Introduction to Coastal Numerical Modeling

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Outline of Presentation:

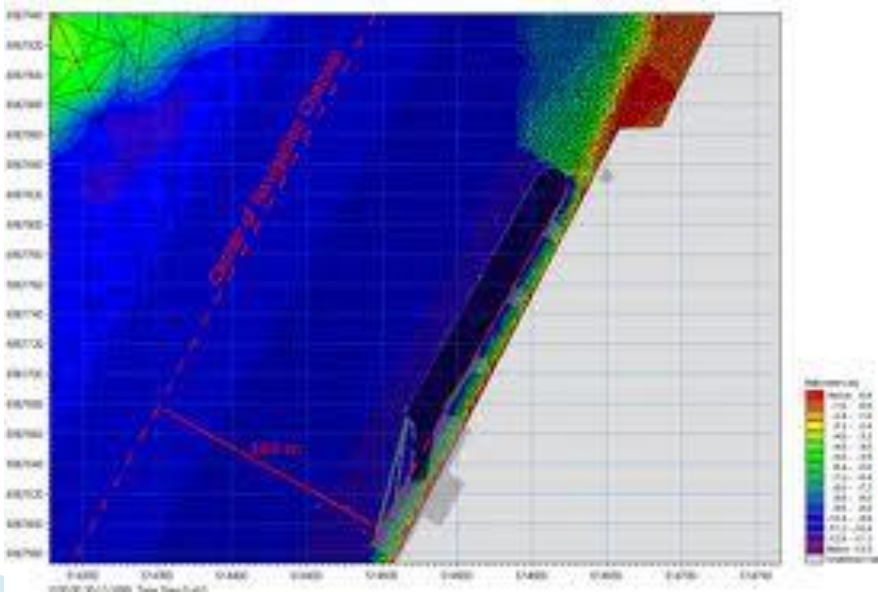
- ✓ Overview of hydraulic modeling study in Coastal Engineering
- ✓ Important Modelling Concepts based on DID Guidelines 2001
- ✓ Conclusion

What is Coastal Modeling?

- **Simulating the coastal environment**
  - **Water level**
  - **Wind**
  - **Waves**
  - **Current (speed & direction)**
  - **Sediment transport**

Coastal Modeling

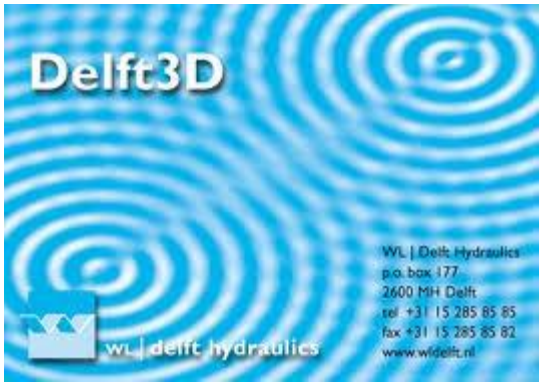
- Physical Modeling
- Numerical Modeling
- Hybrid Modeling



Some Coastal Numerical Modelling Tools

DHI

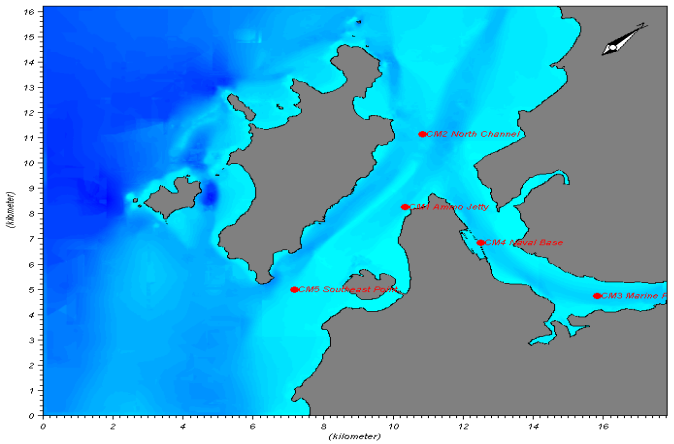
telemac



All software models are almost the same!

Why Numerical Modeling?

- Resource Constraints
  - Time
  - Money
  - Spatial Coverage



Why Need Coastal Modeling?

- Understanding hydraulic phenomena/ coastal impacts due to development (Erosion/sedimentation/sediment plume problems affecting project area).
- Planning and assessment of coastal development
- Develop possible strategy to alleviate problem wherever practicable.
- Monitoring feedback
- Etc….

Typical Scope of Works for Numerical Modelling:

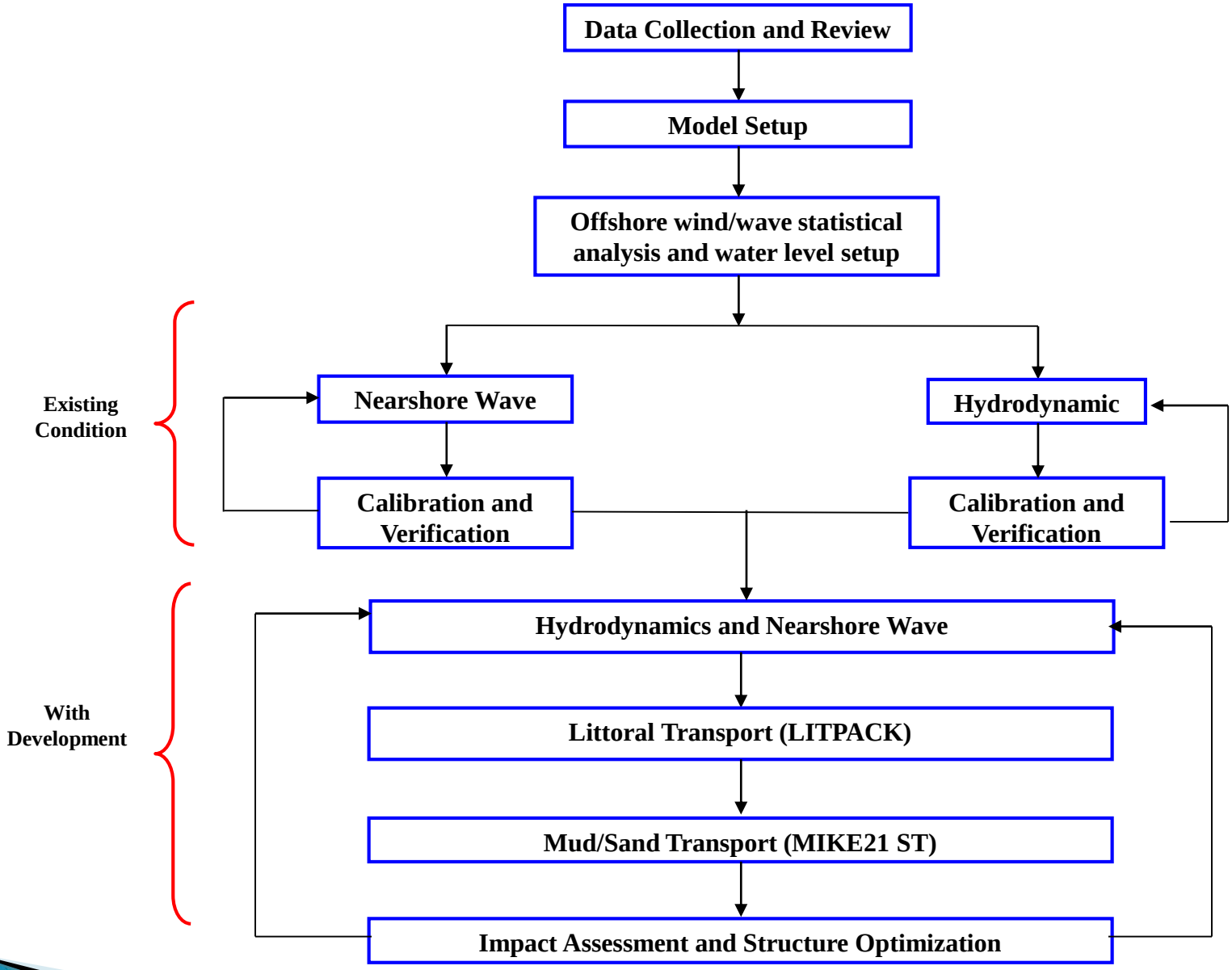
- Collect and collate field data for the modeling study;
- Investigate the marine regime at the proposed project area taking into account the physical parameters within the area;
- Develop further understanding of the problem and identify the possible influencing factors leading to the problem;
- Carry out hydraulic modeling
  - to determine the current flows and sedimentation pattern within and around the project area;
  - as the input for permanent structure design;
- Identify possible strategy to alleviate the sedimentation problem.

Some Terms in Numerical Modelling:

- **Hydrodynamic Modelling – study of current and water level fluctuation**
- **Waves Modelling – study of wave propagation, growth and decay of waves in nearshore area**
- **Sediment Transport Modelling – study of cohesive & non-cohesive sediments while assessing bed level changes**

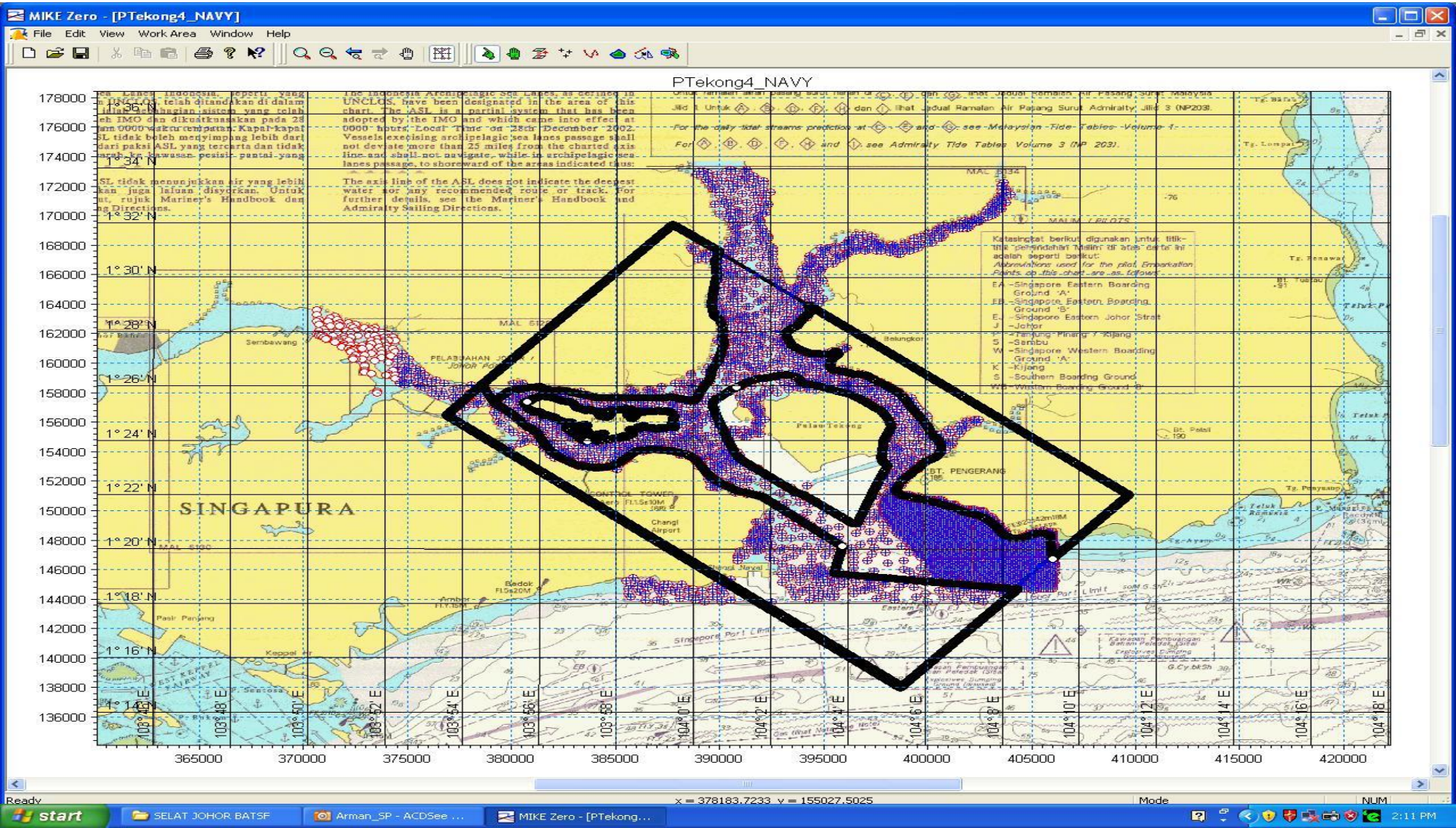
General Numerical Modelling Concepts:

- Data Collection
- Model Set-up
- Offshore Wind/Wave Condition
- Hydrodynamic Simulation
- Calibration & Verification
- Wave/ Sedimentation Modelling
- Results

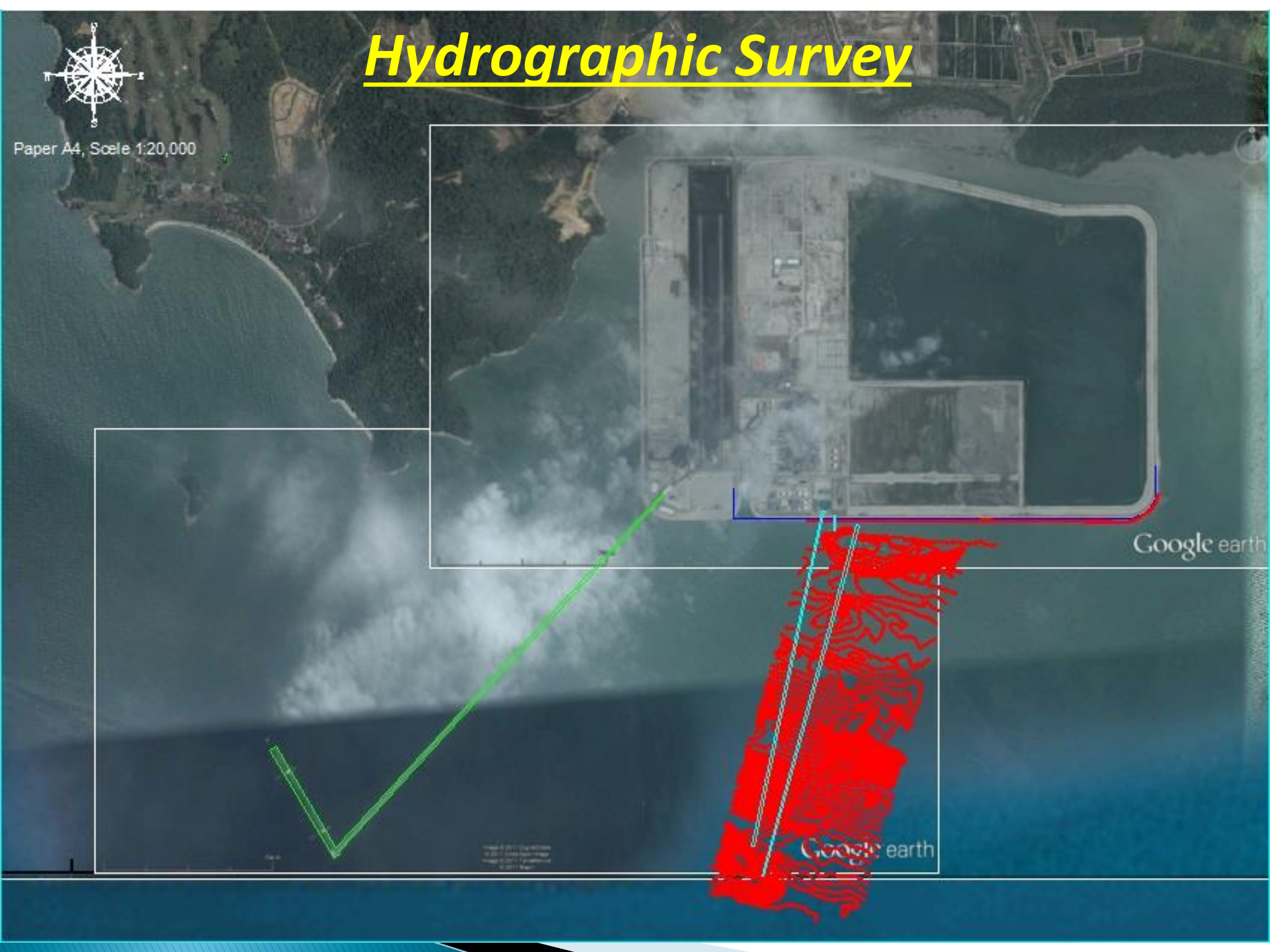

Data Collection and Review
Model Setup
Offshore wind/wave statistical analysis and water level setup
Existing Condition
Nearshore Wave
Hydrodynamic
Calibration and Verification
Calibration and Verification
With Development
Hydrodynamics and Nearshore Wave
Littoral Transport (LITPACK)
Mud/Sand Transport (MIKE21 ST)
Impact Assessment and Structure Optimization

Data Collection

1. Bathymetry Data



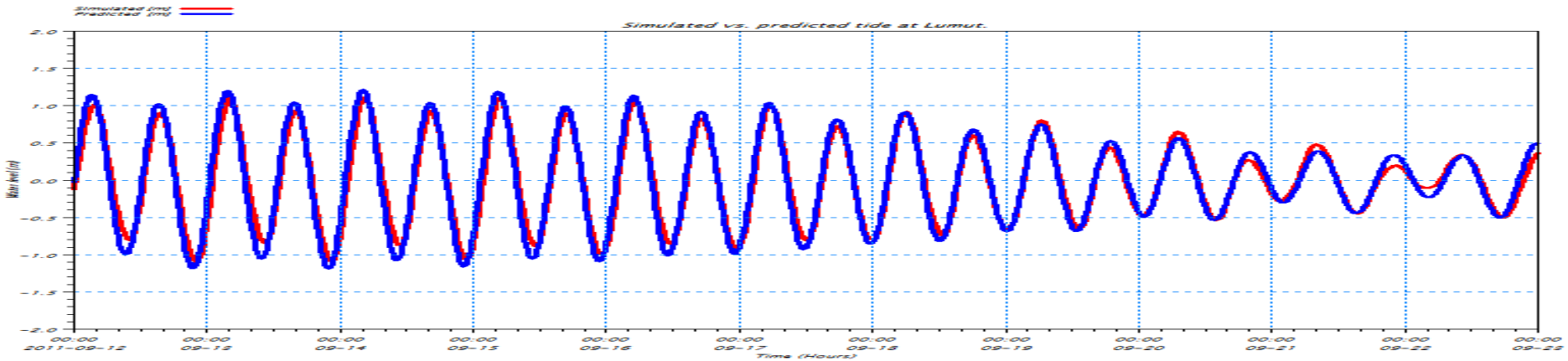
Hydrographic Survey



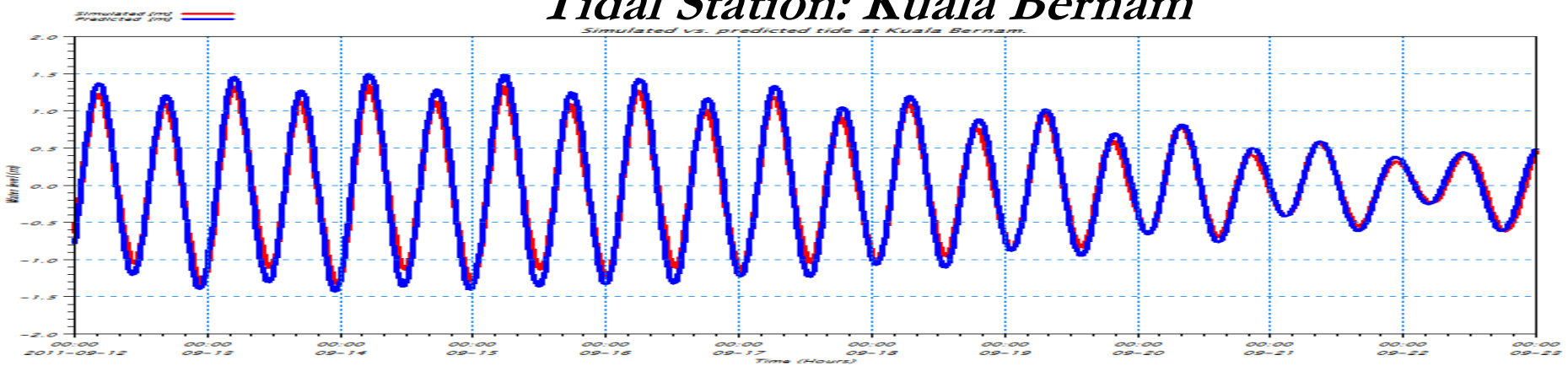
Data Collection

2. Tidal Data (Water Level Measurement)

Tidal Station: Lumut

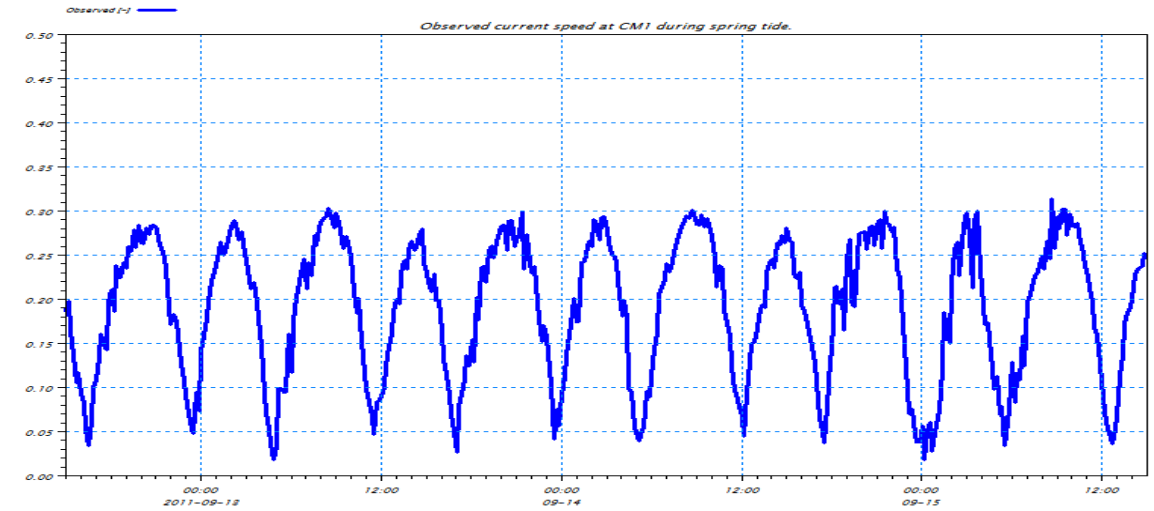


Tidal Station: Kuala Bernam

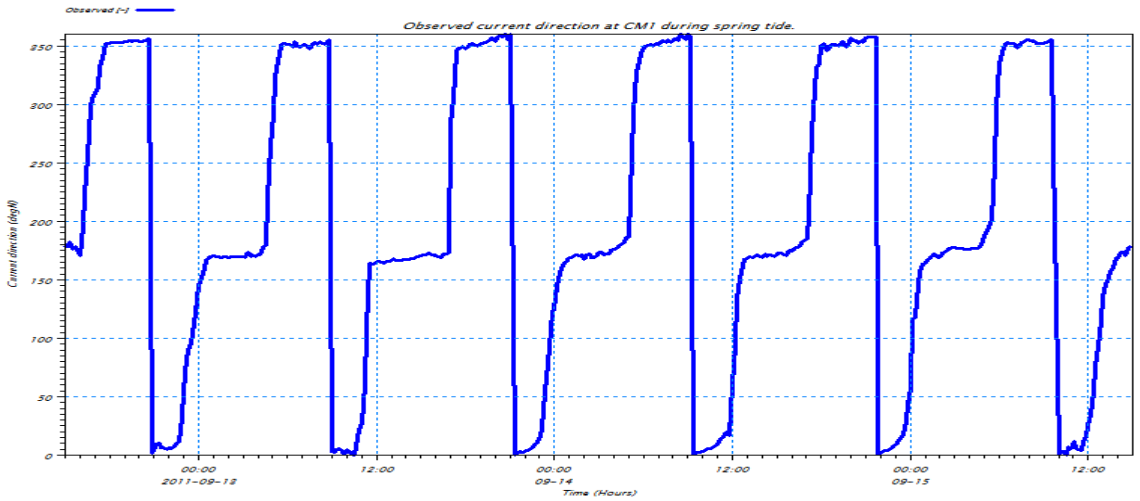


Data Collection

3. Current Data



Current Speed (m/s)



Current Direction (degree)

Data Collection

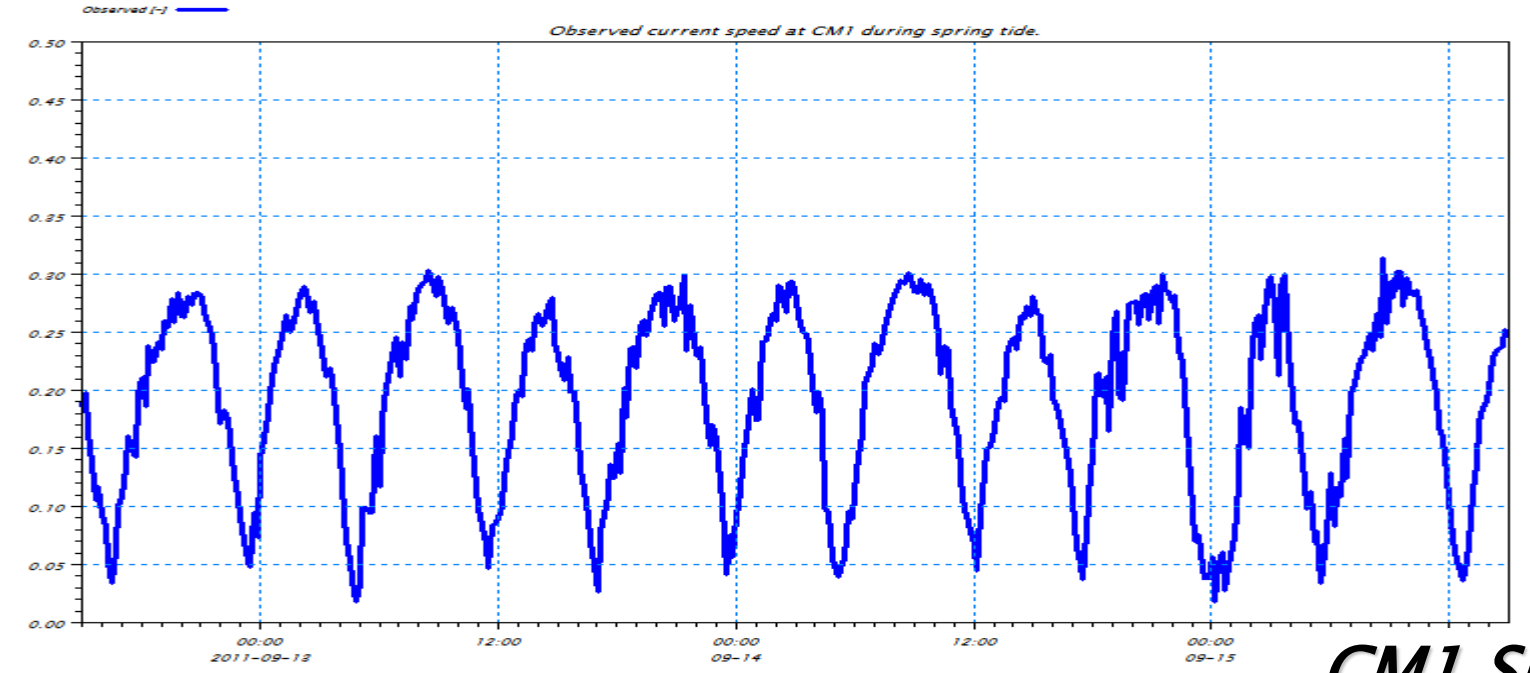
Current meter measurement

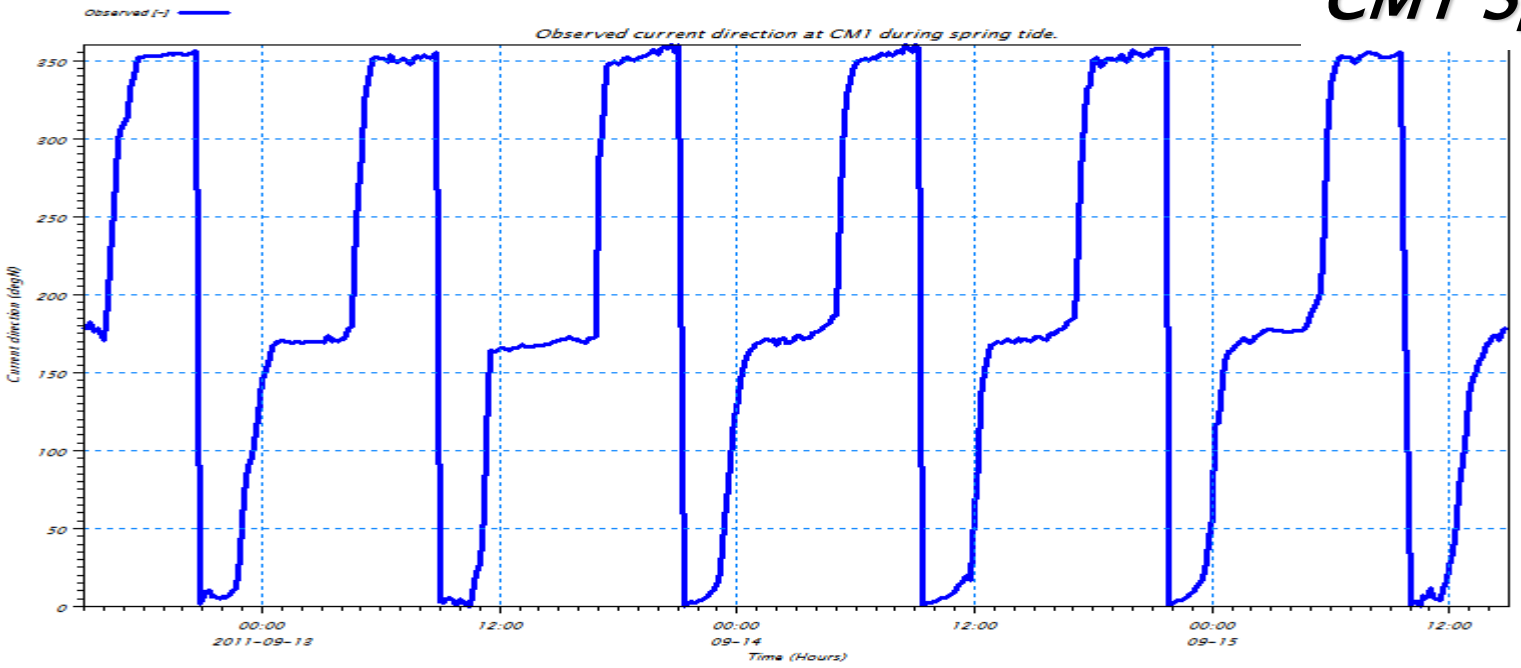
- ***3 days on each spring and neap at two (2) locations or more.***
- ***Example:***

Spring: 12/09/2011 - 15/09/2011

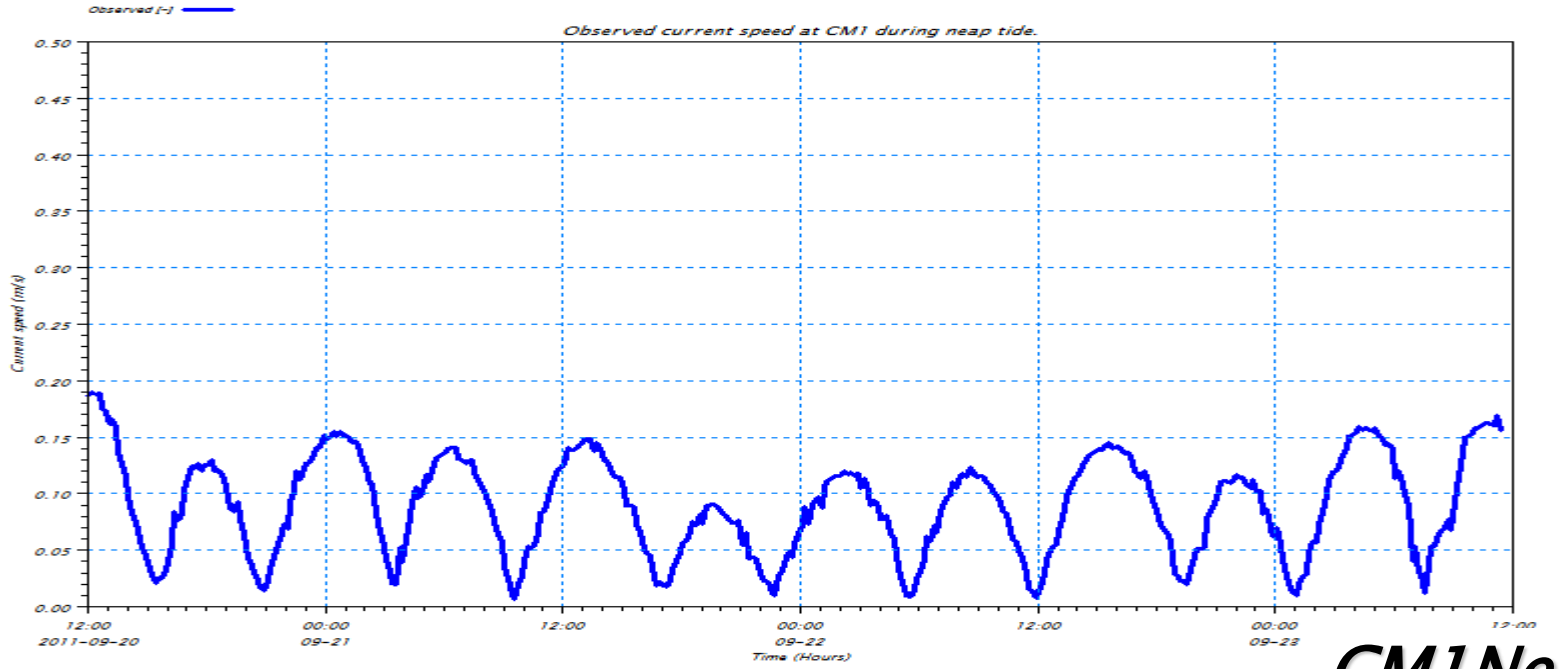
Neap: 20/09/2011 – 23/09/2011

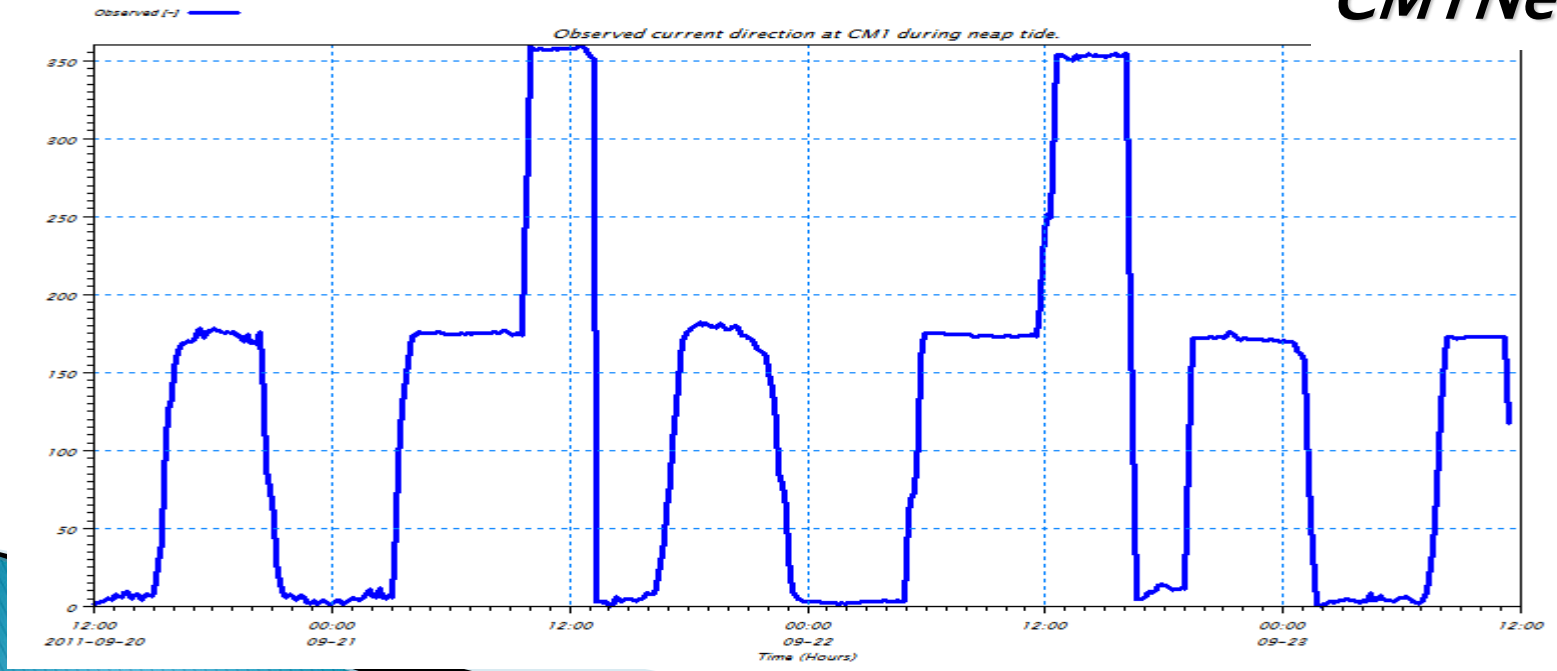
Location	Coordinates	
	Latitude (N)	Longitude (E)
CM1	4° 24’ 50.7”	100° 34’ 36.1”
CM2	4° 26’ 37.3”	100° 34’ 58.2”


Observed [-]
Observed current speed at CM1 during spring tide.
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
00:00
2011-09-13
12:00
00:00
09-14
12:00
00:00
09-15


Observed [-]
Observed current direction at CM1 during spring tide.
Current direction (degN)
350
300
250
200
150
100
50
0
00:00
2011-09-13
12:00
00:00
09-14
12:00
00:00
09-15
12:00
Time (Hours)

CM1 Spring

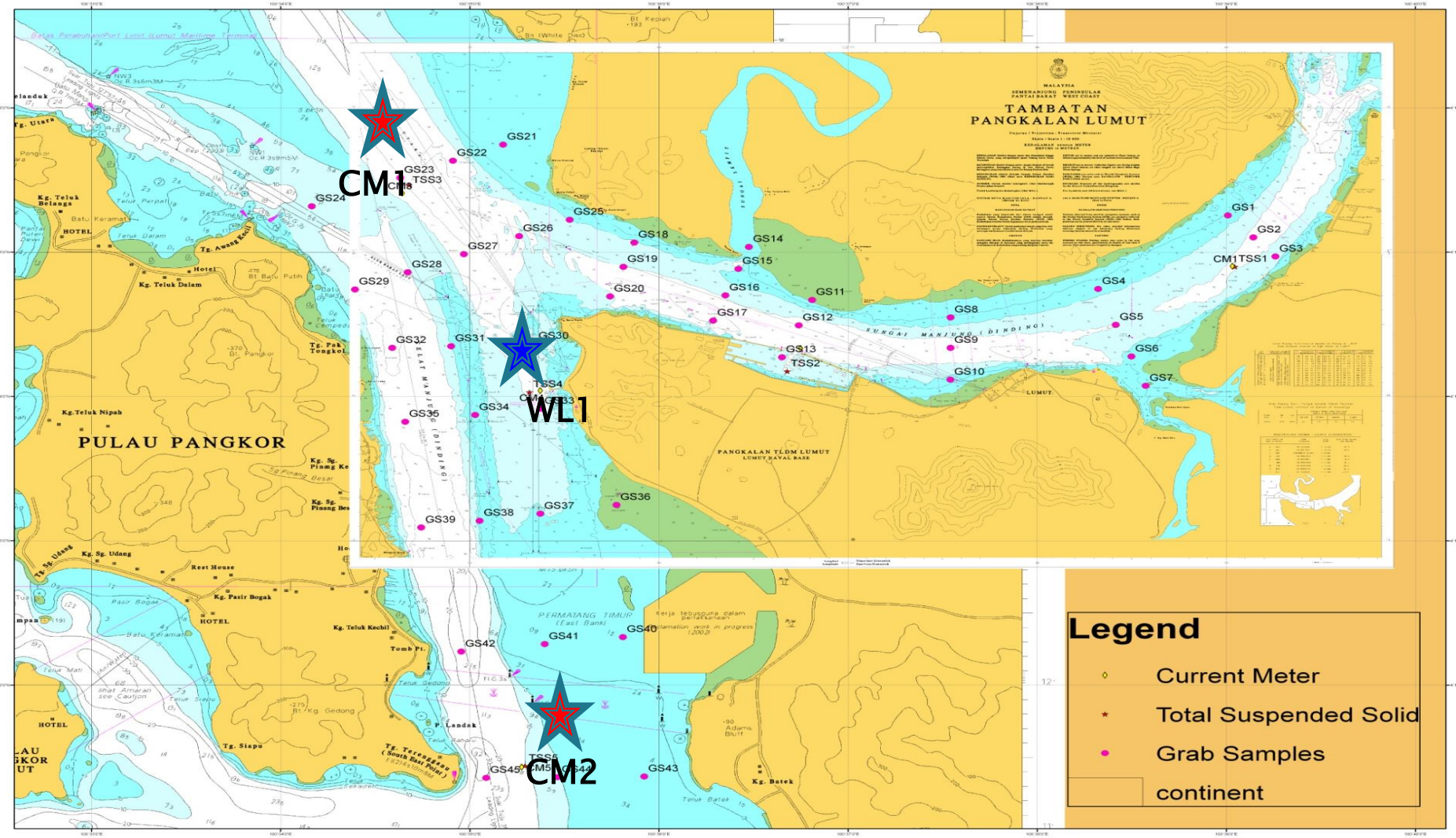

Observed [-]
Observed current speed at CM1 during neap tide.
Current speed (m/s)
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
12:00
2011-09-20
00:00
09-21
12:00
00:00
09-22
12:00
00:00
09-23
Time (Hours)


Observed [-]
Observed current direction at CM1 during neap tide.
350
300
250
200
150
100
50
0
12:00
2011-09-20
00:00
09-21
12:00
00:00
09-22
12:00
00:00
09-23
12:00
Time (Hours)

CM1Neap

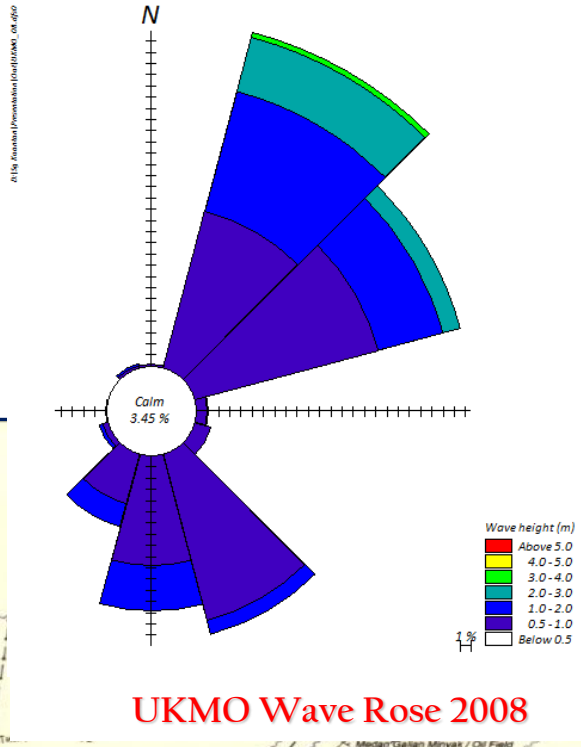
Data Collection

Location of measurements



Data Collection

4. Wave Data (Offshore wave)



UKMO Wave Rose 2008

- UKMO Point Location

Data Collection

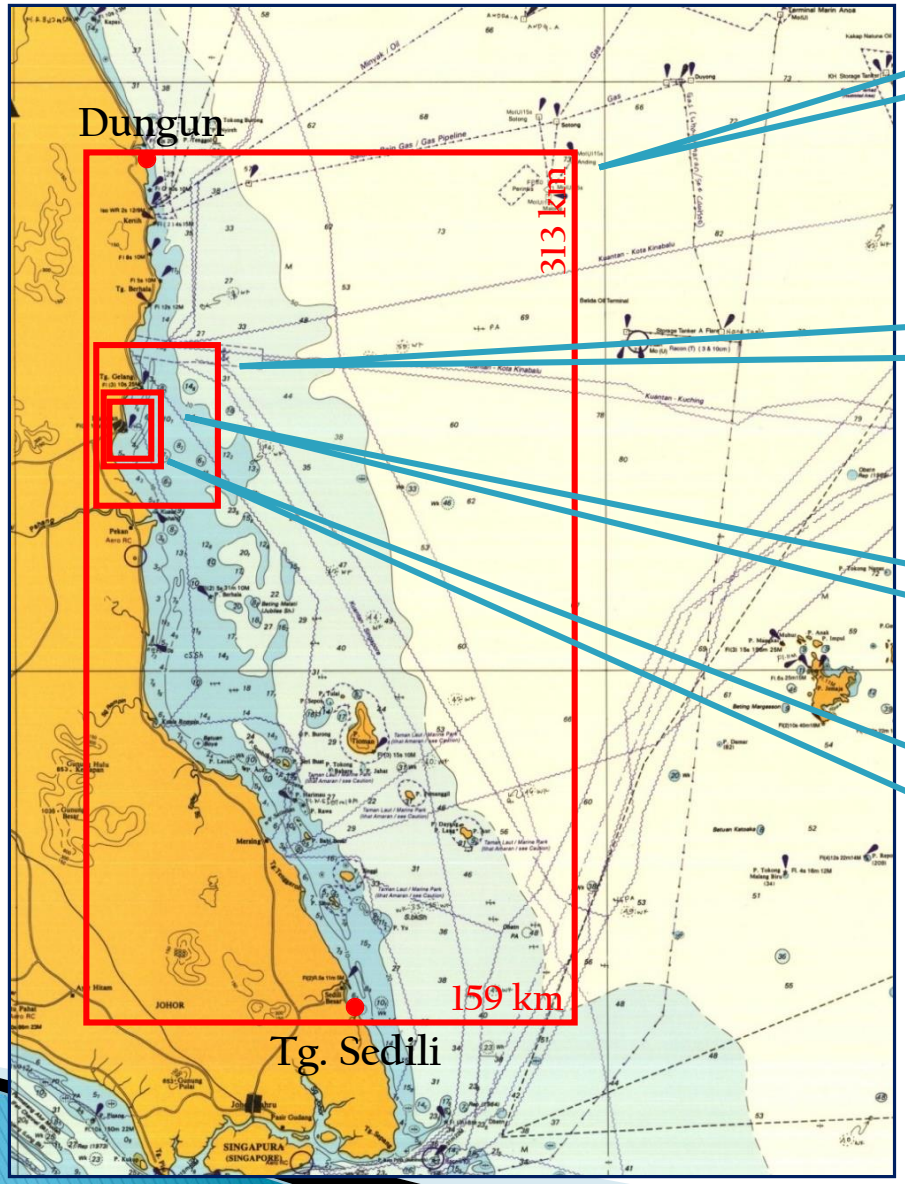
5. Water & Bed Samplings

Model Set-up

Hydrodynamic Model

A hydrodynamic model for simulation of water level variations and current flows in response to a variety of forcing functions. The water levels are resolved on a rectangular grid covering the area of interest. The system solves the equations of continuity and conservation of momentum using implicit finite difference methods.

Model Area:



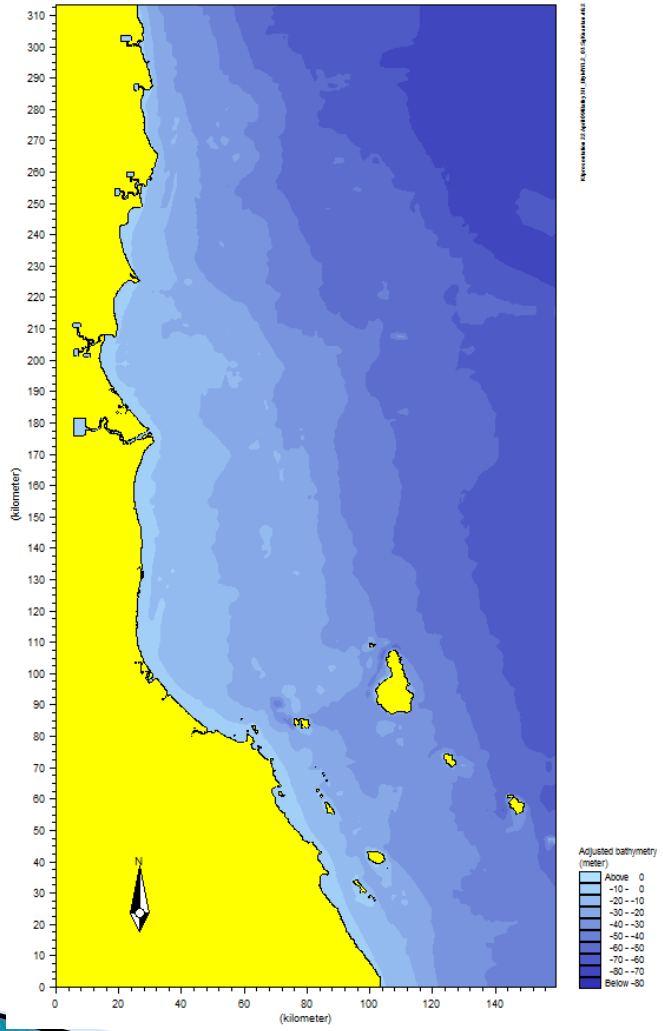
Coarse grid model setup
dx,dy= 270m Grid Spacing

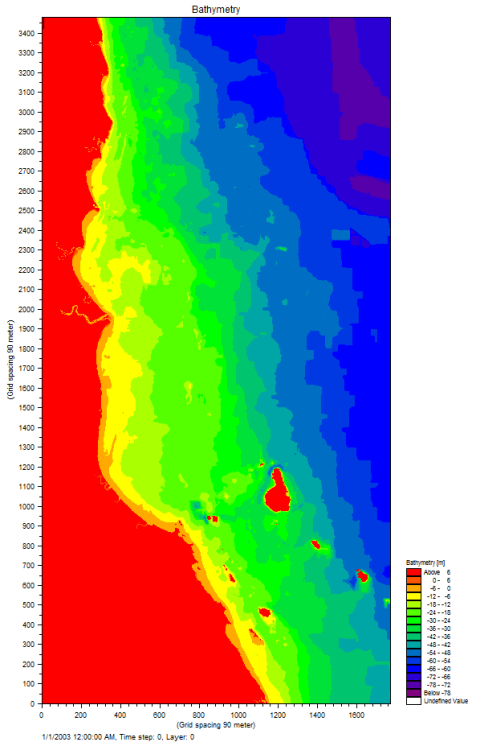
Medium grid model setup
dx,dy= 90m Grid Spacing

Fine grid model setup
dx,dy= 30m Grid Spacing

Local grid model setup
dx,dy= 10m Grid Spacing

Model Set-up

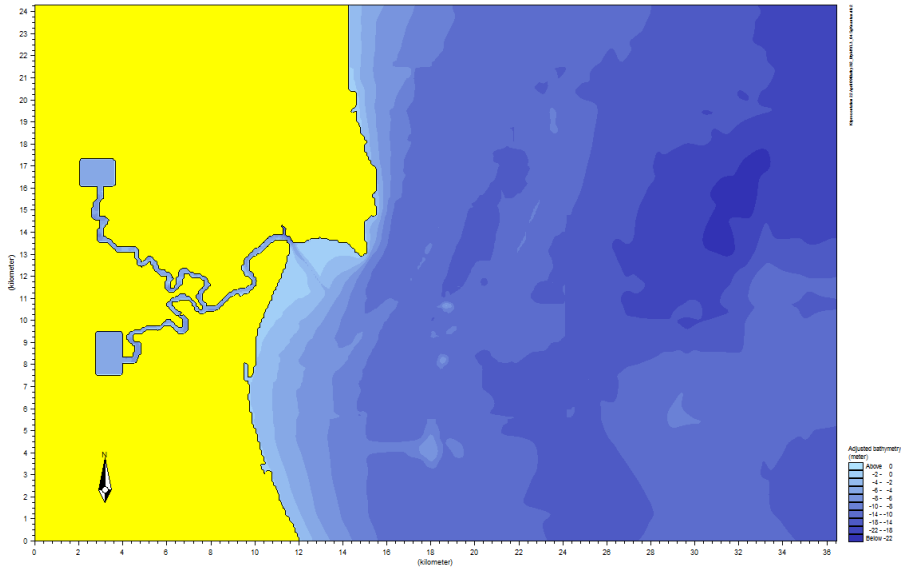




- Coarse Grid Model

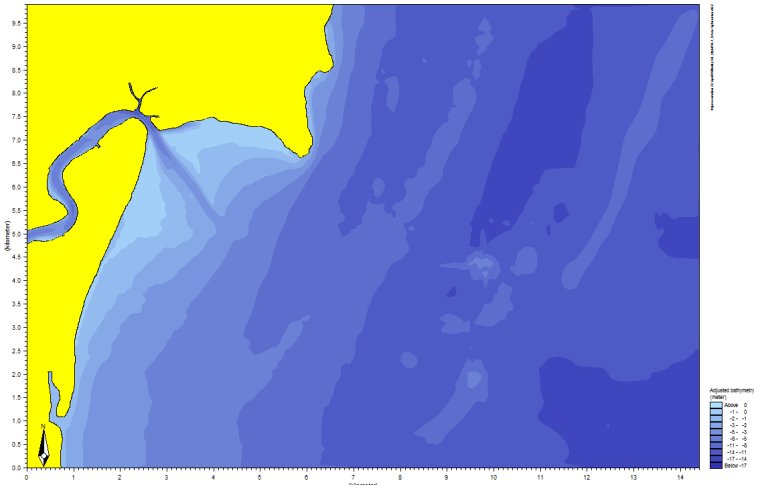
(590 x 1160 @ 270 m grid spacing)

Model Set-up



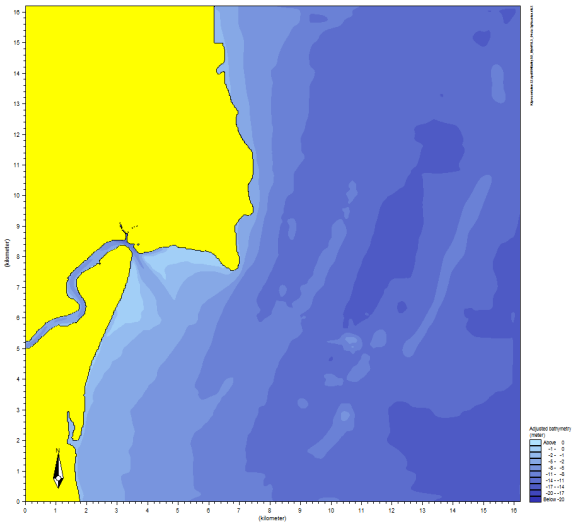
- Medium Grid Model

  (405 x 270 @ 90 m grid spacing



- Local Grid Model

  1440 x 990 @ 30 m grid spacing



- Fine Grid Model

  540 x 540 @ 10 m grid spacing

Calibration & Verification

Calibration involves

- *Comparison of simulated and measured water levels and current velocity*
- *Fine tuning and adjustment of model parameters to obtain good agreement between simulated and measured values*

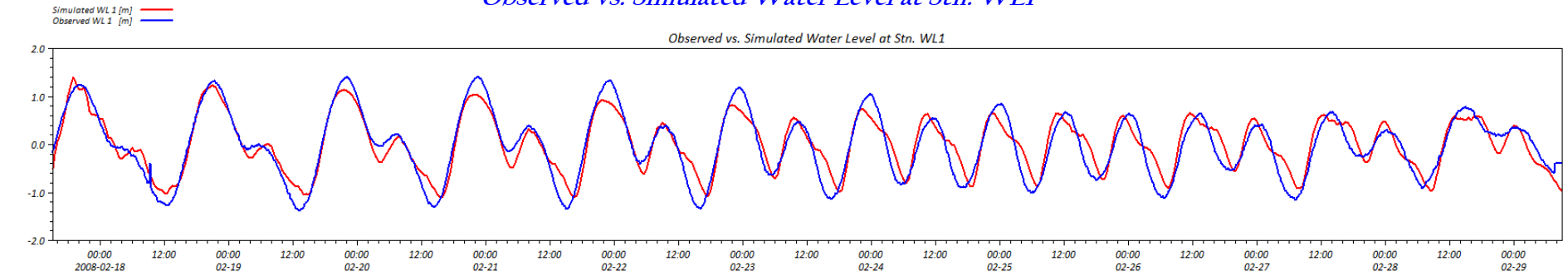
Verification involves

- *Comparing output of calibrated model against measured values (different location from calibration station)*
- *Ensuring that the differences are within tolerable limits*
- *Average Differences: Current Speed/Direction = 20% / 20°*

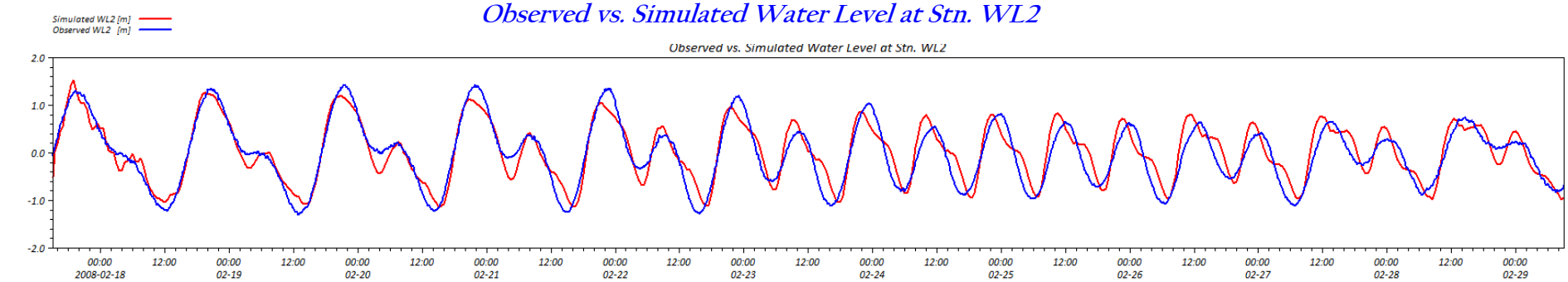
  Water Level = 10%

Calibration & Verification

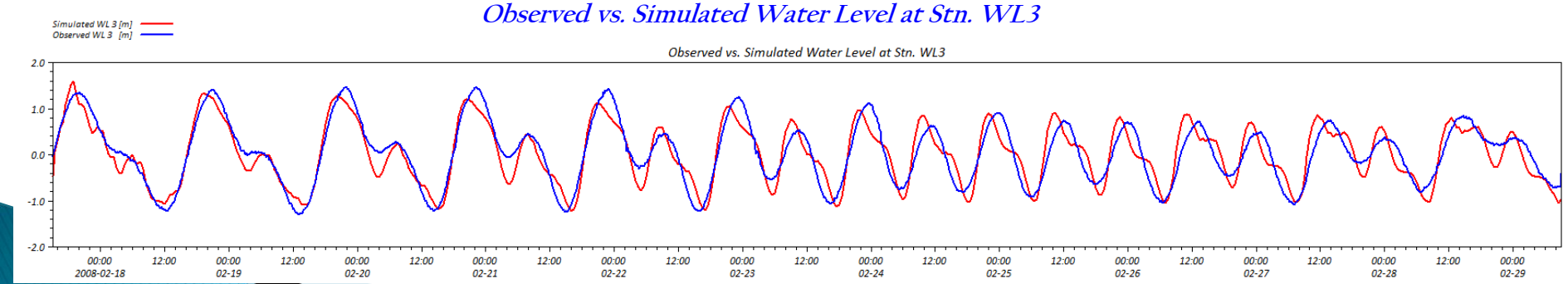
Observed vs. Simulated Water Level at Stn. WL1



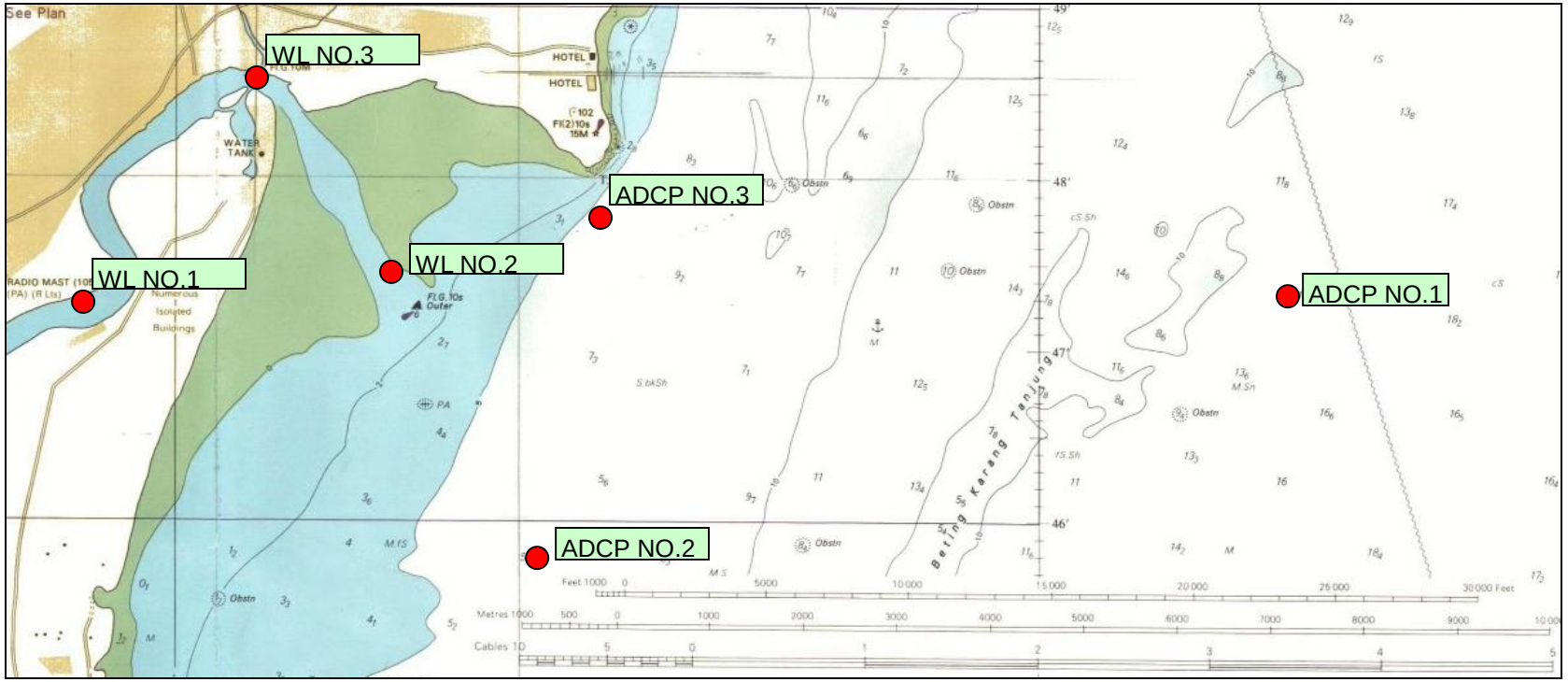
Observed vs. Simulated Water Level at Stn. WL2



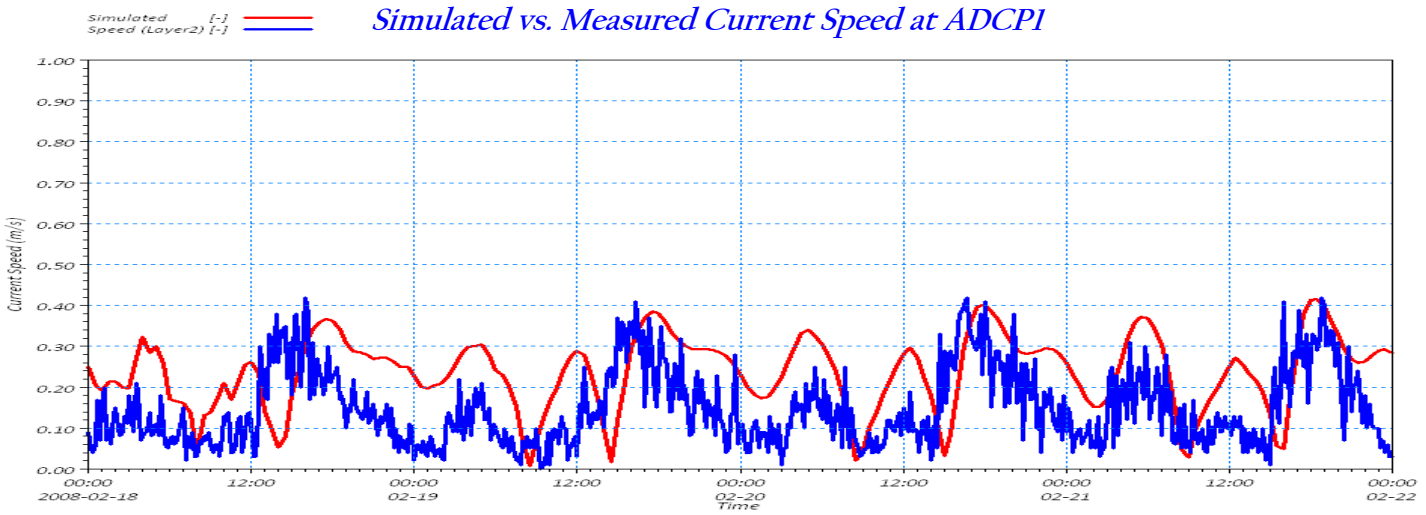
Observed vs. Simulated Water Level at Stn. WL3

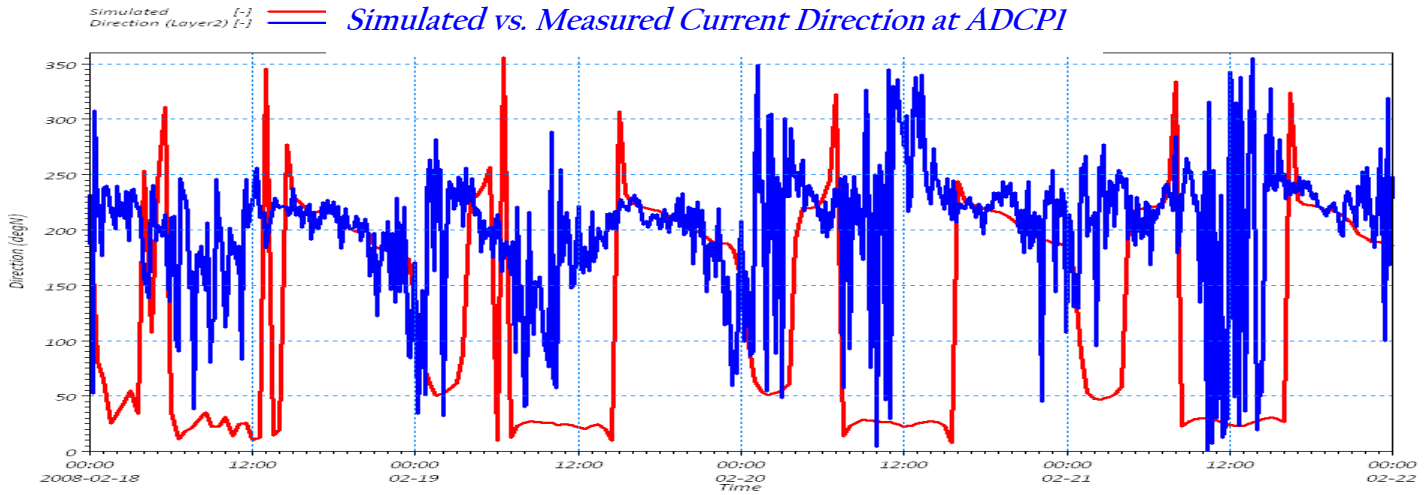


Calibration Points

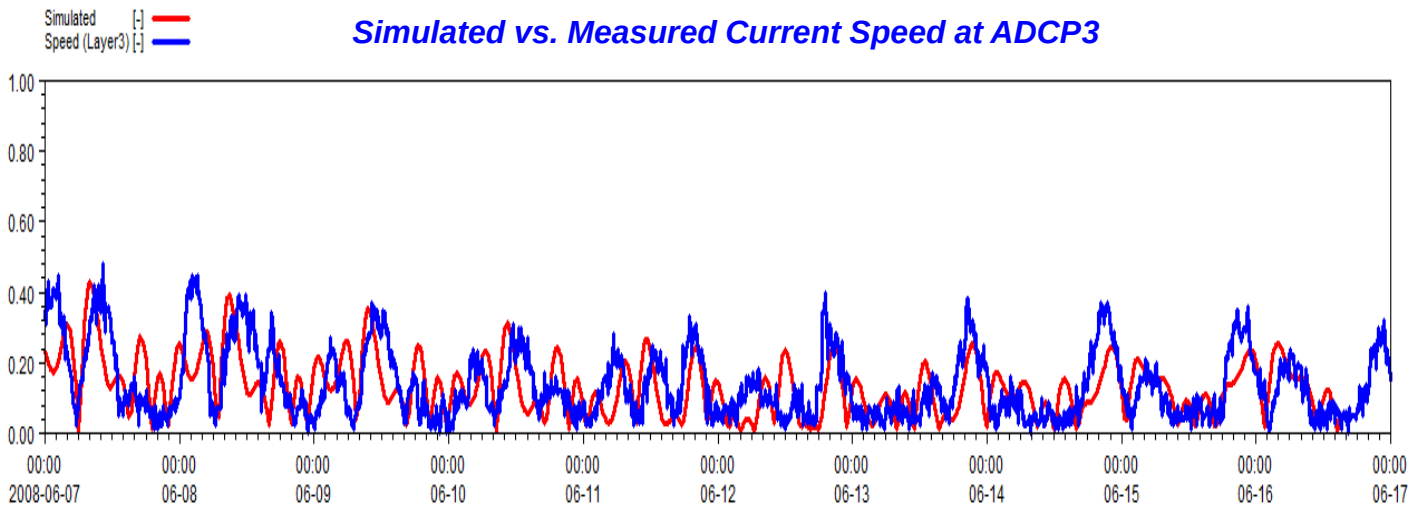


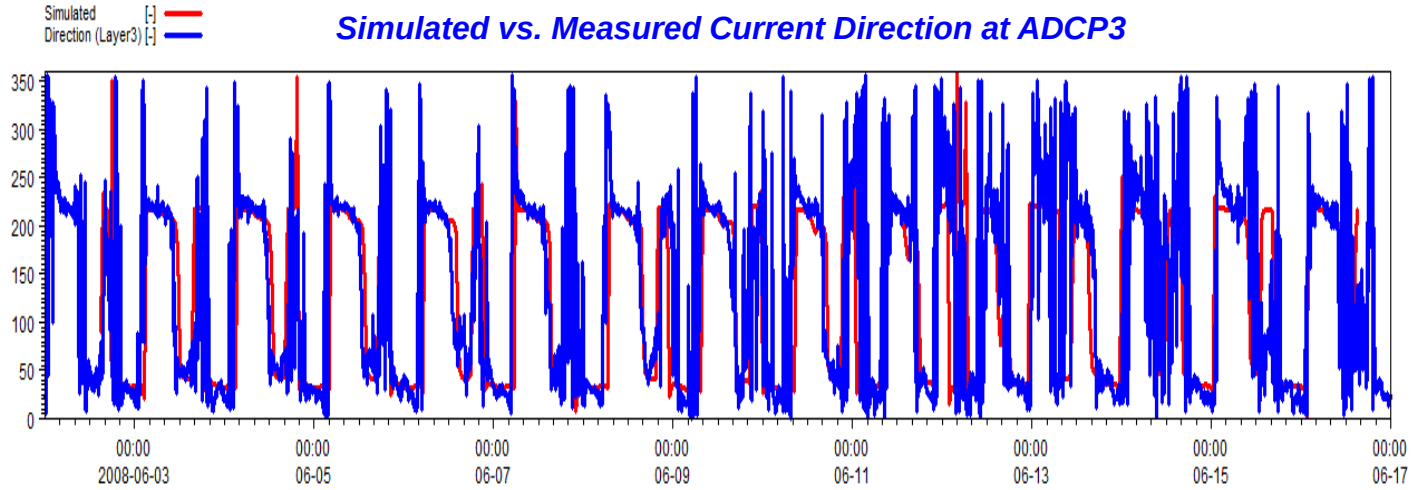
Calibration : Simulated vs Measured Current (ADCP)



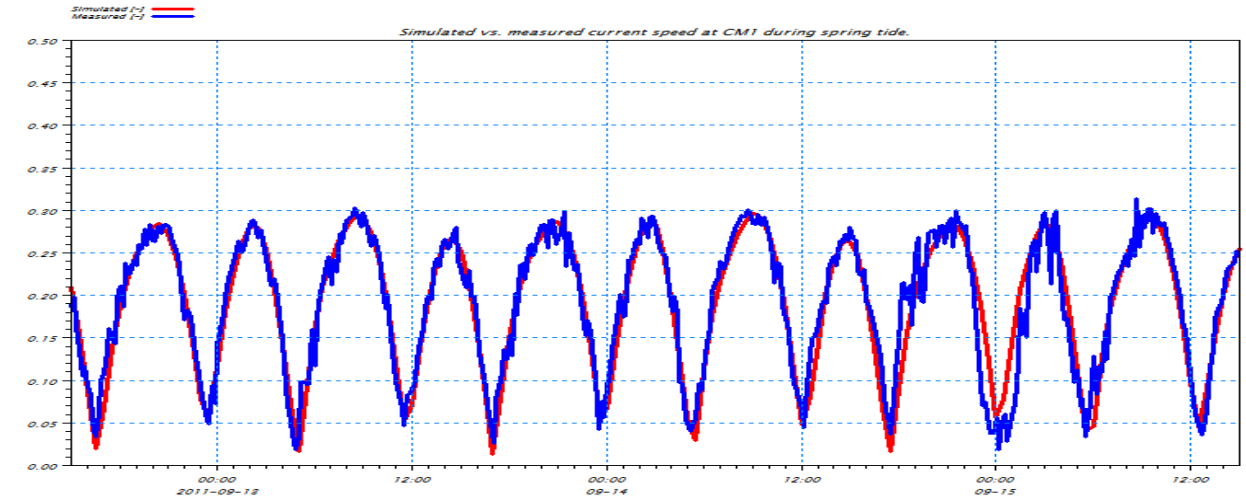


Verification : Simulated vs Measured Current (ADCP)





Calibration & Verification

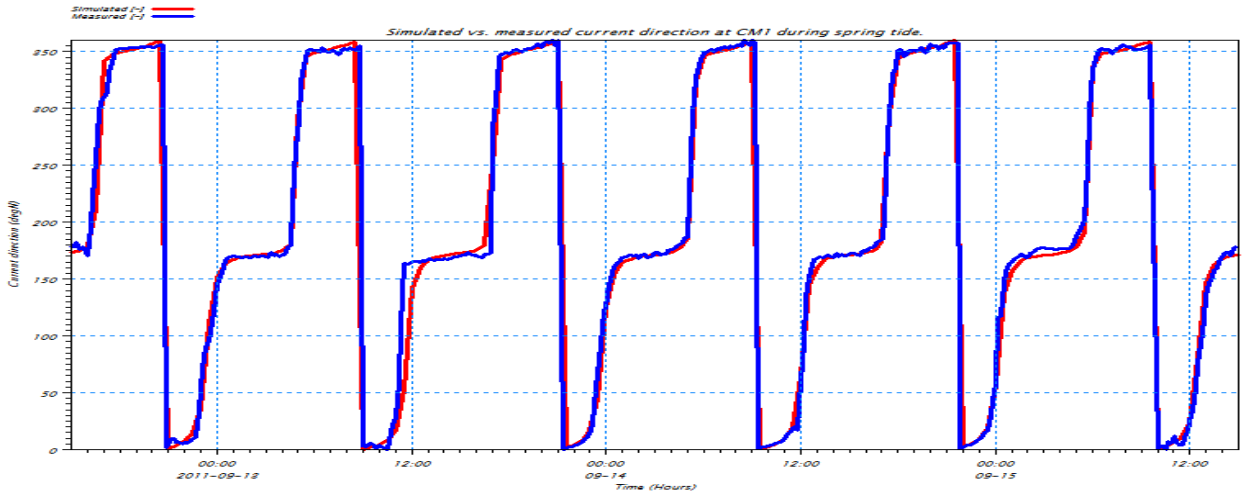


Current Speed

Simulated

vs

Measured



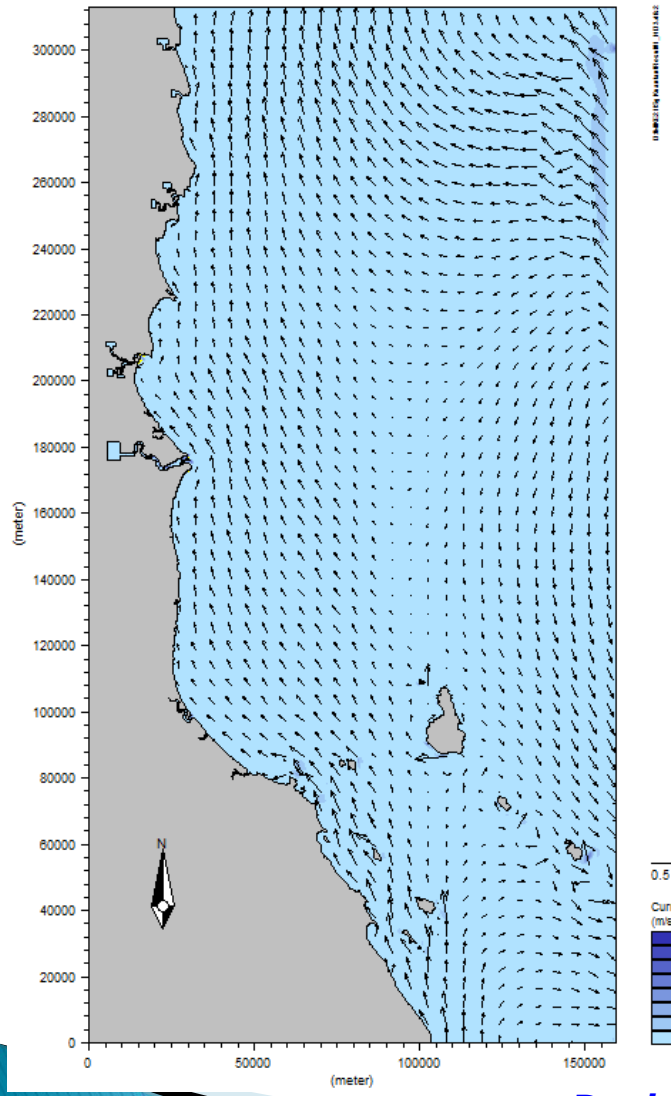
Current Direction

Simulated

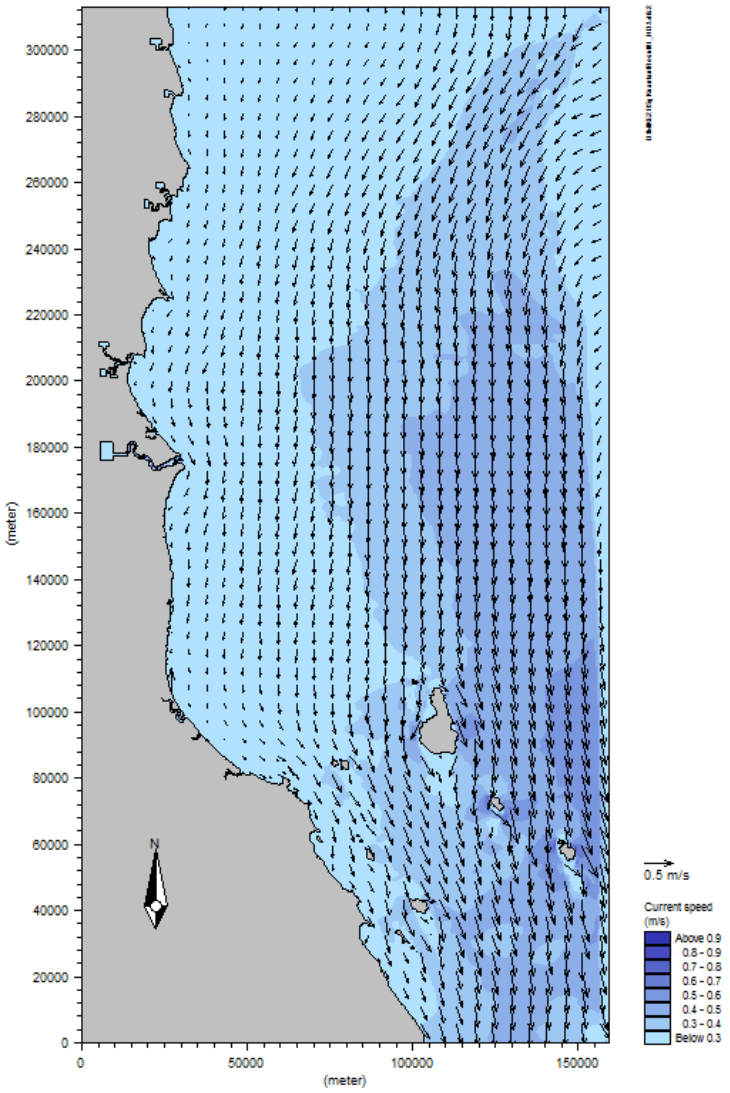
vs

Measured

HD Simulation – Coarse Grid

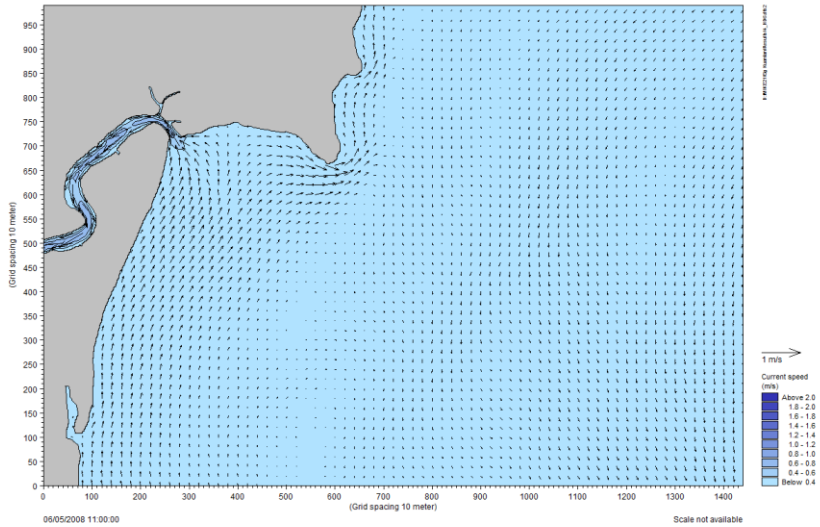


During Flooding

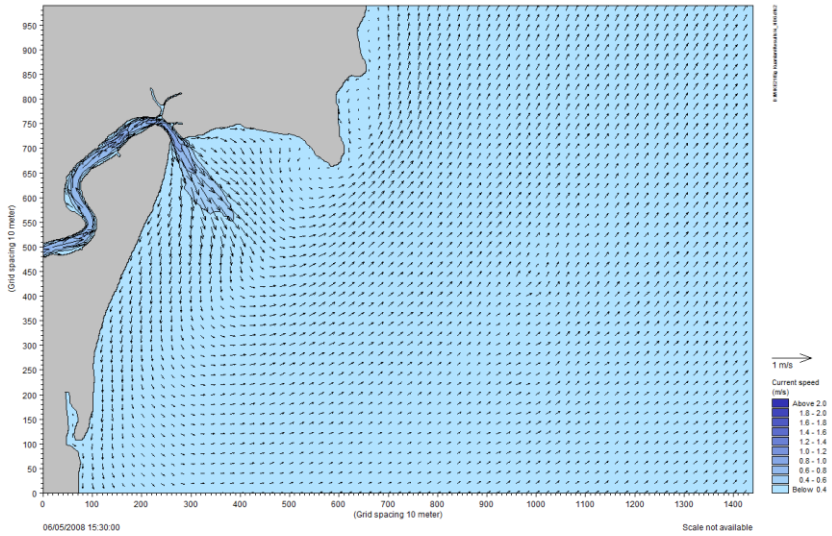


During Ebbing

HD Simulation – Local Grid - Spring

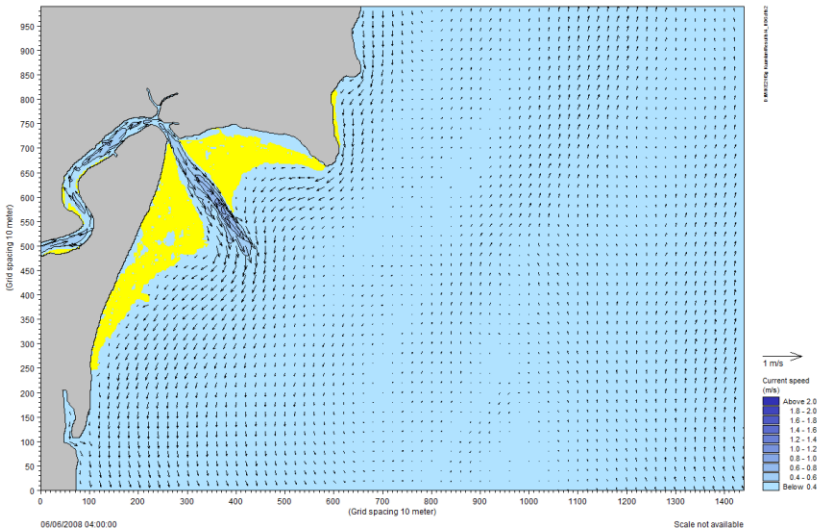


Current Speed During High Tide

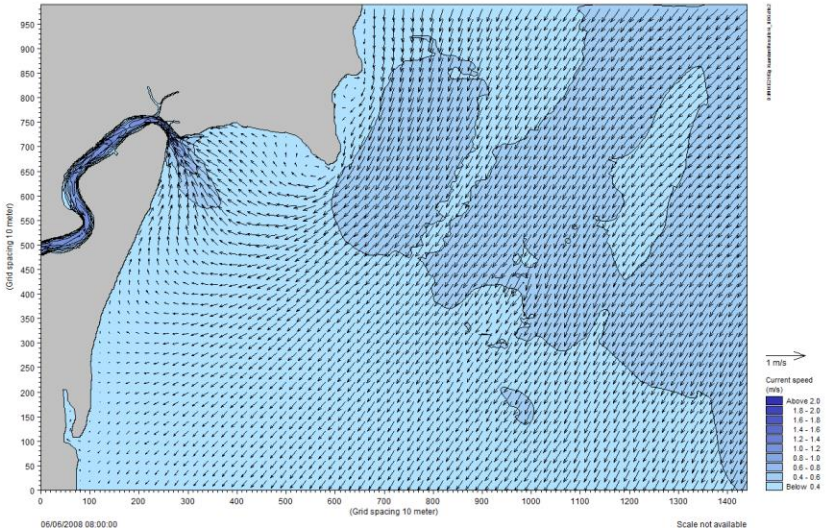


Current Speed During Low Tide

HD Simulation – Local Grid - Spring

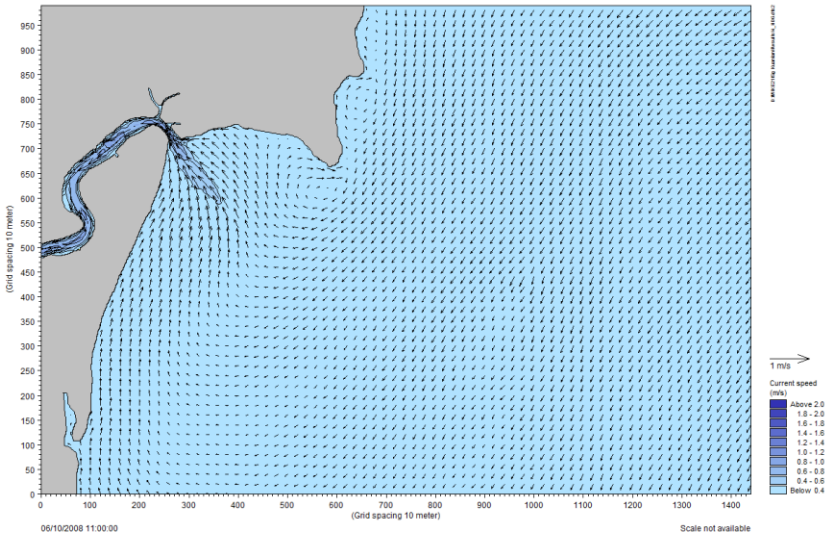


Current Speed During Low Tide

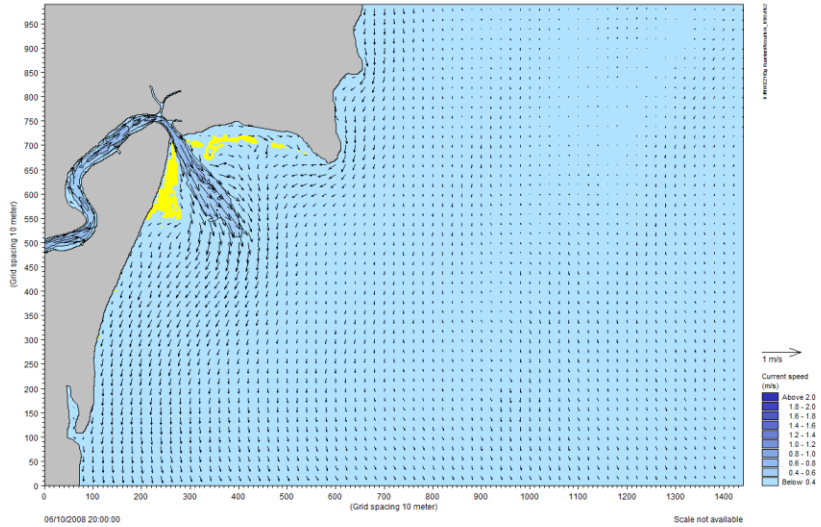


Current Speed During High Tide

HD Simulation – Local Grid - Neap

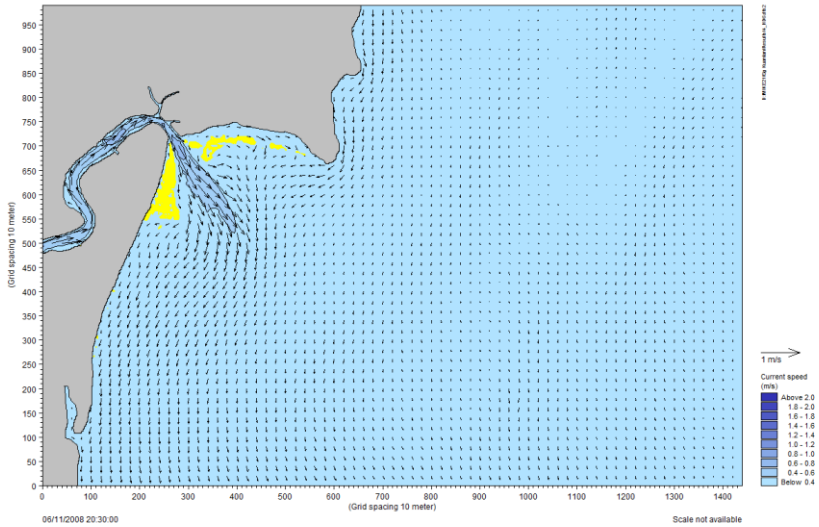


Current Speed During High Tide

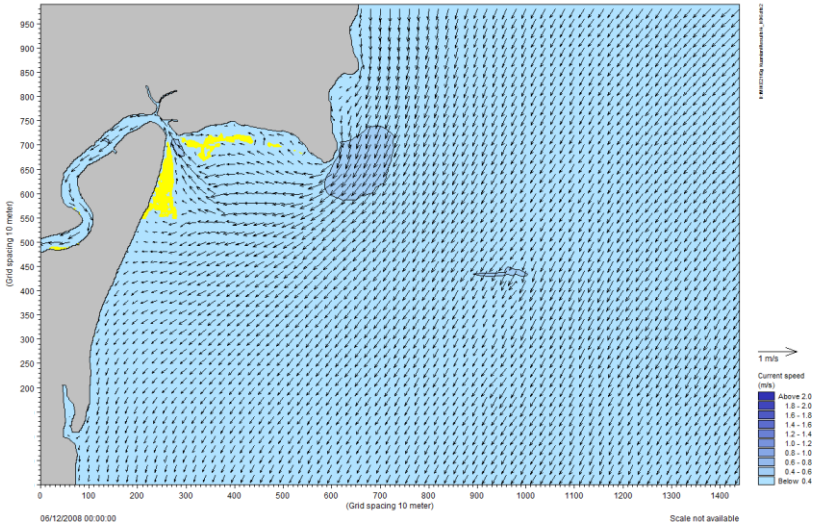


Current Speed During Low Tide

HD Simulation – Local Grid - Neap



Current Speed During Low Tide



Current Speed During High Tide

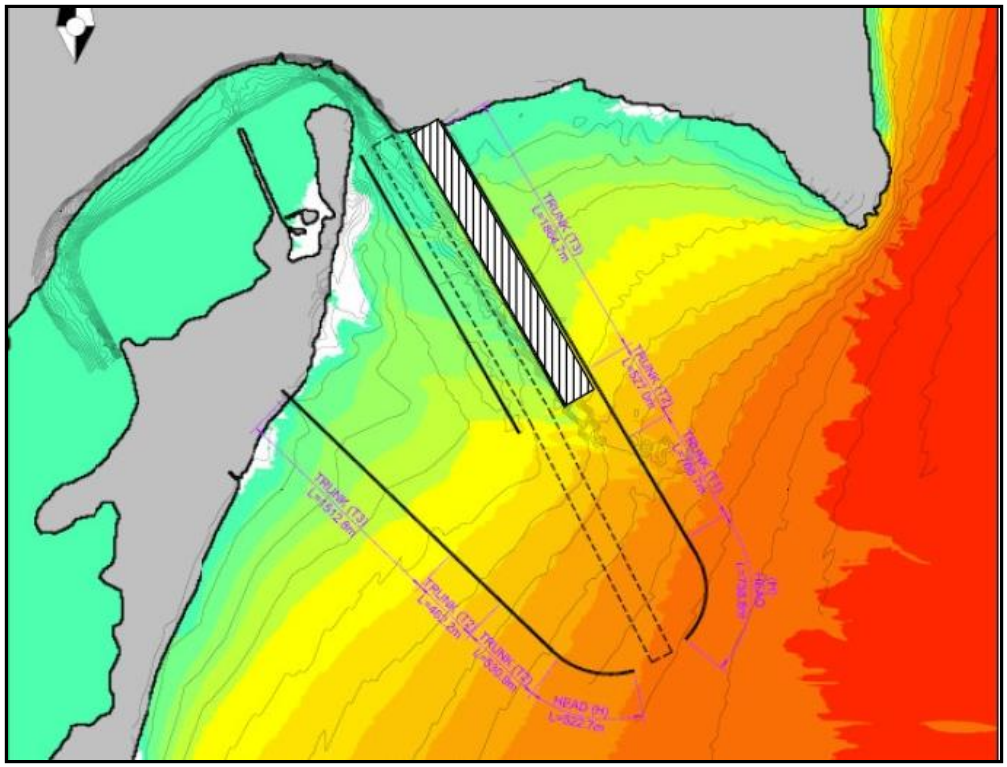
Proposed Options During Conceptual Stage

Option 1

Option 2

Option 3

Proposed Options: Option 3



Conclusion

Modelling Works enable us to:

- Study the dynamics of the site
- Assess the impacts to the coastal area
- Look for appropriate alternatives/ mitigative measures (at reasonable cost)
- Make decision based on best engineering practices (Decision making tools)

Thank You!