Port of Tacoma
Bollard Study for PCT
KPFF Job No. 10092300204

Prepared by KPFF Consulting Engineers

July 5, 2024

kpff 60 YEARS

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1. EXECUTIVE SUMMARY

This report presents the results of a Bollard Study for Pierce County Terminal (PCT) at the Port of Tacoma in Tacoma, Washington. The purpose of this study is to determine if the existing 125-kip mooring bollards are adequate for the vessels anticipated to berth at the terminal.

This study includes summarizing the information gathered and reviewed, developing site-specific 25-year return period wind speeds, and a vessel mooring analysis. The maximum allowable wind speeds reported from the mooring analysis on the existing bollards limits the wind speeds between 21 and 24 knots depending on the mooring arrangement. These wind speed capacities are all lower than the 25-year return period which ranges from 30.6 and 41.4 knots, blowing off the berth. In all arrangements, the 25-year return period wind speed is higher than the wind speed at which mooring loads exceed bollard capacities.

At least some of the existing bollards should be upgraded to accommodate mooring 14,000 and 20,000 TEU vessels at PCT. The final determination of the required bollard capacity, quantity, and location requires further analysis.

A preliminary analysis was conducted to determine the required bollard capacities considering the 25-year return period wind speeds. The preliminary analysis found that 10 wharf mooring bollards need to be upgraded to a 440-kip capacity to accommodate the 14,000 and 20,000 TEU vessels to berth at PCT. The rough engineers estimate to upgrade these 10 mooring bollards to allow for 14,000 and 20,000 TEU vessels to berth at PCT is $3,657,700.

2. Introduction

The fender system for Pierce County Terminal (PCT) was recently upgraded, at least in part, to accommodate larger vessels than the berths were originally designed for. A number of the ship-to-shore cranes at PCT were recently raised to allow them to service larger vessels with taller container stacks. Additionally, the Port is developing plans to deepen the Blair Waterway to allow for larger vessels. Considering the other efforts recently completed or in progress to facilitate berthing larger vessels, the Port has asked KPFF to prepare a study to evaluate if the existing mooring bollards are adequate for the vessels that will berth at the terminal.

3. Information Reviewed

3.1. Record Drawings

Record drawings of the facility were compiled and reviewed to understand the existing bollard arrangements, capacity, and wharf geometry. The following record drawings were reviewed:

- 1972 Pierce County Terminal Wharf Complex
- 1975 Pierce County Terminal Berth B
- 2003 Pierce County Terminal Wharf and Phase 2 Dredging and Slip 5 Mitigation
- 2023 PCT Fender System Replacement Project

3.2. Relevant Codes, Standards, and Guides

The following industry codes, standards, and guidelines were reviewed for relevant mooring recommendations:

- Uniform Facilities Criteria (UFC) 4-159-03, Design: Moorings, 2020.
- Design of Marine Facilities Engineering for Port and Harbor Structures (Third), Gaythwaite J. W., American Society of Civil Engineers, 2016.
- Mooring of Ships to Piers and Wharves, Coasts Oceans Ports and Rivers Institute (American Society of Civil Engineers) & Gaythwaite J.W., American Society of Civil Engineers, 2014.
- Port of Long Beach Wharf Design Criteria, Version 5.0, 2021
- California Building Code Chapter 31F [SLC], Marine Oil Terminals, 2016.
- PIANC MarCom WG 9 – Development of Modern Marine Terminals, 1987

3.3. Other Information

The following documents related to vessels currently berthing at or anticipated to berth at PCT were reviewed:

- Assessment of Ultra Large Container Ships (ULCS) in the Blair Waterway, File No: TSIR 1301, October 2013, Puget Sound Pilots
- Washington United Terminals (WUT) Fender Replacement Study, December 30, 2016, BergerABAM

- Tacoma Harbor Navigation Improvement Study, Final Integrated Feasibility Report and Environmental Assessment, June 2022, US Army Corps of Engineers
- General Guidelines for Vessels Transiting Restricted Waterways or Ports, July 26, 2023, Puget Sound Pilots

4. Existing Bollards

4.1. Bollards at PCT

Table 1 summarizes the stated capacities of the existing bollards indicated in the record drawings listed in Section 3.1. The record drawings indicate that the berth was designed for 8,800 TEU and 14,000 TEU vessels. The existing bollard capacities have not been independently verified.

Table 1: PCT Bollard Capacities

Bollard Location	Stated Capacity kips
Typical Bollard Along Face of Wharf	125
East Mooring Dolphin	350
West Mooring Dolphin	150

Figure 1 shows the detail of the typical existing mooring bollard along the face of the wharf, Figure 2 shows the detail of the east mooring dolphin bollard detail, and Figure 3 shows the plan view of the west mooring dolphin. All mooring bollards are pipe bollards filled with concrete.

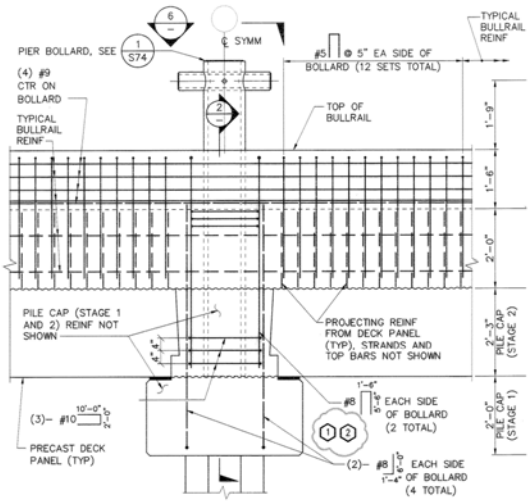

Figure 1 - Typical Bollard Along Face of Wharf Detail

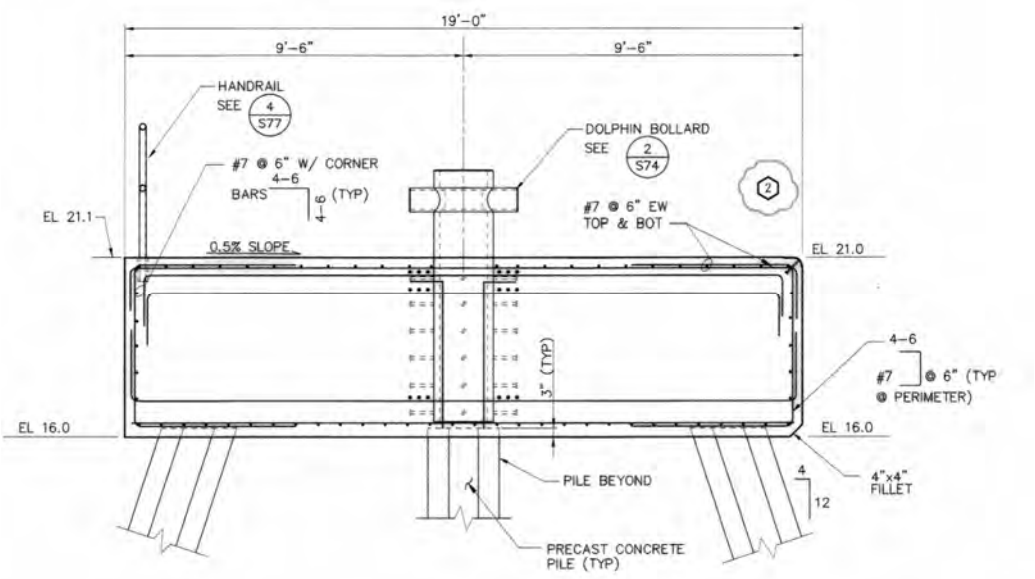

Figure 2 - East Mooring Dolphin Bollard Detail

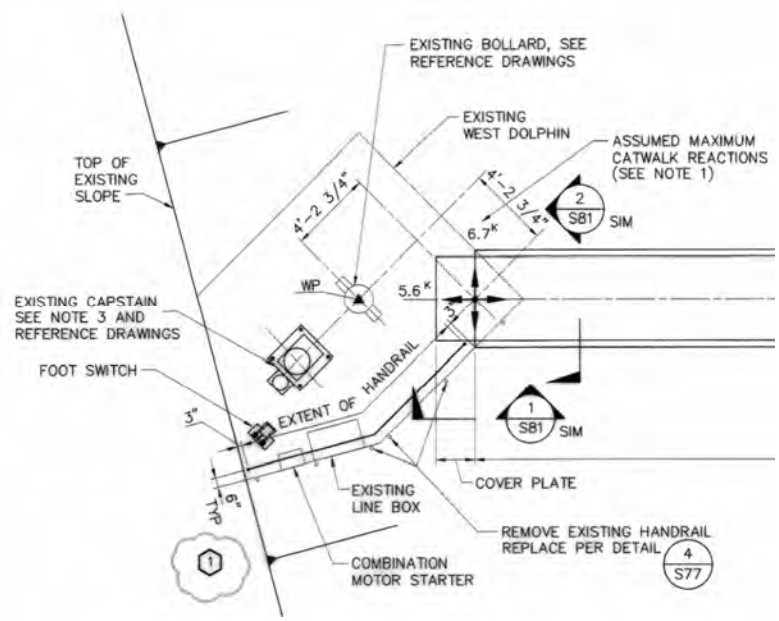

Figure 3 - West Mooring Dolphin

4.2. Bollards at Nearby Terminals

The bollard capacities at other terminals in the area were reviewed and compared to PCT. Table 2 summarizes stated bollard capacities at three other terminals along the Blair Waterway in Tacoma and Terminal 5 (T5) in Seattle. Bollard capacities at Washington United Terminals (WUT) and East Blair One (EB1) are similar to PCT, while Husky and T5 bollards have higher stated capacities. Record drawings

indicate that WUT and EB1 were designed for 8,800 TEU and 14,000 TEU vessels and have typical bollard capacities of 125 kips, whereas Husky and T5 were designed for 14,000 TEU and 18,000 TEU vessels and have typical bollard capacities of 200 kips and 441 kips, with 400 kip bollards at the middle and south end where the ends of larger vessels are anticipated to moor.

Table 2: Stated Bollard Capacities at Other Terminals in the Area

Terminal	Bollard Location	Bollard Capacity
WUT	Typical Wharf	125 kips
	North Dolphin	400 kips
	South Dolphin	400 kips
EB1	Typical Wharf	125 kips
	South Dolphin	350 kips
Husky	Typical Wharf	200 kips
	North End of Wharf	300 kips
	South End and Middle of Wharf	400 kips
T5	Typical Wharf	441 kips

4.3. Bollard Capacity Guidelines

The 20,000 TEU and 14,000 TEU vessels have displacements equal to or greater than 200,000 tons. Design of Marine Facilities Engineering for Port and Harbor Structures provides guidelines for bollard capacities based on vessel displacement based on guidelines from the British Standards Institute (BSI) and the German Society for Harbor and Foundation Engineering (EAU). For displacements greater than or equal to 200,000 tons, a bollard capacity of 2,000 kN, or about 450 kips, is recommended.

PIANC MarCom WG 9 also includes bollard capacity guidelines. Due to the age of the report, the recommendations only include vessels with displacements up to 100,000 tons, for which a bollard capacity of 1,000 kN, or about 225 kips, is recommended.

The existing 125-kip bollards at PCT are undersized compared to these guidelines.

5. Vessel Mooring Analysis

Mooring arrangements were developed, and a detailed mooring analysis was performed for vessels currently moored and anticipated to be moored at the berth. The analysis considered one vessel berthed for high and low tide elevations. The vessel sizes and their arrangements used in the analysis were developed from references researched in Section 3 and were reviewed by PCT terminal operators.

The analysis method consisted of a quasi-static approach using the software program OPTIMOOR by Tension Technology International. OPTIMOOR is recognized as a reliable tool for performing quasi-static mooring analysis by UFC 4-159-03 in sections 3-2.6 and 3-3.1.

5.1. OPTIMOOR Inputs

5.1.1. Design Still Water Levels

The elevations in Table 3 are relative to MLLW and are based on the current tidal data epoch from 1983 to 2001. The mooring analysis considered the vessel moored at both MHHW and MLLW tides.

Table 3: Tidal Data at Tacoma NOAA Station 9446484

Datum	Water Level (feet)
MHHW	11.78
MHW	10.9
MLW	2.84
NAVD88	2.39
MLLW	0
Pier Deck Elevation	21.4
Current Depth of Berth	-51

5.1.2. Vessel Characteristics

Two vessel sizes were evaluated in this study to represent those that currently moor or are anticipated to be moored at PCT. The Port provided information for the following vessels used in the analysis:

1. Thalassa Hellas 13,800 TEU Class Container Carrier
2. Imabari Shipbuilding Co General Arrangement 20,000 TEU Type Container Carrier

A summary of the two design vessels is listed below in Table 4.

Table 4: Vessel Characteristics

Vessel Characteristics	Vessel	
	14,000 TEU	**20,000 TEU**
LOA	1209 ft	1312 ft
Breadth	167.3 ft	192.9 ft
Design Draft	47.6 ft	47.6 ft
Windage Area - Transverse	26,599 ft^2	32,915 ft^2
Windage Area - Longitudinal	154,920 ft^2	200,518 ft^2

5.1.3. Berthing Scenarios Considered

Due to the PCT wharf length, it is possible to moor one 14,000 TEU or one 20,000 TEU vessel at a time. The vessels' geometry and mooring arrangements were considered to determine potential berthing scenarios. These potential berthing scenarios were reviewed by the terminal operators and are summarized in Appendix B.

5.1.4. Mooring Line Properties

WUT provided properties for mooring lines for a 14,000 TEU vessel, which were used in all analyses and are listed below in Table 5.

Table 5: Assumed Mooring Line Properties

Line Material	HMPE
Line Diameter	1.8 in
Line Circumference	5.7 in
Strength of Line	135 tons
Tail Material	D-Flex
Tail Diameter	3.9 in
Tail Circumference	12.4 in
Strength of Tail	146 tons

5.2. Mooring Line Arrangements

Mooring line arrangements were developed in OPTIMOOR, evaluated, revised, and iterated to maximize the allowable wind speed for each berthing scenario while keeping the loads on the existing bollards below their listed capacities. A wind rose limit analysis was used to determine the maximum allowable wind speed at which none of the existing bollards exceeded 100% of their listed capacity. Operational limits on vessel displacement were not considered.

The final iteration of the OPTIMOOR analysis for each berthing scenario is attached in Appendix A. Included are the input assumptions described in Section 5.1, the vessel and mooring line arrangements from iterating, the maximum wind speed achieved, and the demand-capacity ratios of the existing bollards. Table 6 summarizes the maximum allowable wind speed for each mooring arrangement considered.

Table 6: Maximum Allowable Wind Speed

Mooring Arrangement	Wind Speed knots
14,000 TEU Vessel	24
20,000 TEU Vessel	21

6. Site-Specific Wind Speed Evaluation

A site-specific wind speed evaluation was conducted using extreme value analysis of historical wind data to determine 25-year return period wind speeds from various compass directions for use in evaluating the adequacy of the existing mooring bollards. Details of this evaluation are included in Appendix C and summarized below.

6.1. Wind Speed Data

Wind speed data used in this evaluation was taken from a National Data Buoy Center database using the anemometer at NOAA station 9446482 at the Port of Tacoma. The available data for this station spans approximately 15 years, commencing from April 2009 and concluding in October 2023, with recordings taken every 6 minutes. This historical data was used to calculate 25-year return period 30-second duration wind speeds in eight sectors.

A 25-year return period for wind speed was selected to be consistent with the recommendations in the ASCE Manual of Practice for mooring transient vessels and with Port of Long Beach Wharf Design Criteria, which references CBC Section 3105 (i.e., MOTEMS).

6.2. Height and Exposure Correction

Coefficients for correction of the height and exposure type were applied to the wind speed data obtained from the recorded data from the NOAA station to translate that information to equivalent wind speeds from different directions at the wharf. The wind speed data was pre-processed into eight equal sectors of direction, as shown in Figure 4. Station data was recorded at 35.7 feet above the water level and 22.3 feet above the land surface. The exposure category for the wind coming from over water is Exposure D, whereas the wind from over the land is Exposure B. The wind speed data was corrected using modification factors from ASCE 7-22 to adjust to Exposure C and a height of 33 feet.

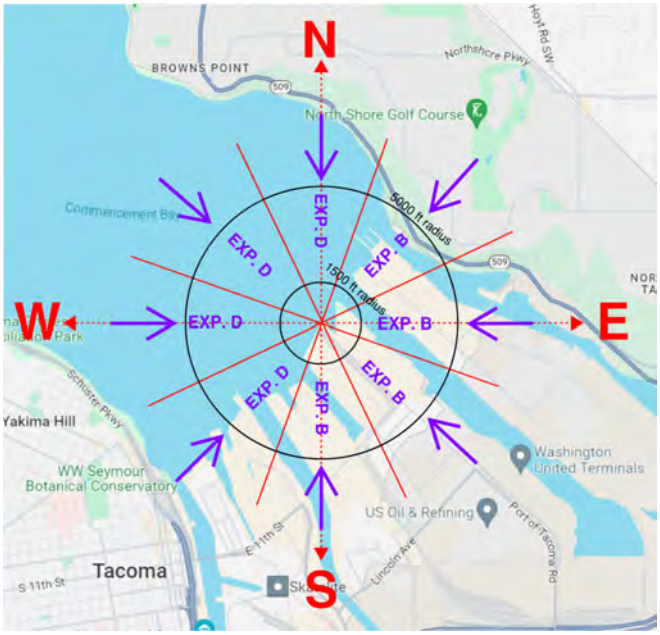

Figure 4: Exposure of Each Sector at the Anemometer Station

Exposure factors were applied to correct for the actual exposure conditions for each sector at PCT, as shown in Figure 5.

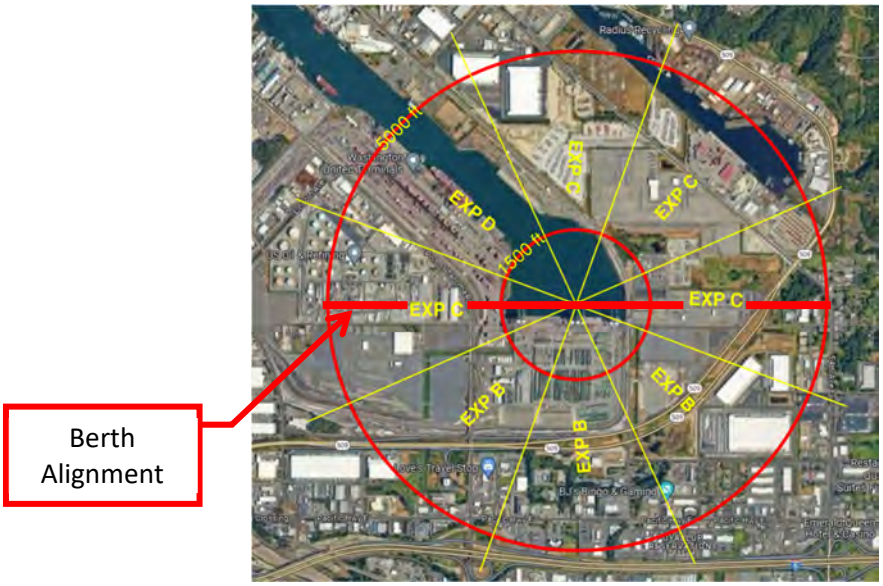

Figure 5: Exposure Type at Each Sector of PCT

6.3. Results

The wind speed rose included in Figure 6 and tabulated numerically in Table 7 summarizes the 25-year return period (25 YRP) 30-second duration wind speed for each sector.

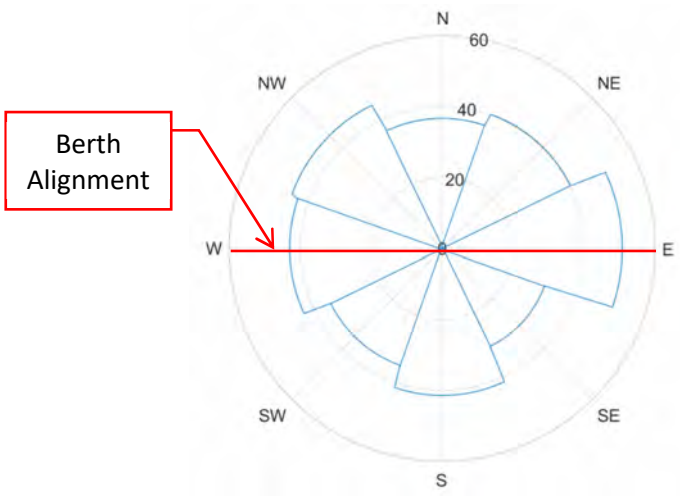

Figure 6: 25-Year Return Period 30-Second Duration Wind Speed Rose (knots)

Table 7: 25 YRP Wind Speed for Each Sector

Sector (Deg)	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335
Exposure	C	C	C	B	B	B	C	D
Z_s	33	33	33	33	33	33	33	33
α	9.8	9.8	9.8	7.5	7.5	7.5	9.8	11.5
Z_g	2460	2460	2460	3280	3280	3280	2460	1935
K_z	1.00	1.00	1.00	0.71	0.71	0.71	1.00	1.19
Modification factor=$(K_{zst})^{0.5}$	**1.00**	**1.00**	**1.00**	**0.84**	**0.84**	**0.84**	**1.00**	**1.09**
Design Wind Speed (m/s)	18.87	20.68	26.08	15.76	21.29	17.99	22.10	23.13
Design Wind Speed (mi/hr)	42.21	46.26	58.35	35.26	47.62	40.25	49.45	51.75
Design Wind Speed (knot)	36.68	40.20	50.70	30.64	41.38	34.98	42.97	44.97

K_z: velocity pressure exposure coefficient at station height z; Z_s: Height for reporting the Design Wind Speed (10m/33ft); α: parameter of calculating K_z (table 26.11-1 ASCE7-22); Z_g: Nominal height of atmospheric boundary layer used in ASCE7-22 (table 26.11-1).

Winds from 110 to 245 degrees blow vessels off the berth and have the most significant impact on bollard loads. Winds from these directions have 25 YRP wind speeds between 30.6 and 41.4 knots.

The maximum allowable wind speed determined for the five berthing scenarios considered in Section 5.2 is 24 knots, which is less than these 25-YRP wind speeds.

6.4. Operational Wind Limit for Cranes

Nearby on the Blair Waterway, WUT has indicated that the container cranes have operational limits corresponding to wind speeds measured by anemometers on the cranes. The cranes are set to sound an alarm at 35 mph, or 30.4 knots, and shut down at 40 mph, or 34.8 knots. The mooring analysis discussed in Section 5 indicates that the existing bollard capacities are exceeded at wind speeds less than those that would cause the cranes to alarm or shut down.

7. Preliminary Bollard Upgrade Evaluation

A preliminary analysis was conducted to determine the required bollard capacities and locations considering the 25-year return period wind speeds from Section 6 and the mooring arrangements from Appendix B. The OPTIMOOR results from the initial vessel mooring analysis in Section 5 were used as a starting point to evaluate which bollards need to be upgraded and to what capacity. Bollard capacities and mooring arrangements were iterated to determine preliminary bollard upgrade locations and capacities. A wind rose limit is provided for each case using the final bollard capacities. The wind limit rose indicates the allowable wind speed from every direction as limited by bollard capacity.

For each proposed mooring condition, a wind limit rose from OPTIMOOR was overlaid and compared with the 25-year return period wind speed rose demands. An example of one configuration is included in Figure 7. The teal line indicates allowable wind speeds (in knots) for winds blowing from each direction for the preliminarily proposed bollard capacities. The red lines indicate the 25-year return period wind speeds for each of the eight sectors (in knots). The teal line is outside the red lines in all directions, indicating that the proposed bollard capacities are adequate.

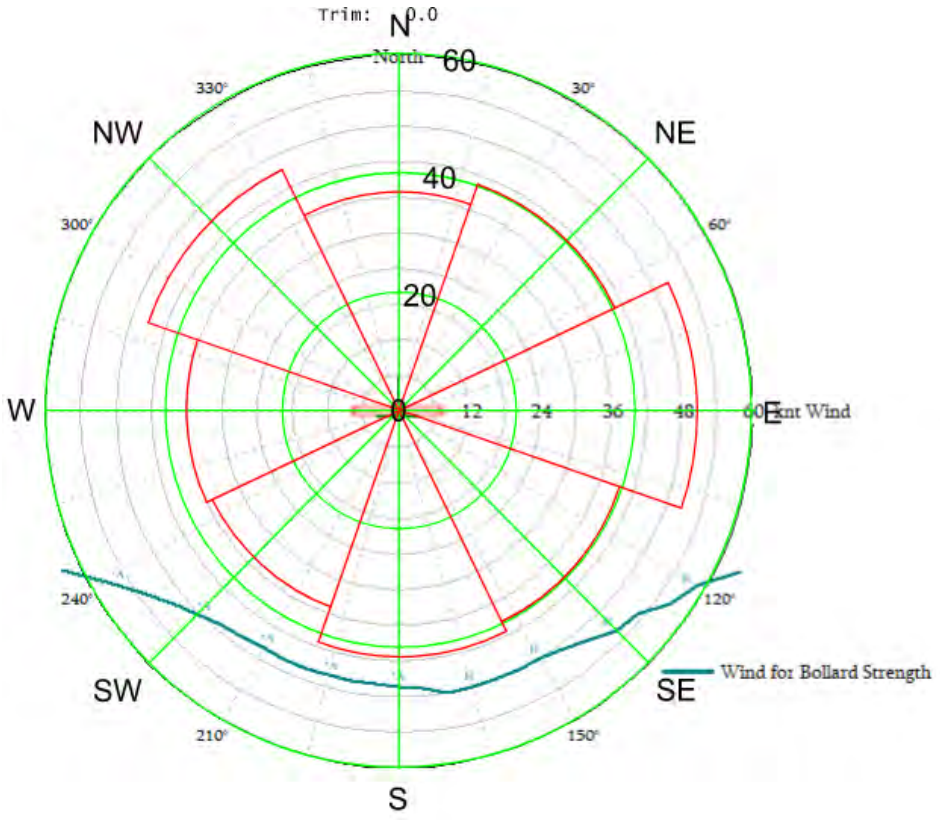

Figure 7 - Wind Rose Demand and Capacity of Bollards

The preliminary analysis found that 10 wharf mooring bollards need to be upgraded to a capacity of 440 kips. Examples of bollards having these capacities are shown in Figure 8.

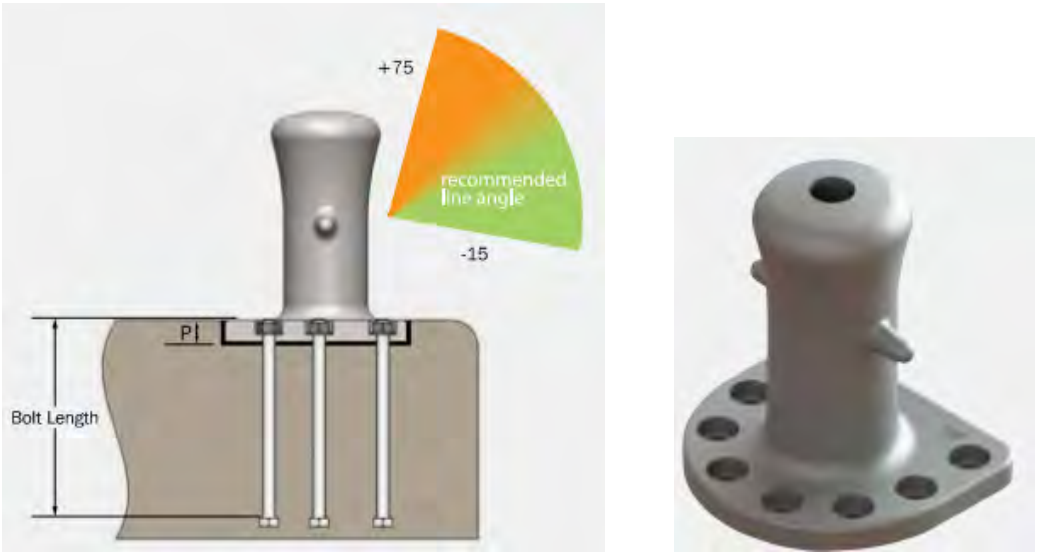

Figure 8 – 440-kip Capacity Single Bitt Bollard

A preliminary rough order of magnitude engineer's cost estimate for upgrading the bollards was prepared. The costs include the demolition of existing bollards and adjacent portions of the wharf, wharf reconstruction and strengthening, furnishing and installing new bollards, and existing fender removal and reinstallation where there are conflicts. It is assumed that the required wharf strengthening is limited to bullrail, deck, and pile cap modifications and that no additional piles are required. Based on our preliminary analysis, a rough order of magnitude engineer's estimate to upgrade these 10 mooring bollards is $3,657,700. Appendix F has a breakdown for the rough order of magnitude engineer's estimate.

8. Conclusions and Recommendations

8.1. Summary of Analysis

Background information was gathered and reviewed, site-specific design wind speed was evaluated, and vessel mooring analysis was completed to evaluate the capacity of the existing mooring bollards to safely moor the vessels that are berthing or anticipated to berth at PCT.

A preliminary analysis was then conducted to determine the required bollard capacities and locations considering the 25-year return period wind speeds from Section 6 and the mooring arrangements from Appendix B. For each proposed mooring condition, a wind limit rose from OPTIMOOR was overlaid and compared with the 25-year return period wind speed rose demands.

8.2. Conclusions

Comparisons to other berths in the area and industry guidelines, as well as mooring analysis, all indicate that the existing 125-kip bollards are undersized for 14,000 and 20,000 TEU vessels.

Other berths in the area serving vessels of similar size have bollard capacities ranging from 200 to 441 kips. Industry guidelines recommend bollard capacities in the range of 450 kips.

The maximum allowable wind speeds for all berthing arrangements considered in the mooring analysis ranged from 21 to 24 knots. From the site-specific wind speed evaluation, the maximum 30-second design wind speed with a 25-year return period was found to range from 30.6 and 41.4 knots, blowing off the berth. In all arrangements, the 25-year return period wind speed is higher than the wind speed at which mooring loads exceed bollard capacities.

By overlaying and comparing the wind limit roses from OPTIMOOR with the 25-year return period wind speed rose demands for all mooring conditions in the preliminary bollard upgrade evaluation, it was found that 10 of the existing bollards need to be upgraded from their current 125-kip capacity.

8.3. Recommendations

Some of the existing bollards should be upgraded to accommodate mooring 14,000 and 20,000 TEU vessels at PCT. The preliminary analysis found that 10 wharf mooring bollards need to be upgraded to a capacity of 440 kip. Based on this preliminary analysis, a rough order of magnitude engineer's estimate to upgrade these 10 mooring bollards is $3,657,700.

If 14,000 and 20,000 TEU vessels are to berth at PCT before upgrading the bollard capacities, a plan should be implemented to monitor wind speed or bollard loads such that the vessel departs from the berth before existing bollard capacities are exceeded.

Prepared by:

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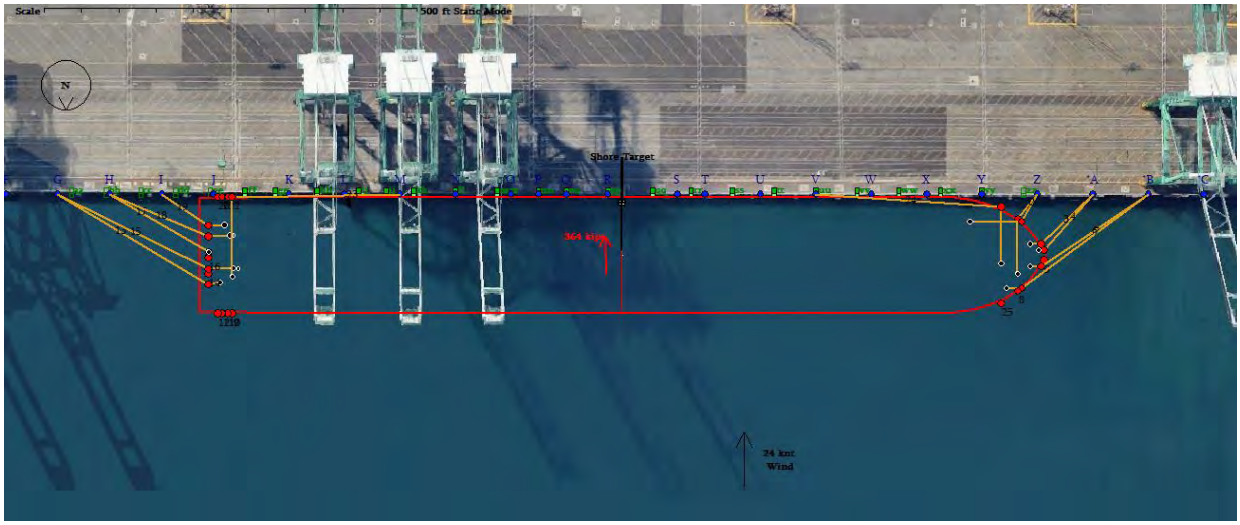
APPENDIX A: OPTIMOOR ANALYSIS

kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 14,000 TEU - MHHW

Arrangement for Thalassa Hellas at POT-PCT



Vessel Data for Thalassa Hellas

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\Thalassa Hellas.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

LBP:1154.9
Breadth: 167.3
Depth: 97.9
Port Target: 0.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 18183 above deck level
Side projected windage area: 96828 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour — Longitudinal datum at Midship

X-dist	-583.0	571.4
Depth	97.9	97.9

Midship Area

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	571.4	51.9	0.0	78.6	350	20	5.7 pe 298	433 12.4 pp 322
2	576.8	47.8	0.0	74.3	350	20	5.7 pe 298	433 12.4 pp 322
3	605.4	16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
4	609.3	7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
5	609.3	-7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
6	605.4	-16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
7	576.8	-47.8	0.0	21.3	350	20	5.7 pe 298	433 12.4 pp 322
8	571.4	-51.9	0.0	24.5	350	20	5.7 pe 298	433 12.4 pp 322
9	-562.2	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
10	-568.7	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
11	-576.6	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
12	-583.0	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
13	-596.8	-42.0	0.0	17.5	350	20	5.7 pe 298	433 12.4 pp 322
14	-596.8	-26.6	0.0	39.8	350	20	5.7 pe 298	433 12.4 pp 322
15	-596.8	-19.8	0.0	50.6	350	20	5.7 pe 298	433 12.4 pp 322
16	-596.8	-4.1	0.0	0.0	350	20	5.7 pe 298	433 12.4 pp 322
17	-596.4	4.9	0.0	0.0	350	20	5.7 pe 298	433 12.4 pp 322

18	-596.8	26.9	0.0	39.7	350	20	5.7	pe	298	433	12.4	pp	322
19	-596.8	42.3	0.0	23.4	350	20	5.7	pe	298	433	12.4	pp	322
20	-583.0	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
21	-576.6	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
22	-568.7	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
23	-562.2	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
24	547.7	69.4	0.0	81.5	350	20	5.7	pe	298	433	12.4	pp	322
25	547.7	-69.4	0.0	51.1	350	20	5.7	pe	298	433	12.4	pp	322

Codes for Types of Line:
pe: polyester (broken-in)
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\PCT.bth)
Units in ft & kips
Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1279.6	38.7	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	125
F	-889.0	4.0	1.5	125
G	-814.0	4.0	1.5	125
H	-739.0	4.0	1.5	125
I	-664.0	4.0	1.5	125
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	125
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	125
*A	680.0	4.0	1.5	125
*B	760.0	4.0	1.5	125
*C	840.0	4.0	1.5	125
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1198.8	81.2	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft^2)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3

cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3
ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips

	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for Thalassa Hellas at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 11.78 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 15.2
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 39.9 above Pier
Wind Speed: 24 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 26599
Total Side Windage Area:154920

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	0.62 (fwd)	0.07 (inw)	0.6° (port)	0.00 (up)
at its Port Target	-4.31 (aft)	-5.18 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	Worst Direction True	Line Tension	Percent Strength
1-Z	1.51	136.8			-95°	175°	54.8	18%
2-Z	1.47	132.8			-95°	175°	45.8	15%
3-*A	1.34	124.9			-95°	175°	65.9	22%
4-*A	1.28	119.7			-90°	180°	59.4	20%
6-*B	2.37	203.7			-95°	175°	47.6	16%
7-*B	2.97	249.4			-95°	175°	39.3	13%
13-G	3.47	269.9			-110°	160°	51.4	17%
15-G	3.78	292.2			-110°	160°	39.5	13%
17-H	2.02	167.3			-110°	160°	68.8	23%

18-H	2.44	196.6		-120°	150°	39.1	13%
19-I	1.24	111.9		-105°	165°	124.0	42%
23-M	4.32	355.3		-100°	170°	50.7	17%
24-V	4.58	348.0		150°	60°	24.9	8%

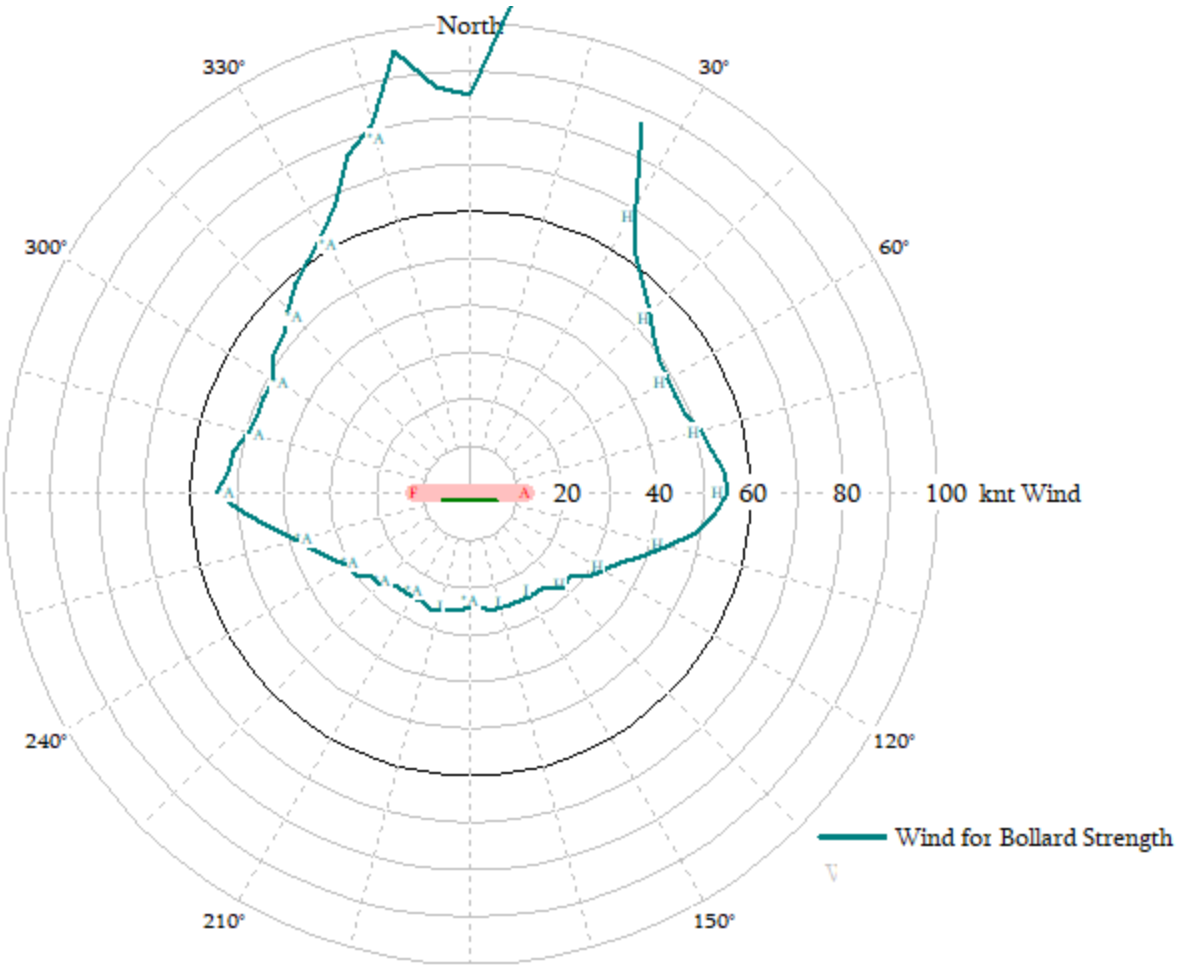
Fender	Thrust	Compression	Pressure	Flatside Cover
ff	25	0.07	0.8	100%
gg	25	0.07	0.8	100%
hh	24	0.07	0.8	100%
ii	24	0.07	0.8	100%
jj	24	0.07	0.8	100%
kk	23	0.07	0.8	100%
ll	23	0.07	0.7	100%
mm	23	0.07	0.8	100%
nn	24	0.07	0.8	100%
oo	24	0.07	0.8	100%
pp	25	0.07	0.8	100%
qq	26	0.07	0.8	100%
rr	28	0.08	0.9	100%
ss	29	0.08	0.9	100%
tt	31	0.09	1.0	100%
uu	33	0.09	1.1	100%
vv	35	0.10	1.1	100%
ww	37	0.10	1.2	100%
xx	39	0.11	1.3	100%
yy	41	0.12	1.3	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
G	76.6	46.7			90.8	73%	59°	13.7
H	88.9	54.6			107.2	86%	58°	24.5
I	84.6	75.1			124.0	99%	48°	51.1
M	-50.0	3.0			50.7	41%	-87°	7.8
V	24.6	1.7			24.9	20%	86°	3.5
Z	-49.5	60.7			100.4	80%	-39°	62.8
*A	-84.3	82.4			**125.2**	**100%**	-46°	42.3
*B	-70.5	48.2			86.9	70%	-56°	16.0

Approximate natural periods
Surge: 115 Sway: 75 Roll: 80 secs

Wind Capability Rose for Thalassa Hellas at POT-PCT

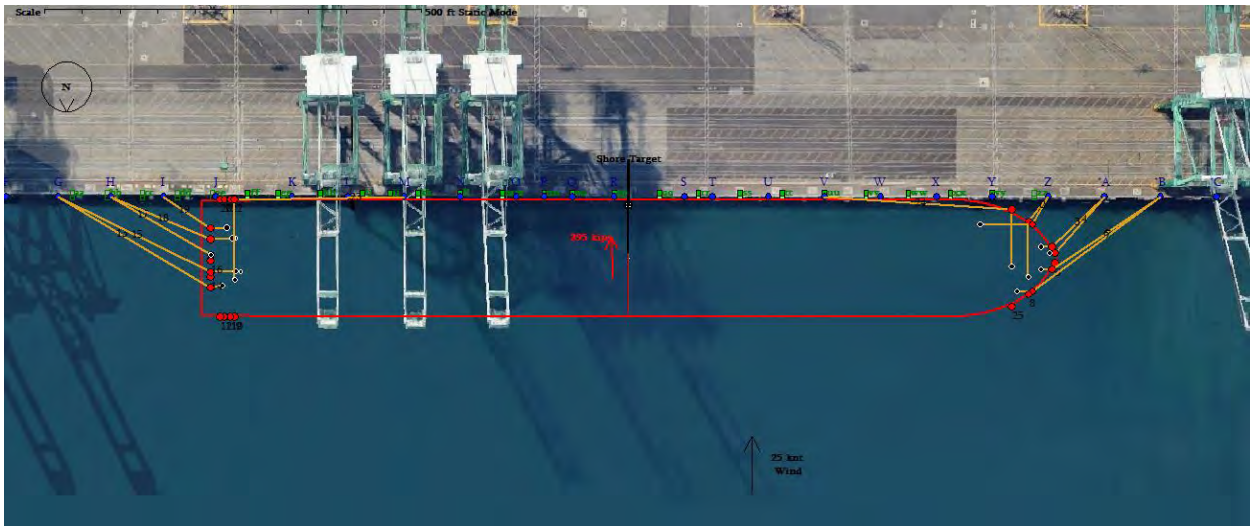
Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 11.78 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 14,000 TEU - MLLW

Arrangement for Thalassa Hellas at POT-PCT



Vessel Data for Thalassa Hellas

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\Thalassa Hellas.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

LBP:1154.9
Breadth: 167.3
Depth: 97.9
Port Target: 0.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 18183 above deck level
Side projected windage area: 96828 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour — Longitudinal datum at Midship

X-dist	-583.0	571.4
Depth	97.9	97.9

Midship Area

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	571.4	51.9	0.0	78.6	350	20	5.7 pe 298	433 12.4 pp 322
2	576.8	47.8	0.0	74.3	350	20	5.7 pe 298	433 12.4 pp 322
3	605.4	16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
4	609.3	7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
5	609.3	-7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
6	605.4	-16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
7	576.8	-47.8	0.0	21.3	350	20	5.7 pe 298	433 12.4 pp 322
8	571.4	-51.9	0.0	24.5	350	20	5.7 pe 298	433 12.4 pp 322
9	-562.2	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
10	-568.7	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
11	-576.6	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
12	-583.0	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
13	-596.8	-42.0	0.0	17.5	350	20	5.7 pe 298	433 12.4 pp 322
14	-596.8	-26.6	0.0	39.8	350	20	5.7 pe 298	433 12.4 pp 322
15	-596.8	-19.8	0.0	50.6	350	20	5.7 pe 298	433 12.4 pp 322
16	-596.8	-4.1	0.0	0.0	350	20	5.7 pe 298	433 12.4 pp 322
17	-596.4	4.9	0.0	0.0	350	20	5.7 pe 298	433 12.4 pp 322

18	-596.8	26.9	0.0	39.7	350	20	5.7	pe	298	433	12.4	pp	322
19	-596.8	42.3	0.0	23.4	350	20	5.7	pe	298	433	12.4	pp	322
20	-583.0	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
21	-576.6	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
22	-568.7	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
23	-562.2	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
24	547.7	69.4	0.0	81.5	350	20	5.7	pe	298	433	12.4	pp	322
25	547.7	-69.4	0.0	51.1	350	20	5.7	pe	298	433	12.4	pp	322

Codes for Types of Line:
pe: polyester (broken-in)
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\PCT.bth)
Units in ft & kips
Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1279.6	38.7	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	125
F	-889.0	4.0	1.5	125
G	-814.0	4.0	1.5	125
H	-739.0	4.0	1.5	125
I	-664.0	4.0	1.5	125
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	125
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	125
*A	680.0	4.0	1.5	125
*B	760.0	4.0	1.5	125
*C	840.0	4.0	1.5	125
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1198.8	81.2	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft^2)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3

cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3
ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips

	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for Thalassa Hellas at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\2 PCT (14,000 TEU) - MIDDLE\PCT.opt)

Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 0.00 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 3.4
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 28.1 above Pier
Wind Speed: 25 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 26599
Total Side Windage Area:154920

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	0.68 (fwd)	0.08 (inw)	0.5° (port)	0.00 (up)
at its Port Target	-3.92 (aft)	-4.71 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-Z	1.43	130.1			-95°	175°	57.3	19%
2-Z	1.38	126.2			-90°	180°	47.4	16%
3-*A	1.31	121.4			-90°	180°	63.6	21%
4-*A	1.24	116.3			-90°	180°	57.3	19%
6-*B	2.36	201.7			-95°	175°	45.1	15%
7-*B	2.97	247.7			-90°	180°	37.5	13%
13-G	3.42	268.4			-110°	160°	48.7	16%
15-G	3.73	290.7			-115°	155°	37.9	13%
17-H	1.98	165.1			-110°	160°	65.3	22%

18-H	2.38	194.2		-120°	150°	37.9	13%
19-I	1.17	107.6		-105°	165°	123.6	41%
23-M	4.34	353.7		-100°	170°	48.0	16%
24-V	4.52	346.6		150°	60°	25.0	8%

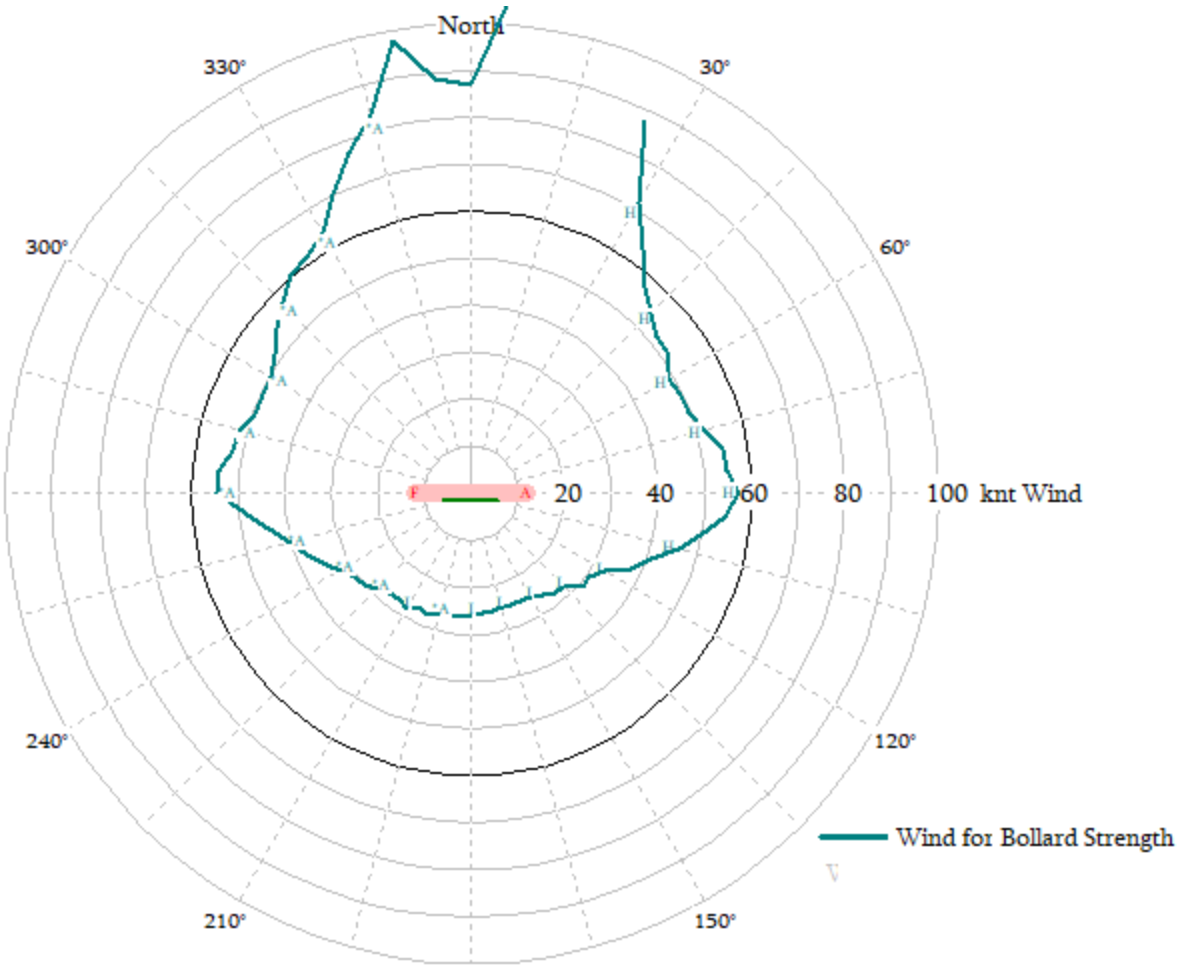
Fender	Thrust	Compression	Pressure	Flatside Cover
ff	27	0.08	0.9	100%
gg	27	0.08	0.9	100%
hh	26	0.07	0.8	100%
ii	26	0.07	0.8	100%
jj	25	0.07	0.8	100%
kk	25	0.07	0.8	100%
ll	25	0.07	0.8	100%
mm	25	0.07	0.8	100%
nn	25	0.07	0.8	100%
oo	26	0.07	0.8	100%
pp	26	0.07	0.9	100%
qq	28	0.08	0.9	100%
rr	30	0.08	1.0	100%
ss	32	0.09	1.0	100%
tt	33	0.09	1.1	100%
uu	35	0.10	1.1	100%
vv	38	0.11	1.2	100%
ww	40	0.11	1.3	100%
xx	42	0.12	1.4	100%
yy	44	0.13	1.4	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
G	73.6	44.5			86.5	69%	59°	9.1
H	86.5	52.3			102.4	82%	59°	16.5
I	89.1	77.4			123.6	99%	49°	37.1
M	-47.7	2.7			48.0	38%	-87°	5.1
V	24.9	1.7			25.0	20%	86°	2.5
Z	-57.3	71.0			104.5	84%	-39°	51.0
*A	-83.5	82.1			120.7	97%	-45°	29.2
*B	-67.6	46.3			82.6	66%	-56°	10.6

Approximate natural periods
Surge: 111 Sway: 95 Roll: 80 secs

Wind Capability Rose for Thalassa Hellas at POT-PCT

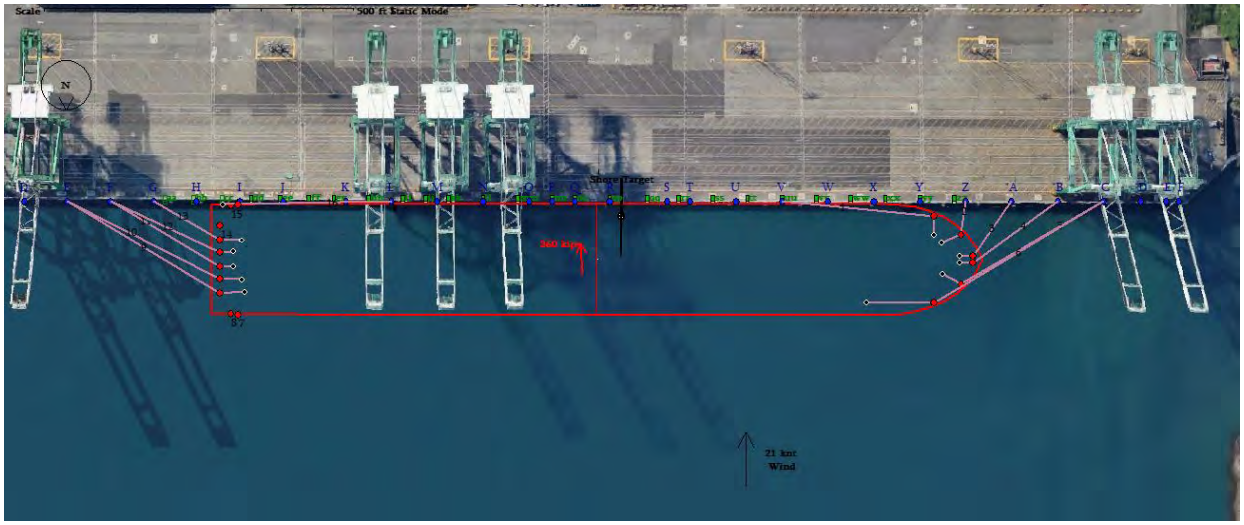
Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 0.00 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 20,000 TEU - MHHW

Arrangement for 20,000 TEU vessel at POT-PCT



Vessel Data for 20,000 TEU vessel

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\20,000 TEU Vessel.vsl)

Units in ft, inches, & kips

Longitudinal datum at Midship

LBP:1270.0
Breadth: 192.9
Depth: 107.9
Port Target: 43.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 21283 above deck level
Side projected windage area:123937 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour	Longitudinal datum at Midship	
X-dist	-641.1	628.3
Depth	107.9	107.9

Midship Area

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	587.6	75.0	0.0	32.5	350	1.2	18.1 pp 384	
2	634.7	43.0	0.0	37.2	350	1.2	18.1 pp 384	
3	656.0	5.6	0.0	23.8	350	1.2	18.1 pp 384	
4	656.0	-5.6	0.0	23.8	350	1.2	18.1 pp 384	
5	634.7	-43.0	0.0	37.2	350	1.2	18.1 pp 384	
6	587.6	-75.0	0.0	117.6	350	1.2	18.1 pp 384	
7	-624.5	-95.8	22.0	26.0	350	1.2	18.1 pp 384	
8	-636.7	-94.1	22.0	17.0	350	1.2	18.1 pp 384	
9	-655.1	-58.6	22.0	42.3	350	1.2	18.1 pp 384	
10	-655.1	-34.1	22.0	37.6	350	1.2	18.1 pp 384	
11	-655.1	-12.7	22.0	22.5	350	1.2	18.1 pp 384	
12	-655.1	12.7	22.0	22.5	350	1.2	18.1 pp 384	
13	-655.1	34.1	22.0	37.6	350	1.2	18.1 pp 384	
14	-655.1	58.6	22.0	42.3	350	1.2	18.1 pp 384	
15	-636.7	94.1	22.0	17.0	350	1.2	18.1 pp 384	
16	-624.5	95.8	22.0	26.0	350	1.2	18.1 pp 384	

Codes for Types of Line:
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\PCT.bth)

Units in ft & kips

Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1277.4	39.6	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	125
F	-889.0	4.0	1.5	125
G	-814.0	4.0	1.5	125
H	-739.0	4.0	1.5	125
I	-664.0	4.0	1.5	125
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	125
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	125
*A	680.0	4.0	1.5	125
*B	760.0	4.0	1.5	125
*C	840.0	4.0	1.5	125
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1193.1	82.3	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3

ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips

	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for 20,000 TEU vessel at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 11.78 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 15.2
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 49.9 above Pier
Wind Speed: 21 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 32915
Total Side Windage Area:200518

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	2.22 (fwd)	0.05 (inw)	1.0° (port)	0.00 (up)
at its Port Target	-7.74 (aft)	-11.6 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-V	0.24	302.5			150°	60°	13.9	4%
2-Z	0.08	112.7			-70°	200°	66.3	17%
3-*A	0.10	149.5			-70°	200°	87.1	23%
4-*B	0.13	211.3			-90°	180°	69.1	18%
5-*C	0.20	327.8			-95°	175°	38.4	10%
6-*C	0.28	464.3			-95°	175°	24.5	6%
9-E	0.28	359.8			-110°	160°	51.8	13%
10-E	0.27	343.5			-110°	160°	39.1	10%
11-F	0.20	255.1			-110°	160°	73.8	19%
12-F	0.19	243.9			-110°	160°	45.7	12%
13-G	0.14	188.4			-110°	160°	96.6	25%
16-L	0.18	302.5			-100°	170°	75.4	20%

Fender	Thrust	Compression	Pressure	Flatside Cover
dd	22	0.06	0.7	100%
ee	21	0.06	0.7	100%
ff	20	0.06	0.7	100%
gg	20	0.06	0.6	100%

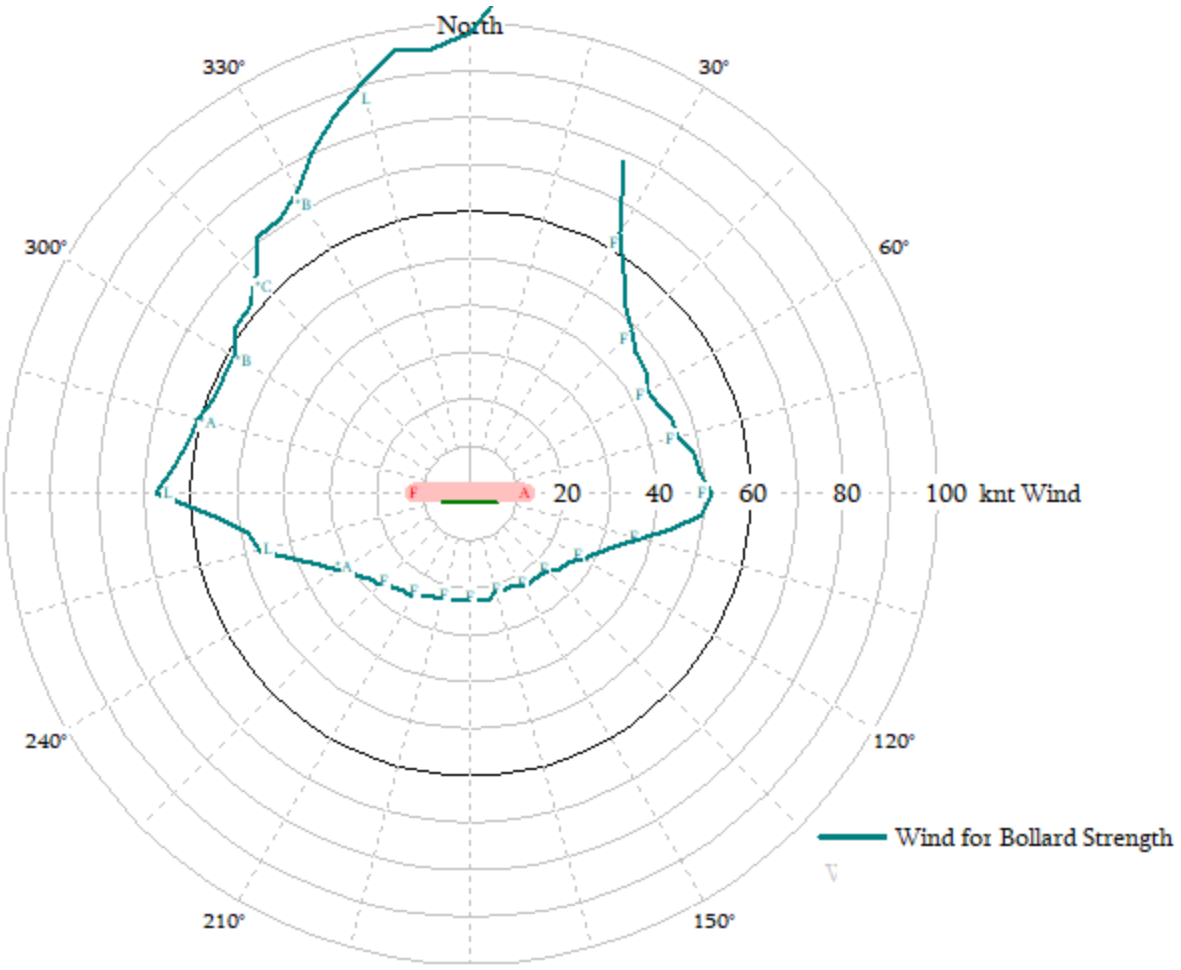
hh	19	0.05	0.6	100%
ii	19	0.05	0.6	100%
jj	18	0.05	0.6	100%
kk	18	0.05	0.6	100%
ll	17	0.05	0.5	100%
mm	16	0.05	0.5	100%
nn	16	0.05	0.5	100%
oo	16	0.05	0.5	100%
pp	16	0.05	0.5	100%
qq	17	0.05	0.5	100%
rr	18	0.05	0.6	100%
ss	18	0.05	0.6	100%
tt	19	0.05	0.6	100%
uu	20	0.06	0.6	100%
vv	20	0.06	0.7	100%
ww	21	0.06	0.7	100%
xx	22	0.06	0.7	100%
yy	23	0.07	0.7	100%
zz	26	0.07	1.1	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
E	74.1	48.7			90.9	73%	57°	20.0
F	94.1	64.1			119.4	96%	56°	35.8
G	66.9	54.7			96.6	77%	51°	43.1
L	-72.7	7.2			75.4	60%	-84°	18.6
V	13.6	1.3			13.9	11%	85°	2.5
Z	-12.3	50.7			66.3	53%	-14°	40.8
*A	-48.5	64.8			87.1	70%	-37°	32.3
*B	-54.7	38.4			69.1	55%	-55°	17.3
*C	-53.7	31.1			62.8	50%	-60°	9.6

Approximate natural periods
Surge: 182 Sway: 79 Roll: 91 secs

Wind Capability Rose for 20,000 TEU vessel at POT-PCT

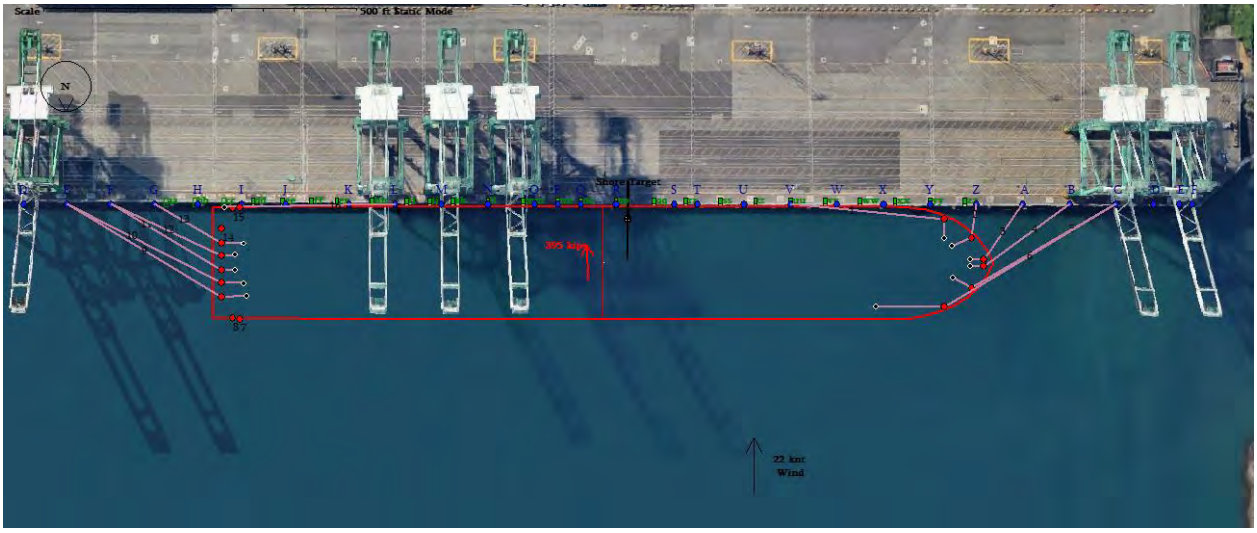
Analysis for Time: 1319 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 11.78 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 20,000 TEU - MLLW

Arrangement for 20,000 TEU vessel at POT-PCT



Vessel Data for 20,000 TEU vessel

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\20,000 TEU Vessel.vsl)

Units in ft, inches, & kips

Longitudinal datum at Midship

LBP:1270.0
Breadth: 192.9
Depth: 107.9
Port Target: 43.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 21283 above deck level
Side projected windage area:123937 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour		Longitudinal datum at Midship
X-dist	-641.1	628.3
Depth	107.9	107.9

Midship Area

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	587.6	75.0	0.0	32.5	350	1.2	18.1 pp 384	
2	634.7	43.0	0.0	37.2	350	1.2	18.1 pp 384	
3	656.0	5.6	0.0	23.8	350	1.2	18.1 pp 384	
4	656.0	-5.6	0.0	23.8	350	1.2	18.1 pp 384	
5	634.7	-43.0	0.0	37.2	350	1.2	18.1 pp 384	
6	587.6	-75.0	0.0	117.6	350	1.2	18.1 pp 384	
7	-624.5	-95.8	22.0	26.0	350	1.2	18.1 pp 384	
8	-636.7	-94.1	22.0	17.0	350	1.2	18.1 pp 384	
9	-655.1	-58.6	22.0	42.3	350	1.2	18.1 pp 384	
10	-655.1	-34.1	22.0	37.6	350	1.2	18.1 pp 384	
11	-655.1	-12.7	22.0	22.5	350	1.2	18.1 pp 384	
12	-655.1	12.7	22.0	22.5	350	1.2	18.1 pp 384	
13	-655.1	34.1	22.0	37.6	350	1.2	18.1 pp 384	
14	-655.1	58.6	22.0	42.3	350	1.2	18.1 pp 384	
15	-636.7	94.1	22.0	17.0	350	1.2	18.1 pp 384	
16	-624.5	95.8	22.0	26.0	350	1.2	18.1 pp 384	

Codes for Types of Line:
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\PCT.bth)

Units in ft & kips

Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1277.4	39.6	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	125
F	-889.0	4.0	1.5	125
G	-814.0	4.0	1.5	125
H	-739.0	4.0	1.5	125
I	-664.0	4.0	1.5	125
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	125
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	125
*A	680.0	4.0	1.5	125
*B	760.0	4.0	1.5	125
*C	840.0	4.0	1.5	125
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1193.1	82.3	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3

ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips

	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for 20,000 TEU vessel at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR\4 PCT (20,000 TEU) - MIDDLE\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 0.00 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 3.4
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 38.2 above Pier
Wind Speed: 22 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 32915
Total Side Windage Area:200518

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	2.35 (fwd)	0.05 (inw)	1.0° (port)	0.00 (up)
at its Port Target	-7.82 (aft)	-11.1 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-V	0.23	300.6			150°	60°	14.8	4%
2-Z	0.07	105.8			-70°	200°	65.5	17%
3-*A	0.09	145.5			-70°	200°	84.3	22%
4-*B	0.13	208.6			-90°	180°	67.9	18%
5-*C	0.20	326.1			-95°	175°	37.4	10%
6-*C	0.28	462.8			-90°	180°	23.6	6%
9-E	0.27	357.4			-110°	160°	50.5	13%
10-E	0.26	341.1			-110°	160°	37.8	10%
11-F	0.19	251.8			-110°	160°	72.9	19%
12-F	0.19	240.4			-115°	155°	44.5	12%
13-G	0.14	183.3			-110°	160°	99.2	26%
16-L	0.18	299.7			-100°	170°	77.7	20%

Fender	Thrust	Compression	Pressure	Flatside Cover
dd	24	0.07	0.8	100%
ee	23	0.07	0.7	100%
ff	22	0.06	0.7	100%
gg	22	0.06	0.7	100%

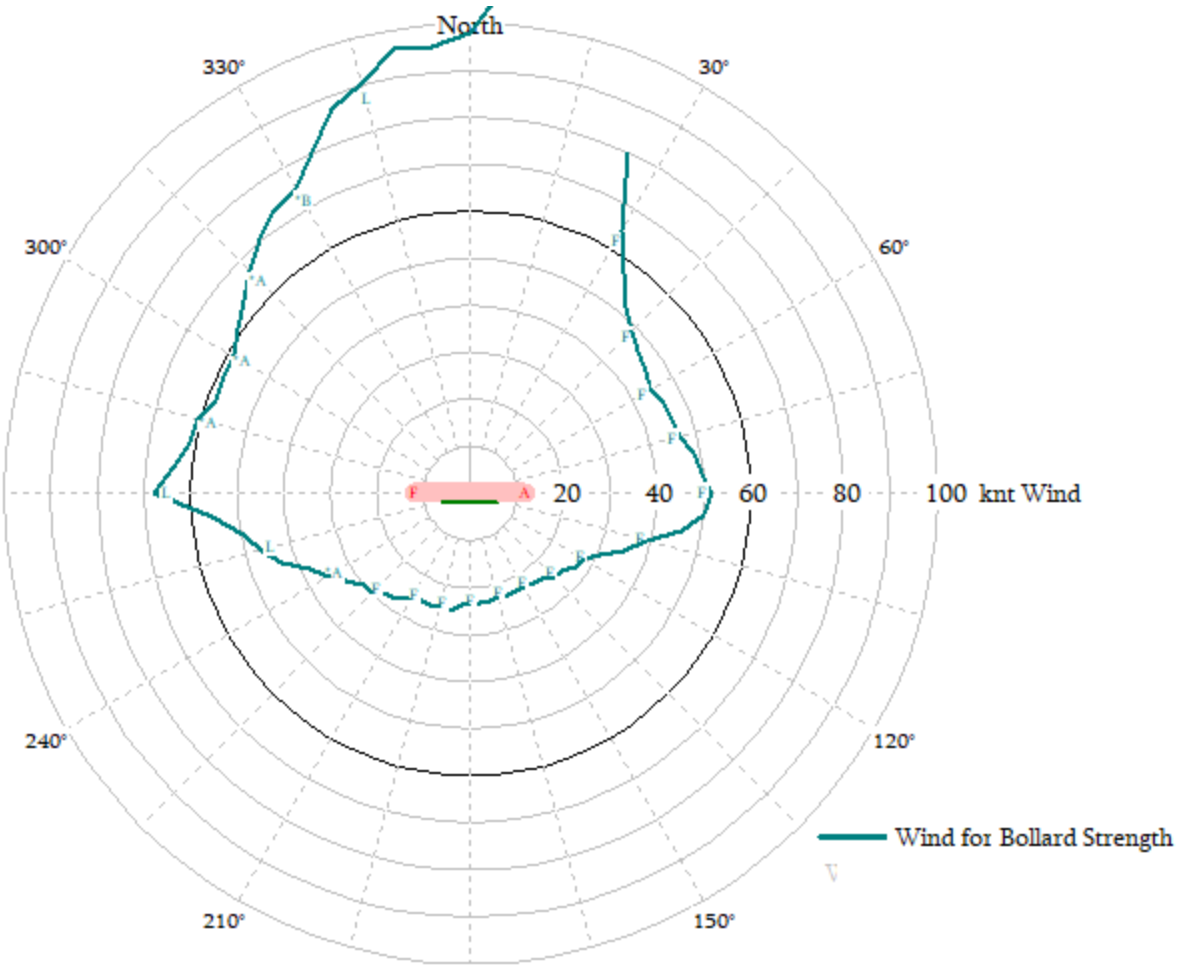
hh	21	0.06	0.7	100%
ii	20	0.06	0.7	100%
jj	20	0.06	0.6	100%
kk	19	0.05	0.6	100%
ll	19	0.05	0.6	100%
mm	18	0.05	0.6	100%
nn	18	0.05	0.6	100%
oo	18	0.05	0.6	100%
pp	18	0.05	0.6	100%
qq	19	0.05	0.6	100%
rr	19	0.05	0.6	100%
ss	20	0.06	0.6	100%
tt	21	0.06	0.7	100%
uu	22	0.06	0.7	100%
vv	23	0.06	0.7	100%
ww	23	0.07	0.8	100%
xx	24	0.07	0.8	100%
yy	25	0.07	0.8	100%
zz	29	0.08	1.2	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
E	72.6	47.6			88.3	71%	57°	16.3
F	93.8	63.7			117.2	94%	56°	29.7
G	71.0	57.8			99.2	79%	51°	38.1
L	-75.6	7.4			77.7	62%	-84°	16.1
V	14.6	1.4			14.8	12%	85°	2.0
Z	-13.5	54.6			65.5	52%	-14°	33.6
*A	-48.6	64.4			84.3	67%	-37°	24.4
*B	-54.6	38.1			67.9	54%	-55°	13.0
*C	-52.4	30.3			60.9	49%	-60°	7.1

Approximate natural periods
Surge: 178 Sway: 101 Roll: 91 secs

Wind Capability Rose for 20,000 TEU vessel at POT-PCT

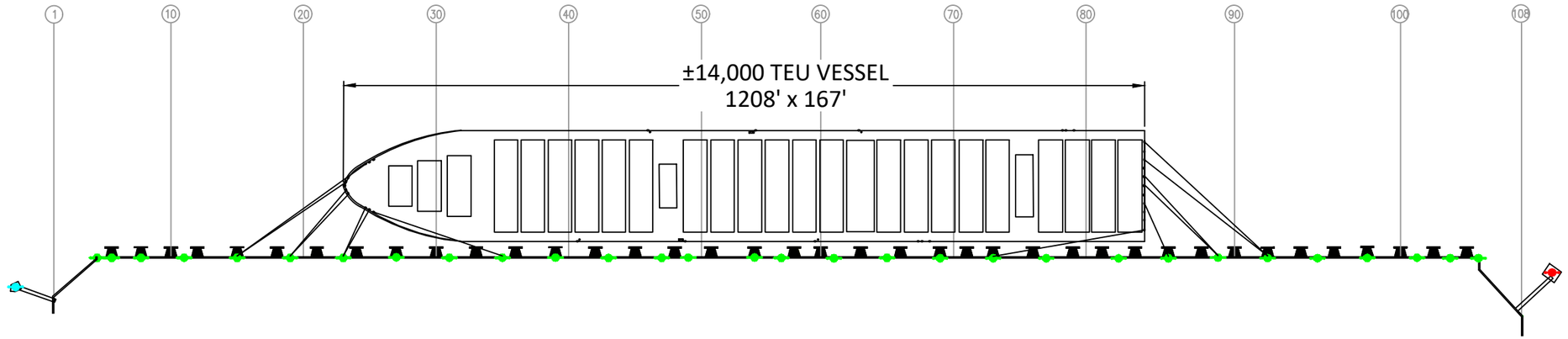
Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 0.00 above datum
Draft: 47.6
Trim: 0.0

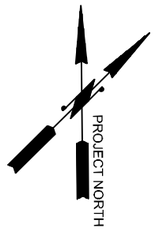


APPENDIX B: MOORING ARRANGEMENTS EVALUATED

NOTE

1. EXISTING BOLLARD CAPACITY IS EXCEEDED FOR WIND SPEEDS ABOVE 24 KNOTS.





PCT - 14,000 TEU MOORING PLAN

SCALE: 1/16" = 1'-0"

LEGEND:

- FENDER UNIT
- EXISTING 125 KIP PIER BOLLARD
- EXISTING 150 KIP WEST DOLPHIN BOLLARD
- EXISTING 350 KIP EAST DOLPHIN BOLLARD

kpff
2407 North 31st Street, Suite 100
Tacoma, Washington 984087
(253) 386-0150 Fax (253) 396-0162

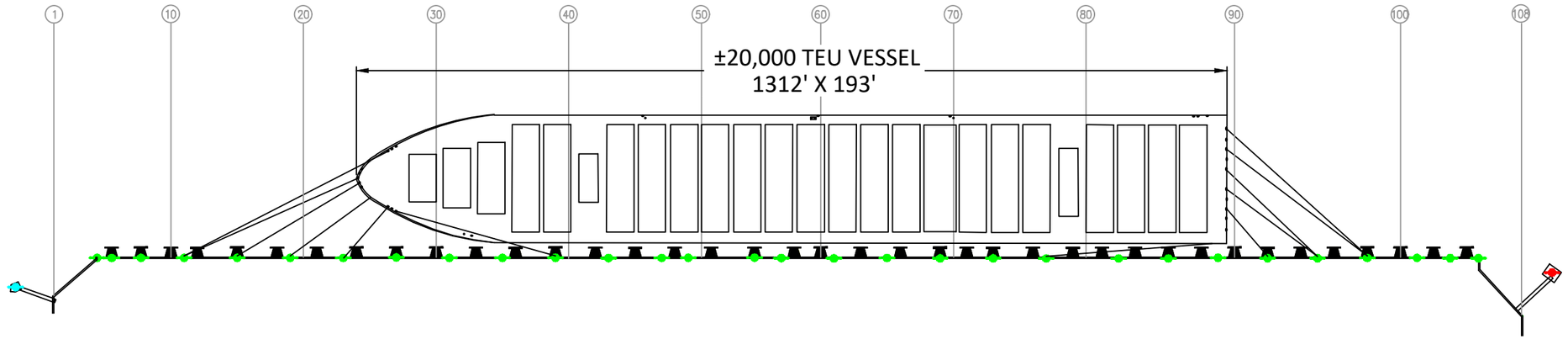
PCT - 14,000 TEU MOORING PLAN

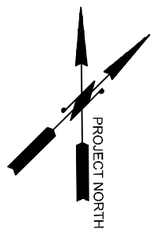
DATE: **05/01/2024**	SCALE: **AS SHOWN**
DRAWN BY: GM	SHT **1** OF **2**

Plotted: May 01, 2024 - 11:16am gmachuca Layout: POT WHARF PLAN
X:\2023\10092300204 POT Bollard-Berthing Study for PCT\6.01 Drawings\Exhibits\(1) PCT WHARF PLAN-14000 TEU.dwg

NOTE:

1. EXISTING BOLLARD CAPACITY IS EXCEEDED FOR WIND SPEEDS ABOVE 21 KNOTS.





PCT - 20,000 TEU MOORING PLAN

SCALE: 1/16" = 1'-0"

LEGEND:

- FENDER UNIT
- EXISTING 125 KIP PIER BOLLARD
- EXISTING 150 KIP WEST DOLPHIN BOLLARD
- EXISTING 350 KIP EAST DOLPHIN BOLLARD

kpff

2407 North 31st Street, Suite 100
Tacoma, Washington 984087
(253) 386-0150 Fax (253) 396-0162

PCT - 20,000 TEU MOORING PLAN

DATE: **05/01/2024**	SCALE: **AS SHOWN**
DRAWN BY: GM	SHT **2** OF **2**

Plotted: May 01, 2024 - 11:17am gmachuca Layout: POT WHARF PLAN
X:\2023\10092300204 POT Bollard-Berthing Study for PCT\6.01 Drawings\Exhibits\(2) PCT WHARF PLAN-20000 TEU.dwg

APPENDIX C: WIND STUDY

Wind Study for Washington United and Pierce County Terminals at Port of Tacoma

Date: July 03, 2024

1. Introduction

The purpose of this study was to determine site-specific 30-second duration design wind speeds from various directions at the Port of Tacoma for use in evaluating mooring loads on bollards at Washington United and Pierce County Terminals. The calculations discussed herein generally conform to the procedures of ASCE7-22. Fi>een years of wind speed data from the anemometer station located at the Port of Tacoma and owned by NOAA were processed and evaluated by developing codes in the MATLAB programing language. A thresholding approach based on the sampling time windows was used for filtering data and removing very low-intensity levels of wind. As part of the analysis, envelope design wind speeds were calculated using two sets of available data, including 5-second gust and 120-second average wind speeds. Height and exposure correction factors were considered, and the 30-second design wind speeds corresponding to a 25-year return period are reported for eight distinct sectors. Wind Rose plots are also provided.

2. Anemometer Station and Database

The wind records utilized in this study were sourced from the comprehensive online database of the National Data Buoy Center. The specific station used for this study is situated on the northern side of the General Central Peninsula at the Port of Tacoma. The station, identified by the serial number 9446482 and the station ID TCMW1, is owned and maintained by the NOAA's National Ocean Service. The available data for this station spans approximately 15 years, commencing from April 2009 and concluding in October 2023, with recordings taken every 6 minutes. Figure 1.

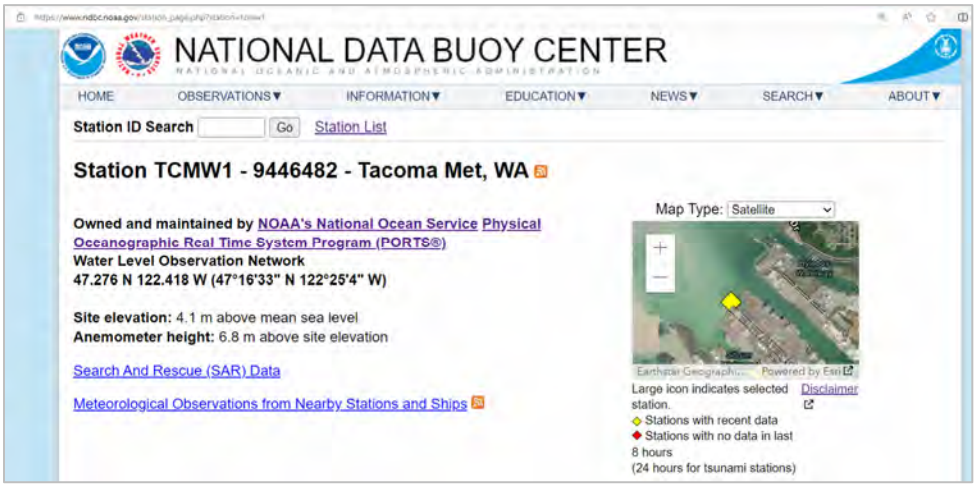


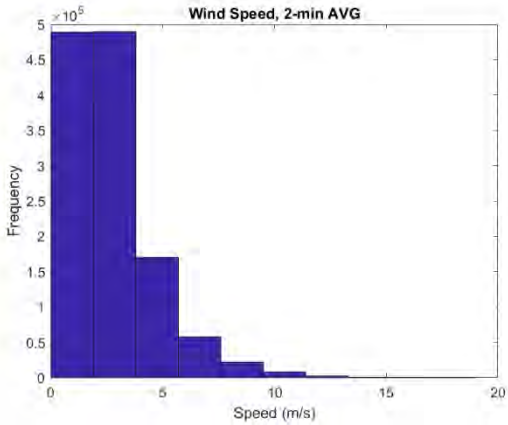
Figure 1. TCMW1 anemometer station website from National Data Buoy Center.

Each record includes the date, time, wind direction, 2-minute average wind speed, and 5-second gust wind speed. The source data was accessed from the following link: h7 ps://www.ndbc.noaa.gov/station_history.php?station=tcmw1

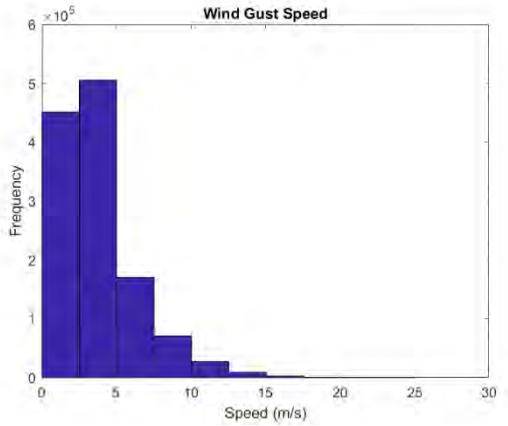
3. Statistical Evaluation of the Dataset

As a first step in understanding the historical data, histograms of winds from all directions. Two sets of wind speed data were processed and evaluated, the first set being wind speed averaged over a 120-second duration, and the second set averaged over a 5-second duration. Results for both sets are included in subsequent sections.

3-1- Histograms of Winds from All Directions



(120-second wind speed)



(5-second gust wind speed)

Figure 2. Histogram of the wind speeds (all directions).

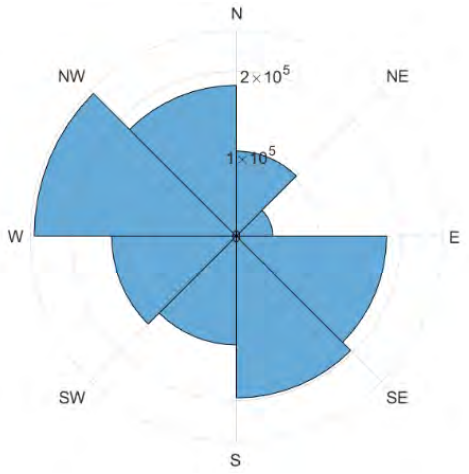


Figure 3. Histogram of the wind direction (all directions).

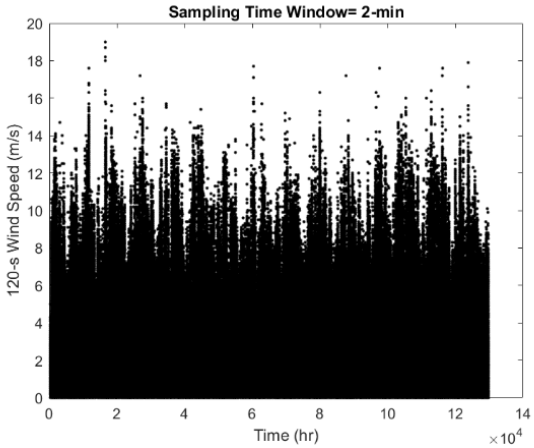


Figure 4. Wind speeds vs time (in hours) for 120-second average wind. Time zero is April 2009.

3-2- Filtering, Binning, and Representing Data

For evaluating extreme wind events with a high wind speed and low probability of occurrence, using wind data recorded every 6 minutes would result in a poor fit to the probability density functions. Different approaches are discussed in the literature (Pintar et al. 2015), such as considering monthly maximum wind speed data or using a thresholding approach to eliminate the low-speed wind data below specific values. In this study, an approach similar to the second one is used. However, a time window threshold is used instead of a wind speed threshold. Several sampling time windows starting from 6 hours to a month were considered. Below a threshold of 6 hours, there is a high probability of correlations between recorded wind speeds (Pintar et al. 2015) leading to the wrong estimation. Finally, among all the sampling time windows, the ones that lead to the best-fi7 ed model (highest accuracy) were selected. The following presents histograms of all data for four different sampling time window thresholds of 24, 96, 336, and 722 hours.

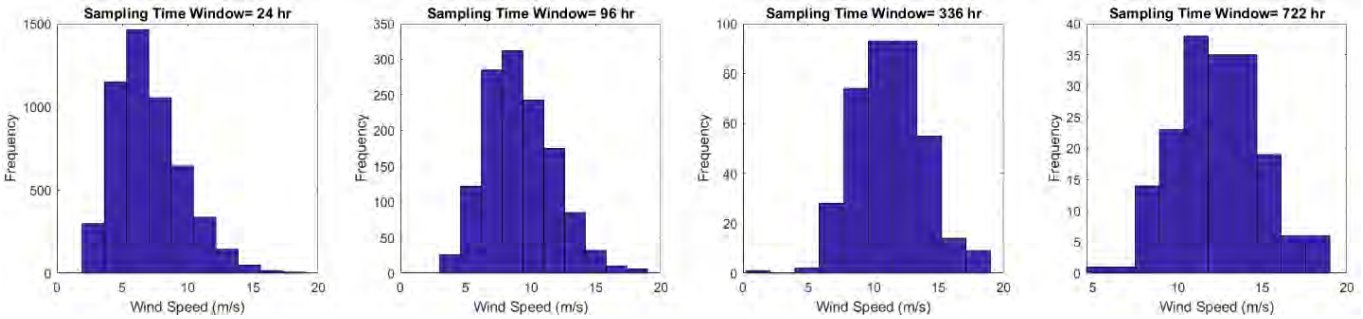


Figure 5. Histograms of maximum wind speeds for different sampling time window thresholds (for 120s average wind speed data).

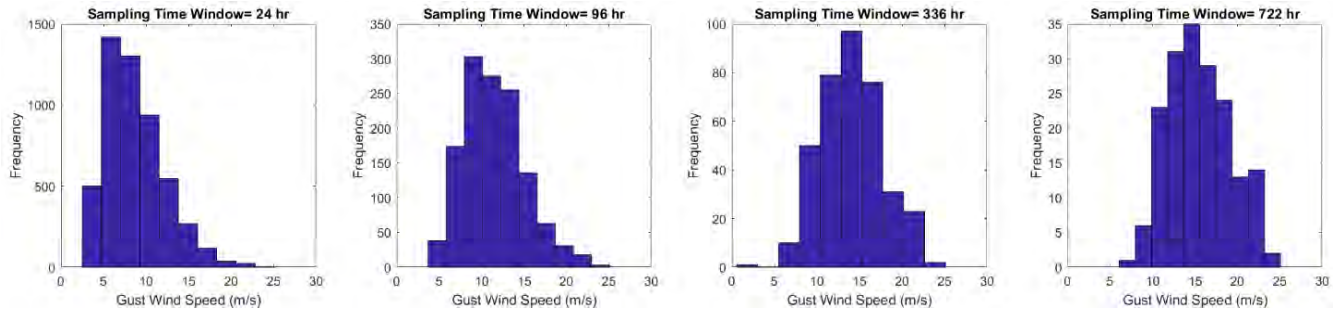


Figure 6. Histograms of maximum wind speeds for different sampling time window thresholds (for 5s gust wind speed data).

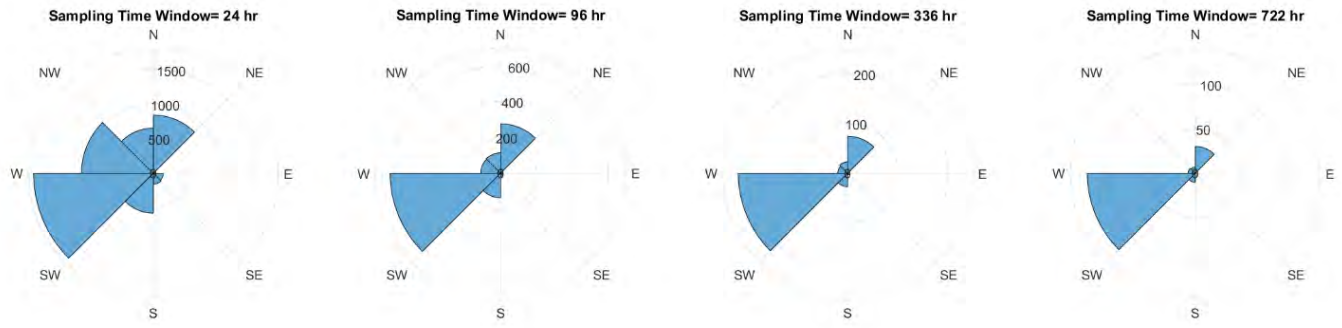


Figure 7. Histograms of wind direction for different sampling time window thresholds.

In addition to the histograms above for different sampling time windows, the data was evaluated for eight sectors of direction, with the angles shown in the figure and table below. The angles for these sectors were selected to evaluate the wind speed in directions parallel and perpendicular to vessels at each terminal.

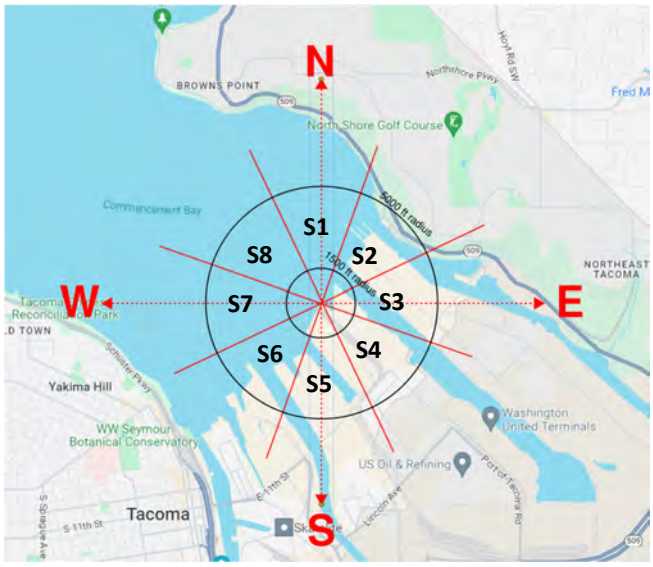


Figure 8. Defined sectors for the station site.

Table 1. Sector angles (from north clockwise).

Sector	S1	S2	S3	S4	S5	S6	S7	S8
Angles (degree)	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335

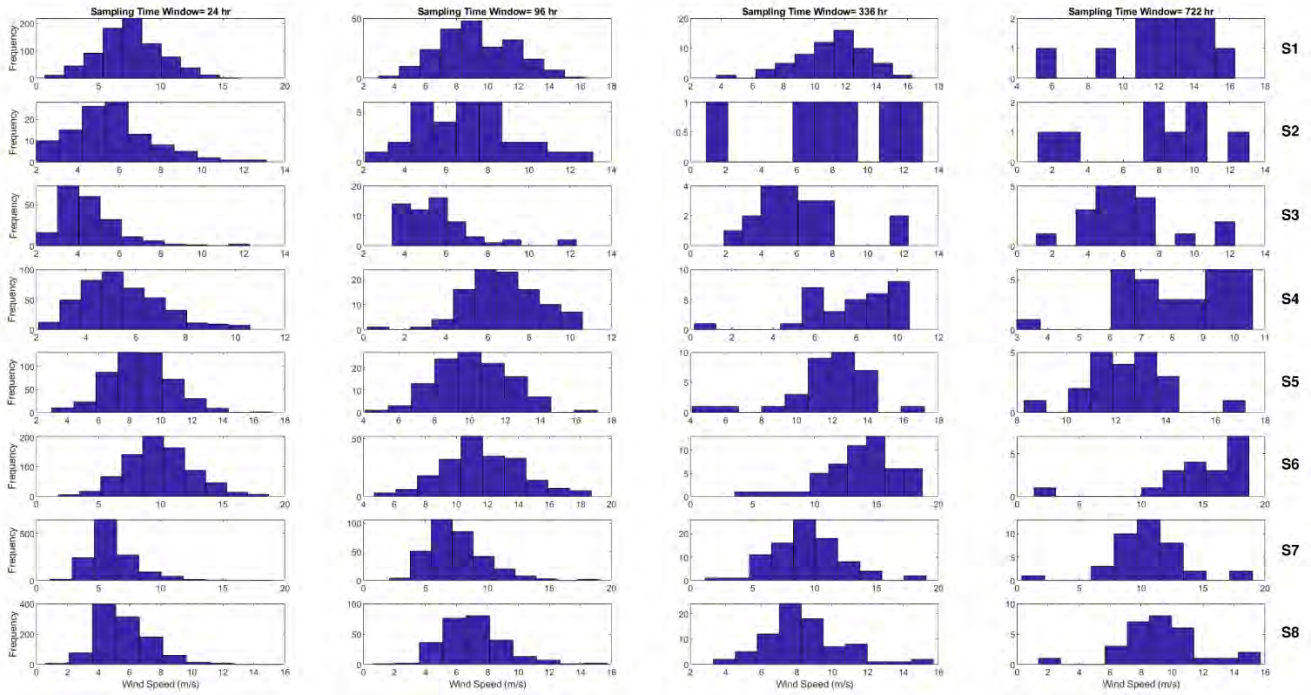


Figure 9. Histograms of the wind speed for different sectors and sampling time window thresholds for 120s wind speed data.

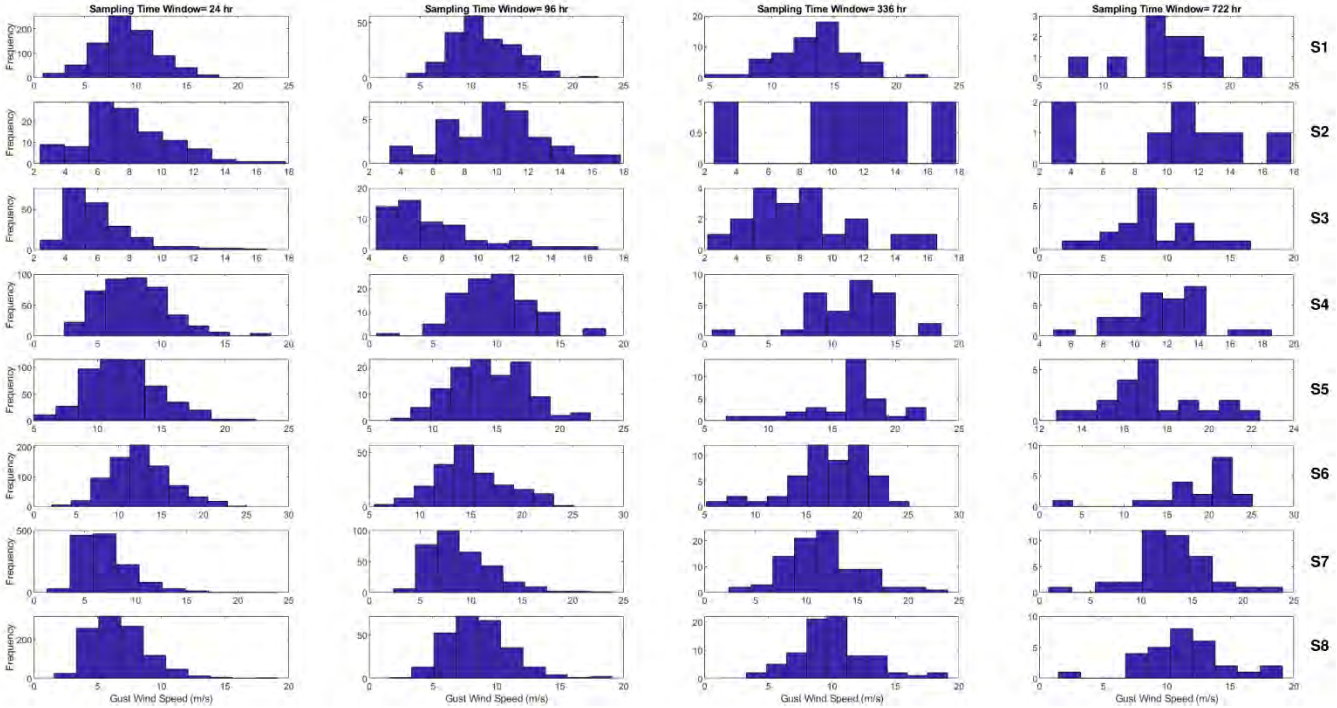


Figure 10. Histograms of the wind speed for different sectors and sampling time window thresholds for 5s gust wind speed data.

4. Design Wind Speed Calculation

This section estimates the 25-year return period 30-second duration design wind speed at the project site. For this purpose, a> er defining eight sectors, four well-known probability distribution functions were adopted for the extreme value analysis (Goda 2010), including *Lognormal (LN), Weibull (WB), Extreme Value (EV), and Generalized Extreme Value (GE)*, to develop probabilistic models to estimate the design wind speed. It is important to note that among different sampling time window thresholds in the previous section, results from 2-week and 1-month time windows were used for the design wind speed calculation due to the higher accuracy of fi7 ed models. The two sets of data, including wind speeds for the 5-second gust wind speed and 120-second wind speed, were analyzed, the results of both sets were converted to the 30-second duration wind speeds, and the maximum of two sets was selected. The accuracy of fi7 ed models was evaluated, and the correction factors for station height and exposure were applied to the calculated wind speed to convert it to Exposure C at the standard height of 33> .

4-1- Fitting Probability Density Functions and Results

There are pre-defined functions in MATLAB programming language to fit the probability density functions by performing a maximum negative likelihood approach (Abramowitz et al. 2013; Evans et al. 1993; Johnson et al. 1993 and 1994). All probability models are fi7 ed to the data for all sectors and two sampling time windows of two weeks and one month.

Table 2. Functions of the adopted probability distributions and their main parameter.

Probability Distribution	Function	Parameter 1*	Parameter 2*	Parameter 3*
Lognormal	$y = f(x\|\mu,\sigma) = \frac{1}{x\sigma\sqrt{2\pi}}\exp\left\{\frac{-(\log x-\mu)^2}{2\sigma^2}\right\}, \quad \text{for } x>0.$	μ	σ	—
Extreme Value	$y = f(x\|\mu,\sigma) = \sigma^{-1}\exp\left(\frac{x-\mu}{\sigma}\right)\exp\left(-\exp\left(\frac{x-\mu}{\sigma}\right)\right)$	μ	σ	—
Weibull	$y = abx^{b-1}e^{-ax^b}$	a	b	—
Generalized Extreme Value	$y = f(x\|k,\mu,\sigma) = \left(\frac{1}{\sigma}\right)\exp\left(-\left(1+k\frac{(x-\mu)}{\sigma}\right)^{-\frac{1}{k}}\right)\left(1+k\frac{(x-\mu)}{\sigma}\right)^{-1-\frac{1}{k}}$	μ	σ	k

* Parameters 1 to 3 are mathematical input parameters of each of probability distribution functions.

Table 3. Value of parameters of all fitted probability distribution models for all eight sectors and sampling time windows of 2-week and 1-month for 120s wind speed data.

Lognormal				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	2.29	2.45	0.27	0.28
S2	2.38	2.08	0.16	0.94
S3	1.91	1.81	0.52	0.63
S4	2.03	1.97	0.22	0.30
S5	2.17	2.24	0.66	0.26
S6	2.65	2.68	0.13	0.20
S7	2.41	2.49	0.28	0.38
S8	1.95	1.97	0.30	0.57

Extreme Value				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	11.47	13.37	2.45	2.24
S2	11.72	11.67	1.61	2.52
S3	9.04	8.64	2.92	3.05
S4	8.62	8.40	1.51	1.72
S5	10.48	10.48	1.62	1.65
S6	15.20	16.00	1.67	1.92
S7	13.16	14.44	3.04	3.04
S8	8.20	8.77	1.83	1.84

Weibull				
Sector	A		B	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	11.18	13.13	4.49	5.26
S2	11.61	10.99	7.33	2.43
S3	8.44	7.92	2.68	2.33
S4	8.47	8.18	5.35	4.40
S5	10.20	10.32	4.85	6.08
S6	15.10	15.85	8.98	7.59
S7	12.77	14.01	4.17	4.19
S8	7.97	8.46	4.41	3.95

Generalized Extreme Value				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	9.31	11.54	2.51	3.15
S2	10.37	11.19	1.59	3.28
S3	6.47	5.94	3.03	3.19
S4	7.34	6.99	1.73	2.12
S5	9.11	9.10	2.33	2.04
S6	13.75	14.97	1.82	3.10
S7	10.48	11.86	2.98	3.78
S8	6.68	7.20	1.78	2.30

Sector	k	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	-0.28	-0.63
S2	-0.28	-1.17
S3	-0.30	-0.30
S4	-0.43	-0.52
S5	-0.54	-0.44
S6	-0.35	-1.02
S7	-0.25	-0.47
S8	-0.26	-0.44

Table 4. Value of parameters of all fitted probability distribution models for all eight sectors and sampling time windows of 2-week and 1-month for 5s wind speed data.

Lognormal				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	2.46	2.64	0.28	0.27
S2	2.04	2.40	1.63	0.68
S3	2.21	2.10	0.56	0.62
S4	2.36	2.34	0.23	0.27
S5	2.54	2.60	0.55	0.26
S6	2.93	2.95	0.12	0.17
S7	2.63	2.72	0.31	0.39
S8	2.12	2.16	0.28	0.49

Extreme Value				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	13.78	16.25	3.40	3.46
S2	13.64	14.58	2.71	2.76
S3	12.30	11.71	3.92	4.16
S4	12.00	11.99	2.10	2.16
S5	15.22	15.38	2.99	2.94
S6	19.95	20.66	2.44	2.03
S7	16.62	18.31	4.10	3.85
S8	9.84	10.69	2.52	2.63

Weibull				
Sector	A		B	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	13.37	15.85	4.14	4.56
S2	12.54	14.02	1.74	3.22
S3	11.47	10.71	2.62	2.28
S4	11.78	11.74	5.25	4.99
S5	14.75	15.08	4.34	5.15
S6	19.80	20.53	8.38	9.26
S7	16.04	17.75	3.82	4.06
S8	9.51	10.26	3.96	3.63

Generalized Extreme Value				
Sector	μ		σ	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	10.92	13.23	2.99	3.62
S2	12.37	14.49	4.51	2.36
S3	8.88	8.01	4.33	4.45
S4	10.42	10.46	2.76	3.04
S5	12.66	12.91	3.75	3.15
S6	17.86	19.06	2.14	3.18
S7	12.98	15.04	4.07	5.04
S8	7.74	8.46	2.13	2.95

Sector	k	
	Sampling Time Window: 2-Week	Sampling Time Window: 1-Month
S1	-0.18	-0.29
S2	-1.04	-1.07
S3	-0.36	-0.32
S4	-0.65	-0.75
S5	-0.41	-0.32
S6	-0.17	-0.77
S7	-0.26	-0.52
S8	-0.17	-0.37

4-2- Accuracy of Fitted Models

To evaluate the accuracy of each fi7ed model, the coefficient of determination (R2) between the observed data and simulated values is calculated and compared. For example, the simulated-observed curves for sector 1 of 5-second gust wind speed with a 2-week sampling time window are shown. It is seen that for the larger wind speed range, except the Lognormal distribution, all other distributions work well.

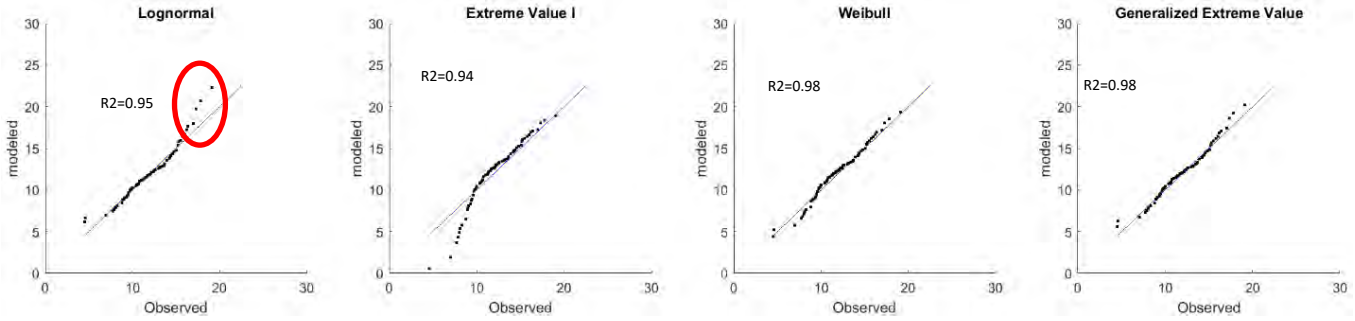


Figure 11. Simulated values versus observed values for the wind speed at sector Q1 of 5-second gust wind speed with the 2-week sampling window.

In Figure 12 and Figure 13, the parameter R2 of each model is shown for all sectors with respect to the wide range of sampling time windows. Figure 12 shows the results for the 120-second wind speed data while Figure 13 presents the R2 for 5-second gust wind speed models. The values corresponding to Figure 12 and Figure 13 are shown in

Table 5 and Table 6. It was determined that, in many sectors and for many time sampling time windows, the Lognormal probability of distribution has lower R2 values, primarily due to its failure to estimate larger wind speeds. Therefore, this probability function was eliminated from the list of models and not used in subsequent analysis.

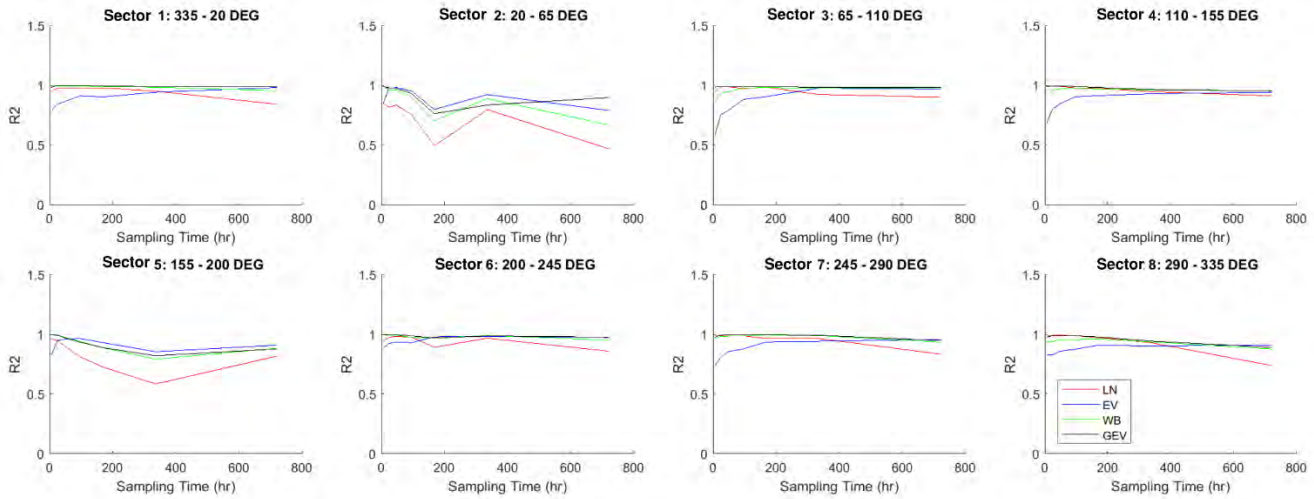


Figure 12. R2 of different fitted models for different sectors versus the sampling time windows for the 120-second wind data.

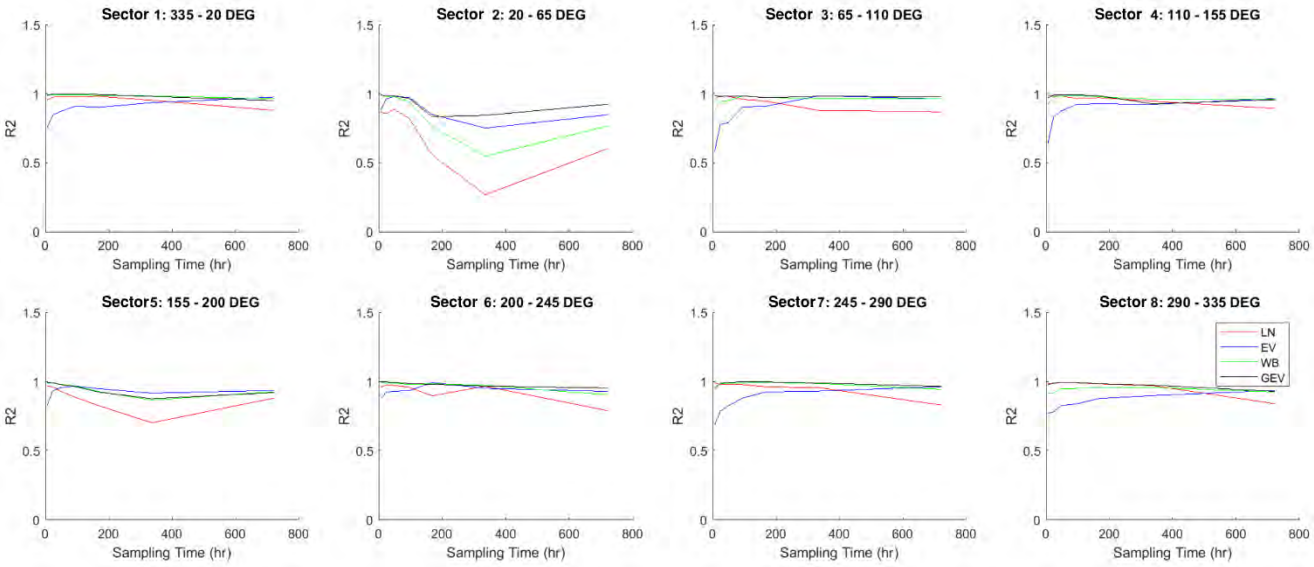


Figure 13. R2 of different fitted models for different sectors versus the sampling time windows for the 5-second wind data.

Table 5. R2 coefficient for the fitted model to 120-second wind speed.

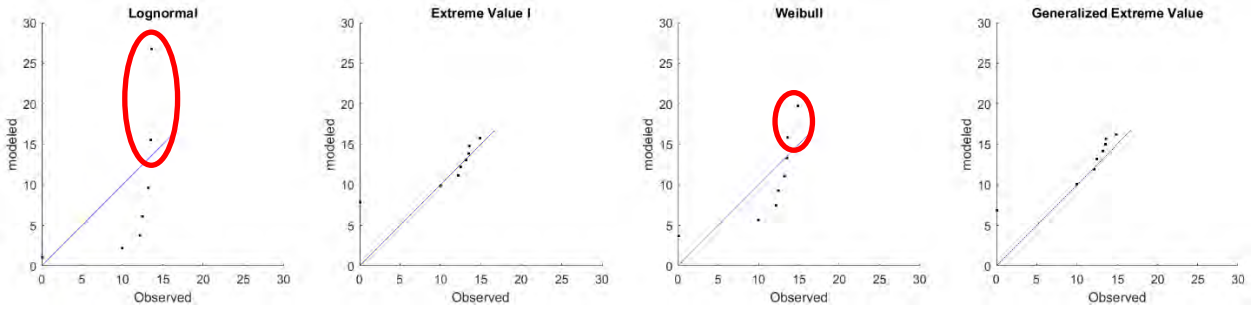
Sampling Time Window	Distribution	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335	Average
1-Month	LN	0.84	0.47	0.90	0.91	0.82	0.86	0.83	0.74	0.80
	EV	0.98	0.79	0.97	0.94	0.91	0.98	0.96	0.91	0.93
	WB	0.95	0.67	0.98	0.96	0.89	0.96	0.93	0.88	0.90
	GE	0.99	0.90	0.99	0.96	0.88	0.98	0.95	0.89	0.94
2-Weeks	LN	0.95	0.8	0.92	0.95	0.58	0.96	0.96	0.93	0.88
	EV	0.94	0.92	0.98	0.93	0.86	0.98	0.94	0.9	0.93
	WB	0.99	0.89	0.98	0.96	0.79	0.99	0.98	0.94	0.94
	GE	0.99	0.84	0.98	0.96	0.82	0.99	0.99	0.95	0.94

Table 6. R2 coefficient for the fitted model to 5-second gust wind speed.

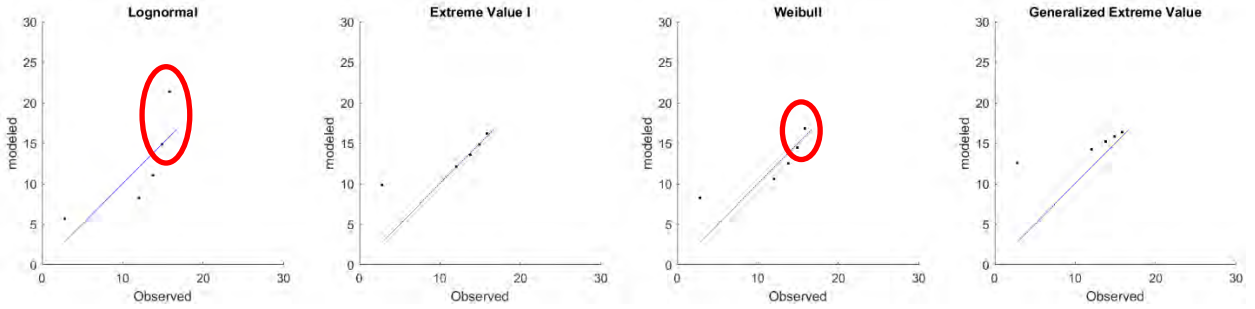
Sampling Time Window	Distribution	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335	Average
1-Month	LN	0.88	0.60	0.87	0.90	0.88	0.79	0.83	0.84	0.82
	EV	0.98	0.84	0.96	0.97	0.94	0.93	0.96	0.94	0.94
	WB	0.96	0.77	0.96	0.97	0.93	0.90	0.95	0.93	0.92
	GE	0.95	0.92	0.98	0.96	0.92	0.95	0.96	0.92	0.95
2-Weeks	LN	0.95	0.27	0.87	0.95	0.70	0.97	0.96	0.98	0.97
	EV	0.94	0.75	0.98	0.92	0.92	0.95	0.93	0.92	0.90
	WB	0.98	0.54	0.97	0.96	0.86	0.97	0.98	0.98	0.96
	GE	0.98	0.84	0.98	0.93	0.88	0.97	0.99	0.99	0.97

In addition to the Lognormal distribution, the Weibull distribution was found to not work well in some cases (see highlighted cells in the above tables), and larger values were estimated compared with other models. For a more accurate investigation, in Figure 14, the simulated versus observed data is depicted for all probability models. It was evident that the accuracy of Lognormal and Weibull is not high, so their results were excluded from the rest of the analysis only for sector Q2.

2-Week Sampling Time Window, 5-secondGust Wind Speed



1-Month Sampling Time Window, 5-secondGust Wind Speed



1-Month Sampling Time Window, 120-secondWind Speed

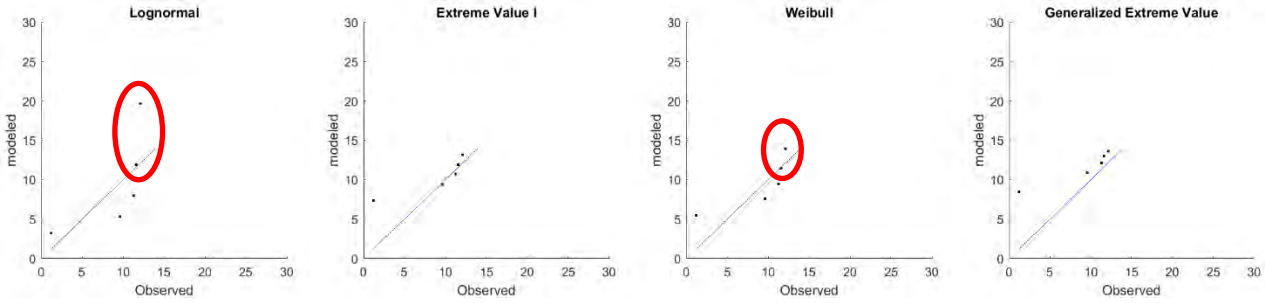


Figure 14. Simulated vs observed wind speed for sector Q2.

4-3- 25-yr Return Period Wind Speed Calculation

A>er fi6 ng the probability density functions to the wind data of each sector, the 25-year return period wind speed can be calculated using the following equation given by Goda (2010), where WSP_{RT} is the estimated design wind speed at RT years return period, and λ is the occurrence rate of the events per year, which is 12, and 26 for the 1-month and 2-week sampling time windows, respectively.

$$WSP_{RT} = F^{-1}(1 - \frac{1}{\lambda . RT}) \quad (1)$$

A>er calculating the wind speed from the above equation, it is necessary to correct it for recorded wind duration, the height of the station, and site exposure condition of the recorded data to be able to report the final 30-second design wind speed for the Type C exposure at the height of 33-feet according to the ASCE7-22.

4-3-1- Wind Speed Averaging Time Correction

To consider the effect of recorded wind speed duration, coefficients for converting the 120-second wind speed and 5-second wind speed to the target 30-second wind speed were applied based on figure C26.5-1 of ASCE7-22 (Figure 15 of this report) by using the Synoptic wind curve. In this figure V_t, and V_{3600} are the t-second gust and 3600 second gust wind speeds, respectively.

Modification Factor 5-s to 30-s	0.89
Modification Factor 120-s to 30-s	1.16

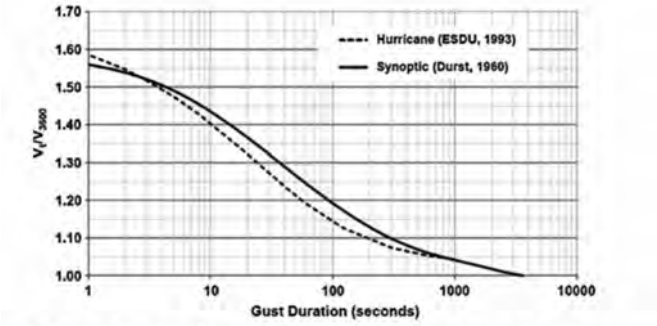


Figure C26.5-1. Maximum speed averaged over t (s) to hourly mean speed.

Figure 15. Relationship between wind speed with different averaging periods according to ASCE7-22, C26.5-1.

4-3-2- Height and Exposure Correction

A coefficient for correction of the height and exposure of the station was applied to the wind speed obtained from recorded data for each sector. In Table 7, the height and

exposure of each sector of the station are identified based on the information from the National Data Buoy Center database website, the topography of the surrounding area, and the definition of ASCE7-22 in Chapter 26. The difference in the height of the station is due to its location. It is situated on the edge of the port, and its height from the sea water level is 35.7>, while its height from the land is 22.3>. By using the equation given in the notes of table 26.10-1 of ASCE7-22, coefficient K_z (velocity pressure exposure coefficient at height z) is calculated for each sector and used to adjust the speeds to the standard exposure Type C.

It is important to note that the exposure type for some sectors falls between the distinct classes defined by the ASCE7-22. In these cases, the exposures with the highest correction factor were used.

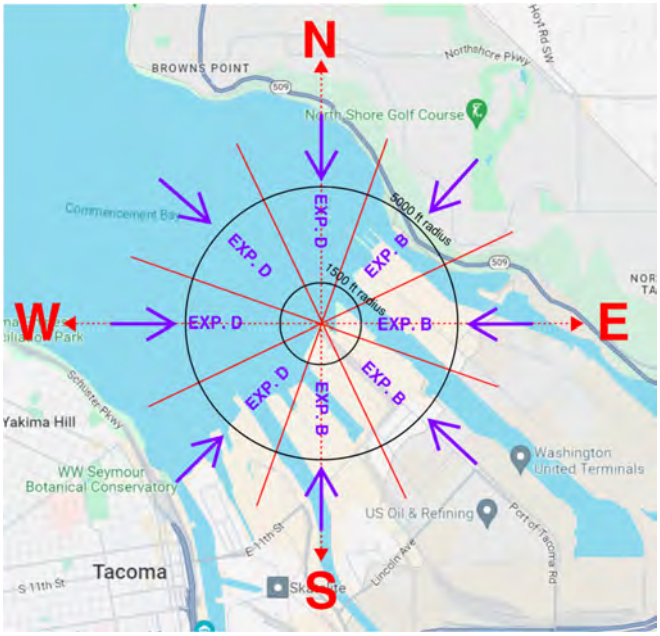


Figure 16. Exposure of each sector at the anemometer station.

Table 7. Height and exposure correction factor for the recorded wind speed at the selected station.

Sector (Deg)	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335
Exposure	D	B	B	B	B	D	D	D
Z_{st}	35.7	35.7	22.3	22.3	22.3	35.7	35.7	35.7
Z_0	33	33	33	33	33	33	33	33
α	11.5	7.5	7.5	7.5	7.5	11.5	11.5	11.5
Z_g	1935	3280	3280	3280	3280	1935	1935	1935
K_{zst}	1.20	0.72	0.64	0.64	0.64	1.20	1.20	1.20
Modification factor=$1/(K_{zst})^{0.5}$	**0.91**	**1.18**	**1.25**	**1.25**	**1.25**	**0.91**	**0.91**	**0.91**

K_{zst}: velocity pressure exposure coefficient at station height Z_{st}; Z_{st}: Station height; Z_0: Height for reporting the Design Wind Speed (10m/33>); α: parameter of calculating K_{zst} (table 26.11-1 of ASCE7-22); Z_g: Nominal height of atmospheric boundary layer used in ASCE7-22 (table 26.11-1).

4-3-3- Design Wind Speed at the Anemometer Station

The performance of the three previously mentioned fi7ed probability models was found to be similar. Therefore, the 25-year return period wind speed was conservatively taken as the maximum of all three models (WB, EV, GE). Correction factors for wind recording duration, station height, and site exposure were then applied to calculate the final design wind speeds. Table 8 and Table 9 show the details of calculations and Table 10 depicts the summary of design wind speeds for each sector before and a>er applying correction factors. The results are also depicted graphically in Figure 17.

Table 8. Estimated 25-year return period wind speed using the fitted model to 120-second wind speed data for 2-week and 1-month sampling time windows.

Sampling Time Window	Distribution	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335	Average
1-Month	EV	17.27	16.07	13.96	11.40	13.34	19.34	19.73	11.98	15.39
	WB	18.28	22.53	16.75	12.15	13.74	19.94	21.22	13.15	17.22
	GE	16.41	13.96	14.56	10.85	13.37	17.99	19.35	12.01	14.81
	Max of All PDF	18.28	16.07	16.75	12.15	13.74	19.94	21.22	13.15	16.41
	30s Wind Speed (1.16*Max)	21.20	18.64	19.43	14.09	15.94	23.13	24.62	15.25	19.04
	Modification factor=$1/(K_{zst})^{0.5}$	0.91	1.18	1.25	1.25	1.25	0.91	0.91	0.91	__
	Final Wind Speed (m/s)	**16.66**	**18.91**	**20.99**	**15.23**	**17.22**	**18.18**	**19.34**	**11.99**	**17.31**
2-Weeks	EV	16.05	14.73	14.50	11.42	13.51	18.32	18.84	11.62	14.87
	WB	16.95	14.97	16.97	12.01	15.00	18.60	20.00	12.17	15.83
	GE	16.78	15.15	15.04	11.09	13.31	18.45	20.07	12.17	15.26
	Max of All PDF	16.95	15.15	16.97	12.01	15.00	18.60	20.07	12.21	15.87
	30s Wind Speed (1.16*Max)	19.66	17.57	19.69	13.93	17.40	21.58	23.28	14.16	18.41
	Modification factor=$1/(K_{zst})^{0.5}$	0.91	1.18	1.25	1.25	1.25	0.91	0.91	0.91	__
	Final Wind Speed (m/s)	**17.92**	**20.68**	**24.67**	**17.46**	**21.80**	**19.67**	**21.22**	**12.91**	**19.54**

Table 9. Estimated 25-year return period wind speed using the fitted model to 5-second gust wind speed data for 2-week and 1-month sampling time windows.

Sampling Time Window	Distribution	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335	Average
1-Month	EV	22.28	19.39	18.95	15.75	20.52	24.19	25.02	15.27	20.17
	WB	23.23	24.10	23.00	16.66	21.15	24.79	27.25	16.60	22.10
	GE	23.26	16.70	19.59	14.46	21.22	23.15	24.17	15.52	19.76
	Max of All PDF	23.26	19.39	23.00	16.66	21.22	24.79	27.25	16.60	21.52
	30s Wind Speed (0.89*Max)	20.70	17.26	20.47	14.83	18.89	22.06	24.25	14.77	19.15
	Modification factor=1/$(K_{zst})^{0.5}$	0.91	1.18	1.25	1.25	1.25	0.91	0.91	0.91	__
	Final Wind Speed (m/s)	**18.87**	**20.31**	**25.65**	**18.58**	**23.67**	**20.11**	**22.11**	**13.47**	**20.35**
2-Weeks	EV	20.13	18.70	19.63	15.93	20.82	26.38	24.50	24.27	14.45
	WB	20.99	36.74	23.39	16.81	22.70	25.09	24.74	26.17	15.25
	GE	22.23	16.70	19.75	14.60	21.21	25.23	26.14	25.71	16.09
	Max of All PDF	22.23	18.70	23.39	16.81	22.70	26.38	26.14	26.17	22.82
	30s Wind Speed (0.89*Max)	19.78	16.64	20.82	14.96	20.20	23.48	23.26	23.29	20.31
	Modification factor=1/$(K_{zst})^{0.5}$	0.91	1.18	1.25	1.25	1.25	0.91	0.91	0.91	__
	Final Wind Speed (m/s)	**18.03**	**19.59**	**26.09**	**18.75**	**25.32**	**21.40**	**21.21**	**21.23**	**21.45**

Table 10. Final 30-second design wind speed before and after height and exposure corrections.

	Unit	Sector								Average
		335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335	
Before Height and Exposure Correction	m/s	21.20	18.64	20.82	14.96	20.20	23.48	24.62	23.29	22.82
	mi/hr	47.4	41.7	46.6	33.5	45.2	52.5	55.1	52.1	51.0
	Knot	41.2	36.2	40.5	29.1	39.3	45.6	47.8	45.3	44.3
After Height and Exposure Correction (Exposure C, and 33' Height)	m/s	18.87	20.68	26.09	18.75	25.32	21.40	22.11	21.23	21.45
	mi/hr	42.2	46.3	58.4	41.9	56.6	47.9	49.5	47.5	48.0
	Knot	36.7	40.2	50.7	36.4	49.2	41.6	43.0	41.3	41.7

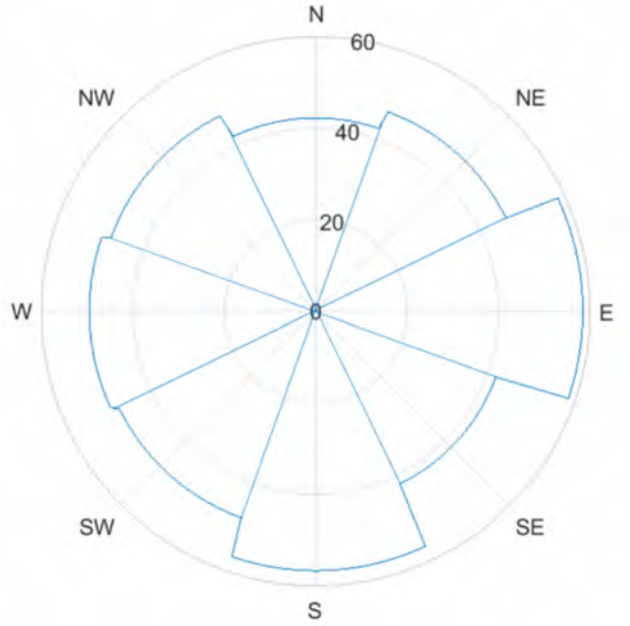
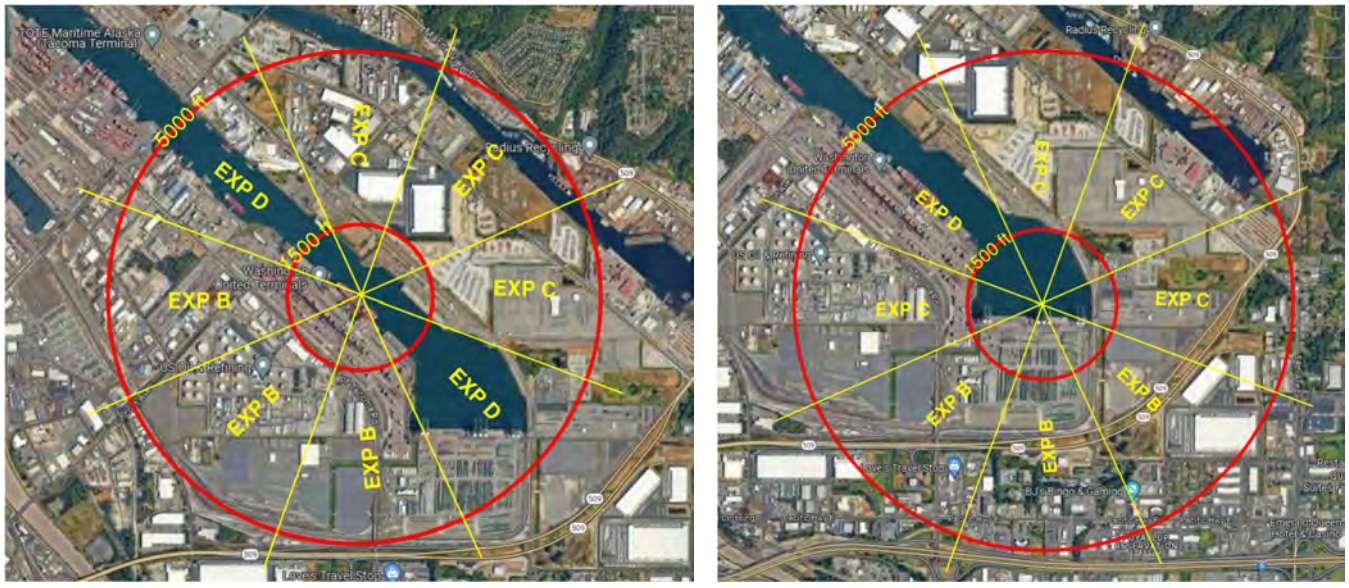


Figure 17. Final 30-second design wind speed (mi/hr) for 10’ height and exposure type C.

4-3-4- Design Wind Speed at WUT and PCT terminals

In this section, the 30-second design wind speed at two project sites, namely, Washington United Terminal and Pierce County Terminal, are given according to their exposure category for the height of 33 feet in Figure 18. Final design wind speeds are given in Table 11 and

Table 12 as well as Figure 19.



Washington United Terminal Pierce County Terminal

Figure 18. Exposure type at each sector of Washington United Terminal and Pierce County Terminal.

Table 11. Design wind speed at each sector of Washington United Terminal based on the exposure type.

Sector (Deg)	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335
Exposure	C	C	C	D	B	B	B	D
Z_s	33	33	33	33	33	33	33	33
α	9.8	9.8	9.8	11.5	7.5	7.5	7.5	11.5
Z_g	2460	2460	2460	1935	3280	3280	3280	1935
K_z	1.00	1.00	1.00	1.19	0.71	0.71	0.71	1.19
Modification factor=$(K_{zst})^{0.5}$	**1.00**	**1.00**	**1.00**	**1.09**	**0.84**	**0.84**	**0.84**	**1.09**
Design Wind Speed (m/s)	18.87	20.68	26.08	20.43	21.29	17.99	18.59	23.13
Design Wind Speed (mi/hr)	42.21	46.26	58.35	45.69	47.62	40.25	41.58	51.75
Design Wind Speed (knot)	36.68	40.20	50.70	39.71	41.38	34.98	36.13	44.97

K_z: velocity pressure exposure coefficient at station height z; Z_s: Height for reporting the Design Wind Speed (10m/33>); α: parameter of calculating K_z (table 26.11-1 ASCE7-22); Z_g: Nominal height of atmospheric boundary layer used in ASCE7-22 (table 26.11-1).

Table 12. Design wind speed at each sector of Pierce County Terminal based on the exposure type.

Sector (Deg)	335-20	20-65	65-110	110-155	155-200	200-245	245-290	290-335
Exposure	C	C	C	B	B	B	C	D
Z_s	33	33	33	33	33	33	33	33
α	9.8	9.8	9.8	7.5	7.5	7.5	9.8	11.5
Z_g	2460	2460	2460	3280	3280	3280	2460	1935
K_z	1.00	1.00	1.00	0.71	0.71	0.71	1.00	1.19
Modification factor=$(K_{zst})^{0.5}$	**1.00**	**1.00**	**1.00**	**0.84**	**0.84**	**0.84**	**1.00**	**1.09**
Design Wind Speed (m/s)	18.87	20.68	26.08	15.76	21.29	17.99	22.10	23.13
Design Wind Speed (mi/hr)	42.21	46.26	58.35	35.26	47.62	40.25	49.45	51.75
Design Wind Speed (knot)	36.68	40.20	50.70	30.64	41.38	34.98	42.97	44.97

K_z: velocity pressure exposure coefficient at station height z; Z_s: Height for reporting the Design Wind Speed (10m/33>); α: parameter of calculating K_z (table 26.11-1 ASCE7-22); Z_g: Nominal height of atmospheric boundary layer used in ASCE7-22 (table 26.11-1).

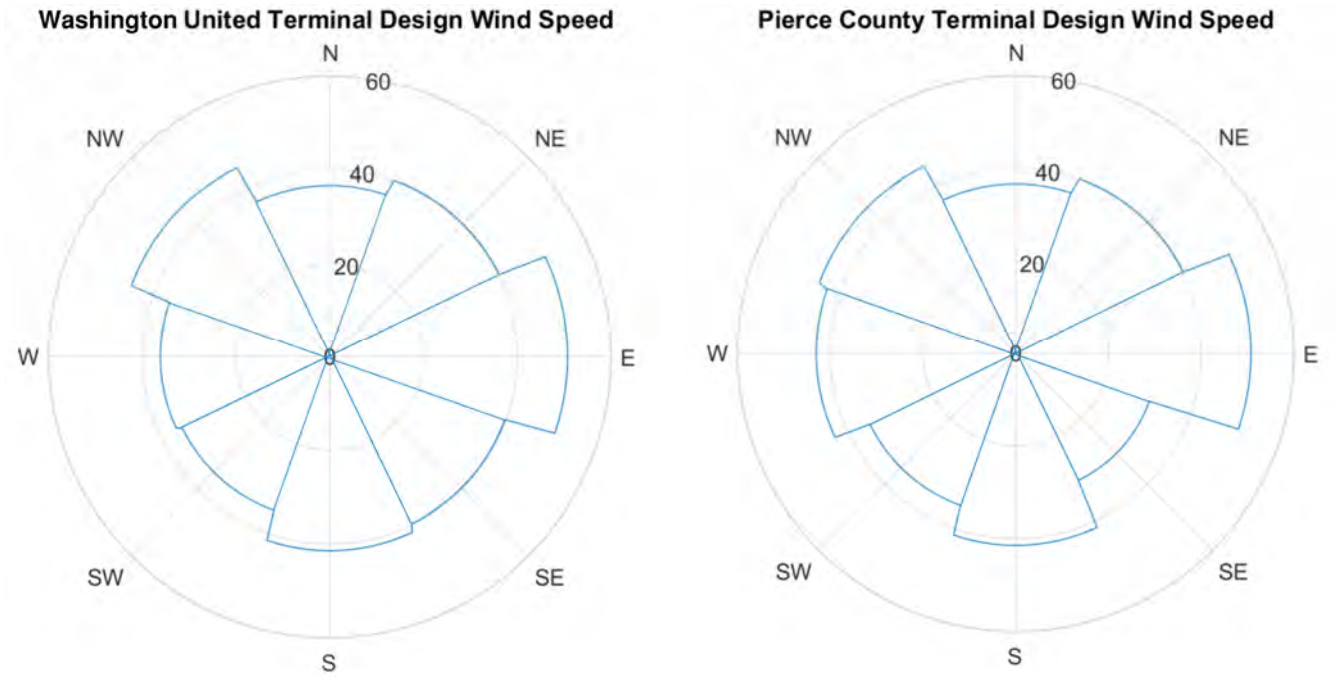
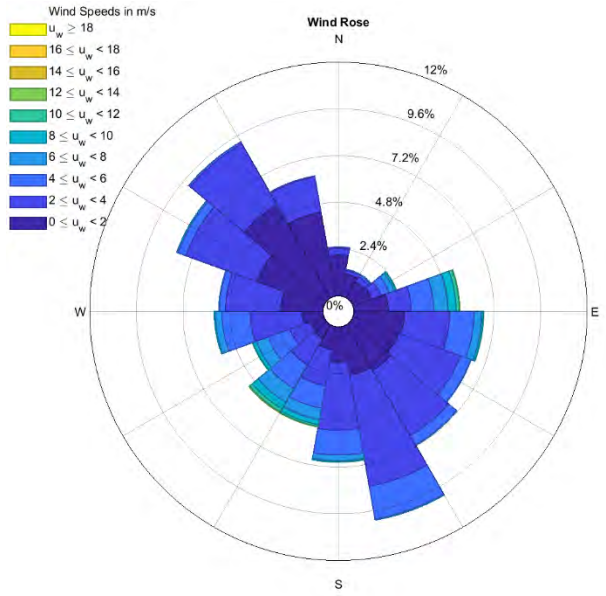


Figure 19. Final 30-second design wind speed (in knots) at each sector of Washington United Terminal and Pierce County Terminal accounting for exposure categories.

5. Wind Rose

Wind Rose diagrams were developed for 120-second and 5-second wind speeds using programs published in MATLAB programing language by Periera (2024). The codes are available in the link provided in the references. These diagrams show that most winds blow from the NW and SE; however, more intense winds are observed from the SW and E.

120-second wind speed



5-second gust wind speed

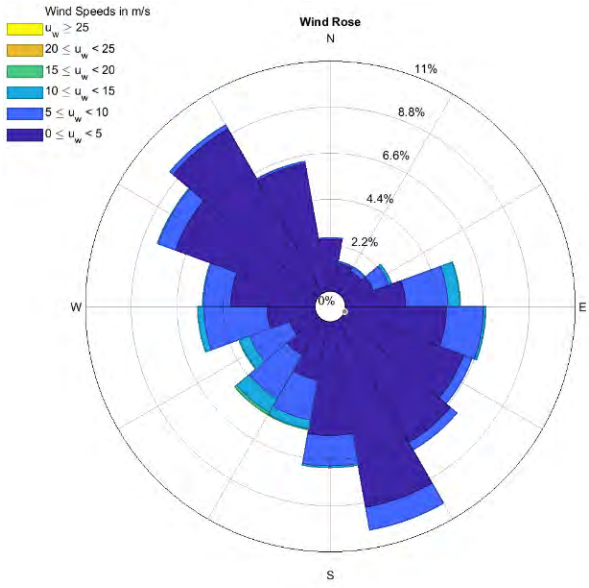


Figure 20. Wind Rose diagrams for all recorded station data for both 120-second and 5-second gust wind speeds.

6. References

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7. Appendix: Code

This is the main code wri7en in MATLAB language to fit the probability functions to the dataset and calculate the design wind speed.

```
function [DS,Dist,R2] = WindFit(WindData,T,Lambda)
% ========================================================================%
% This program fits the probability distribution functions to the database,
% and then obtain the design wind speed for the desired T-yr return period.
%
% Inputs:
%       WindData: WindData
%       T: return period
%       Lambda: Recurrence rate of the wind for wind speed calculation
% Outputs:
%       DS: Estimated wind speed at T-yr return period from all
%           distributions.
%       Dist: parameters of fitted probability distribution functions
%       R2: Determination Coefficient of Simulated versus Observed data for
%           all probability models.
%========================================================================%

s=8; % parameter for the selection of 120s wind speed or 5/8 sec wind speed from data base. 7: use 2-min wind speed,
8: use 5 sec wind speed

close all

%% Fitting Model and Estimating the RT-year Return Period
% Fitting the probability distributions to data with maximum likelihood method
[LN]=fitdist(WindData(WindData(:,s)>0 & WindData(:,s)<80,s),'Lognormal');     % lognormal
[EV]=fitdist(WindData(WindData(:,s)>0 & WindData(:,s)<80,s),'Extreme Value'); % Gumble (extreme value type)
[WB]=fitdist(WindData(WindData(:,s)>0 & WindData(:,s)<80,s),'Weibull');       % Weibull
[GE]=fitdist(WindData(WindData(:,s)>0 & WindData(:,s)<80,s),'gev');           % Frechet (generalized extreme value
type)

% Obtaining the wind speed for the return period
WSPT_LN = logninv(1-1/(Lambda*T),LN.mu,LN.sigma);
WSPT_EV = evinv(1-1/(Lambda*T),EV.mu,EV.sigma);
WSPT_WB = wblinv(1-1/(Lambda*T),WB.A,WB.B);
WSPT_GE = gevinv(1-1/(Lambda*T),GE.k,GE.sigma,GE.mu);

Dist=struct('LN',LN,'EV',EV,'WB',WB,'GE',GE);
DS=struct('LN',WSPT_LN,'EV',WSPT_EV,'WB',WSPT_WB,'GE',WSPT_GE);

%% Modeled vs Observed Wind Speed, Correlation Coefficient test for the accuracy

[ECDF,x]=ecdf(sort(WindData(WindData(:,s)>0,s)));

WSPT_LN_INV = logninv(ECDF(2:end-1),LN.mu,LN.sigma);
LN_R2=corr(x(2:end-1),WSPT_LN_INV)^2;

WSPT_EV_INV = evinv(ECDF(2:end-1),EV.mu,EV.sigma);
EV_R2=corr(x(2:end-1),WSPT_EV_INV)^2;

WSPT_WB_INV = wblinv(ECDF(2:end-1),WB.A,WB.B);
WB_R2=corr(x(2:end-1),WSPT_WB_INV)^2;

WSPT_GE_INV = gevinv(ECDF(2:end-1),GE.k,GE.sigma,GE.mu);
GE_R2=corr(x(2:end-1),WSPT_GE_INV)^2;

R2=struct('LN',LN_R2,'EV',EV_R2,'WB',WB_R2,'GE',GE_R2);

end
```

APPENDIX D: OPTIMOOR PRELIMINARY BOLLARD UPGRADES ANALYSIS

kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 14,000 TEU - MHHW

Arrangement for Thalassa Hellas at POT-PCT

Vessel Data for Thalassa Hellas

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\Thalassa Hellas.vsl)
Units in ft, inches, & kips
Longitudinal datum at Midship

LBP:1154.9
Breadth: 167.3
Depth: 97.9
Port Target: 0.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 18183 above deck level
Side projected windage area: 96828 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour		Longitudinal datum at Midship
X-dist	-583.0	571.4
Depth	97.9	97.9

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	571.4	51.9	0.0	78.6	350	20	5.7 pe 298	433 12.4 pp 322
2	576.8	47.8	0.0	74.3	350	20	5.7 pe 298	433 12.4 pp 322
3	605.4	16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
4	609.3	7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
5	609.3	-7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
6	605.4	-16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
7	576.8	-47.8	0.0	21.3	350	20	5.7 pe 298	433 12.4 pp 322
8	571.4	-51.9	0.0	24.5	350	20	5.7 pe 298	433 12.4 pp 322
9	-562.2	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
10	-568.7	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
11	-576.6	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
12	-583.0	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
13	-596.8	-42.0	0.0	17.5	350	20	5.7 pe 298	433 12.4 pp 322

14	-596.8	-26.6	0.0	39.8	350	20	5.7	pe	298	433	12.4	pp	322
15	-596.8	-19.8	0.0	50.6	350	20	5.7	pe	298	433	12.4	pp	322
16	-596.8	-4.1	0.0	0.0	350	20	5.7	pe	298	433	12.4	pp	322
17	-596.4	4.9	0.0	0.0	350	20	5.7	pe	298	433	12.4	pp	322
18	-596.8	26.9	0.0	39.7	350	20	5.7	pe	298	433	12.4	pp	322
19	-596.8	42.3	0.0	23.4	350	20	5.7	pe	298	433	12.4	pp	322
20	-583.0	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
21	-576.6	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
22	-568.7	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
23	-562.2	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
24	547.7	69.4	0.0	81.5	350	20	5.7	pe	298	433	12.4	pp	322
25	547.7	-69.4	0.0	51.1	350	20	5.7	pe	298	433	12.4	pp	322

Codes for Types of Line:
pe: polyester (broken-in)
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\PCT.bth)

Units in ft & kips

Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1279.6	38.7	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	440
F	-889.0	4.0	1.5	440
G	-814.0	4.0	1.5	440
H	-739.0	4.0	1.5	440
I	-664.0	4.0	1.5	440
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	440
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	440
*A	680.0	4.0	1.5	440
*B	760.0	4.0	1.5	440
*C	840.0	4.0	1.5	440
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1198.8	81.2	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3
ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for Thalassa Hellas at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 11.78 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 15.2
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 39.9 above Pier
Wind Speed: 25 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 26599
Total Side Windage Area:154920

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	0.69 (fwd)	0.07 (inw)	0.6° (port)	0.00 (up)
at its Port Target	-4.62 (aft)	-5.57 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-Z	1.51	136.8			-95°	175°	58.0	19%
2-Z	1.47	132.8			-95°	175°	48.4	16%
3-*A	1.34	124.9			-95°	175°	70.2	24%
4-*A	1.28	119.7			-90°	180°	63.3	21%
6-*B	2.37	203.7			-95°	175°	50.1	17%

7-*B	2.97	249.4		-95°	175°	41.0	14%
13-G	3.47	269.9		-110°	160°	54.2	18%
15-G	3.78	292.2		-110°	160°	41.2	14%
17-H	2.02	167.3		-110°	160°	73.6	25%
18-H	2.44	196.6		-120°	150°	41.1	14%
19-I	1.24	111.9		-105°	165°	135.5	45%
23-M	4.32	355.3		-100°	170°	53.4	18%
24-V	4.58	348.0		150°	60°	25.4	9%

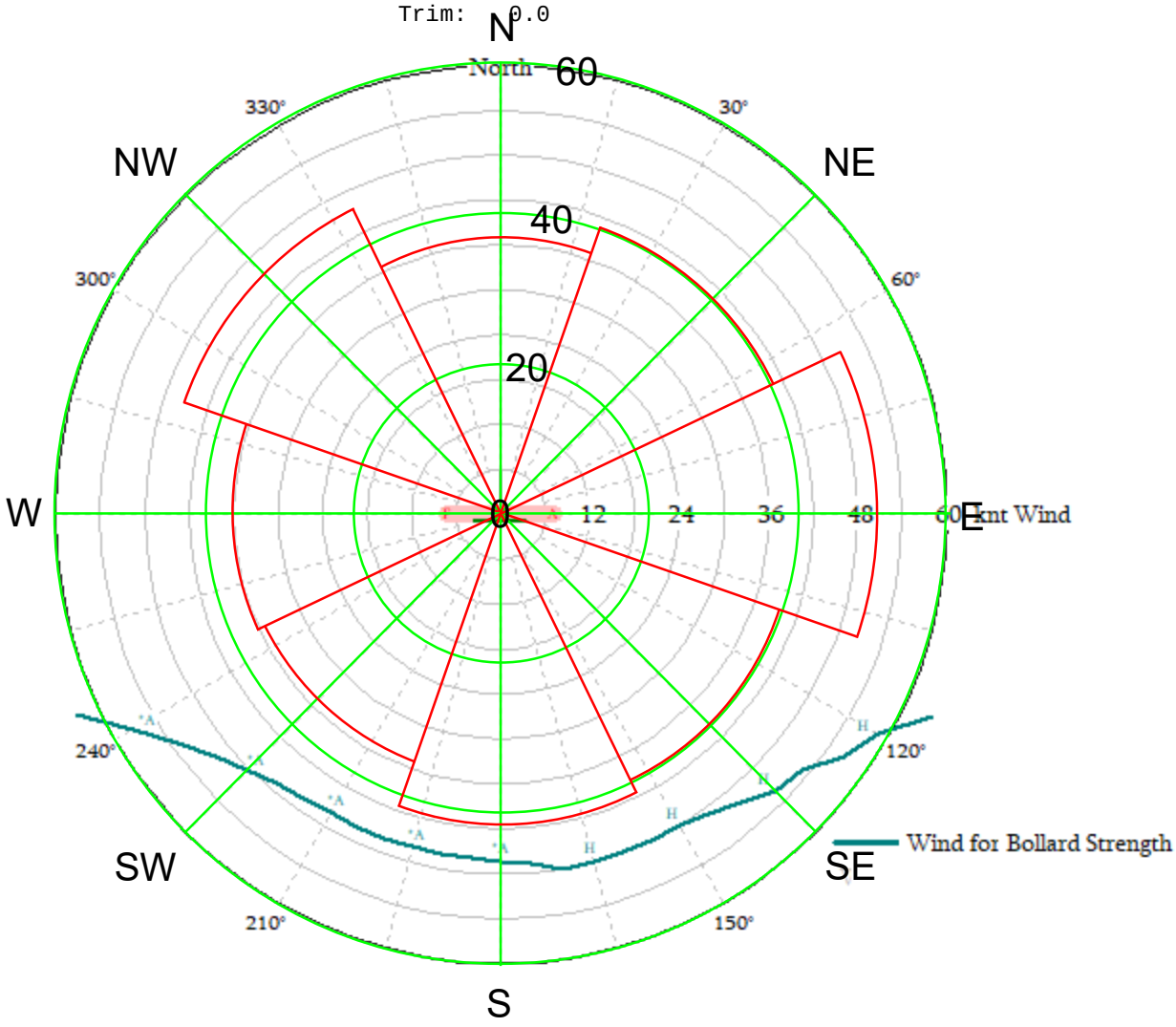
Fender	Thrust	Compression	Pressure	Flatside Cover
ff	27	0.08	0.9	100%
gg	27	0.07	0.9	100%
hh	26	0.07	0.8	100%
ii	26	0.07	0.8	100%
jj	25	0.07	0.8	100%
kk	25	0.07	0.8	100%
ll	25	0.07	0.8	100%
mm	25	0.07	0.8	100%
nn	25	0.07	0.8	100%
oo	26	0.07	0.8	100%
pp	26	0.07	0.8	100%
qq	28	0.08	0.9	100%
rr	29	0.08	0.9	100%
ss	31	0.09	1.0	100%
tt	33	0.09	1.1	100%
uu	35	0.10	1.1	100%
vv	37	0.10	1.2	100%
ww	39	0.11	1.3	100%
xx	41	0.12	1.3	100%
yy	44	0.13	1.4	100%

Hook/ Bollard	X- Force	Y- Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
G	80.3	49.4			95.4	22%	58°	14.4
H	94.2	58.6			114.0	26%	58°	26.0
I	91.8	83.0			135.5	31%	48°	55.7
M	-52.7	3.3			53.4	43%	-86°	8.2
V	25.0	1.7			25.4	20%	86°	3.6
Z	-52.8	64.1			106.3	24%	-39°	66.4
*A	-89.9	87.6			133.3	30%	-46°	45.0
*B	-74.0	50.4			91.1	21%	-56°	16.7

Approximate natural periods
Surge: 115 Sway: 75 Roll: 80 secs

Wind Capability Rose for Thalassa Hellas at POT-PCT

Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 11.78 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 14,000 TEU - MLLW

Arrangement for Thalassa Hellas at POT-PCT

Vessel Data for Thalassa Hellas

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\Thalassa Hellas.vsl)

Units in ft, inches, & kips

Longitudinal datum at Midship

LBP:1154.9
Breadth: 167.3
Depth: 97.9
Port Target: 0.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 18183 above deck level
Side projected windage area: 96828 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour		Longitudinal datum at Midship
X-dist	-583.0	571.4
Depth	97.9	97.9

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	571.4	51.9	0.0	78.6	350	20	5.7 pe 298	433 12.4 pp 322
2	576.8	47.8	0.0	74.3	350	20	5.7 pe 298	433 12.4 pp 322
3	605.4	16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
4	609.3	7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
5	609.3	-7.2	0.0	7.2	350	20	5.7 pe 298	433 12.4 pp 322
6	605.4	-16.1	0.0	16.0	350	20	5.7 pe 298	433 12.4 pp 322
7	576.8	-47.8	0.0	21.3	350	20	5.7 pe 298	433 12.4 pp 322
8	571.4	-51.9	0.0	24.5	350	20	5.7 pe 298	433 12.4 pp 322
9	-562.2	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
10	-568.7	-83.7	0.0	52.8	350	20	5.7 pe 298	433 12.4 pp 322
11	-576.6	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
12	-583.0	-83.7	0.0	27.7	350	20	5.7 pe 298	433 12.4 pp 322
13	-596.8	-42.0	0.0	17.5	350	20	5.7 pe 298	433 12.4 pp 322
14	-596.8	-26.6	0.0	39.8	350	20	5.7 pe 298	433 12.4 pp 322
15	-596.8	-19.8	0.0	50.6	350	20	5.7 pe 298	433 12.4 pp 322
16	-596.8	-4.1	0.0	0.0	350	20	5.7 pe 298	433 12.4 pp 322

17	-596.4	4.9	0.0	0.0	350	20	5.7	pe	298	433	12.4	pp	322
18	-596.8	26.9	0.0	39.7	350	20	5.7	pe	298	433	12.4	pp	322
19	-596.8	42.3	0.0	23.4	350	20	5.7	pe	298	433	12.4	pp	322
20	-583.0	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
21	-576.6	83.7	0.0	27.4	350	20	5.7	pe	298	433	12.4	pp	322
22	-568.7	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
23	-562.2	83.7	0.0	114.4	350	20	5.7	pe	298	433	12.4	pp	322
24	547.7	69.4	0.0	81.5	350	20	5.7	pe	298	433	12.4	pp	322
25	547.7	-69.4	0.0	51.1	350	20	5.7	pe	298	433	12.4	pp	322

Codes for Types of Line:
pe: polyester (broken-in)
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\PCT.bth)
Units in ft & kips
Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1279.6	38.7	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	440
F	-889.0	4.0	1.5	440
G	-814.0	4.0	1.5	440
H	-739.0	4.0	1.5	440
I	-664.0	4.0	1.5	440
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	440
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	440
*A	680.0	4.0	1.5	440
*B	760.0	4.0	1.5	440
*C	840.0	4.0	1.5	440
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1198.8	81.2	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-794.0	18.0	6.2	68.3

bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3
ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for Thalassa Hellas at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\2 PCT (14,000 TEU) - MIDDLE (sheet 1)\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 0.00 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 3.4
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 28.1 above Pier
Wind Speed: 25 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 26599
Total Side Windage Area:154920

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	0.68 (fwd)	0.08 (inw)	0.5° (port)	0.00 (up)
at its Port Target	-3.92 (aft)	-4.72 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-Z	1.43	130.1			-95°	175°	57.3	19%
2-Z	1.38	126.2			-90°	180°	47.4	16%
3-*A	1.31	121.4			-90°	180°	63.6	21%
4-*A	1.24	116.3			-90°	180°	57.3	19%
6-*B	2.36	201.7			-95°	175°	45.1	15%
7-*B	2.97	247.7			-90°	180°	37.5	13%
13-G	3.42	268.4			-110°	160°	48.7	16%
15-G	3.73	290.7			-115°	155°	37.9	13%

17-H	1.98	165.1		-110°	160°	65.3	22%
18-H	2.38	194.2		-120°	150°	37.9	13%
19-I	1.17	107.6		-105°	165°	123.6	41%
23-M	4.34	353.7		-100°	170°	48.0	16%
24-V	4.52	346.6		150°	60°	25.0	8%

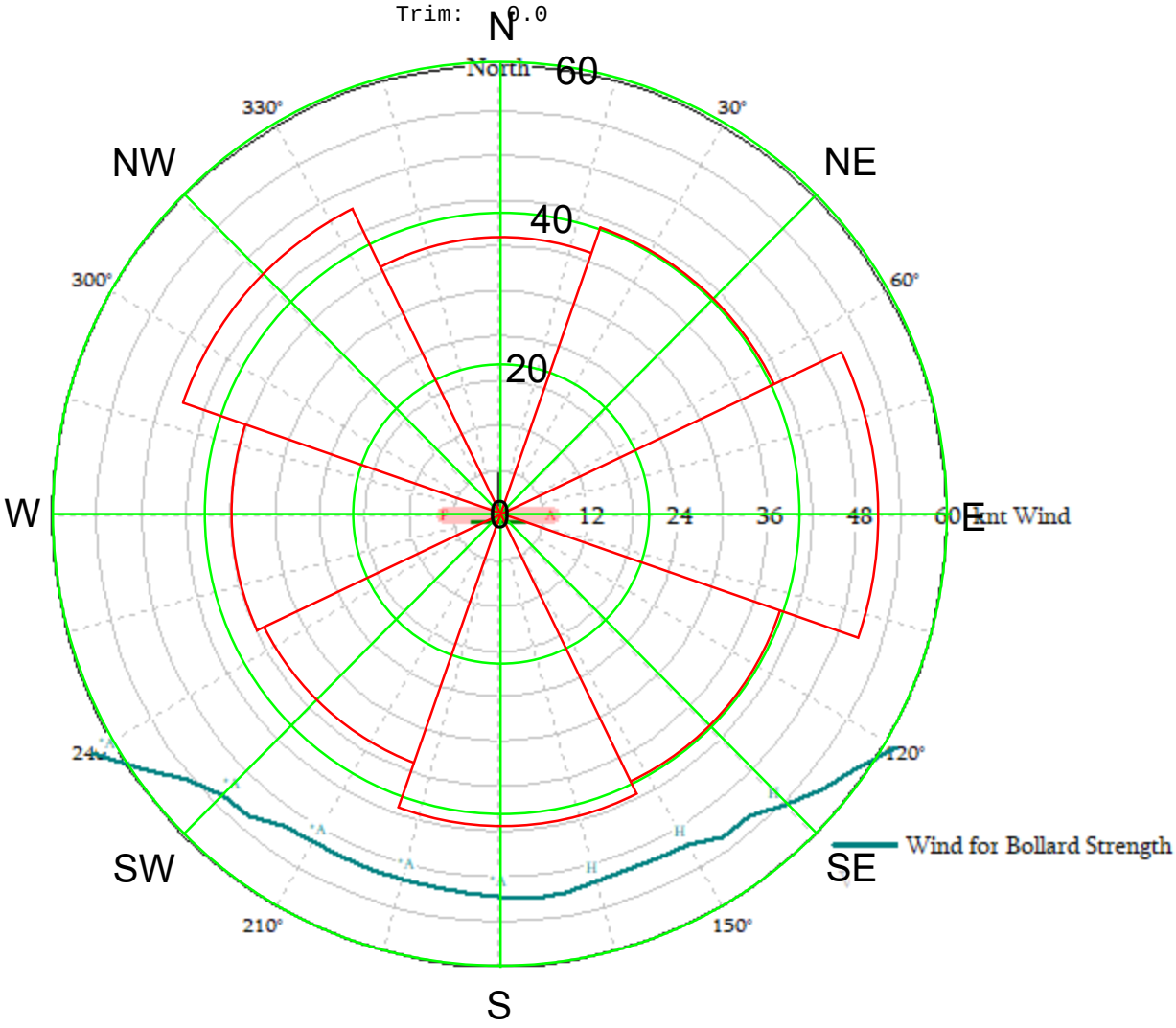
Fender	Thrust	Compression	Pressure	Flatside Cover
ff	27	0.08	0.9	100%
gg	27	0.08	0.9	100%
hh	26	0.07	0.8	100%
ii	26	0.07	0.8	100%
jj	25	0.07	0.8	100%
kk	25	0.07	0.8	100%
ll	25	0.07	0.8	100%
mm	25	0.07	0.8	100%
nn	25	0.07	0.8	100%
oo	26	0.07	0.8	100%
pp	26	0.07	0.9	100%
qq	28	0.08	0.9	100%
rr	30	0.08	1.0	100%
ss	32	0.09	1.0	100%
tt	33	0.09	1.1	100%
uu	35	0.10	1.1	100%
vv	38	0.11	1.2	100%
ww	40	0.11	1.3	100%
xx	42	0.12	1.4	100%
yy	44	0.13	1.4	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
G	73.6	44.5			86.5	20%	59°	9.1
H	86.5	52.3			102.4	23%	59°	16.5
I	89.1	77.4			123.6	28%	49°	37.1
M	-47.7	2.7			48.0	38%	-87°	5.1
V	24.9	1.7			25.0	20%	86°	2.5
Z	-57.3	71.0			104.5	24%	-39°	51.0
*A	-83.5	82.1			120.7	27%	-45°	29.2
*B	-67.6	46.3			82.6	19%	-56°	10.6

Approximate natural periods
Surge: 111 Sway: 95 Roll: 80 secs

Wind Capability Rose for Thalassa Hellas at POT-PCT

Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 0.00 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 20,000 TEU - MHHW

Arrangement for 20,000 TEU vessel at POT-PCT

Vessel Data for 20,000 TEU vessel

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\20,000 TEU Vessel.vsl)

Units in ft, inches, & kips

Longitudinal datum at Midship

LBP:1270.0
Breadth: 192.9
Depth: 107.9
Port Target: 43.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 21283 above deck level
Side projected windage area:123937 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour	Longitudinal datum at Midship	
X-dist	-641.1	628.3
Depth	107.9	107.9

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	587.6	75.0	0.0	32.5	350	1.2	18.1 pp 384	
2	634.7	43.0	0.0	37.2	350	1.2	18.1 pp 384	
3	656.0	5.6	0.0	23.8	350	1.2	18.1 pp 384	
4	656.0	-5.6	0.0	23.8	350	1.2	18.1 pp 384	
5	634.7	-43.0	0.0	37.2	350	1.2	18.1 pp 384	
6	587.6	-75.0	0.0	117.6	350	1.2	18.1 pp 384	
7	-624.5	-95.8	22.0	26.0	350	1.2	18.1 pp 384	
8	-636.7	-94.1	22.0	17.0	350	1.2	18.1 pp 384	
9	-655.1	-58.6	22.0	42.3	350	1.2	18.1 pp 384	
10	-655.1	-34.1	22.0	37.6	350	1.2	18.1 pp 384	
11	-655.1	-12.7	22.0	22.5	350	1.2	18.1 pp 384	
12	-655.1	12.7	22.0	22.5	350	1.2	18.1 pp 384	
13	-655.1	34.1	22.0	37.6	350	1.2	18.1 pp 384	
14	-655.1	58.6	22.0	42.3	350	1.2	18.1 pp 384	
15	-636.7	94.1	22.0	17.0	350	1.2	18.1 pp 384	
16	-624.5	95.8	22.0	26.0	350	1.2	18.1 pp 384	

Codes for Types of Line:
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\PCT.bth)
Units in ft & kips
Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1277.4	39.6	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	440
F	-889.0	4.0	1.5	440
G	-814.0	4.0	1.5	440
H	-739.0	4.0	1.5	440
I	-664.0	4.0	1.5	440
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	440
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	440
*A	680.0	4.0	1.5	440
*B	760.0	4.0	1.5	440
*C	840.0	4.0	1.5	440
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1193.1	82.3	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft²)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3
jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3

ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ss	64	186	288	320	301	282	282	288	253	263	kips

	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for 20,000 TEU vessel at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\PCT.opt)
Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 11.78 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 15.2
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 49.9 above Pier
Wind Speed: 25 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 32915
Total Side Windage Area:200518

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	3.17 (fwd)	0.07 (inw)	1.1° (port)	0.00 (up)
at its Port Target	-9.12 (aft)	-14.3 (out)	-0.1° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-V	0.24	302.5			150°	60°	19.2	5%
2-Z	0.08	112.7			-70°	200°	100.9	26%
3-*A	0.10	149.5			-70°	200°	122.2	32%
4-*B	0.13	211.3			-90°	180°	92.5	24%
5-*C	0.20	327.8			-95°	175°	51.1	13%
6-*C	0.28	464.3			-90°	180°	32.3	8%
9-E	0.28	359.8			-110°	160°	69.0	18%
10-E	0.27	343.5			-110°	160°	53.1	14%
11-F	0.20	255.1			-110°	160°	100.2	26%
12-F	0.19	243.9			-110°	160°	64.1	17%
13-G	0.14	188.4			-110°	160°	135.1	35%
16-L	0.18	302.5			-100°	170°	96.4	25%

Fender	Thrust	Compression	Pressure	Flatside Cover
dd	31	0.09	1.0	100%
ee	30	0.08	1.0	100%
ff	29	0.08	0.9	100%
gg	28	0.08	0.9	100%

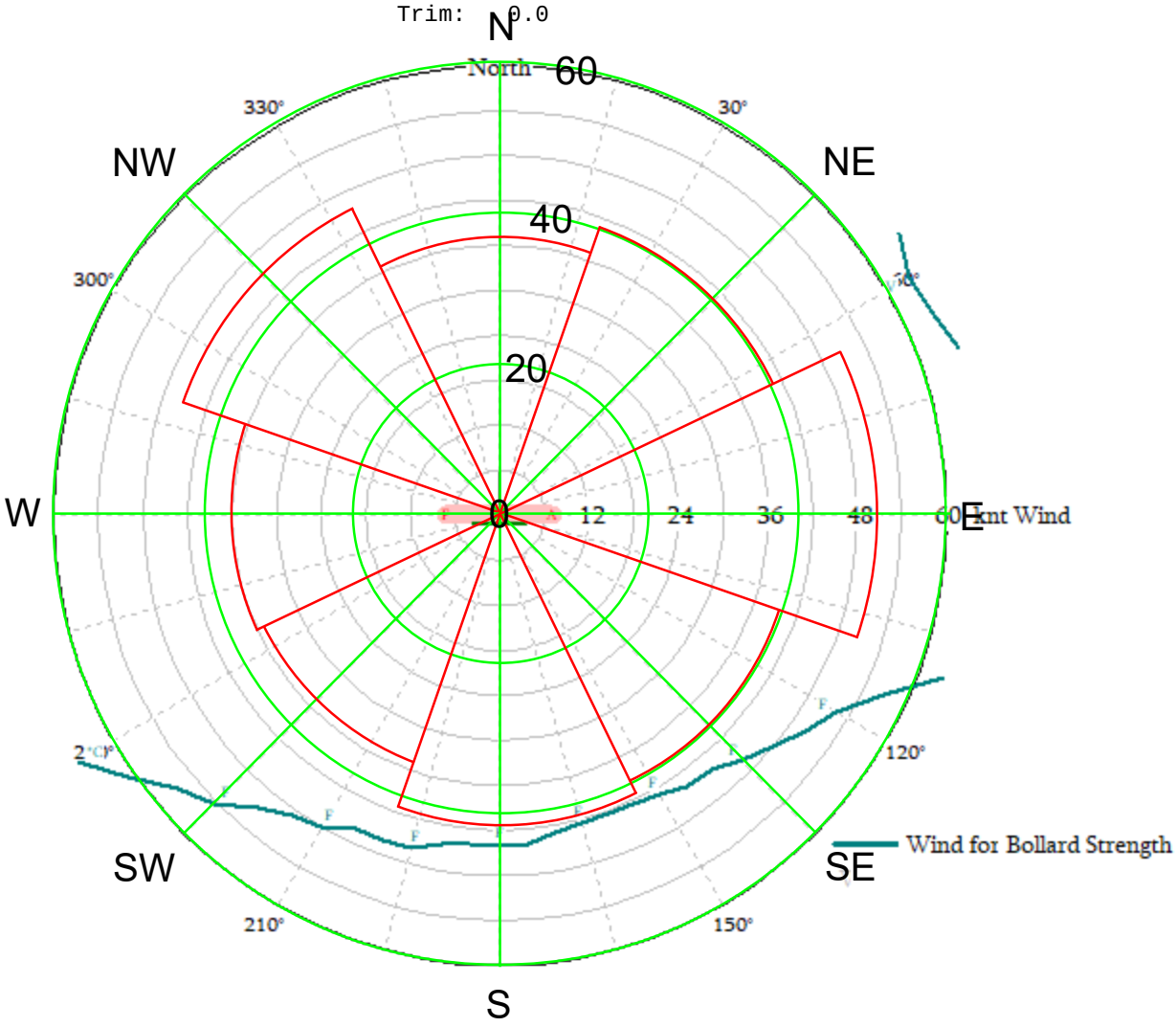
hh	27	0.08	0.9	100%
ii	26	0.07	0.8	100%
jj	26	0.07	0.8	100%
kk	25	0.07	0.8	100%
ll	24	0.07	0.8	100%
mm	23	0.07	0.8	100%
nn	23	0.06	0.7	100%
oo	23	0.06	0.7	100%
pp	23	0.07	0.8	100%
qq	24	0.07	0.8	100%
rr	25	0.07	0.8	100%
ss	26	0.07	0.8	100%
tt	27	0.08	0.9	100%
uu	28	0.08	0.9	100%
vv	29	0.08	0.9	100%
ww	30	0.08	1.0	100%
xx	31	0.09	1.0	100%
yy	33	0.09	1.1	100%
zz	37	0.10	1.5	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
E	98.6	66.8			122.1	28%	56°	26.7
F	127.8	90.7			164.2	37%	55°	48.9
G	91.5	79.7			135.1	31%	49°	59.6
L	-92.8	10.8			96.4	22%	-83°	23.6
V	18.8	1.8			19.2	15%	85°	3.4
Z	-19.9	77.6			100.9	23%	-14°	61.2
*A	-68.2	91.0			122.2	28%	-37°	44.8
*B	-73.3	51.5			92.5	21%	-55°	23.0
*C	-71.3	41.4			83.4	19%	-60°	12.7

Approximate natural periods
Surge: 182 Sway: 79 Roll: 91 secs

Wind Capability Rose for 20,000 TEU vessel at POT-PCT

Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 11.78 above datum
Draft: 47.6
Trim: 0.0



kpff	PROJECT	BY	SHEET NO.
	LOCATION	DATE	
	CLIENT		JOB NO.

PCT 20,000 TEU - MLLW

Arrangement for 20,000 TEU vessel at POT-PCT

Vessel Data for 20,000 TEU vessel

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\20,000 TEU Vessel.vsl)

Units in ft, inches, & kips

Longitudinal datum at Midship

LBP:1270.0
Breadth: 192.9
Depth: 107.9
Port Target: 43.0 fwd from midship -75.3 from CL and 0.0 above deck
Stbd Target: 0.0 fwd from midship 75.3 from CL and 0.0 above deck
End-on projected windage area: 21283 above deck level
Side projected windage area:123937 above deck level
Fendering possible from: 0.505 LBP aft of midship
to: 0.495 LBP fwd of midship
Current drag data based on: OPTIMOOR (Generic Data)
Wind drag data based on: Post-Panamax Container Ship
Hull Pressure Limit (kips/ft²): 3.1

Flatside Contour	Longitudinal datum at Midship	
X-dist	-641.1	628.3
Depth	107.9	107.9

Line No.	Fair-Lead X	Fair-Lead Y	Ht on Deck	Dist to Winch	Brake Limit	Pre-Tension	Line Size-Type-BL	Tail Segment-1 Lgth-Size-Type-BL
1	587.6	75.0	0.0	32.5	350	1.2	18.1 pp 384	
2	634.7	43.0	0.0	37.2	350	1.2	18.1 pp 384	
3	656.0	5.6	0.0	23.8	350	1.2	18.1 pp 384	
4	656.0	-5.6	0.0	23.8	350	1.2	18.1 pp 384	
5	634.7	-43.0	0.0	37.2	350	1.2	18.1 pp 384	
6	587.6	-75.0	0.0	117.6	350	1.2	18.1 pp 384	
7	-624.5	-95.8	22.0	26.0	350	1.2	18.1 pp 384	
8	-636.7	-94.1	22.0	17.0	350	1.2	18.1 pp 384	
9	-655.1	-58.6	22.0	42.3	350	1.2	18.1 pp 384	
10	-655.1	-34.1	22.0	37.6	350	1.2	18.1 pp 384	
11	-655.1	-12.7	22.0	22.5	350	1.2	18.1 pp 384	
12	-655.1	12.7	22.0	22.5	350	1.2	18.1 pp 384	
13	-655.1	34.1	22.0	37.6	350	1.2	18.1 pp 384	
14	-655.1	58.6	22.0	42.3	350	1.2	18.1 pp 384	
15	-636.7	94.1	22.0	17.0	350	1.2	18.1 pp 384	

16	-624.5	95.8	22.0	26.0	350	1.2	18.1 pp	384

Codes for Types of Line:
pp: polypropylene dry (broken-in)

Berth Data for POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\PCT.bth)

Units in ft & kips

Solid Pier Shields Wind

Left to Right of Screen Site Plan Points:	270°
Width of Channel (for Current):	800
Pier Height (Fixed) above Datum:	22.2
Seabed Depth in way of Ship below Datum:	51.0
Dist of Berth Target to Right of Origin:	0.0
Wind Speed Specified at Height:	32.8
Current Specified at Depth:	0.0

Hook/ Bollard	X-Dist to Origin	Dist to Fender Line	Ht above Pier	Allowable Load
A	-1277.4	39.6	1.5	350
B	-1131.6	4.0	1.5	125
C	-1089.0	4.0	1.5	125
D	-1039.0	4.0	1.5	125
E	-964.0	4.0	1.5	440
F	-889.0	4.0	1.5	440
G	-814.0	4.0	1.5	440
H	-739.0	4.0	1.5	440
I	-664.0	4.0	1.5	440
J	-589.0	4.0	1.5	125
K	-480.0	4.0	1.5	125
L	-400.0	4.0	1.5	440
M	-320.0	4.0	1.5	125
N	-240.0	4.0	1.5	125
O	-160.0	4.0	1.5	125
P	-120.0	4.0	1.5	125
Q	-80.0	4.0	1.5	125
R	-20.0	4.0	1.5	125
S	80.0	4.0	1.5	125
T	120.0	4.0	1.5	125
U	200.0	4.0	1.5	125
V	280.0	4.0	1.5	125
W	360.0	4.0	1.5	125
X	440.0	4.0	1.5	125
Y	520.0	4.0	1.5	125
Z	600.0	4.0	1.5	440
*A	680.0	4.0	1.5	440
*B	760.0	4.0	1.5	440
*C	840.0	4.0	1.5	440
*D	905.1	4.0	1.5	125
*E	949.3	4.0	1.5	125
*F	971.3	4.0	1.5	125
*G	1193.1	82.3	1.5	150

Fender	X-Dist to Origin	Ht above Datum	Width Along Side	Face Contact Area (ft^2)
aa	-794.0	18.0	6.2	68.3
bb	-744.0	18.0	6.2	68.3
cc	-694.0	18.0	6.2	68.3
dd	-644.0	18.0	6.2	68.3
ee	-594.0	18.0	6.2	68.3
ff	-544.0	18.0	6.2	68.3
gg	-500.0	18.0	6.2	68.3
hh	-440.0	18.0	6.2	68.3
ii	-380.0	18.0	6.2	68.3

jj	-340.0	18.0	6.2	68.3
kk	-300.0	18.0	6.2	68.3
ll	-240.0	18.0	6.2	68.3
mm	-180.0	18.0	6.2	68.3
nn	-120.0	18.0	6.2	68.3
oo	-80.0	18.0	6.2	68.3
pp	-20.0	18.0	6.2	68.3
qq	45.0	18.0	6.2	68.3
rr	100.0	18.0	6.2	68.3
ss	160.0	18.0	6.2	68.3
tt	220.0	18.0	6.2	68.3
uu	280.0	18.0	6.2	68.3
vv	340.0	18.0	6.2	68.3
ww	400.0	18.0	6.2	68.3
xx	460.0	18.0	6.2	68.3
yy	520.0	18.0	6.2	68.3
zz	580.0	18.0	6.2	68.3

Fender Load-Compression Data

aa	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
bb	64	186	288	320	301	282	282	288	307	320	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
cc	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
dd	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ee	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ff	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
gg	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
hh	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ii	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
jj	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
kk	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ll	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
mm	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
nn	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
oo	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
pp	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
qq	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
rr	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

ss	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
tt	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
uu	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
vv	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
ww	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
xx	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
yy	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft
zz	64	186	288	320	301	282	282	288	253	263	kips
	0.18	0.54	0.90	1.26	1.62	1.98	2.17	2.35	2.53	2.60	ft

Static Mooring Response for 20,000 TEU vessel at POT-PCT

(file C:\Users\njohal\KPFF, Inc\KPFF SPRC 2023 Projects - Documents\10092300204 POT WUT-PCT Bollard-Berthing Study\5.05 Structural\OPTIMOOR - Phase 2 - for bollard capacity\4 PCT (20,000 TEU) - MIDDLE (sheet 2)\PCT.opt)

Units in ft & kips

Remarks:

Static Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Water Level: 0.00 above Datum (initialised at this water level)
Draft: 47.60 (initialised at this draft))
Trim: 0.00 (initialised at this trim)
Bottom Clearance: 3.4
Fwd Offset of Vessel Target: 0.0 from Berth Target
Vessel Port Target: 38.2 above Pier
Wind Speed: 25 knots
Wind Direction from: All° (solid pier shields wind)

Total End-on Windage Area: 32915
Total Side Windage Area:200518

	Longitudinal	Transverse	Yaw Moment/LBP	
Movement of Vessel	3.03 (fwd)	0.07 (inw)	1.1° (port)	0.00 (up)
at its Port Target	-8.84 (aft)	-13.0 (out)	0.0° (stbd)	0.00 (up)

Line to Bollard	Pull -in	Tot.Line Length	In-Line ±Motion	Winch Slip	Worst Direction to Screen	True	Line Tension	Percent Strength
1-V	0.23	300.6			150°	60°	18.6	5%
2-Z	0.07	105.8			-70°	200°	89.7	23%
3-*A	0.09	145.5			-70°	200°	107.9	28%
4-*B	0.13	208.6			-90°	180°	83.8	22%
5-*C	0.20	326.1			-95°	175°	46.0	12%
6-*C	0.28	462.8			-90°	180°	28.9	8%
9-E	0.27	357.4			-110°	160°	62.2	16%
10-E	0.26	341.1			-110°	160°	47.5	12%
11-F	0.19	251.8			-110°	160°	91.1	24%
12-F	0.19	240.4			-115°	155°	57.0	15%
13-G	0.14	183.3			-110°	160°	126.9	33%
16-L	0.18	299.7			-100°	170°	93.3	24%

Fender	Thrust	Compression	Pressure	Flatside Cover
dd	31	0.09	1.0	100%
ee	30	0.08	1.0	100%

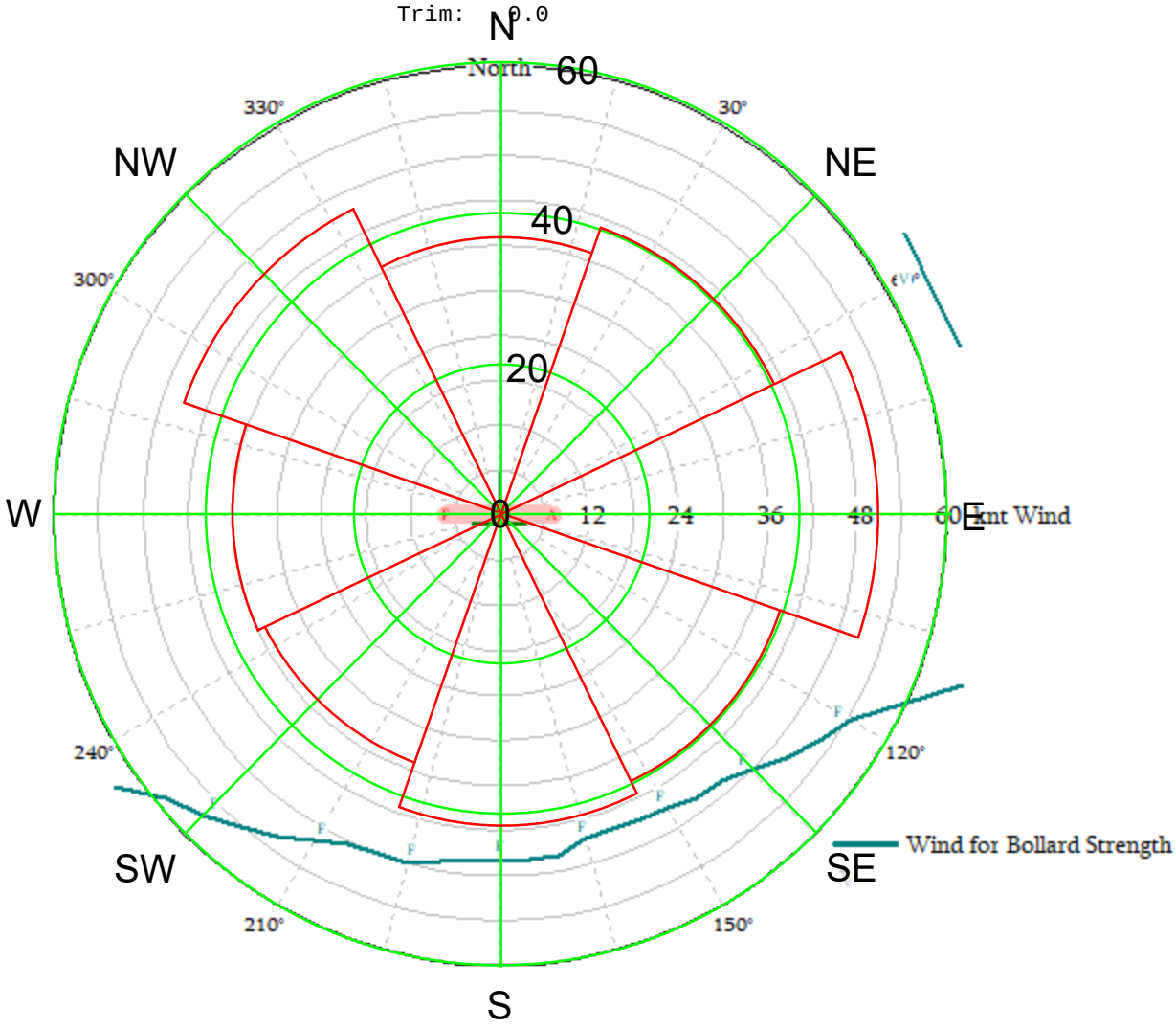
ff	29	0.08	0.9	100%
gg	28	0.08	0.9	100%
hh	27	0.08	0.9	100%
ii	26	0.07	0.8	100%
jj	26	0.07	0.8	100%
kk	25	0.07	0.8	100%
ll	24	0.07	0.8	100%
mm	23	0.07	0.8	100%
nn	23	0.06	0.7	100%
oo	23	0.06	0.7	100%
pp	23	0.07	0.8	100%
qq	24	0.07	0.8	100%
rr	25	0.07	0.8	100%
ss	26	0.07	0.8	100%
tt	27	0.08	0.9	100%
uu	28	0.08	0.9	100%
vv	29	0.08	0.9	100%
ww	30	0.09	1.0	100%
xx	32	0.09	1.0	100%
yy	33	0.09	1.1	100%
zz	38	0.11	1.5	100%

Hook/ Bollard	X-Force	Y-Force	Other X-Load	Other Y-Load	Total Force	%Bollard Strength	Direction in Plan	Bollard Uplift
E	89.6	59.9			109.6	25%	56°	20.2
F	117.2	82.0			147.9	34%	55°	37.4
G	89.4	76.1			126.9	29%	50°	48.4
L	-90.8	10.0			93.3	21%	-84°	19.3
V	18.4	1.7			18.6	15%	85°	2.5
Z	-19.4	74.8			89.7	20%	-15°	45.5
*A	-62.4	82.4			107.9	25%	-37°	31.0
*B	-67.5	47.1			83.8	19%	-55°	16.0
*C	-64.4	37.2			74.9	17%	-60°	8.7

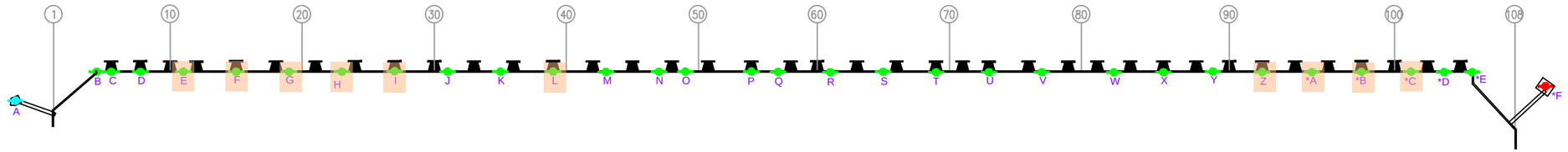
Approximate natural periods
Surge: 178 Sway: 101 Roll: 91 secs

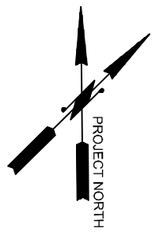
Wind Capability Rose for 20,000 TEU vessel at POT-PCT

Analysis for Time: 1314 Jan 03 2024 (initialised at 1314 Jan 03 2024)
Ref:
Remarks: Remarks:
Water Level: 0.00 above datum
Draft: 47.6
Trim: 0.0



APPENDIX E: SUMMARY OF BOLLARD UPGRADES





WHARF PLAN

SCALE: 3/16" = 1'-0"

UPGRADED BOLLARD - 440 KIP

LEGEND:

- FENDER UNIT
- EXISTING 125 KIPS PIER BOLLARD
- EXISTING 150 KIPS WEST DOLPHIN BOLLARD
- EXISTING 350 KIPS EAST DOLPHIN BOLLARD

kpff
2407 North 31st Street, Suite 100
Tacoma, Washington 984087
(253) 386-0150 Fax (253) 396-0162

PCT

DATE: 2024-07-03 | SCALE: AS SHOWN

DRAWN BY: GM | SHT 1 OF 1

Plotted: Jul 03, 2024 - 4:07pm gmachuca Layout: POT WHARF PLAN
X:\2023\10092300204 POT Bollard-Berthing Study for PCT\6.01 Drawings\Exhibits\2024-01-03_PCT WHARF PLAN.dwg

APPENDIX F: PRLIMINARY BOLLARD UPGRADES COST ESTIMATE

POT PCT Bollard Study
Preliminary Bollard Upgrade Concept
Rough Order of Magnitude Engineer's Opinion of Probable Cost

July 5, 2024

	Item	Quantity	Unit	Unit Cost	Amount
Section A - Mobilization and Demobilization					
1	Mobilization & Demobilization *(22.5% of total)*	1	LS	$413,640	$413,700
	Subtotal - Section A - Mobilization and Demobilization				**$413,700**
Section B - Removal and Demolition					
2	Existing bollard removal	1	LS	$4,200	$4,200
3	Concrete and paving demo	1	LS	$455,300	$455,300
	Subtotal - Section B - Removal and Demolition				**$459,500**
Section C - Bollard Installation					
4	Furnish and install (10) 200-ton bollards	10	EA	$8,110	$81,100
	Subtotal - Section C - Bollard Installation				**$81,100**
Section D - Wharf Strengthening					
5	CIP concrete placement	268	CY	$3,500	$938,900
6	Ballast placement	200	CY	$150	$30,100
7	6" pavement placement	3080	SF	$10	$30,800
8	Furnish (8) 6' wide prestress haunched panels	8	EA	$11,000	$88,000
9	Furnish (12) 5' wide prestress haunched panels	12	EA	$9,167	$110,000
10	Install (20) prestress haunched panels	1	LS	$40,000	$40,000
	Subtotal - Section D - Wharf Strengthening				**$1,237,800**
Section E - Existing Fender Removal and Reinstallation					
11	Existing fender removal and reinstallation	5	EA	$12,000	$60,000
	Subtotal - Section E - Existing Fender Removal and Reinstallation				**$60,000**
	Subtotal Construction Cost				**$2,252,100**
	Design & Construction Contingency 40%				**$900,840**
	Sales Tax 10.2%				**$229,714**
	Consultant Design Fees				**$275,000**
	Total Rough Order of Magnitude Engineer's Opinion of Probable Cost (2024$)				**$3,657,700**

Notes:

1 All amounts are rounded.
2 Contingency is intended to account for the concept level of the design
3 Assume no additional piles are needed.