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The State of the Art and Science of Coastal Engineering

ANALYSIS OF ENGINEERING FEASIBILITY OF AN OPEN PIER AGAINST COASTAL HAZARDS ALONG LUZON ISLAND

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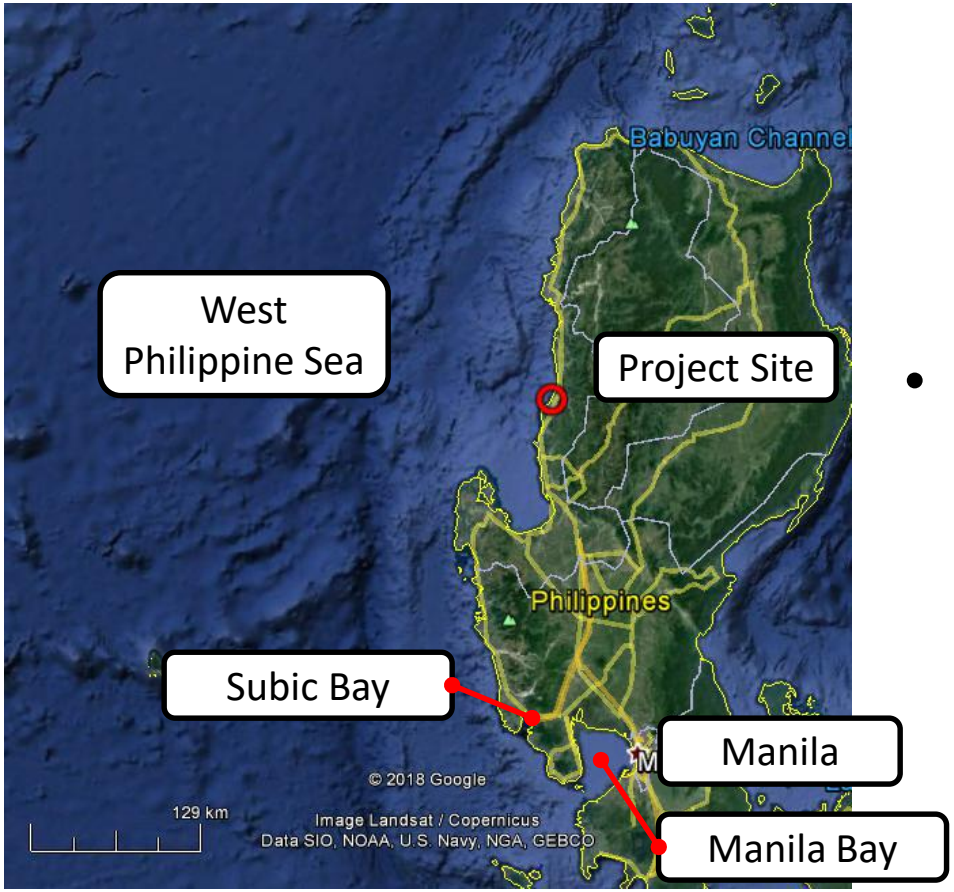
August 3, 2018

Introduction

Project Location and Background

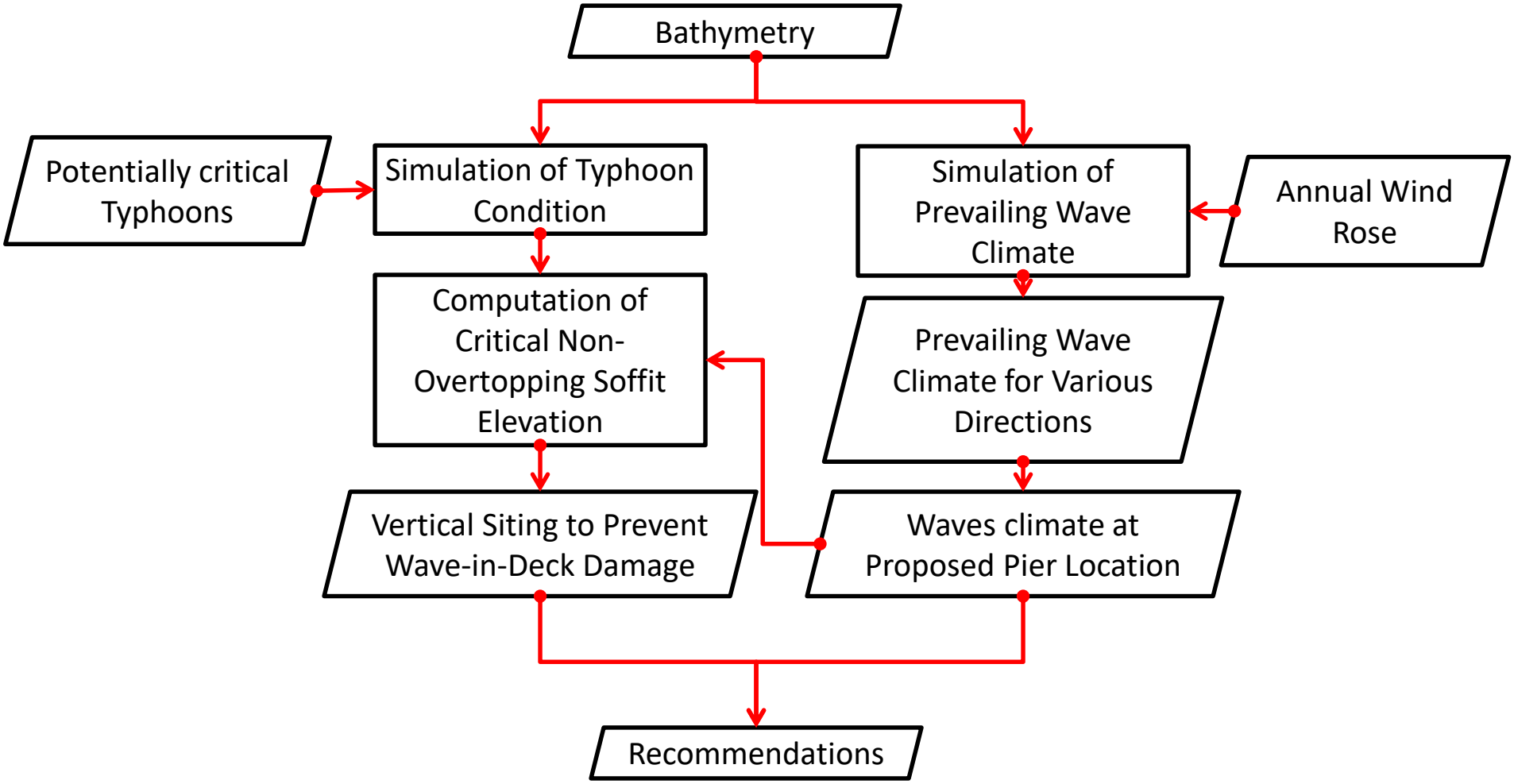


- A proponent plans to construct a oil/gas depot within a property exposed to the West Philippine Sea and adjacent to a river
- However, no protective breakwater or harbour will be constructed

Project Objectives

- The scope of the project was to conduct studies whose results would be used as reference by the Client's team to assess the feasibility, costs, and planning of the project, namely:
  - Engineering Geotechnical and Geohazard Assessment
  - Hydrologic and Hydraulic Study
  - **Coastal Engineering Study**

Methodology



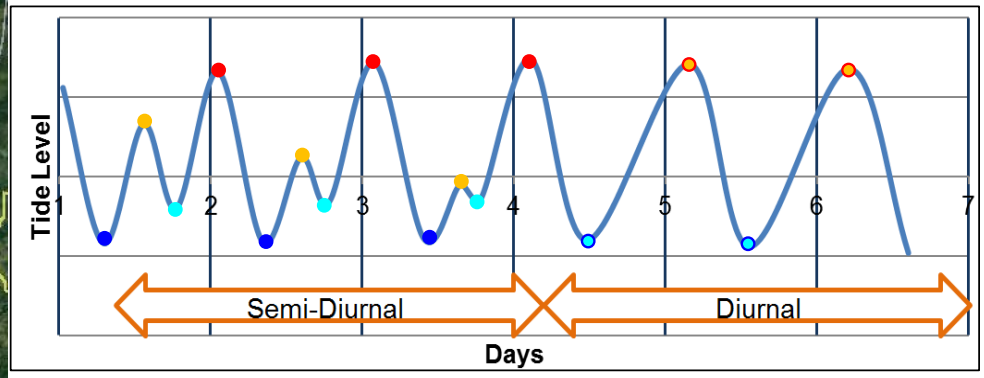
Project Area Data

Exposure / Fetch

Direction	Fetch (km)
N	133
NNW	217
NW	263
WNW	260
W	260
WSW	192
SW	105

Tide Levels

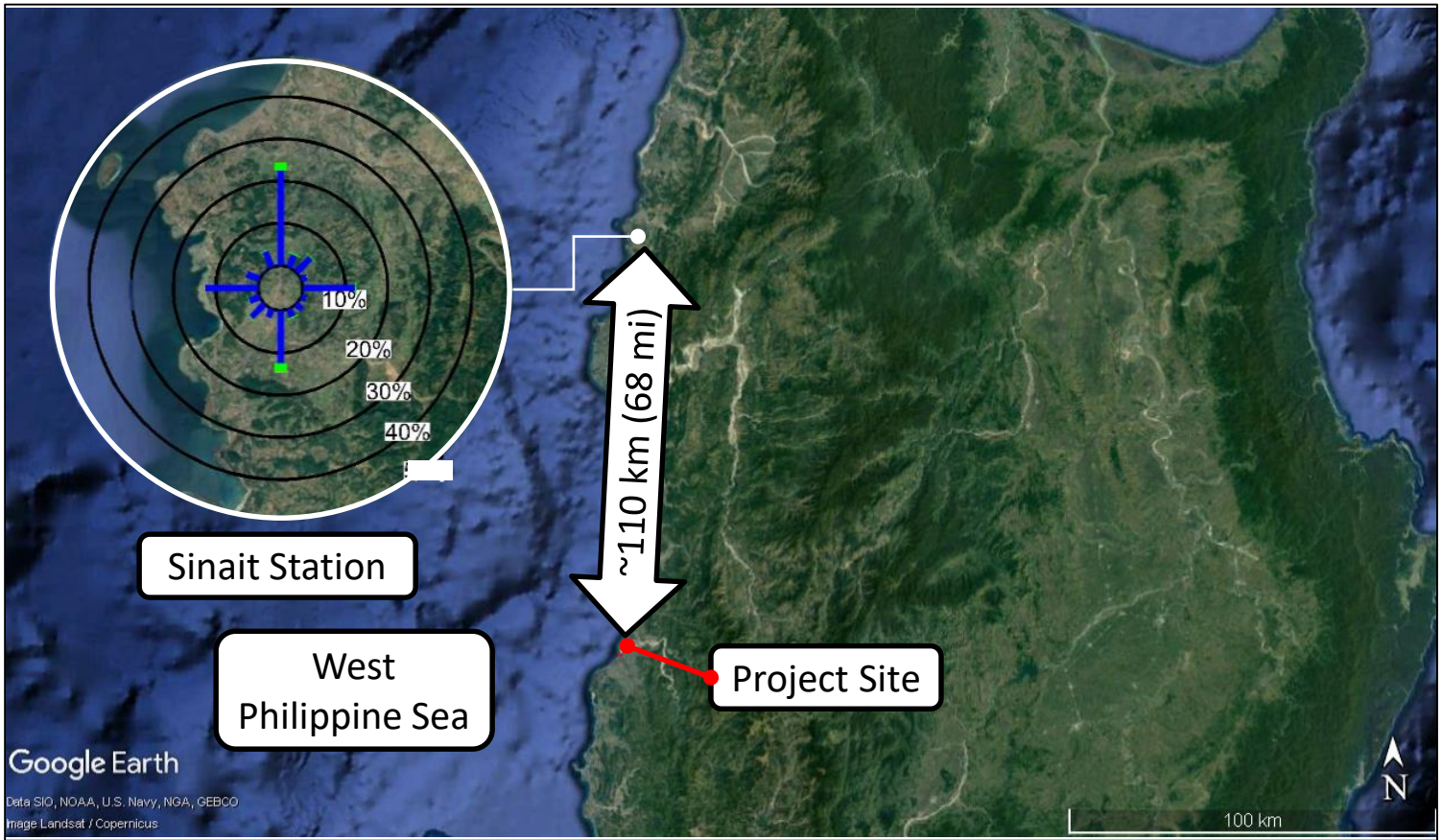
Tide	Level (m)	Level (ft)
MHHW	0.41	1.34
MHW	0.37	1.21
MTL	0	0
MLW	-0.31	-1.02
MLLW	-0.33	-1.08
Range	**0.74**	**2.43**



LEGEND

- Higher High Tide
- Lower High Tide
- High Tide
- Lower Low Tide
- Higher Low Tide
- Low Tide

Wind Rose


10%
20%
30%
40%
Sinait Station
~110 km (68 mi)
West
Philippine Sea
Project Site
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
100 km
N
Legend:
V = 1 – 4 m/
V = 5 – 8 m/s
V = 9 – 12 m/s
V = 13– 15 m/s
V > 16 m/s

Deepwater Wave Hindcast

Direction	Velocity Range	Annual Occurrence (%)	Remarks on Wind	Hs0 (m)	T0 (s)	
N	1-4	22.4	Prevailing	0.48	3.01	
	5-8	1.9		1.24	4.53	6th Highest
	9-12	0.2		2.12	5.69	Highest
NNW	1-4	4.0	4th Prevailing	0.52	3.20	
	5-8	0.1		1.39	4.92	3rd Highest
NW	1-4	3.3		0.53	3.28	
WNW	1-4	3.3		0.54	3.29	
W	1-4	12.4	2nd Prevailing	0.53	3.27	
	5-8	0.1		1.45	5.07	2nd Highest
WSW	1-4	2.6		0.51	3.16	
	5-8	0.1		1.35	4.83	5th Highest
SW	1-4	4.3	3rd Prevailing	0.76	2.91	
	5-8	0.2		1.38	4.34	4th Highest

Vessel Requirements

Vessel Data

Geometry	Dimension
Vessel Type	Oil Tanker
Length Overall (Loa)	232 m
Full Load Draft	13.6 m
Molded Breadth	35 m
Draft Requirement	15.29 m
MLLW	0.33 m
Minimum Depth Requirement	15.29 m
Minimum Depth Requirement (rounded)	16 m

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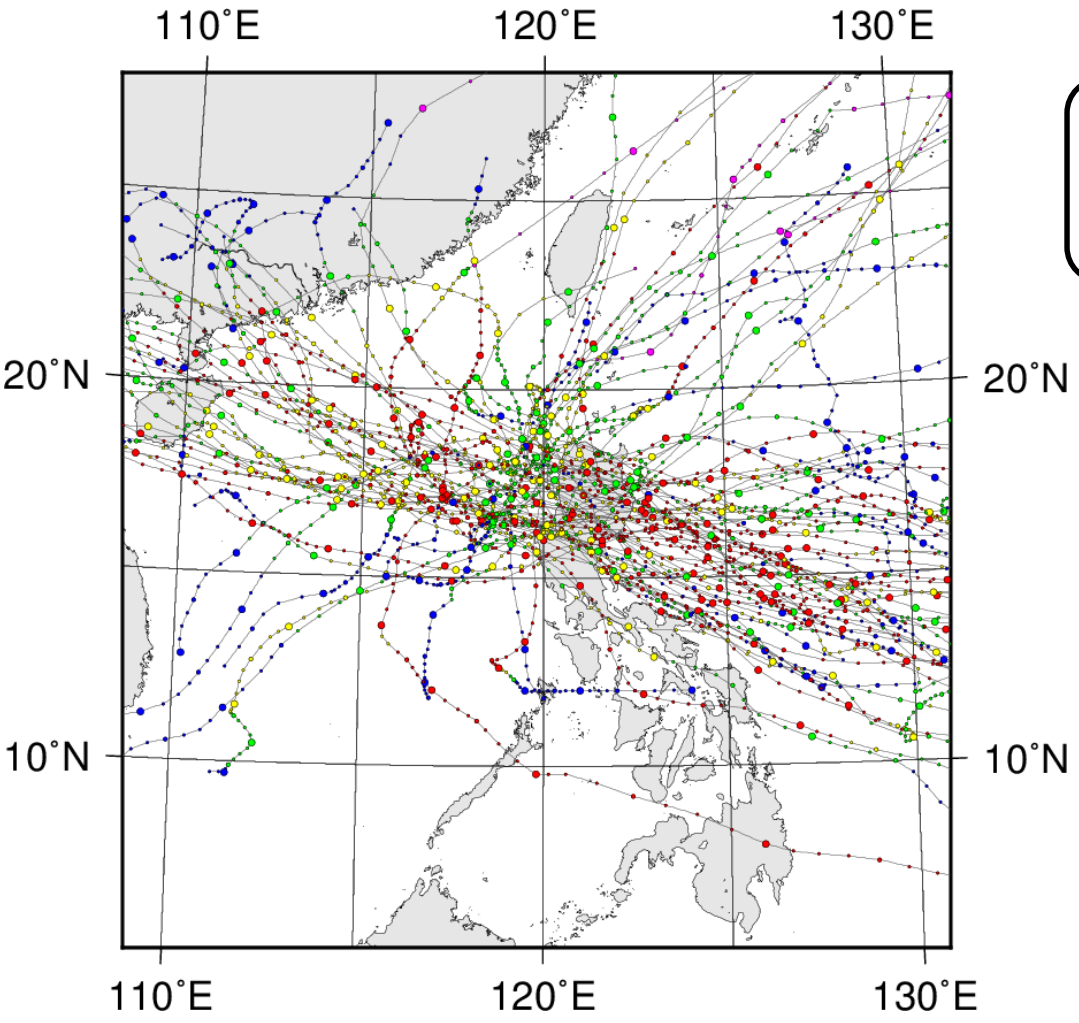
Due to bathymetry, this would result in a 104m long pier, perpendicular to the shore

Selection of Design Typhoon

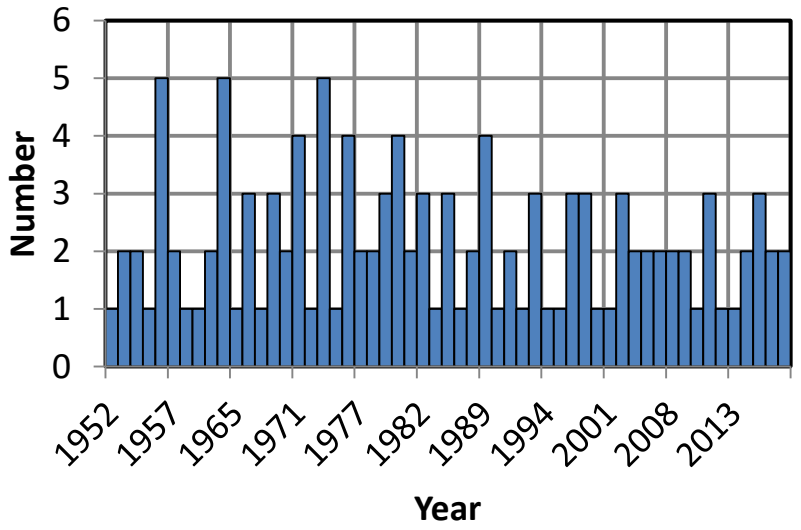
Exposure to Typhoons



Source: http://agora.ex.nii.ac.jp/digital-typhoon/

A list of all typhoons whose maximum wind location passed within a 200 km radius of the site was listed.

Number of Typhoons Passing within 200 km of the Project Site



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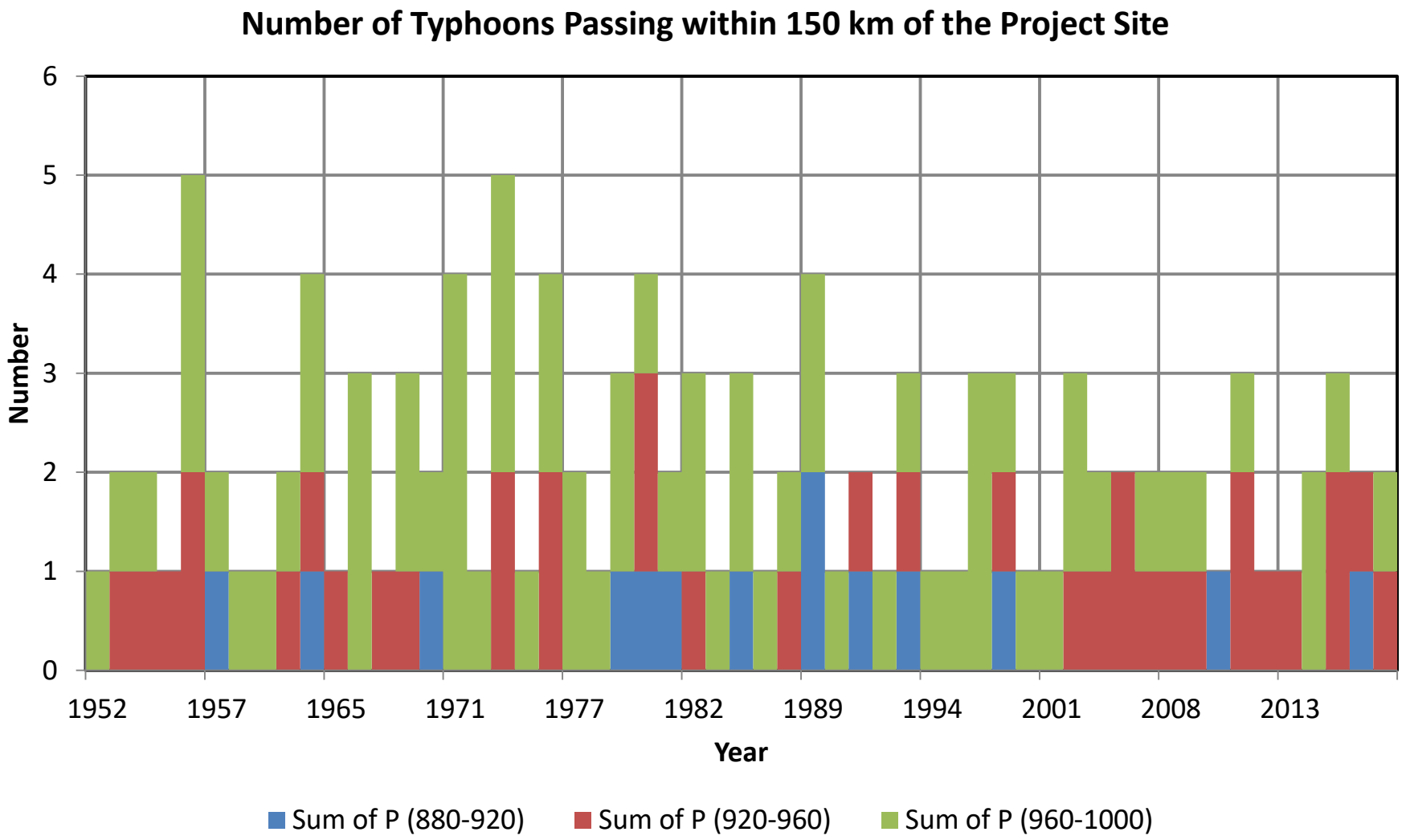
Exposure to Typhoons

Distribution of Central Pressure



Exposure to Typhoons

Source: http://agora.ex.nii.ac.jp/digital-typhoon/

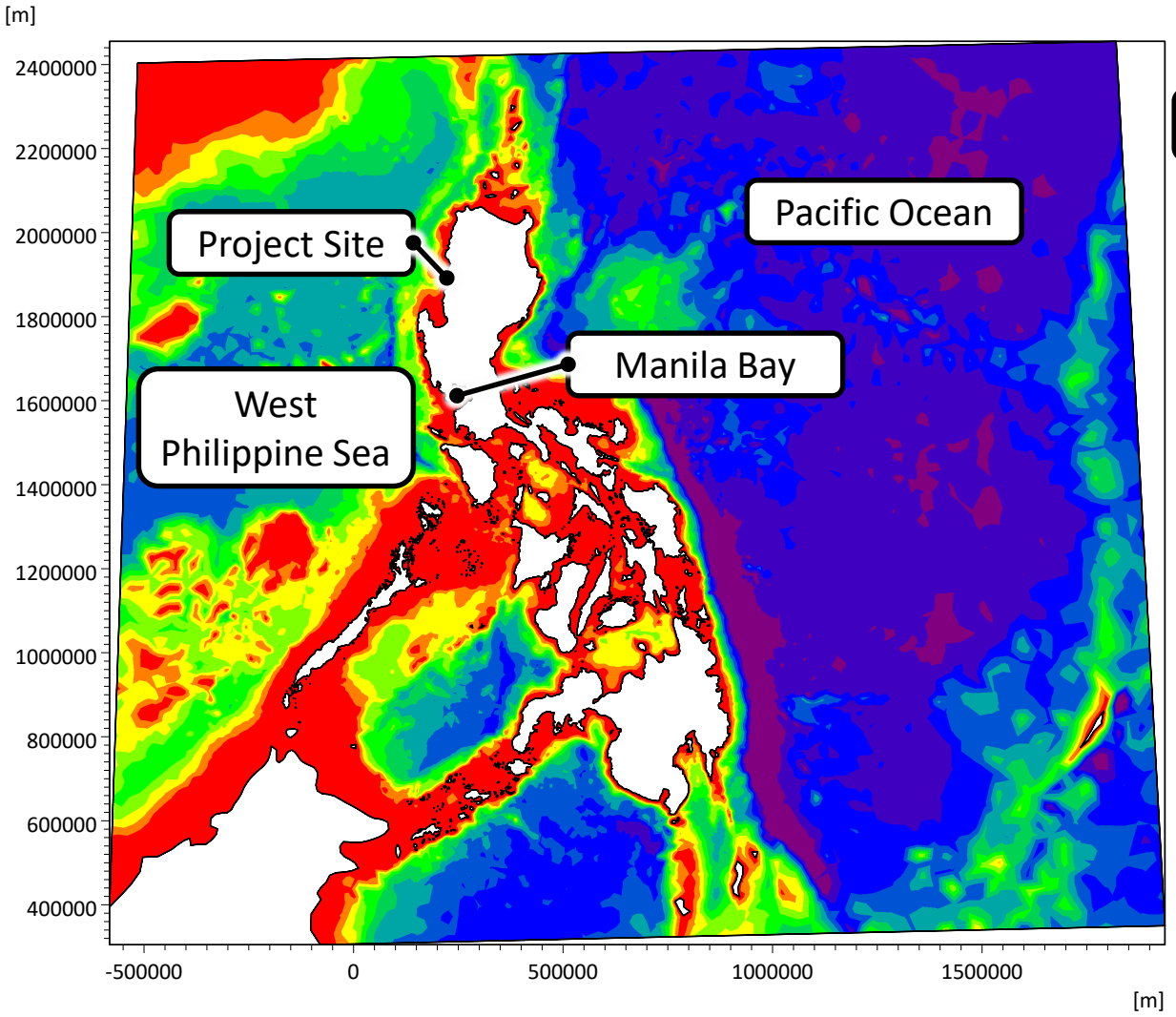
Through detailed analysis of Rmax, V, Relative Track, and Distance to the Site; the following potentially critical typhoons were selected for detailed simulation.

No	International / Local Name	Start	End
1	Rita / Kading	11-Oct-78	29-Oct-78
2	Ellen / Herming	31-Aug-83	9-Sep-83
3	Betty / Aring	29-Oct-80	7-Nov-80

Numerical Model

Computational Domain

Regional



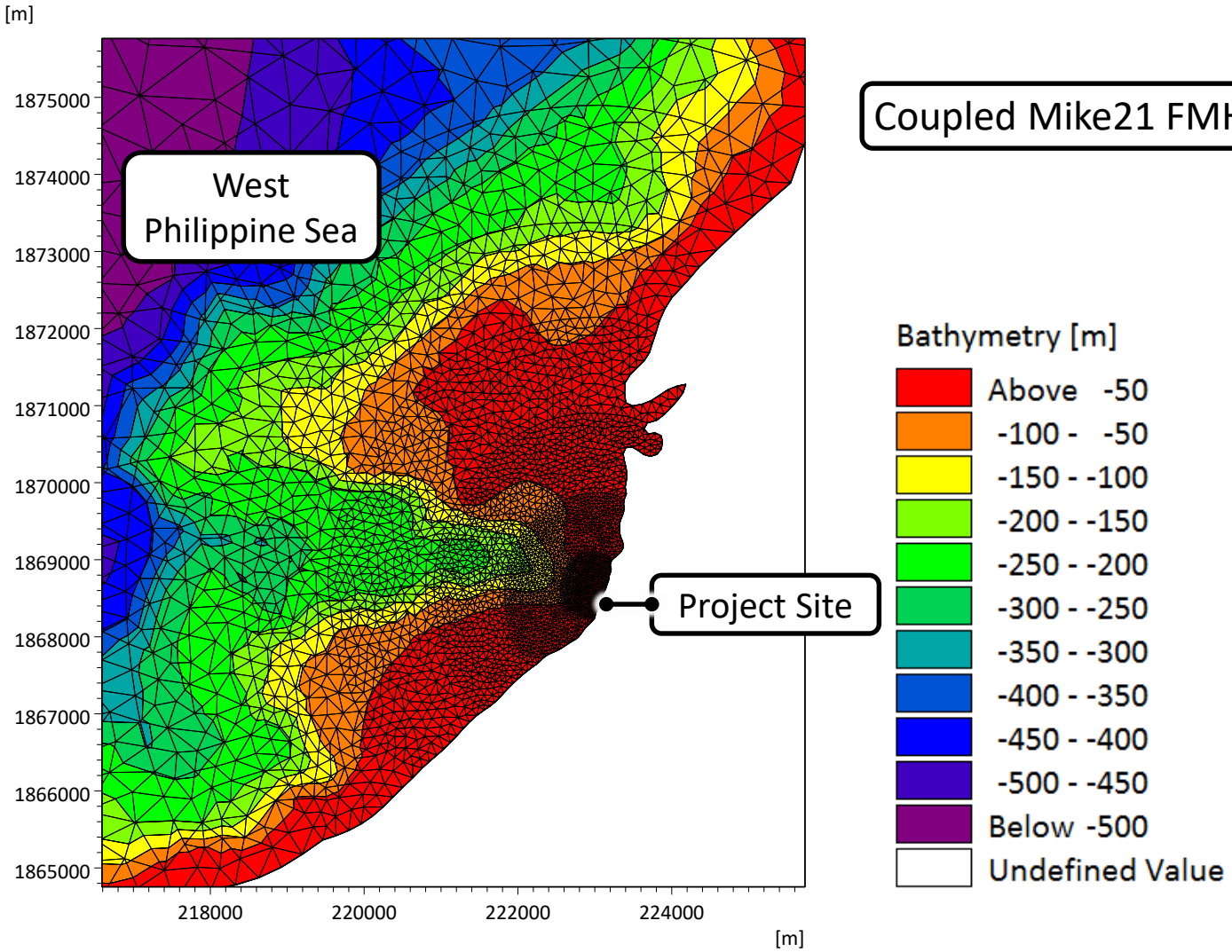
Coupled Mike21 FMHD+SW

Bathymetry [m]

- Above -600
- -1200 - -600
- -1800 - -1200
- -2400 - -1800
- -3000 - -2400
- -3600 - -3000
- -4200 - -3600
- -4800 - -4200
- -5400 - -4800
- -6000 - -5400
- Below -6000
- Undefined Value

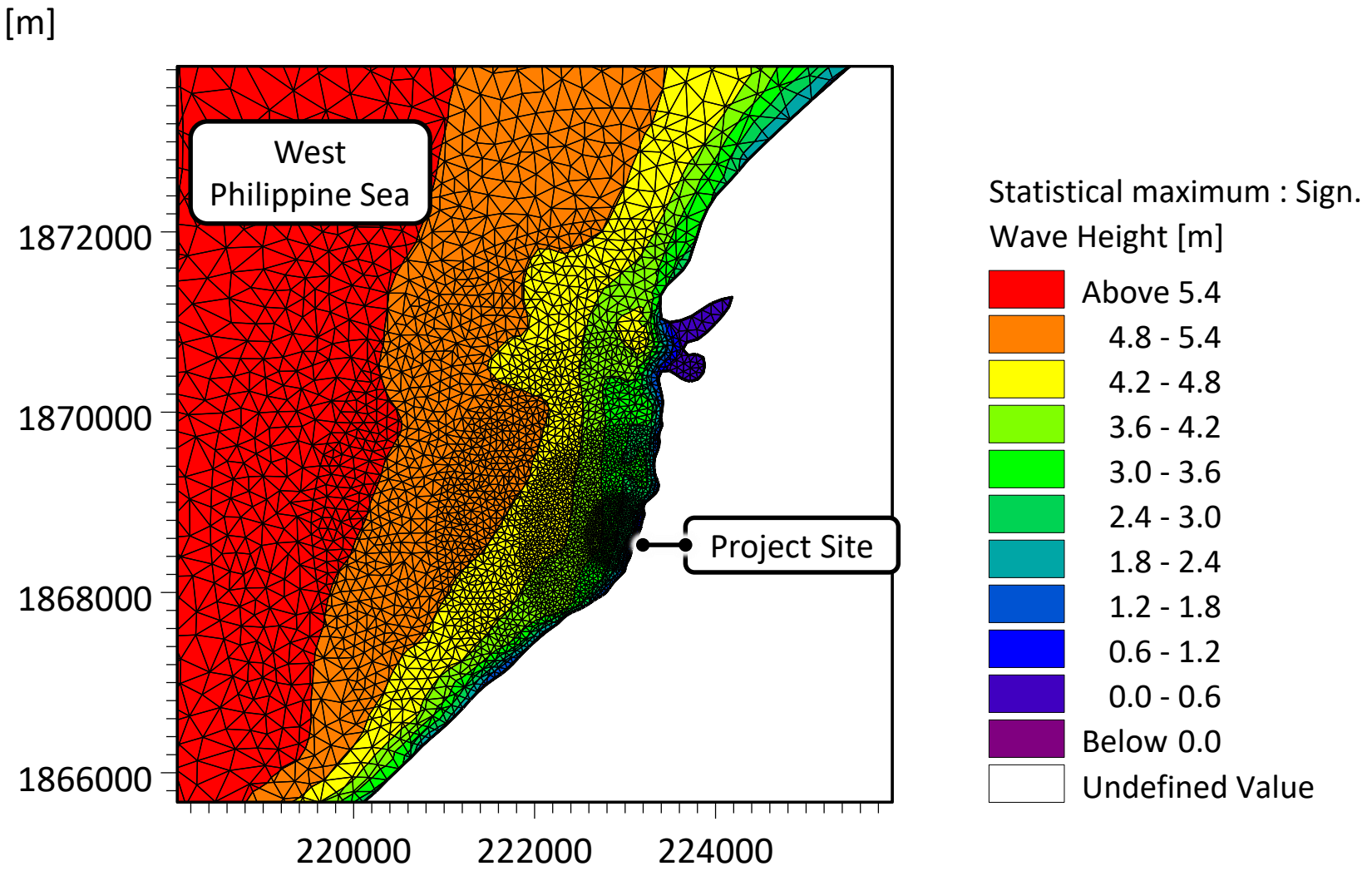
Computational Domain

Local



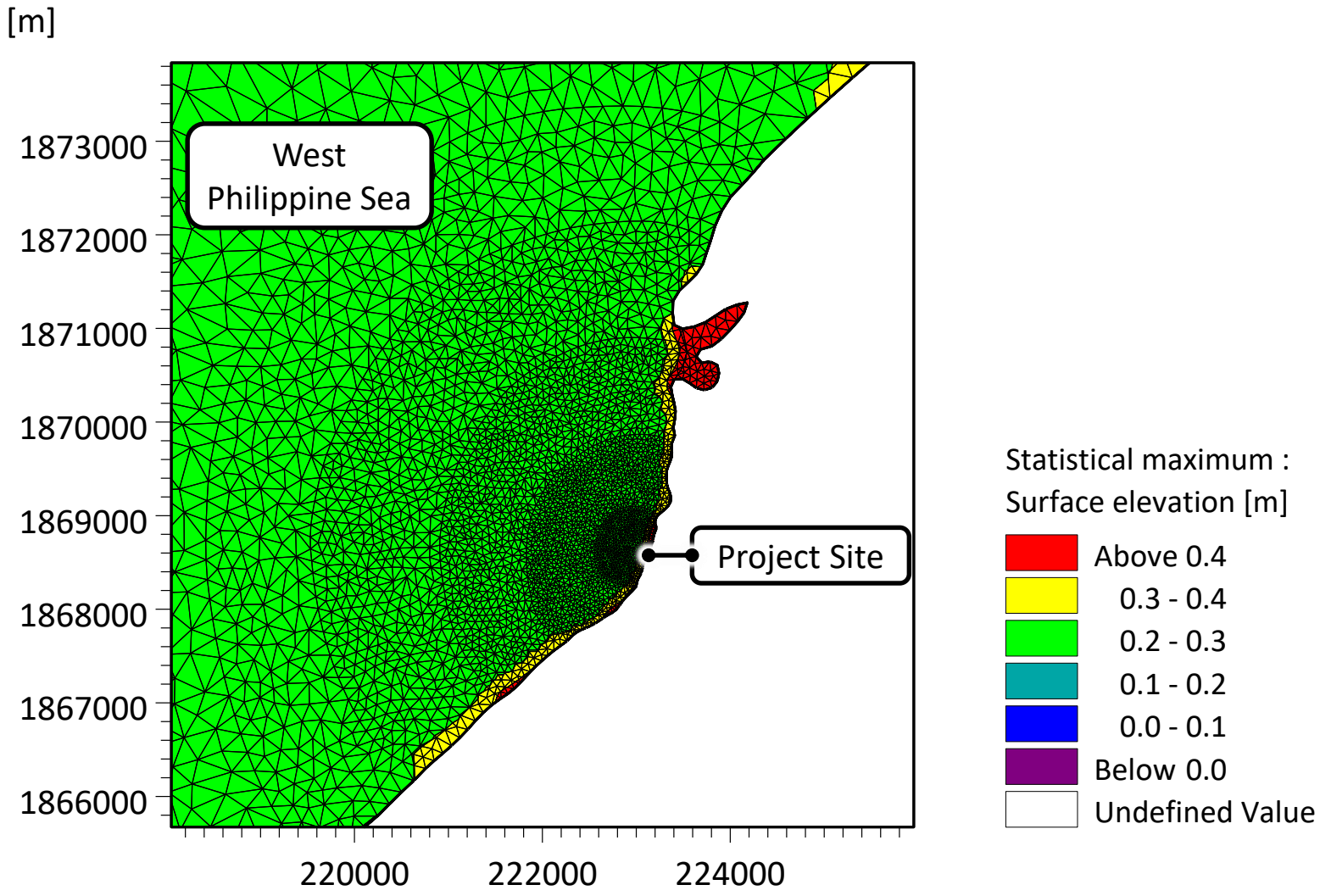
Sample Results

Rita Hs Max

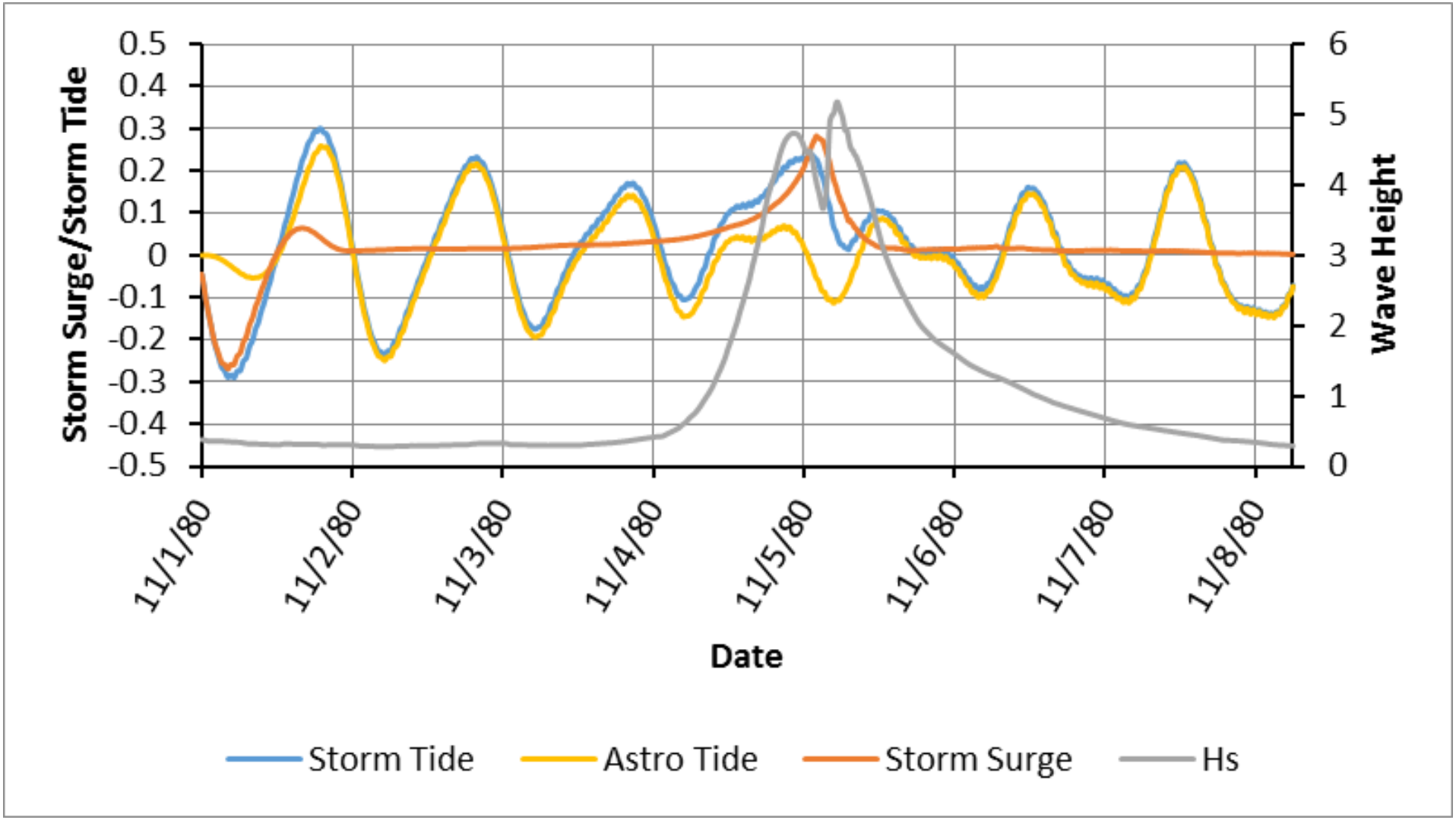


Sample Results

Rita STL Max



Sample Results



Critical Results

Typhoon	Critical Storm Surge	Significant Wave Height, Hs (m)	Significant Wave Period, T02 (sec)	Free Surface Elevation, η (m)	Non-Overtopping Water Surface Elevation (m)
RITA / KADING 1978	0.21	2.58	4.21	1.44	2.06
ELLEN / HERMING 1983	0.37	2.88	5.02	1.59	2.37
BETTY / ARING 1980	0.28	5.18	6.57	2.98	3.67

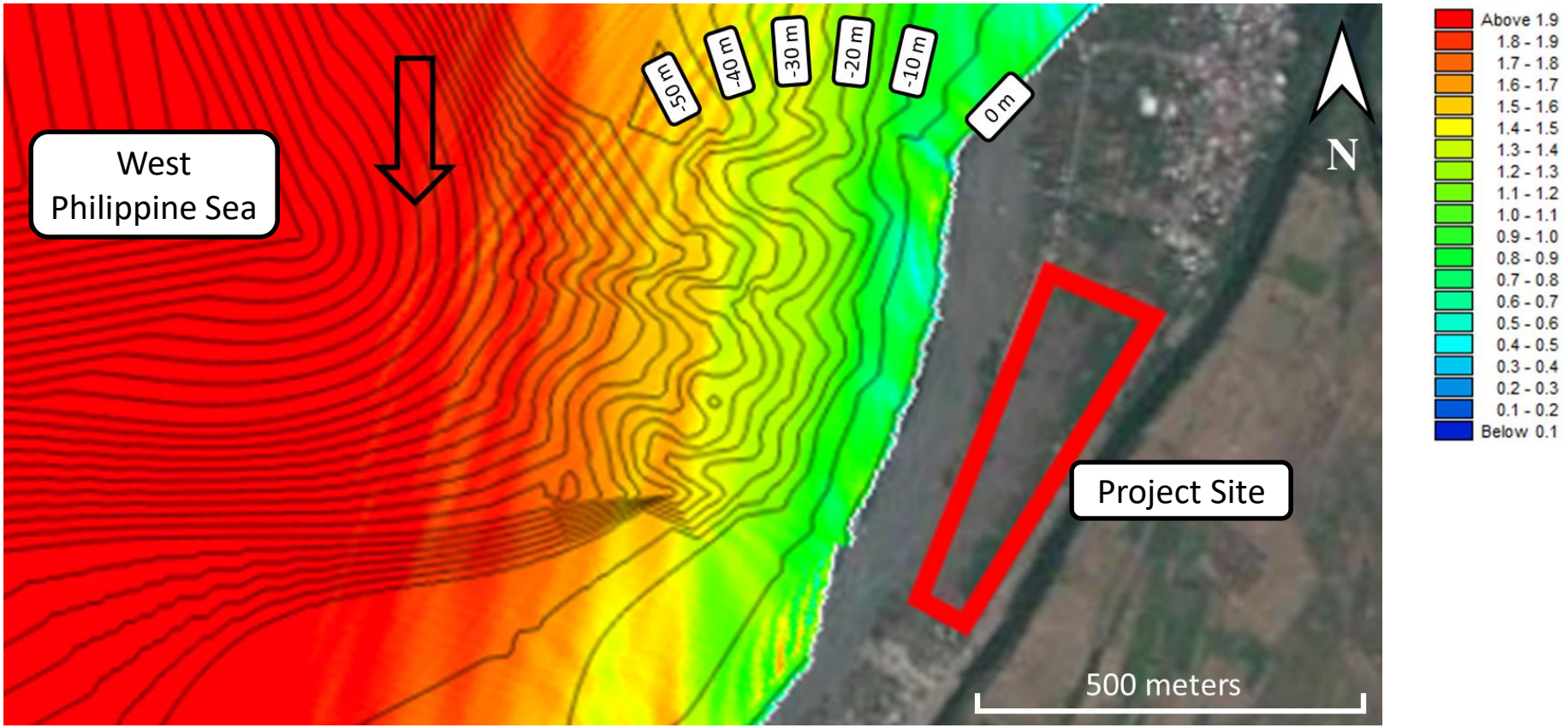
The pier would thus require a minimum soffit elevation of +3.67 m + freeboard, to ensure:

- additional wave-in-deck forces are avoided; and
- that equipment on the deck of the pier will not be impinged significantly by waves

Prevailing Wave Conditions

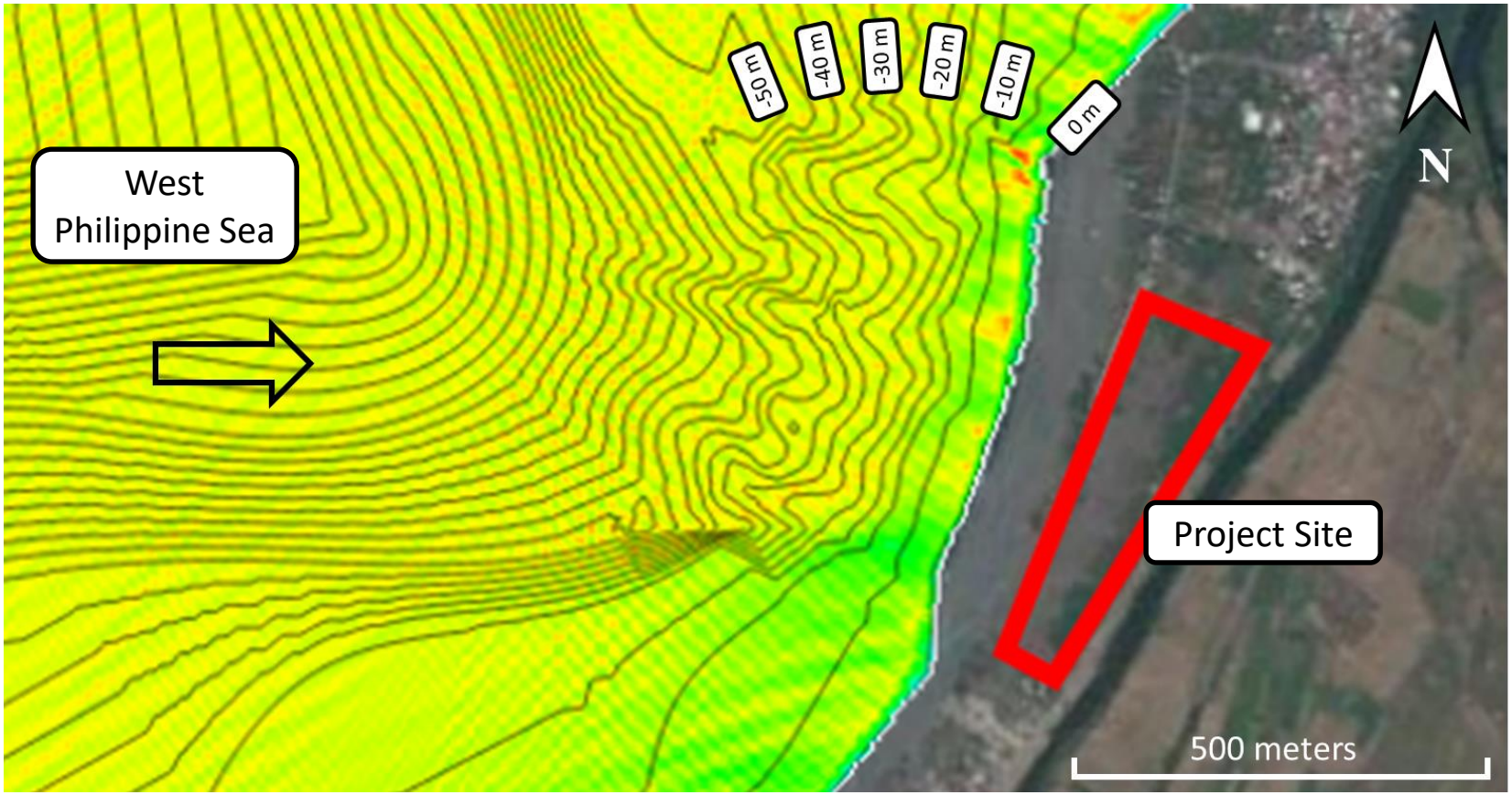
Prevailing Conditions

Sample Results



Prevailing Conditions

Sample Results



Conclusions

Extreme Prevailing Condition

Direction	Wind Speed (mps)	Annual Occurrence (%)	Range of Prevailing Hs (m)
N	9-12	0.2	**1.0-1.3**
NNW	5-8	0.1	**1.4-1.5**
NW	1-4	3.3	**0.4-0.5**
WNW		3.3	
W	5-8	0.1	**1.5-1.6**
WSW	5-8	0.1	**1.0-1.1**
SW	5-8	0.2	**0.2-0.4**

Based on discussions with Proponent, the prevailing wave conditions are within their tolerable limits for operation.

Ship Size	Threshold Wave Height for Cargo Handling
Small (<500 GT)	0.3 m
Medium-Large	0.5 m
Very Large (>50,000 GT)	**0.7~1.5 m**

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Conclusions

Conclusions

- The design vessel able to withstand the highest prevailing waves.
- Due to the bathymetry, the pier will need to be at least **106 m** long to reach the required minimum depth of required for the design vessel.
- The soffit elevation should be at least **MTL+3.56 m** to avoid wave-in-deck forces and impinging of large storm waves on heavy equipment.
- The historically highest wave height which the pier should be able to withstand is **5.2 m.**

Recommendations & Way Forward

- An open pier type loading bay may be constructed and usable during **prevailing** conditions.

- A **minimum non-overtopping soffit elevation (NOSE)** of **MTL+4.2m** (=3.6 +0.6 flood freeboard, DPWH) is needed for an open pier.

- Vessels should **NOT** be moored to the pier during **storm** conditions.

Way Forward

- Plan alignment of pier will be optimized based on prevailing wave climate.
- The preliminary structural design will be conducted to obtain indicative costing of the pier structure.

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