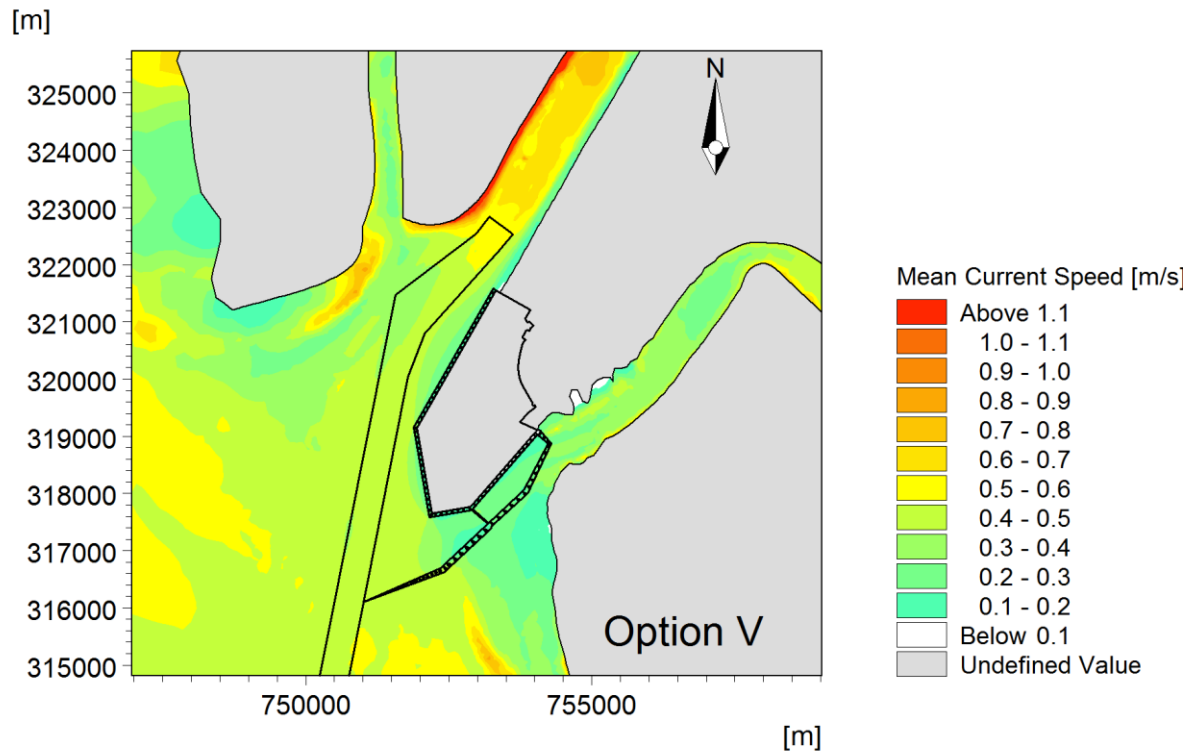
Current Speed at flood tide (Option V)



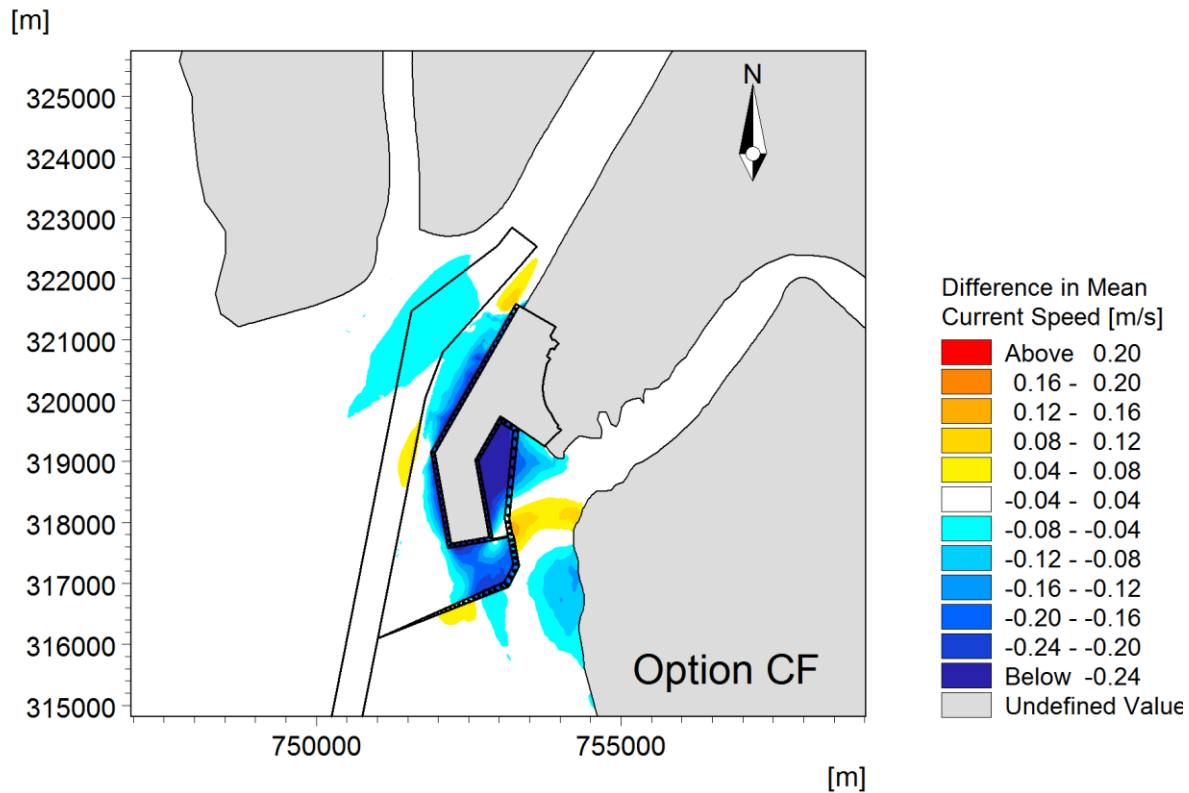
Mean Current Speed (Option CF)



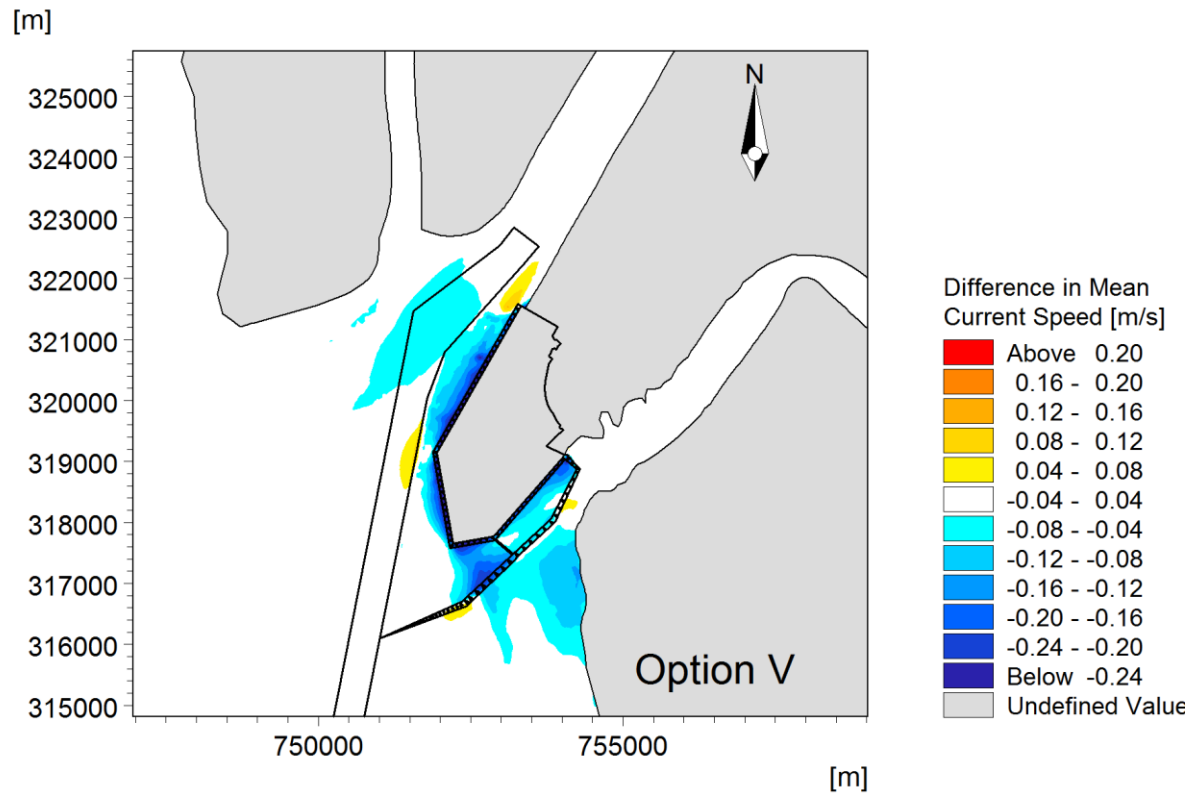
Mean Current Speed (Option V)



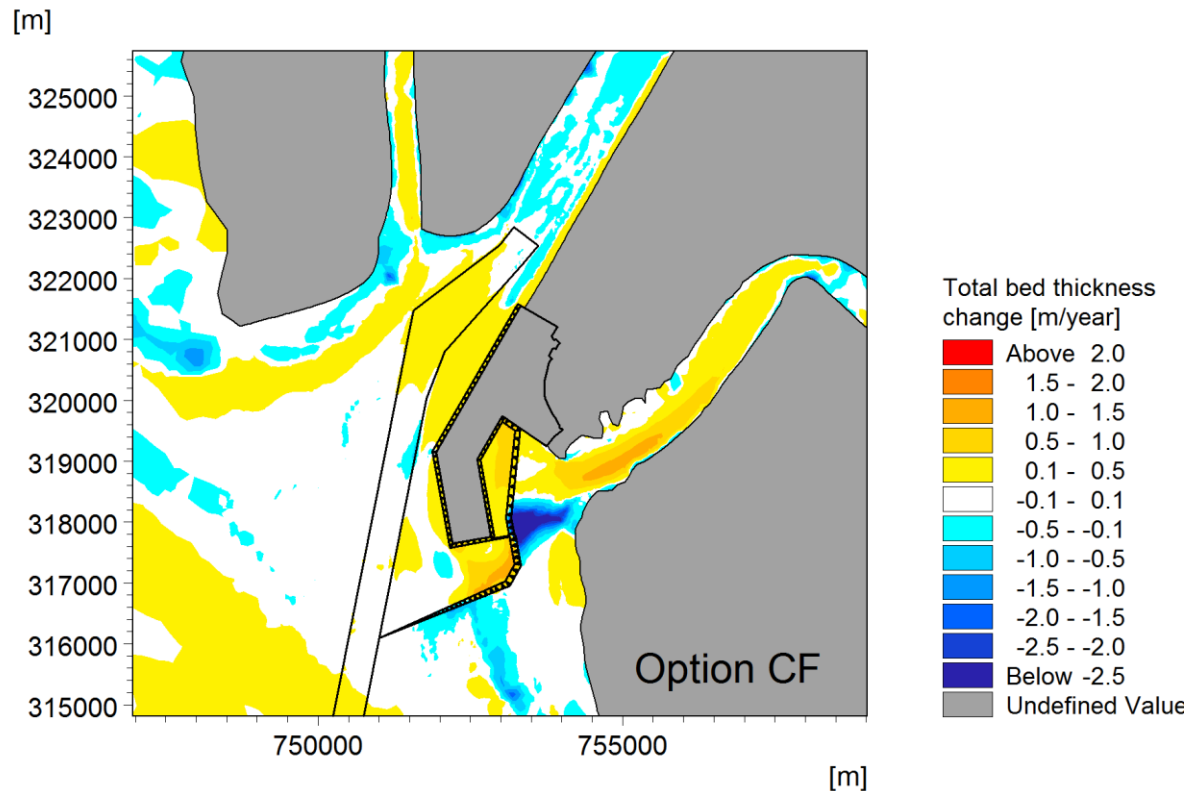
Difference in Mean Current Speed (Option CF)



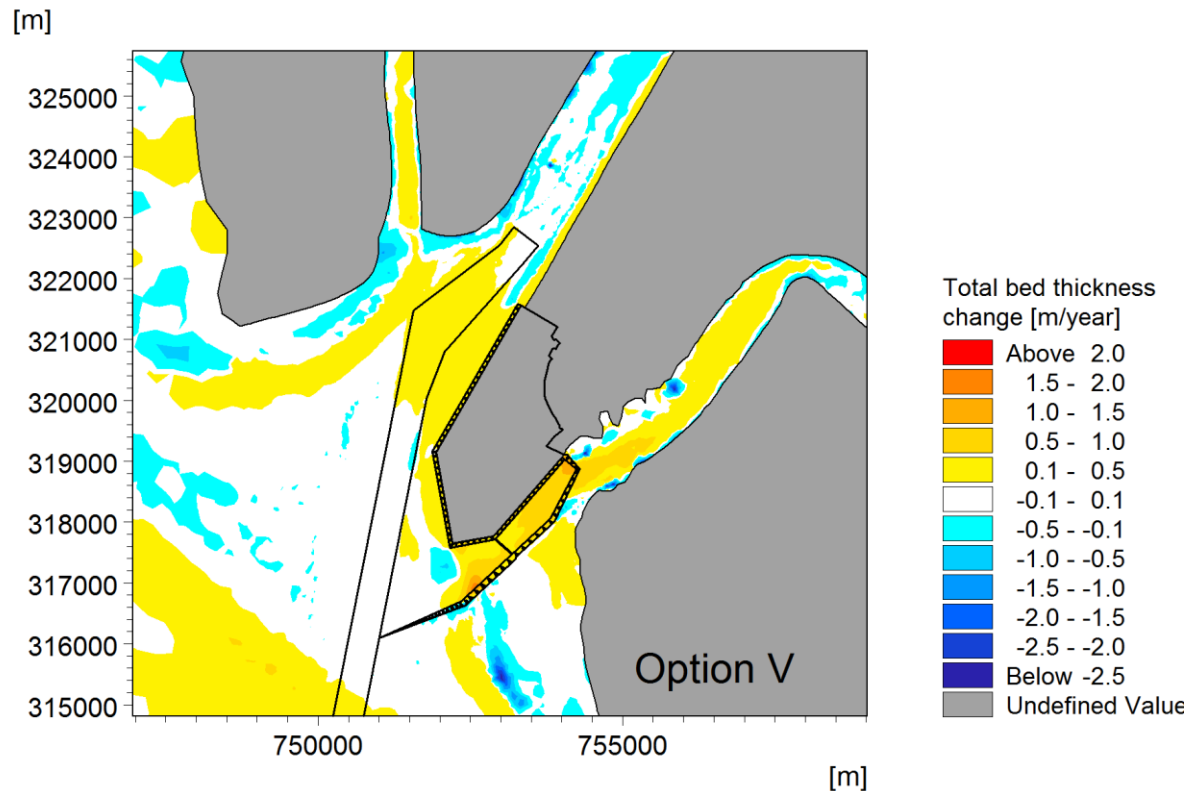
Difference in Mean Current Speed (Option V)



Bed Level Change (Option CF)



Bed Level Change (Option V)



Sedimentation Volume (detail)

Options	West Area 1 (1,000 m ³ /yr)	West Area 2 (1,000 m ³ /yr)	West Area 3 (1,000 m ³ /yr)
Option CF	200 – 300	50 – 100	50 – 100
Option V	200 – 300	50 – 100	50 – 100

i.e: Western berth sedimentation is essentially identical

Options	East Area 1 (1,000 m ³ /yr)	East Area 2 (1,000 m ³ /yr)
Option CF	300 – 500	400 – 700
Option V	400 – 700	300 – 500

i.e: Highest rates occur @ later phases of Option CF, but @ earlier phases of Option V

Summary

Options	West Berthing Area (1,000 m ³ /yr)	East Berthing Area (1,000 m ³ /yr)
Option CF	300 – 500	700 – 1,200
Option V	300 – 500	700 – 1,200

i.e:

- The total expected sedimentation is broadly similar.
- Total Net Present Value dredging costs for Option V are more, as the higher sedimentation rates for the Eastern side occur during the earlier phases.
- Training walls for the CF option may be able to limit sedimentation on Eastern berths

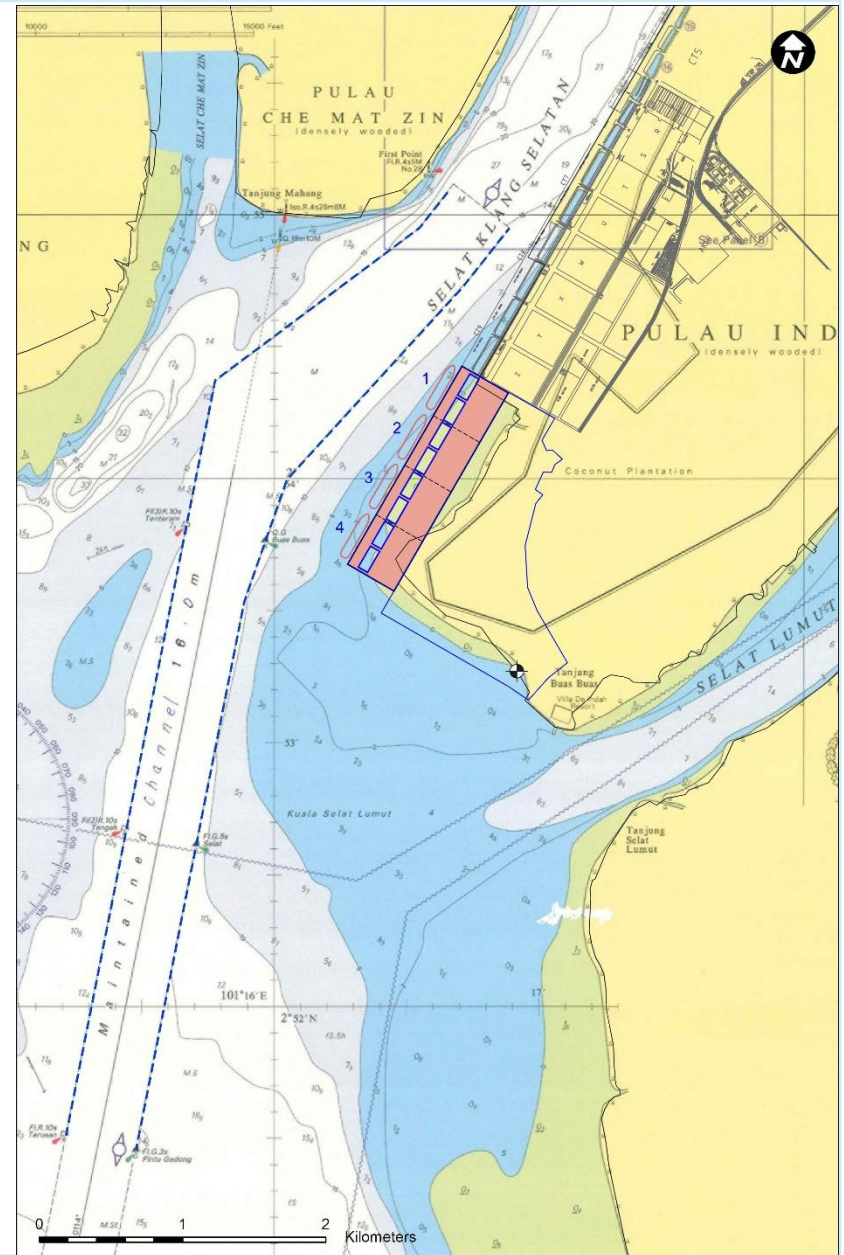
Two Options “Crooked Finger” (CV) and “V”

	“Crooked Finger”	“V”
Berth Connectivity	+	-
Additional Land	-	150ha
# Berths	18	17
Sedimentation	=	=
Cost (MYR Billion)	13.3	14.5

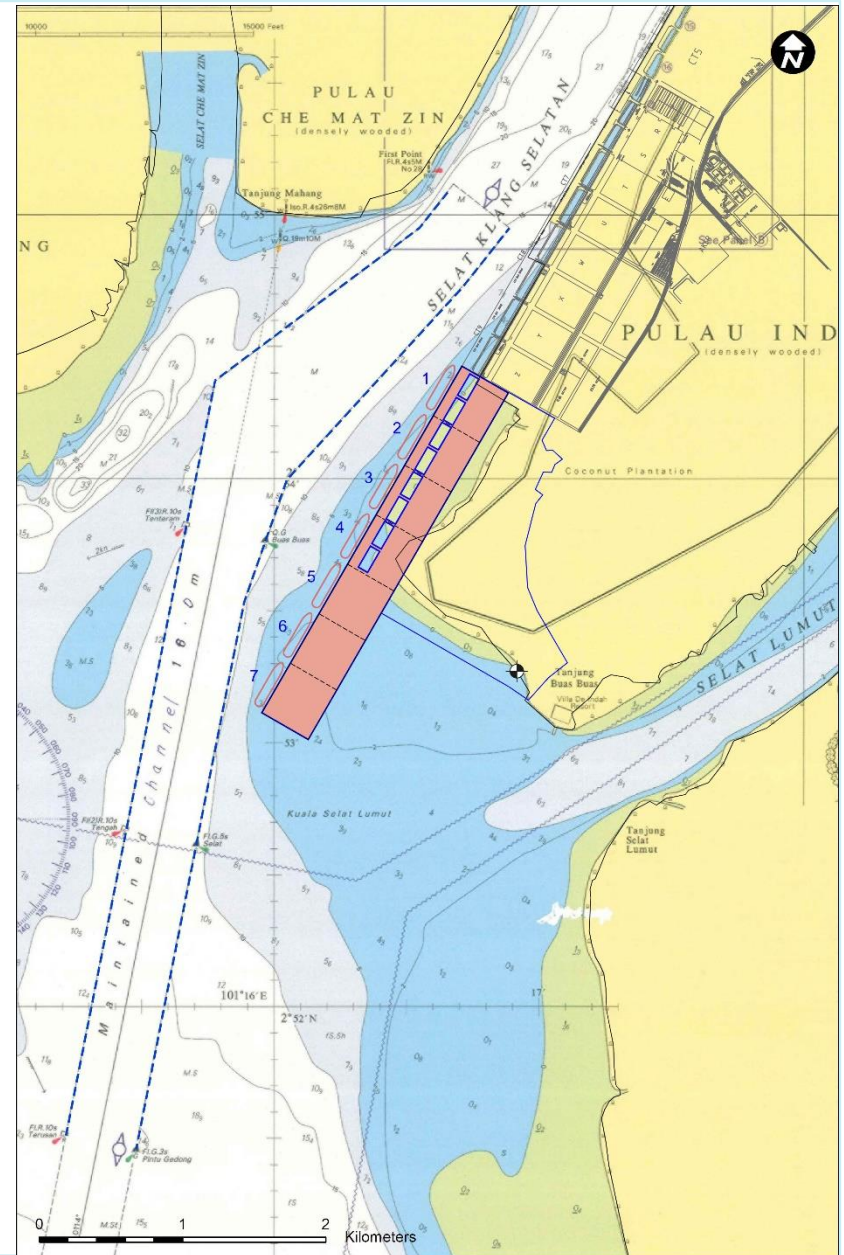
Conclusion: The “Crooked Finger” option is recommended

Quay Phasing

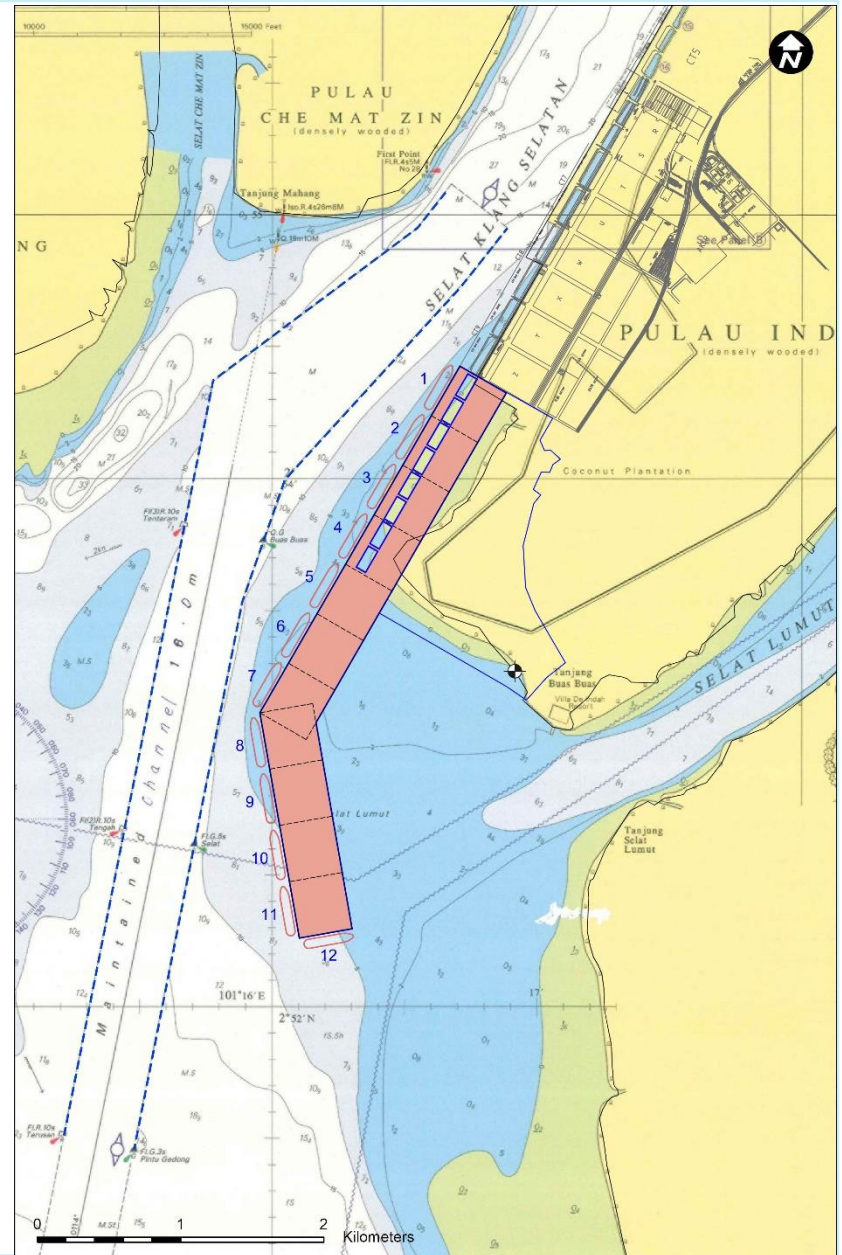
Additional 4 x 400m berths



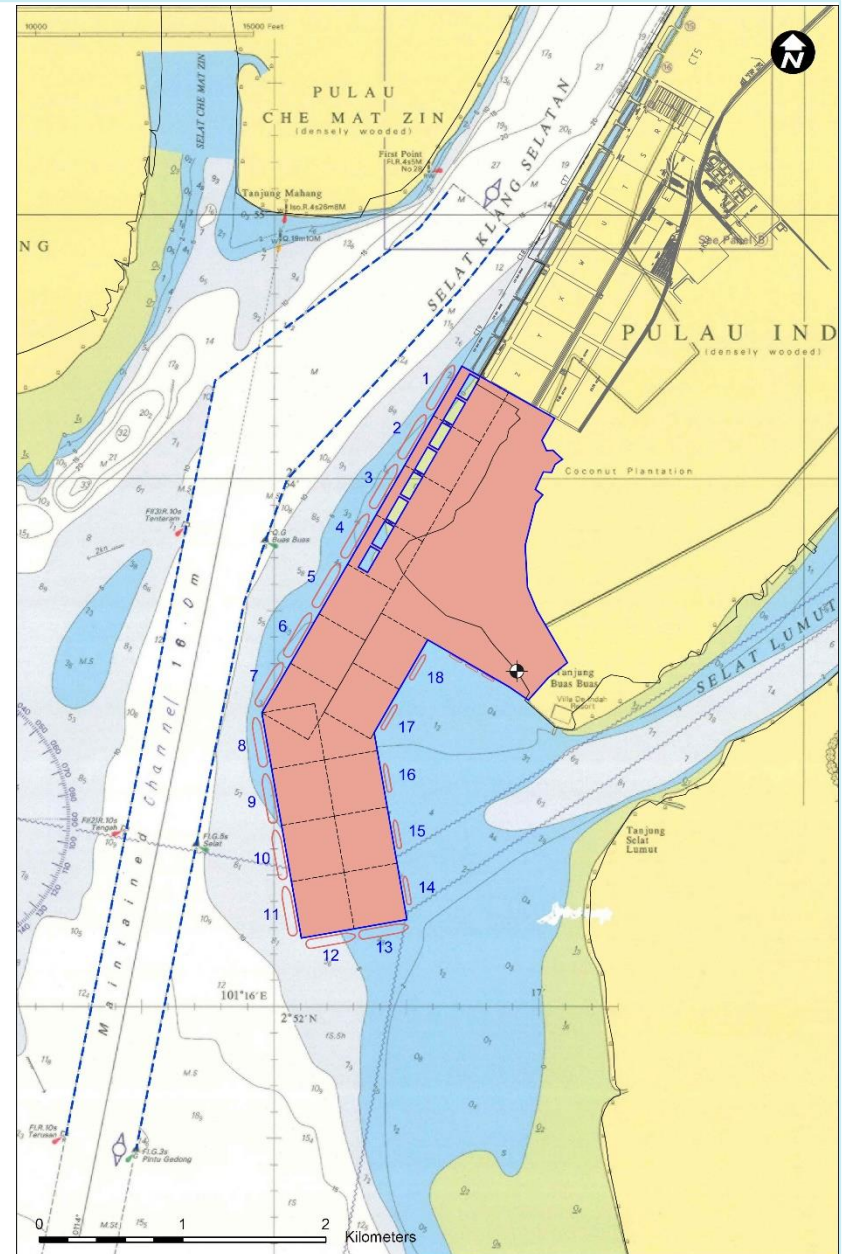
Additional 7 x 400m berths



Additional 12 x 400m berths



Additional 18 x 400m berths + 560m Barge berths



Final Layout Option

Final Development

Additions

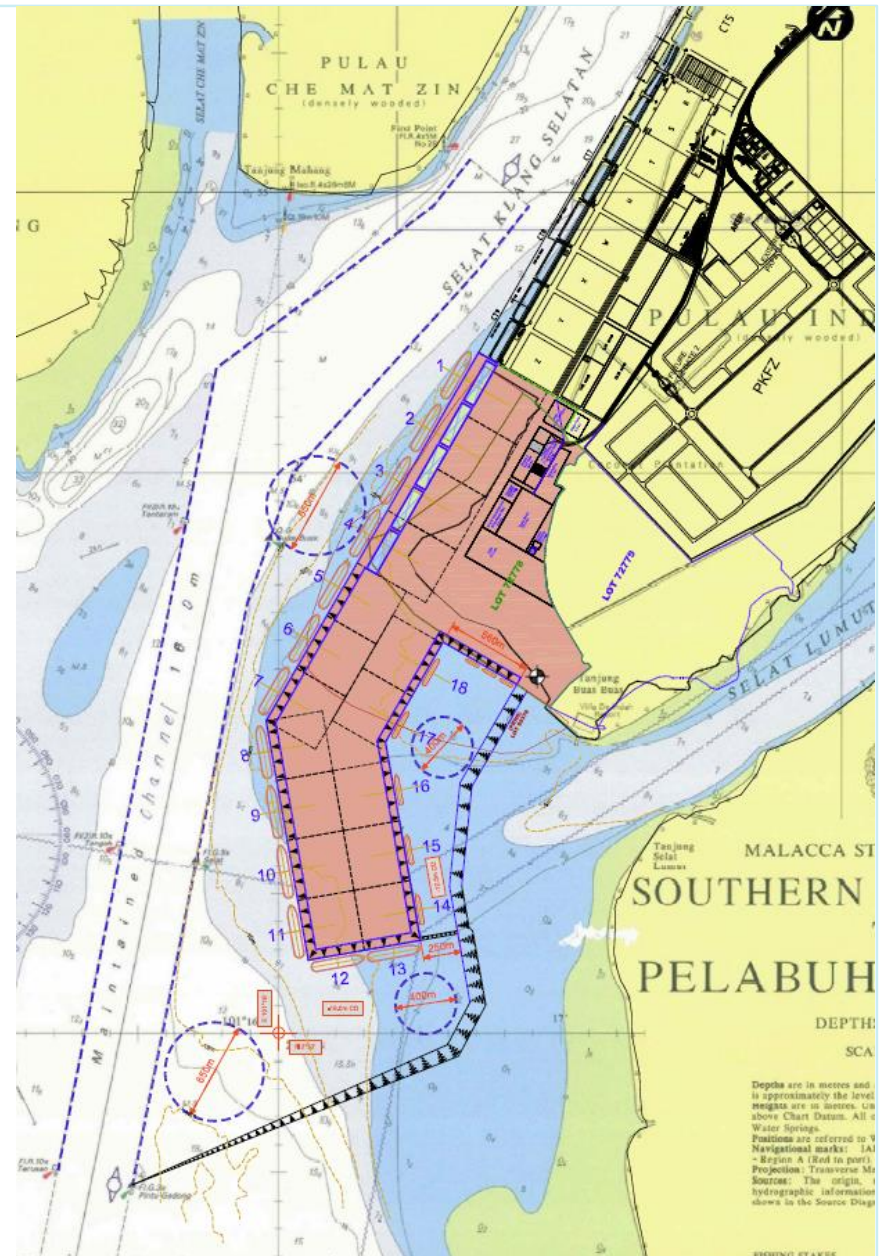
- 560m long barge/tug berth on south face of Pulau Indah
- Dredging basin on east side expanded to permit access to new berths

Potential Developments

- Training wall @ east to minimise flow across dredged basin

To review

- # & positions of bridges
- Spatial planning for yard



Tasks Ahead

Marine & Eng' Studies

Marine Traffic Simulation

- Evaluation of marine traffic impacts associated with the development of new berths

Navigation Simulation

- Evaluation of marine traffic impacts associated with the development of new berths

Layout Planning

- Preliminary Yard Layout

Q & A