Appendix B OMC International - Mooring Study

PORT KEMBLA OUTER HARBOUR MOORING STUDY

PREPARED FOR

AECOM AUSTRALIA PTY LTD

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OMC International Pty Ltd
ABN 77 066 709 724
6 Paterson Street, Abbotsford
Victoria Australia 3067

Ph: +61 3 9412 6500
Fx: +61 3 9415 9105
admin@omc-international.com
www.omc-international.com

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CONTENTS

1 Introduction

AECOM Australia Pty Ltd (AECOM) has commissioned OMC International (OMC) to undertake a numerical modelling study at the proposed outer harbour berth at Port Kembla, New South Wales.

The report summarises a numerical modelling study of dynamic vessel motions, mooring line tensions and fender deflections for the design container vessel, cargo vessel and tug boat moored at the proposed berths in a number of environmental design long wave (seiching) conditions.

The design environmental conditions for the berth were supplied by AECOM.

The core component of the study consisted of time-domain simulation runs for each vessel representing combinations of loading states, mooring configurations, wave conditions and wind speeds.

All dynamic simulations of vessel motions, mooring line tensions and anchor loads have been undertaken using the numerical ship motion model, **SPMS** (**S**imulation **M**odel for the **M**otions of **S**hips), developed by Dr. W.T. O'Brien of OMC International Pty Ltd. Dual frequency DGPS equipment has been used to measure full-scale vessel motions and squat of free moving vessels and validate the accuracy of the predictive models used in the SPMS/DUKC systems installed in several Australian ports.

In addition, a major calibration and validation program for the SPMS moored ship model has been completed during 1998/99 for two vessels at Port Taranaki on the west coast of New Zealand. This exercise involved DGPS measurement of moored ship motions, direct measurement of line tensions and collection of short and long wave data at the berth. These data were used to fine tune the model and provide full confidence in its ability to predict moored vessel response in sea, swell and long waves.

A general description of the **SPMS** model is given in Appendix A.

2 Study Data

2.1 Site Location

The mooring analyses have been carried out at Port Kembla Outer Harbour for the following locations, as depicted in Figure 2.1 (Maunsell Dr. 60039301-SK-066):

- Location 1: Container Vessel
- Location 2 & 4: Cargo Vessel
- Location 3: Tug Boat

2.2 Vessel Data

The principal dimensions and mass properties of the design vessels used in the modelling study are summarised in Table 2.1 below. These have been based on the design vessel characteristics provided by AECOM in the Port Kembla Outer Harbour Development Brief (Reference 1).

Table 2.1 Properties of Design Vessels

Properties	**Container Vessel**	**Cargo Vessel**	**Tug Boat**
Length overall (m)	318.2	229.0	35.0
Length between perpendiculars (m)	300.0	221.0	32.0
Beam (m)	50.0	36.6	12.0
Moulded depth (m)	22.0	19.3	5.3
Laden Draft Condition			
Displacement (t)	135,486	85,300	890
Draft (m)	14.0	13.6	5.0
KG (m)	21.0	12.0	4.9
GM_f (m)	2.5	3.4	1.5
Ballast Draft Condition			
Displacement (t)	97,357	-	-
Draft (m)	10.0	-	-
KG (m)	17.1	-	-
GM_f (m)	11.4	-	-

KG = Keel to centre of mass

GM_f (m) = Centre of mass to metacentre

2.3 Environmental Data

Low frequency wave spectra have been provided at each of the defined locations by AECOM based on modelling work undertaken by Cardno Lawson Treloar.

No swell or current data have been considered in the analyses. A scenario for wind loading alone has been considered for the Cargo vessel only.

Location 1:

Two low frequency wave spectra provided at the Location 1 berth are plotted in Figure 2.2.

A summary of the wave conditions for each option is given as:

Spectrum 1:

$H_{s\ Long}$ = 0.23 m; $Tp_{\ Long}$ = 58.0 sec

Spectrum 2:

$H_{s\ Long}$ = 0.20 m; $Tp_{\ Long}$ = 74.0 sec

The wave direction for all cases was assumed to be along the berth onto the bow of the moored vessel.

Location 2:

Two low frequency wave spectra provided at the Location 2 berth are plotted in Figure 2.3.

A summary of the wave conditions for each option is given as:

Spectrum 1:

$H_{s\ Long}$ = 0.15 m; $Tp_{\ Long}$ = 58.0 sec

Spectrum 2:

$H_{s\ Long}$ = 0.13 m; $Tp_{\ Long}$ = 68.0 sec

The wave direction for all cases was assumed to be along the berth onto the bow of the moored vessel.

For one scenario, a wind speed of 40 m/s onto the beam of the vessel blowing the vessel off the fenders has been assumed, with no concurrent long wave loading.

Location 3:

Two low frequency wave spectra provided at the Location 3 berth are plotted in Figure 2.4.

A summary of the wave conditions for each option is given as:

Spectrum 1:

$H_{s\ Long}$ = 0.33 m; $Tp_{\ Long}$ = 56.0 sec

Spectrum 2:

$H_{s\ Long}$ = 0.42 m; $Tp_{\ Long}$ = 160.0 sec

The wave direction for all cases was assumed to be along the berth onto the stern of the moored tug.

Location 4:

Two low frequency wave spectra provided at the Location 4 berth are plotted in Figure 2.5. These represent spectra for the Existing and Developed Harbour scenarios.

A summary of the wave conditions is given as:

Spectrum 1 for the Developed Harbour:

$H_{s\ Long}$ = 0.22 m; $Tp_{\ Long}$ = 60.0 sec

Spectrum 1 for the Existing Harbour:

$H_{s\ Long}$ = 0.25 m; $Tp_{\ Long}$ = 58.0 sec

The wave direction was assumed to be along the berth onto the bow of the moored vessel.

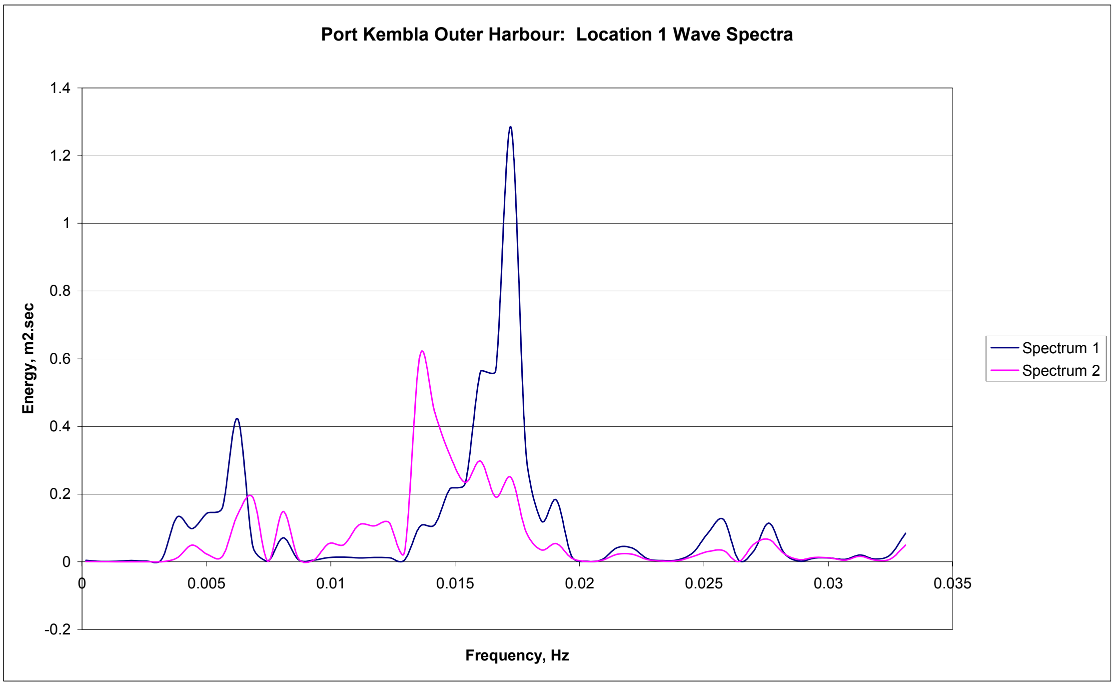


Figure 2.2 Location 1 Wave Spectra

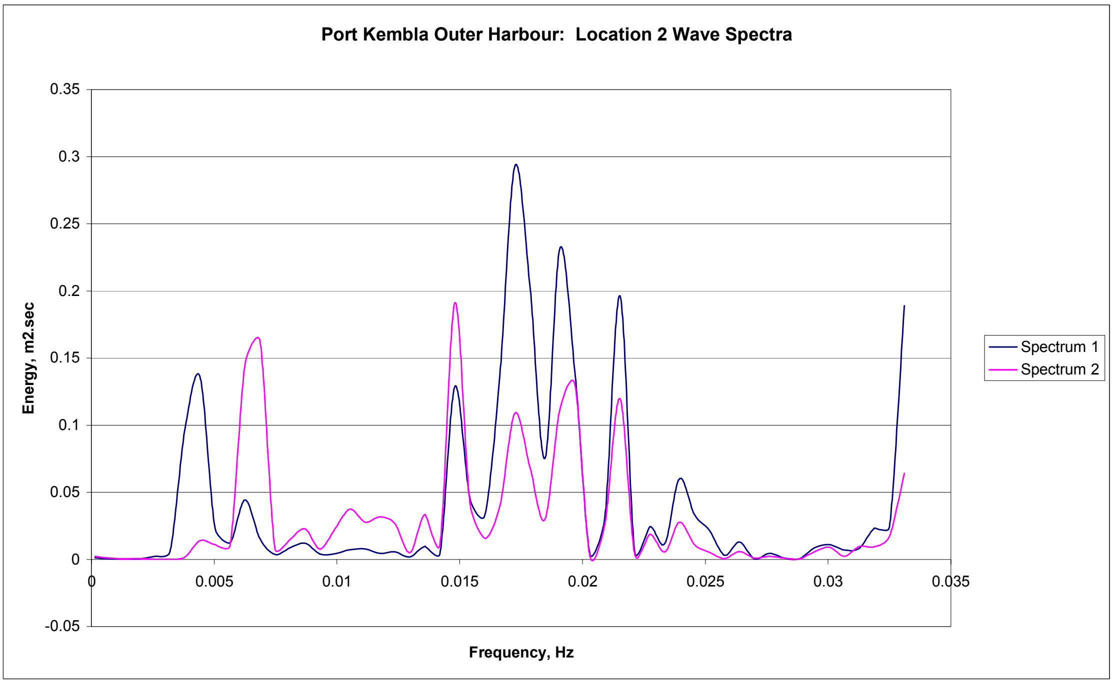


Figure 2.3 Location 2 Wave Spectra

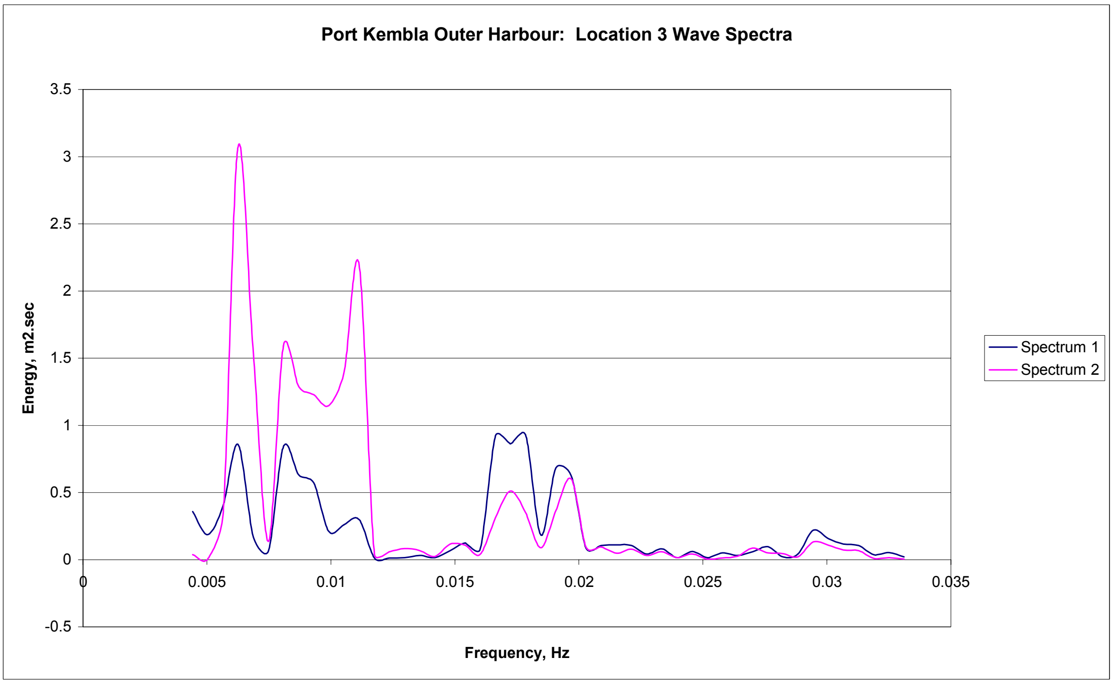


Figure 2.4 Location 3 Wave Spectra

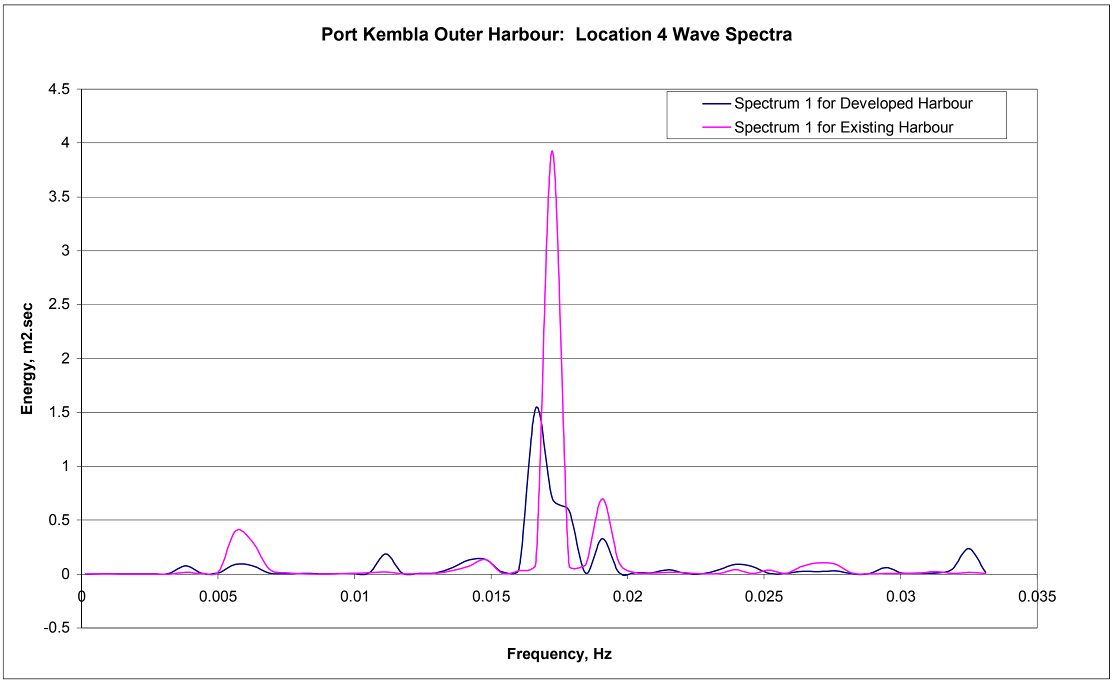


Figure 2.5 Location 4 Wave Spectra

2.4 Water Level Data

All modelling has been done at MHWS.

2.5 Mooring Data

The mooring line types modelled are summarised in Table 2.2 below. The 88mm polypropylene lines have been used for the container and cargo vessels, with the 40mm polypropylene lines used for the tug boat.

Typical mooring data were utilised, together with Guaranteed Minimum Breaking Loads (GMBL) for the selected size. Minimum breaking loads are based on data provided by rope manufacturers (Marlow Ropes). Load/extension data supplied by the manufacturer for worked ropes were used in all runs.

Line pretensions of 8 tonnes were used for the container and cargo vessels, with 0.4 tonnes used for the tug boat.

Table 2.2: Mooring Line Data

Type	% Extens @ 50% GMBL	Diam. mm	Weight, Kg/100m	GMBL, Tonne
Polypropylene "Nelson"	7.5 7.5	88.0 40.0	351 72	90.6 20.5

2.6 Fender Data

Container and Cargo Vessel (Location 2)

SUC1250 RH Fenders were used in the analyses. Rated Reaction = 90.4t @ 52.5% deflection.

The fenders are spaced at 20m intervals as depicted in Maunsell Drawing 60039301-SK-066. The fenders are referenced from stern to bow in the results.

Tug Boat

Continuous 300 x 300 DD series Fenders were used in the analyses. Rated Reaction = 23.4t @ 50.0% deflection.

Cargo Vessel (Location 4)

Continuous 380 x 190 Cylindrical Fenders were used in the analyses. Rated Reaction = 16.7t @ 100.0% deflection (ID).

2.7 Mooring Configuration

The mooring configurations are shown in Figures 2.6, 2.7 and 2.8 for the container vessel, cargo vessel and tug boat respectively. As depicted in these Figures, the mooring lines are referenced from stern to bow in the results.

For the container vessel, 16 mooring lines have been modelled utilising a 4-2-2-2-2-2-4 arrangement, i.e.:

- 4 head and stern lines;
- 2 fore and aft breast lines;
- 2 fore and aft spring lines;

For the cargo vessel, 12 mooring lines have been modelled utilising a 3-2-1-1-2-3 arrangement, i.e.:

- 3 head and stern lines;
- 2 fore and aft breast lines;
- 1 fore and aft spring line;

For the tug boat, 4 mooring lines have been modelled, i.e.:

- 2 fore and aft breast lines;

2.8 Limit Criteria

Vessel Motions:

A common measure of limiting vessel motions involves use of maximum allowable H_{10} centroidal motions (surge, sway, heave, roll, pitch and yaw), defined as the mean of the 10% largest *double* amplitude (eg. peak to peak) motions recorded during each simulation run (except sway which is single amplitude).

Table 2.3 defines the assumed container vessel limiting values based on the criteria from PIANC (Reference 2) for 100% and 50% efficiency of loading.

Table 2.3: Container Vessel Limiting Centroidal Vessel Motions *(H10 Double Amplitude*)*

Efficiency	Surge, m	Sway, m	Heave, m	Roll, Deg	Pitch, Deg	Yaw, Deg
100%	1.0	0.6	0.8	3.0	1.0	1.0
50%	2.0	1.2	1.2	6.0	2.0	1.5

** Note the motions are peak to peak except for sway which is single amplitude*

Table 2.4 defines the assumed cargo vessel limiting values based on the criteria from PIANC (Reference 2).

Table 2.4: Cargo Vessel Limiting Centroidal Vessel Motions *(H10 Double Amplitude*)*

Surge, m	Sway, m	Heave, m	Roll, Deg	Pitch, Deg	Yaw, Deg
2.0	1.5	1.0	5.0	2.0	3.0

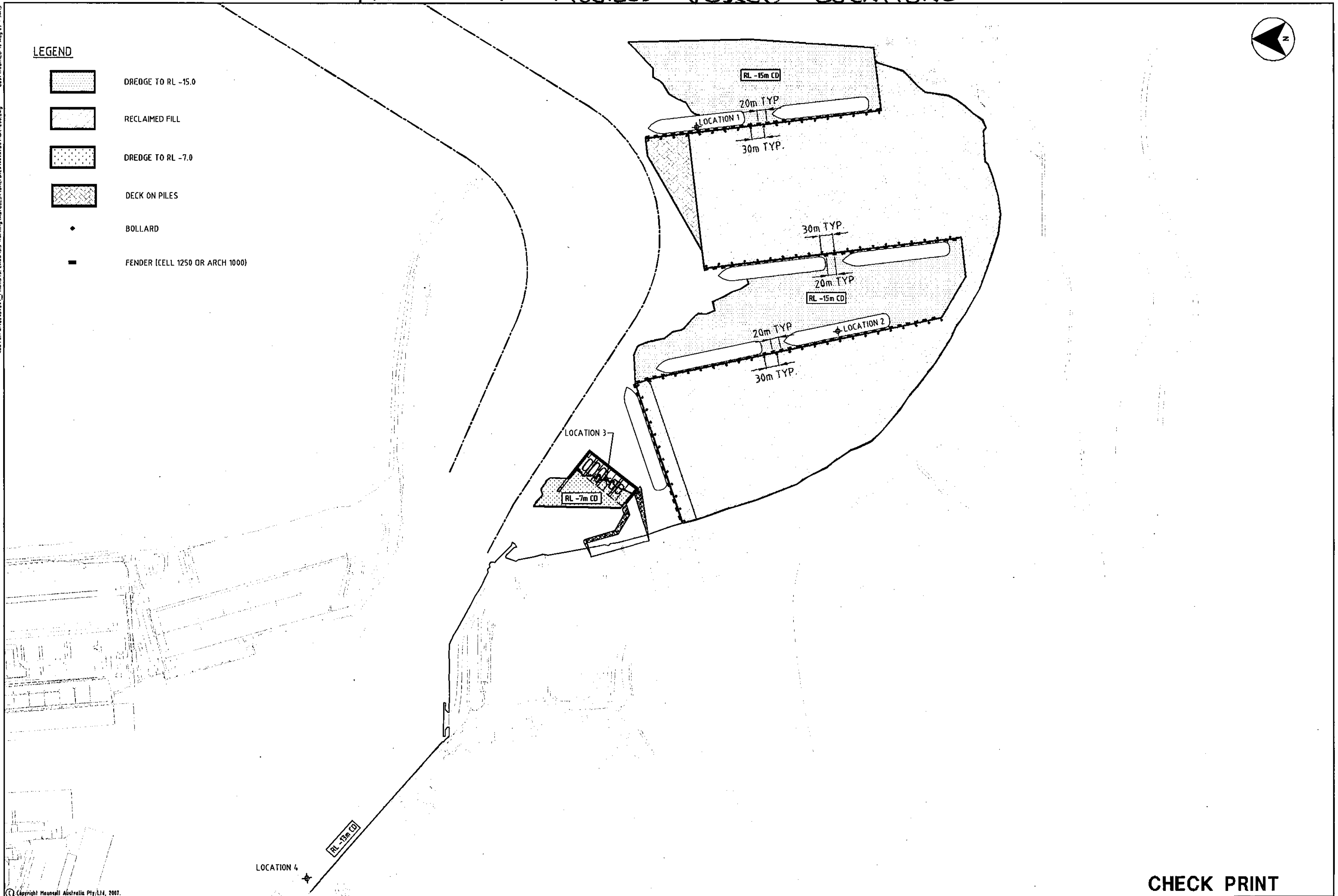
** Note the motions are peak to peak except for sway which is single amplitude*

Limiting motions for the tug boat have not been provided.

Mooring Lines Tensions - based on generally accepted practice, peak mooring line tensions should not exceed 55% of the Guaranteed Minimum Breaking Load (GMBL).

Fender Deflections - maximum fender deflections should not exceed the maximum deflections set by the fender manufacturer for the particular type of fender.

FIGURE 2.1 MOORED VESSEL LOCATIONS



REVISION IN PROGRESS

No	BY	DATE	DESCRIPTION	APPD

THE SIGNING OF THIS TITLE BLOCK CONFIRMS THE DESIGN AND DRAFTING OF THIS PROJECT HAVE BEEN PREPARED AND CHECKED IN ACCORDANCE WITH THE MAUNSELL QUALITY ASSURANCE SYSTEM TO ISO 9001-2000

DESIGNED	PF	CHECKED	
DRAWN	MT	CHECKED	PAS
APPROVED		DATE	

SCALES: 25 0 50 100m — 1:2500 FULL SIZE A1

CHECK PRINT — PRELIM / FINAL — INITIAL / DATE

DISCIPLINE
DISCIPLINE
DISCIPLINE
DISCIPLINE
BACKDRAFTED/CORRECTED
CONFIRMED

DESIGN BY: MAUNSELL | AECOM
Maunsell Australia Pty Ltd
A.B.N. 20 093 846 925

PORT KEMBLA OUTER HARBOUR DREDGING

OPTION 3D
MOORING ASSESSMENT LAYOUT

STATUS: SKETCH
DRAWING NO: 60039301-SK-066
REV:

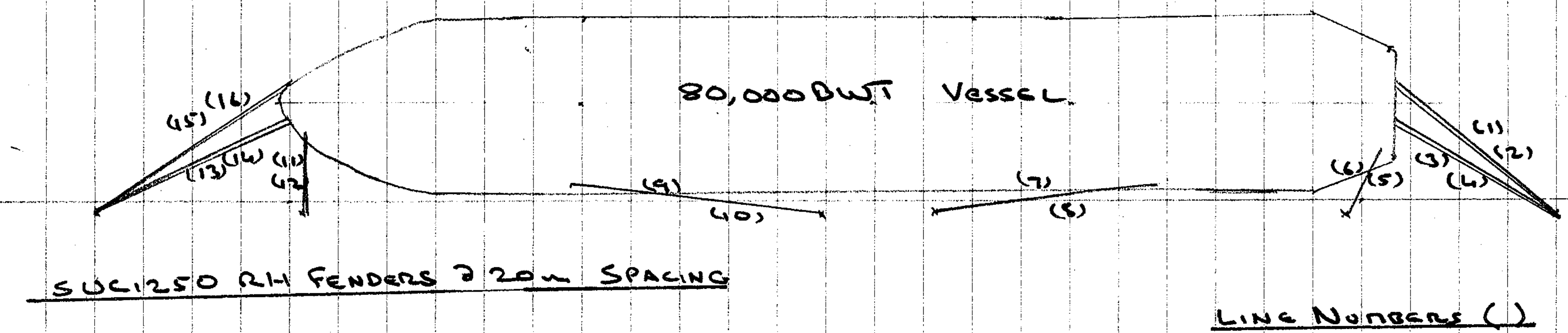
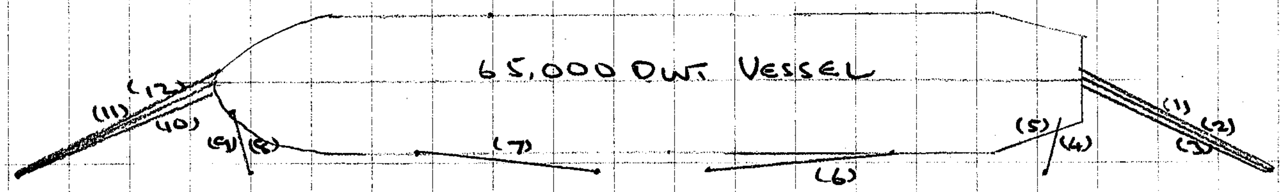


FIGURE 2.5 PORT KEMBLA OUTER HARBOUR

80,000 DWT CONTAINER VESSEL - LOCATION 1



SUC1250 RH FENDERS @ 20m SPACING (LOCATION 2)

CYLINDRICAL 380×190 CONTINUOUS FENDERS (LOCATION 4)

LINE NUMBERS ( )

FIGURE 2.7 PORT KEMBLA OUTER HARBOUR

65,000 DWT CARGO VESSEL

project: PORT KEMBLA OUTER HARBOUR DEVELOPMENT
page: 1
by: J. Opkar
file/ref no: TUG BOAT ARRANGEMENT AT LOCATION 3.
date: 16/7/2009

NOT TO SCALE

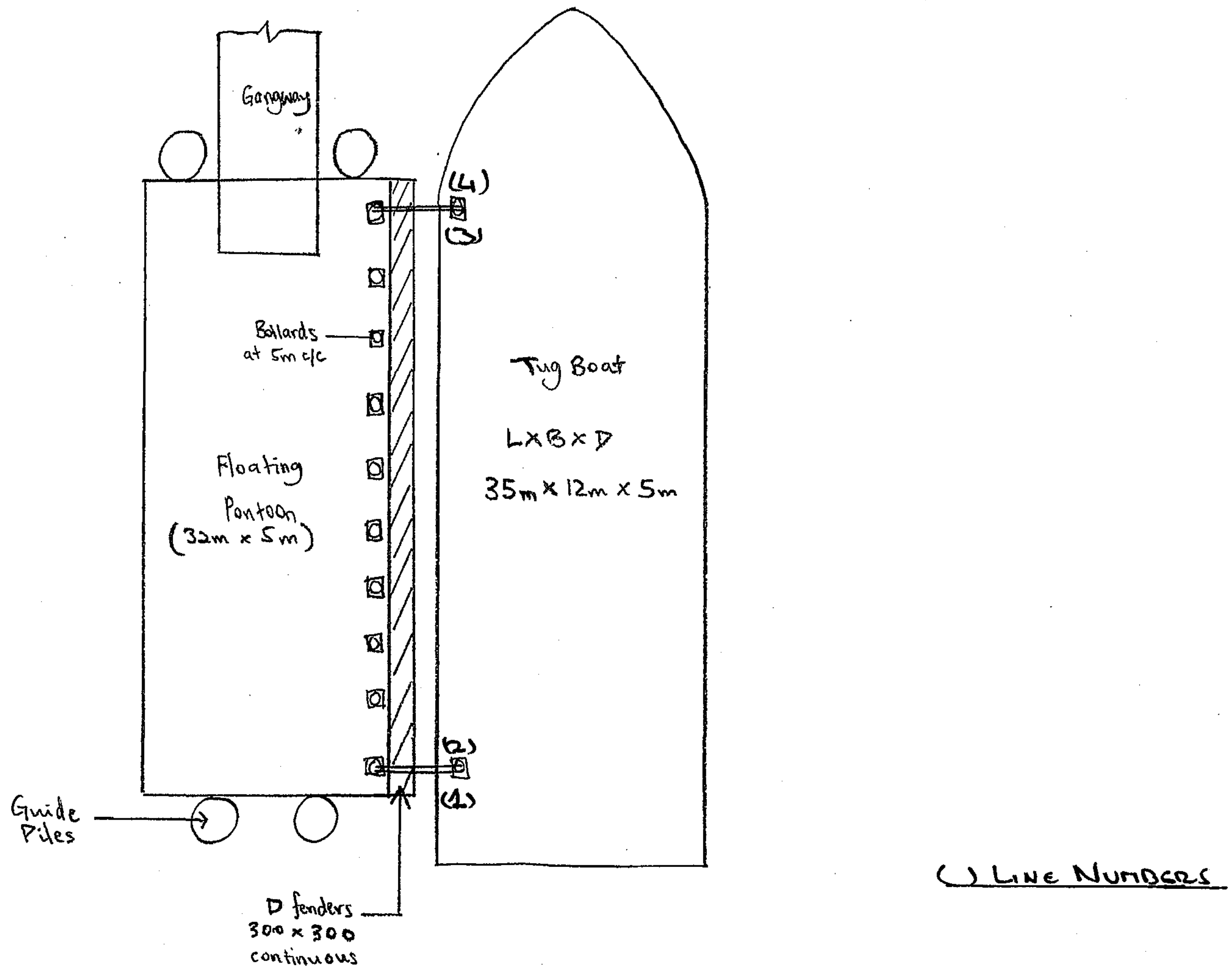


FIGURE 2.8 PORT KEMBLA OUTER HARBOUR TUG BOAT

3 Study Method

The design vessel hull shapes for the container and cargo vessel and tug boat were modelled numerically for the specified loading conditions, using body plans for the hull obtained from typical vessels.

Frequency-domain analyses were undertaken to compute hydrodynamic coefficients (added mass and damping) in six degrees-of-freedom for the range of frequencies relevant to the specified wave spectra and for the appropriate vessel draft and water depth. These *frequency-dependent* added mass and damping coefficients were then used to compute *frequency-independent* added mass and retardation functions, using impulse response functions and convolution integrals. Further frequency-domain analyses were undertaken to compute wave exciting force coefficients and phasing for waves approaching from the dominant wave direction (head-on to the vessel) and for wave directions corresponding to the directional spread of wave energy (standard deviation of spreading = 38^{o}). The *frequency-independent* added mass and retardation functions and the directional wave exciting force coefficients and phasing obtained for each vessel draft were used in time-domain simulations of vessel displacements, mooring line tensions and fender reactions for that vessel load condition.

Time-domain analyses were undertaken for six degrees-of-freedom motions of the moored vessel for the various combinations of vessel loading state and wave spectrum. Each computer run comprised 15 tests with different irregular wave trains, each test having waves with the same spectral energy but different surface profiles. The duration of each test was equivalent to 3000 seconds of prototype time, with the first 300 seconds being used for model "start-up". Time steps of 0.125 second were used in all runs.

The actual nonlinear stiffness characteristics of mooring lines and fenders were used in all time-domain analyses.

The maximum vessel motions, peak mooring line tensions and fender deflections obtained during each test were analysed using an Extreme Value Type I analysis to provide mean and 5% probability of exceedance values for the run i.e. values which would be expected to be exceeded once in every 20 tests.

4 Summary of Computer Runs

Ten (10) time-domain simulation runs have been carried out for the design vessels for the various combinations of locations, vessel loading states and wave spectrum, as specified in Table 4.1. Each run comprised 15 tests, each test simulating a different irregular wave train with the same spectral energy but different surface profiles. One (1) static analysis has been undertaken for design wind loading only (Run 303).

Table 4.1 Summary of Computer Runs

Run No.	Vessel Type	Laden State	Loading State: Wave Spectrum (WS)/ Wind	Hs Long (m)	Tp Long (s)	Wind (m/s)
101	Container	Laden	WS #1 (Loc.1)	0.23	58	-
102	Container	Laden	WS #2 (Loc.1)	0.20	74	-
201	Container	Ballast	WS #1 (Loc.1)	0.23	58	-
202	Container	Ballast	WS #2 (Loc.1)	0.20	74	-
301	Cargo	Laden	WS #1 (Loc.2)	0.15	58	-
302	Cargo	Laden	WS #2 (Loc.2)	0.13	68	-
303	Cargo	Laden	Wind only	-	-	40
401	Tug	Laden	WS #1 (Loc.3)	0.33	56	-
402	Tug	Laden	WS #2 (Loc.3)	0.42	160	-
501	Cargo	Laden	WS #1 (Loc.4, DH*)	0.22	60	-
502	Cargo	Laden	WS #1 (Loc.4, EH**)	0.25	58	-

Note: * DH: Spectrum 1 Developed Harbour
** EH: Spectrum 1 Existing Harbour

5 Summary of Results

The results obtained for H_{10} double amplitude (*peak-to-trough*) centroidal motions of the design vessels are summarised in Table 5.1 for each run given in Table 4.1. These motions represent the *mean* of the H_{10} double amplitude motions computed during the fifteen tests in each run. Note that the exception is Run 303 (static wind loading only), with the motions for the run representing the relevant vessel static excursion in response to the design wind loading.

Figures B1 to B28 in Appendix B summarise the time series of the wave elevation and the moored vessel surge and sway motions for all runs (except Run 303).

Details of the H_{10} double amplitude wave elevations and centroidal vessel motions (surge, sway, heave, roll, pitch and yaw) for each test run of the time domain simulations are summarised in Appendix C.

The static excursions and mooring loads for Run 303 are provided in Appendix D.

Table 5.1: Centroidal Vessel Motions

Run No.	H10 Double Amplitude Vessel Motions* (Mean of 15 Tests)					
	Surge, M	**Sway, m**	**Heave, m**	**Roll, deg.**	**Pitch, deg.**	**Yaw, Deg.**
101	2.05	0.97	0.29	0.10	0.14	0.33
102	2.49	0.68	0.25	0.09	0.11	0.25
201	2.22	0.38	0.29	0.10	0.14	0.19
202	2.87	0.21	0.25	0.08	0.11	0.11
301	1.49	0.56	0.18	0.11	0.10	0.24
302	1.48	0.43	0.15	0.09	0.07	0.19
303**	0.16	0.77	0.00	0.00	0.00	0.23
401	0.85	0.05	0.64	0.19	0.94	0.17
402	0.74	0.05	0.82	0.19	1.09	0.18
501	2.74	0.72	0.27	0.17	0.14	0.30
502	2.61	0.86	0.28	0.18	0.15	0.34

** Note the motions are peak to peak except for sway which is single amplitude*

*** Note that Run 303 is for wind loading only and the motions refer to a single amplitude excursion in response to the static loading*

The results obtained for peak mooring line forces and fender deflections are summarised in Table 5.2. These values represent the mean and the *5% exceedance* value of the peak values computed during the fifteen tests in each run. Note that the exception is Run 303 (static wind loading only), with the loads representing the relevant static loads in response to the design wind loading.

Details of the peak mooring line forces, fender deflections and vessel displacements developed during each test of the time domain simulations are summarised in Appendix E. Details of peak mooring line forces for all lines during each test of the time domain simulations are summarised in Appendix F. Mooring lines are numbered from stern to head. Fenders in contact with the vessel are numbered in order from stern to head.

Table 5.2: Line Tensions and Fender Deflections

Run No.	Mean Peak Line Tensions and Fender Deflections (15 tests)			5% Exceedance Peak Line Tensions and Fender Deflections (15 tests)		
	Line Tension, tonne	Line Tension, % (GMBL)	Fender Deflect-ions, %	Line Tension, tonne	Line Tension, % (GMBL)	Fender Deflect-Ions, %
101	47.4	52.3	33.6	65.2	72.0	50.0
102	35.1	38.8	25.0	45.9	50.7	35.4
201	29.4	32.4	22.9	38.9	42.9	33.0
202	25.7	28.4	14.6	33.2	36.6	22.1
301	29.3	32.3	16.0	39.9	44.0	19.9
302	24.9	27.5	12.8	34.0	37.5	16.7
303*	32.8	36.2	0.0	-	-	-
401	5.5	26.7	5.9	7.8	37.9	7.3
402	6.3	30.5	6.7	9.1	44.7	9.1
501	44.8	49.4	90.5	61.2	67.6	>100
502	47.4	52.3	95.0	72.0	79.5	>100

** Note that Run 303 is for static wind loading only*

6 Discussion of Results

Eleven (11) runs have been undertaken for the design environmental conditions for the design container vessel in laden and ballast (location 1), the cargo vessel in laden (location 2 & 4) and the tug boat (location 3).

The following observations are made from the results of the numerical modelling:

Container Vessel

1. The vessel sway motions are larger for spectrum #1 and surge motions are larger for spectrum #2. This is a result of the natural period of the moored vessel in sway (approximately 50s for the laden vessel and 40s for the ballast vessel) being closely aligned with spectrum #1's shorter wave period, whilst the natural period of the vessel in surge (>100s) is more aligned to spectrum #2's longer wave period.
2. The vessel motions are generally larger for the laden vessel except for surge which is marginally greater for the ballast vessel. This is a result of the natural period of the ballast vessel in surge being less than the laden vessel and more closely aligned to the prevailing long wave periods.
3. The mooring line loads are greatest for spectrum #1. This is a result of the natural period of the moored vessel in sway (approximately 50s for the laden vessel and 40s for the ballast vessel) being closely aligned with spectrum #1's shorter wave period, and the shorter breasting lines being the most critically loaded lines.
4. The vessel mooring lines loads are greatest for the laden vessel. Again this is a result of the laden vessel being more responsive to sway motions which impart the highest mooring line loads.
5. The influence of the assumed low frequency energy on the dynamic vessel motions is significant. This is due to the very low hydrodynamic damping which exists in these modes at such low frequencies. These results indicate that particularly the laden vessel (of large mass-displacement and with a long natural period of oscillation in the horizontal modes), may experience problems when there is significant wave energy in the region 0.005 Hz – 0.03 Hz.
6. Vessel Motions:
   - Laden Vessel: For Spectra 1 and 2, the vessel motions exceed the recommended limiting criteria for surge and sway for 100% and surge for 50% efficiency, as given in Table 2.3.
   - Ballast Vessel: For Spectra 1 and 2, the vessel motions exceed the recommended limiting criteria for surge for 100% and 50% efficiency, as given in Table 2.3.
7. Vessel Mooring Loads:

- Laden Vessel: For Spectrum 1, the 5% exceedance peak line tensions (72.0%) exceeds the recommended limiting criteria
- Ballast Vessel Mooring Loads: All line loads are within the recommeded limiting tensions.

8. The breasting lines are the most heavily loaded line. The breasting line loads are most sensitive to the sway motions.
9. The fender forces are significant for all cases, but within recommeded maximum deflections.

Cargo Vessel – Location 2

10. The vessel motions and mooring line loads are within the limiting criteria.
11. The vessel motions and mooring line loads are greatest for spectrum #1. This is a result of the natural period of the moored vessel in sway (approximately 40s) being closely aligned with spectrum #1's shorter wave period.
12. Vessel Motions:
    - All motions satisfy the recommended criteria for both spectra.
13. Vessel Mooring Loads:
    - All line loads are within the recommeded limiting tensions.
14. The breasting lines are the most heavily loaded line. The breasting line loads are most sensitive to the sway motions.

Cargo Vessel – Location 4

15. The vessel motions and mooring line loads are greater than for location 2. This is due to the larger wave climate, with the energy concentrated at the lower periods, and therefore closely aligned with the natural response period of the vessel in sway. As such the breasting line loads are the most heavily loaded.
16. Vessel Motions:
    - The surge motion exceeds the recommended criteria.
17. Vessel Mooring Loads:
    - The 5% exceedance breasting line load (67.6%) exceeds the recommended limiting tensions.
18. The assumed fenders are heavily loaded, and exceed the stated capacity.
19. There is minimal change in vessel motions and mooring loads between the existing and developed harbour situations.

Tug Boat

20. The vessel motions horizontal motions are not significant, however the heave motion is significant reflecting the large heave wave exciting forces from the long period waves. It should be noted that the mooring pontoon

is expected to heave approximately in phase and of similar magnitude as the tug in response to the prevailing long wave, and as such the relative heave motion between the two is expected to be minimal.

21. The vessel line loads are not significant. This is a result of the natural period of the tug boat being small in relation to prevailing long wave period.

7 General Conclusions & Recommendations

The major conclusions and recommendations arising from this moored vessel study are:

1. Long wave energy at this site of the magnitude analysed in this study will be critical to the resulting vessel motions and mooring loads, and the magnitude of the long wave energy at the berth should be confirmed.
2. A "looser" mooring configuration would marginally reduce the vessel line loads, however may increase the vessel motions.
3. The Cavotec MoorMaster units have significantly reduced long wave excitation of moored container vessels at Salalah, Oman and their use should be considered as a possible option to reduce the long wave excitation.

8 References

1. AECOM: Port Kembla Outer Harbour Development Brief for Mooring Assessment 29 May 2009

2. PIANC: Criteria for Movements of Moored Ships in Harbours Report of Working Group No. 24 of the PTC II. Supplement to Bulletin No. 88 1995.

Appendix A: General Description of SPMS Model

1 GENERAL DESCRIPTION OF SPMS MODEL

A numerical model, **SPMS** (**S**imulation Package for the Motions of Ships), has been developed by Dr. W.T. O'Brien of O'Brien Maritime Consultants Pty. Ltd. for the analysis of various problems associated with the motions of vessels, either moored, towed or free moving along channels or in deep water. Development of the SPMS model began in 1962 and since then it has been extended to solve a wide variety of maritime projects in Australia and overseas.

The major components of the SPMS model are summarised below, using the following categories of vessel motion problems:

- Free Moving Ships - Vertical Motions in Waves
- Free Moving Ships - Horizontal and Vertical Motions in Waves
- Moored Vessels - Horizontal and Vertical Motions in Waves

1.1 Definition of Vessel Motions:

Surge - longitudinal translation of vessel

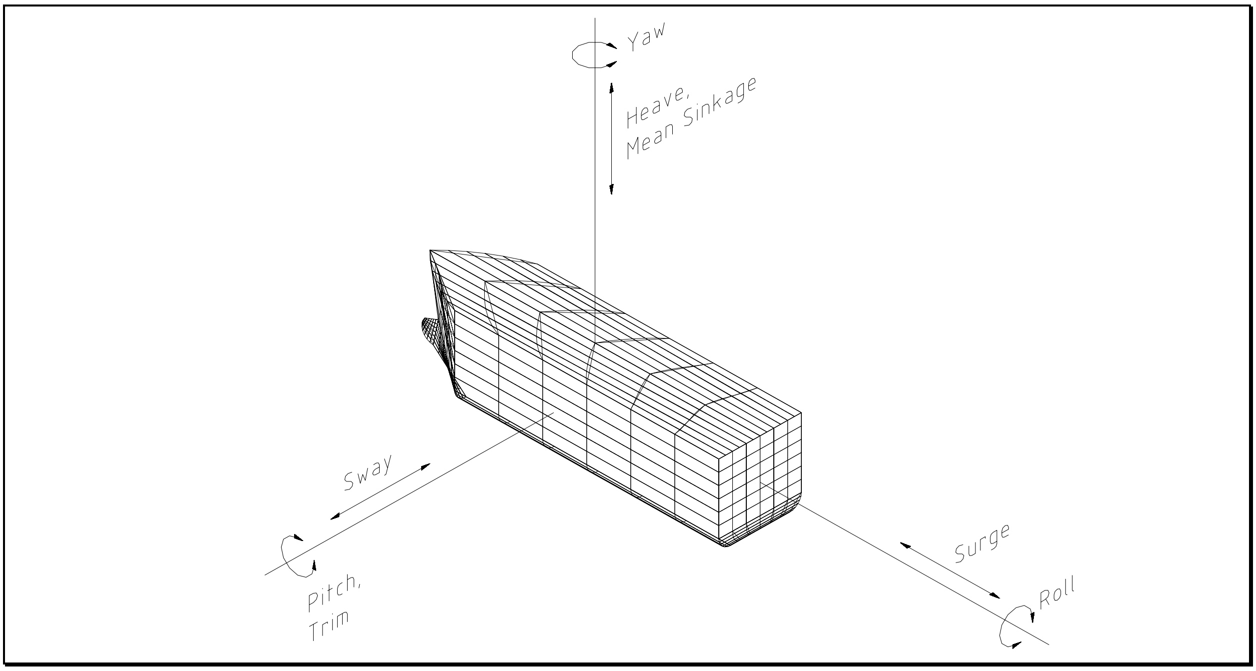
Sway - lateral translation of vessel

Heave - vertical translation of vessel

Roll - rotation of vessel around longitudinal axis through centroid

Pitch - rotation of vessel around lateral axis through centroid

Yaw - rotation of vessel around vertical axis through centroid



1.2 FREE MOVING SHIPS - VERTICAL MOTIONS IN WAVES

Vertical displacements of a ship in waves are caused by heave, roll and pitch motions. This category of ship motion applications is important because it includes determination of minimum underkeel clearance requirements for ships entering or leaving port; this parameter has a major influence on both port economics and maritime safety.

Hydrodynamic coefficients

The first stage in the **SPMS** model for the analysis of the vertical motions of ships in waves is the computation of hydrodynamic coefficients (added mass and damping) and wave exciting force coefficients and phases for heave, roll and pitch motions, plus appropriate coupling coefficients due to surge, sway and yaw motions. These added mass, damping and wave exciting force coefficients are computed using an extremely efficient and accurate ship theory approach, extended to include the effects of small underkeel clearances. Shearing forces and bending and torsional moments along the vessel are also calculated by the model. Forward speed of unrestrained vessels is incorporated by using the wave encounter frequency and by adjusting the slope of the hydrodynamic mass along the length of the ship. Provision is made in the analysis to include additional roll damping due to viscous effects.

Typically, hydrodynamic coefficients and first-order wave exciting force coefficients and phases are computed for a range of wave periods appropriate to the sea/swell energy spectra for the site. The wave exciting force coefficients in heave, roll and pitch are computed for directional wave spectra (sea and swell). Hydrodynamic and wave exciting force coefficients are dependent on the ratio of water depth/vessel draft and need to be recomputed if either parameter is changed eg. due to tidal flow, dredging or change in loading state of the vessel.

Response Amplitude Operators

Response amplitude operators (RAOs) are defined as the vessel's response to excitation by a regular wave train of unit amplitude, for specified wave period and direction. The response operators are computed as motion amplitudes and phase lags in heave, roll and pitch, using frequency domain analysis. Response operators can be computed in the **SPMS** software for a range of wave periods, directions, water depths and ship speeds within a single run.

Frequency-domain analysis of vessel motions

Because of the linear response of free moving ships in waves of moderate height, the major analytical tool in the **SPMS** model for analysis of vertical motions is the frequency-domain model. This model uses response spectra computed by the hydrodynamic model and measured or computed wave spectra to compute significant and expected maximum centroidal motions and vertical displacements. This technique, combined with the computational efficiency of the strip theory hydrodynamic model, allows the significant and expected maximum vertical displacements of ships in waves to be computed very quickly on a notebook or desktop PC. This high speed computation of vertical ship displacements in waves is extremely important in real-time applications, such as the real-time UKC systems described below.

Time-domain simulation of vessel motions

In addition to frequency-domain analyses to determine significant and expected maximum values of centroidal motions and vertical displacements, **SPMS** also provides a time-domain simulation model to compute time histories of vessel motions in irregular wave trains. This model uses the RAOs (amplitude and phasing) for heave, roll and pitch computed by the hydrodynamic model described above. Output from the simulation includes time-histories of centroidal motions (heave, roll and pitch) and vertical displacements of specified points, usually located on the keel at the fore and aft perpendiculars and at the four shoulders. Statistical data including mean, RMS and peak values of centroidal motions and vertical displacements are provided for each simulation.

Wave modelling

The **SPMS** models for frequency domain analysis and time domain simulation of vessel motions in waves each require mathematical modelling of the appropriate wave climate for the particular site. The **SPMS** model accepts three different types of wave input:

regular waves or wave groups;

uni-directional irregular waves;

directional irregular waves.

Regular waves are specified by wave height, period and direction and are mainly of theoretical interest because of their rare occurrence in nature. *Irregular* wave trains are generated internally in the **SPMS** model, using spectral ordinates, phasing and directional spreading data. Spectral ordinates can either be input from measured wave data or generated as Pierson-Moskowitz or Jonswap spectra, using specified values of Hs (significant wave height) and Tp (peak spectral period). Phasing can be input from analysis of measured wave data or be generated internally as random phasing. Different wave angles of approach to the vessel can be specified for different segments of the total wave spectrum (eg. local wind wave and swell will generally approach the vessel from different directions). Directional spreading of wave energy is controlled through use of cosine squared spreading parameters, selected as being appropriate for sea, swell and long wave spectra at the particular site.

Real-time UKC models

The hydrodynamic model, frequency domain model and wave models in **SPMS** (described above) have been used as the core models in real-time UKC systems for the ports of Hay Point and Brisbane in Queensland and Fremantle, Dampier, Port Hedland, Bunbury and Geraldton in Western Australia. These are the first such actual applications anywhere in the world which allow port authorities and users to maximise the available draft and tidal windows for export and import ships, depending upon measured tide and wave conditions prevailing or predicted at the time of vessel entry or departure. The core technology for real-time UKC modelling also includes models which have been developed for tide and wave prediction, computation of vessel squat, computation of UKC parameters (bottom clearance and manoeuvrability margin) along the vessel transit and maximisation of vessel drafts and tidal windows (earliest and latest times of sailing). The software for the core technology has been interfaced with real-time tide and wave measurement systems.

2 FREE-MOVING SHIPS - HORIZONTAL AND VERTICAL MOTIONS IN WAVES

This category of ship motion application is important in problems related to ships manoeuvring in port entrance channels and during berthing and unberthing operations in exposed locations.

The horizontal and vertical motions of ships in waves analysed in the SPMS model in an analogous manner to that described above for vertical motions only. The major difference between the two sets of models is that the former involves solution of mathematical equations for six degrees-of-freedom motions (surge, sway, heave, roll, pitch and yaw) instead of heave, roll and pitch motions only.

3 MOORED VESSELS - HORIZONTAL AND VERTICAL MOTIONS IN WAVES

For moored vessels, dynamic analyses are preceded by pretensioned and quasi-static analyses of the vessel under steady wind, current and wave drift forces. A large variety of different mooring and fendering systems can be handled by the **SPMS** model, including spread mooring systems (using either buoys or swamp moorings), wharf moorings with lines to breasting dolphins or bollards, side and stern fender systems, single point moorings systems, towed vessels using hawsers and bridles, and interconnected systems of deep ocean moorings. In addition, the model can handle two or more vessels moored together, either side-by-side or in tandem, including tug/barge systems with Articouple connections which permit relative motion of two vessels in pitch but not in other modes

Elements of the Moored Vessel Package include:-

STATIC ANALYSES:

The **SPMS** model operates in sequence through three stages of static analysis. The first two stages of this sequence are essential pre-analysis models for the time domain simulation of the dynamic motions of moored vessels. The basic mooring analysis models are also used during each time step in the time-domain simulation of moored vessels.

The three stages of static analysis are as follows:

Pretensioned Analysis

In the first stage, the mooring system is analysed in terms of the desired ship position in the berth and the specified line pretensions. Output data from the model includes the unstressed length of each mooring line, deflections and reaction loads of fenders and, for buoy moorings, the position of buoys, lengths of mooring chain on the seabed, uplifts on all anchors and clump weights, buoy loadings and maximum chain tensions.

Quasi-Static Analysis

The second stage of static analysis involves the direct solution of mooring line tensions and fender reactions for quasi-static loadings applied to the ship by steady wave drift forces, wind forces and current forces. This analysis facilitates preliminary design of mooring systems by enabling rapid comparison of a large number of static loading conditions (corresponding, for example, to variation in wind or current direction, position of ship in berth, loading condition, etc.).

Response Analysis

The third stage of static analysis computes two types of mooring response characteristics:

(a) Load-displacement characteristics for each mooring line;

(b) Load-displacement characteristics for the complete mooring system, corresponding to displacements and rotations of the vessel in all six degrees-of-freedom.

Response analyses are only undertaken when the stiffness characteristics of individual mooring lines or the complete moored vessel need to be examined. They can be skipped if not required for dynamic analysis.

DYNAMIC ANALYSES:

For dynamic analysis of moored vessels, **SPMS** includes both frequency-domain and time-domain analyses, as described below.

Frequency-domain analysis (including hydrodynamic coefficients)

The first stage in the **SPMS** model for the dynamic analysis of moored vessels in waves is the computation of hydrodynamic coefficients (added mass and damping) and wave exciting force coefficients and phases for all six degrees-of-freedom motions. These coefficients are computed using an extremely efficient and accurate strip theory approach, extended to include surge motions and the effects of small underkeel clearances. Shearing forces and bending and torsional moments along the vessel are also calculated by the model. Provision is made in the analysis to include additional roll damping due to viscous effects

Typically, hydrodynamic coefficients and first-order wave exciting force coefficients and phases are computed for a range of wave periods appropriate to the sea/swell energy spectra for the site. The wave exciting force coefficients in all six degrees-of-freedom are computed for directional wave spectra (sea and swell) identified as being critical in terms of vessel motions and peak mooring line and fender forces. Hydrodynamic and wave exciting force coefficients are dependent on the ratio of water depth/vessel draft and need to be recomputed if either parameter is changed.

The hydrodynamic and wave exciting force coefficients and phases computed by frequency domain analysis form an important input to the time-domain simulation models described below. However, the hydrodynamic coefficients in all six modes of motion, plus coupling modes, must be converted from frequency-dependent coefficients to frequency-independent coefficients before being used in time-domain simulations - this transformation is achieved in the **SPMS** model by the use of retardation functions and convolution integrals.

Time-domain analysis

The major purpose of this model is to analyse moored vessels which have nonlinear restraints such as mooring lines and fenders and which therefore cannot be handled by frequency domain analysis (which requires system linearity).

Two types of time-domain analysis are provided for moored or towed vessels in the **SPMS** model:

(i) Wave frequency motions in all six modes;

(ii) Slow drift oscillations in planar modes (surge, sway, yaw).

Both types of analysis involve computation of mooring line forces and fender reactions to provide the overall restraining forces and moments on the vessel at each time step of a dynamic simulation run. All forces acting on the vessel are computed with respect to a ship-bound coordinate system. The resulting ship motions are then transformed into an earth-bound coordinate system to enable the response of the mooring/fendering system to be solved exactly. The restraining forces and moments exerted on the ship by the mooring/fendering system are then transformed back into ship-bound coordinates for the next iteration cycle.

Unique features

Each stage of static analysis and each time-step in time domain simulation includes the following features:

- exact catenary equations are solved for each mooring chain and ship line, without recourse to finite element approximations;
- high computational efficiency is attained in the solution of all non-linear equations, using specific correction formulae which provide second-order convergence;
- the effect of nonlinearities in the load-displacement characteristics of various types of fenders and mooring lines (including all types of fender characteristics, steel wires, with or without synthetic tails, nylon lines, polypropylene lines, etc) is fully accounted for; as is the additional elasticity provided by each length of mooring line between ship fairlead and winch.;
- the three-dimensional response of the complete mooring system is fully accounted for;
- for mooring chains connected to anchors, sloping seabeds are included and the model includes the effect of changing length of mooring chain on the seabed under applied loading and lifting of clump weights off the seabed under extreme loading conditions.

- • -

Appendix B: Scenario Time Series Runs for Surge and Sway

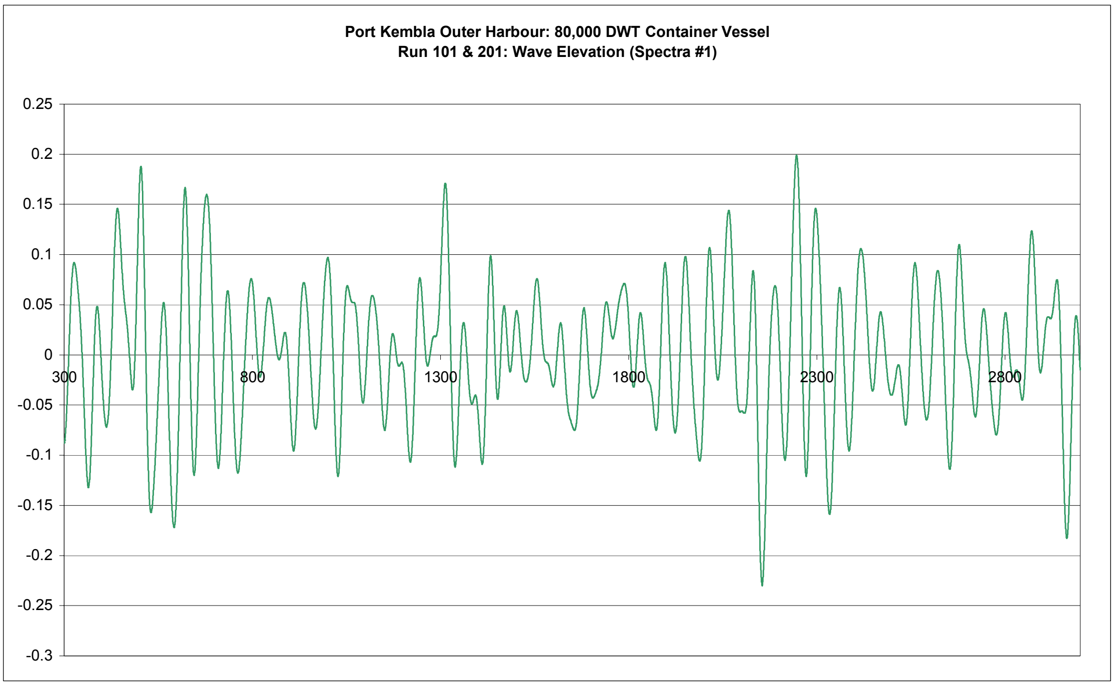


Figure B1: Run 101 & 201: Wave Elevation (Spectra #1)

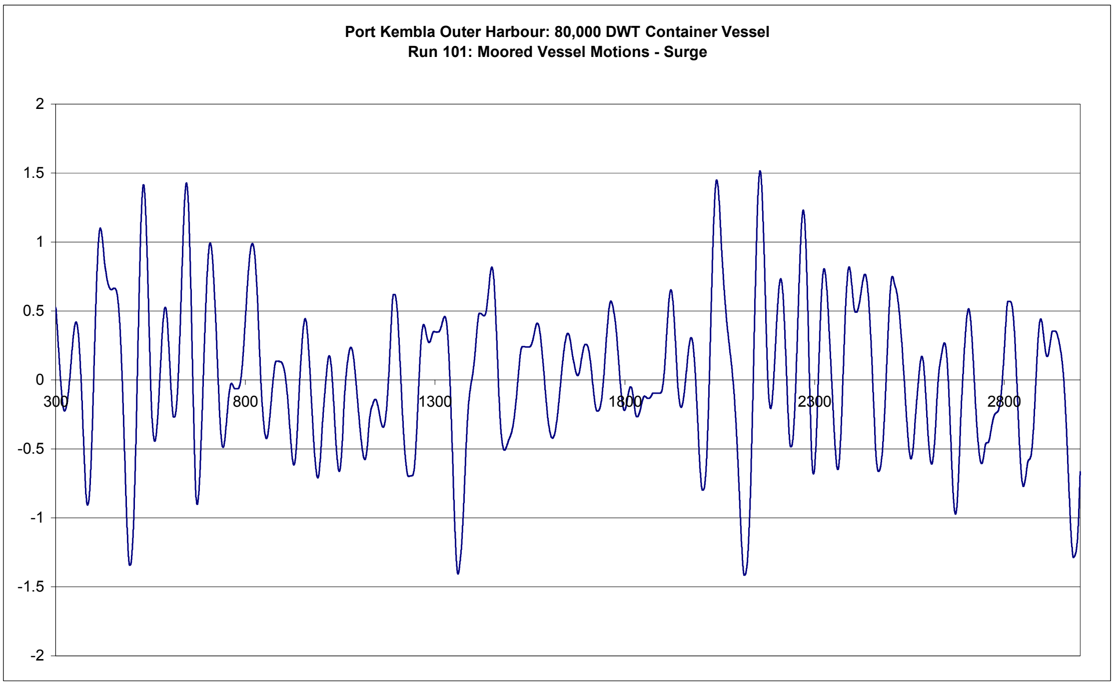


Figure B2: Run 101: Surge Motion Time History

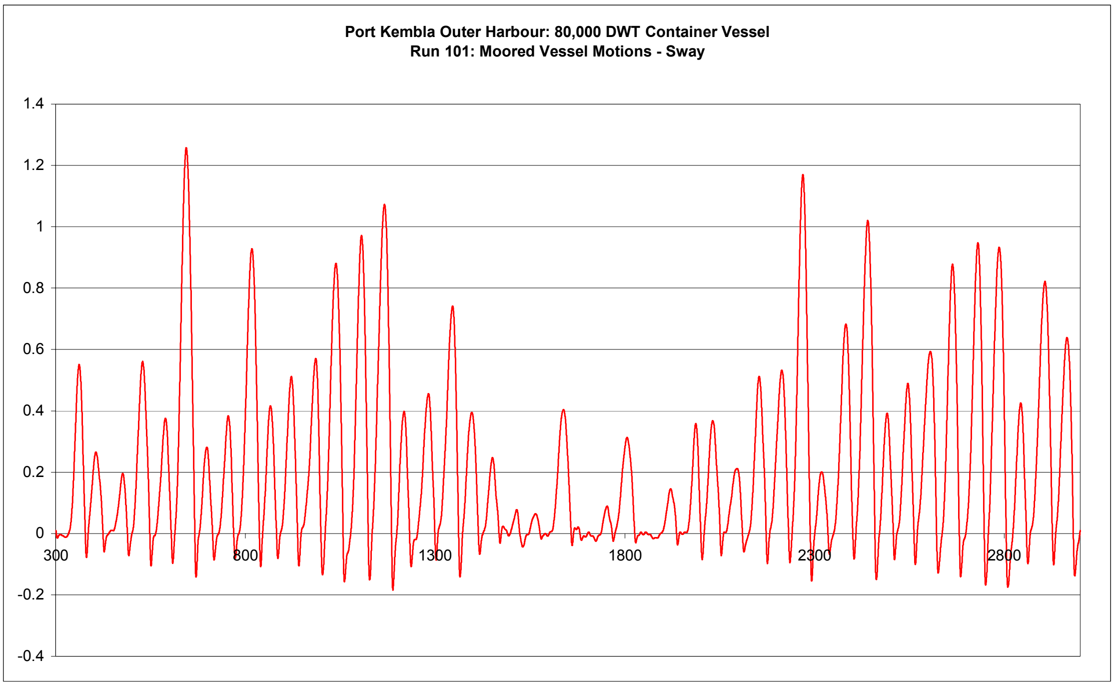


Figure B3: Run 101: Sway Motion Time History

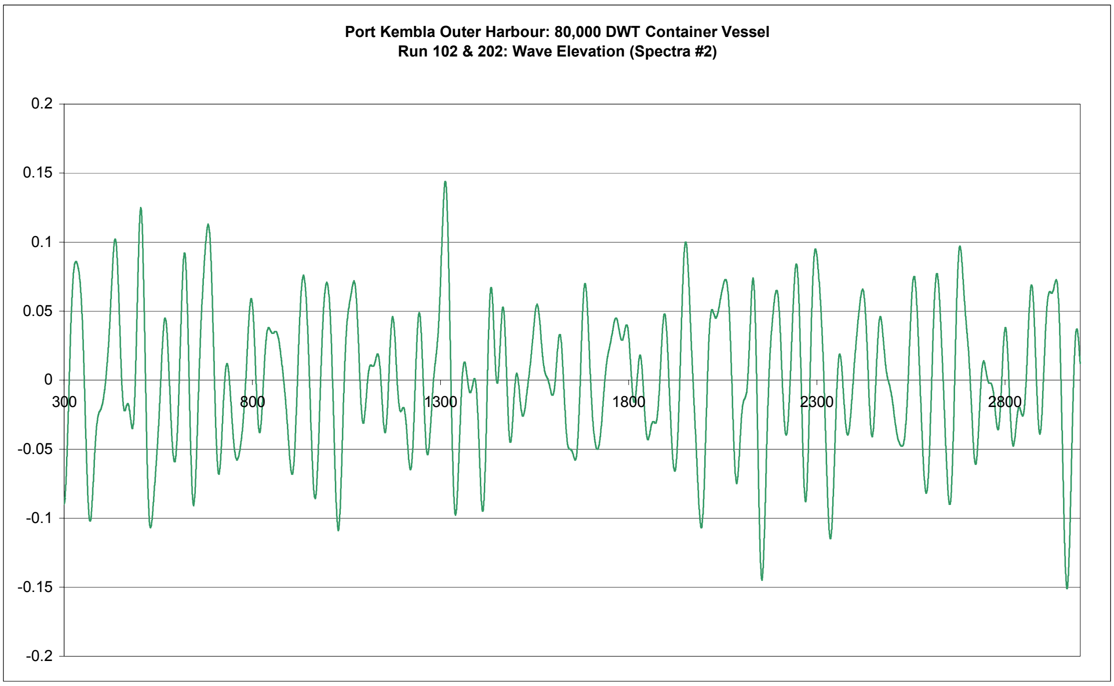


Figure B4: Run 102 & 202: Wave Elevation (Spectra #2)

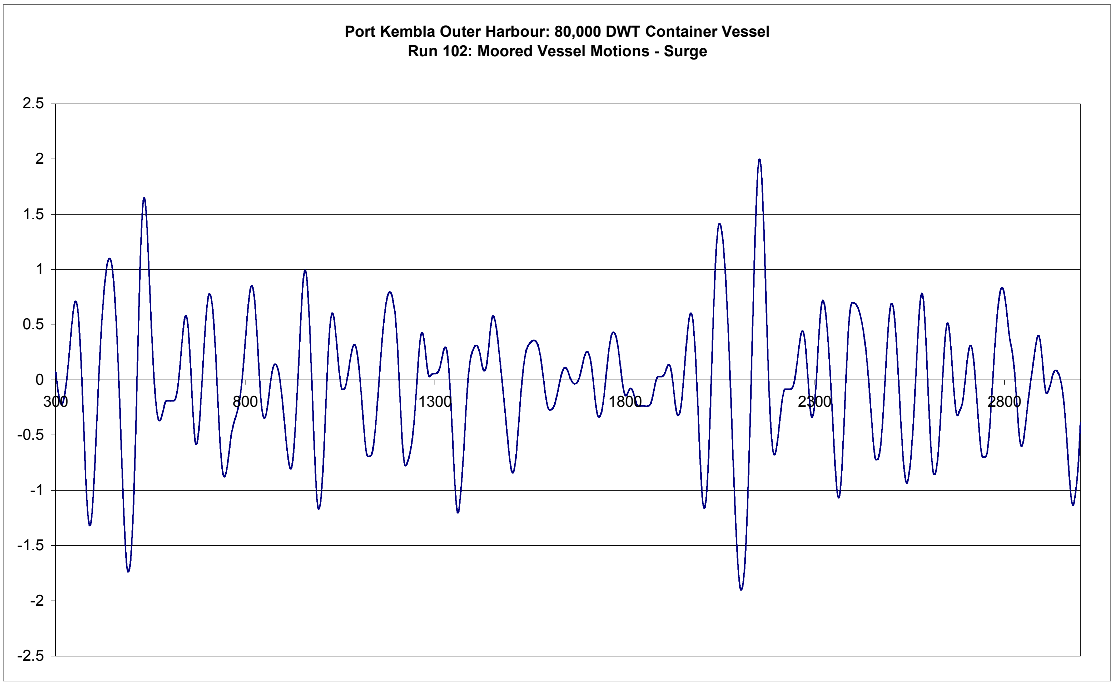


Figure B5: Run 102: Surge Motion Time History

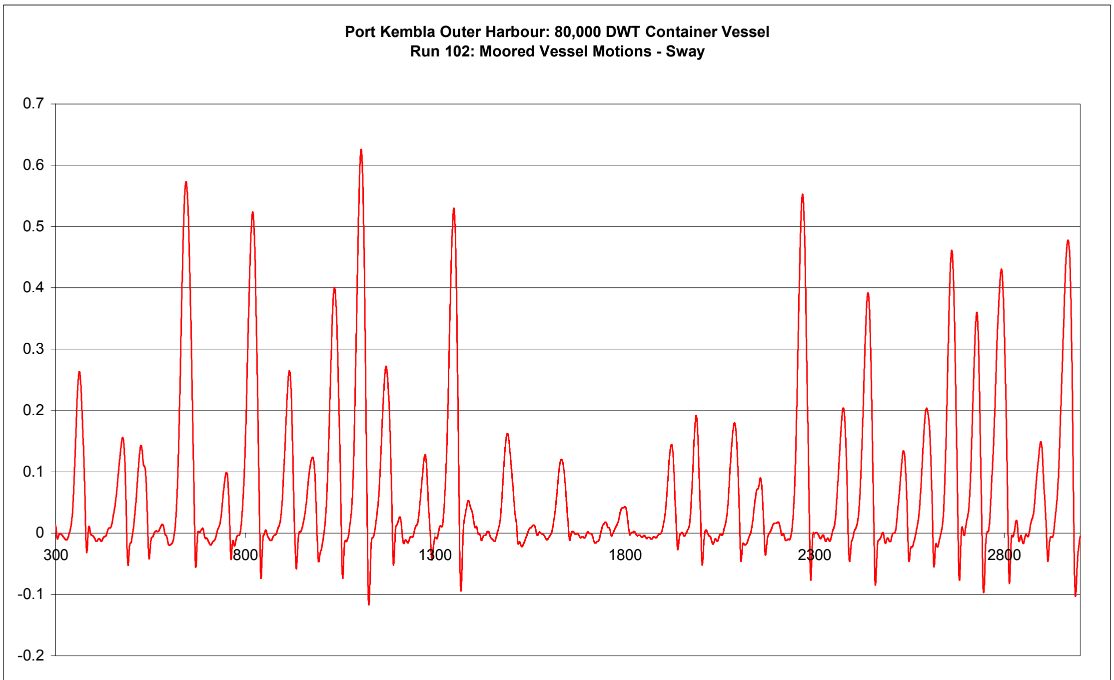


Figure B6: Run 102: Sway Motion Time History

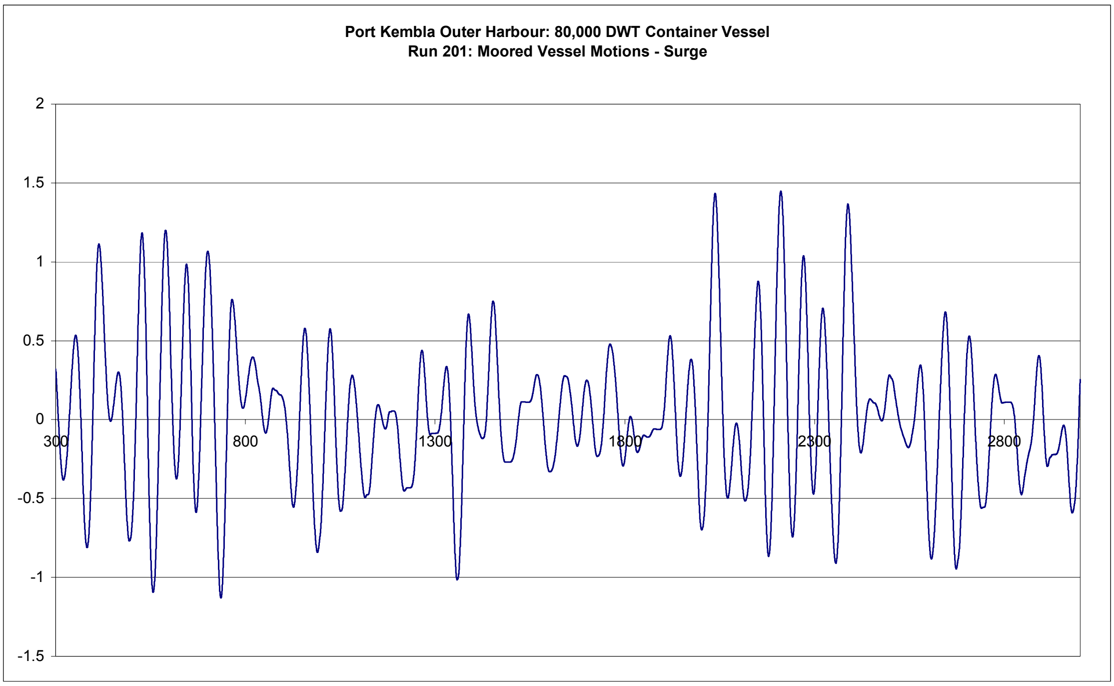


Figure B7: Run 201: Surge Motion Time History

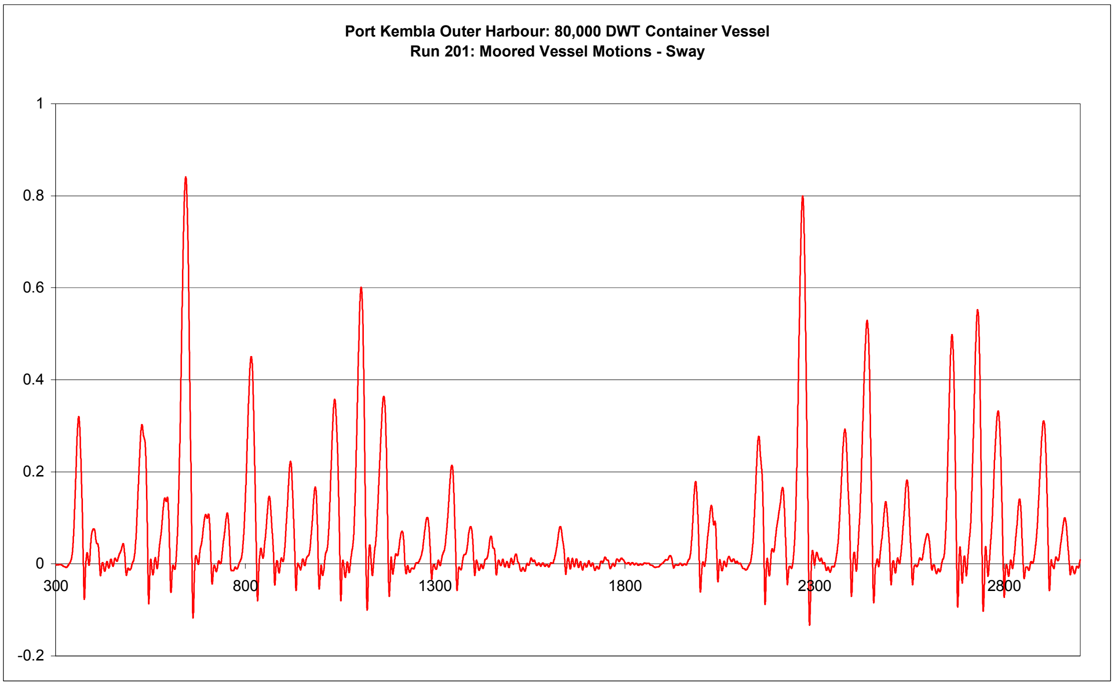


Figure B8: Run 201: Sway Motion Time History

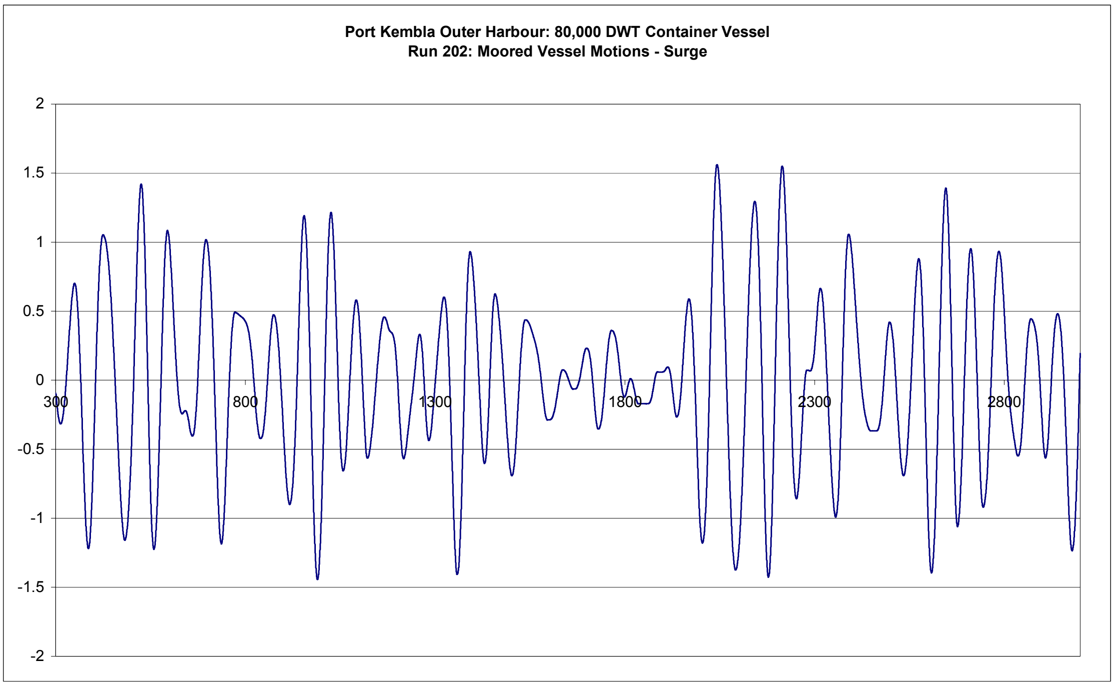


Figure B9: Run 202: Surge Motion Time History

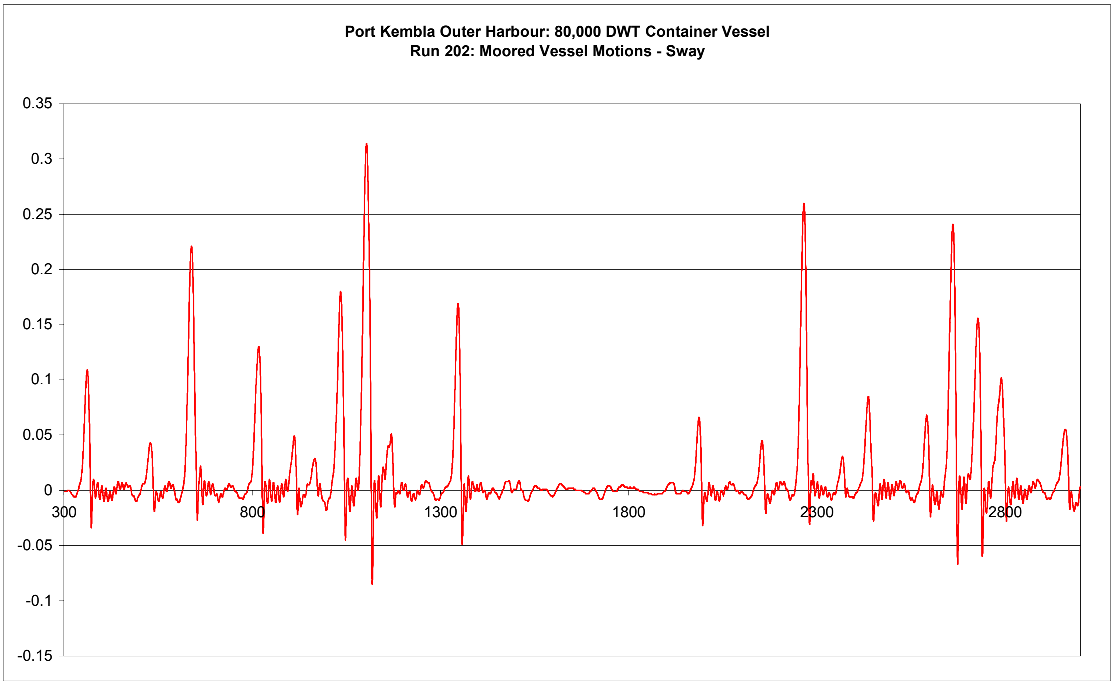


Figure B10: Run 202: Sway Motion Time History

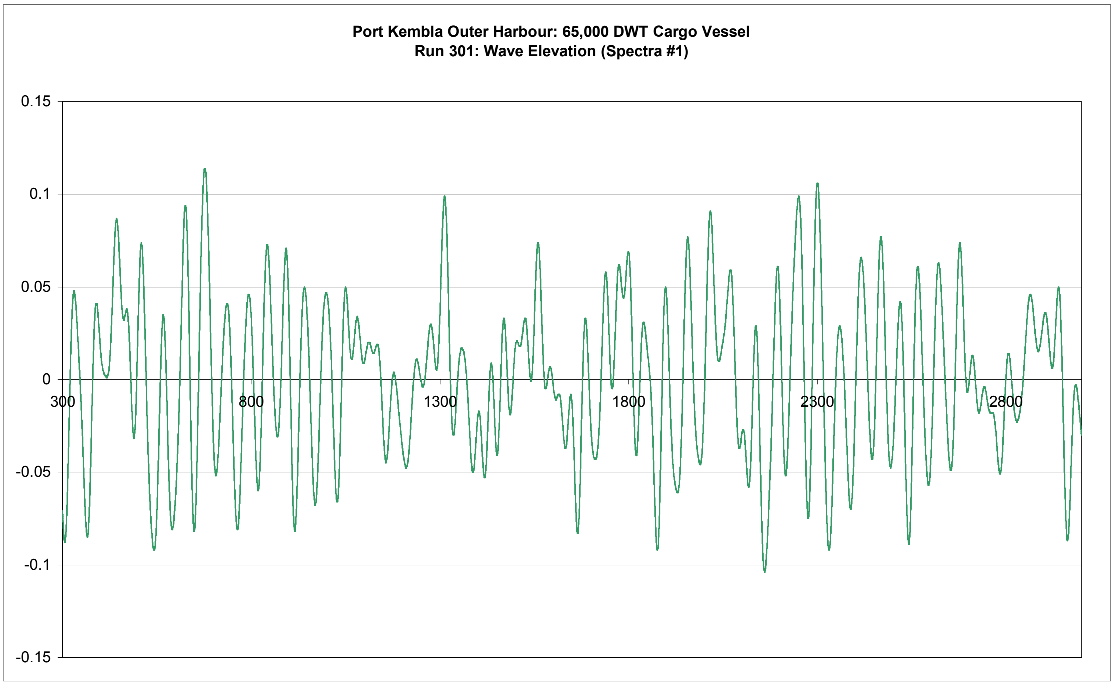


Figure B11: Run 301: Wave Elevation (Spectra #1)

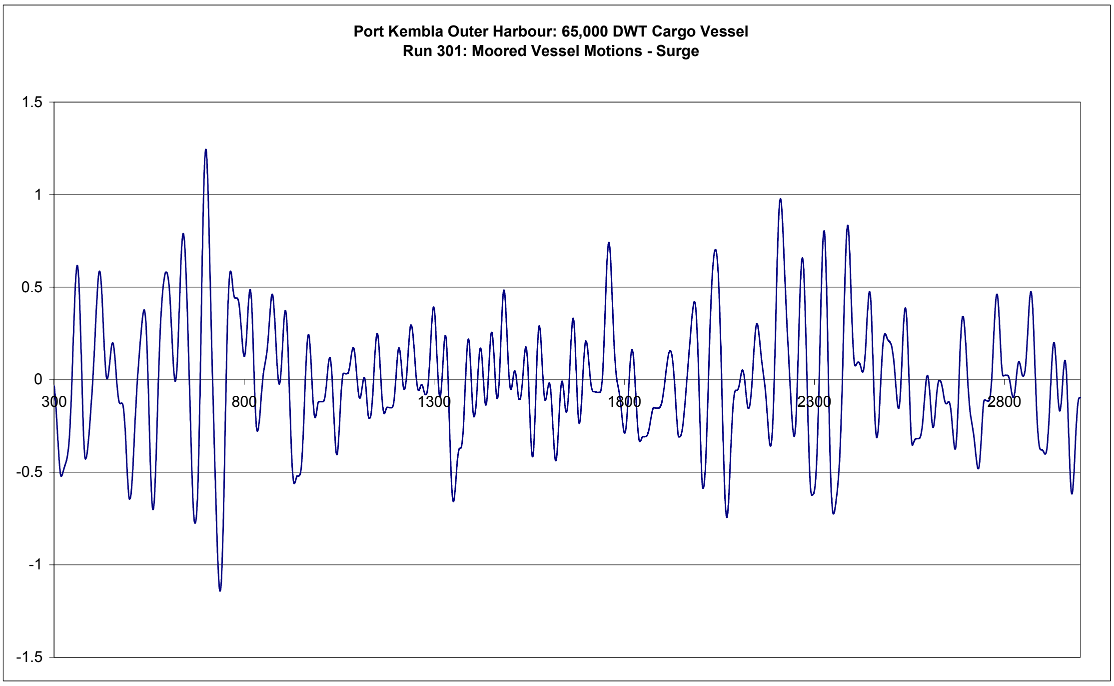


Figure B12: Run 301: Surge Motion Time History

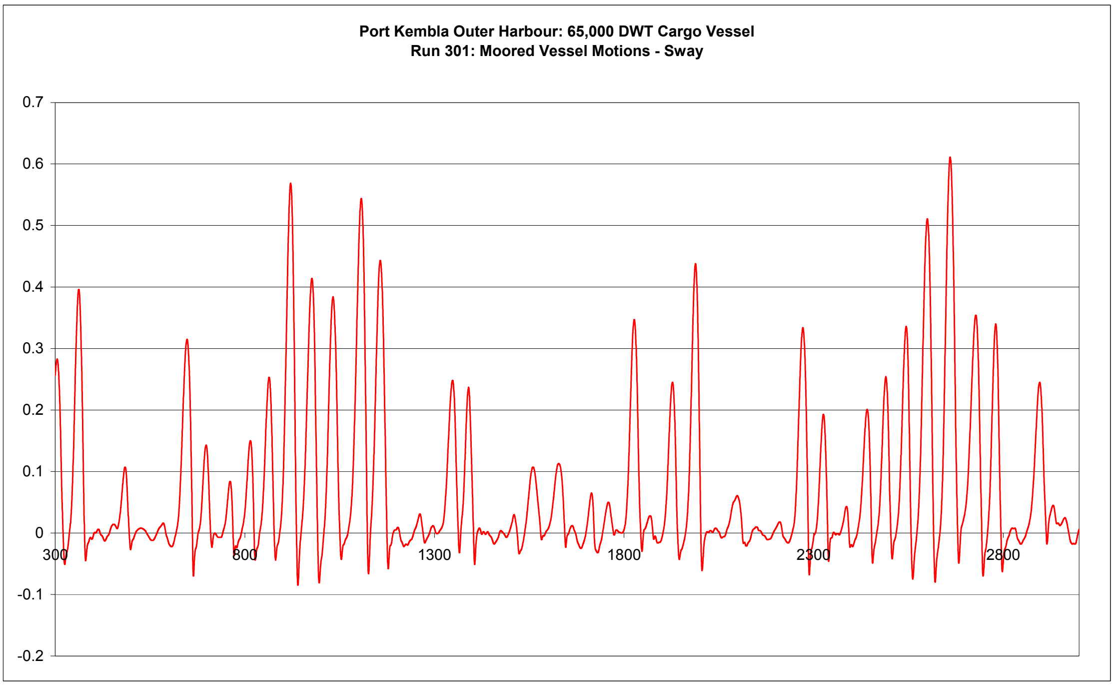


Figure B13: Run 301: Sway Motion Time History

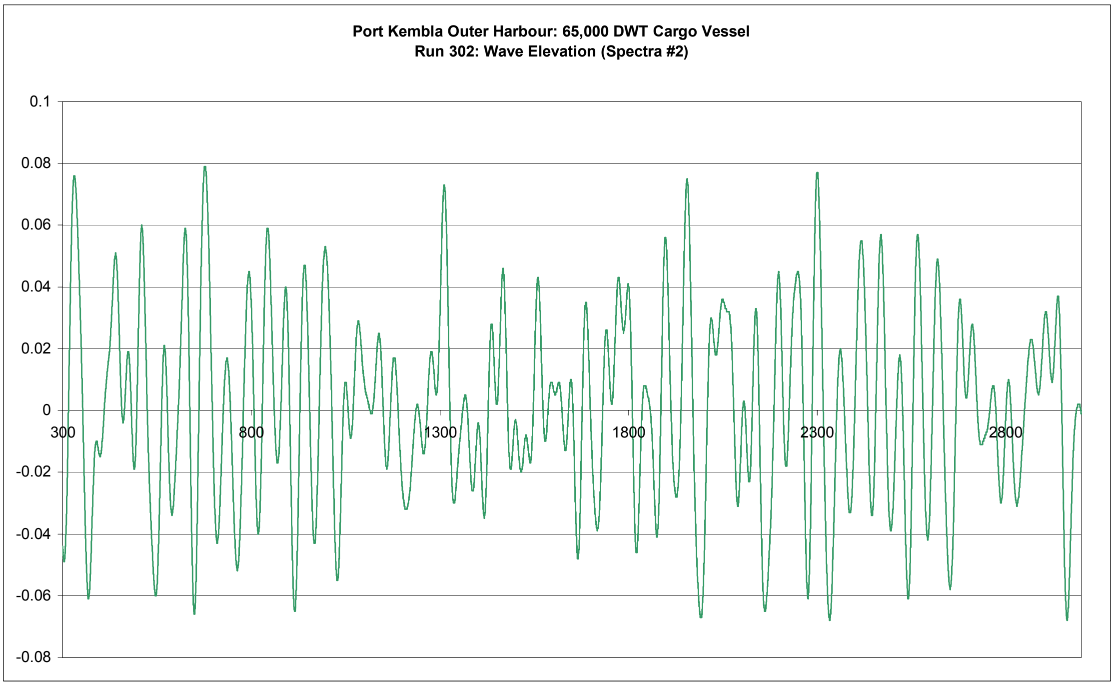


Figure B14: Run 302: Wave Elevation (Spectra #2)

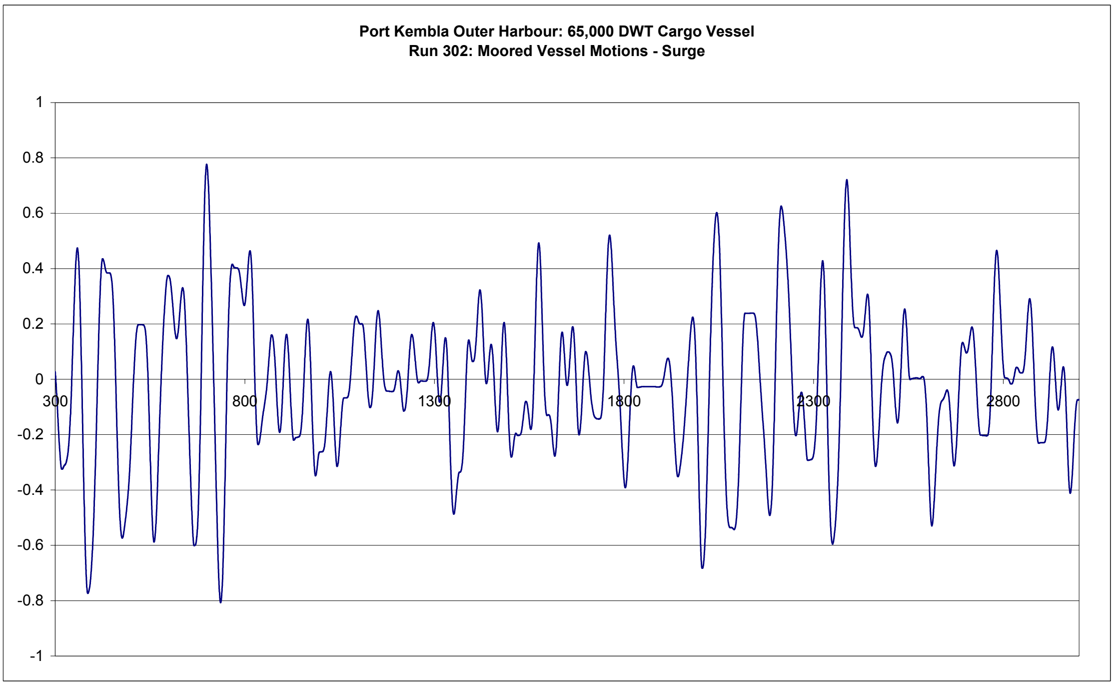


Figure B15: Run 302: Surge Motion Time History

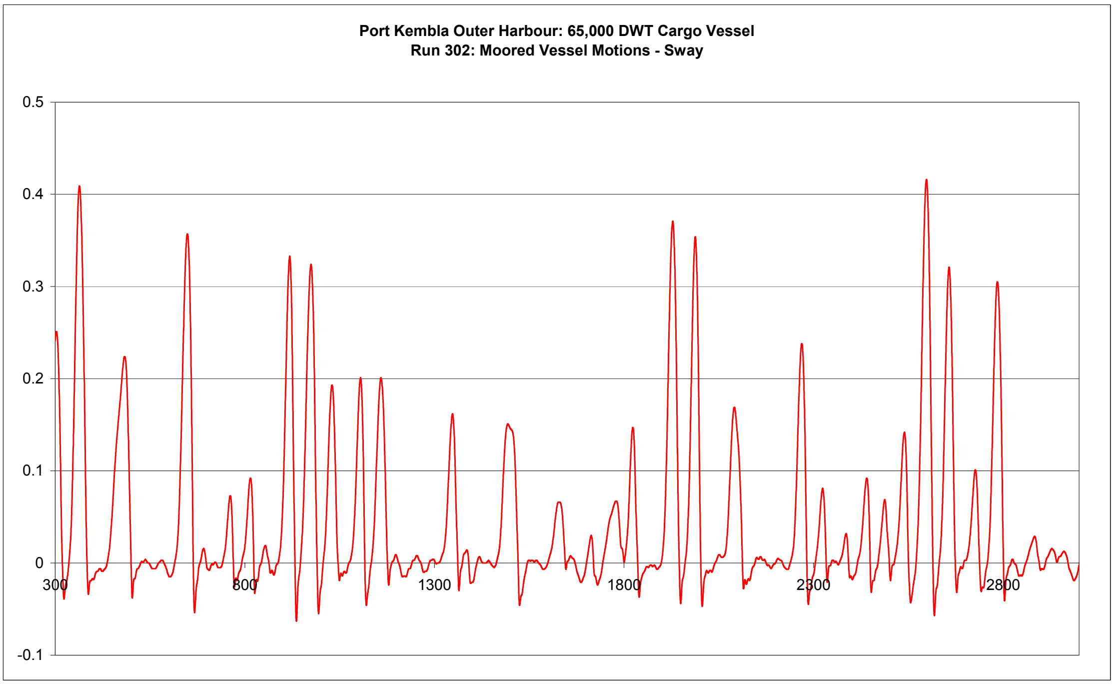


Figure B16: Run 302: Sway Motion Time History

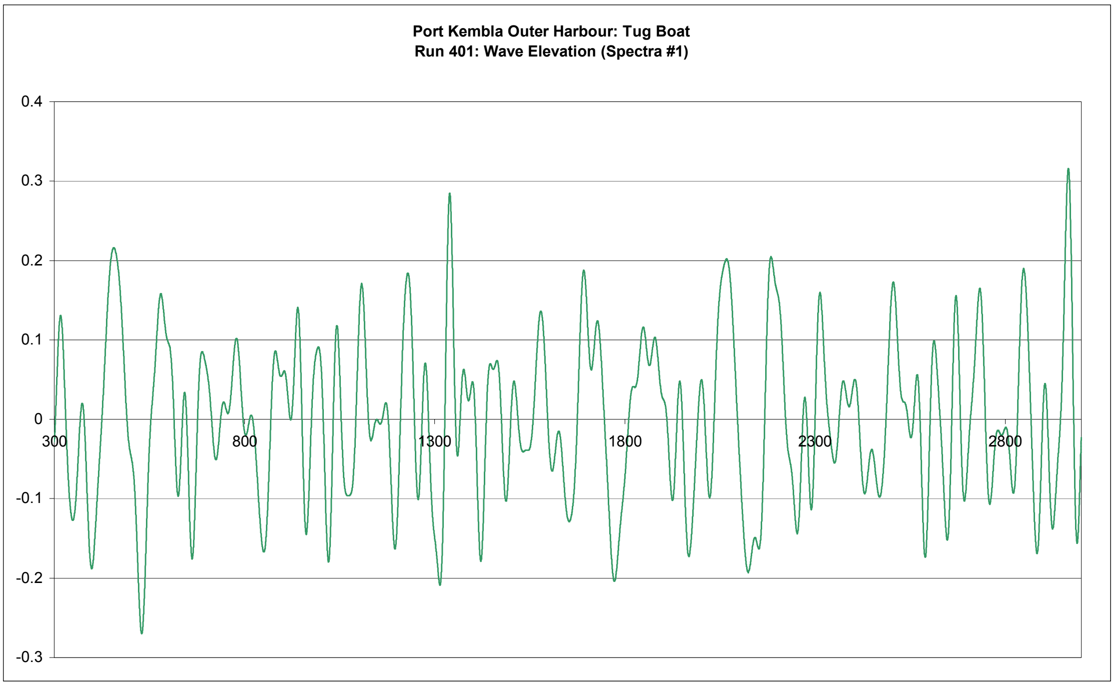


Figure B17: Run 401: Wave Elevation (Spectra #1)

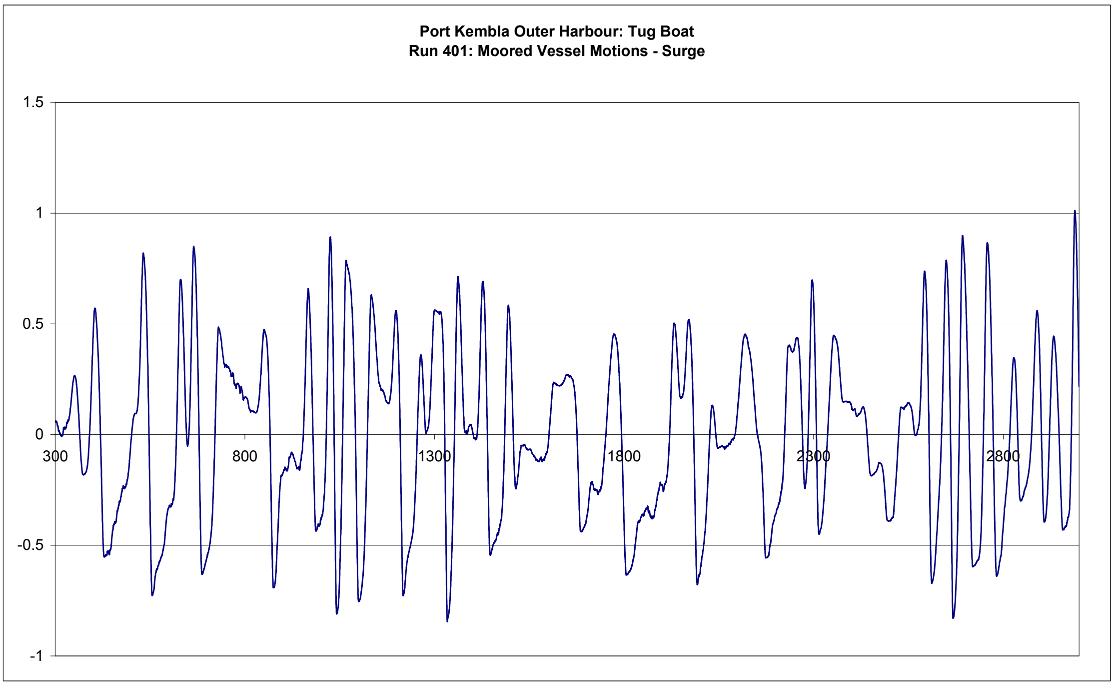


Figure B18: Run 401: Surge Motion Time History

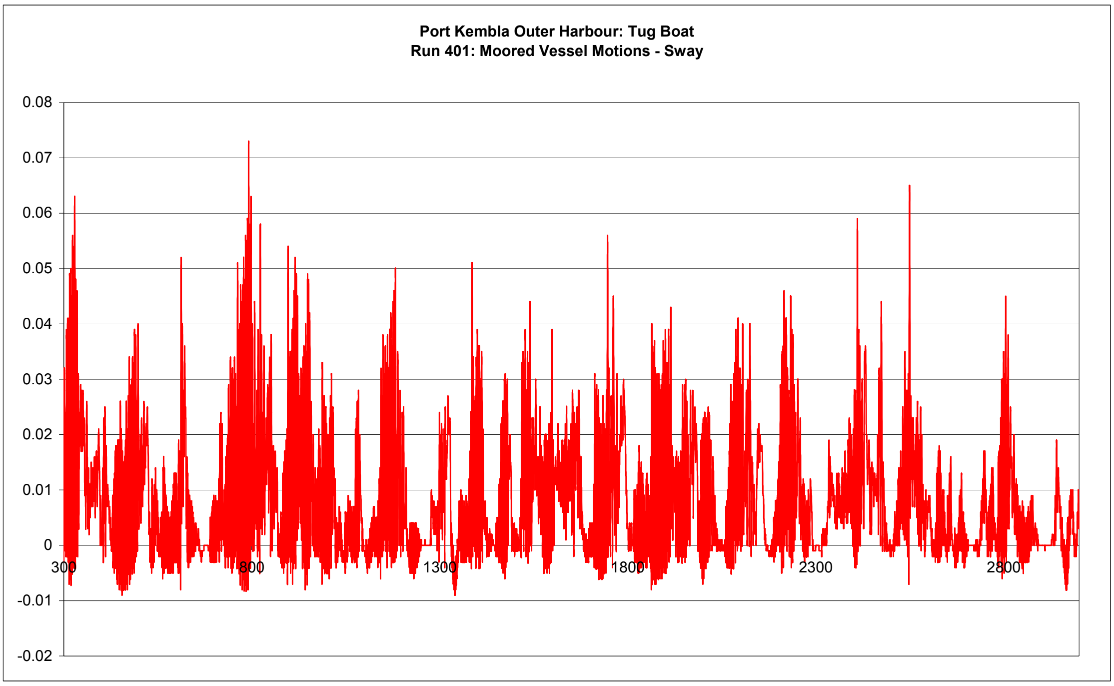


Figure B19: Run 401: Sway Motion Time History

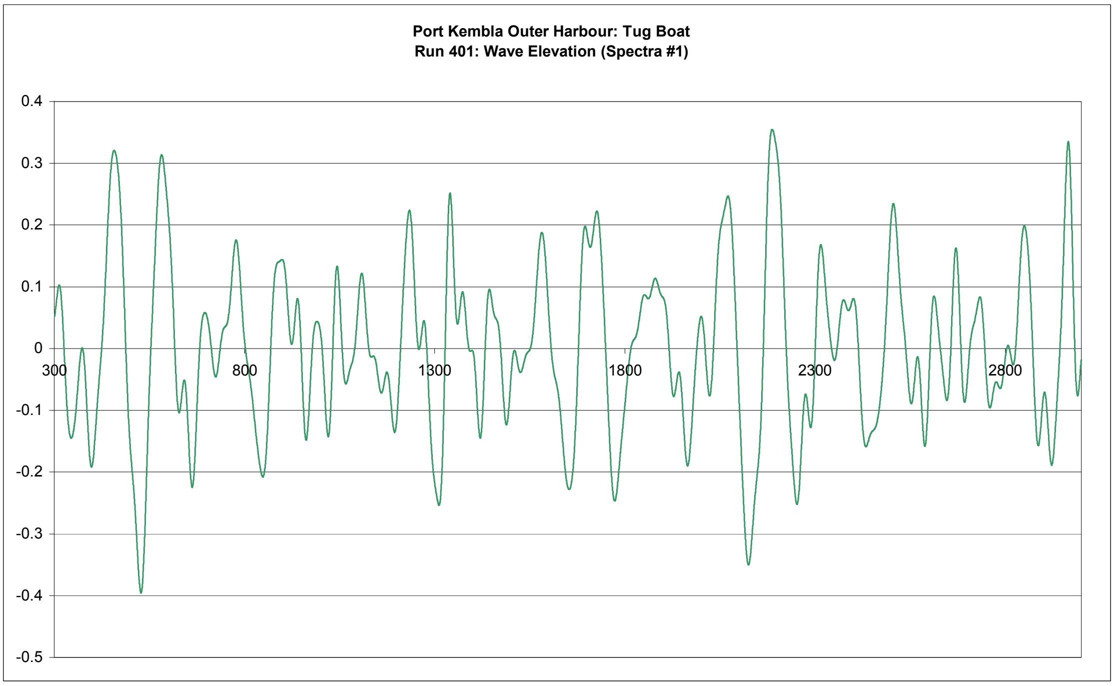


Figure B20: Run 402: Wave Elevation (Spectra #2)

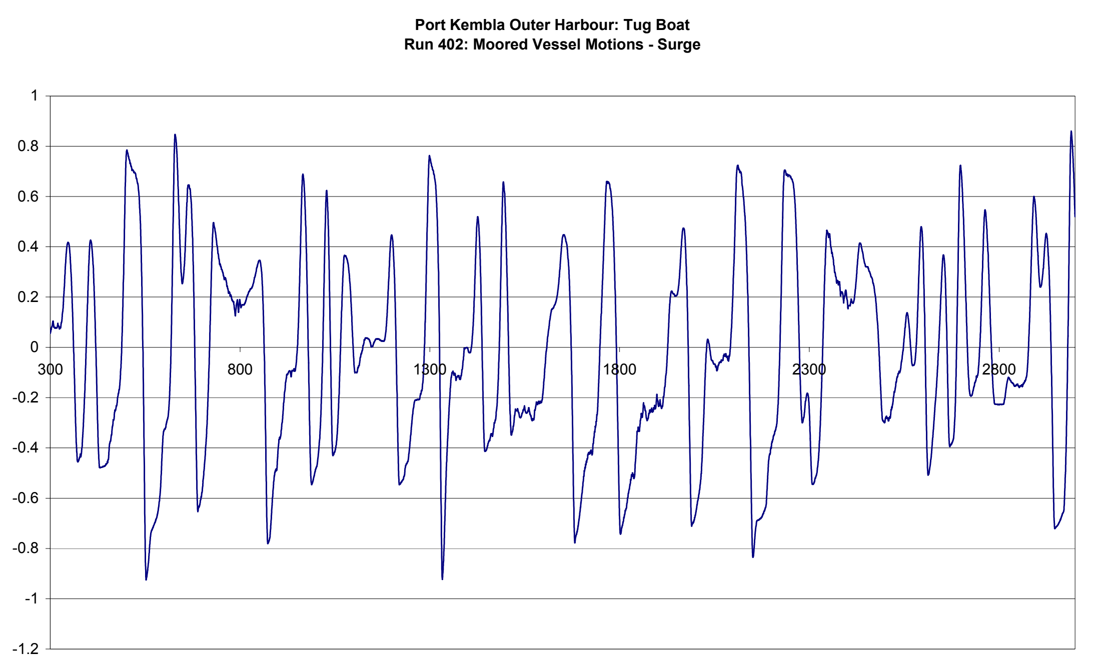


Figure B21: Run 402: Surge Motion Time History

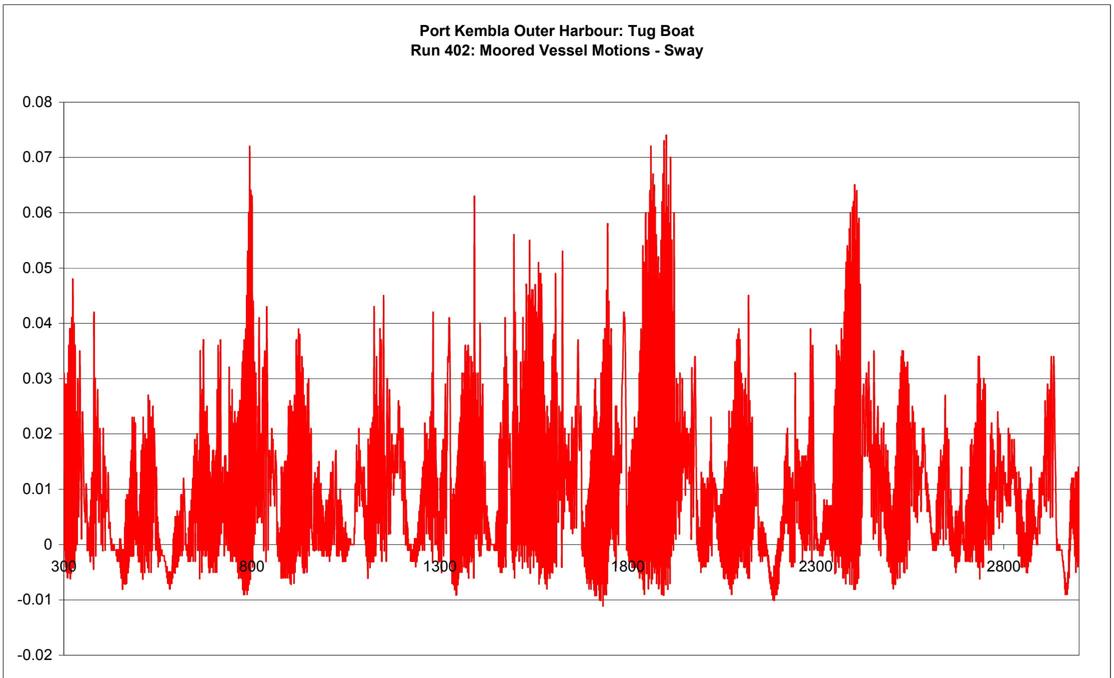


Figure B22: Run 402: Sway Motion Time History

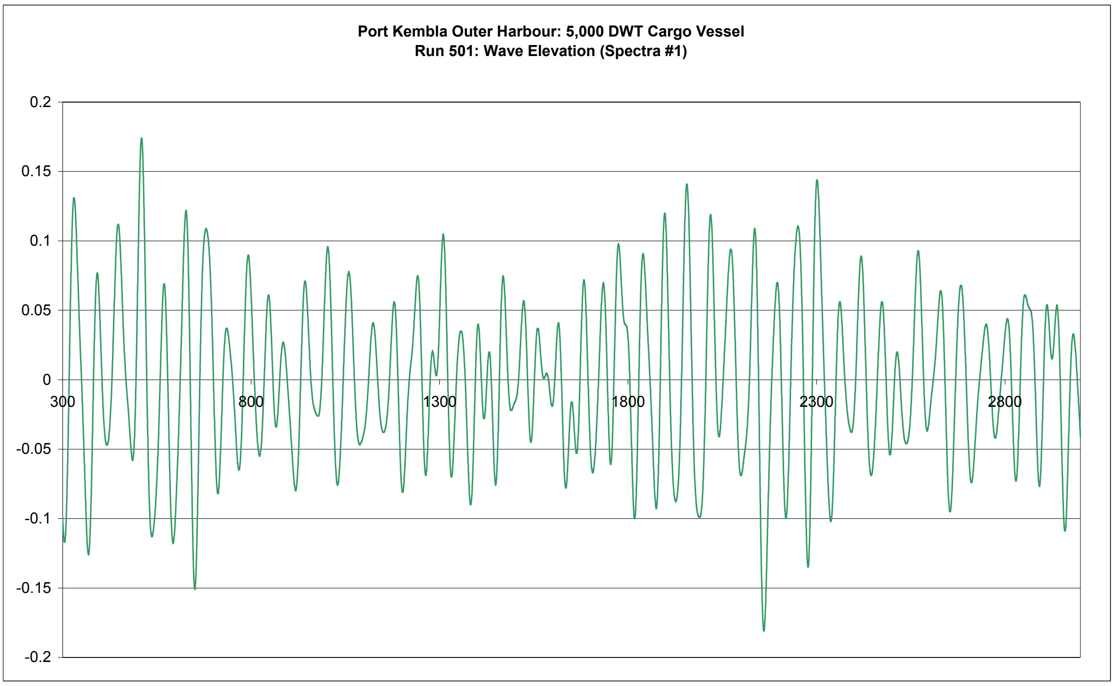


Figure B23: Run 501: Wave Elevation (Spectra #1 for Developed Harbour)

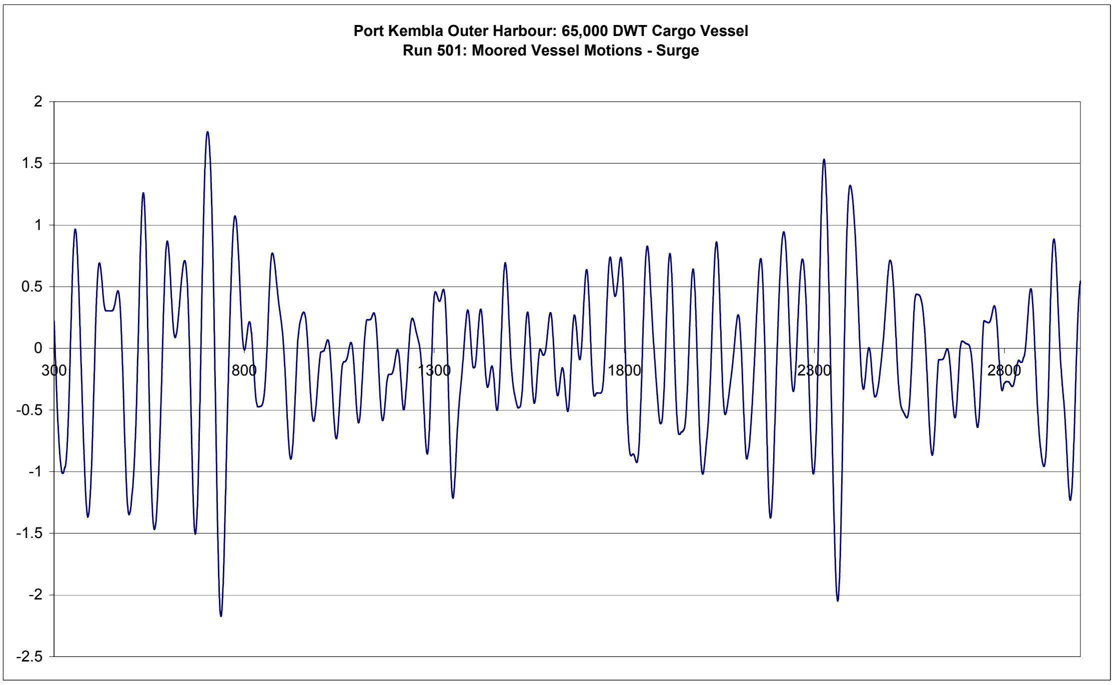


Figure B24: Run 501: Surge Motion Time History

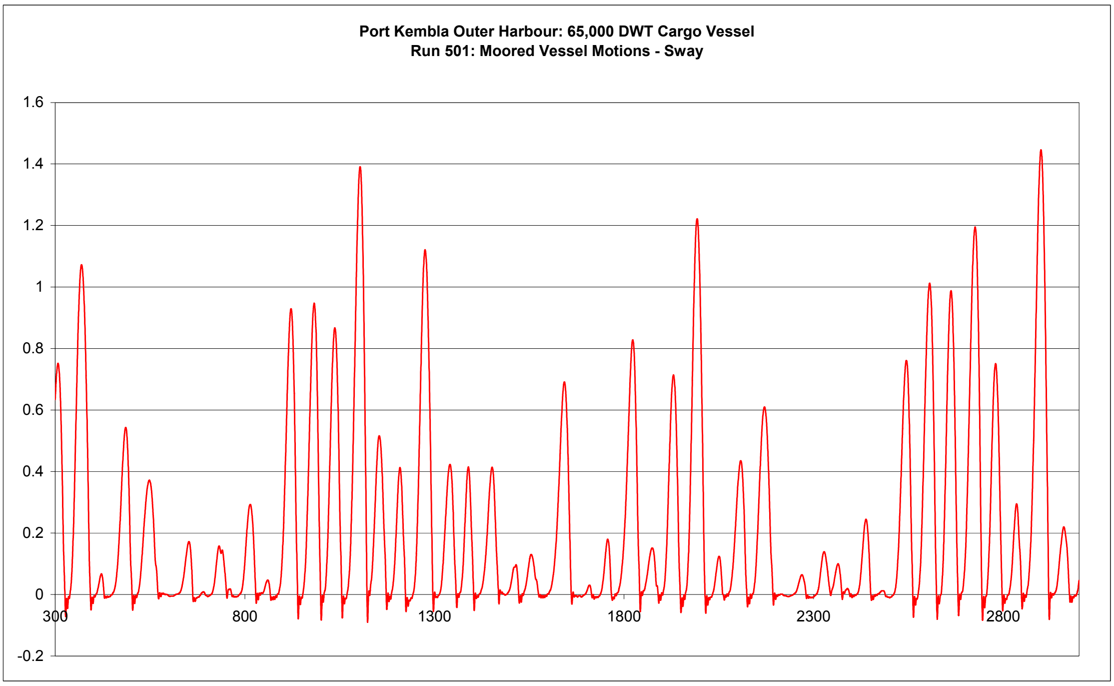


Figure B25: Run 501: Sway Motion Time History

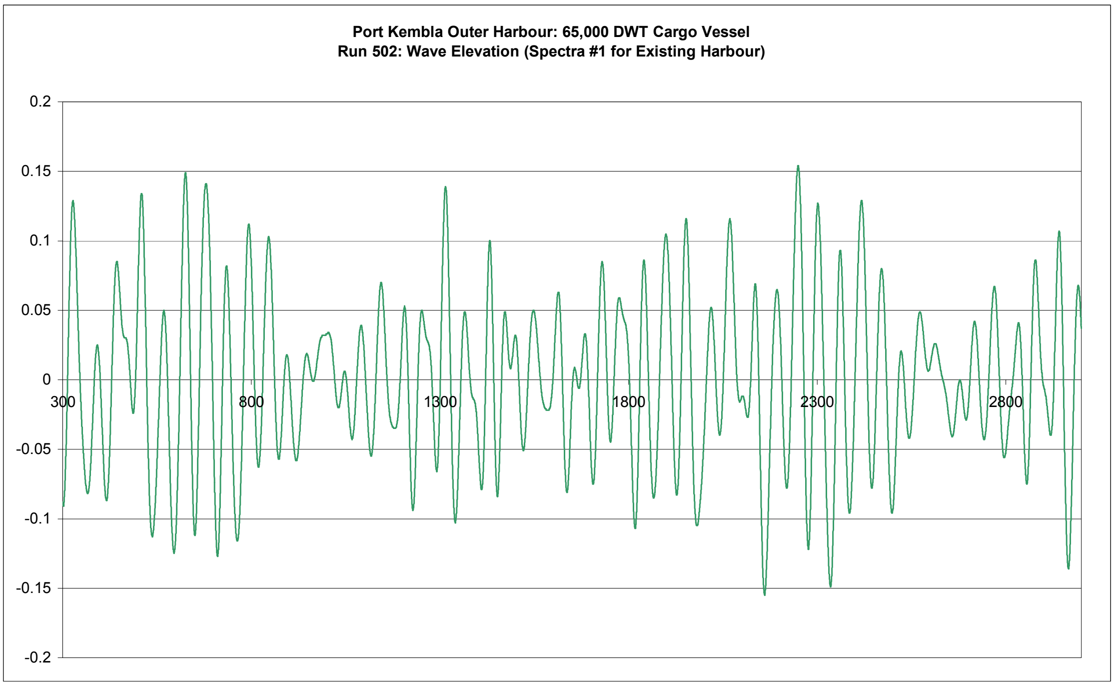


Figure B26: Run 502: Wave Elevation (Spectra #1 for Existing Harbour)

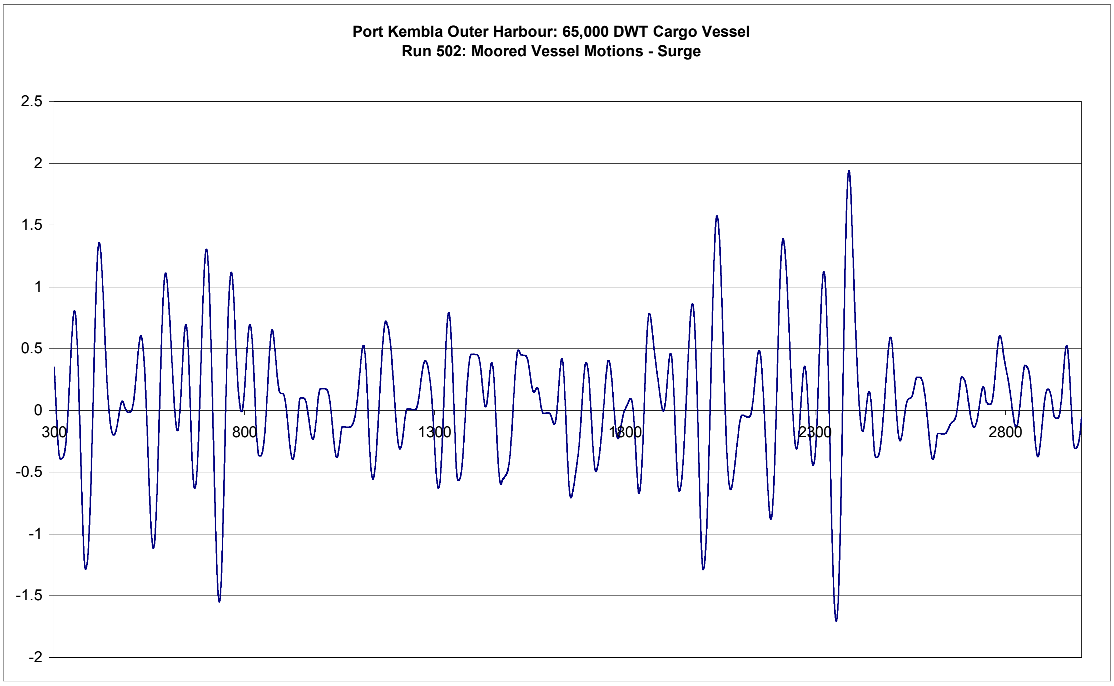


Figure B27: Run 502: Surge Motion Time History

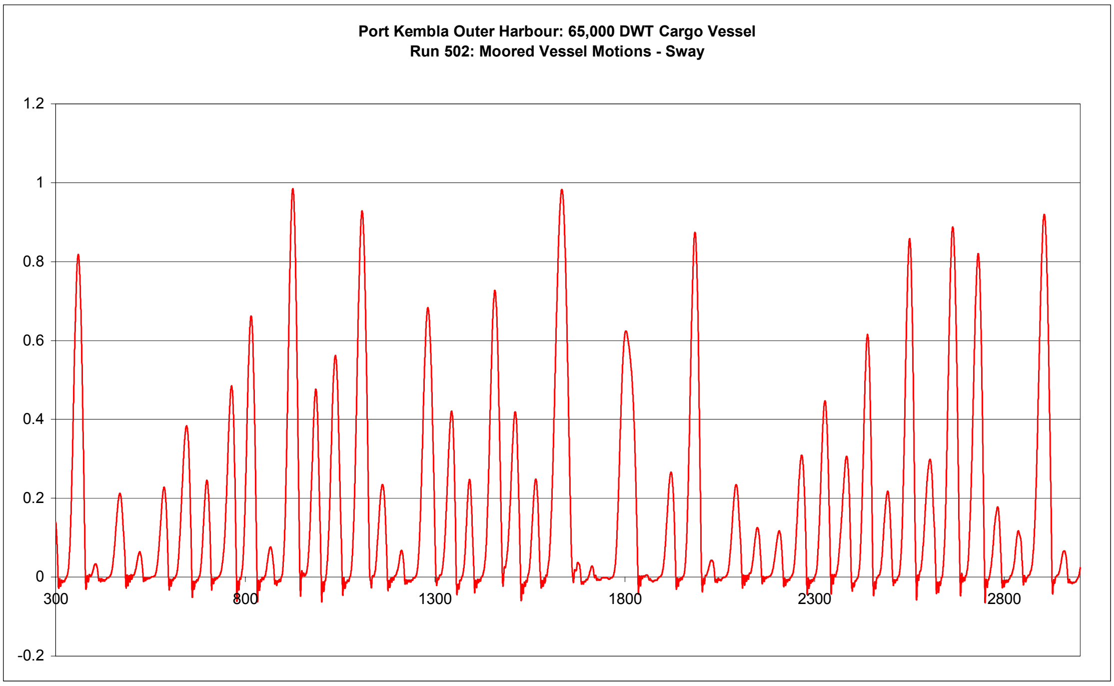


Figure B28: Run 502: Sway Motion Time History

Appendix C: Detailed results for H_{10} wave elevations and vessel motions

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 101: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.23m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
====================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.266	1.711	1.072	0.233	0.096	0.106	0.317
2	0.327	2.436	0.890	0.315	0.124	0.140	0.329
3	0.326	2.213	1.040	0.419	0.087	0.193	0.313
4	0.320	1.882	0.923	0.341	0.107	0.150	0.317
5	0.234	1.944	1.066	0.263	0.111	0.132	0.372
6	0.230	2.009	0.874	0.274	0.109	0.132	0.379
7	0.181	2.204	1.226	0.273	0.098	0.137	0.436
8	0.227	2.119	0.836	0.289	0.105	0.148	0.308
9	0.216	1.918	0.581	0.309	0.082	0.130	0.190
10	0.213	1.808	1.243	0.262	0.107	0.133	0.365
11	0.243	2.037	0.490	0.250	0.112	0.117	0.224
12	0.327	2.948	0.840	0.389	0.105	0.201	0.268
13	0.256	1.744	1.022	0.257	0.106	0.114	0.381
14	0.202	1.520	1.263	0.221	0.101	0.122	0.376
15	0.304	2.284	1.215	0.286	0.105	0.139	0.425
MEAN	0.258	2.052	0.972	0.292	0.104	0.140	0.333
S.D.	0.050	0.346	0.231	0.055	0.010	0.026	0.069
5.0	0.352	2.696	1.403	0.395	0.123	0.189	0.461

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 102: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.20m; Tz = 74s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
====================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.219	2.352	0.894	0.267	0.109	0.101	0.303
2	0.248	2.541	0.499	0.281	0.099	0.120	0.194
3	0.225	2.356	0.540	0.298	0.086	0.123	0.217
4	0.194	1.737	0.995	0.217	0.098	0.101	0.282
5	0.285	2.543	0.846	0.259	0.099	0.112	0.316
6	0.185	2.677	0.635	0.243	0.098	0.109	0.237
7	0.164	2.436	0.760	0.233	0.100	0.102	0.288
8	0.205	2.781	0.546	0.237	0.098	0.102	0.237
9	0.173	1.918	0.293	0.216	0.073	0.089	0.133
10	0.181	2.240	0.666	0.197	0.103	0.099	0.266
11	0.244	2.804	0.750	0.278	0.096	0.111	0.272
12	0.282	3.912	0.684	0.323	0.086	0.129	0.199
13	0.223	2.049	0.638	0.255	0.093	0.101	0.240
14	0.202	2.134	0.873	0.240	0.091	0.107	0.278
15	0.213	2.911	0.570	0.254	0.080	0.101	0.243
MEAN	0.216	2.493	0.679	0.253	0.094	0.107	0.247
S.D.	0.036	0.517	0.181	0.033	0.009	0.010	0.048
5.0	0.284	3.457	1.016	0.315	0.111	0.127	0.336

```
Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

RUN NO.  201: Spectra 1

Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.23m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
====================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.266	1.989	0.432	0.230	0.108	0.104	0.155
2	0.327	2.604	0.350	0.309	0.120	0.138	0.196
3	0.326	2.624	0.354	0.408	0.088	0.189	0.172
4	0.320	2.270	0.379	0.334	0.108	0.147	0.190
5	0.234	1.992	0.587	0.254	0.104	0.128	0.219
6	0.230	2.286	0.376	0.270	0.103	0.129	0.313
7	0.181	2.095	0.498	0.264	0.092	0.134	0.206
8	0.227	2.303	0.282	0.279	0.108	0.146	0.162
9	0.216	1.911	0.167	0.301	0.074	0.127	0.083
10	0.213	2.044	0.434	0.255	0.098	0.132	0.168
11	0.243	2.105	0.117	0.245	0.076	0.114	0.069
12	0.327	2.918	0.290	0.378	0.112	0.197	0.129
13	0.256	2.120	0.377	0.253	0.097	0.111	0.242
14	0.202	1.846	0.556	0.216	0.112	0.119	0.228
15	0.304	2.176	0.507	0.281	0.117	0.138	0.246
MEAN	0.258	2.219	0.380	0.285	0.101	0.137	0.185
S.D.	0.050	0.296	0.132	0.053	0.014	0.026	0.063
5.0	0.352	2.770	0.626	0.385	0.127	0.185	0.303

Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

RUN NO. 202: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.20m; Tz = 74s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
===================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.219	3.058	0.329	0.263	0.113	0.099	0.153
2	0.248	3.049	0.127	0.276	0.077	0.119	0.081
3	0.225	2.833	0.157	0.292	0.070	0.121	0.090
4	0.194	1.853	0.327	0.212	0.088	0.098	0.137
5	0.285	3.578	0.356	0.255	0.098	0.110	0.165
6	0.185	3.747	0.193	0.236	0.091	0.106	0.170
7	0.164	2.636	0.232	0.227	0.090	0.100	0.127
8	0.205	2.528	0.154	0.232	0.089	0.101	0.100
9	0.173	1.867	0.065	0.212	0.044	0.087	0.040
10	0.181	1.932	0.184	0.193	0.076	0.097	0.096
11	0.244	3.482	0.161	0.273	0.082	0.109	0.094
12	0.282	3.857	0.170	0.318	0.085	0.127	0.078
13	0.223	2.481	0.174	0.250	0.076	0.099	0.092
14	0.202	3.352	0.278	0.234	0.081	0.105	0.143
15	0.213	2.768	0.172	0.249	0.083	0.100	0.100
MEAN	0.216	2.868	0.205	0.248	0.083	0.105	0.111
S.D.	0.036	0.664	0.083	0.033	0.015	0.011	0.037
5.0	0.284	4.107	0.359	0.310	0.111	0.125	0.179

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

RUN NO. 301: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.15m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
====================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.172	1.296	0.797	0.176	0.096	0.087	0.261
2	0.174	1.814	0.463	0.190	0.102	0.094	0.181
3	0.212	1.908	0.508	0.247	0.130	0.126	0.285
4	0.195	1.380	0.501	0.193	0.111	0.108	0.260
5	0.135	1.498	0.410	0.163	0.105	0.092	0.175
6	0.165	1.767	0.635	0.193	0.134	0.095	0.281
7	0.131	1.194	0.778	0.159	0.127	0.086	0.306
8	0.142	1.246	0.616	0.190	0.125	0.088	0.254
9	0.132	1.291	0.366	0.177	0.087	0.085	0.192
10	0.151	1.221	0.579	0.164	0.097	0.095	0.251
11	0.157	1.437	0.337	0.158	0.095	0.091	0.202
12	0.195	1.650	0.715	0.230	0.119	0.114	0.279
13	0.171	1.450	0.502	0.176	0.085	0.104	0.240
14	0.144	1.688	0.657	0.173	0.119	0.086	0.245
15	0.171	1.549	0.570	0.168	0.112	0.092	0.246
MEAN	0.163	1.493	0.562	0.184	0.110	0.096	0.244
S.D.	0.025	0.230	0.140	0.025	0.016	0.012	0.040
5.0	0.209	1.921	0.824	0.231	0.139	0.118	0.318

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

RUN NO. 302: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.13m; Tz = 68s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
==================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.158	1.362	0.591	0.168	0.081	0.077	0.215
2	0.145	1.608	0.335	0.161	0.090	0.076	0.159
3	0.165	1.881	0.433	0.203	0.096	0.088	0.222
4	0.140	1.109	0.398	0.146	0.101	0.078	0.204
5	0.125	1.596	0.266	0.140	0.080	0.075	0.152
6	0.123	1.615	0.379	0.149	0.119	0.069	0.188
7	0.110	1.311	0.753	0.132	0.117	0.068	0.263
8	0.120	1.043	0.473	0.144	0.100	0.065	0.195
9	0.114	1.291	0.222	0.142	0.072	0.065	0.136
10	0.118	1.097	0.382	0.122	0.076	0.071	0.187
11	0.135	1.680	0.336	0.140	0.083	0.071	0.196
12	0.155	2.013	0.584	0.186	0.103	0.082	0.256
13	0.124	1.427	0.379	0.143	0.070	0.079	0.183
14	0.126	1.906	0.465	0.149	0.090	0.075	0.181
15	0.128	1.208	0.402	0.131	0.098	0.068	0.171
MEAN	0.132	1.476	0.427	0.150	0.092	0.074	0.194
S.D.	0.017	0.310	0.135	0.021	0.015	0.007	0.035
5.0	0.164	2.054	0.678	0.190	0.120	0.086	0.259

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 401: Spectra 1

Wave Spectra: Sea   - zero
Swell - Hs = zero
Long - Hs = 0.33m; Tz = 56s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 2 stern & bow breast lines
: 0 No. forward & aft spring line
All Lines   : Line pretensions = 0.4 tonne
: ALL LINES 40.0MM polypropylene lines

: Line GMBL   = 20.5 tonne
Fender Arrangement   :300 x 300 DD Continuous Fenders

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.376	0.879	0.054	0.675	0.186	1.027	0.171
2	0.417	0.925	0.045	0.773	0.186	1.061	0.166
3	0.412	1.255	0.042	0.763	0.203	1.155	0.162
4	0.285	0.681	0.046	0.535	0.184	0.751	0.175
5	0.293	0.552	0.049	0.521	0.172	0.857	0.178
6	0.374	0.941	0.042	0.698	0.202	1.060	0.170
7	0.273	0.754	0.048	0.498	0.173	0.761	0.177
8	0.362	0.735	0.048	0.651	0.170	0.922	0.182
9	0.345	0.617	0.048	0.595	0.185	0.814	0.185
10	0.319	0.797	0.048	0.575	0.196	0.871	0.170
11	0.373	0.758	0.052	0.662	0.203	0.957	0.179
12	0.349	0.994	0.045	0.629	0.196	1.011	0.170
13	0.347	0.982	0.043	0.641	0.173	0.993	0.167
14	0.338	0.796	0.039	0.608	0.191	0.878	0.172
15	0.414	1.038	0.045	0.737	0.195	1.043	0.167
MEAN	0.352	0.847	0.046	0.637	0.188	0.944	0.173
S.D.	0.045	0.181	0.004	0.085	0.012	0.120	0.006
5.0	0.436	1.185	0.054	0.795	0.209	1.167	0.185

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 402: Spectra 1

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.42m; Tz = 159.8s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 2 stern & bow breast lines
: 0 No. forward & aft spring line
All Lines : Line pretensions = 0.4 tonne
: ALL LINES 40.0MM polypropylene lines

: Line GMBL = 20.5 tonne
Fender Arrangement : 300 x 300 DD Continuous Fenders

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.419	0.639	0.045	0.746	0.169	0.977	0.181
2	0.572	0.876	0.052	1.033	0.226	1.277	0.183
3	0.639	1.013	0.044	1.138	0.206	1.591	0.166
4	0.439	0.573	0.049	0.768	0.165	0.998	0.171
5	0.388	0.494	0.046	0.708	0.193	0.867	0.179
6	0.451	0.859	0.044	0.779	0.193	1.198	0.168
7	0.359	0.649	0.049	0.655	0.187	0.908	0.178
8	0.504	0.783	0.048	0.895	0.215	1.205	0.174
9	0.455	0.895	0.047	0.824	0.170	0.979	0.176
10	0.465	0.666	0.047	0.830	0.191	1.304	0.176
11	0.456	0.640	0.050	0.837	0.199	1.051	0.176
12	0.449	0.832	0.053	0.806	0.175	1.090	0.172
13	0.371	0.846	0.045	0.669	0.162	0.962	0.185
14	0.309	0.548	0.047	0.559	0.175	0.738	0.177
15	0.594	0.791	0.053	1.038	0.190	1.222	0.172
MEAN	0.458	0.740	0.048	0.819	0.188	1.091	0.176
S.D.	0.090	0.150	0.003	0.156	0.019	0.213	0.005
5.0	0.625	1.020	0.054	1.110	0.223	1.487	0.185

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

RUN NO. 501: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.22m; Tz = 60s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
===================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.206	2.211	0.664	0.181	0.160	0.118	0.256
2	0.354	3.646	0.430	0.348	0.132	0.166	0.237
3	0.261	2.886	0.710	0.306	0.152	0.162	0.349
4	0.288	3.483	0.447	0.322	0.111	0.162	0.224
5	0.216	3.556	0.783	0.221	0.128	0.139	0.216
6	0.260	2.583	0.744	0.278	0.222	0.135	0.385
7	0.152	2.277	0.814	0.220	0.194	0.118	0.290
8	0.216	2.312	0.801	0.294	0.157	0.134	0.301
9	0.210	2.351	0.598	0.328	0.142	0.142	0.283
10	0.225	2.032	0.834	0.239	0.205	0.133	0.280
11	0.206	2.837	0.454	0.198	0.117	0.113	0.256
12	0.312	2.970	1.087	0.372	0.216	0.176	0.414
13	0.236	2.351	0.563	0.238	0.156	0.136	0.242
14	0.209	2.606	0.770	0.239	0.176	0.105	0.300
15	0.262	2.935	1.040	0.257	0.220	0.147	0.392
MEAN	0.241	2.736	0.716	0.269	0.166	0.139	0.295
S.D.	0.050	0.513	0.197	0.057	0.038	0.021	0.063
5.0	0.334	3.692	1.084	0.376	0.236	0.178	0.412

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

RUN NO. 502: Existing Spectra

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.25m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
```

H10 WAVE ELEVATIONS & VESSEL MOTIONS: (m, deg)
====================================

Test No.	Wave	Surge	Sway	Heave	Roll	Pitch	Yaw
1	0.184	1.797	1.005	0.172	0.168	0.118	0.302
2	0.288	2.353	1.074	0.271	0.226	0.116	0.328
3	0.396	3.560	0.552	0.444	0.172	0.227	0.356
4	0.360	3.362	0.498	0.345	0.145	0.199	0.237
5	0.174	2.856	0.676	0.242	0.163	0.142	0.314
6	0.258	2.720	0.552	0.313	0.152	0.145	0.308
7	0.139	1.776	1.079	0.230	0.245	0.112	0.384
8	0.232	1.723	0.985	0.229	0.171	0.122	0.443
9	0.231	2.268	0.731	0.296	0.152	0.117	0.362
10	0.228	1.886	0.761	0.261	0.180	0.136	0.317
11	0.229	2.476	0.400	0.216	0.134	0.136	0.270
12	0.440	4.025	1.495	0.516	0.265	0.259	0.548
13	0.205	2.561	0.605	0.234	0.123	0.157	0.228
14	0.195	3.139	1.701	0.197	0.231	0.139	0.437
15	0.257	2.638	0.786	0.231	0.192	0.133	0.255
MEAN	0.254	2.609	0.860	0.280	0.181	0.151	0.339
S.D.	0.084	0.691	0.369	0.093	0.042	0.044	0.087
5.0	0.412	3.899	1.548	0.454	0.260	0.232	0.501

Appendix D: Detailed excursion and line loads for Run 303

SPMS MOORED SHIP STUDY
=====================

```
RUN NO.          : 303
RUN DESCRIPTION  :

     Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

     RUN NO.  303: Wind only

     Wave Spectra: Sea   -  zero
                   Swell -  Hs = zero
                   Long  -  Hs = zero
     Wind                -  Vw = 40 m/s from West (off fenders)
     Current             -  Vc = 0 m/s
     Mooring Arrangement  : 3 No. head & stern lines
                          : 2 No. forward & aft breast lines
                          : 1 No. forward & aft spring line
              H/St Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne
              B/Sp Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne

                          : ALL LINES 88.0mm polyprop
     Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

MOORING RESPONSE (QUASI-STATIC LOADING):
======================================

MOORING	MAX LINE TENS
1	15.29
2	15.06
3	14.31
4	32.75
5	32.75
6	8.18
7	9.88
8	15.07
9	15.07
10	7.71
11	7.75
12	7.80

SHIP MOTIONS:

SURGE = 0.164 M	SWAY = 0.770 M	HEAVE = 0.002 M
ROLL = -0.007 DEG	PITCH = 0.001 DEG	YAW = -0.230 DEG

PORT FENDER FORCES & DISPTS:

0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

****

Appendix E: Detailed results for peak mooring line tensions all lines

SPMS MOORED SHIP STUDY
======================

RUN NO. : 101
RUN DESCRIPTION :

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 101: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.23m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
DATE                 :  22/ 4/ 6
```

PEAK LINE TENSIONS (%(GMBL)):
==================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	21.7 18.0	21.7 18.0	22.3 17.7	22.3 17.7	28.1	28.1	16.9	16.9	20.7	20.7	54.0	54.0
2	24.6 23.8	24.6 23.8	27.1 22.3	27.1 22.3	26.4	26.4	25.2	25.2	26.2	26.2	40.7	40.7
3	23.7 22.0	23.7 22.0	25.9 21.1	25.9 21.1	37.5	37.5	22.5	22.5	24.3	24.3	49.3	49.3
4	24.6 18.2	24.6 18.2	26.3 18.1	26.3 18.1	30.2	30.2	18.4	18.4	23.2	23.2	56.5	56.5
5	22.7 19.8	22.7 19.8	24.7 18.8	24.7 18.8	29.4	29.4	20.8	20.8	22.0	22.0	52.7	52.7
6	21.6 21.7	21.6 21.7	23.4 21.1	23.4 21.1	32.2	32.2	21.3	21.3	21.0	21.0	56.6	56.6
7	20.8 23.2	20.8 23.2	22.2 22.7	22.2 22.7	33.1	33.1	24.1	24.1	19.1	19.1	62.9	62.9
8	26.9 21.5	26.9 21.5	29.6 20.7	29.6 20.7	22.7	22.7	22.6	22.6	26.8	26.8	53.3	53.3
9	22.8 23.3	22.8 23.3	24.8 22.3	24.8 22.3	22.5	22.5	22.3	22.3	21.8	21.8	34.5	34.5
10	19.9 22.0	19.9 22.0	21.4 21.8	21.4 21.8	33.5	33.5	23.4	23.4	18.9	18.9	60.5	60.5
11	21.3 24.6	21.3 24.6	22.9 23.5	22.9 23.5	26.0	26.0	24.0	24.0	20.8	20.8	30.7	30.7
12	26.6 26.0	26.6 26.0	28.5 25.0	28.5 25.0	31.4	31.4	24.9	24.9	23.5	23.5	49.6	49.6
13	18.9 18.4	18.9 18.4	20.3 17.6	20.3 17.6	31.7	31.7	19.0	19.0	19.6	19.6	50.6	50.6
14	23.8 18.4	23.8 18.4	25.0 18.8	25.0 18.8	34.6	34.6	15.1	15.1	19.9	19.9	67.1	67.1
15	27.8 23.2	27.8 23.2	29.3 22.8	29.3 22.8	25.9	25.9	21.3	21.3	23.4	23.4	66.0	66.0
MEAN =	23.2	23.2	24.9	24.9	29.7	29.7	21.5	21.5	22.1	22.1	52.3	52.3
MEAN =	21.6	21.6	21.0	21.0								
S.D. =	2.6	2.6	2.9	2.9	4.4	4.4	3.0	3.0	2.4	2.4	10.6	10.6
S.D. =	2.5	2.5	2.3	2.3								
5.0% EXC.=	28.0	28.0	30.3	30.3	37.8	37.8	27.0	27.0	26.6	26.6	72.0	72.0
% EXC.=	26.3	26.3	25.2	25.2								

SPMS MOORED SHIP STUDY

RUN NO. : 102
RUN DESCRIPTION :

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 102: Spectra 2

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.20m; Tz = 74s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 4 No. head & stern lines
: 2 No. forward & aft breast lines
: 2 No. forward & aft spring line
H/St Lines : Line pretensions = 8.0 tonne
: ALL LINES 88.0mm polyprop

: Line GMBL = 90.6 tonne
B/Sp Lines : Line pretensions = 8.0 tonne
: ALL LINES 88.0mm polyprop

: Line GMBL = 90.6 tonne

: ALL LINES 88.0mm polyprop
Fender Arrangement : SUC1250 RH Fenders @ 20m centres
DATE : 22/ 4/ 6

PEAK LINE TENSIONS (%(GMBL)):

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	25.4 22.2	25.4 22.2	27.5 21.5	27.5 21.5	32.9	32.9	22.5	22.5	22.9	22.9	48.8	48.8
2	21.9 22.9	21.9 22.9	23.7 22.1	23.7 22.1	30.4	30.4	22.6	22.6	20.8	20.8	34.5	34.5
3	24.5 23.4	24.5 23.4	26.8 22.6	26.8 22.6	30.9	30.9	22.2	22.2	23.9	23.9	31.6	31.6
4	20.8 19.9	20.8 19.9	22.5 19.8	22.5 19.8	32.3	32.3	18.5	18.5	19.8	19.8	47.8	47.8
5	27.0 20.4	27.0 20.4	28.9 19.4	28.9 19.4	25.1	25.1	21.1	21.1	23.9	23.9	45.4	45.4
6	22.1 23.5	22.1 23.5	23.9 22.6	23.9 22.6	30.4	30.4	22.6	22.6	23.1	23.1	34.3	34.3
7	23.6 21.6	23.6 21.6	26.0 20.4	26.0 20.4	27.5	27.5	22.8	22.8	24.1	24.1	39.1	39.1
8	28.9 23.5	28.9 23.5	31.9 22.1	31.9 22.1	22.3	22.3	24.5	24.5	28.0	28.0	34.8	34.8
9	21.0 18.5	21.0 18.5	22.7 18.4	22.7 18.4	19.1	19.1	17.7	17.7	20.0	20.0	27.5	27.5
10	23.4 20.0	23.4 20.0	25.3 19.0	25.3 19.0	22.6	22.6	20.8	20.8	22.5	22.5	37.6	37.6
11	25.8 27.4	25.8 27.4	28.2 26.0	28.2 26.0	28.9	28.9	27.5	27.5	24.9	24.9	40.6	40.6
12	40.4 29.8	40.4 29.8	45.2 27.8	45.2 27.8	29.7	29.7	31.7	31.7	38.3	38.3	36.3	36.3
13	21.2 20.5	21.2 20.5	23.1 19.8	23.1 19.8	24.8	24.8	20.5	20.5	20.8	20.8	34.2	34.2
14	23.3 20.0	23.3 20.0	24.8 19.6	24.8 19.6	27.7	27.7	18.7	18.7	21.3	21.3	44.6	44.6
15	27.1 24.9	27.1 24.9	30.1 23.6	30.1 23.6	24.6	24.6	26.3	26.3	27.1	27.1	35.6	35.6
MEAN =	25.1	25.1	27.4	27.4	27.3	27.3	22.7	22.7	24.1	24.1	38.2	38.2
MEAN =	22.6	22.6	21.6	21.6								
S.D. =	4.9	4.9	5.7	5.7	4.1	4.1	3.7	3.7	4.6	4.6	6.1	6.1
S.D. =	3.1	3.1	2.6	2.6								
5.0% EXC.=	34.2	34.2	38.0	38.0	34.8	34.8	29.5	29.5	32.7	32.7	49.6	49.6
% EXC.=	28.3	28.3	26.6	26.6								

SPMS MOORED SHIP STUDY
======================

```
RUN NO.          : 201
RUN DESCRIPTION  :

     Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

     RUN NO.  201: Spectra 1

     Wave Spectra: Sea   -  zero
                   Swell -  Hs = zero
                   Long  -  Hs = 0.23m; Tz = 58s
     Wind                -  Vw = 0 m/s
     Current             -  Vc = 0 m/s
     Mooring Arrangement  : 4 No. head & stern lines
                          : 2 No. forward & aft breast lines
                          : 2 No. forward & aft spring line
              H/St Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne
              B/Sp Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne

                          : ALL LINES 88.0mm polyprop
     Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
DATE             :  22/ 4/ 6
```

PEAK LINE TENSIONS (%(GMBL)):
=================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	22.0	22.0	23.7	23.7	19.3	19.3	17.9	17.9	20.5	20.5	34.3	34.3
	17.4	17.4	16.6	16.6								
2	23.3	23.3	25.6	25.6	20.1	20.1	20.9	20.9	23.9	23.9	26.1	26.1
	20.3	20.3	19.2	19.2								
3	23.4	23.4	25.3	25.3	32.5	32.5	23.7	23.7	21.4	21.4	27.2	27.2
	22.9	22.9	21.6	21.6								
4	24.5	24.5	26.9	26.9	25.1	25.1	19.2	19.2	24.0	24.0	34.1	34.1
	18.6	18.6	17.8	17.8								
5	20.4	20.4	21.9	21.9	21.5	21.5	19.6	19.6	19.0	19.0	37.4	37.4
	18.8	18.8	17.9	17.9								
6	23.0	23.0	24.9	24.9	22.4	22.4	21.1	21.1	21.7	21.7	33.2	33.2
	20.4	20.4	19.4	19.4								
7	21.5	21.5	23.3	23.3	20.3	20.3	22.4	22.4	20.5	20.5	38.3	38.3
	21.7	21.7	20.6	20.6								
8	22.5	22.5	24.8	24.8	22.6	22.6	26.4	26.4	23.3	23.3	32.9	32.9
	25.4	25.4	23.9	23.9								
9	18.1	18.1	19.4	19.4	17.8	17.8	21.0	21.0	17.4	17.4	24.0	24.0
	20.3	20.3	19.3	19.3								
10	22.0	22.0	23.9	23.9	23.3	23.3	25.7	25.7	20.9	20.9	30.2	30.2
	24.6	24.6	23.2	23.2								
11	20.1	20.1	21.7	21.7	19.3	19.3	21.1	21.1	19.2	19.2	16.9	16.9
	20.4	20.4	19.4	19.4								
12	26.0	26.0	28.5	28.5	24.9	24.9	24.0	24.0	24.8	24.8	29.0	29.0
	23.2	23.2	22.3	22.3								
13	20.8	20.8	22.4	22.4	20.8	20.8	18.4	18.4	19.7	19.7	31.7	31.7
	17.8	17.8	17.0	17.0								
14	20.5	20.5	21.9	21.9	23.2	23.2	18.2	18.2	19.4	19.4	38.1	38.1
	17.8	17.8	17.0	17.0								
15	21.8	21.8	23.8	23.8	18.3	18.3	18.2	18.2	21.8	21.8	42.5	42.5
	18.6	18.6	18.5	18.5								
MEAN =	22.0	22.0	23.9	23.9	22.1	22.1	21.2	21.2	21.2	21.2	31.7	31.7
MEAN =	20.5	20.5	19.6	19.6								
S.D. =	1.9	1.9	2.3	2.3	3.6	3.6	2.8	2.8	2.1	2.1	6.5	6.5
S.D. =	2.5	2.5	2.3	2.3								
5.0% EXC.=	25.6	25.6	28.1	28.1	28.9	28.9	26.3	26.3	25.1	25.1	43.8	43.8
% EXC.=	25.3	25.3	23.9	23.9								

SPMS MOORED SHIP STUDY
======================

RUN NO. : 202
RUN DESCRIPTION :

Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

RUN NO. 202: Spectra 2

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.20m; Tz = 74s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 4 No. head & stern lines
: 2 No. forward & aft breast lines
: 2 No. forward & aft spring line
H/St Lines : Line pretensions = 8.0 tonne
: ALL LINES 88.0mm polyprop

: Line GMBL = 90.6 tonne
B/Sp Lines : Line pretensions = 8.0 tonne
: ALL LINES 88.0mm polyprop

: Line GMBL = 90.6 tonne

: ALL LINES 88.0mm polyprop
Fender Arrangement : SUC1250 RH Fenders @ 20m centres
DATE : 22/ 4/ 6

PEAK LINE TENSIONS (%(GMBL)):
==================

Test No.		Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1		26.5	26.5	29.0	29.0	22.1	22.1	24.3	24.3	25.5	25.5	32.4	32.4
		23.1	23.1	21.8	21.8								
2		23.7	23.7	25.8	25.8	24.4	24.4	24.3	24.3	22.7	22.7	19.2	19.2
		22.9	22.9	21.6	21.6								
3		22.8	22.8	24.7	24.7	24.7	24.7	22.3	22.3	22.1	22.1	19.8	19.8
		21.5	21.5	20.4	20.4								
4		21.1	21.1	22.9	22.9	22.6	22.6	18.1	18.1	20.2	20.2	27.0	27.0
		17.2	17.2	16.4	16.4								
5		27.6	27.6	30.3	30.3	22.0	22.0	25.3	25.3	27.7	27.7	35.4	35.4
		24.2	24.2	22.8	22.8								
6		27.6	27.6	30.2	30.2	24.8	24.8	28.3	28.3	26.1	26.1	24.6	24.6
		27.0	27.0	25.4	25.4								
7		25.5	25.5	28.1	28.1	19.7	19.7	23.2	23.2	25.2	25.2	21.5	21.5
		22.5	22.5	21.2	21.2								
8		27.7	27.7	30.4	30.4	25.9	25.9	30.2	30.2	26.4	26.4	20.5	20.5
		28.9	28.9	27.1	27.1								
9		18.9	18.9	20.3	20.3	15.9	15.9	17.6	17.6	18.3	18.3	14.3	14.3
		17.5	17.5	16.9	16.9								
10		19.9	19.9	21.5	21.5	19.7	19.7	22.7	22.7	19.1	19.1	19.3	19.3
		21.9	21.9	20.7	20.7								
11		27.2	27.2	29.8	29.8	23.4	23.4	26.9	26.9	26.1	26.1	19.0	19.0
		25.8	25.8	24.3	24.3								
12		32.1	32.1	35.4	35.4	25.3	25.3	29.3	29.3	30.4	30.4	19.2	19.2
		27.7	27.7	26.0	26.0								
13		23.7	23.7	25.8	25.8	18.1	18.1	20.1	20.1	22.5	22.5	16.8	16.8
		19.4	19.4	18.5	18.5								
14		29.2	29.2	32.1	32.1	23.3	23.3	26.2	26.2	27.7	27.7	26.5	26.5
		25.2	25.2	23.8	23.8								
15		23.4	23.4	25.4	25.4	19.3	19.3	21.3	21.3	22.3	22.3	23.6	23.6
		20.6	20.6	19.5	19.5								
MEAN	=	25.1	25.1	27.4	27.4	22.1	22.1	24.0	24.0	24.2	24.2	22.6	22.6
MEAN	=	23.0	23.0	21.8	21.8								
S.D.	=	3.6	3.6	4.2	4.2	2.9	2.9	3.8	3.8	3.5	3.5	5.7	5.7
S.D.	=	3.5	3.5	3.2	3.2								
5.0% EXC.	=	31.9	31.9	35.2	35.2	27.6	27.6	31.1	31.1	30.6	30.6	33.3	33.3
% EXC.	=	29.6	29.6	27.7	27.7								

SPMS MOORED SHIP STUDY
======================

```
RUN NO.          : 301
RUN DESCRIPTION  :

     Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

     RUN NO.  301: Spectra 1

     Wave Spectra: Sea   -  zero
                   Swell -  Hs = zero
                   Long  -  Hs = 0.15m; Tz = 58s
     Wind                -  Vw = 0 m/s
     Current             -  Vc = 0 m/s
     Mooring Arrangement  : 3 No. head & stern lines
                          : 2 No. forward & aft breast lines
                          : 1 No. forward & aft spring line
              H/St Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne
              B/Sp Lines  : Line pretensions =  8.0 tonne
                          : ALL LINES 88.0mm polyprop

                          : Line GMBL        =  90.6 tonne

                          : ALL LINES 88.0mm polyprop
     Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
DATE             :  22/ 4/ 6
```

PEAK LINE TENSIONS (%(GMBL)):
==================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	17.9	18.4	18.4	30.6	30.6	17.2	20.9	34.8	34.8	19.3	19.7	19.7
2	20.8	21.6	22.0	21.7	21.7	24.0	26.0	26.9	26.9	24.1	24.1	23.5
3	20.1	20.6	20.7	28.3	28.3	25.1	23.5	31.4	31.4	23.5	23.2	22.6
4	18.8	19.4	19.8	22.9	22.9	18.9	23.9	33.9	33.9	19.2	19.3	19.1
5	18.7	19.3	19.7	19.7	19.7	20.7	23.4	25.9	25.9	20.5	20.4	20.0
6	18.7	19.3	19.7	27.6	27.6	22.1	23.6	38.8	38.8	21.0	20.8	20.3
7	19.1	19.6	19.8	28.4	28.4	17.5	22.1	46.6	46.6	19.2	19.5	19.4
8	17.0	17.5	17.8	25.7	25.7	21.6	21.1	35.2	35.2	21.9	21.9	21.5
9	16.7	17.2	17.5	22.9	22.9	18.8	20.1	22.9	22.9	19.9	20.2	20.0
10	18.4	18.8	18.7	27.2	27.2	21.5	21.0	32.3	32.3	21.0	21.0	20.6
11	19.8	20.5	20.9	22.3	22.3	21.5	24.7	24.1	24.1	19.8	19.5	19.1
12	20.9	21.7	22.0	36.1	36.1	21.0	25.9	35.2	35.2	22.3	22.7	22.5
13	17.3	17.8	18.0	29.5	29.5	20.1	20.3	27.3	27.3	21.5	21.8	21.6
14	20.9	21.7	22.2	25.4	25.4	19.9	27.0	37.7	37.7	18.3	18.3	18.0
15	22.9	23.7	24.1	21.9	21.9	21.3	27.8	28.2	28.2	19.7	19.4	18.8
MEAN =	19.2	19.8	20.1	26.0	26.0	20.7	23.4	32.1	32.1	20.7	20.8	20.4
S.D. =	1.7	1.8	1.9	4.3	4.3	2.2	2.5	6.4	6.4	1.7	1.6	1.6
5.0% EXC.=	22.4	23.2	23.6	34.0	34.0	24.8	28.1	44.0	44.0	23.9	23.9	23.4
% EXC.=												

```
                                    SPMS MOORED SHIP STUDY
                                    ======================
 RUN NO.          : 302
 RUN DESCRIPTION  :

      Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

      RUN NO.  302: Spectra 2

      Wave Spectra: Sea   -  zero
                    Swell -  Hs = zero
                    Long  -  Hs = 0.13m; Tz = 68s
      Wind                -  Vw = 0 m/s
      Current             -  Vc = 0 m/s
      Mooring Arrangement  : 3 No. head & stern lines
                           : 2 No. forward & aft breast lines
                           : 1 No. forward & aft spring line
               H/St Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne
               B/Sp Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne

                           : ALL LINES 88.0mm polyprop
      Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
 DATE             :  22/ 4/ 6

 PEAK LINE TENSIONS (%(GMBL)):
 ==================
```

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	17.3	17.7	18.0	26.4	26.4	18.4	20.7	26.3	26.3	20.2	20.5	20.3
2	18.3	18.9	19.2	24.4	24.4	23.0	22.4	23.9	23.9	24.5	24.6	24.2
3	20.9	21.7	22.2	29.5	29.5	24.6	26.9	31.4	31.4	23.8	23.7	23.1
4	15.6	16.1	16.3	22.7	22.7	16.5	19.0	25.3	25.3	17.4	17.5	17.4
5	19.0	19.7	20.1	20.1	20.1	21.3	23.7	20.1	20.1	21.1	21.1	20.7
6	17.1	17.7	18.0	19.5	19.5	19.6	21.1	27.1	27.1	19.1	19.0	18.6
7	17.8	18.1	18.0	31.0	31.0	20.2	19.8	42.2	42.2	20.0	20.6	20.6
8	15.3	15.6	15.6	20.9	20.9	20.3	16.9	30.0	30.0	21.8	22.0	21.7
9	17.3	17.7	17.8	18.6	18.6	18.1	19.2	17.1	17.1	18.9	19.0	18.8
10	16.8	17.3	17.5	20.4	20.4	16.5	20.4	25.1	25.1	15.4	15.5	15.3
11	18.8	19.4	19.6	22.0	22.0	21.6	22.1	25.8	25.8	19.9	19.6	19.1
12	22.8	23.7	24.2	32.0	32.0	27.1	28.8	27.2	27.2	27.1	27.2	26.6
13	17.9	18.4	18.5	26.3	26.3	18.4	20.4	24.4	24.4	18.6	18.6	18.3
14	20.4	21.2	21.7	21.2	21.2	24.0	26.4	31.0	31.0	23.4	23.4	22.9
15	16.5	17.0	17.4	16.0	16.0	17.3	20.3	22.4	22.4	16.1	15.9	15.6
MEAN =	18.1	18.7	18.9	23.4	23.4	20.5	21.9	26.6	26.6	20.5	20.5	20.2
S.D. =	2.0	2.2	2.3	4.7	4.7	3.1	3.3	5.8	5.8	3.2	3.2	3.1
5.0% EXC.=	21.9	22.7	23.2	32.2	32.2	26.3	28.0	37.4	37.4	26.5	26.6	26.1
% EXC.=												

SPMS MOORED SHIP STUDY
=====================

RUN NO. : 401
RUN DESCRIPTION :

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 401: Spectra 1

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.33m; Tz = 56s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 2 stern & bow breast lines
: 0 No. forward & aft spring line
All Lines : Line pretensions = 0.4 tonne
: ALL LINES 40.0MM polypropylene lines

: Line GMBL = 20.5 tonne
Fender Arrangement :300 x 300 DD Continuous Fenders
DATE : 4/ 3/18

PEAK LINE TENSIONS (%(GMBL)):
=================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	16.3	16.3	29.2	29.2								
2	20.7	20.7	32.0	32.0								
3	18.7	18.7	34.9	34.9								
4	13.1	13.1	18.9	18.9								
5	14.3	14.3	17.6	17.6								
6	18.7	18.7	24.0	24.0								
7	17.7	17.7	25.8	25.8								
8	18.5	18.5	27.0	27.0								
9	16.5	16.5	20.7	20.7								
10	15.9	15.9	23.3	23.3								
11	21.3	21.3	37.1	37.1								
12	16.8	16.8	24.9	24.9								
13	15.0	15.0	25.0	25.0								
14	19.3	19.3	25.0	25.0								
15	19.3	19.3	35.8	35.8								
MEAN =	17.5	17.5	26.7	26.7								
S.D. =	2.3	2.3	6.0	6.0								
5.0% EXC.=	21.8	21.8	37.9	37.9								

SPMS MOORED SHIP STUDY
=====================

RUN NO. : 402
RUN DESCRIPTION :

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 402: Spectra 1

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.42m; Tz = 159.8s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 2 stern & bow breast lines
: 0 No. forward & aft spring line
All Lines : Line pretensions = 0.4 tonne
: ALL LINES 40.0MM polypropylene lines

: Line GMBL = 20.5 tonne
Fender Arrangement : 300 x 300 DD Continuous Fenders
DATE : 4/ 3/18

PEAK LINE TENSIONS (%(GMBL)):
=================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	15.9	15.9	26.7	26.7								
2	21.4	21.4	33.4	33.4								
3	21.7	21.7	49.9	49.9								
4	13.9	13.9	25.9	25.9								
5	14.6	14.6	29.0	29.0								
6	16.1	16.1	27.4	27.4								
7	14.8	14.8	25.2	25.2								
8	18.6	18.6	35.6	35.6								
9	16.3	16.3	28.1	28.1								
10	16.5	16.5	29.9	29.9								
11	20.2	20.2	36.3	36.3								
12	16.0	16.0	27.8	27.8								
13	14.1	14.1	23.9	23.9								
14	13.3	13.3	18.3	18.3								
15	20.2	20.2	39.7	39.7								
MEAN =	16.9	16.9	30.5	30.5								
S.D. =	2.8	2.8	7.6	7.6								
5.0% EXC.=	22.1	22.1	44.7	44.7								

```
                                 SPMS MOORED SHIP STUDY
                                 ======================
 RUN NO.          : 501
 RUN DESCRIPTION  :

      Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

      RUN NO.  501: Spectra 1

      Wave Spectra: Sea   -  zero
                    Swell -  Hs = zero
                    Long  -  Hs = 0.22m; Tz = 60s
      Wind                -  Vw = 0 m/s
      Current             -  Vc = 0 m/s
      Mooring Arrangement  : 3 No. head & stern lines
                           : 2 No. forward & aft breast lines
                           : 1 No. forward & aft spring line
               H/St Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne
               B/Sp Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne

                           : ALL LINES 88.0mm polyprop
      Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
 DATE             :  22/ 4/ 6
```

PEAK LINE TENSIONS (%(GMBL)):
==================

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	24.7	25.3	25.3	37.8	37.8	23.9	30.6	44.5	44.5	22.6	23.4	23.4
2	30.8	32.3	33.2	37.6	37.6	38.3	42.2	30.1	30.1	34.5	33.8	32.5
3	28.0	29.2	29.9	29.8	29.8	30.6	37.5	44.9	44.9	27.8	27.3	26.4
4	30.7	32.2	33.1	34.0	34.0	36.8	41.7	34.0	34.0	32.8	32.1	31.1
5	29.0	30.4	31.2	33.8	33.8	39.3	39.4	53.4	53.4	37.7	37.4	36.1
6	27.8	29.1	29.8	38.0	38.0	28.4	37.6	64.9	64.9	30.6	30.9	30.3
7	26.3	27.5	28.2	35.8	35.8	25.2	35.5	60.9	60.9	24.2	24.2	23.7
8	28.5	29.3	29.4	28.9	28.9	29.9	31.9	49.3	49.3	28.6	28.8	28.2
9	20.7	21.4	21.8	38.7	38.7	27.7	26.0	38.4	38.4	28.5	28.5	27.9
10	25.7	26.5	26.8	38.6	38.6	24.7	30.1	56.1	56.1	22.3	22.1	21.7
11	27.6	28.6	29.0	28.2	28.2	32.0	34.1	37.4	37.4	31.5	31.3	30.4
12	27.3	28.1	28.1	61.6	61.6	32.7	31.6	60.7	60.7	36.2	36.7	36.0
13	23.6	24.6	25.2	28.3	28.3	26.0	31.1	37.2	37.2	26.8	26.9	26.3
14	31.9	33.1	33.4	36.9	36.9	34.7	37.9	45.6	45.6	32.1	31.8	30.8
15	27.3	28.6	29.3	43.9	43.9	34.6	36.9	62.6	62.6	33.6	33.4	32.3
MEAN =	27.3	28.4	28.9	36.8	36.8	31.0	34.9	48.0	48.0	30.0	29.9	29.1
S.D. =	2.9	3.1	3.2	8.2	8.2	5.0	4.7	11.3	11.3	4.7	4.6	4.3
5.0% EXC.=	32.7	34.2	34.9	52.2	52.2	40.4	43.6	69.1	69.1	38.8	38.5	37.2
% EXC.=												

```
                                SPMS MOORED SHIP STUDY
                                ======================
 RUN NO.          : 502
 RUN DESCRIPTION  :

      Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

      RUN NO.  502: Existing Spectra

      Wave Spectra: Sea   -  zero
                    Swell -  Hs = zero
                    Long  -  Hs = 0.25m; Tz = 58s
      Wind                -  Vw = 0 m/s
      Current             -  Vc = 0 m/s
      Mooring Arrangement  : 3 No. head & stern lines
                           : 2 No. forward & aft breast lines
                           : 1 No. forward & aft spring line
               H/St Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne
               B/Sp Lines  : Line pretensions =  8.0 tonne
                           : ALL LINES 88.0mm polyprop

                           : Line GMBL        =  90.6 tonne

                           : ALL LINES 88.0mm polyprop
      Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
 DATE             :  22/ 4/ 6

 PEAK LINE TENSIONS (%(GMBL)):
 ==================
```

Test No.	Line 1	Line 2	Line 3	Line 4	Line 5	Line 6	Line 7	Line 8	Line 9	Line 10	Line 11	Line 12
1	22.3	22.9	23.0	36.0	36.0	20.8	24.4	39.0	39.0	24.0	24.4	24.2
2	24.8	25.7	26.0	37.7	37.7	29.5	30.9	62.7	62.7	29.5	29.6	29.0
3	32.5	34.1	35.0	45.0	45.0	33.5	44.1	46.5	46.5	35.0	35.3	34.5
4	32.0	33.0	33.0	31.1	31.1	33.3	40.0	36.9	36.9	32.9	32.8	31.9
5	24.6	25.5	26.1	35.4	35.4	30.6	32.4	62.9	62.9	29.2	29.7	29.3
6	29.1	30.1	30.4	26.5	26.5	28.5	38.2	37.9	37.9	26.0	25.8	25.0
7	22.8	23.5	23.8	46.2	46.2	21.6	27.9	61.4	61.4	24.9	25.6	25.6
8	23.9	23.9	23.1	40.3	40.3	26.5	23.4	72.5	72.5	29.2	29.6	29.1
9	21.2	22.0	22.5	41.5	41.5	29.2	26.7	43.4	43.4	31.0	31.4	30.9
10	20.3	20.9	21.0	33.8	33.8	25.7	22.7	43.1	43.1	27.9	28.1	27.6
11	22.7	23.6	24.2	32.5	32.5	29.5	29.4	28.1	28.1	29.1	29.2	28.5
12	33.5	34.8	35.2	63.2	63.2	38.6	40.8	72.4	72.4	42.9	43.5	42.7
13	29.4	30.5	30.9	31.6	31.6	32.3	35.8	45.2	45.2	29.4	28.9	27.8
14	33.6	35.0	35.5	42.6	42.6	31.8	42.9	78.0	78.0	28.2	27.6	26.6
15	31.9	33.3	33.8	30.6	30.6	28.8	40.6	46.3	46.3	26.0	25.6	24.7
MEAN =	27.0	27.9	28.2	38.3	38.3	29.3	33.3	51.8	51.8	29.7	29.8	29.2
S.D. =	4.9	5.2	5.3	9.0	9.0	4.6	7.5	15.3	15.3	4.7	4.8	4.7
5.0% EXC.=	36.1	37.6	38.2	55.0	55.0	37.8	47.2	80.2	80.2	38.4	38.7	37.9
% EXC.=												

Appendix F: Detailed results for peak mooring line tensions and fender deflections

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 101: Spectra 1

```
Wave Spectra: Sea    -  zero
              Swell  -  Hs = zero
              Long   -  Hs = 0.23m; Tz = 58s
Wind                 -  Vw = 0 m/s
Current              -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	11	48.93	54.01	12	33.58	1.711	1.622	0.947
2	11	36.90	40.73	12	27.67	2.436	1.518	0.981
3	11	44.67	49.30	12	35.33	2.213	1.559	1.042
4	11	51.15	56.46	12	28.58	1.882	1.489	0.951
5	11	47.79	52.75	12	37.67	1.944	1.750	1.067
6	11	51.29	56.61	12	30.42	2.009	1.527	0.879
7	11	56.96	62.87	12	51.50	2.204	2.162	1.187
8	11	48.32	53.33	12	34.92	2.119	1.412	0.827
9	11	31.27	34.51	12	17.17	1.918	0.930	0.536
10	11	54.85	60.54	12	43.75	1.808	2.102	0.953
11	11	27.83	30.72	1	18.58	2.037	0.915	0.617
12	11	44.94	49.60	12	34.33	2.948	1.418	0.684
13	11	45.88	50.64	12	31.92	1.744	1.706	1.183
14	11	60.76	67.06	12	38.00	1.520	2.030	1.228
15	11	59.77	65.97	12	40.50	2.284	2.161	1.074

PEAK LINE TENSIONS:

MEAN	=	52.34% GMBL
STANDARD DEVIATION	=	10.55% GMBL
5.0% EXCEEDANCE	=	72.02% GMBL

MAX FENDER DEFLECTIONS:

MEAN	=	33.59%
STANDARD DEVIATION	=	8.79%
5.0% EXCEEDANCE	=	49.98%

H10 VESSEL DISPLACEMENTS:

MEAN	=	2.052	1.620	0.944 m
S.D.	=	0.346	0.388	0.207 m
5.0% EXC.	=	2.696	2.344	1.329 m

Port Kembla Outer Harbour Moored Ship Study : 14m laden Container Vessel

RUN NO. 102: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.20m; Tz = 74s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	11	44.25	48.84	12	34.08	2.352	1.425	0.762
2	11	31.24	34.48	1	18.42	2.541	0.842	0.538
3	11	28.61	31.58	12	20.33	2.356	0.936	0.593
4	11	43.32	47.81	12	31.67	1.737	1.498	0.862
5	11	41.13	45.40	12	28.83	2.543	1.471	0.818
6	11	31.06	34.28	12	21.83	2.677	0.977	0.653
7	11	35.41	39.08	12	33.00	2.436	1.286	0.790
8	11	31.55	34.82	12	20.83	2.781	1.008	0.540
9	11	24.88	27.46	12	13.42	1.918	0.531	0.313
10	11	34.04	37.57	12	23.92	2.240	1.169	0.604
11	11	36.78	40.60	12	25.75	2.804	1.265	0.721
12	3	40.92	45.17	12	26.33	3.912	0.958	0.497
13	11	30.95	34.16	12	24.00	2.049	1.043	0.630
14	11	40.40	44.59	12	25.58	2.134	1.314	0.819
15	11	32.27	35.62	12	26.75	2.911	1.074	0.545

PEAK LINE TENSIONS:		MAX FENDER DEFLECTIONS:		H10 VESSEL DISPLACEMENTS:			
MEAN =	38.76% GMBL	MEAN =	24.98%	MEAN =	2.493	1.120	0.646 m
STANDARD DEVIATION =	6.39% GMBL	STANDARD DEVIATION =	5.61%	S.D. =	0.517	0.264	0.150 m
5.0% EXCEEDANCE =	50.68% GMBL	5.0% EXCEEDANCE =	35.44%	5.0% EXC. =	3.457	1.611	0.926 m

Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

RUN NO. 201: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.23m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL       =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL       =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
    Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	11	31.10	34.33	12	21.75	1.989	0.676	0.427
2	11	23.65	26.10	12	19.33	2.604	0.766	0.456
3	5	29.41	32.46	1	30.50	2.624	0.581	0.575
4	11	30.85	34.05	12	21.00	2.270	0.739	0.505
5	11	33.85	37.36	12	30.92	1.992	0.859	0.537
6	11	30.07	33.19	12	22.33	2.286	0.995	0.410
7	11	34.70	38.30	12	27.33	2.095	0.886	0.560
8	11	29.81	32.90	12	20.75	2.303	0.683	0.275
9	11	21.72	23.97	12	16.00	1.911	0.299	0.217
10	11	27.39	30.23	12	24.17	2.044	0.773	0.434
11	3	19.62	21.66	1	11.42	2.105	0.229	0.193
12	11	26.27	29.00	12	19.17	2.918	0.589	0.263
13	11	28.74	31.72	1	23.33	2.120	0.762	0.521
14	11	34.55	38.13	12	26.08	1.846	0.945	0.619
15	11	38.51	42.51	12	29.33	2.176	1.053	0.518

PEAK LINE TENSIONS:

MEAN =	32.39% GMBL
STANDARD DEVIATION =	5.64% GMBL
5.0% EXCEEDANCE =	42.90% GMBL

MAX FENDER DEFLECTIONS:

MEAN =	22.89%
STANDARD DEVIATION =	5.42%
5.0% EXCEEDANCE =	33.00%

H10 VESSEL DISPLACEMENTS:

MEAN =	2.219	0.722	0.434 m
S.D. =	0.296	0.231	0.137 m
5.0% EXC. =	2.770	1.154	0.689 m

Port Kembla Outer Harbour Moored Ship Study : 14m Ballast Container Vessel

RUN NO. 202: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.20m; Tz = 74s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 4 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 2 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	11	29.35	32.40	12	20.33	3.058	0.661	0.292
2	3	23.39	25.82	12	10.75	3.049	0.285	0.194
3	3	22.41	24.74	1	16.83	2.833	0.303	0.233
4	11	24.45	26.99	12	19.67	1.853	0.560	0.410
5	11	32.06	35.39	12	19.17	3.578	0.998	0.366
6	3	27.39	30.23	1	12.17	3.747	0.550	0.212
7	3	25.46	28.10	12	17.92	2.636	0.479	0.317
8	3	27.52	30.38	12	12.50	2.528	0.394	0.169
9	3	18.39	20.30	1	8.92	1.867	0.111	0.101
10	7	20.56	22.69	12	12.58	1.932	0.387	0.199
11	3	27.03	29.83	12	9.75	3.482	0.366	0.186
12	3	32.10	35.43	1	12.83	3.857	0.326	0.164
13	3	23.39	25.82	1	11.42	2.481	0.327	0.246
14	3	29.11	32.13	12	19.83	3.352	0.550	0.352
15	3	22.99	25.38	12	14.92	2.768	0.386	0.165

PEAK LINE TENSIONS:

MEAN	= 28.38% GMBL
STANDARD DEVIATION	= 4.42% GMBL
5.0% EXCEEDANCE	= 36.62% GMBL

MAX FENDER DEFLECTIONS:

MEAN	= 14.64%
STANDARD DEVIATION	= 3.97%
5.0% EXCEEDANCE	= 22.05%

H10 VESSEL DISPLACEMENTS:

MEAN	=	2.868	0.446	0.240 m
S.D.	=	0.664	0.205	0.088 m
5.0% EXC.	=	4.107	0.828	0.405 m

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

RUN NO. 301: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.15m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	8	31.55	34.82	1	18.25	1.296	0.880	0.639
2	8	24.36	26.89	1	16.00	1.814	0.606	0.418
3	8	28.43	31.38	9	14.08	1.908	0.887	0.562
4	8	30.69	33.87	1	16.00	1.380	0.751	0.601
5	8	23.50	25.94	1	13.67	1.498	0.577	0.398
6	8	35.14	38.79	1	17.75	1.767	0.946	0.599
7	8	42.24	46.62	9	20.58	1.194	1.097	0.740
8	8	31.90	35.21	9	15.17	1.246	0.907	0.569
9	8	20.77	22.92	1	13.17	1.291	0.580	0.377
10	8	29.23	32.26	9	15.50	1.221	0.847	0.592
11	7	22.38	24.70	1	15.17	1.437	0.612	0.361
12	4	32.70	36.09	1	17.25	1.650	0.975	0.745
13	4	26.71	29.48	1	12.92	1.450	0.782	0.564
14	8	34.14	37.68	1	17.50	1.688	0.909	0.658
15	8	25.56	28.21	9	16.25	1.549	0.823	0.563

PEAK LINE TENSIONS:

MEAN	=	32.32% GMBL
STANDARD DEVIATION	=	6.26% GMBL
5.0% EXCEEDANCE	=	44.00% GMBL

MAX FENDER DEFLECTIONS:

MEAN	=	15.95%
STANDARD DEVIATION	=	2.09%
5.0% EXCEEDANCE	=	19.85%

H10 VESSEL DISPLACEMENTS:

MEAN	=	1.493	0.812	0.559 m
S.D.	=	0.230	0.159	0.121 m
5.0% EXC.	=	1.921	1.108	0.785 m

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel

RUN NO. 302: Spectra 2

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.13m; Tz = 68s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : SUC1250 RH Fenders @ 20m centres
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:
==

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	4	23.95	26.43	1	14.50	1.362	0.694	0.575
2	11	22.32	24.64	1	13.25	1.608	0.485	0.299
3	8	28.43	31.38	9	14.92	1.881	0.686	0.421
4	8	22.94	25.32	1	12.58	1.109	0.603	0.437
5	7	21.48	23.71	1	10.42	1.596	0.445	0.266
6	8	24.59	27.14	1	12.17	1.615	0.580	0.359
7	8	38.21	42.17	9	17.25	1.311	0.969	0.685
8	8	27.17	29.99	9	11.25	1.043	0.678	0.417
9	7	17.43	19.24	1	10.00	1.291	0.378	0.254
10	8	22.74	25.10	1	9.92	1.097	0.578	0.384
11	8	23.36	25.78	1	14.25	1.680	0.534	0.347
12	4	29.03	32.04	1	14.17	2.013	0.834	0.554
13	4	23.79	26.26	1	10.83	1.427	0.543	0.397
14	8	28.06	30.97	1	14.08	1.906	0.588	0.450
15	8	20.33	22.44	1	12.00	1.208	0.540	0.463

```
PEAK LINE TENSIONS:                   MAX FENDER DEFLECTIONS:              H10 VESSEL DISPLACEMENTS:
------------------                    ----------------------               ------------------------

MEAN               =  27.51% GMBL     MEAN                =  12.77%        MEAN       =  1.476   0.609   0.421 m
STANDARD DEVIATION =   5.36% GMBL     STANDARD DEVIATION =    2.11%        S.D.       =  0.310   0.149   0.117 m
 5.0% EXCEEDANCE   =  37.50% GMBL      5.0% EXCEEDANCE   =   16.70%         5.0% EXC. =  2.054   0.887   0.639 m
```

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 401: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.33m; Tz = 56s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 2 stern & bow breast lines
                     : 0 No. forward & aft spring line
         All Lines   : Line pretensions =  0.4 tonne
                     : ALL LINES 40.0MM polypropylene lines

                     : Line GMBL        =  20.5 tonne
Fender Arrangement   :300 x 300 DD Continuous Fenders
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	3	5.98	29.17	1	6.67	0.879	0.075	0.058
2	3	6.55	31.95	1	5.33	0.925	0.057	0.063
3	3	7.16	34.93	1	5.33	1.255	0.054	0.056
4	3	3.87	18.88	1	5.00	0.681	0.059	0.066
5	3	3.60	17.56	1	5.33	0.552	0.061	0.069
6	3	4.91	23.95	1	5.67	0.941	0.053	0.058
7	3	5.29	25.80	1	5.67	0.754	0.061	0.062
8	3	5.54	27.02	1	6.33	0.735	0.057	0.064
9	3	4.25	20.73	1	7.67	0.617	0.069	0.066
10	3	4.78	23.32	1	5.67	0.797	0.062	0.062
11	3	7.60	37.07	1	7.00	0.758	0.064	0.072
12	3	5.10	24.88	1	5.33	0.994	0.063	0.059
13	3	5.12	24.98	15	6.00	0.982	0.060	0.056
14	3	5.13	25.02	1	5.33	0.796	0.055	0.054
15	3	7.34	35.80	1	6.00	1.038	0.058	0.059

```
PEAK LINE TENSIONS:                  MAX FENDER DEFLECTIONS:            H10 VESSEL DISPLACEMENTS:
------------------                   ----------------------             ------------------------

MEAN               =  26.74% GMBL    MEAN               =   5.89%       MEAN       =  0.847   0.061   0.062 m
STANDARD DEVIATION =   5.98% GMBL    STANDARD DEVIATION =   0.74%       S.D.       =  0.181   0.006   0.005 m
 5.0% EXCEEDANCE   =  37.89% GMBL     5.0% EXCEEDANCE   =   7.27%        5.0% EXC. =  1.185   0.071   0.071 m
```

Port Kembla Outer Harbour Moored Ship Study : Tug Vessel
RUN NO. 402: Spectra 1

Wave Spectra: Sea - zero
Swell - Hs = zero
Long - Hs = 0.42m; Tz = 159.8s
Wind - Vw = 0 m/s
Current - Vc = 0 m/s
Mooring Arrangement : 2 stern & bow breast lines
: 0 No. forward & aft spring line
All Lines : Line pretensions = 0.4 tonne
: ALL LINES 40.0MM polypropylene lines

: Line GMBL = 20.5 tonne
Fender Arrangement : 300 x 300 DD Continuous Fenders

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	3	5.47	26.68	1	7.67	0.639	0.058	0.064
2	3	6.85	33.41	1	8.00	0.876	0.066	0.068
3	3	10.23	49.90	15	7.33	1.013	0.057	0.074
4	3	5.31	25.90	1	5.67	0.573	0.065	0.059
5	3	5.95	29.02	15	6.00	0.494	0.065	0.062
6	3	5.61	27.37	1	7.33	0.859	0.057	0.059
7	3	5.17	25.22	1	5.67	0.649	0.066	0.067
8	3	7.29	35.56	15	9.67	0.783	0.063	0.062
9	3	5.77	28.15	1	7.67	0.895	0.057	0.066
10	3	6.13	29.90	1	5.33	0.666	0.061	0.063
11	3	7.45	36.34	1	7.00	0.640	0.060	0.069
12	3	5.70	27.80	1	7.00	0.832	0.061	0.075
13	3	4.90	23.90	1	5.67	0.846	0.067	0.065
14	3	3.75	18.29	1	5.00	0.548	0.062	0.062
15	3	8.14	39.71	1	6.00	0.791	0.063	0.067

PEAK LINE TENSIONS:

MEAN = 30.48% GMBL
STANDARD DEVIATION = 7.61% GMBL
5.0% EXCEEDANCE = 44.67% GMBL

MAX FENDER DEFLECTIONS:

MEAN = 6.73%
STANDARD DEVIATION = 1.26%
5.0% EXCEEDANCE = 9.09%

H10 VESSEL DISPLACEMENTS:

MEAN = 0.740 0.062 0.065 m
S.D. = 0.150 0.004 0.005 m
5.0% EXC. = 1.020 0.068 0.074 m

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

RUN NO. 501: Spectra 1

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.22m; Tz = 60s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	8	40.31	44.49	1	83.68	2.211	0.894	0.692
2	7	38.27	42.24	1	87.89	3.646	0.592	0.579
3	8	40.71	44.93	1	89.47	2.886	1.046	0.814
4	7	37.77	41.69	1	87.89	3.483	0.668	0.548
5	8	48.34	53.36	1	70.00	3.556	0.829	0.826
6	8	58.79	64.89	1	93.68	2.583	1.238	0.784
7	8	55.22	60.95	16	92.63	2.277	1.094	0.838
8	8	44.66	49.29	1	91.05	2.312	1.019	0.750
9	4	35.05	38.69	1	77.37	2.351	0.883	0.624
10	8	50.87	56.15	16	88.95	2.032	1.105	0.820
11	8	33.91	37.43	1	104.74	2.837	0.734	0.538
12	4	55.84	61.63	1	104.21	2.970	1.448	1.201
13	8	33.66	37.15	1	81.58	2.351	0.768	0.645
14	8	41.34	45.63	1	91.05	2.606	1.032	0.853
15	8	56.74	62.63	16	112.63	2.935	1.406	1.036

PEAK LINE TENSIONS:

MEAN	=	49.41% GMBL
STANDARD DEVIATION	=	9.77% GMBL
5.0% EXCEEDANCE	=	67.63% GMBL

MAX FENDER DEFLECTIONS:

MEAN	=	90.45%
STANDARD DEVIATION	=	10.80%
5.0% EXCEEDANCE	=	110.59%

H10 VESSEL DISPLACEMENTS:

MEAN	=	2.736	0.984	0.770 m
S.D.	=	0.513	0.253	0.181 m
5.0% EXC.	=	3.692	1.456	1.107 m

Port Kembla Outer Harbour Moored Ship Study : 13.6m laden Cargo Vessel Loc 4

RUN NO. 502: Existing Spectra

```
Wave Spectra: Sea   -  zero
              Swell -  Hs = zero
              Long  -  Hs = 0.25m; Tz = 58s
Wind                -  Vw = 0 m/s
Current             -  Vc = 0 m/s
Mooring Arrangement  : 3 No. head & stern lines
                     : 2 No. forward & aft breast lines
                     : 1 No. forward & aft spring line
         H/St Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne
         B/Sp Lines  : Line pretensions =  8.0 tonne
                     : ALL LINES 88.0mm polyprop

                     : Line GMBL        =  90.6 tonne

                     : ALL LINES 88.0mm polyprop
Fender Arrangement   : Cylindrical fenders (continuous) 380 * 190
```

PEAK LINE TENSIONS, FENDER DEFLECTIONS & VESSEL DISPLACEMENTS:
==

	LINE TENSIONS			FENDER DEFLECTIONS (%)		VESSEL DISPLACEMENTS (m) (H10 Double Amplitude)		
Test No.	Line No.	Tonne	%(GMBL)	No.	%	long	lat (fwd)	lat (aft)
1	8	35.37	39.04	1	98.95	1.797	0.780	1.131
2	8	56.78	62.67	1	88.95	2.353	1.339	1.110
3	8	42.11	46.48	1	89.47	3.560	0.956	0.689
4	7	36.24	40.00	1	100.53	3.362	0.645	0.686
5	8	57.02	62.94	1	80.53	2.856	1.029	0.695
6	7	34.60	38.19	1	83.68	2.720	0.874	0.629
7	8	55.65	61.42	16	101.05	1.776	1.540	0.988
8	8	65.69	72.51	1	105.26	1.723	1.413	1.199
9	8	39.30	43.38	1	92.11	2.268	1.049	0.889
10	8	39.09	43.15	16	83.16	1.886	1.147	0.721
11	4	29.44	32.49	1	86.84	2.476	0.689	0.515
12	8	65.61	72.42	1	150.00	4.025	1.957	1.561
13	8	40.97	45.22	1	73.16	2.561	0.737	0.680
14	8	70.63	77.96	1	110.00	3.139	1.594	1.736
15	8	41.96	46.31	16	80.53	2.638	1.034	0.696

```
PEAK LINE TENSIONS:                   MAX FENDER DEFLECTIONS:                H10 VESSEL DISPLACEMENTS:
-------------------                   -----------------------                -------------------------

MEAN               =  52.28% GMBL     MEAN               =   94.95%          MEAN       =  2.609   1.119   0.928 m
STANDARD DEVIATION =  14.58% GMBL     STANDARD DEVIATION =   18.41%          S.D.       =  0.691   0.380   0.358 m
 5.0% EXCEEDANCE   =  79.48% GMBL      5.0% EXCEEDANCE   =  129.28%           5.0% EXC. =  3.899   1.827   1.596 m
```