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Ferry Operations at Lymington: the W-class Ferries

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FERRY OPERATIONS AT LYMINGTON: THE W-CLASS FERRIES

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1. Introduction

In November 2007, a study for the Lymington Harbour Commissioners commenced. It comprised two phases, the first to study the existing level of marine risk presently on the river and recommend suitable risk control measures, should it be concluded that these were needed; the second phase built on the first and related to the effect of proposed new ferries on marine risk in the Lymington River.

This report deals with the second phase only. Its detailed Terms of Reference are given in Appendix 1 and in essence they require an assessment of the change in marine risk on the Lymington River associated with the introduction into service on the River of the Wightlink W-class vehicular/passenger ferries. Various stakeholders had expressed concerns in Phase 1 which related to the increase in size and power of the new vessels and any resultant impact on safety in the river. If Phase 2 of the study should demonstrate the likelihood of any increase in risk with the new vessels, then suitable risk control measures were to be proposed to reduce them to a level that was as low as reasonably practicable.

Phase 1 of this study was carried out early in 2008 and reported in March 2008 (Reference 1). It provided an assessment, supported by field measurements and historical incident data, of the level of risk before the introduction of the new ferries. A Risk Register was developed which listed a number of incidents, covering concerns voiced by stakeholders, which could occur on the River, together with control measures, either already in place or proposed. This served as the benchmark and a basis for comparison when the second phase of the study was undertaken later in the year on the arrival of the new ferries.

This report describes the extensive trials carried out with the new vessels in the second phase to provide objective data to inform the ultimate risk assessment, updates the incident statistics and re-visits the Risk Register. Finally, it draws some conclusions and provides some recommendations.

2. Aims and Scope

2.1 Aims

The main aim of the Phase 2 study is the same as that of Phase 1:

- To assess the marine risk and provide control measures to ensure, within the ALARP principle, that any change in risk resulting from the introduction of the W-class ferries is kept as low as possible by means of control measures, recommended as a result of the study.

Supplementary aims of the Phase 2 study are as follows:

- To provide sufficient field measurements to give rational and objective support for the conclusions reached and recommendations made.
- To involve, wherever possible, interested stakeholders by suitable accommodations within the field trials programme. By so doing, this continued a process, begun in Phase 1, to satisfy paragraphs 2.2.13 and 2.2.14 of the Port and Marine Safety Code (PMSC)
- To satisfy all other relevant requirements under the PMSC

2.2 Scope

The scope of Phase 2 was changed from the draft version proposed in Phase 1 (Reference 1) as were the Terms of Reference, as may be seen by comparing Appendix 1 of Reference 1 with Appendix 1 of this report. A large trials programme was developed and its final form is given in Appendix 2. As described in Section 5.2 below, this was modified for various reasons as the trials progressed, but enough of the full programme was achieved in this modified form to allow risk to be assessed and control measures to be recommended.

Some modelling was carried out, notably by the development of a manoeuvring simulation model of the W-class vessel, adjusted to match the behaviour of the full-size vessel (See Appendix 3). This was used in a subordinate role to explore conditions not experienced in the trials and to achieve a greater understanding of certain features of the W-class behaviour.

Information was provided of interest to those considering the environmental impact of the new ferries, although it is stressed that consideration of risk to the environment was not part this study.

In addition to the trials several meetings with stakeholders were held.

3. Summary of Phase 1 Findings

The overall conclusions and recommendations of the Phase 1 study were:

3.1 Phase 1 Conclusions

- The present level of marine risk on the river, as measured by the number of ferry-related incidents over the past 10 years, is low, with suitable risk management measures in place for sailing and other activities.
- Commercial ferries and leisure users have been able to co-exist on the river satisfactorily for a large number of years
- The new ferries are larger in several respects than the existing ferries. Much of the increase in displacement and changes in hull shape are a result of the survivability requirements now mandatory for all ro-ro passenger ferries. Some of the increase in above water enclosed volume is probably due to the greater stowage volume required by present traffic demand.
- Passing in the river is a consequence of a 3-boat 30 minute service or a mixed service run with 2 boats.
- Waiting in the river is disruptive to leisure users and prolonged use of the thrusters to hold station, especially at low water, may cause large eddies to form in the river. These are disruptive to leisure craft and other users of the river.
- The drawdown from the present ferries is low, generally of the order of 40mm to 50mm or less near the banks in Short Reach. On one occasion, however, a drawdown between 150mm and 170mm was measured as a ferry passed close to the measurement location. No breaking waves were witnessed as a result of drawdown or water level recovery. Free wave heights and frequencies from the ferries are similar in magnitude to those caused by some smaller vessels.
- Natural ambient waves at the Pylewell measurement location can be noticeably higher than the free waves produced by the ferries.

- Boats affected by wash in the river react to wave frequency rather more than wave height.
- Maximum tidal stream values in an ebbing spring tide are of the order of about 1.2 knots in Short Reach Lay-by; in Horn Reach on a similar tide, they are much less at about 0.33 knot. Over most of the tidal cycle the flow velocities were considerably less than these values, however, implying that overground speed in both Horn Reach and Short Reach Lay-by will be very similar to the through-water speed for much of the tidal cycle.
- There should be no need for the new ferries to navigate Horn Reach any differently from the existing ferries.

3.2 Phase 1 Recommendations

- Make ferry waiting in the river the exception and unhindered passing the rule
- In peak season, increase the Harbour Master's patrols in Short Reach, especially in the region of the passing place
- Ensure that ferries continue to make sound signals on leaving the terminal when junior sailing is in progress, and make it common practice to give similar signals when inbound at the Cocked Hat navigation post.
- Ensure that the navigation posts in the river mark the limits of the navigable channel and provide a visual indication of the channel in all conditions, including fog.
- Install visual tide boards on navigation posts
- Ensure that a structured programme of trials is undertaken with the new ferries.

A Risk Register was produced based on evidence found during Phase 1. This Register was intended to form the basis of the main risk assessment, to be re-visited at the end of Phase 2 to determine both any change in risk and the measures needed to reduce any increase to a value which was as low as reasonably practicable.

4. Purpose of the Phase 2 Trials

The purpose of the Phase 2 trials was to provide objective information and informed observations to support the proposed risk control measures and the final comparative assessment of marine risk on the river.

The trials programme was developed from recommendations in Phase 1 and discussions with stakeholders during the period between the completion of this Phase and the arrival of the new ferries on the river. The intention of the programme was to address stakeholders' concerns directly by expanding the Phase 1 measurement programme, combined with observations and measurements on the ferry and on the river.

A crucial element of the whole study was the input from independent master mariners in the BMT team. Their experience and judgement were called upon when assessing matters of seamanship and operation of the new ferries, together with decisions regarding the suitability of the risk control measures proposed in this report. In this way, the trials results and the mariners' judgement combined to provide an evidence-based determination of the change in marine risk likely with the introduction of the W-class ferries.

Accordingly the BMT team comprised a project leader with two independent and experienced Master Mariners, together with ABPmer who measured the tidal stream flows in Short Reach Lay-by in the vicinity of the Pylewell Boom navigation post.

The conduct of the ferry operations was assessed by ensuring that at least one of the Master Mariners was present on the bridge of a W-class vessel during all trials; other members of the team observed either on the bridge or on the river in the vicinity of the ferry. These observations, combined with measurements of wash, drawdown, thruster slipstreams, ship's tracks and speeds allowed the overall goal of the Phase 2 trials to be achieved.

It should be emphasised that, although some of the measurements were used to assess environmental effects, the use and interpretation of such measurements was not carried out by BMT whose remit related solely to matters concerned with river safety. It should also be emphasised that the Phase 2 trials, while extensive, were carried out in such a way as to ensure that the necessary information was obtained to complete the risk assessment without any unnecessary extension of the programme.

5. The Phase 2 Trials

5.1 Scope

The overall scope of the trials, as presented to, and agreed by, stakeholders, is given in Appendix 4. From this was developed the initial trials programme in Appendix 2.

A key feature of the approach to the trials was flexibility. Although the programme provided a desirable target, it was realised that there were a number of elements which would require a flexible approach, such as the availability of the right strength and direction of wind, the right amount of river traffic (especially as the trials were held at the end of the sailing season) and other imponderables which were likely to occur as the trials progressed. In the event, this flexible approach proved to be justified.

Trials were carried out from early September to December on the days shown in Table 1; those marked * indicate when measurements on the river were made. The first run allowed the BMT Master Mariners to assess whether they felt that the behaviour of the new vessel and the competence of those crew members able to handle it was such that the trials and the associated Wightlink training programme could go ahead in safety. It was agreed that they could, but that the Harbour Master should provide an escort on the river for all W-class movements according to the following policy:

- For winds over 20 knots, the W-class ferries would be escorted everywhere on the river on training runs
- When upstream of the Harbour Master's pontoon, the W-class ferries would be escorted at all times during training and trials.
- The Harbour Master would attend all trials and escort the W-class ferries.

The fact that Wightlink were training masters and crews for the W-class should be borne in mind when assessing the results of the trials. As will be described below, the control response of the new vessels differed from the C-class (or Saint-class), familiar to the masters and crews, and this difference had to be overcome. For some this took time while for others it did not but, in spite of this, the overall scope was achieved.

In general terms, trials with the W-class comprised calm weather runs in the absence of river traffic to determine the overall handling behaviour of the vessels, their wash, drawdown etc. For most of the runs a spring ebb tide was chosen, with trials run at high water, mid-tide and low water, both inbound and outbound. These were to be repeated in river traffic and then repeated again in strong winds. During the trials period runs in wind were arranged on the basis of weather forecasts, but were sometimes frustrated when the predicted conditions did not materialise. For this reason, trials in winds from a large number of directions were not possible but, to an acceptable extent, this gap was filled by the use of computer models and the professional judgement of the Master Mariners in the BMT team, together with discussions with the Wightlink masters.

Trial Date	Description
8 Sept 2008	Preliminary assessment of trial safety
9 Sept 2008	Familiarisation Runs; no on-board measurements
11 Sept 2008	Familiarisation Runs; no on-board measurements
16 Sept 2008*	Single W-class calm water runs and C-class passing; emergency stops
18 Sept 2008*	Single W-class calm water runs and C-class passing; emergency stops
23 Sept 2008	River passage, mainly for training; no measurements made
24 Sept 2008	First W-class thruster slipstream measurements and Wednesday Junior Sailing Trial; no on-board measurements
25 Sept 2008	River passage, mainly for training; no measurements made
28 Sept 2008	Single W-class calm water runs and C-class passing; trial with river traffic
1 Oct 2008*	Single W-class in windy conditions and C-class passing
8 Oct 2008	Second W-class thruster slipstream measurements, including "idle" setting
9 Oct 2008	First trial with "idle" setting on aft thruster and "operational" on forward thruster; no on-board measurements
15 Oct 2008*	First W/W-class passing with "idle aft" arrangement on one vessel
16 Oct 2008*	Single W-class with "idle aft" arrangement; C-class passing
22 Oct 2008	C-class thruster slipstream measurements
23 Oct 2008	Single W-class with "idle aft" arrangement in windy conditions
12 Nov 2008	First sailing trials with single W-class on "idle aft" arrangement
13 Nov 2008	C-class tracking with on board measurements
19 Nov 2008	C-class emergency stop tests
28 Nov 2008*	Second W/W passing with "idle aft" on both ships; benign conditions
8 Dec 2008	Trials with MOB dummy and W-class
17 Dec 2008*	Trials with "intermediate aft" setting in benign conditions
18 Dec 2008	Trials with "intermediate aft" setting; Second sailing trials
3 March 2009	Third W/W passing; windy conditions; "intermediate aft"

Table 1

One set of trials involved the use of a Man Overboard (MOB) dummy to assess the effects of a person in the water being run down by the ferry. This is discussed in Section 6.11 below.

Passing trials were important and a number of C/W passings were carried out, together with special trials for W/W passing. These were in both benign and windy conditions and had a two-fold purpose:

- To see to what extent, if any, the ferries were subject to hydrodynamic and aerodynamic interaction effects.
- To see how much space was available to other users when W-class vessels passed in the Short Reach Lay-by region using the Transit Marks.

In addition to the trials on the W-class ferries, a limited number of trials and observations were carried out on C-class vessels while operating their normal service on the river.

5.2 Planned and Achieved Schedule

Referring to the planned trials schedule in Appendix 2, the contents allocated to Days 1 to 4 were achieved to the satisfaction of BMT, although no emergency stops were carried out in strong winds for either W- or C-class vessels. This was not perceived as a serious omission because the stopping ability of the W-class was not in question as a result of the calm weather stopping trials, and its ability to hold station while stopped in a strong wind on the beam was satisfactory, as demonstrated below. The wind obtained for the trials allocated to Day 3 was a strong steady wind of BF 6 to 7 from the south west, whereas that for the trials of Day 4 will be chosen to reflect the overall intention for outstanding trials in wind.

It was possible to carry out only one day of trials in "normal" river traffic. What was regarded as a medium traffic density was obtained on a Sunday at the end of September, toward the end of the sailing season, and this accounted for the contents of Day 5.

Because the later trials were carried out at a time when there was little leisure sailing in progress, the co-operation of stakeholders was sought and separate "Sailing Trials" were carried out with the active participation of the Lymington Town Sailing Club and the Royal Lymington Yacht Club. Attention was focussed on dinghy sailing and a number of boats and owners were assembled and encouraged to sail around a W-class vessel as she proceeded in and out of the river. This was most useful and the de-brief after the first trial, together with feedback after both trials, provided valuable, informed, opinions.

The first sailing trial coincided with comparatively light winds from NNW which, while useful, did not give the full picture so an additional trial was run in stronger winds from SW.

As will be described below, some unscheduled trials were carried out with different thruster settings on the W-class vessel in an attempt to reduce the hydrodynamic disturbance associated with operation of its aft thruster.

Waiting trials and trials with the vessel berthed with were also carried out. In the first an extended stop-and-hold manoeuvre was witnessed in strong beam winds which enabled the disturbance to the river to be assessed. In the other, not shown separately on the programme, velocities in the thruster slipstreams of both the W- and C-class vessels were measured.

Attempts were made to adhere to the ferry overground speed limits in the trials programme, but in the event practical aspects of running the trials vessel in the midst of a 3, then a 2, boat C-class service prevented this being achieved in all cases. As the trails continued, however, typical speed profiles were obtained, together with information from the masters as to the sort of speeds they would use on given occasions. The results obtained are therefore believed to cover a range of typical overground speeds.

5.3 Measured Parameters

The following parameters were measured:

On board (at various intervals throughout each run)

C-Class
- Local Time
- Heading
- Position (latitude and longitude)

W-class
- Local time
- Heading
- Overground speed
- Position (latitude and longitude)
- True wind speed and direction

For the C-class vessels the information was logged manually from the GPS monitor on the bridge; for the W-class vessel screen dumps from the ECDIS system were downloaded, stored and analysed.

On the river
- Water level change with local time
- Local wind speed and direction 2 metres above high water springs
- Tidal stream velocities
- Longitudinal flow in the inter-tidal region of the banks near Harpers Post South
- Overground speed of various vessels on an occasional basis
- Slipstream velocities at various distances off and depths down to 1000mm below the water surface. This was done for the thrusters of both C- and W-class ferries when moored alongside the North End berth. Data from thrusters acting both to port and starboard were obtained.

Water level and local wind measurements were made on the following navigation marks:

- The Green post at the ferry terminal
- The Red post off the Royal Lymington Yacht Club
- Harpers Post South
- Cocked Hat
- Enticott
- Pylewell Boom

Tidal stream measurements were made at a location some 12 metres west of the Pylewell Boom navigation post, just on the edge of the navigation channel.

Many trial runs were photographed from on board and on the water and most were captured on video.

Further details are given in Appendix 5.

5.4 Operational Aspects of the Trials

5.4.1 Introduction

The trials listed in Table 1 were undertaken over a period of 3 months and certain operational measures were necessary to ensure that maximum value was obtained from each one. This Section describes the measures taken.

5.4.2 Manning and Safety

Each trial was carried out with one BMT Master Mariner on the bridge of the W-class vessel accompanied by another member of the BMT team to log the ECDIS information. For C-class measurements one member of the team travelled on board a vessel on regular service. In each case the master was made aware of the trials taking place and, although the trial was organised by the BMT team, it was made clear that the master had the ultimate sanction over whether a particular trial went ahead or not, based on his assessment of risk to the vessel.

The Harbour Master provided escort RIBs for each trial in order to inform other river users that the trials vessel was operating on the river as well as providing a mobile observation platform. On several occasions, members of the BMT team took advantage of this and travelled on the Harbour Master's vessels to observe at river (and therefore small boat) level.

5.4.3 Sailing Trials, Briefing and De-briefing

A Wednesday Junior Sailing Trial was undertaken by the W-class vessel moving along Horn Reach at 4 knots while the junior sailors and the accompanying safety RIBs were on the water. Representatives from the Royal Lymington Yacht Club (RLymYC), the LHC and BMT observed all runs and assessed the situation in the comparatively light winds prevailing on the day. Observations made by BMT suggested that the junior sailors dealt with the situation well and were able to cope with the wind shadow effects. They found enough water space to keep clear of the ferries and appeared to be able to sail without any significantly greater disruption than is presently the case with the C-class vessels. It is understood that representatives from the RLymYC were satisfied with the trial, would modify their operations as required and continue with the Wednesday Junior Sailing programme.

The two Sailing Trials were carried out with the helpful co-operation of the Lymington Town Sailing Club and RLymYC who provided a number of sailing vessels and crews. The were asked at a pre-trial meeting to sail in a responsible manner, but to interact with the ferry as they would normally while either racing or simply sailing up and down the river. All those sailing were provided with a timetable of runs and a number of informed observers were placed in escorting RIBs.

A de-briefing was held after the first sailing trial with representatives from the Harbour Master's office, Wightlink (the ferry master for the trial) and BMT supplementing the club members who had taken part. For the second trial a pre-trial briefing was held, with considered feedback passed to LHC and BMT by the use of feed-back forms from those who took part in this and the earlier trial.

5.4.4 Ship Trial Condition

In Reference 1 it was stated that, for the Phase 2 trials, *"Both classes of ferry* (i.e. the C-class and W-class) *should be run at representative draughts"*. For the C-class there was little option but to accept its operating draught on the day because these vessels were operating the service schedule with whatever load they had at the time.

For the W-class, the following statements are made in Reference 2:

"It is therefore proposed to run all trials at a realistic maximum load condition, likely to be met in service"

"Such a load condition would provide a severe, but realistic, test of wash, drawdown, backflow, handling, stopping, station-keeping while waiting, and passing when in service."

Proceeding on this basis, a suitable load condition was estimated. This was deduced for a deadweight comprising:

- 3 commercial vehicles at 30 tonnes each
- 45 cars at 2.1 tonnes each
- 300 passengers at 75kg each
- Water - 8.5 tonnes
- Fuel and stores – 28 tonnes (24 fuel, 4 tonnes stores)

This gives a deadweight of around 250 tonnes and was taken as the realistic maximum load condition.

In order to obtain the draught, a deadweight/draught scale is needed and this was obtained from the actual lightship weight of 1155.2 tonnes and a displacement/draught relationship computed from the lines of the W-class vessels. The result is shown in Figure 1.

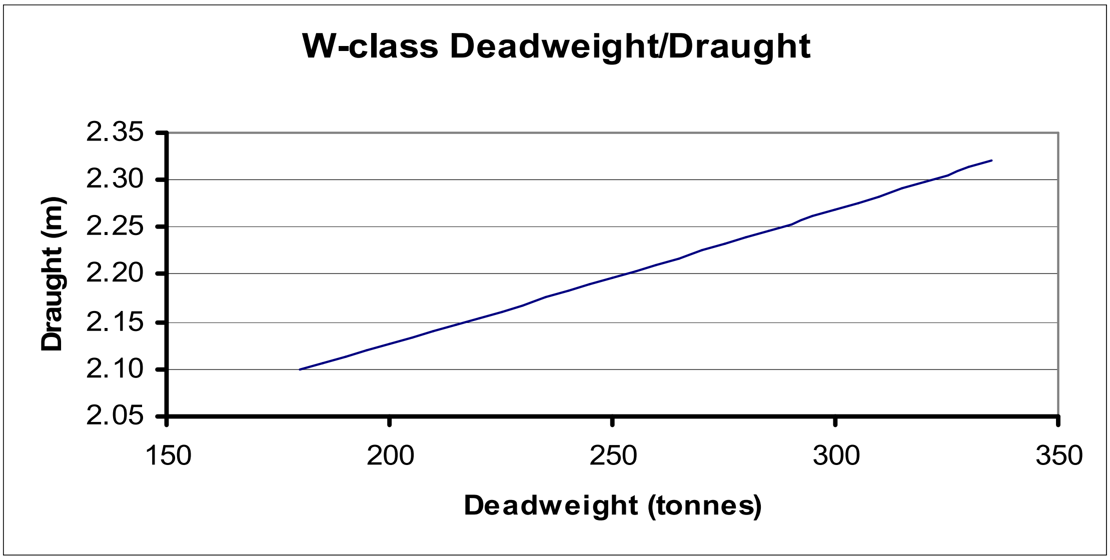


Figure 1: W-class. Effect of Deadweight on Draught

For the chosen deadweight of 250 tonnes, a draught of just under 2.2 metres was appropriate and this was used as a target value for the trials. For each trial the draughts were checked visually at bow, stern and amidships; an electronic draught indicator was also available on the bridge.

In passing, it is of interest to note from Figure 1 that a variation of ±50 tonnes changes the draught by about ±70mm, so performance at the trials draught can be taken as representative of a fairly wide range of loadings.

The load on board was simulated by filling void spaces in the hull with water until the required draught had been obtained. In the event, the Wight Light vessel, used for most of the trials, was in a heeled condition for the very early runs between 8 and 10 September, but this was rectified by 11 September and there was no heel for the remaining trials.

For trials in wind on 1 and 23 October two large articulated lorries were loaded to provide extra windage fore and aft. These were removed after the 23 October trials.

In the final trials from 12 November, the vessel was run at a fixed draught of about 2.0 metres, representing a deadweight around 150 tonnes, considered to be a light load.

5.4.5 Thruster Usage

As will become apparent, the thruster rotational speeds on the W-class were the subject of attention during the trials. This was because the wash and slipstream from the aft thruster gave rise to serious concerns as to its effects on small craft near to the stern of the vessel.

From extensive observations made at the time, it was agreed that the wash and slipstream aft thruster were intolerable and means had to be found to reduce their disturbance. Working with the Wightlink Senior Route and Training Masters, it was found that the thruster rotation could be set to two modes of operation: a so-called "idle" mode and an "operational" mode. It was generally accepted when the ferries arrived on the river that the thrusters were to be driven by one engine each, with the thruster baseplates rotating at the "operational" speed. After noticing that use of just the forward thruster with the aft one stopped created very little disturbance on the river, and knowing that the ships had been manoeuvred with both thrusters on the "idle" setting at the builders, a run was tried with fore and aft thrusters both on the "idle" setting. While this produced none of the severe wash effects at the stern noted with the "operational" setting, control and speed were both compromised.

However, with the forward thruster on the "operational" setting, "pulling" the ship through the water in the manner of a tractor tug, and the aft thruster on "idle", control and speed were deemed by the Captain to be satisfactory, at least in benign conditions. As will be seen, this arrangement was then subjected to a series of trials to determine a safe operating profile, after which an additional "intermediate" thruster rotational speed became available and was the subject of further trials.

5.5 Metocean Conditions

5.5.1 Winds and Tides

Reference 10 minute mean winds and tide heights met on the trials were obtained at the Royal Lymington Yacht Club Starting Platform on http.//www.channelcoast.org/ and are shown in Table 2.

Date	Wind Speeds (kts)	Wind Directions (°)	Tide Heights (m)
16 Sept 2008	8 to 14	90 to 110	0.5 to 2.9
18 Sept 2008	1 to 7	80 to 290	0.6 to 2.9
28 Sept 2008	7 to 11	225 to 260	0.7 to 2.8
1 Oct 2008	14 to 22	270 to 320	0.8 to 3.2
15 Oct 2008	10 to 17	270 to 300	0.6 to 3.1
16 Oct 2008	8 to 16	280 to 325	0.5 to 3.2
23 Oct 2008	26 to 29	220 to 230	1.5 to 2.3
12 Nov 2008			
28 Nov 2008	3 to 8	000 to 080	1.0 to 3.0
17 Dec 2008			
18 Dec 2008	13 to 16	250	1.5 to 1.9

Table 2

5.5.2 Tidal Streams

Figure 2 shows measured tidal streams at the Pylewell location through a number of spring tidal cycles.

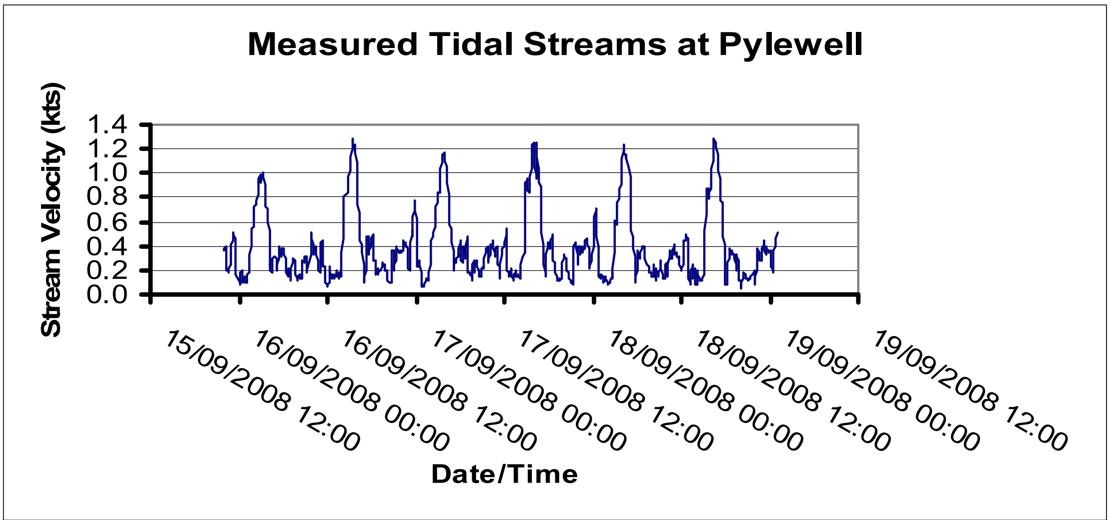


Figure 2: Measured Tidal Streams on 15 to 19 September 2008

5.5.3 Ambient Waves

As can be seen from Table 2, most of the trials met benign wind conditions, but on 1 October the forecast was fulfilled and more severe winds were encountered. Typical measurements of the natural waves made on this day near high water are shown in Figure 3.

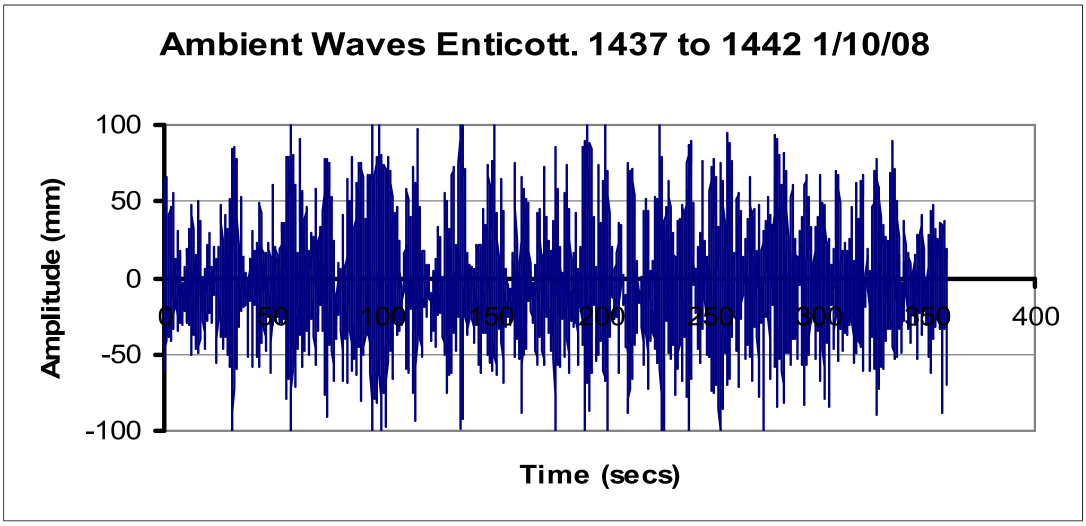


Figure 3: Measured Ambient Waves at Enticott in Windy Conditions

5.6 User Operations

Apart from the special cases of the Wednesday Junior Sailing and the other Sailing trials, other river users were on the river in company with the new ferry. Casual sporadic feedback was obtained and this was useful to build an impression of their feelings with regard to the new vessels. In addition, observations were made of the way users behaved in the vicinity of the ferry which in itself provided valuable information.

This allowed a picture to be built up of the way the users and the new ferries would interact and gave sufficient information for the assessment made, in Section 6.12 below, of both ferry and user behaviour on the river.

6. Results Obtained

6.1 Behaviour of C- and W-Class Ferries

6.1.1 Introduction

In this Section, results related to the manoeuvring and handling of the new ferries are discussed and compared with the behaviour of the C-class ferries. This provides an objective measure of the behaviour of the new ferries on the river and leads ultimately to objective measures of the way the handling of the new ferries relates to the space available in the river.

First, however, it is relevant to discuss briefly the way in which the ferries are controlled because it has, naturally enough, an impact on the safety of operations.

6.1.2 Ferry Control

Both the W- and C-class ferries are propelled and controlled by two Voith thrusters, one forward, one aft. In the W-class they are situated on the centreline whereas on the C-class they are located on the port deadrise forward and the starboard deadrise aft. This arrangement on the old vessels is presumably because they were designed to operate with a slipway with no auxiliary aids; this is not the case with the W-class.

The Voith Units

The Voith units on the W-class are physically closer to the ends of the hull than those on the C-class and an impression of this can be gained from Figure 4.

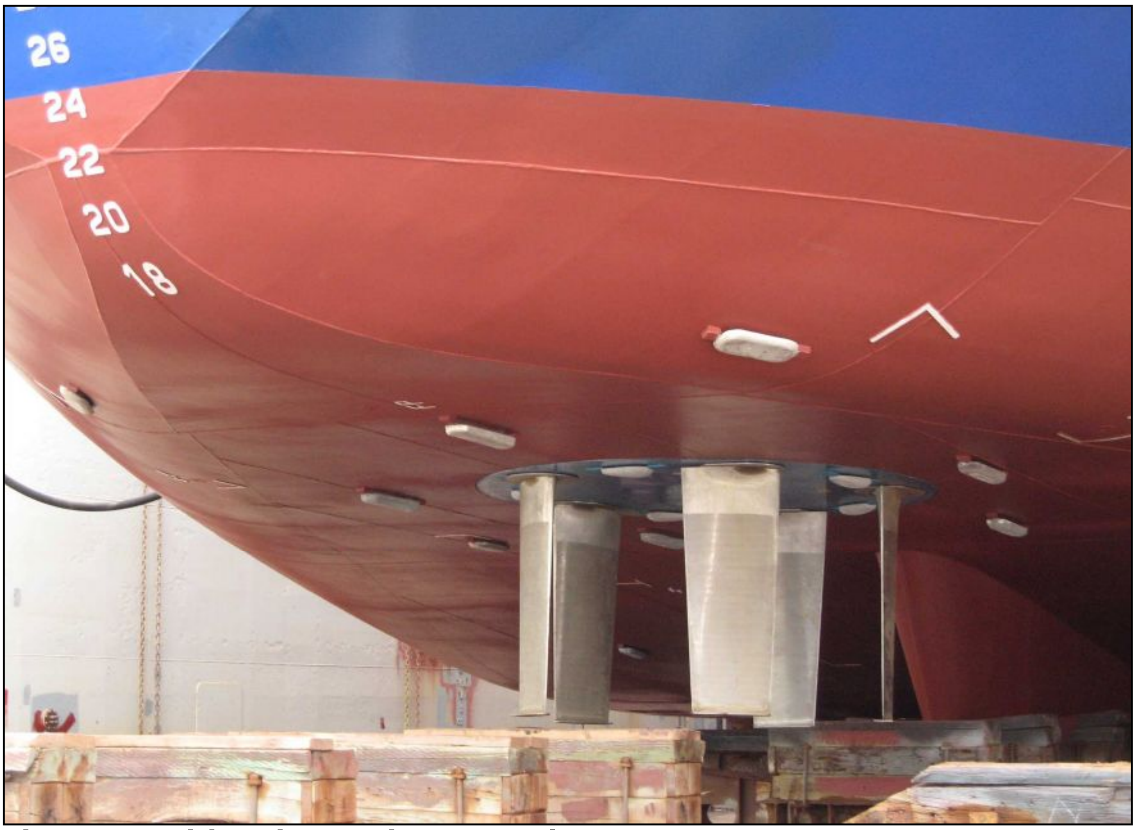


Figure 4: Voith Unit Location on W-class

The Voith baseplate rotates at a constant speed when set to "idle", "intermediate" or "operational" mode. Movement ahead or astern is achieved by setting the "telegraph" ahead or astern which in turn activates the vertical blades on the rotor. Each blade changes its orientation to the onset flow as the rotor turns and is therefore able to create "lift" which, when added for all the blades, creates thrust in a given direction. When the "telegraph" is set "ahead" the resultant thrust moves the ship ahead; the opposite movement occurs if the "telegraph" is set astern. To steer the ship, wheels on the control console also activate the blades, but in such a way that the resultant thrust acts in a lateral direction, thereby turning the ship. Figure 5 shows these controls.

It is clear that this mode of operating allows the thrust to be changed very quickly, especially if the control systems are electronic. This is the case on the W-class vessels, in contrast to the C-class vessels which had mechanical linkages to the Voith units, manually operated throughout. As a result, changing thrust direction on the Voith units is very rapid on the W-class as there is only the mechanical inertia of the blades to overcome, not that of the whole propulsor (as in a single screw vessel, for example); the baseplate does not change speed as the ship is controlled. In the C-class, manual operation of the wheels means that thrust vector changes are generally slower than on the W-class.

The location of the W-class Voith units on the centreline fore and aft allows a more predictable behaviour of the vessel when manoeuvring because their slipstream is unimpeded by the hull for most thrust vector directions. This is not the case for the C-class when turning; in this situation one or other of the thruster slipstreams will be impeded significantly by the hull.

Figure 5: Thruster Controls

Finally, it may be noted that the controls of the two thrusters on the W-class ships cannot be ganged together as is the case on the C-class ships. When implemented on these ships, the forward thrust vector is changed in concert with that of the aft thruster in such a way that it turns to an angle that is (360^o – δ) where δ is the vector angle of the aft thruster. It is believed by some that this capability can help in tight turns, although independent action of fore and aft thrusters on the W-class during the trials did not seem to compromise turning. However, a possible advantage of ganging the thrusters together arises from the fact that by using only the aft thruster to steer imposes a side-force on the ship as well as a turning moment. To prevent this causing the ship to slide sideways, it is necessary to adopt a sufficient drift angle, (directed toward the centre of the turn) with the result that the stern swings out; with a high beam/low draught hull the drift angle required will tend to be large, especially in deep water. Ganging the thrusters together eliminates at best, or reduces at least, the side force, thereby raising the possibility of a reduced stern swing and using of less of the available water space.

Bridge Control Positions

The C-class vessels are controlled from the centre of the wheelhouse. This option is also available on the W-class, but control in either direction, ahead or astern, may be from either bridge wing, as with the Saint class operating on the Porstmouth-Fishbourne route.

It is possible to hand over control from one conning location to the other, but the procedure is not as straight-forward as might be supposed. Unlike the situation with the Saint class where the control actions at one station on the bridge are synchronised with all the others (presumably because the control linkages are mechanical), this is not the case with the electronic controls of the W-class. To transfer control from one location to another, it is necessary to set the "telegraph" levers and wheels to exactly the same settings at both the location from which control is to be passed and that to which control is to be passed. If they do not agree exactly, control will not pass. To complete the handover, the helmsman presses a control button once, an indicator light flashes and he then presses it again after which the indicator light steadies if control has been passed successfully. If this is the case, the helmsman calls out that he has control, while the helmsman at the other station waits for several seconds to ensure that this is in fact the case. It is important that these procedures are adhered to otherwise there is potential for an incident to develop with nobody actually being in control of the vessel, albeit for only a short period of time. Although there were some problems with handovers in the early trials, the procedure just described was finally developed by the training master in an attempt to overcome these. Handovers were to take place only when the ship was on a steady course and those witnessed in later trials were generally successful, although not always so.

If the W-class are controlled from the centre of the bridge at all times, hand-overs are, of course, unnecessary, but, for those masters who wish to change control locations, these have to be done during passage in the river at locations where hand-over problems, should they arise, do not compromise safety.

There remains, however, a feeling of unease within BMT that a risk still remains in the hand-over procedures, although the MCA have approved the current system. A solution could be to have the controls at all the conning positions synchronised at all times. This in itself might create a risk if the controls at the conning position not in use are inadvertently disturbed. However, the record of the Saint Class vessels, which have synchronised systems and have been sailing for many years, is good with no related incidents to date. Nevertheless, it is recommended that Wightlink carry out a detailed risk assessment of the two systems and, if synchronisation is shown to present a lower risk, modify the systems on the W-Class accordingly.

Get-you-home Thruster Usage

For one trial the aft thruster was set to the "zero thrust" mode and an outbound run attempted with the forward thruster in its "operational" mode. The purpose was to see if control could be maintained in the event of a power failure on a thruster and its associated engine(s). Such an event on a C-class vessel results in an effective loss of control which gives significant problems for any "get-you-home" manoeuvres with these vessels.

The run with the W-class was carried out in very benign conditions and, although successful, the master felt he was at the limits of controllability when navigating the bends in the river.

This may be explained by the fact that the drag of the aft thruster acts in a directionally stabilising manner, trying to hold the ship to a straighter course and making turning more sluggish. This is demonstrated in Figure 6 which compares turning circles with and without the aft thruster operating. These results were obtained from the simulation model mentioned above.

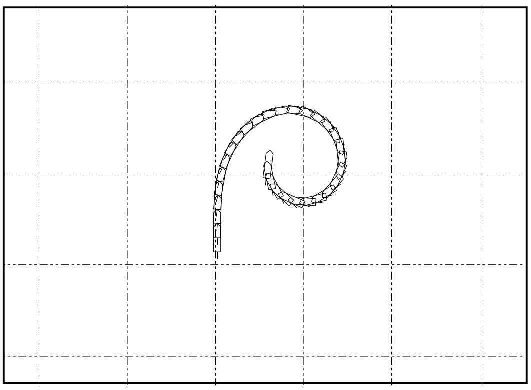
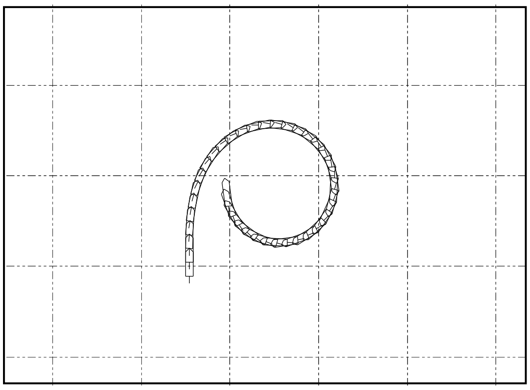



Figure 6: Simulated Turning Circles. Left – both thrusters running, right – aft thruster stopped.

6.1.3 Ferry Behaviour on the River

In this Section the behaviour of the C- and W-class ferries in benign conditions is examined. This is done by means of data measured on board the vessels, supplemented, where necessary, by results from the simulation model.

On-board information was logged every 30 seconds on the C-class and every 30 or 20 seconds on the W-class during each trial run on the river. They are shown here in reconstructed form in a deliberately simplified display showing the salient features of the river. These are:

- The channel as defined by the 2.3 metre sounding contours
- The main navigation posts
- The main salt marsh areas
- The main land masses

The ship icons show the direction of movement and are plotted at the time intervals logged on board.

C-class

Handling

Typical runs for the C-class outbound are shown in Figures 7 to 12.

For Figures 7 to 12, the following may be noted:

- In Figure 11, an outbound run at low water, the ferry had to ease down in order to pass an inbound vessel in the Short Reach Lay-by.
- At high tidal levels the ferry uses more space in the river at the Cocked Hat Bend because it needs greater drift angles in the turn (Figure 7); these reduce slightly at low water (Figure 11) together with a lower speed in the bend.
- The inbound run in Figure 12 was undertaken after dark and it may be seen that, with very little traffic on the river, the ferry crossed the waterspace available directly from Tar Barrel to Cocked Hat. It also went wide at the Cocked Hat bend due, perhaps to the following current felt at the start of the flood.
- The ferry did not always move along the leading lines.

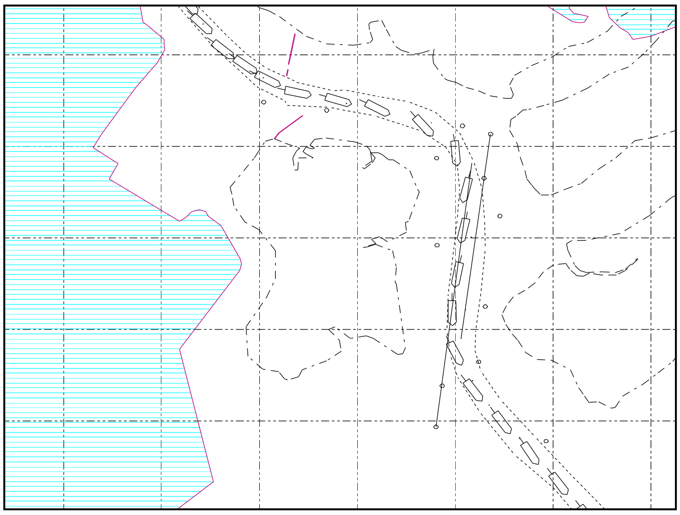


Figure 7: Caedmon outbound: tidal height 3.08m. Run 57

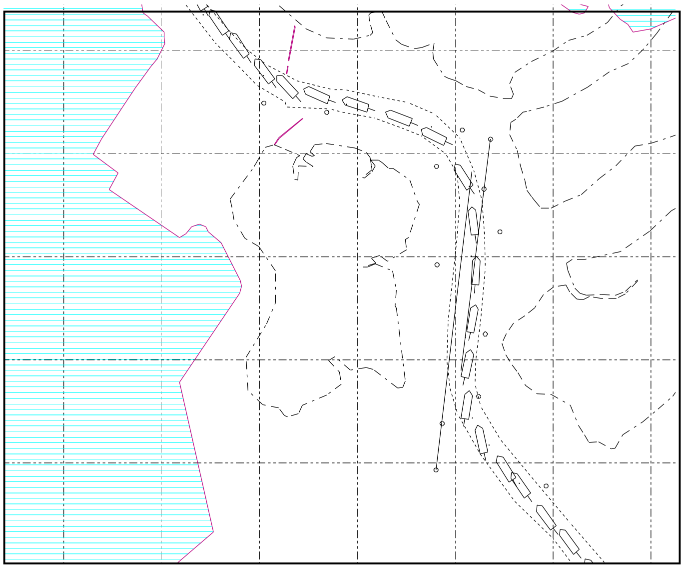


Figure 8: Caedmon inbound: tidal height 2.84m. Run 58

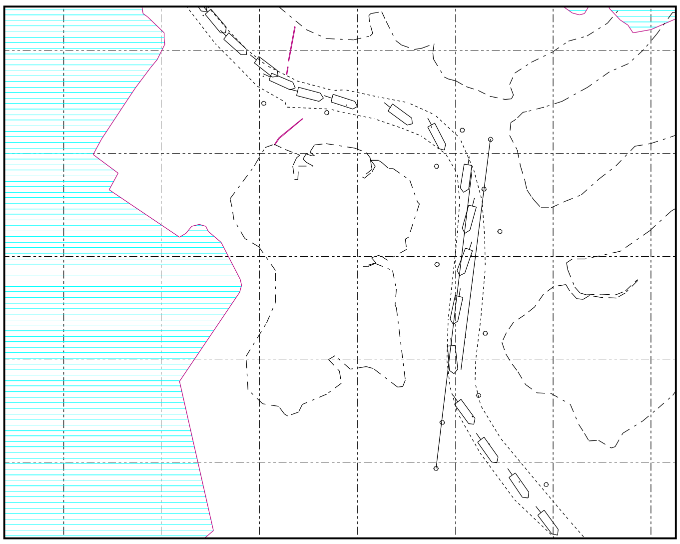


Figure 9: Caedmon outbound: tidal height 1.98m. Run 59

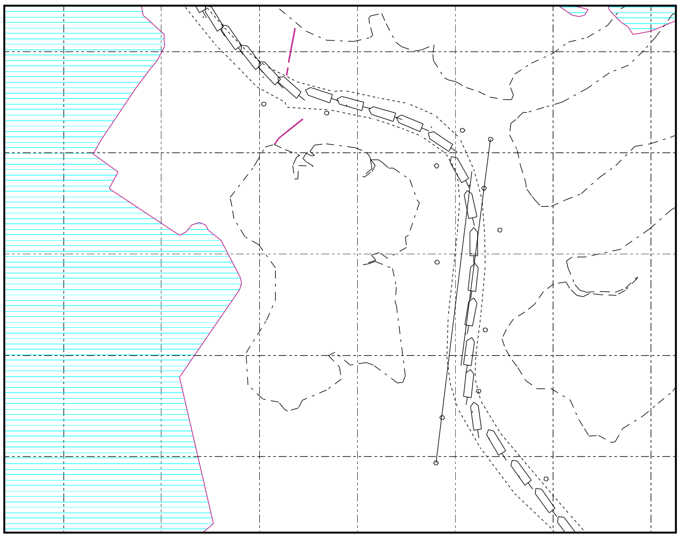


Figure 10: Caedmon inbound: tidal height 0.79m. Run 60

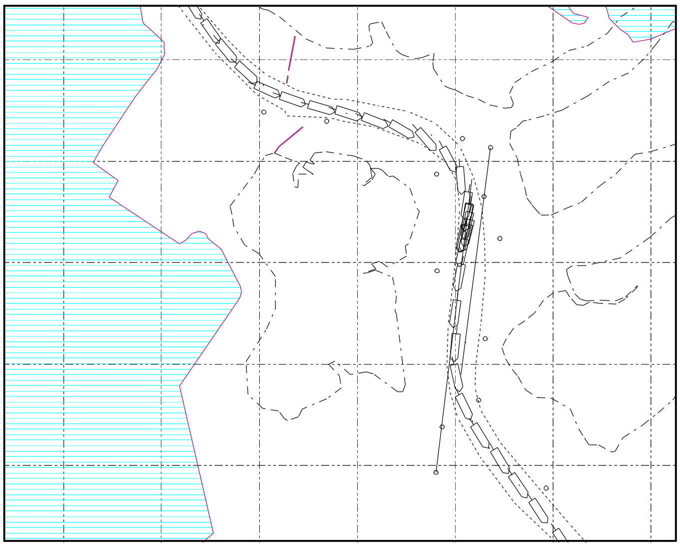


Figure 11: Caedmon outbound: tidal height 0.46m. Run 61

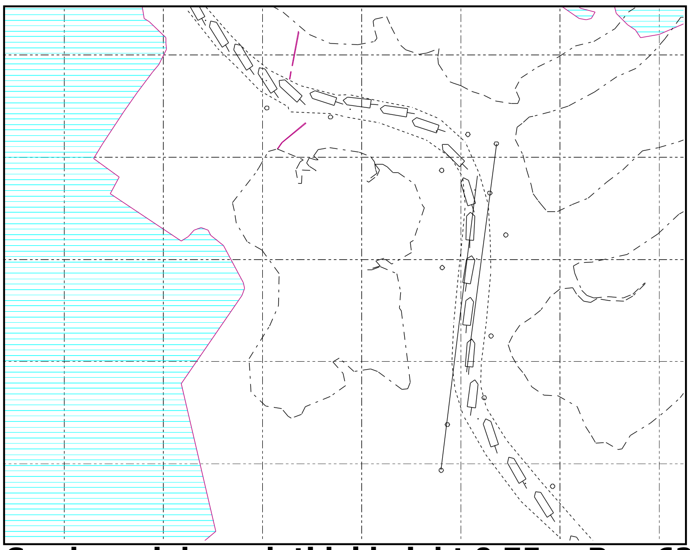


Figure 12: Caedmon inbound: tidal height 0.75m. Run 62

Speed Profiles

Overground speed profiles are shown in Figures 13 and 14.

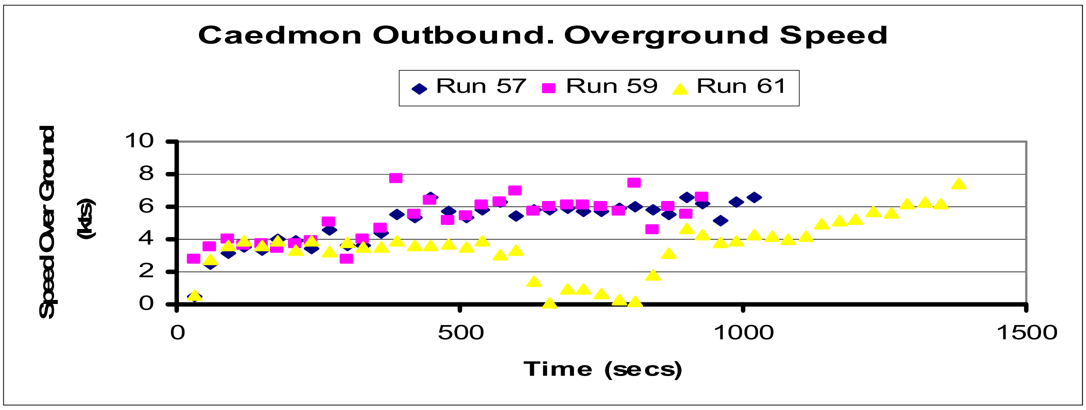


Figure 13: Caedmon Outbound Overground Speed Profiles

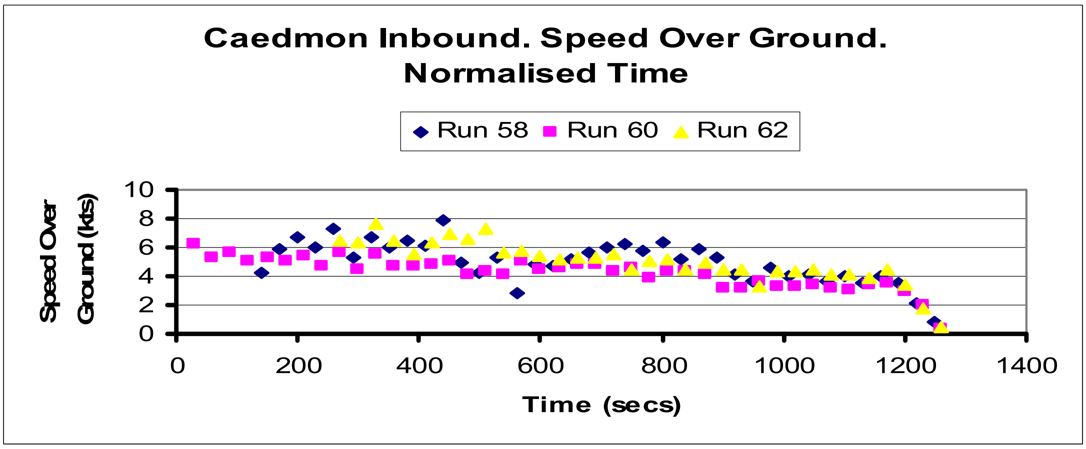


Figure 14: Caedmon Inbound Overground Speed Profiles. (Normalised time)

Regarding Figures 13 and 14, the following may be noted:

- The times in Figure 14 have been normalised to a common stopping time for ease of comparison.
- Outbound and inbound, the ferry kept to the inside of the Cocked Hat bend, whereas it tended to keep to the starboard side of the channel in the Tar Barrel bend.
- Speed was lost in the bends rather more in the deeper tidal conditions
- Outbound, overground speed in Short Reach Lay-by reached 6 knots, but inbound it tended to be lower at around 4.5 to 5.5 knots in this region, only reaching 6 knots at high water.

Track Distributions

In Appendix 6 are shown the distribution of tracks across the channel for the C-class inbound and outbound runs. These are for gates perpendicular to the channel at the following locations:

- Post Number 7 (Gate 1)
- Tar Barrel (Gate 2)
- Pylewell Boom (Gate 3)

- Enticott (Gate 4)
- Cocked Hat(Gate 5)
- Wave Screen (Gate 6)
- Royal Lymington Yacht Club (Gate 7)
- Ferry Terminal (Gate 8)

The data for the gate locations and widths (across the 2 metre contours) was taken from chart BA2021 and the ferry positions across the river are shown as fractions of the local width at the gate, measured from the gate centre. For reference, the same chart shows that the leading lines at the Pylewell gate (Gate 3) are at the following fractions of the local width: -0.37 (outbound) and 0.20 (inbound), all taken from the western edge.

In spite of the small number of runs for each case, the detailed results in the Appendix yielded useful information and show:

- At Pylewell the C-class vessel remained on the leads inbound for two of the three runs, the other run seeing the vessel cross the river, in the absence of river traffic, from Tar Barrel to Cocked Hat.
- Outbound the vessel stayed outside the leads for all runs.
- When outbound, the vessel stayed on the starboard side of the channel at Tar Barrel; this was not the case with inbound runs when one run was nearer the port side.
- At the Cocked Hat bend the vessel kept well to the inside (western edge) of the channel inbound and outbound.
- At the wave screen, the centre of the vessel was more or less in the middle of the channel both inbound and outbound.
- Off the RLymYC, the ferry generally stayed on or near the centre of the available channel between the 2 metre contours.
- At Post 7 the vessel tended to be just to starboard of centre outbound and near, or on either side of, centre inbound.

This data for the C-class performance has been discussed in some detail as it forms a benchmark for comparison with the W-class results.

W-Class

Thrusters on "Operational" Settings

Handling

Initially, outbound W-class runs using the both thrusters on the "operational" setting are presented for comparison with the C-class tracks at high, mid and low tides. These are from runs about three weeks in to the training period using a helmsman who had the greatest river experience. Figure 15 shows a run at high water.

This may be compared with Figure 9 and it is seen that a similar route to the C-class was taken by the W-class at this state of the tide, although the W-class passed a C-class vessel in the Short Reach Lay-by. Figure 16 shows an inbound run involving passing a C-class but this time at low water.

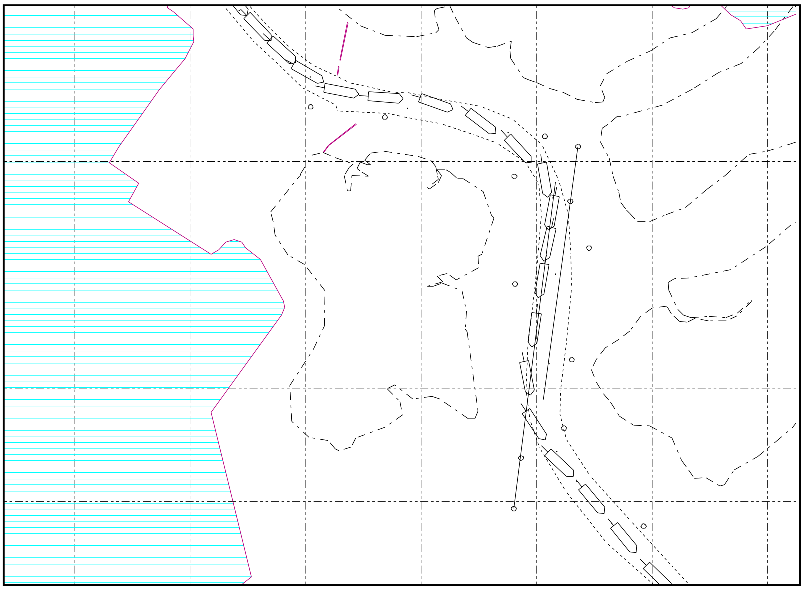


Figure 15: W-class outbound: tidal height 2.80m. Run 18

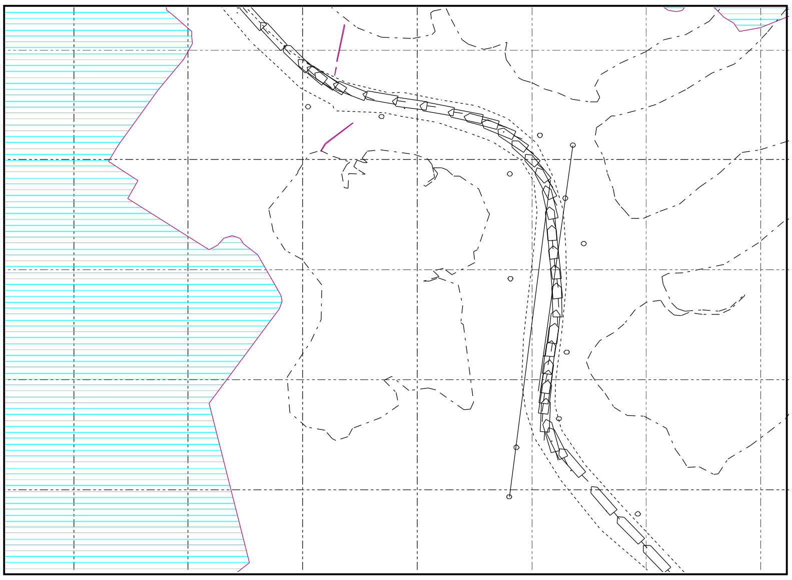


Figure 16: W-class inbound: tidal height 0.68m. Run 21

Comparing the track of Figure 16 with that of Figure 12 at a similar state of the tide, it is seen immediately that, as the W-class vessel had to pass a C-class, its track was well over to starboard in the lay-by and its overground speed low, unlike those of the C-class in Figure 12. The overground speed of the W-class of around 3 to 3.8 knots compares with 5.3 to 5.5 knots of the C-class in the run in Figure 12 showing that the new ferries had good low speed control at this state of the tide. However, it should be noted that the speed of both classes at spring low water conditions will be low for the reasons of safe and prudent navigation in the reduced water space available and due to the fact that in shallow water, ahead resistance increases, thereby reducing speed for given control settings.

Passage round the Cocked Hat bend and through the wave screen showed less drift with the W-class than the C-class.

Thrusters on "Operational Forward"/"Idle Aft" Settings

Turning to runs with the W-class aft thruster on its "idle" setting, Figure 17 shows an outbound run at high water in benign conditions.

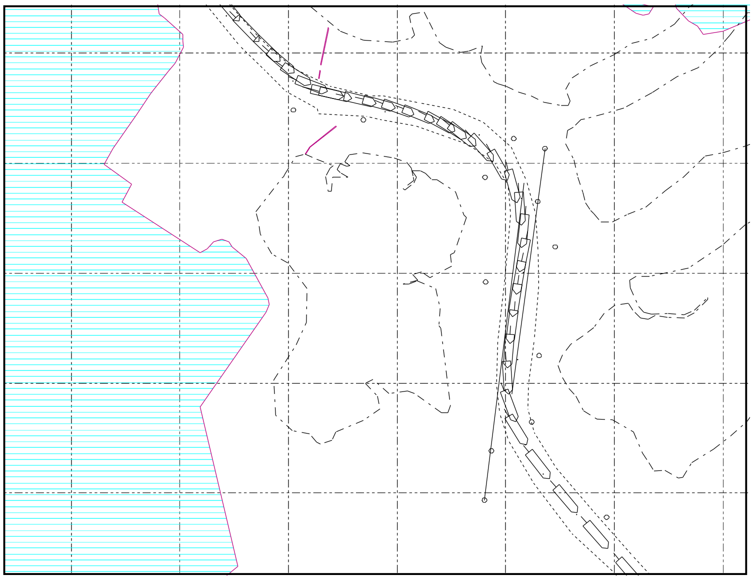


Figure 17: W-class outbound: tidal height 3.11m. Run 36.

This was a good run; there was no tendency to "hang the stern out" excessively round the Cocked Hat bend, and, on exit from the bend, a track was chosen toward the middle of the channel in the lay-by area. It should be noted that this route was taken because there was negligible river traffic. Speed prior to the Tar Barrel bend was low at around 4 knots, and did not increase until the vessel was in Long Reach.

A mid-ebb tide outbound run is shown in Figure 18. In the light winds prevailing, the manner in which the following current takes the stern at Cocked Hat is clear, but the vessel recovers about half way down the lay-by to turn at the Tar Barrel bend on the starboard side of the channel. A comparison with Figure 8 shows that, at a similar state of the tide, the C-class vessel took a similar line.

A low water outbound run is shown in Figure 19. This run was truncated by a stop-and-hold manoeuvre in the lay-by, but it may be seen that after navigation of the Cocked Hat bend the vessel drifted over to the east before stopping on the western side of the lay-by area. The way the ship changes position in the lay-by while waiting may be noted, the wind at the time ranging from 13 to 7 knots from 297^{o}.

Inbound runs at high, late-mid and low water are shown in Figures 20 to 22. It is seen that in all three runs the vessel stayed close to the starboard side of the channel, near to the 2.3 metre contour, with a position outside the leads in all cases.

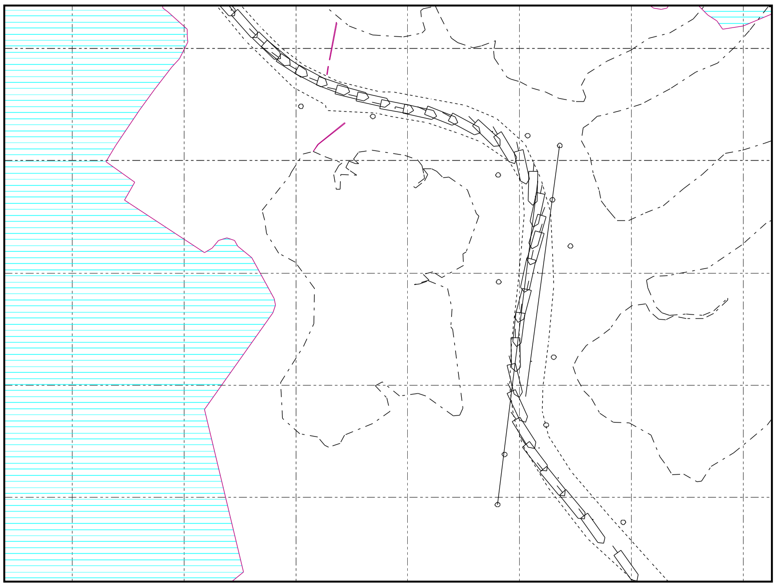


Figure 18: W-class outbound: tidal height 1.56m. Run 40.

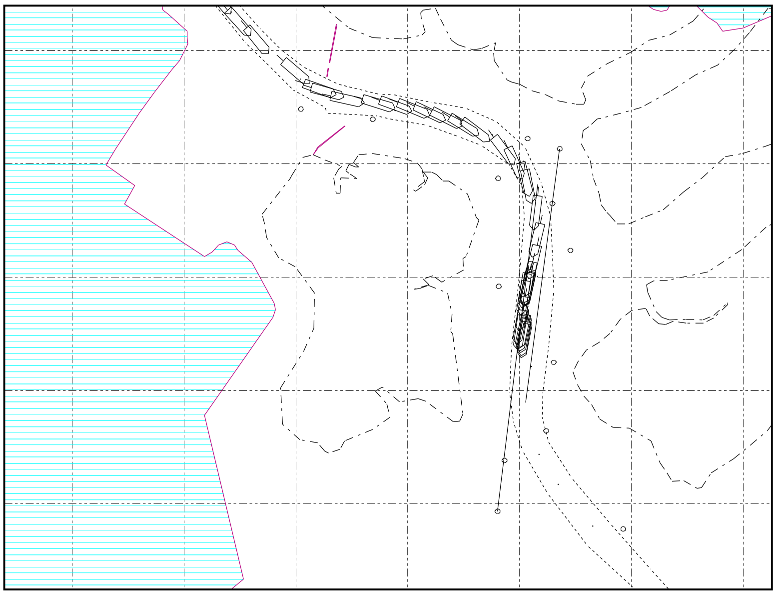


Figure 19: W-class outbound: tidal height 0.55m. Run 42.

For the high water run (Figure 20) an overground speed of just under 6 knots was maintained through the lay-by area, after which it reduced to around 4 knots on exit from the Cocked Hat bend. The vessel was conned from the centre console until the Cocked Hat bend, after which control was passed to the starboard bridge wing. The way in which the stern was "kicked" to port on passing through the wave screen may be noted. This control movement needs a change in the aft thrust vector direction thereby producing a rapid change of slipstream at the stern which can affect small boats in the vicinity. This is discussed further below.

The late mid-tide run of Figure 21 was undertaken in a heading current of just under a knot, giving a through water speed around 5 knots in the lay-by where a C-class vessel was passed.

The low water run of Figure 22 did not involve passing and was stopped early due to service boat movements.

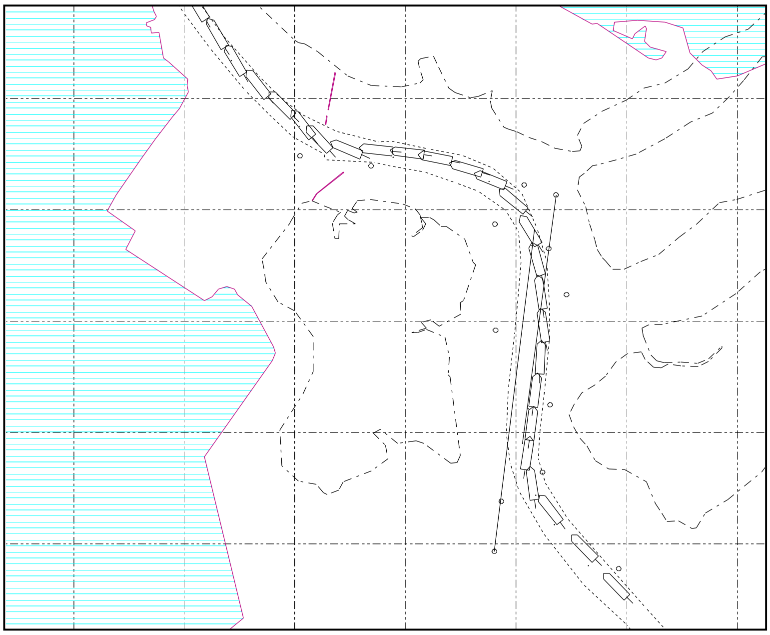


Figure 20: W-class inbound: tidal height 3.23m. Run 37.

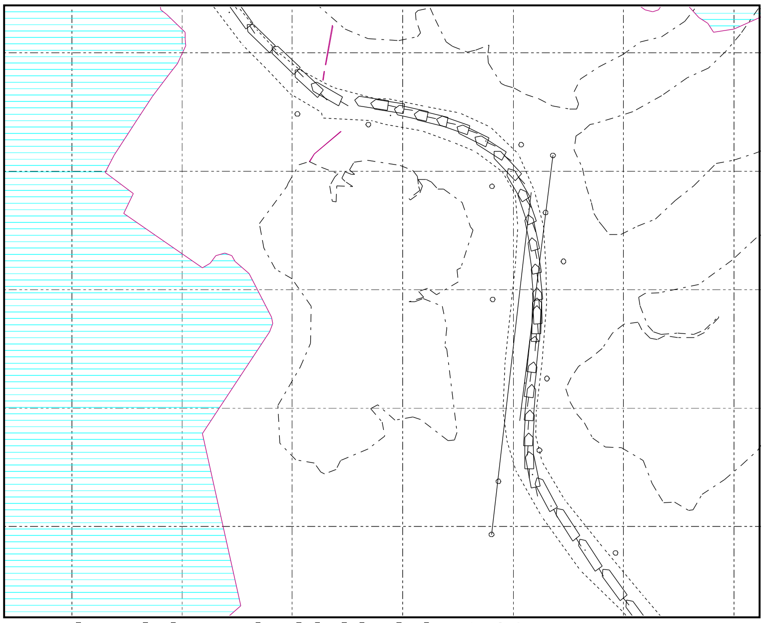


Figure 21: W-class inbound: tidal height 0.83m. Run 41.

Again the vessel was kept quite close to the starboard limit of the channel, outside the lead. It is understood that this is not uncommon practice among the masters and leaves plenty of space to pass. It is a technique which has consequences on river space between the vessel and the bank and is discussed further in Section 6.1.6 below.

Speed Profiles

Overground speed profiles for the runs in Figures 17 to 22 with the thrusters on the "operational"/"idle" settings are shown in Figures 23 (outbound) and 24 (inbound).

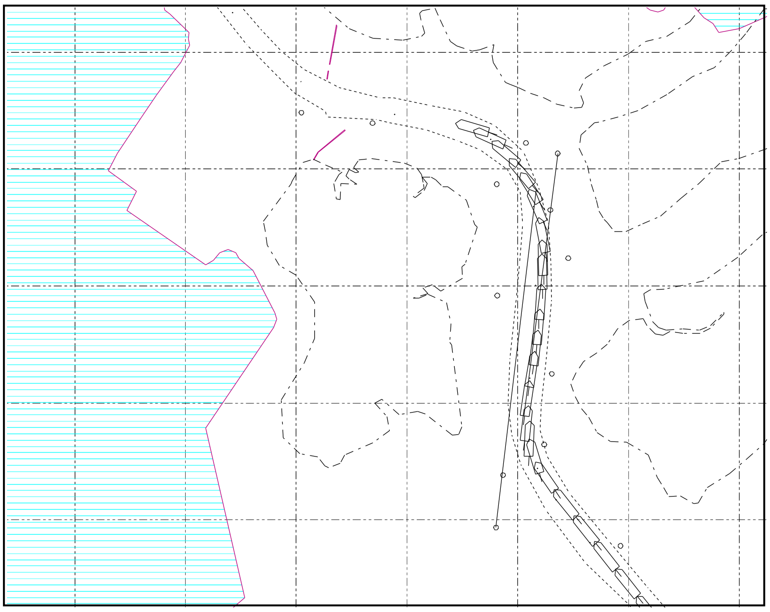


Figure 22: W-class inbound: tidal height 0.51m. Run 43.

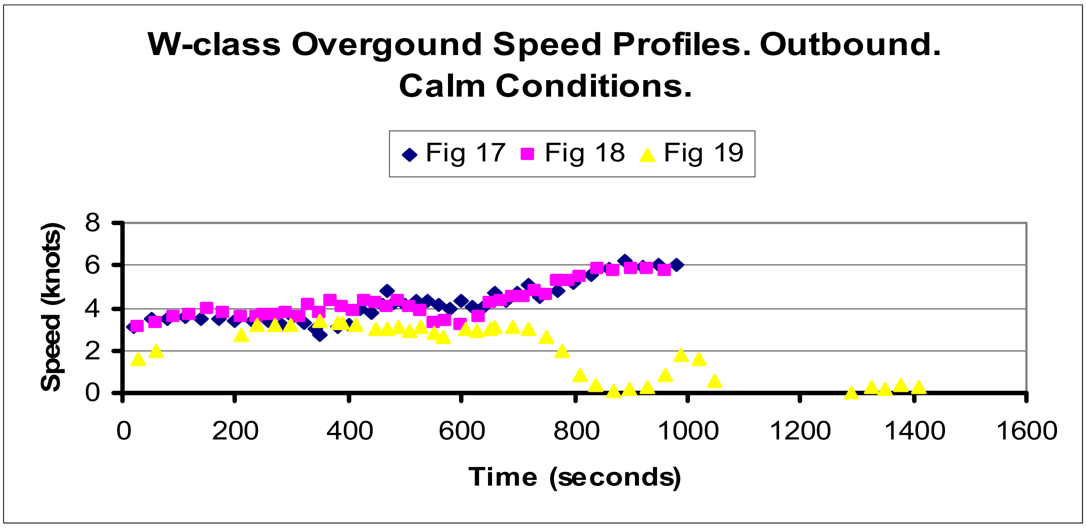


Figure 23: W-class Overground Speed Profiles. Outbound.

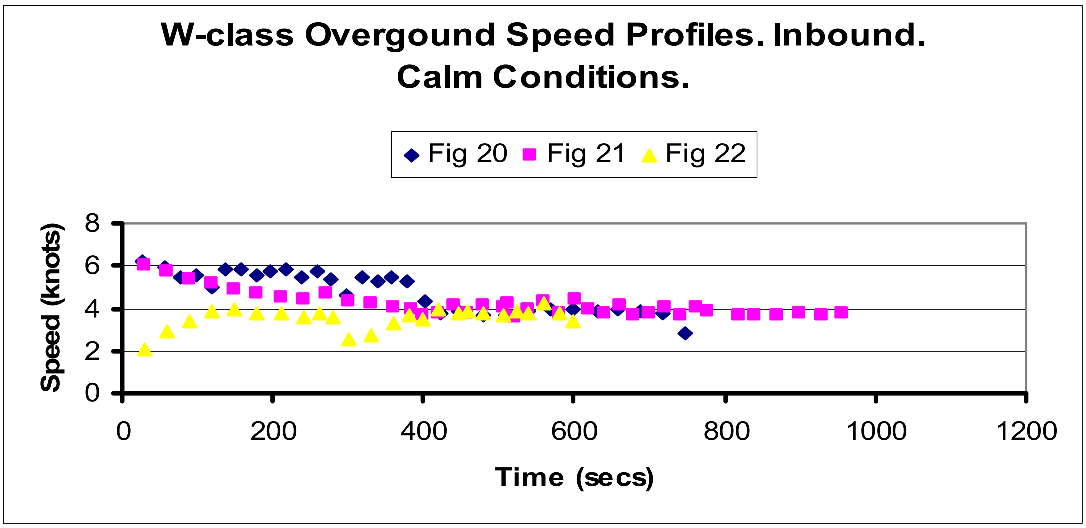


Figure 24: W-class Overground Speed Profiles. Inbound.

The outbound runs all started in the vicinity of the linkspan and similar velocity profiles for the through runs in Figures 17 and 18 may be noted. These results were achieved in spite of the presence of different currents in the river for each run, an outcome that is no doubt due to the fact that overground speeds are continuously displayed on the bridge. Similar results were obtained with the C-class (Figure 13). This suggests that there would be no significant change in speed holding or speed profile for outbound runs with the W-class compared to the existing situation with the C-class.

The generally lower inbound speeds may be seen in Figure 24. This feature was also noted in the C-class results in Figure 13 and is caused in part by the inbound ship giving priority to the outbound ship if a passing manoeuvre, as in the runs of Figures 20 and 21, takes place. As mentioned above, the run in Figure 22 was a short run, deliberately aborted at Cocked Hat.

Track Distributions

Also shown in Appendix 6 are the track distributions for the W-class. These use the nomenclature given above for the C-class tracks, but most measured tracks (amounting to about 70) for the W-class ferries were used.

From the distribution plots, the following may be noted:

- At Tar Barrel inbound, there was a tendency to pass slightly to the east of the centre of the "channel" defined by the 2 metre contours.
- At Pylewell, some inbound runs were on the inbound leads, but there was a significant number outside with a few inside.
- At Enticott inbound there was a greater track spread, fairly evenly distributed about the centre of the channel.
- At Cocked Hat inbound, the tracks were clearly distributed closer to the inside of the bend, while at the wave screen they were distributed about the channel centre, with a bias toward the eastern side.
- Off the RLymYC there was a wide spread about the centre of the available waterspace, with rather more on the western side. This is no doubt because many of the runs were heading past the linkspan toward the North End or Freshwater berths, while others were dummy runs to the linkspan. The track bias to the west is confirmed by the gate at the ferry terminal when a clear bias to the west is seen. This is due to the number of runs passing the terminal en route for the up-river berths.
- Outbound, the bias in the tracks at the terminal and RLymYC is clear and is caused for the reasons given above.
- Passage outbound through the wave screen was biased slightly to the east of centre, but passage around the Cocked Hat bend was well to the inside of the bend in all runs.
- The same applied at Enticott, while at Pylewell, whereas some of the runs were on the outbound leads, the bias was clearly in favour of passing outside them.
- The Tar Barrel bend was generally taken on the starboard (west) side of the channel, after which the ferry was set to remain to starboard past Post 7.

Thrusters on "Operational Forward"/"Intermediate Aft" Settings

Initial trials with the aft thruster on an "intermediate" setting while the forward one remained on its "operational" setting were carried out in relatively benign conditions and therefore find a place in this Section of the report. The wind was west-south-westerly at about 14 knots with the second sailing trials taking place at the same time. For these trials, the ferry did not have the large articulated trucks on deck fore and aft which were a feature of some of the trials in wind described in Section 6.1.4 below.

Results with the "intermediate" setting aft for winds in excess of the limit for the "operational"/"idle" settings will be given once the trials have been completed.

Figure 25 shows an outbound track.

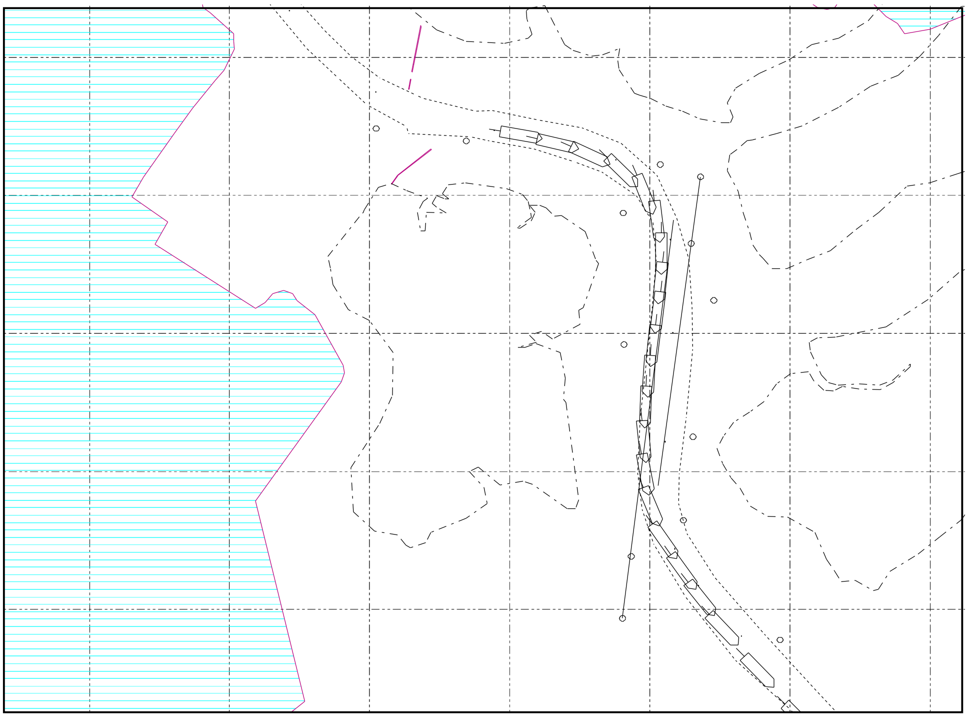


Figure 25: W-class outbound: tidal height 1.47m, run 74

After some initial over-control, the run settled down and the track was very much the same as that achieved with the "operational"/"idle" settings.

On the inbound run shown in Figure 26, however, the vessel sheered to port on passing the Pylewell Boom post. Overground speed at the time was about 4.9 knots and it was felt that bank effects were the cause. Unfortunately no wind measurements were made for this run as the ship-board anemometer was not working.

The amount of water space used in rounding the Cocked Hat bend may be noted.

Even though the wind was not strong during this set of trials, the master commented that he could feel its effect. However, all runs were conducted satisfactorily, although the pattern set in the runs of Figures 25 and 26 was repeated in that navigation of the Cocked Hat bend outbound used smaller drift angles than inbound navigation of the same bend.

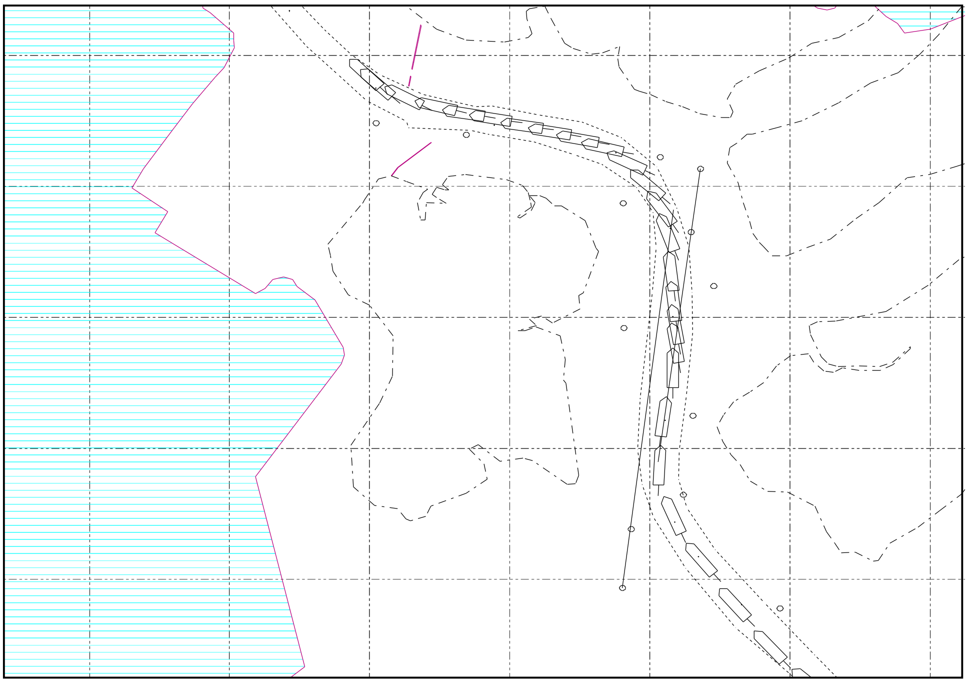


Figure 26: W-class inbound: tidal height 1.69m, run 75

On the run shown in Figure 27, the master tried using the aft thruster in a pure steering mode, providing no (or at least negligible) forward propulsive thrust. This was done to see if wake effects were reduced; the improvement, if any, was small, but handling was satisfactory, although less positive than when using the aft thruster to propel as well as steer. For all other runs, therefore, the aft thruster reverted to a propelling, as well as controlling, role.

Although wake and wash effects were more evident than those with the "operational"/"idle" settings, they were felt to be satisfactory for the more severe weather conditions for which the "operational"/"intermediate" setting is destined. An exception to this was when the ship was accelerating up to speed from stop when more disturbance was caused in the wake if both thrusters were used. After some experimentation, the following procedure was found to be acceptable:

- Start to build up speed relying, initially, on the forward thruster
- As the speed builds and is nearly at the desired value, gradually increase the power of the aft thruster until it matches the speed
- Match both thrusters to the required speed.

6.1.4 Behaviour in Wind

Thrusters on "Operational Forward"/"Idle Aft" Settings

In the first set of trials in strong winds, the thrusters were on the "operational"/"idle" settings. The wind was relatively steady, especially in the outer reaches of the river, with speeds during the first set of trials gusting up to 40 knots as measured on the ship and up to 36 knots as measured on the RLymYC starting platform. For the first set of trials, two large articulated trucks were positioned on the vehicle deck fore and aft in what was regarded as a "worst case" configuration; these added windage area for these particular tests. For all runs, the same helmsman was used for that section of the route between the ferry terminal and the Tar Barrel bend, other helmsmen taking over for the Long Reach leg.

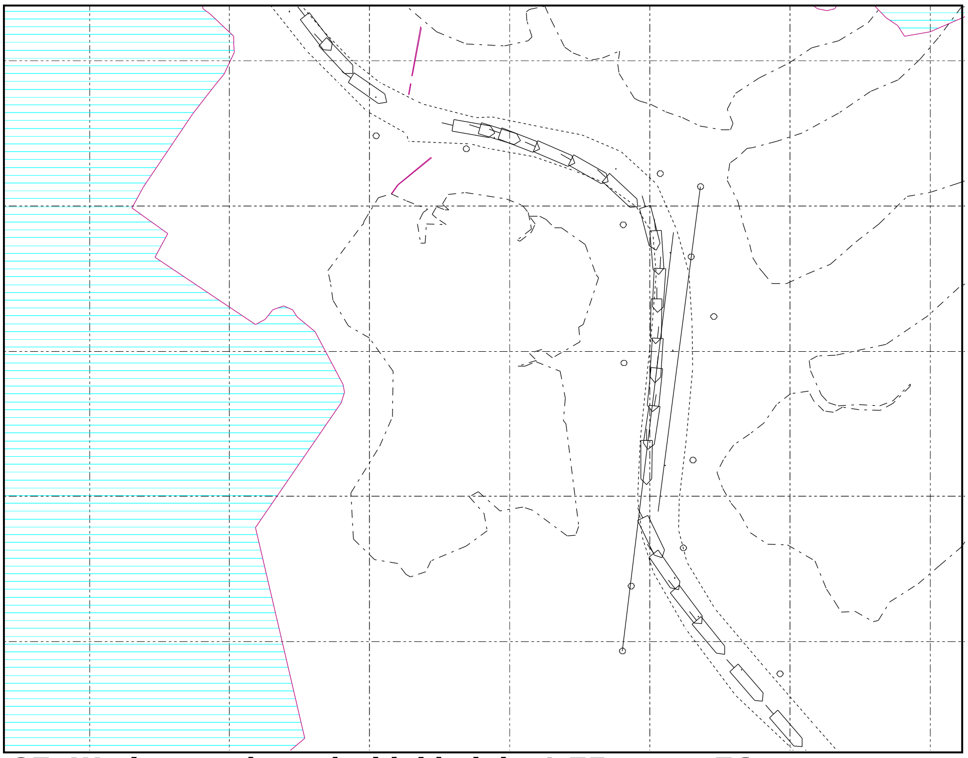


Figure 27: W-class outbound: tidal height 1.75m, run 76

Figure 28 shows the 2 minute mean true wind speeds measured on the ferry Wight Light, corrected for wind gradient to the standard height of 10 metres above the water. The measurements were obtained on an outbound run when the wind was at its strongest for the day; Figure 29 shows the measured true wind directions for the same run.

Note that in Figure 28 the 10 minute mean wind speeds measured at the RLymYC starting platform are shown for comparison with the ship measurements; "CCO" is the value given by the Channel Coastal Observatory and "LHC" is the value given on the appropriate link from the LHC website.

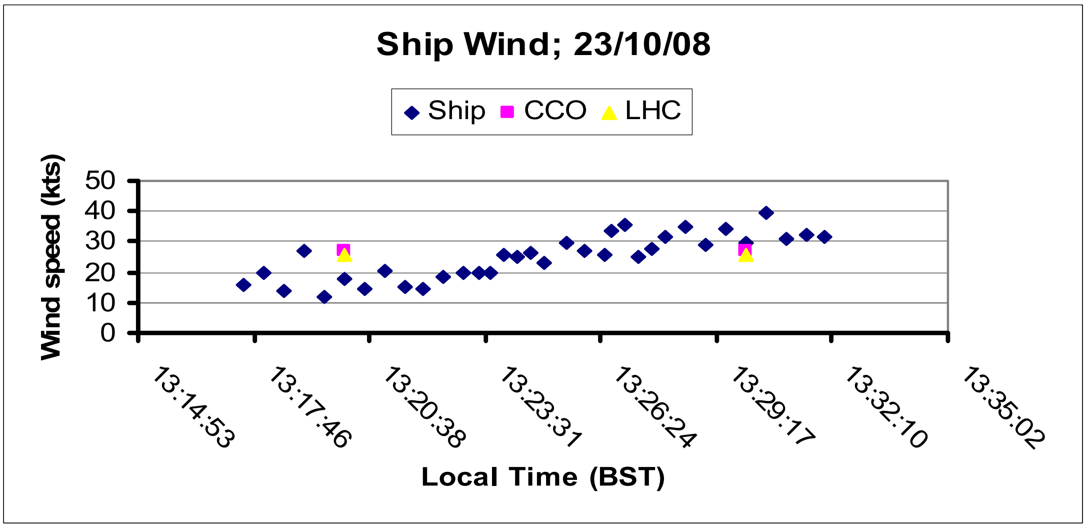


Figure 28: True Wind Speed Measured on Board W-class Ferry Outbound

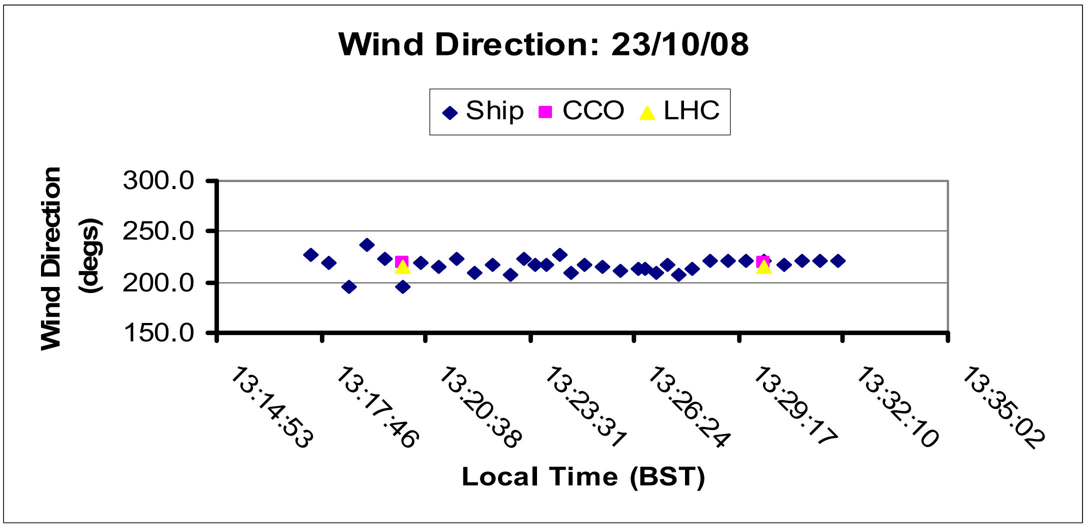


Figure 29: True Wind Direction Measured on Board W-class Ferry Outbound

These plots are typical of the wind information on the day. The following observations may be made:

- The wind direction was reasonably steady for most of the run downriver from the wave screen.
- The wind speed increased as the ferry moved down the river from the relatively sheltered area of Horn Reach to the end of Long Reach where the start platform is located.
- The 10 minute mean wind speeds from the fixed platform give sufficient agreement with the on-board results to suggest that the true wind data from the ferry gave a good picture of the wind throughout the run.
- From the start of the run near the ferry terminal to the region of the wave screen (from 13:14 to about 13:23 local time) the wind direction is much less steady than in the outer reaches of the river. Wind direction shifted from about 190^o to nearly 250^o, an effect which seems to be borne out by the experience of the local sailing fraternity.

The track for this run is shown in Figure 30. It may be seen that excessive drift angles were not needed, even in Long Reach where the wind was at its strongest and the Solent tide was flooding. This is in sharp contrast to a C-class vessel which operated in the same conditions and had to use quite large drift angles to counter the wind. Bearing in mind the increased windage of the W-class vessels compared to that of the C-class, the resultant track from this run, carried out with the "operational"/"idle" thruster settings, suggests that the W-class was handled satisfactorily in these winds. On board observations indicated that the helmsmen (changed after the Tar Barrel bend) had satisfactory control at all times.

True wind speeds for the inbound run which followed that of Figure 30 are shown in Figure 31. The wind had dropped slightly, but the variations in direction and speed can still be seen as the ferry moved from the outer reaches of the river to the ferry terminal.

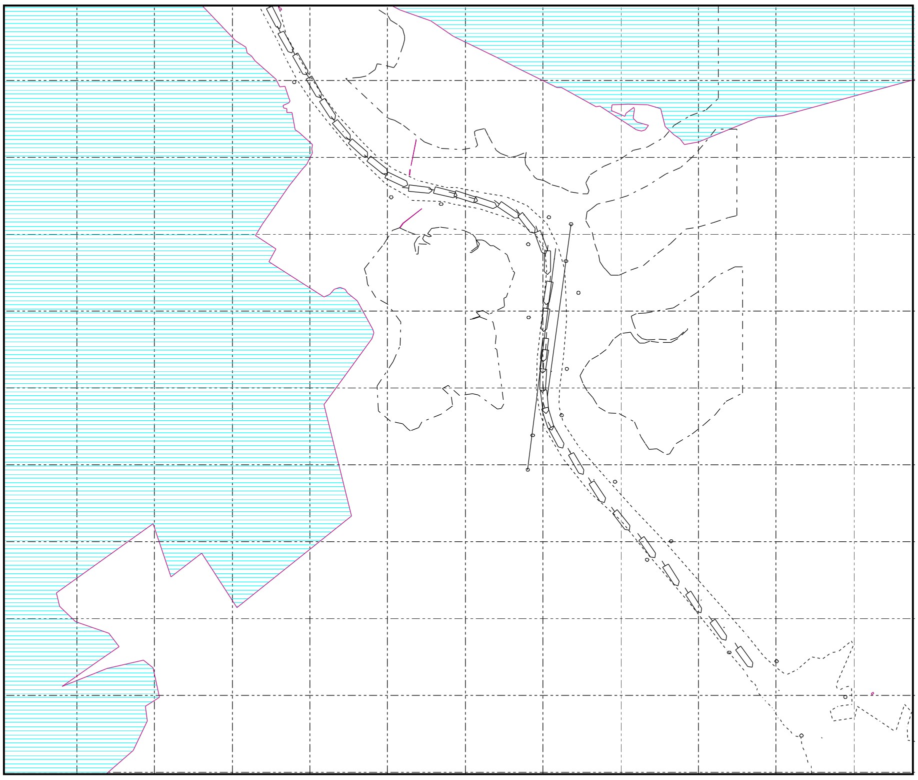
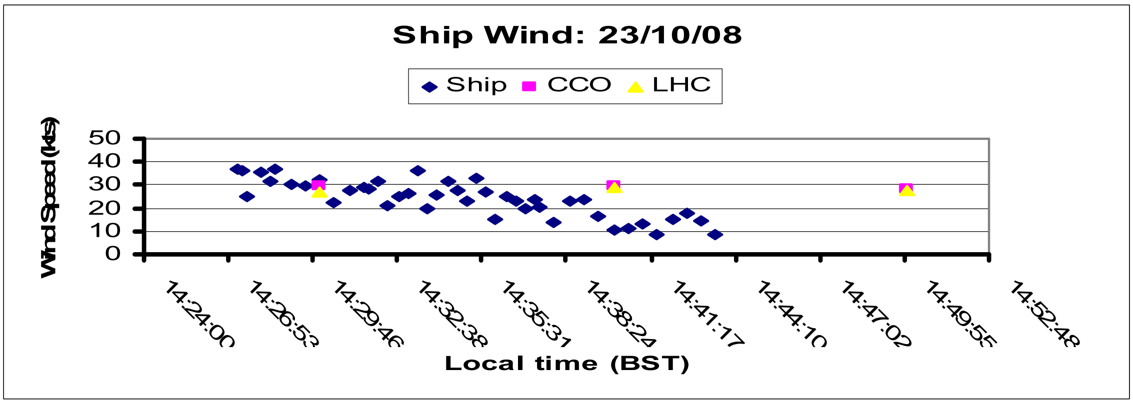


Figure 30: W-class Outbound Run in a Strong South Westerly Wind. Tidal height 1.71m. Run 46.



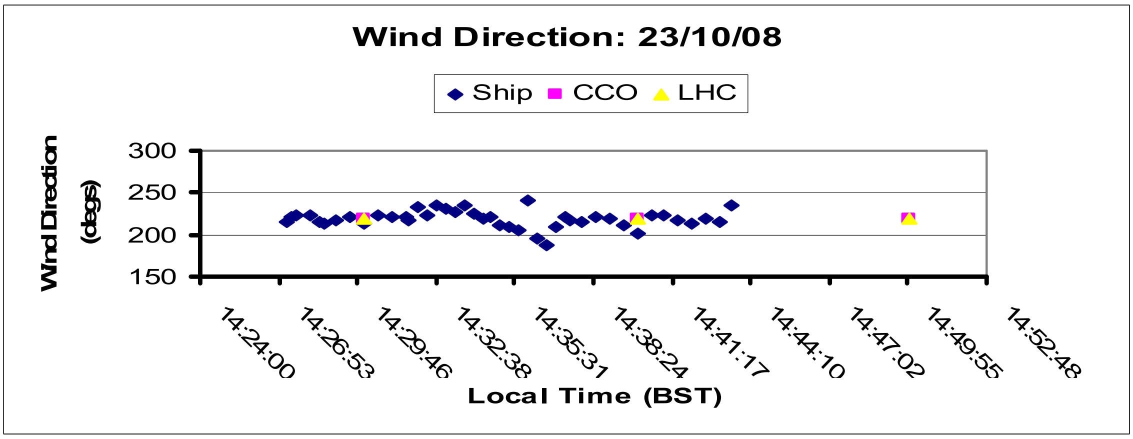


Figure 31: True Wind Speed and Direction Measured on Board W-class Ferry Inbound. Run 47.

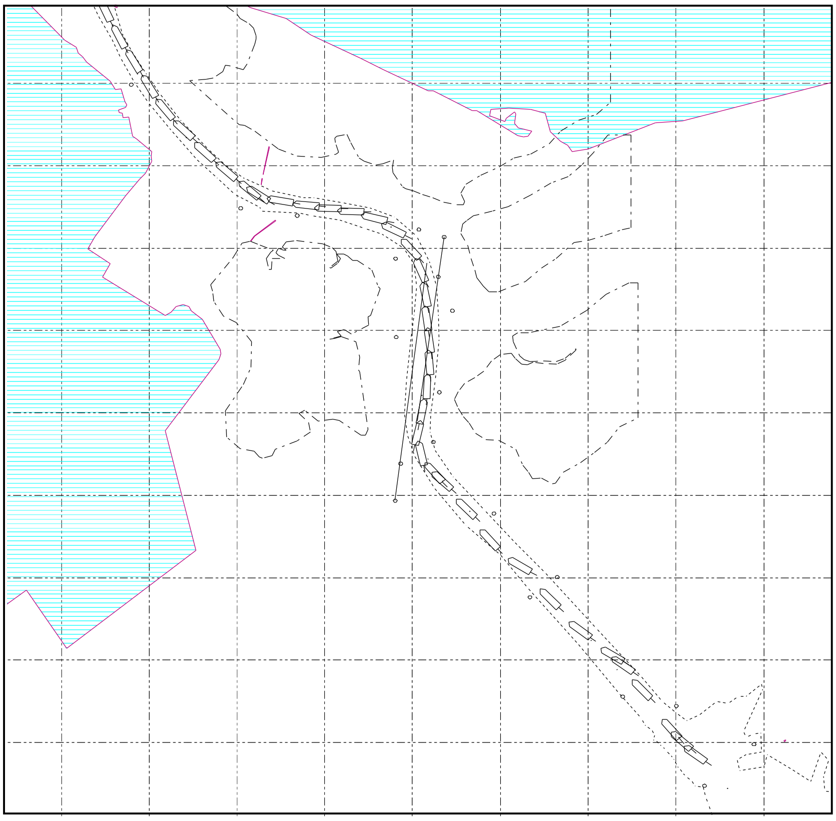


Figure 32: W-class Inbound Run in a Strong South Westerly Wind. Tidal height 1.8m. Run 47.

Figure 32 shows the measured track. Some problems occurred in Long Reach; these were due in part to the rather more variable wind direction (see Figure 31) there and in part from changing over the aft thruster setting from "operational" to "idle" in that part of the run. Immediate use of the forward thruster allowed control to be regained and the run proceeded without further problems. Nevertheless, it is clear that fairly large drift angles were adopted in the lay-by area, and when rounding Cocked Hat bend, even though the overground speed was maintained at just under 6 knots; the strong ebb flow also had an impact. Control was maintained throughout this run, but the track indicates that wind and current posed a somewhat more severe test of handling than the outbound run of Figure 30.

Nevertheless, all the runs in the strong south westerly wind were successful and the master and other helmsmen were of the opinion that good control was possible at all times with the "operational"/"idle" thruster settings. It may be concluded from this that the "operational"/"idle" thruster settings can be used for winds up to 25 knots, gusting to 30. However, it must be remembered that this performance was obtained by the helmsman who, at the time, had the greatest (but still limited) experience of handling the W-class vessel in a wide range of wind conditions. Due to the light winds experienced in many of the training runs, not all helmsmen were exposed to windy conditions during training. The W-class has significantly greater windage than the C-class and, until such time as other helmsmen have demonstrated satisfactory capabilities in these vessels in strong winds using the required thruster settings, it is recommended that safe operational limits for the "operational"/"idle" thruster settings be restricted, in the interim, to winds of 20 knots, gusting 25, as measured at the Royal Lymington Yacht Club starting platform.

Thrusters on "Operational Forward"/"Intermediate Aft" Settings

Strong winds were encountered on 3 March 2009, after the main body of the trials had been completed.

For a detailed description of the trials held on the day, reference should be made to Appendix 11. Suffice it to say here that the following conclusions were drawn relating to W-class behaviour in the strong winds experienced on the day:

- The W-class can be handled in south and south-westerly winds with mean speeds up to 30 knots gusting 42 knots, as measured at the Royal Lymington Yacht Club Starting Platform.
- The masters, experienced in handling the C-class in strong winds, are able to adapt to the W-class in strong winds
- Strong head winds have a significant effect on the speed of the W-class (see also "Speed Loss in Head Wind" section below).
- Strong beam winds cause the W-class to sideslip rapidly.

Arising from this and the runs with the "operational"/"idle" configuration is the recommendation that a Safe Operating Profile for the W-class ferries is:

- Use the "operational forward"/"idle aft" thruster setting for winds up to a mean value of 25 knots, gusting 30, as measured at the Royal Lymington Yacht Club starting platform
- Use the "operational forward"/"intermediate aft" thruster setting for winds greater than a mean value of 25 knots, gusting 30, up to a mean value of 30 knots, gusting 42, as measured at the Royal Lymington Yacht Club starting platform

As recommended in Section 7.2.2 and Appendix 11, an appropriate formal procedure should be developed between LHC and Wightlink to show that masters can demonstrate sufficient experience to be allowed to operate at the higher wind speeds.

Stop-and-Hold Manoeuvres

Stop-and-hold manoeuvres are necessary if the ferry has to wait anywhere on the route. One such manoeuvre was undertaken and is shown in Figure 33.

The measured wind speed and direction during this manoeuvre is shown in Figure 34; it is seen to be abaft the beam (a mean wind direction of about 240^{o}) for the whole time with speeds ranging from 12 knots to 32 with high values dominating.

It can be seen from Figure 33 that the ship stayed in roughly the same location throughout the manoeuvre, but shifted both along and across the water space. At the end of the stop-and-hold, it dropped back to allow an outbound C-class vessel to pass and, had there been small craft bunched astern, they would have been inconvenienced with such an astern movement unless some sort of prior warning had been given.

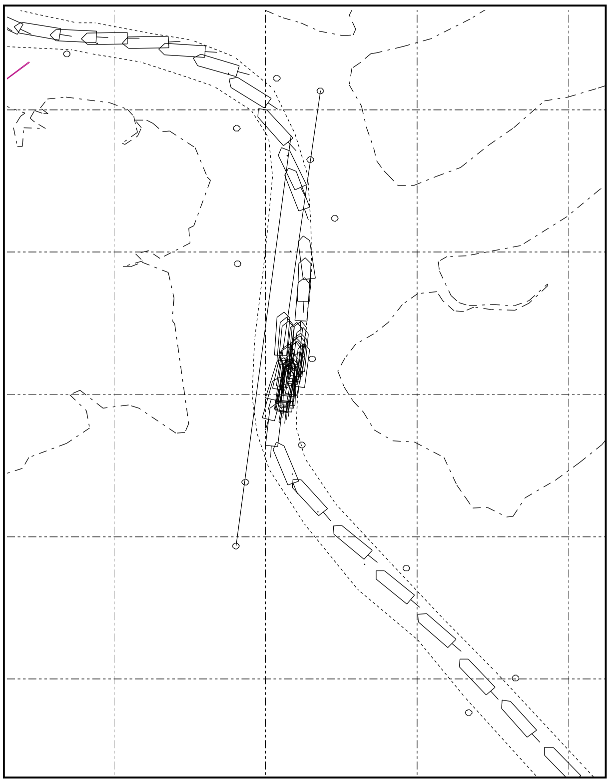
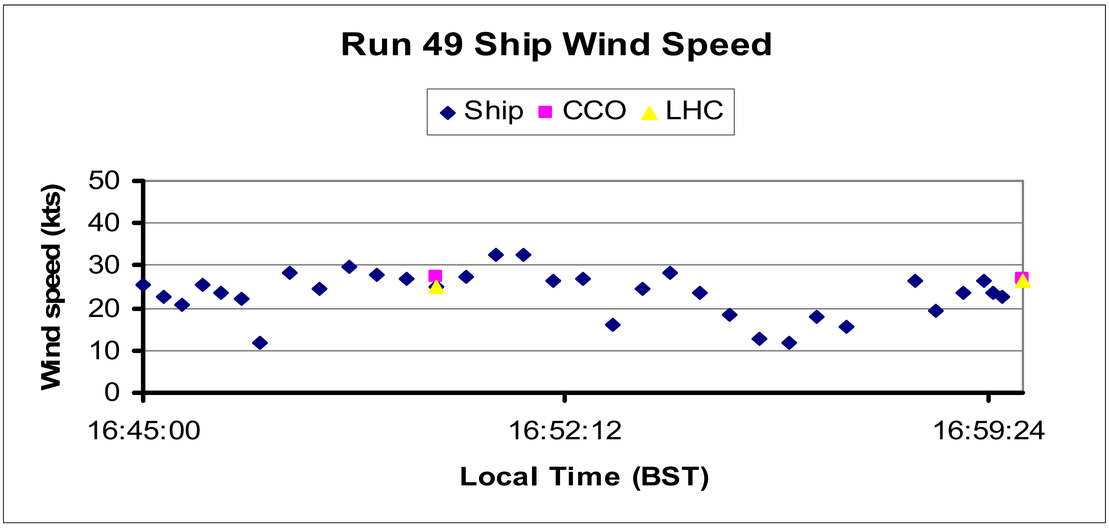


Figure 33: W-class inbound with Stop-and-Hold. Tidal height 2.29m Run 49

Although the stop-and-hold manoeuvre was successful in the comparatively strong winds at the time, success came at a price. As soon as the ship stopped, it began to drift rapidly to port toward the Pylewell Boom navigation post. It was impossible to control this drift with the aft thruster on the "idle" setting, so it was necessary to revert to the "operational" setting. To stop and reverse the drift, additional power was required to overcome the inertial effects of the drifting ship (see Figure 35) and this resulted in severe slipstream effects on the leeward side of the vessel. Observers at river level soon concluded that the disturbance in the river was intolerable and could be hazardous to any small craft in its vicinity. In light winds of 12 to 15 knots, however, the thruster disturbance was very much reduced and deemed acceptable by those observers present on the river at the time.



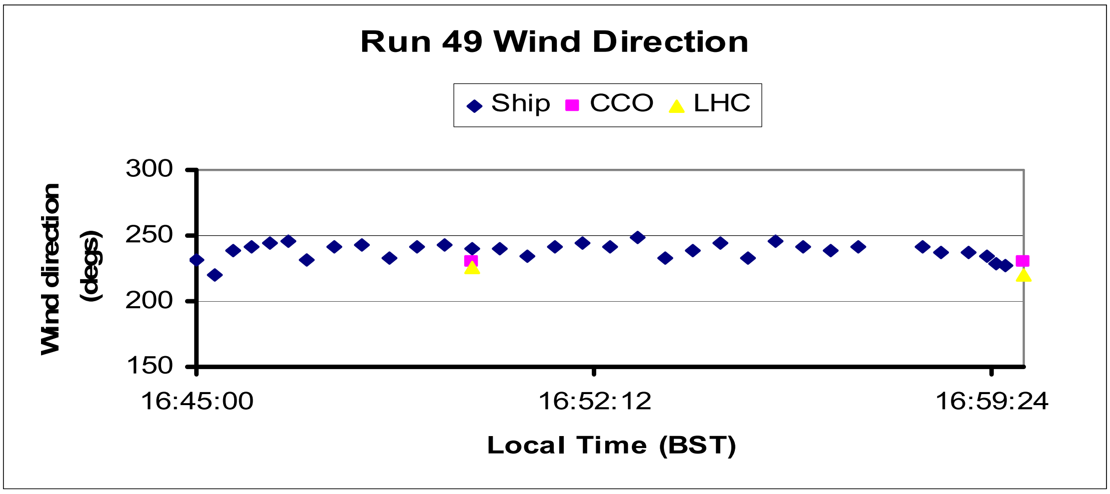


Figure 34: W-class Stop and Hold Manoeuvre: True Wind Speeds and Directions

It was also the case that the indirect slipstream effects mentioned in Section 7.3.1 of Reference 1 were not apparent to observers on the river. These were expected to be large slow-moving eddies, resulting from the thruster slipstreams, remote from the vessel and its wake, and convected along the river by the tidal stream; none were seen.

For estimates of the power required to hold steady against a beam wind and the additional power to overcome inertial effects, recourse was made to the simulation model of the W-class mentioned above. This incorporates aerodynamic coefficients for wind forces in surge and sway, together with moments in yaw. Because these were obtained from wind tunnel measurements, they take account of wind gradient and assume the stated wind is at the standard 10 metres height above the water. The windage areas were those given in Table 2 of Reference 1. Some stakeholders pointed out that the articulated vehicle shown in Figure 12 of the Reference was situated at an unrealistically high elevation. While agreeing with this, it may be mentioned that the petroleum tanker-type of lorry used in the drawing will have a height above deck of about 3.4 metres, somewhat less than the height of a container lorry at about 4.5 metres. As the maximum deck clearance on the W-class is 4.7 metres, it was assumed therefore that the petroleum tank lorry on the drawing was deliberately elevated to approximate the windage of something like a container lorry. In order to obtain a conservative result, therefore, the windage estimated for the misplaced lorry was used to represent the maximum additional loaded windage, on the assumption of container lorries on deck fore and aft. This gave a severe test in the simulation runs, although a few runs carried out without vehicles on deck showed little change.

Accordingly, the simulation model with the loaded windage of Reference 1 was used to prepare Figures 35 and 36.

Both thrusters were assumed to be on the "operational" setting for this exercise.

Bearing in mind that each thruster engine is rated at 636kW and its MCR would be about 540 kW, it is seen that in a steady 30 knots of wind the power predicted to hold station is quite modest, but builds rapidly as wind speed increases; it increases even more if the ship has moved off station and has to be brought back. All of this would increase the power required and hence the amount of disturbance caused in the river.

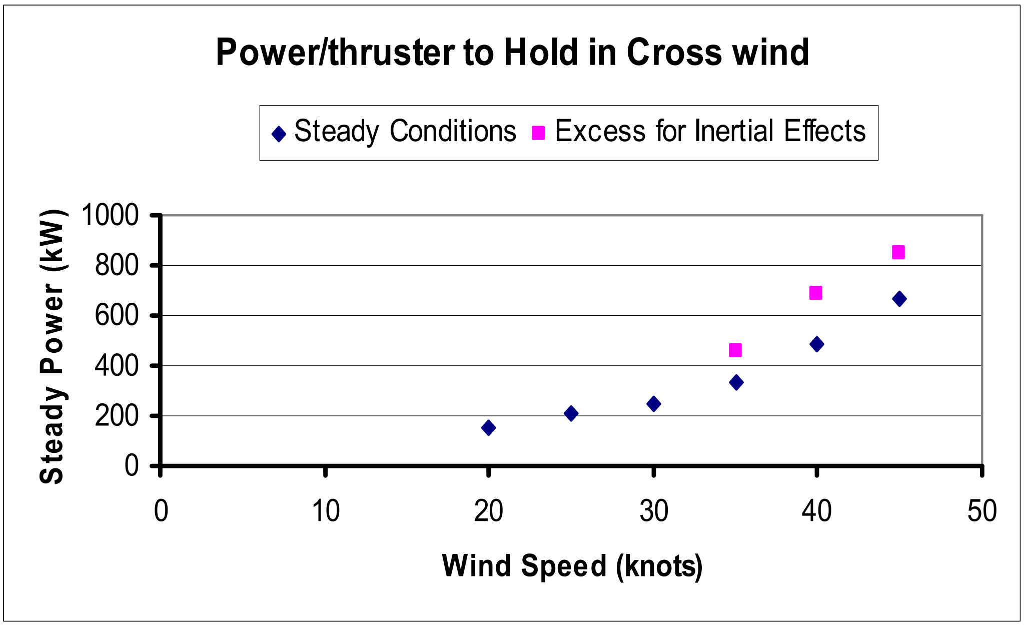


Figure 35: Simulation Results for Thruster Power required in a Beam Wind

Speed Loss in a Head Wind

It is well-established that the W-class has a higher windage than the C-class. In many cases attention has been focussed on the increased lateral windage area, but the longitudinal area is of relevance as well because it can cause a loss of speed in a head wind at a given thruster setting. This was observed in the trials and the simulation model was used to produce Figure 36 by way of demonstration.

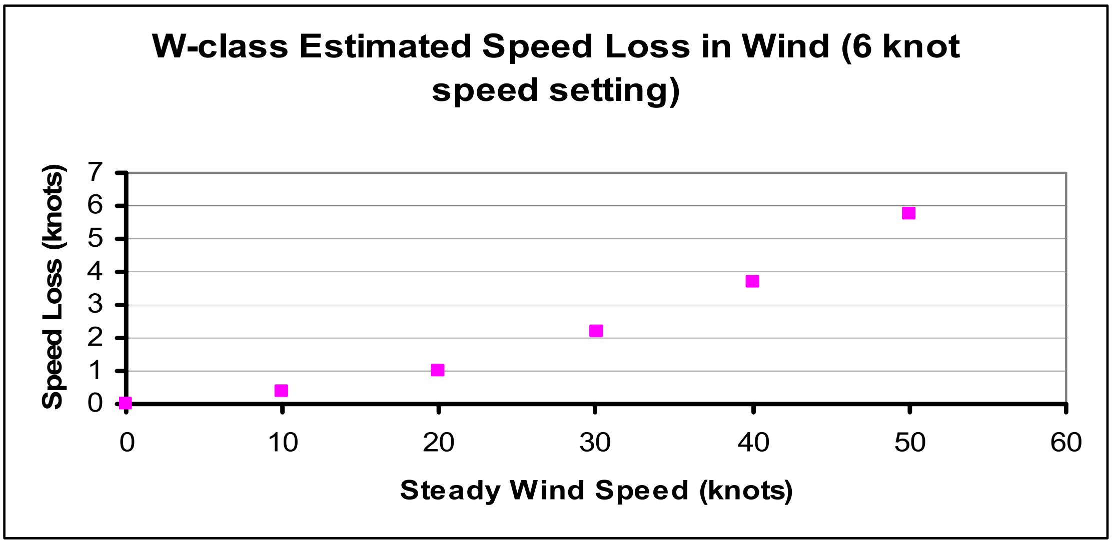


Figure 36: Estimated W-class Speed Loss in Head Wind

The results in the Figure were obtained for high water springs on the assumption that the thruster settings for a 6 knot speed through the water in the stated depth remained unchanged throughout. The forward thruster was on the "operational" setting while the aft thruster remained on "idle".

It is seen that for winds over 20 knots the estimated speed loss was significant while a 50 knot headwind brings the vessel almost to a halt, an event confirmed in the strong wind trials of 3 March. Clearly the "idle" setting on the aft thruster would have to be dispensed with, and the "intermediate" setting used, to maintain through-water speed at the higher wind speeds.

Effect of Wind Direction

During the trials weather forecasts were checked frequently for the desired winds. Often these did not materialise and it was necessary to accept what winds arrived on the day. It was recognised that behaviour in the prevailing south-westerly wind had to be observed, especially in strong winds, and this was done. Strong winds from other directions were not forthcoming and it was not possible to extend the trials to cover these.

However, it was recognised that it was necessary to check behaviour in other winds, so it was decided to use the simulation model to assess this aspect of the study. This was intended not so much as an exercise in the finer points of shiphandling, but rather an attempt to find, in broad terms, additional relevant information, if any, on the effect of wind on the W-class ferries. This showed what additional factors one might need to be aware of and the relative effects of various wind directions; in all runs a steady 25 knot wind was imposed from the appropriate direction.

Accordingly, simulation runs were carried out at high water, not only for the prevailing south-westerly winds, but also for winds from the north, east and south to cover the other, less frequent, wind directions. An extension of this work, for strong winds from the east, is discussed in the next sub-section.

All the simulation runs were manually controlled in real time from the control panel on the screen, shown in Appendix 3.

Some account was taken of the natural sheltering on the river of the type already demonstrated above; this assumed sheltering of the natural wind in the upper reaches, with the stated steady wind speed reached at or near the Cocked Hat bend outbound. In all cases each run was carried out at 4 knots through the water in Horn Reach and 6 knots in the remainder of the river; only outbound runs were studied because these posed the additional handling problem of rounding the Tar Barrel bend in such a way as to hold the ship against the strongest winds in Long Reach.

The resulting tracks are shown in Figures 37 to 40.

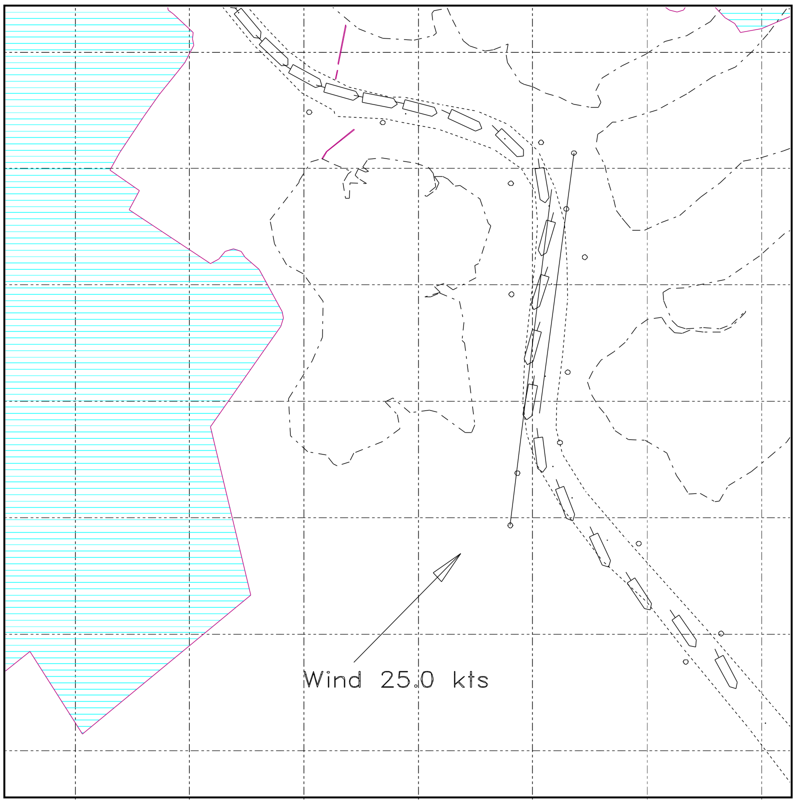


Figure 37: Simulation Results for South-westerly Wind

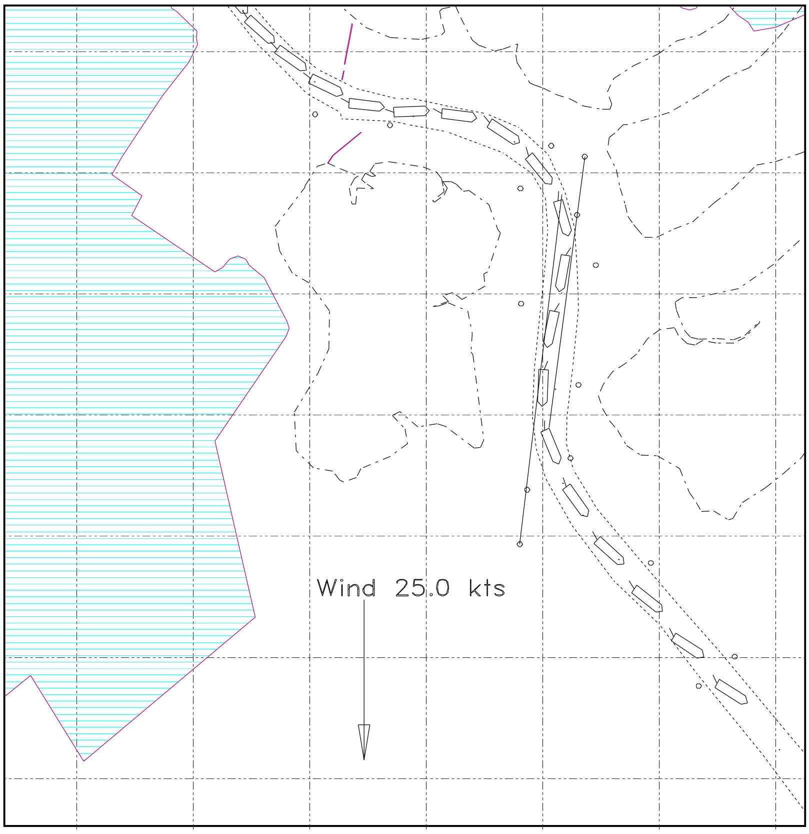


Figure 38: Simulation Results for Northerly Wind

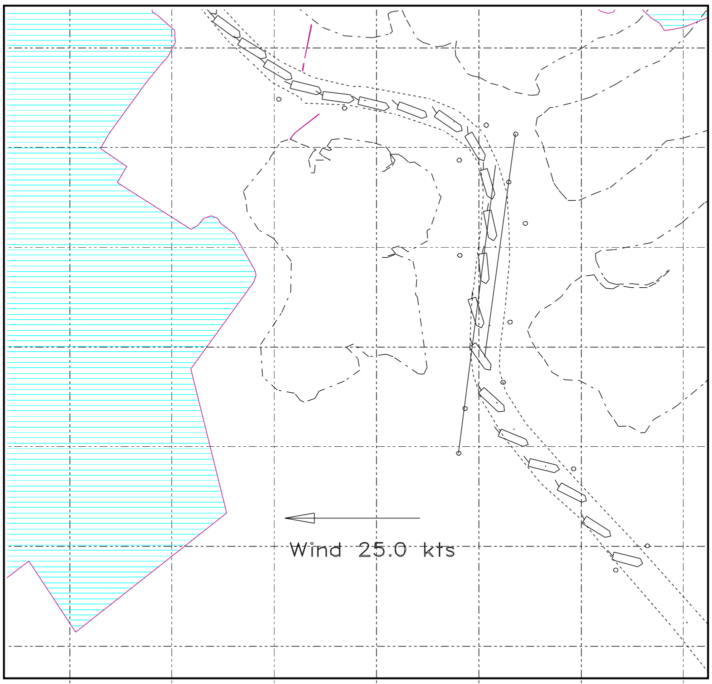


Figure 39: Simulation Results for Easterly Wind

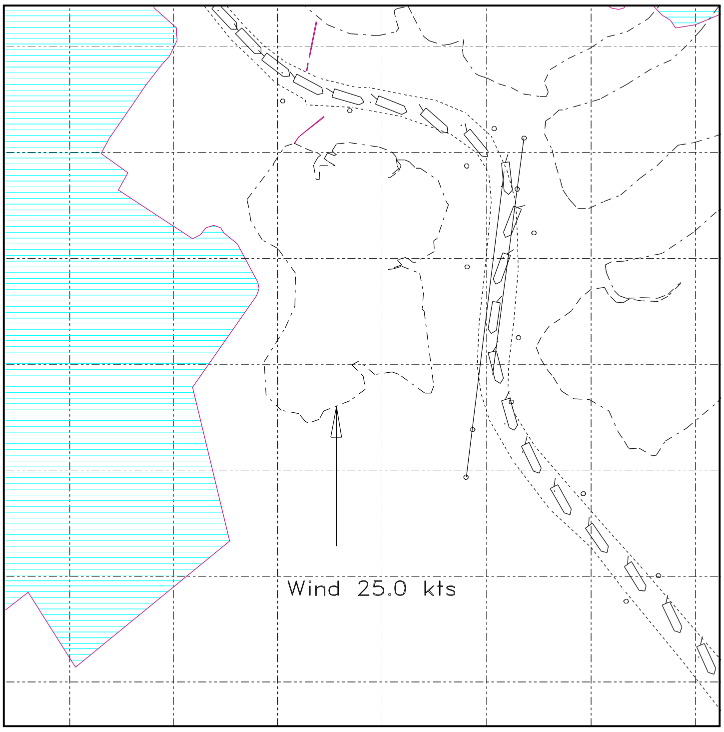


Figure 40: Simulation Results for Southerly Wind

Figure 37 shows a calibration run which may be compared with an actual run in winds similar to those in Figure 30. Bearing in mind that the simulation model was built around estimated data and is of necessity approximate, the comparison is reasonable and suggests that indications for winds from other directions might, at the very least, be of value in identifying potential handling issues in strong winds. It is noted that greater drift angles were needed in all the simulated runs compared to the rather small ones shown from the tracks measured in wind on the trials; this may be due to the fidelity of the simulation model itself, lack of familiarity by the person controlling the simulation with detailed handling techniques in the river and the difference in human factors effects by using high level, compared to perspective, views of the scene.

The run in a northerly wind (Figure 38) showed a tendency to run wide at the Cocked Hat bend with the wind on the starboard quarter which slowed the rate of turn; the only other issue arose when entering Long Reach and attempting to achieve the drift angle required to counter the wind. This was poorly done by the person controlling the simulation; he allowed the vessel to move too far to starboard which led to some over-control.

An easterly wind was more of a challenge (Figure 39) because sheltering was reduced over much of the run, it being assumed that there was no sheltering from the wave screen outwards. This made navigation of the Cocked Hat bend tricky; it was important not to over-rotate there because the wind subsequently took the vessel bodily to the west when moving down the Short Reach Lay-by. Control was made noticeably easier by using the thrusters ganged together as in the C-class vessels, although no doubt a similar technique could be used manually on the W-class where this facility has not been implemented.

Finally, the run in a southerly wind shown in Figure 40 posed further handling demands at the Cocked Hat bend when one had to be aware that the wind could cause over-rotation, thereby compromising control. Once the right technique had been developed, however, it was possible to hold the turn, although this caused the ferry to turn wide, as shown in the Figure. Once again, poor technique at the Tar Barrel bend caused the vessel to pass very close to the navigation post, an event which could have been prevented by slightly delaying entry to the turn.

For comparative purposes, handling in all these wind directions was of a similar level of difficulty, although winds from the easterly and southerly sectors proved the most challenging.

It was not felt, however, that winds from the other directions, when handled by a competent mariner, would pose a threat to marine safety. However, it would be helpful if the Training Master could be present when the W-class experience winds of the type discussed here until sufficient experience has been gained, and handling techniques refined, in winds from easterly and southerly directions.

6.1.5 Countering Strong Cross Currents and Winds

In this section, attention is focussed on behaviour in Long Reach in strong Solent ebb flows. In such a situation, especially if there is a strong easterly wind, the ship is being "pushed" out of the channel and there are two principle shiphandling methods employed to remain in the channel on the correct side. One is to set up a drift angle so that the ship "crabs" down the channel while the other uses the power available in the Voith thrusters to do the same. Clearly the first method can use a good deal of space to the detriment of other users and it would seem that use of the thrusters to both counter the cross wind and current without the need to set up a drift angle would be the preferred option. These two approaches are now explored using the simulation model described in Appendix 3.

The Drift Angle Method

Countering cross-winds and currents with a drift angle is a well-known shiphandling technique which combines the ship speed vector with those produced by both the wind and the current in such a way that the resultant speed vector is aligned in the desired direction of travel. This means turning the ship in such a way that its heading and speed through the water produce the correct resultant speed vector. In other words the ship "crabs" along. The advantage of this method is that it allows ships of all types and powers to deal with cross-flows, but the disadvantage is that, for a given cross-wind/cross-current situation, the slower the ship speed, the greater the resultant drift angle. In open waters this is not a major problem, but in a confined channel large drift angles limit the space available to other users. The C-class, having limited power and offset thruster locations (which themselves limited thruster performance) had to use large drift angles to offset strong cross flows and cross winds if they were not to run out of the channel in Long Reach. The only way they had to limit the magnitude of these drift angles was to increase speed through the water.

To demonstrate the effect of speed through the water, a short simulation study was carried out using the W-class model described above.

Tidal stream atlases indicate that ebb flows can reach as much as 2.5 knots along the 10 metre contour, in the Solent beyond the salt marsh, but about 1.0 knot as a maximum in Long Reach. For a 6 knot ship speed through the water, this requires drift angles of about 10^{o} to counter the current alone, let alone a strong wind from the east.

This is demonstrated in an assumed mid ebb flow across Long Reach of 1.0 knot. Figure 41 shows the results obtained with the thrusters set for 6 knots through the water with no wind, while Figure 42 shows the results for a thruster setting for 8 knots in the same conditions. In both runs "operational forward"/"idle aft" thruster settings were used unchanged throughout the run.

It is seen that the higher speed resulted in a reduced drift angle relative to the track, dropping from about 10^{o} to 5^{o}. This reduction results in a smaller track envelope, thereby releasing more water space for other users.

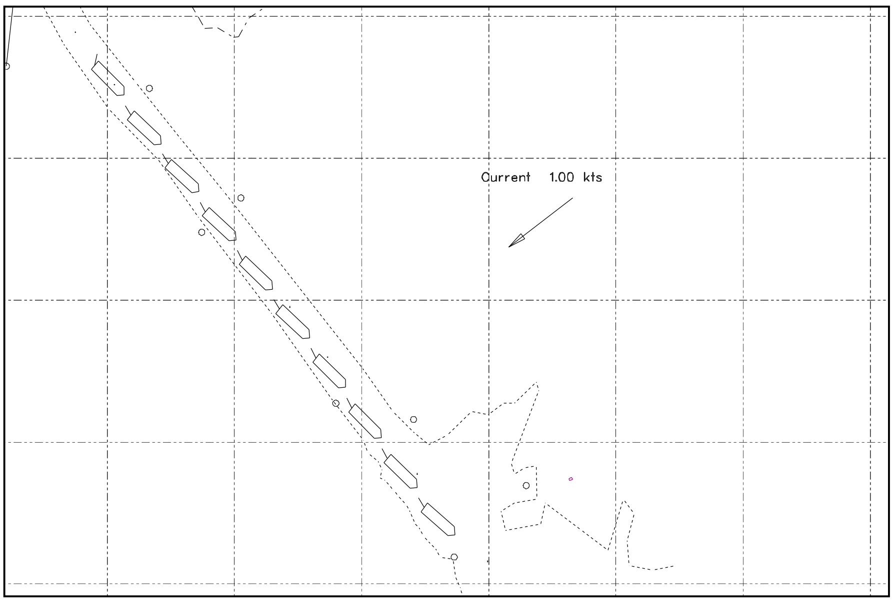


Figure 41: Simulation Results: No Wind, ebb flow, 6 knots Setting

When a 25 knot wind from the east is added, the results in Figures 43 and 44 were obtained with the same thruster settings. In such cases, the situation is more complicated because the wind reduces the forward speed through the water and makes it more difficult to find a "balanced" drift angle. This is readily seen in the plots.

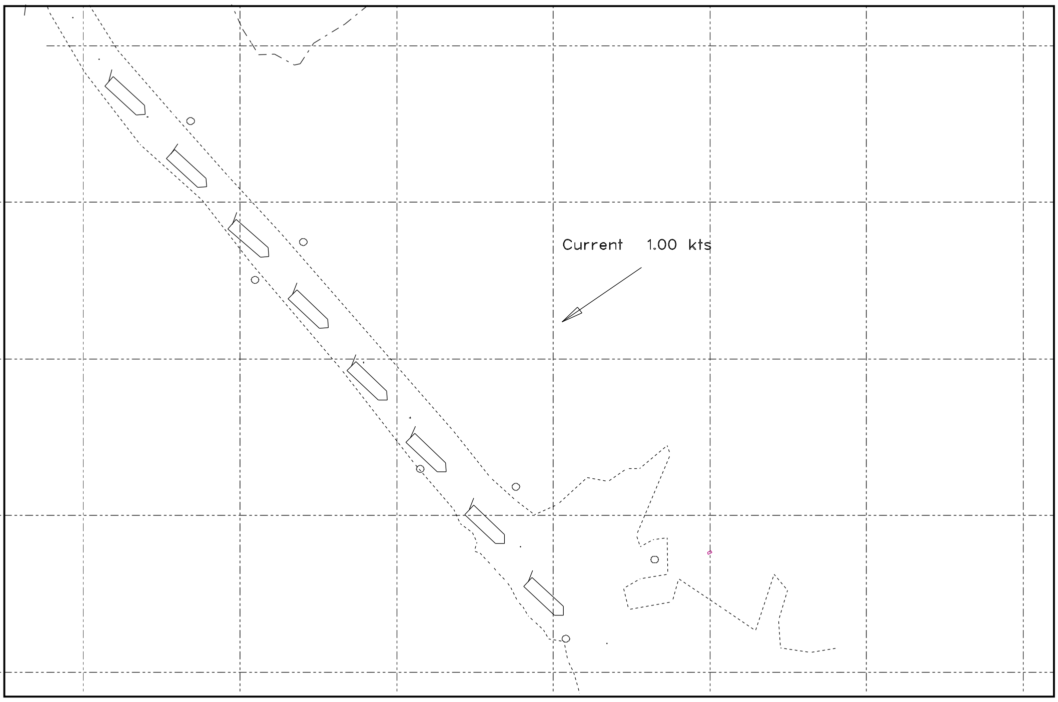


Figure 42: Simulation Results: No Wind, ebb flow, 8 knots Setting

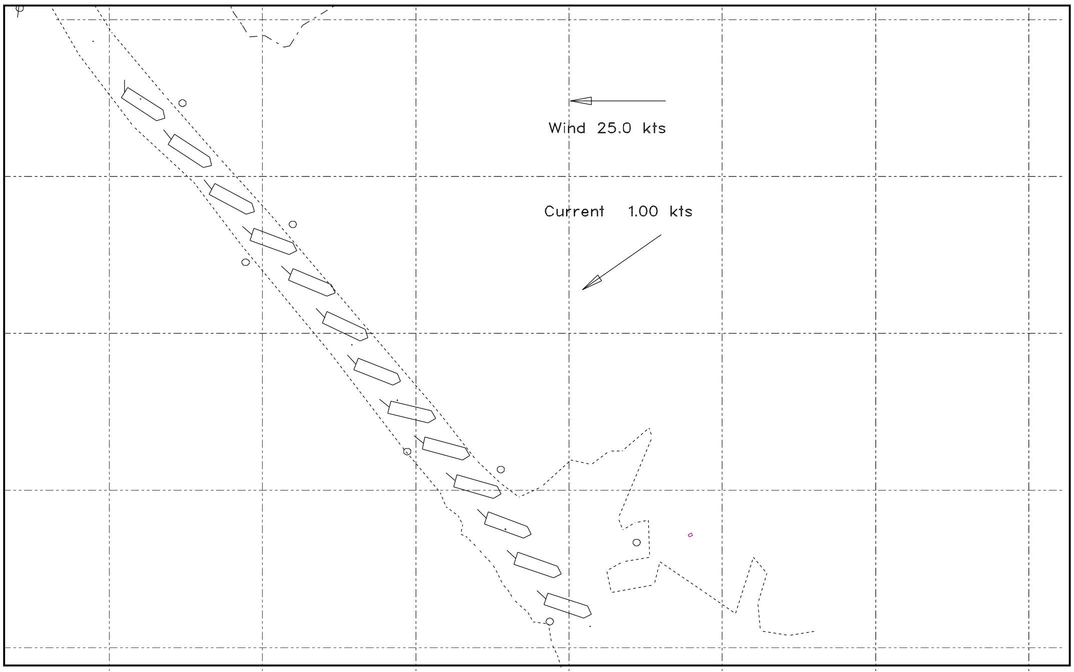


Figure 43: Simulation Results: 25 knot East Wind, ebb flow, 6 knots Setting

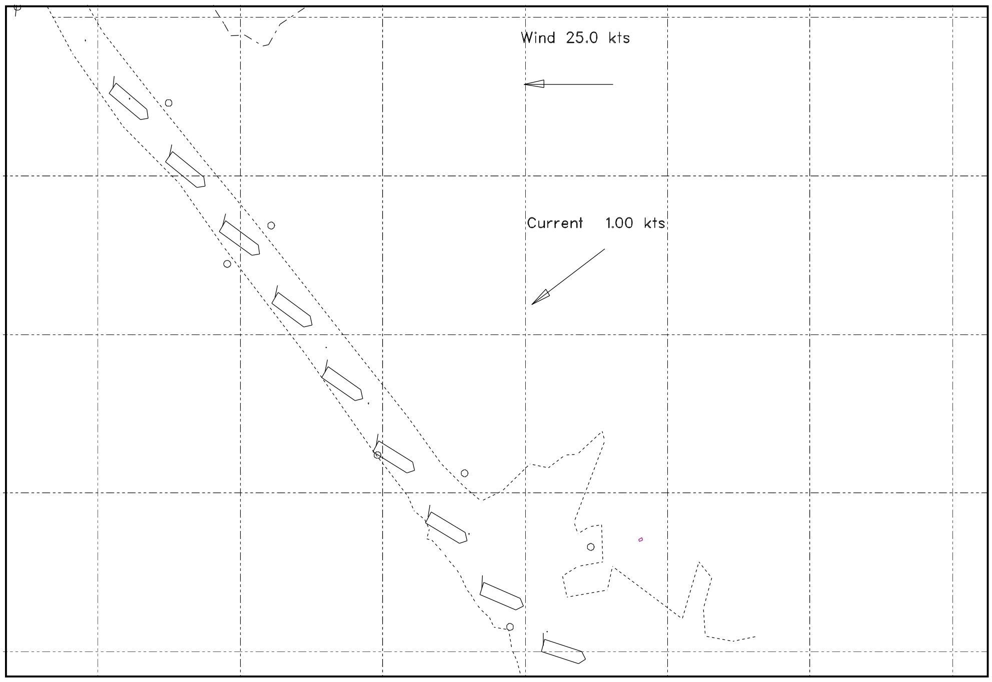


Figure 44: Simulation Results: 25 knot East Wind, ebb flow, 8 knots Setting

In the track of Figure 43, control was compromised by a significant loss of forward speed of about 1.5 knots due to wind, aggravated by easing the vessel into the wind in an attempt to counter lateral drift, resulting in a wide track envelope. This indicates the effects of a strong wind on control of the W-class if it is naively headed into the wind without changing the thruster settings. In view of the increased head windage, the speed loss as the ship is eased into the wind is more severe on the W-class than the C-class, suggesting that the simple approach demonstrated above, in which thruster blade settings are unchanged, would be unsuitable at 6 knots. This is discussed further below.

At the 8 knot thruster settings, again left unchanged throughout the run, the drift angles were reduced (due solely to the increased speed), as seen in Figure 44, and speed loss due to windage was, as a consequence, less, at about 0.5 knots. The ship was more under control, the relative wind was not allowed to get so much on the bow, speed was relatively unaffected and the track was, as a result, steadier. In this run the track envelope had less width than that at the lower speed, thereby using less of the available water space.

This simple exercise has shown the effect of speed through the water on drift angle, with the thruster settings unchanged. By so doing the thruster power was hardly changed from that needed for straight running in benign conditions.

The Thruster Method

Observations on the river to date have shown that the W-class vessels do not assume such high drift angles as the C-class in cross winds and currents in Long Reach. For example, the trials shown in Figures 30 and 32 were obtained in strong south-westerly winds combined with a flooding tide and it is seen that the drift angles were quite modest and a good deal smaller than those from the simulation. This is because the thrusters were used to counter the cross flows thereby significantly reducing the need to adopt large drift angles.

The question now arises as the whether the thrusters on the W-class can be used to eliminate drift the need for drift angles altogether? This would, of course, provide more space for other river users and would appear to be a desirable goal.

A number of simulation runs were therefore carried out with the goal of maintaining a 6 knot speed through the water with no significant drift angle under the wind and current conditions used for the Long Reach runs above.

Figure 45 shows a simulation run in which this goal was achieved; by increasing the magnitudes, and adjusting the angles, of the thrust vectors, the ferry was able to move along the starboard side of Long Reach with minimal drift angle at about 6 knots through the water.

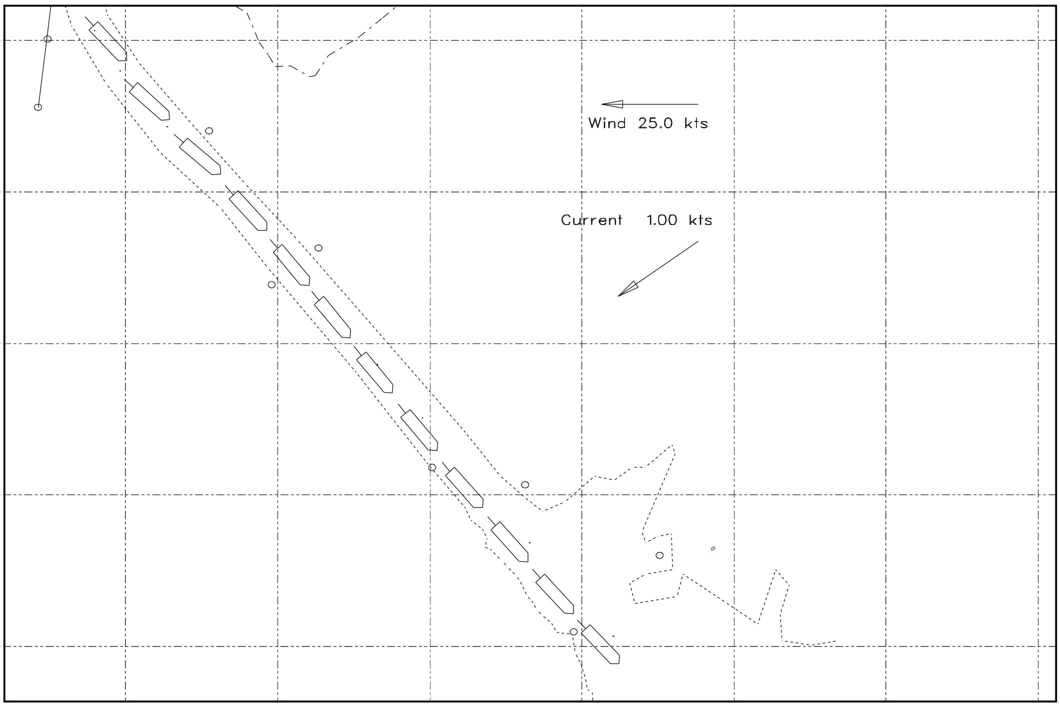


Figure 45: Simulation Results: 25 knot East Wind, ebb flow, thrusters used to eliminate drift and maintain 6 knots

The start of the run was somewhat artificial in that the start conditions for the simulation were simply those for straight running, not what would be expected on exit from the Tar Barrel bend, although the location on the port side of the channel is not impossible. In the early stages of the run, therefore, adjustments to the thrust vectors were made to find the correct balance while, at the same time, the ferry moved slowly across the channel. Thereafter, the ferry was kept to the starboard side of the channel with no drift while maintaining about 6 knots through the water.

Although this run shows that the thrusters on the W-class could, in principle, be used to counter drift under the stated conditions while on the "operational"/"idle" setting, it should be mentioned that the consequence of this is an increase in the power used and the fact that the thrusts from both thrusters are vectored to one side. Estimates suggest that the forward thruster used 3.2 and the aft thruster 4.5 times more power than that required to move at 6 knots through the water in benign conditions, with the engine of the forward thruster near its rated value. The increase in power stems from the need to increase the thruster blade angle, which increases the torque needed to turn the thruster which in turn increases the power needed from the engine, even though the thruster revolutions remain constant at the "operational"/"idle" setting.

6.1.6 Emergency Stopping

Emergency stopping trials were carried out with both C- and W-class vessels.

C-class Vessels

Two trials were carried out with the C-class vessel Caedmon and the results are given in Table 3. For both trials the tide heights were about 2.65m and the wind speed about 10 knots.

Parameter	Trial 1	Trial 2
Initial overground speed (kts)	4	6
Time to stop (secs)	22.6	40.5
Distance to stop (m)	23.3	62.5
Distance/length	0.42	1.14

Table 3

W-class Vessels

Three stopping trials were carried out with the W-class vessels. The results are summarised in Table 4. Wind speeds were less than 5 knots for all runs.

Parameter	Trial 1	Trial 2	Trial 3
Initial overground speed (kts)	5.5	5.9	7
Time to stop (secs)	25.0	40.0	38.0
Distance to stop (m)	39.3	64.0	75.9
Distance/length	0.64	1.05	1.24
Tide height (m)	0.59	1.99	2.92

Table 4

Comparisons are shown in Figure 46.

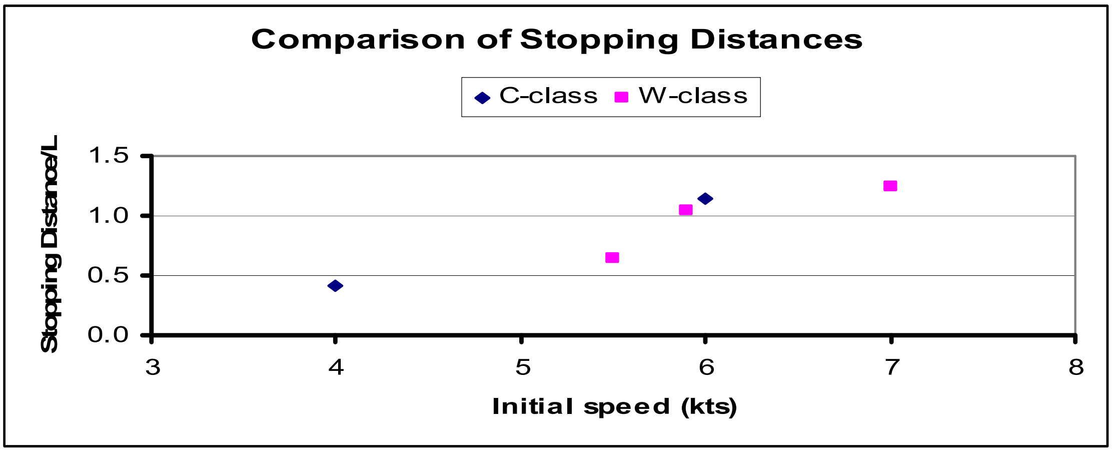


Figure 46: Measured Stopping Distance Comparison

It is seen that the W-class had similar, or slightly better, results than the C-class, although the low value for an initial speed of 5.5 knots is probably due to the low water depth of the trial. However, it is clear that in all conditions both vessels were able to stop in 1.25 times their own length or less.

In relation to these trials, the times to stop the thrusters themselves were checked. An "Emergency Engine Stop" stops the whole drive train and took 1 minute 15 seconds on a trial; the time taken for a thruster to stop rotating after de-clutching its engine varied between 45 and 57 seconds, depending on whether it was set to "operational", "intermediate" or "idle". In an emergency with a person in the water, the engine of the thruster nearest the casualty should be de-clutched to stop its rotation. When it is clearly safe to do so, the thruster can be then re-clutched in and the ship manoeuvred as necessary.

Visibility from the bridge of the W-class is relevant to emergency stopping and the ease with which those in command of the ferry can see an emergency situation developing. Overall visibility from the bridge is good from all positions and there are deep set windows at the bridge wings; however, the sun deck creates a blind spot over a horizontal arc of about 48° from the central conning position and completely hides the ramp in its stowed position. The view from the bridge is further enhanced (and some of the blind spots partially illuminated) by the deployment of CCTV cameras on external areas, such as the foremasts (whose cameras point to the ramp) and the extremes of the bridge wings, all of which can be monitored on the bridge. Nevertheless, in confined waters such as the Lymington River and berthing at Yarmouth, especially when steering/conning is taking place from the bridge wing position, it is important that an additional crew member is stationed on the other bridge wing to monitor developing situations, especially if they involve people in the water. In normal operations such a lookout can also call out distances from other craft, both underway and moored, and fixed objects, because these are not in sight of the helmsman. It should be pointed out that this is not something new to the W-class as it is already the practice on the C-class with their central steering/conning position.

The depth of the blind spot directly ahead was checked by measurement for the W-class and is 18.6 metres observed from the central conning position and 17.4 metres from the bridge wings. For the C-class it is 15.1 metres from the conning position. (In this regard, attention is drawn to the erroneous values of 34 and 22 metres given in Section 7.3.8 of Reference 1; these should be ignored.)

6.1.7 Passing

Both C-class/W-class and W-class/W-class passings occurred in the Short Reach Lay-by area, the former being far more numerous than the latter during the trials. Transit Marks are set up for passing and they are so aligned that, when two C-class vessels pass, a clear water distance of about 15 metres (50 feet) at water level separates the hulls. As the W-class has a similar overall beam to that of the C-class, the overall water space available to other vessels in the vicinity of a passing manoeuvre will be similar to the present situation. Historic trends in the incident records show that navigation in the Short Reach Lay-by does not give rise to many incidents, suggesting that water space in this region is adequate at most states of the tide.

It is of value, however, to see how the ferries actually appear to pass in the Short Reach Lay-by area. Accordingly, a further exploration was carried out.

The situation is illustrated in Figure 47 which shows a cross-section of the river (with a distorted vertical scale) looking north and taken from a bathymetry survey made in June 2008 (Reference 3).

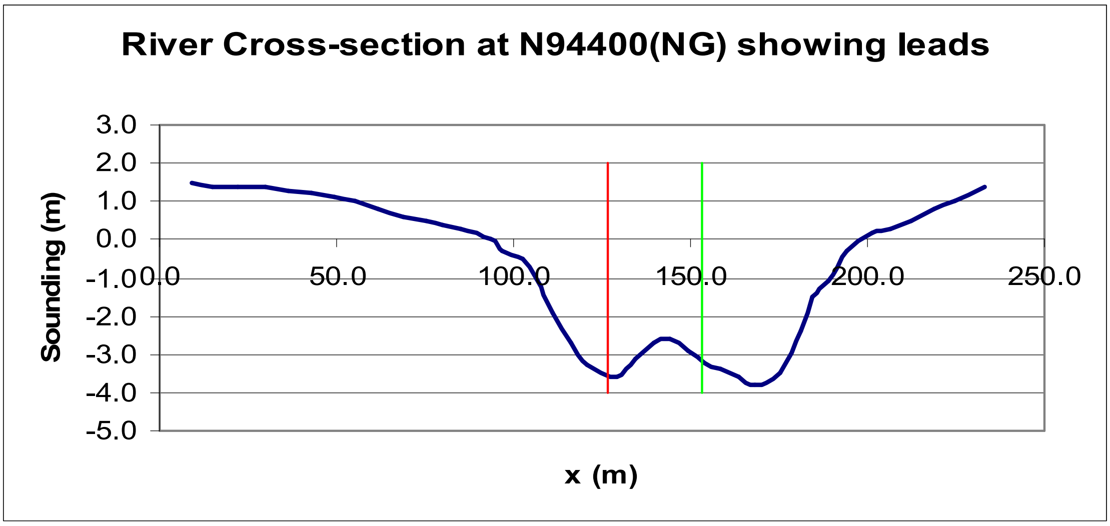


Figure 47: River Cross Section in Layby Area showing Leading Lines.

Also shown on Figure 47 are the inbound (green) and outbound (red) leading lines at the cross-section. The following comments may be made:

- The west bank above chart datum is slightly less steep than its eastern counterpart
- The passing manoeuvres of the C-class ferries have led to two channels, as mentioned in Reference 1.
- The outbound lead follows the deepest part of the outbound "channel"
- The deepest part of the inbound "channel" is displaced from the inbound lead, suggesting that, at the river cross-section location, the inbound passage is regularly made outside the leads or possibly that the aft thruster, located on the starboard side of the C-class vessels, has tended to bias the location of the eastern "channel" outside the leads.
- The inbound lead, possibly as a consequence of this, does not follow the line of the channel so, as shown in the track plots, the ships can only be on the leading lines for comparatively short periods while they occupy the Short Reach Lay-by section of the river.

However, observations of actual runs suggested strongly that passing outside the leads occurred and this was noted in many of the C-class/W-class passing trials. Nevertheless, no hydrodynamic interaction effects were noted on either of the ships in any of the passes. A similar comment applies to the first W-class/W-class passing trials when neither ship seemed to be on the leads. Again, no significant interaction was experienced and the passing manoeuvres were accomplished quite safely.

However, passing outside the leads limits the amount of room available for small craft, especially at low water springs. Passing on the leads would free more water space on the eastern side of the Short Reach Lay-by as indicated in Figure 48 which shows the amount of water space occupied by two W-class vessels, both loaded to 2.3 metre draught, passing on the leads at MLWS, taken as 0.7m from chart BA2021.

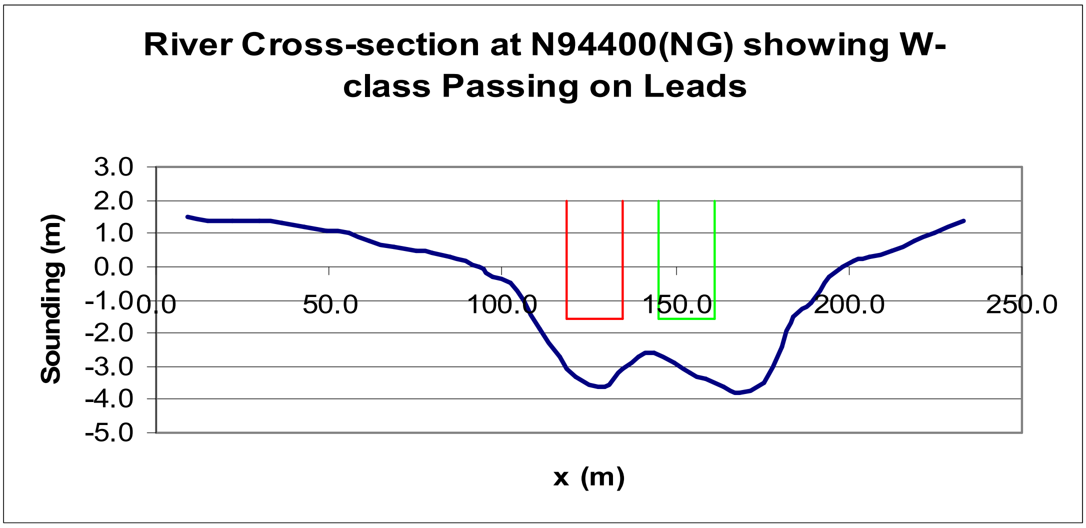


Figure 48: River Cross Section in Layby Area with W-class Passing on Leads at MLWS

It is seen that about 23 metres space is available for a small craft with a draught of 2 metres between the ferry and the eastern bank at MLWS; for a craft of 1 metre draught, the available width increases to 33 metres. For a one metre tide height these change to 28 metres and 40 metres. On the west bank there is less room and at MLWS the space available for the 2 metre draught is about 11.5 metres, and about 21.5 metres for the 1 metre draught; for a one metre tide, these figures change to 12 metres and 25 metres respectively.

While such a passing manoeuvre provides more water space for small craft, the greater waterline beam of the W-class, combined with the lateral separation specified for the C-class, led to concerns that hydrodynamic interaction might become more apparent if W-class vessels were to pass on the leads. Accordingly, a second passing trial was undertaken in which the masters were encouraged to stay on the leads for every passing manoeuvre.

It did not prove possible to achieve a passing at high water with both vessels on the speed limit of 6 knots, the speed of one or the other being lower than this due to the practicalities of achieving the correct timing for passing manoeuvres through speed adjustment. However, most of the passes were on, or nearly on, the leads, and only one incident which could be ascribed to interaction was experienced. This occurred late in the ebb and caused the outbound vessel to sheer briefly on the approach to the Tar Barrel bend, a sheer that was easily controlled and the bend was navigated successfully. At low water, passes were carried out at speeds appropriate to such a tidal state of about 4 knots and no interaction was experienced.

From this it was apparent that W-class/W-class passing on the Transit Marks was not only possible but also desirable because of the extra water space freed by the manoeuvre.

The W/W passing trials were carried out in wind ranging from light and variable to strong. All were completed successfully and safely with no evidence of significant interaction effects while the ships were on the Transit Marks. It became clear that the safe operating wind profile introduced above was as appropriate for passing as for general navigation in the river.

6.1.8 Overall Impressions on Ferry Behaviour

Subjective impressions of the handling of the W-class vessels were obtained from a number of sources. The BMT master mariners provided an independent view from their observations on the bridge and on the water, while the Wightlink masters provided another view derived from their experience of handling the vessels themselves in the river. Both are now considered.

Impressions of BMT Mariners

Observations confirmed that the W-Class ferries (Wight Light and Wight Sky) handled extremely well. The training Captain and the masters under training all reported that they were satisfied with the handling characteristics of the craft and BMT's own extensive observations confirmed the ferries' handling capabilities.

A number of emergency stops were observed by BMT, some induced by the actions of other river users and others as controlled exercises. The ships were able to stop from 6 knots in little over a ship's length; a satisfactory outcome. Indeed the masters reported improved visibility and were confident they could deal at least as well as with the C-Class with any emergency situation thus far experienced.

Both BMT mariners were impressed with the professionalism of the Wightlink staff involved with the steering/conning of the vessel. Many of the crews had been employed on the Lymington/Yarmouth run for many years and, while a number did show certain scepticism about the conning positions on the W Class, they very soon adapted to the new layout. During the training there was no hesitation by any of the bridge team, no matter what rank, to give their views and discuss amongst themselves the handling characteristics of the vessel.

A number of members of the bridge teams expressed concern about the actual position of the controls for the Voith units at the bridge wings. On the Wight Light, the unit housing the controls is set inboard from the extreme end of the bridge wings by about one metre and the Voith controls themselves were a further 0.5 metres inboard. Only if the helmsman has exceptionally long arms is he/she able to keep their hands on the controls and also stand at the extreme of the bridge wing to get the best view of the side of the vessel through the deep windows referred to above. This problem has been brought to the attention of the technical management at Wight Link and it is understood that consideration is being given to make a modification to the unit bringing it nearer to the extreme of the bridge wing. It is recommended that this be done for all vessels of the W-class.

Some concern was also expressed that the emergency escape windows (which are sited one window frame in from the extreme end of the bridge wing on the starboard side aft and the port side forward) restrict the view somewhat due to the heavy hinge bar across the width of the window.

Finally, as a result of a large number of observations of the operations of both C- and W-classes, it was concluded that there was nothing which gave rise to alarm regarding the safe operation of either class. Both classes handled well and were able to cope with developing emergency situations, usually brought about by the conduct of other river users. The W-class ferries have 100% redundancy in their propulsion machinery and are able to bring the extra capability to bear immediately, whereas the C-class have no such ability. Clearly this means that, from the operational point of view, the W-class ferries are considerably safer in this regard.

However, as discussed elsewhere in this report, the available power, if used excessively in the river, produces effects which, without suitable control measures in place, are intolerable.

Impressions of Wightlink Crew

As indicated above, most of the Wightlink crew who conned the W-class soon gained familiarity with the sensitivity of the controls and were able to handle the ships well. Some were unhappy about using the "idle" setting on the aft thruster, believing it was not a true engine setting. However, as Voith themselves pointed out, it is a perfectly valid setting and running the thrusters at lower rotational speeds leads to an increase in their hydrodynamic efficiency.

There were various preferences to the conning positions by the staff, some preferring to con from the bridge wings for much of the river transit, while others preferred the centre con location throughout. (Berthings at both Yarmouth and Lymington were generally controlled from the bridge wing). A by-product of this was that conning from the centre position tended to set the ferry in the middle of the river for much of the transit, while conning from the bridge wings tended to set the ship close to the edge of the navigable space, giving rise to some concern expressed by owners of boats moored alongside this space. This is discussed further in Section 6.4 below.

The greater control of the W-class was frequently commented upon and several times it was noted that certain manoeuvres "would not have been possible with a C-class". These particularly related to low speed manoeuvres in shallow water and in winds and stemmed to a certain extent from the more precise control of the W-class and the location of the thrusters on the centreline. The offset thruster locations on the C-class did not give balanced thrust slipstreams fore and aft in certain manoeuvres which was not helpful to the shiphandler. This is also discussed in Section 6.10 below.

However, those staff who had spent most of their professional life on the C-class vessels noted the inability of the W-class thrust vector controls to "gang together". This has been discussed in Section 6.1.2 where the advantages of this option are discussed.

Some staff simply used the aft thruster as a "rudder" while others attempted to gang the thrust vectors manually. The inability to have an optional "gang" setting was seen by some as an oversight in an otherwise well-provided ship control system. In the longer term it would be beneficial to explore the possibility of including this capability.

Summary

This section has laid foundations for the rest of the study by presenting measurements of ship tracks and speeds obtained during the trials. It has looked at the way the W- and C-class vessels are handled in the river and has shown how the W-class behaves in the wind prevailing in the area. This has been supplemented by a brief simulation study focussing on those wind directions not met in the trials and it was concluded that strong winds from the south and east might pose handling challenges at certain points of the river transit; the handling advantages of increased ship speed in Long Reach in strong cross tide with an easterly wind have also been discussed using examples from the simulation model.

Operational wind limits have been proposed as a result of the trials; in the view of BMT they reduce any handling risk to a tolerable level. Accordingly an interim wind speed limit of 20 knots, gusting 25, as measured at the RLymYC Starting Platform, is proposed for the "idle" aft thruster setting, to be increased to 25 knots, gusting 30 when sufficient helmsmen have experience of operating the vessel in wind. Use of the "intermediate" settings on the aft thruster in higher winds will recommended once the appropriate trials have been run.

Of some importance was the discussion of the way the W-class handled when run with the aft thruster on speed settings other than "operational", as this relates directly to use of alternative setting to reduce thruster slipstream effects at the stern; it was concluded that handling was satisfactory within the proposed wind limits with the settings used in the trials. Stop-and-hold manoeuvres have been discussed and it has been shown how the waiting vessels drift off-station during a lengthy wait, an inconvenient effect experienced by small boat users following astern of inbound ferries.

Stopping distances of both the W- and C-class ferries have been shown to be similar, giving confidence in the larger vessel's ability to stop in an emergency and it was concluded that risks associated with the stopping manoeuvre are lower than those with the C-class (due to better control). As any risks associated with C-class stopping have been tolerated on the river for a large number of years, those associated with the W-class are therefore, in BMT's view, tolerable.

Passing on the Transit Marks is desirable and was shown in Section 6.1.6 unlikely to have been the norm for inbound vessels. Using the leading lines inbound and outbound is recommended because of the additional water space it provides for small craft in low water conditions. The safe operating profile for wind was deemed to be as appropriate for passing as for general navigation on the river.

The Section closed with some impressions of ferry behaviour on the river.

From a handling perspective, it is the BMT view that, provided suitable risk control measures are applied (see also Section 7.2) risks associated with handling will be the similar to or lower than those with the C-class.

6.2 Wash and Drawdown

6.2.1 Wash

Wash proved to have a major impact on the trials. There were three components of wash of interest from the outset:

- The free wave system from the hull
- The additional disturbance to other users from thruster action and the interaction of the thruster slipstream with the hull
- Drawdown

Drawdown is discussed separately in Section 6.2.2, so attention here focuses on the other two components of concern.

Regarding the hull free wave system, observations on the river indicated that this was very small at the speeds of 4 and 6 knots used in the river. In the Solent when speeds up to about 14 knots were demonstrated, the free wave system is large as indicated in Figure 49.

Figure 49: Stern quarter Wave at Speed in Solent

In passing, it may be mentioned that there was no tendency of the thrusters to suck the camera boat toward the hull (a concern of some users) when the photograph in Figure 49 was taken.

In the river the main concern was with the effect of the thrusters. It has been made clear above that the thrusters themselves, located near the ends of the hull, produced significant slipstreams when on the "operational" settings. These produced their own circular wave system, coupled with a series of standing waves astern due to the high speed upper layer of flow issuing from the stern. The standing waves can be seen in Figure 50.

An additional problem arose in that the fast response of the thrusters to control actions from the bridge meant that, in the early trials when helmsmen were learning and tending to over-control, slipstreams would move rapidly from side to side at the stern, especially in the approaches to, or exit from, a bend.

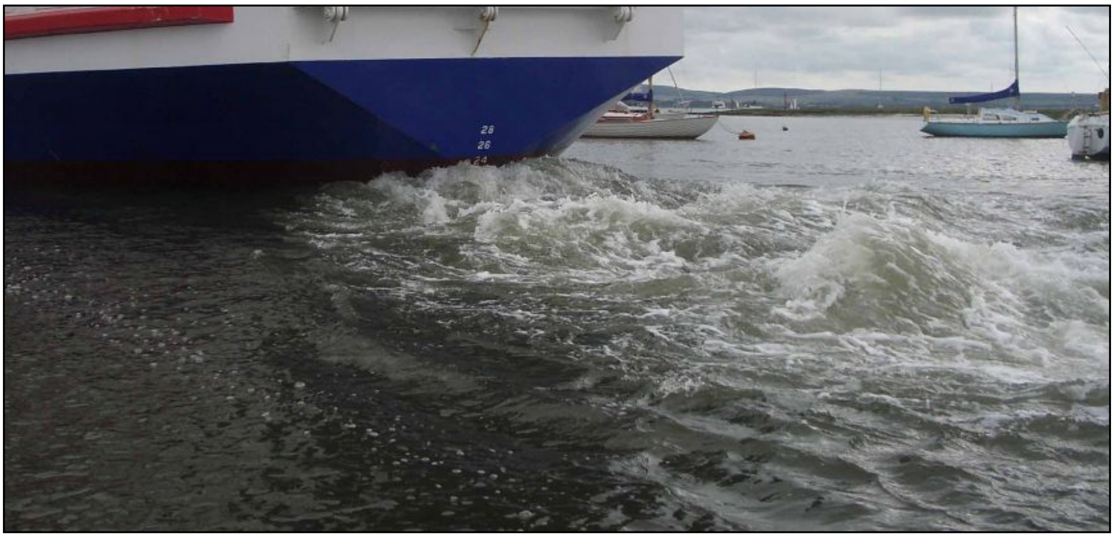


Figure 50: Standing Waves in Wake

It soon became clear that the thruster-induced wash at the stern was intolerable for the safety of other river users. Accordingly a means of reducing the effects of the aft thruster was sought and a solution found when it was realised that it was possible to operate and steer with the thruster rotation set to the so-called "idle" setting, as mentioned in Section 5.4.5. In the "operational" mode the thruster casing rotates at about 100 rpm while at the "idle" setting, it rotates at about 50. The thrusters are more hydrodynamically efficient at this setting, but the available thrust range is limited. As described above, an "intermediate" setting was also used for more severe weather conditions and at this setting the thruster casing rotates at about 75 rpm.

The vessels had been manoeuvred under the "idle" setting while at the builders and it was decided to see if they could be controlled adequately on the river with this setting. As mentioned in Section 5.4.5, an initial run with both thrusters set to "idle" was not successful; speed was limited to just over 4 knots and control in the benign conditions of the trial was felt to be marginal. When the forward thruster was run at the "operational" setting and the aft on "idle" it became clear that a noticeable improvement had been made. It was possible to achieve speeds up to 8 knots through the water, control was satisfactory in the benign conditions prevailing in the trial and wash was considerably reduced.

The effect on handling in various conditions of the "operational"/"idle" combination has been discussed above and it was concluded that adequate and safe control was possible in wind speeds up to 25 knots, gusting 30 to 40, in Long Reach. In regular service there will be times when winds will be greater than this so a thruster setting for the higher wind speeds was sought. In due course a third setting was provided with the thruster rotating at about 70 rpm. This "intermediate" setting gave more control, at the expense of wash that was intermediate between that from the "idle" and "operational" settings. Examples are shown in Figures 51, 52 and 53 with wash measurements in Figures 54, 55 and 56.

Figure 51: Wash with "operational" Settings on both Thrusters. Speed overground 5.6 kts

Figure 52: Wash with "operational" forward/"intermediate" aft Settings. Speed overground 5.3 kts.

It is clear that the wash is considerably reduced with the "idle" and "intermediate settings on the aft thruster; the standing waves are eliminated with the "idle" setting, although there was more evidence of waves with the "intermediate" setting. The structure of the wake, especially when the ship was turning, was also of interest. As can be seen in Figures 51 to 53, the centre of the wake was characterised by eddies upwelling from the slipstream of the forward thruster, modified by passage under the hull and combined with the wake of the hull and that of the aft thruster. This upwelling had most energy with the "operational"/"operational" combination and least with the "operational"/"idle" combination. It was possible to manoeuvre small craft through it without too much effect with the "operational"/"idle" settings and more effect with the "operational"/"intermediate" combination.

Figure 53: Wash with "operational" forward/"idle" aft Settings. Speed overground 5.4 kts.

However, the edge of the wake was characterised by areas of concentrated vorticity (especially when the ship was turning) which can affect small craft. If the keel, centreboard and/or rudder were in some of the stronger eddies, the boat was moved off course, combined with a rotation. This effect was most noticeable in the region from the transom to about a ship's length astern; it was more pronounced with the "operational"/"intermediate" combination than the "operational"/"idle" and most apparent with the "operational"/"operational" combination. Clearly it is an area of the wake best avoided by small craft.

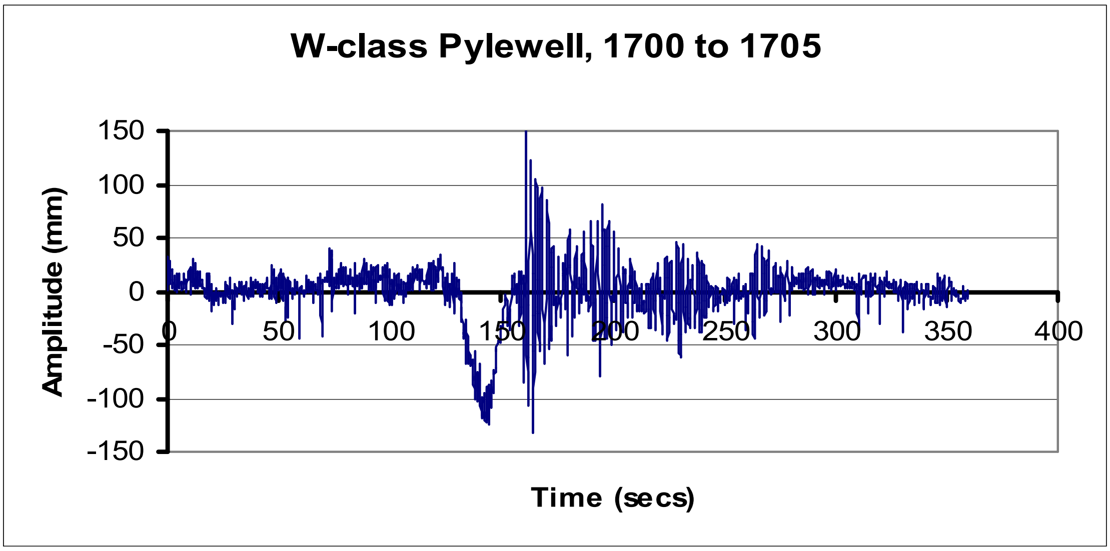


Figure 54: Measured Wash. "operational"/"operational" settings. Speed overground 4.9 kts, mid ebb.

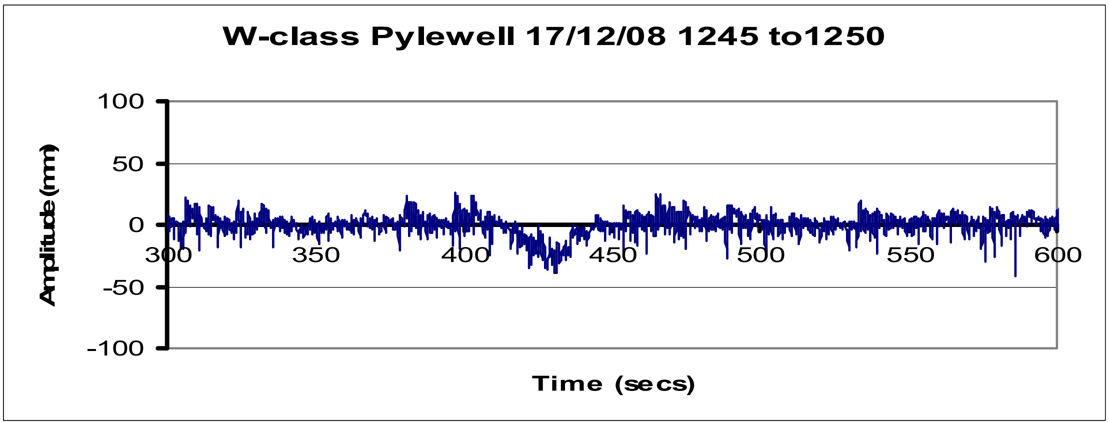


Figure 55: Measured Wash. "Operational"/"intermediate" settings. Speed overground 4.9 kts, inbound, high water.

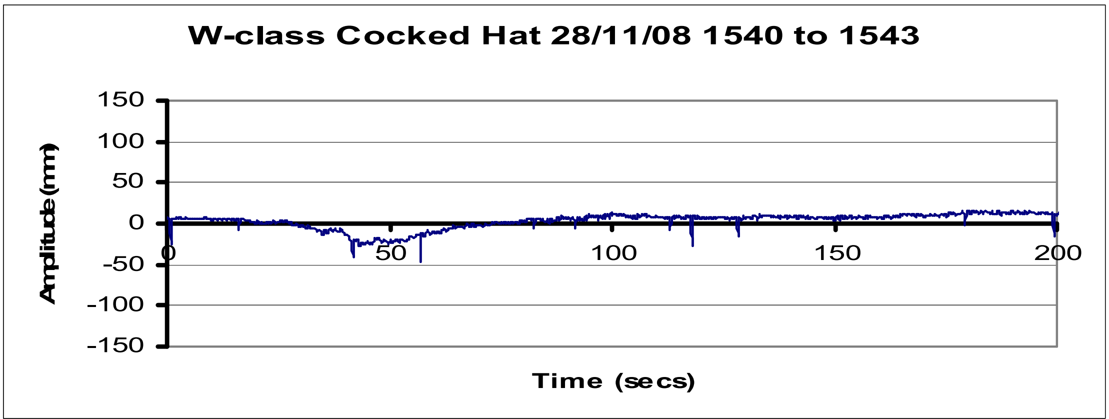


Figure 56: Measured Wash. "Operational"/"idle" settings. Speed overground 3.8 kts, mid ebb.

Turning to the wash disturbance, measurements of wash obtained with the three settings for the aft thruster (Figures 54 to 56) are compared with measured wash from a C-class vessel, a catamaran fishing boat, a small ferry and a RIB in Figures 57 to 59. Finally, Figure 60 shows examples of the ambient waves on a windy day.

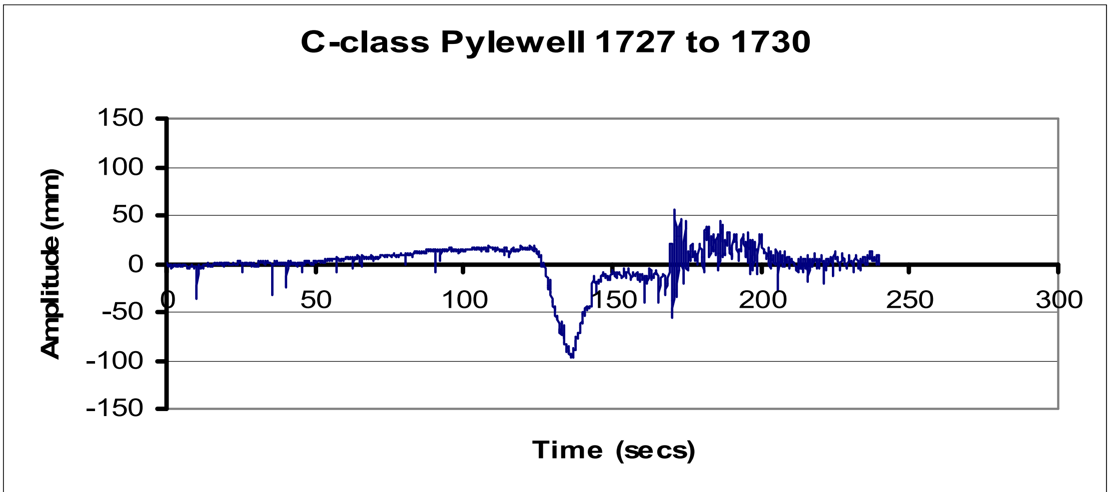


Figure 57: Measured Wash. C-class ferry overground 5.8 kts, mid ebb.

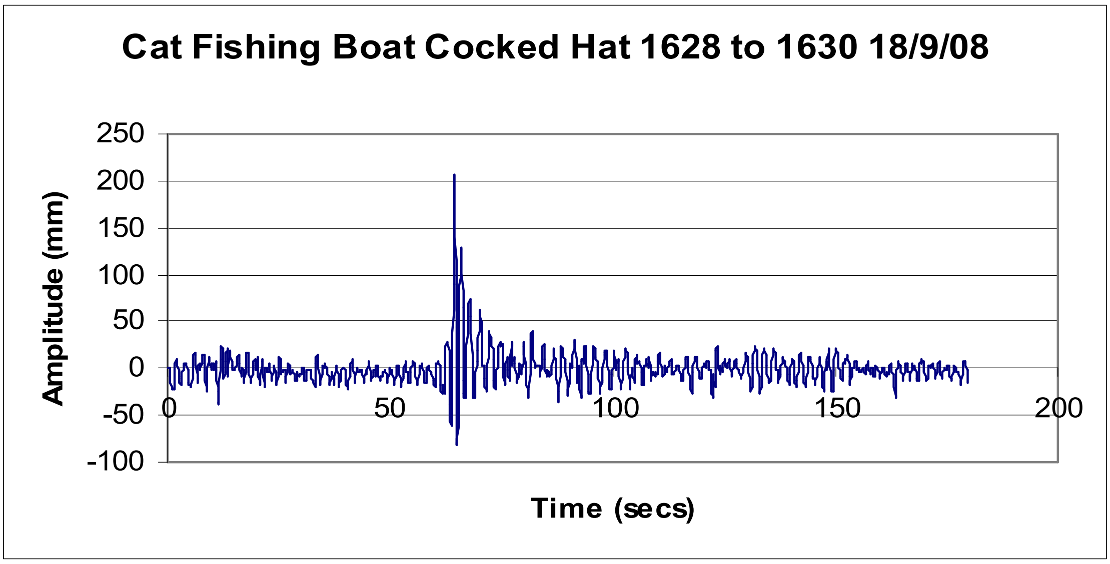


Figure 58: Measured Wash. Catamaran Fishing Boat, mid ebb. Speed unknown

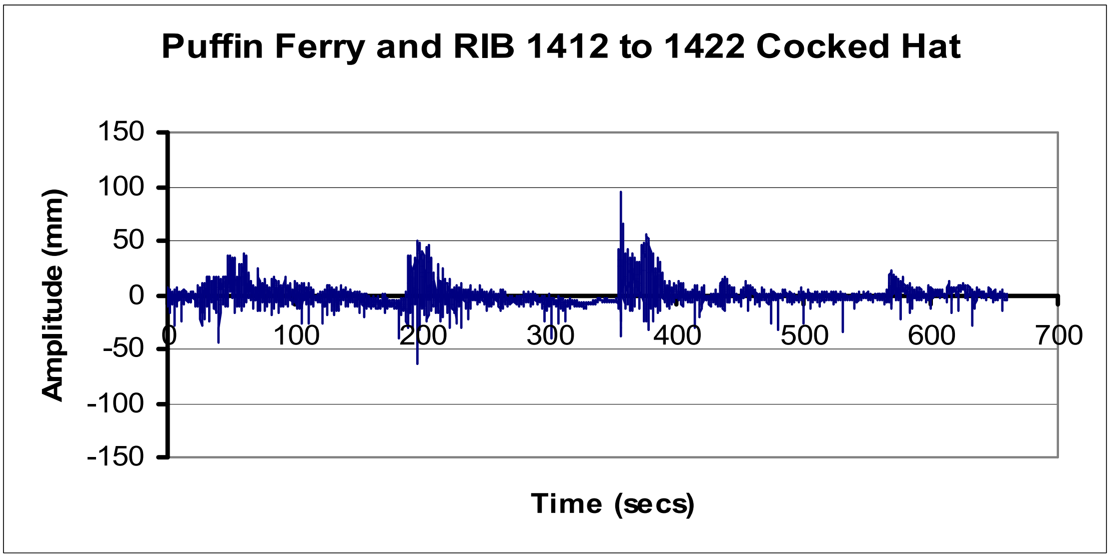
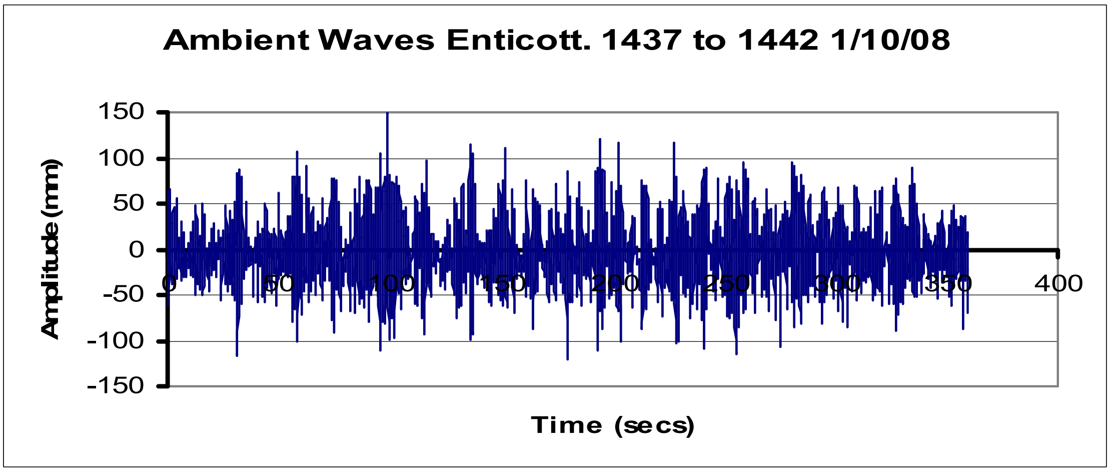


Figure 59: Measured Wash. Small Ferry and RIB. Speeds unknown, high water.



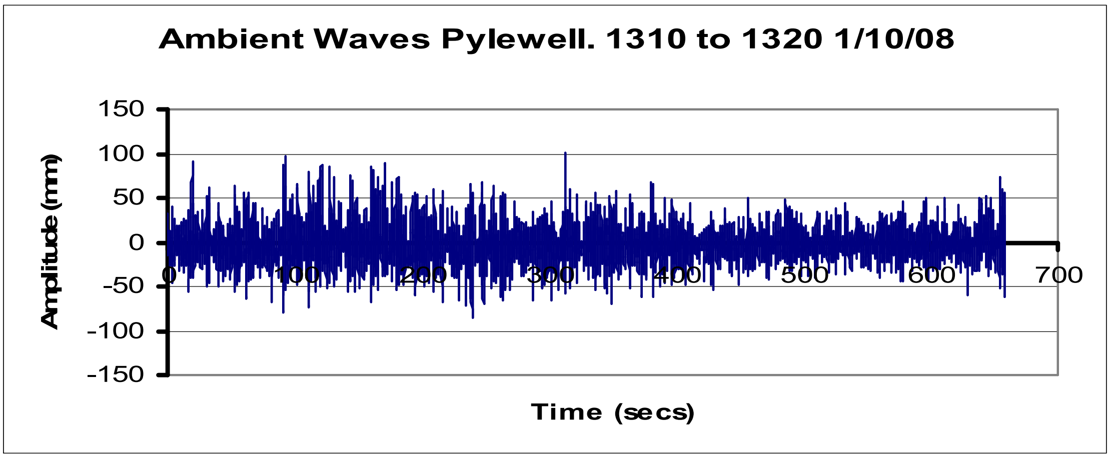


Figure 60: Measured Ambient Wave Amplitudes.

From these plots it is seen that the wash from the W-class when operated in the "operational"/"idle" mode is comparable to, or better than, that from C-class ferries and other boats on the river. It is also less than the ambient waves in the river on a moderately windy day. Wash from the "operational"/"intermediate" mode is similar, but the wash from a W-class vessel operating in "operational"/"operational" mode is noticeably higher and intolerable.

Further wash measurements are shown in Appendix 5 where it is shown that Horn Reach may experience long-period, low amplitude motions of about 100 second period and 20mm amplitude resulting from W-class ferry movements at low water springs. Both C- and W-class ferries showed a "swell up" extending well ahead of them at low water springs in Short Reach, Short Reach Lay-by and Horn Reach.

By way of a post-script, it may be mentioned that wash in the Solent, when the W-class vessels are able to reach speeds of about 14 knots, is quite severe. Should the W-class vessels move at such speeds between Yarmouth and the mouth of the Lymington River, it would be prudent for all small craft to keep well clear. Furthermore, the BMT team witnessed departures from Yarmouth for which full engine power was used. Although it is recognised that this may have been acceptable for demonstration purposes, it is suggested that this practice should be abandoned as its effects on small craft nearby, not to mention the local seabed, could be severe.

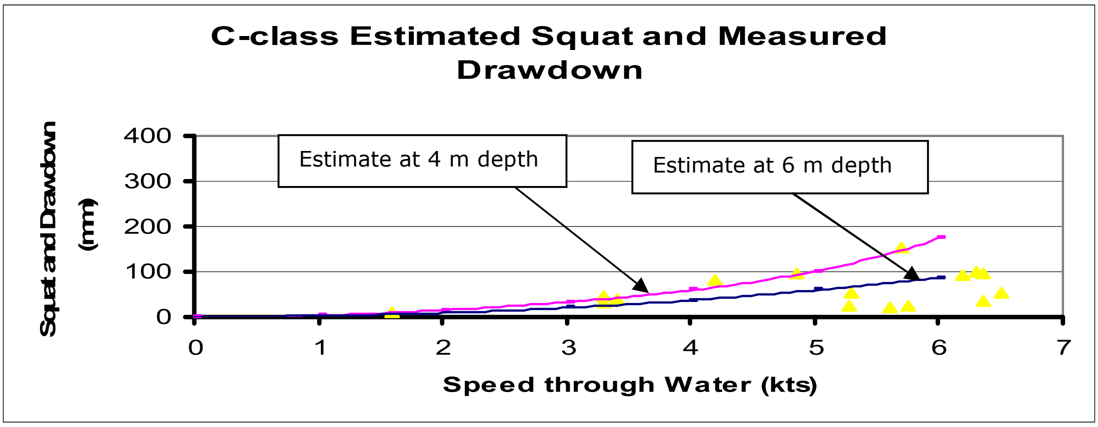
6.2.2 Drawdown

Drawdown measurements are discussed in detail in Appendix 7, but in this section they are considered in relation to safety only. Considerations of environmental matters are not considered in this report.

This section of the report therefore considers drawdown and its connection with squat and backflow; comparisons are also made between drawdown measurements made with C-class and W-class vessels.

Squat was estimated for Phase 1 of the study using the method of Reference 4, a method which has been shown to give reasonable estimates of the squat of ferry hull forms. (See Reference 5 for example). This was modelled with actual hull offsets, rather than global form coefficients to define the hull shape, the latter method which sometimes having to be used in the absence of details of the hull geometry. Hull offsets were used for both C- and W-class squat estimations, thereby ensuring that the shape of the hull was taken into account fully.

Drawdown values were measured over a range of water depths from 4 to 6 metres and speeds through the water from 3 to 6 knots. Drawdown and squat are closely linked; squat is in effect the sinkage caused by the drawdown. If the drawdown measurements are made reasonably close to the vessel, it may be assumed that, as the variation with distance off is quite small over short distances, drawdown is a good measure of squat. To check this for the W- and C-class ferries, Figure 61 shows drawdown values measured for the both classes as they passed close to the Pylewell Boom post inbound, and the Cocked Hat and Harpers South posts inbound and outbound. These measurements are compared with the squat estimated for 4 to 6 metre water depths for these vessels.



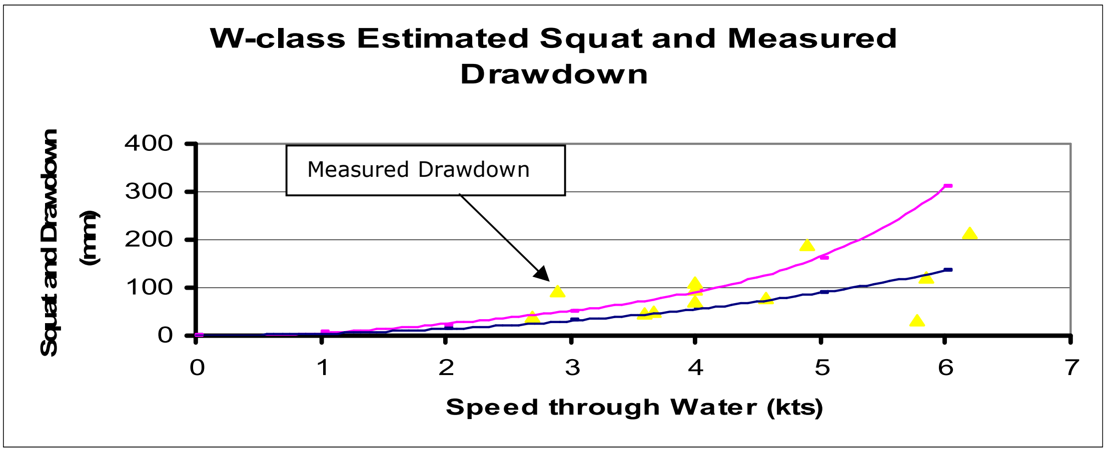


Figure 61: Comparison of Estimated Squat and Measured Drawdown.

The results in the Figure show good agreement between the measured drawdown and estimated squat for the W-class, but the C-class measurements show unusually low values at the higher speeds. The reason for this is not known, but there was rather more uncertainty about the timing and through-water speeds of the C-class transits compared to those of the W-class which, as discussed above, were tracked accurately using the ship's DGPS system.

Assuming that the results in Figure 61 indicate a reasonable correlation between squat and drawdown, it is seen that the mean sinkage of the W-class due to squat, while larger than that of the C-class is unlikely to exceed 400mm in the river and will generally be much less if the 4 to 5 knot through-water speed range, observed on trials in the river between Tar Barrel and the wave screen, applies to normal operations. In such cases, the squat is unlikely to exceed 200mm, so that the chances of a W-class vessel grounding through squat are negligible. This was demonstrated throughout the trials on the river.

Squat is a function primarily of hull shape with some additional effects from the propulsion units. An attempt has been made to allow for the latter in the estimates given above, estimates which may also be used to assess the amount of backflow (or return current) produced in the river as the ferry moves through the water. This is the result of the water accelerating past the ship as it moves through the constricted water space in the river and might be expected to increase at low tide when the amount of water is at a minimum. The squat program gives estimates of the backflow induced by a given hull form and this is plotted in Figure 62 for both classes of ferry at a water depth of 3.5 metres, representing a very low water on a spring tide. Note that the backflow should not be confused with the higher speed flow from the thruster slipstreams, discussed in Section 6.10.

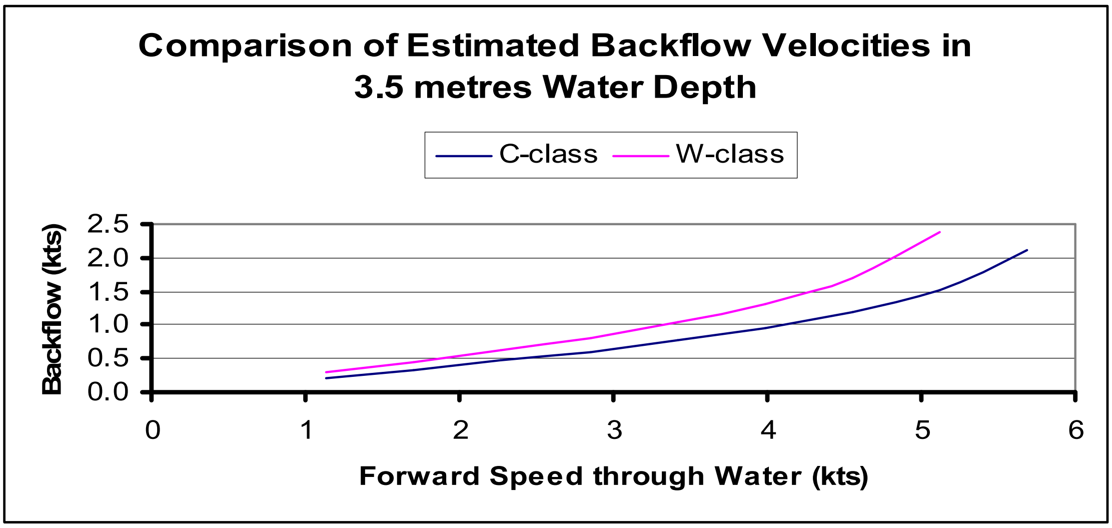


Figure 62: Comparison of Estimated Backflow Velocities induced in 3.5 metres water depth

The values given in this Figure probably represent the maximum attainable values and it should be noted that the ferries in such a low tidal state are likely to be moving at speeds no greater than about 4 knots through the water; indeed the W-class may go slower than the C-class in the same conditions due to increased resistance and the requirement to use less power on its thrusters.

Backflow rates, measured in the intertidal bank region close to the free surface, are presented in Appendix 7 for both C- and W-class vessels, but with water depths in the main channel somewhat greater than 3.5 metres. The maximum measured backflow velocities were about a knot, and of the same order as the natural tidal flow velocities.

From this it would seem that disturbance to small craft from backflow induced by the passage of the hull is likely to be low. Disturbance from the structure of the wake has already been discussed and that from the thruster slipstream from a waiting ferry is presented in Section 6.10. Both effects are far more likely to affect the vessels of leisure users on the river.

However, drawdown is also a measure of the hydrodynamic interaction induced on other craft by the ferries. On the river, this is most obvious by its effect on moored boats and this is discussed in Section 6.5.2.

Summary

This Section has discussed the wash of the W-class ferry and its drawdown. These form a direct comparison with measurements presented for the C-class in Reference 1.

Wash was of particular importance as it relates directly to effects associated with the slipstream from the aft thruster, effects that were originally intolerable, but rendered tolerable by adjusting the speed setting on the thruster. The reduction in wash was demonstrated from the measurements and it was shown to be as low as, if not lower than, that of the C-class.

The amplitudes of free waves from other commercial and leisure craft in the river were shown to be frequently in excess of those from the W-class, as were the ambient waves in the river on a windy day. Evidence for long-period, low amplitude, motions at low water in Horn Reach was also obtained when W-class ferries were on the move in that part of the river; this motion is not likely to pose any risk to users.

W-class drawdown was shown to be greater than that of the C-class in similar conditions, as might be expected from the greater volume of the underwater hull. It was shown to be compatible with squat estimated using BMT software and the same software was used to estimate backflow velocities in the vicinity of the hull. Squat was found to be tolerable from a safety perspective: it was low enough not to raise concerns about grounding and it was concluded that disturbance to small craft from backflow (and the associated interaction effects) is likely to be greater than that from the C-class, but tolerable provided suitable risk control measures are in place. (see Sections 6.5 and 7.2)

6.3 Wind Shadow Effects

Wind shadow effects were discussed in Reference 1 and were observed during the trials. For the special case of a W-class ferry waiting in the lay-by, part of one sailing trial was devoted to exploration of wind shadow, together with some brief visualisation experiments using a smoke machine. Wind measurements using anemometers on some of the navigation posts on the river gave an indication of the extent of the drop in wind speed due to the shadow effect, as well as showing how the effect was extended when two ferries passed in the Short Reach Lay-by area. These are now discussed.

6.3.1 Wind Shadow while the Ferry is Moving

It was expected that, as the windage of the W-class ferries is greater than that of the C-class, wind shadow effects should be more apparent. Measurements of the drop in wind speed as ferries passed are shown in Figure 63.

The mean wind speed at the time was of the order of 10 knots from 277^{o} and as the ferries passed each other it dropped to around 3 knots at the measurement location, some 2 metres above the water level or about the location of the centre of pressure of a small sailing dinghy. It took some 47 seconds from the start of the speed drop until 10 knots wind speed was resumed, due in part to the alignment of the vessels when passing tending to extend the shadow effect.

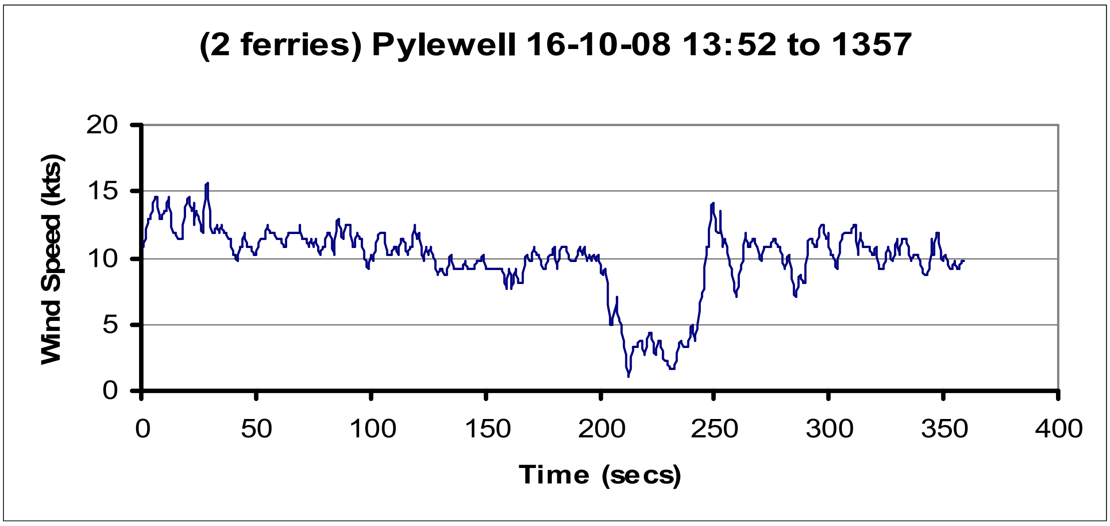
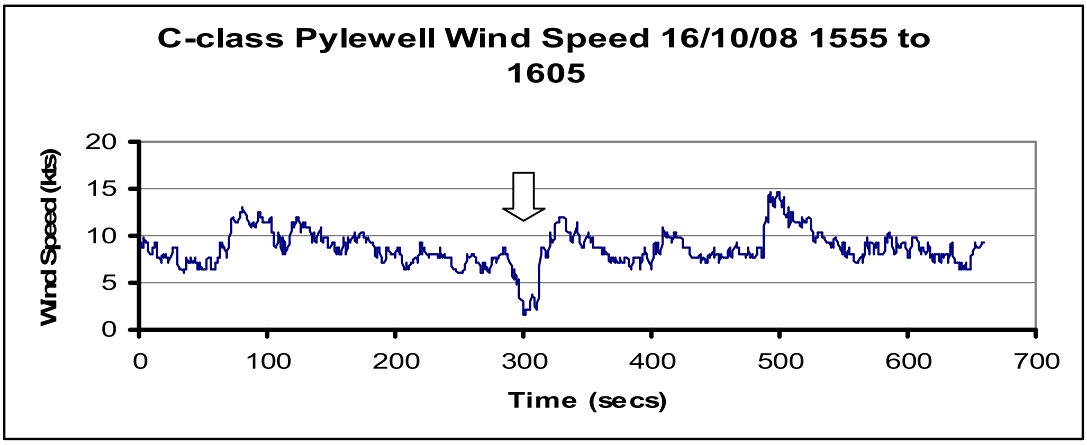


Figure 63: Drop in Wind speed as W-class passes C-class at Pylewell. (W-class overground speed 5.7 kts, tide height 3.23m)

Figure 64 shows the effect of wind speed and direction as one C-class vessel passed Pylewell at the end of the high water stand.



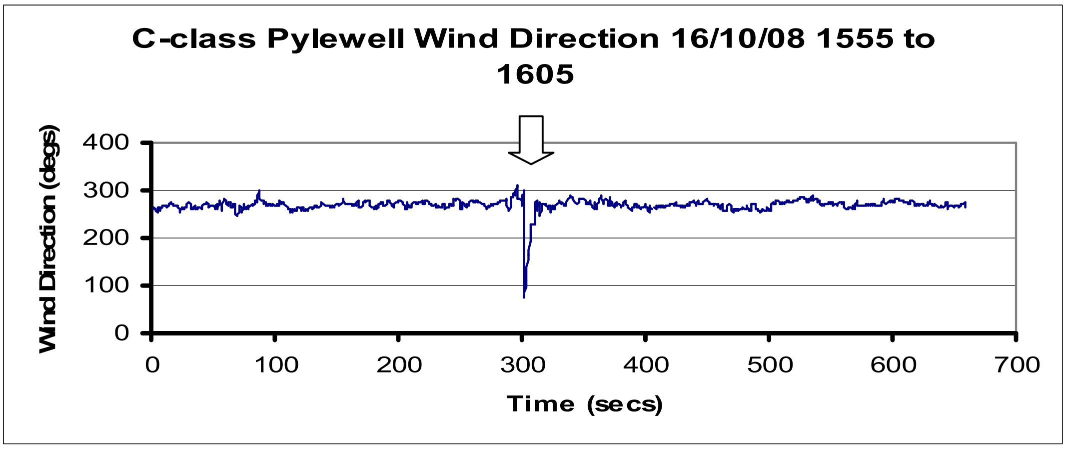


Figure 64: Change in Wind Speed and Direction as one C-class passed Pylewell. (Overground speed 5.2 kts, tide height 2.23m)

The drop in wind speed is about 6 knots and the change in wind direction around 200°. The duration of the effect was about 26 seconds for wind speed and about

20 seconds for wind direction; these times may be compared to the time of 21 seconds for the whole length of the vessel to pass the anemometer.

For comparison, results for one W-class vessel passing the same measurement location at low water are shown in Figure 65. The passing took place some 7.5 minutes after the start of the plot and it was about 40 seconds before the wind speed was restored to its original level. This may be compared with the 38 seconds for the whole length of the ferry to pass. In this run the measurement location was about 4.6 metres above the water, about the height of the centre of pressure of a medium sized sailing yacht, and, as shown in the Figure, the mean wind was from about 290°. The change in wind direction of about 100° to 150° is clear and the rapidity with which the change occurs may be noted. Other examples of measured wind shadow effects are shown in Appendix 5 where it is concluded that main difference between the measured W- and C-class wind shadows is one of the duration of the change in wind direction. The magnitudes of the measured speed losses and changes in wind direction are much the same for both classes.

Observations from the ferry bridge of the effects of wind shadow on sailing vessels, ranging in size from small scows to larger racing and cruising yachts, was that, while they were undoubtedly affected by the wind shadow from the W-class, in most cases they were able to deal with it satisfactorily, with the effect taking hold for about 5 to 15 seconds, depending on the relative velocity between the yacht and the ferry and the direction of the relative wind.

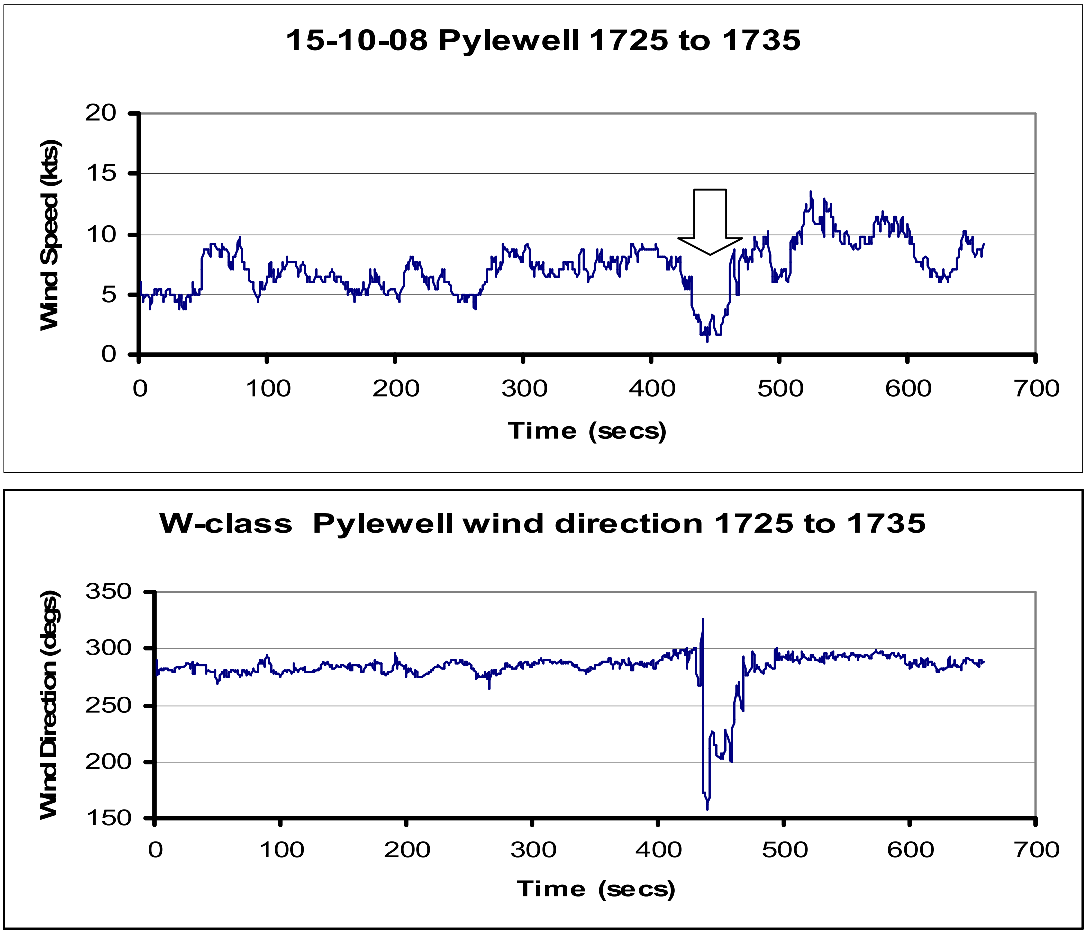


Figure 65: Change in Wind Speed and Direction as one W-class passes Pylewell. (Tide height 0.63m)

Feedback from the sailing trial was very useful as the sailors had taken a number of dinghies close to the ferry to experience the wind shadow on its windward and leeward sides. The impressions gained by those who took part in the trials may be summarised as follows:

- Sailors felt that the size and duration of the W-class wind shadow was noticeably greater than that of the C-class. To the leeward side of the ferry, it was also more turbulent, with significant eddies; significant wind turbulence was also experienced when sailing astern of the ferry.
- It was difficult to predict when and from what direction the wind would re-appear as a vessel sailed out of the wind shadow.
- When 15 to 20 metres from the ferry, all power was lost in the wind shadow, but when 3 metres (10 feet) away one sailor felt his boat being sucked toward the ferry. *(It is assumed that, on grounds of prudence and safety, sailing so close to a W-class ferry will not be common practice)* Another sailor stated that he lost all way when dead to windward about 50 metres off, due to "back eddy winds". When to leeward he could only keep way on when about 80 metres off.
- The wind shadow lasted about 1.5 times longer than that from the C-class.
- The ferry "seemed to quieten the wind all around it"

6.3.2 Wind Shadow while the Ferry is Waiting

Some valuable information was obtained about the structure of the W-class wind shadow when the vessel was asked to wait in a beam wind in the Short Reach Lay-by area. A smoke machine was used to visualise the wind and Figure 66 shows the results.

Figure 66: Flow Visualisation on W-class Sun Deck

In the left hand photo the smoke machine was placed at the deck edge on the windward side of the Sun Deck, away from the disturbance caused by the superstructure. It is seen that the flow is quite well defined and indicates wind that is passing over the deck at an upwards angle, above a probable separation "bubble" over the leeward part of the deck. This is in line with the visualisation shown in Figure 24 of Reference 1, repeated here as Figure 67 for convenience.

The upward flow from the sharp windward upper edge (the "deck" edge) is seen to be similar to that visualised on the W-class vessel and the separation bubble over the deck is clear in the Figure.

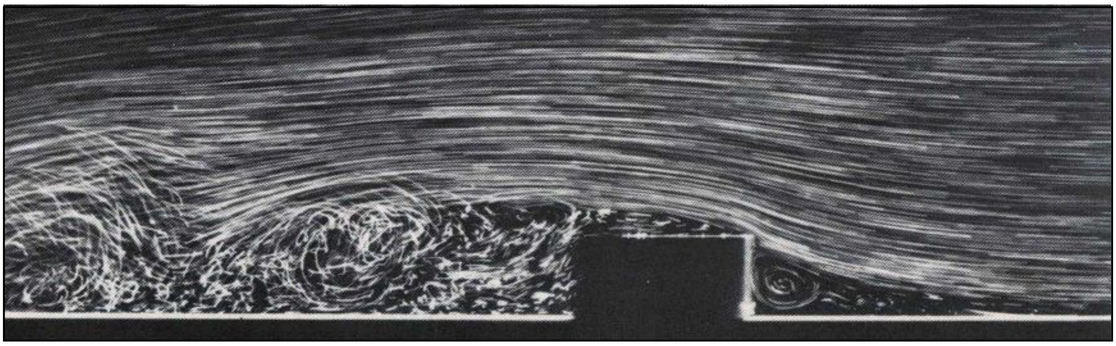


Figure 67: Flow Around a Bluff Body on a Surface. (from "An Album of Fluid Flow", The Parabolic Press, Stanford, California)

To leeward, the flow in Figure 67 is seen to be separated and eddying for some distance downstream, a situation mimicked in the right hand side photo in Figure 66. In this photo, the smoke machine had been moved to the leeward sun deck edge where the smoke immediately began to separate and disperse. Although the flow was very separated and unclear, it is just about possible to see a large eddy forming with its attendant "reverse" flow back toward the ship.

All this suggests that the flow over the upperworks of the W-class is probably similar to that shown in Figure 67 with a large area of disturbed flow to leeward and a rising flow to windward enclosing a separation bubble over the sun deck. It is very probable that the upwind eddy, clearly shown in Figure 67, also exists near the W-class vessel and one or two sailors noted that, if they got close to the windward side of the ferry, their sails went aback. According to one sailor, the wind shadow was "broadly what one would expect" although another felt it was more extensive than he had imagined it would be.

Finally, when two ferries pass in a strong beam wind, it is surmised that the wind shadow of one on the other may affect handling during the passing manoeuvre. This will be tested with two W-class ferries in a trial still to be undertaken when wind conditions are suitable.

Summary

Wind shadow effects were discussed in the light of experience and observations on the river and measurements of wind speed and direction as the ferries passed. The last of these showed that the duration of wind shadow was extended when two ferries passed and that the loss of wind speed was similar from the W-class compared to the C-class. Changes in wind direction were also not dissimilar.

Sailing trials addressed wind shadow and the general impression was that the duration of the effect is more evident with the W-class than the C-class. It was quite possible to lose wind from dinghy sails for a time, but observations showed that sailors generally were able to manage the effect, especially if the ferry was moving and the relative velocity high. The Wednesday Junior Sailors appeared to cope well with wind shadow in a special trial (see Section 5.4.3).

It is therefore the BMT conclusion that the duration and frequency of wind shadow effects will increase slightly, but that they can be dealt with adequately by sailing craft on the river.

6.4 River Space Availability with C- and W-Class

Ferries and leisure craft share the water space available. With the C-class operating in the river, although there were some problems, it was possible for the ferries and the leisure craft to occupy the available space in the river with a remarkably low incident rate (see Reference 1). It is therefore necessary to investigate to what extent this situation may change if W-class vessels are introduced on to the river, bearing in mind their overall beam is similar.

Some indication of the space available for small craft has been given in Section 6.1.6 with regard to the Short Reach Lay-by area, but it is necessary to explore the differences in the amount of space taken up elsewhere in the river by the two types of ferry.

This is done by recourse to the track data obtained with the W- and C-class together with impressions gained by the sailors in the sailing trials. It is unfortunate that the main trials had to take place when there was no significant leisure traffic in the river, and this is where the impressions of the experienced sailors who took part in the trials proved to be most valuable.

First, however, the amount of space taken up by the ferries themselves in normal operation is indicated by the use of composite plots of all measured ferry tracks. For the C-class, these are shown in Figure 68.

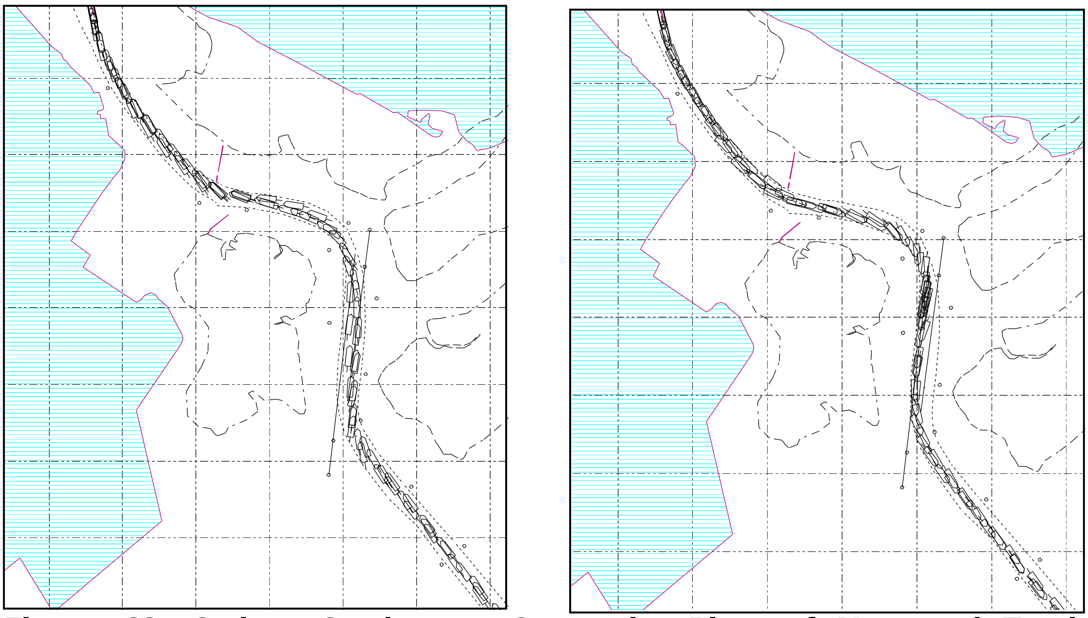


Figure 68: C-class Caedmon. Composite Plots of Measured Tracks; (Inbound on left, outbound on right)

For the W-class, the relevant results are shown in Figure 69. Although these give a visual impression of the amount of space occupied by the ferries in the river in normal transits, it is difficult to draw any sort of conclusions from them without finer detail. This is provided by the statistical information obtained from the gate counts, already introduced as a measure of shiphandling in Section 6.1.3, *Track Distributions*.

Using the track locations at the gates listed in that Section and in Appendix 6, it is possible to compute the mean location of all the tracks at a given gate as well as the standard deviation of their distribution at that gate. The mean value gives a measure of the location of the ship at a given point in the river, while the standard deviation gives a measure of the spread of the tracks at a given gate and, therefore, a picture of the amount of space used by the ferries. Comparing values for the C- and W-classes gives an idea of any differences with the two classes.

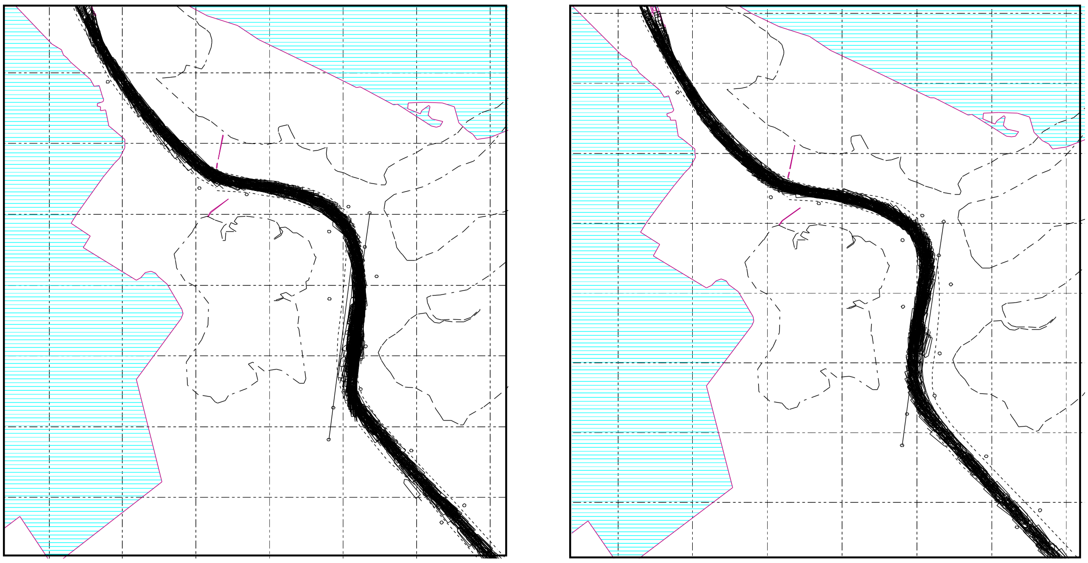


Figure 69: W-class. Composite Plots of Measured Tracks; (Inbound on left, outbound on right)

Before discussing these, the following should be borne in mind:

- Track locations are taken at the centreline of the vessel. Whereas there is little difference in the overall beams of the C- and W-classes, the waterline beams are significantly different. The effective amount of space taken up by each ferry at a given point will, for practical purposes, be the same in terms of local beam.
- Only a small number of tracks were obtained for the C-class, but observations made over a large number of transits on these vessels in a variety of conditions suggested that the measured tracks shown here are representative. This is not surprising because the most of the shiphandlers have been operating on the river for many years and tend to use the same transits and visual cues, whether on the C- or W-class vessels.
- Additional water space will be occupied in the bends as the ferry swings out in the turn. This effect will be increased with new helmsmen tending to over-control, as well as in deeper water (due to higher drift angles resulting from the physics of turning in deep, compared to shallow, water), a time when there is more water space available. The additional length of the W-class will add to this effect on the bends.
- No tracks were obtained for the C-class in strong winds.

Plots of mean values are given in Figure 70 and standard deviations in Figure 71 and the following observations may be made:

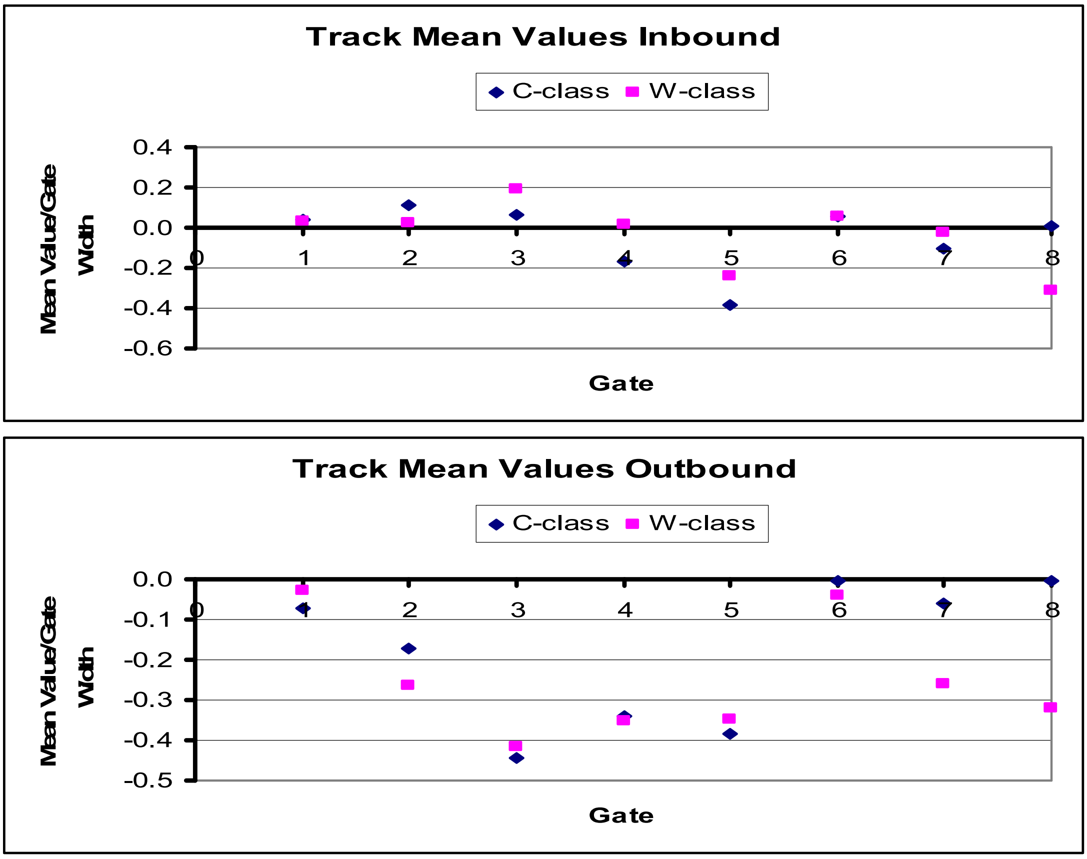


Figure 70: Track Mean Values at Gates

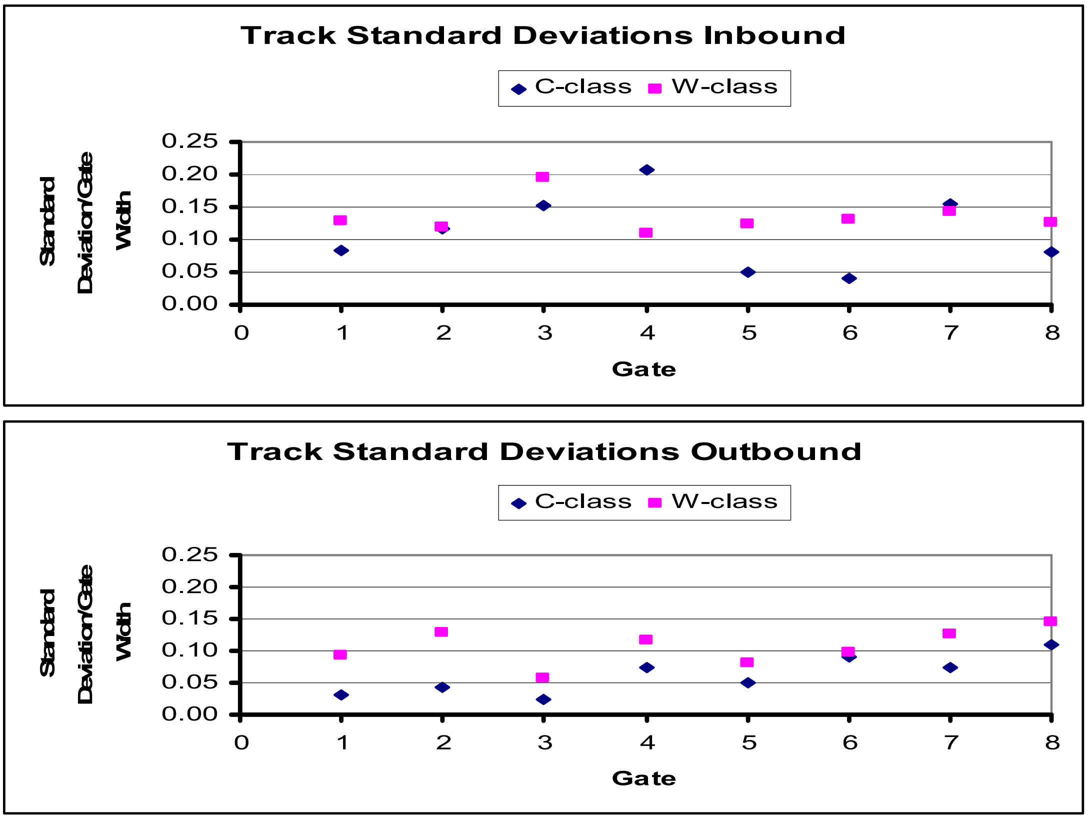


Figure 71: Track Standard Deviations at Gates

- Inbound the mean values suggest that the W-class kept slightly closer to the middle of the channel than the C-class for gates 1 to 7 (Post 7 to the Royal Lymington Yacht Club) with the divergence at gate 8 explained by the need for the W-class to pass the terminal en route for the Freshwater or North End Jetties. An exception is at Pylewell where the W-class kept more to the east than the C-class, thereby reducing the space available for small craft to the east at low states of the tide.
- Outbound there is little to choose in positioning (mean values) between the C- and W-classes from Pylewell to the wave screen, but the W-class tended to keep more to the west at the Tar Barrel turn. Again the discrepancy noted above appears at gate 8, but the W-class vessel is also positioned very much more to the west at gate 7 off the RLymYC for the reasons mentioned above.
- The main difference between the two vessels lies in the spread of the tracks, as indicated by the standard deviations. In general the spread is greater for the W-class than the C-class, suggesting that it used more of the available width than the smaller vessel in the trials.

From this it may be concluded that the W-class ferry took up more space in the river than the C-class, not only due to its increased size, but also because of the way it was handled during the measurement trials.

Feedback from the sailing trials was also of value to this discussion, the impressions of the sailors being summarised as:

- The W-class tended to keep closer to the starboard side of the channel than the C-class. This is probably related to the ability to con the ferry from the bridge wing, unlike the C-class. The excellent visibility from the conning position often results in the handler passing close to the edge of the channel, reflected in the greater track standard deviations.
- Lack of water space is more of a problem in Horn Reach than Short Reach where most of the sailing trials took place. This is especially true if a regatta or racing is taking place and boats are moored in some parts of Horn Reach. (See Section 6.5 below)
- Some sailors did not consider there was an increased problem of space, but others felt it would be preferable for the W-class ferries to proceed as close to the middle of the navigable channel as practicable thereby giving small craft sufficient "escape routes", especially at low water.
- Shoal areas were noted on the channel sides of Cage Boom and Seymours posts, reflecting the location of some posts which do not define the present channel (see Reference 1)
- It was felt that ferry masters should proceed with caution in a busy river and have some appreciation of the potential problems of the leisure craft users. Several BMT discussions with the masters themselves confirmed that they certainly proceed with caution in a busy river and most of them further confirmed that it was common practice for them to stop if they saw a leisure craft in difficulties or potentially sailing into danger. BMT observations confirmed this.

Summary

It was concluded by BMT that, based on the ferry trials, the W-class took up more room in the river than the C-class. Remedial measures are recommended in Section 7.2 below.

Feedback from the sailing trials indicated that, although some sailors felt that there was not an increased problem of water space availability, some thought it would be better if the W-class ferries proceeded as close to the centre of the river as practicable, a suggestion that was endorsed by BMT and used as a recommendation in Section 7.2

6.5 Moored Boat Effects

Moored boats near the channel affect, and are affected by, the ferries. Both are relevant to the safe operation of the river and are now considered.

6.5.1 Effects on Ferries

Figure 72 shows the single point moorings to the west of the channel in Short Reach Lay-by area (northern end) while Figure 72 shows the track taken by the W-class ferry from which the photograph was taken.

Figure 72: Single Point Moorings in Short Reach

It is seen that the three craft on these moorings are encroaching into the navigable channel as the ferry approaches, the scope of the moorings themselves and the heading of the vessels combining to provide a significant incursion into the available water space. The resulting track in Figure 73 shows how the ferry moved across the Short Reach Lay-by to avoid the moored yachts, a necessary manoeuvre independent of ferry type. Another moored yacht, which can just be seen at the bottom of Figure 72, was very close to the bow of the ferry as the photo was taken.

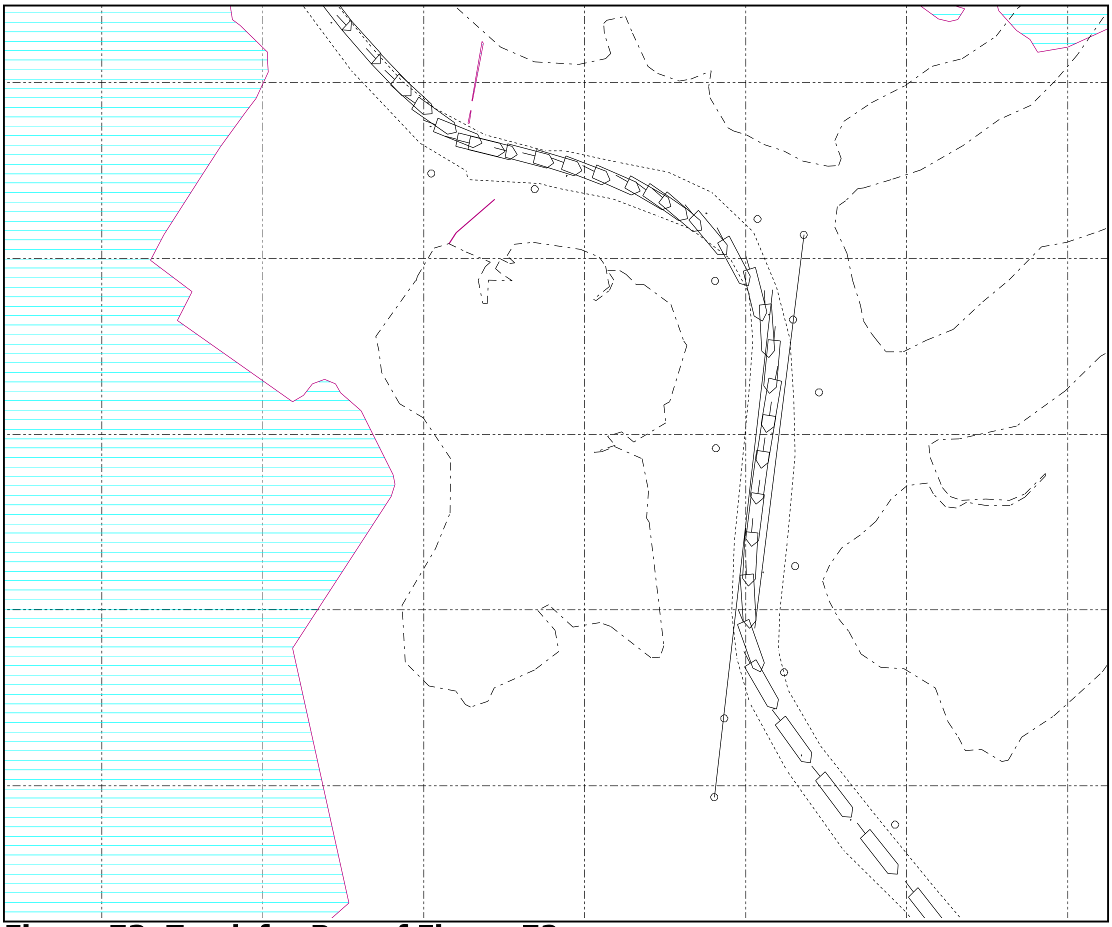


Figure 73: Track for Run of Figure 72.

Although the line of mooring buoys is a useful visual cue for river users, as well as demarcating an area of safe refuge for small craft, the encroachment of boats on single point moorings into the channel is unsatisfactory for safe navigation in this area. It may be mentioned that it is understood that use of moorings in the southern stretch of the Short Reach Lay-by area, extending into Long Reach, has stopped in recent years due to exposure. Because of this, there is no longer any encroachment here. However, for the situation in Figures 72 and 73, had there been significant traffic in the river at the time and the tide had been lower, the need for the ferry to encroach on the other side of the channel would have reduced the amount of water space for inbound vessels.

This leads to the question of the space available at certain states of the tide and wind at the Cocked Hat bend when boats on single point moorings encroach on the navigable space. Figure 74 shows a river cross-section at the Cocked Hat bend in way of Gate 5 used in the track analysis (see Appendix 6). It should be noted that a distorted vertical scale has been used.

Also shown in the Figure are the Cocked Hat and Cage Boom navigation posts and two cross sections representing the midships section of the W-class. The ship cross-sections are located on the mean values for inbound and outbound tracks at Gate 5, obtained during the trials. The left-hand side of the plot is to the southwest and the right hand end to the north east.

The asymmetrical nature of the river cross-section may be noted with generally steeper banks on the eastern side.

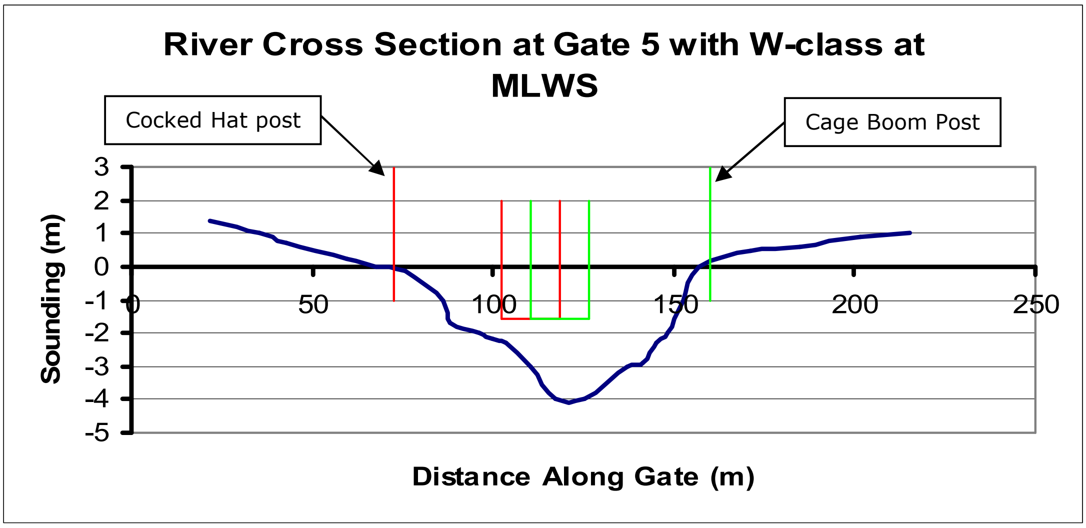


Figure 74: Inbound (green) and Outbound (red) W-class Ferries at Gate 5 in Cocked Hat bend.

The space available for small craft to move either side of the ferry is given in Table 5.

Draught (m)	West out	East out	West in	East in	Tide (m)
1.0	16.0	34.5	24.2	26.3	MLWS
2.0	6.1	29.7	14.3	21.5	MLWS
1.0	34.5	38.6	42.7	30.4	1.0
2.0	16.0	34.5	24.2	26.3	1.0

Table 5

The room for small craft to pass, or for floating moored vessels to swing, is indicated by the clearances (in metres) given in Table 5. The room for the deeper-draughted boats is small at MLWS if the outbound vessels keep to the inside of the bend as they tended to do in the trials. An outbound track more in the middle of the river would be beneficial in this regard and would provide clearances similar to those shown for the inbound mean track.

It is concluded that mooring vessels on single point moorings located on the inside of the Cocked Hat bend is not advisable because, in a strong south-westerly wind they will encroach into the navigation channel and impede outbound vessels. The number of moored boats on the single point moorings on the western side of the Short Reach Lay-by area has been reduced over recent years due to their increased exposure; this has resulted already in a beneficial increase in navigable water space for all users, thereby reducing risk. Re-locating boats moored on the remaining buoys there and on the Cocked Hat Bend will reduce risk further. Boats on single point moorings alongside the channel in Short Reach, between the wave screen and the Cocked Hat Bend, tend to encroach less on the channel and could remain, but it may be mentioned that discussions with stakeholders indicated that a greater spacing between these moorings would benefit small craft by providing them with easier access to "escape routes" behind the moored vessels.

6.5.2 Effects of Ferries

Observations made by a member of the BMT team on board a yacht moored on one of the buoys visible in Figure 72 indicated that, with the C-class, no untoward effects were encountered, although the effect of ferry wash, mentioned in Reference 1, could still be a problem for anyone moving on deck as a ferry passed. The effects of the wash of the W-class vessels have yet to be experienced.

A more notable effect of the ferries on moored vessels was observed at the fore-and-aft moorings in Horn Reach. It is well-known that the C-class ferries cause hydrodynamic interaction effects on vessels nearby as they pass. This effect moves moored vessels in lateral and fore and aft directions, combined with a yawing movement. This effect is greater with the W-class ferries due to their increased size and, on one observed occasion, caused some problems to a yacht in the process of mooring near the RLymYC as a W-class ferry passed nearby.

BMT observations indicated that interaction effects were confined to horizontal plane motions and, provided boats were securely moored and properly fendered, no problems occurred; further observations showed that boats moved as much in windy conditions. In passing, it was also noted that at low water in Horn Reach the ferries could set in train long period (of the order of 2 minutes) motions of the water prism (See Figure A5.6 in Appendix 5, for an example). However, the amplitude of these motions is low, and no evidence was found to suggest that they are likely to put people at risk. Interaction- and wind-induced movements, on the other hand, could result in people on deck overbalancing if they are not anticipating interaction or, in the single point moorings in Short Reach Lay-by, wash effects as well. It would therefore be wise for those on moored boats to be aware of these effects of the W-class ferries and anticipate their occurrence.

Further effects from the ferries relate to use of the thrusters and mainly affect boats and yachts moored in Horn Reach. The first arises from excessive use of the thrusters when berthing or correcting a manoeuvre. In emergencies it may be necessary to resort to use of full power on one or both thrusters. This can produce powerful slipstreams in the vicinity of the ferry which can swamp a small tender or dinghy nearby.

The second thruster-related effect arises if the ferry is on its berth and leaves its thrusters running. This may be because additional power is needed to hold the ship against the berthing face, or simply because the thruster controls have not worked (or been set) properly, leaving them operating when the bridge team is under the impression that they are not. The flow produced by the thrusters can be quite strong and affect vessels moored nearby or passing through. Remedial measures are simply to de-clutch the thrusters from their engines when the vessel is berthed (understood to be Wightlink policy for the W-class) or, at the very least, check from the bridge that the thrusters are operating as expected and not producing powerful slipstreams in the nearby water space. Problems of this type have been witnessed during the trials period and it is assumed that those related to control will be eliminated once the whole propulsion and control system has bedded down and teething troubles eliminated. It also indicates the need for "quick" mooring facilities for the ferries when berthing and unberthing at the Terminal.

Summary

The effects of moored boats intruding into the navigation channel when wind-rode has been discussed from a safety perspective and the effect of the larger ferries on moored vessels has also been addressed.

The need to stop the ferry thrusters when berthed was stressed because of the effect of their slipstream on nearby moored vessels, and the need for leisure users to be aware of the approach of a ferry because of its effect on moored vessels due to wash was also stressed. Movement on deck may be hazardous if the passing ferry has not been observed and the boat responds.

It was also concluded that the practice of placing boats on single point moorings on the Cocked Hat Bend or in the Short Reach Lay-by area should cease. This is because these boats can encroach on to the navigable area of the river, thereby reducing the available space and increasing risk.

6.6 Effects of Tidal State

The effects of tidal state are relevant to safety in two main areas:

- At mid ebb on a spring tide when inbound vessels have to move into a heading current of about 1 knot, thereby increasing their speed through the water. As speed through the water determines the magnitude of hydrodynamic effects such as ship-ship interaction, bank effects, squat, backflow and resistance (and hence power required to maintain overground speed) those ferry passages taking place at such times may have enhanced effects on small craft nearby.
- At low water springs the water space is limited, especially in Short Reach Lay-by, so that room for small vessels is limited. Shallow water also enhances the various hydrodynamic effects just mentioned; the main result of this is to slow the ship down and, on the trials, the ferries seldom did more than about 4.5 knots overground at low water springs in Short Reach Lay-by.

Regarding the first of these effects, it is simply raised here to draw attention to the fact that other river users should be additionally vigilant of inbound ferries at the comparatively brief times around mid ebb spring tides because their speed through the water will be increased and, as a result, their effect on nearby craft may be enhanced. However, it may be mentioned that in neap conditions the tidal stream velocities in the river are generally low while in spring tides the stream velocities in the Short Reach Lay-by are greater than 0.5 knots for only about 16% of the tidal cycle and greater than 1.0 knot for only about 5%; for most of the cycle, they are between 0.2 and 0.4 knots. In Horn Reach tidal streams are unlikely to exceed 0.4 knots during the cycle from high to low water. A corollary of this is that the ground speed of the ferries is, for much of the time, within 0.5 knots of the through-water speed.

Regarding the second effect, it has been shown in Section 6.1.6 that more room would be available for small craft if the ferries were to navigate the Short Reach Lay-by area on the Transit Marks. It has been shown from Figure 47 that, even at MLWS, there is about 33 metres space at 1.0 metre draught available to the east of the ferries if they stay on the leads, while for tide heights of 1.0 metres or more, the available width at 1.0 metre draught increases to about 40 metres. If the ferries persist in the tracks implied by the river cross-section, then the available width to the west at 1.0 metre draught and MLWS is around 18.5

metres. The clearances to the west will not change from the restricted values given in Section 6.1.6 because ferries appear to adhere to the leads outbound.

It is relevant to see how often tide heights are at low spring levels of 0.5 metres or less during the sailing season to gain some appreciation of how often severe space and handling issues are likely to occur due to very low tides. Using the tables of predicted tides for 2008, it is found that tide heights of 0.5 metres or less were predicted to occur 87 times in the whole year out of 706 low waters (12%) and, in the period 1 April to 31 October (assumed to cover the main sailing season), this number dropped to 54 out of about 440 low waters (12%). During the period April to October, low water springs tended to occur early in the morning or in the mid- to late-afternoon. Assuming the afternoon low waters cause the most potential problems, these were predicted to occur 14 times out of 440 low waters in the period or 3%.

So, while not in any way dismissing the issues associated with very low tide heights, it would seem that they are at their most inconvenient for a small percentage of the main sailing season. It is accepted that the percentage may change when the effects of atmospheric pressure are included, but as both low and high pressures affect the tides at Lymington, it is not believed that the change will be large enough to affect the overall conclusion that the frequency is small.

Summary

The effects strong ebb flows in spring conditions, thereby increasing the through-water speed of the inbound ship with a consequent change in hydrodynamic effects, were discussed. The loss of water space at low water springs was also mentioned.

It was noted that the strongest tidal stream (of about 1.2 knots) occurs over a small part of each spring tide and that such tides occur relatively infrequently during the sailing day in the sailing season.

It is concluded that high through-water speeds occur only over a comparatively small part of large spring tidal cycles and these cause inconvenience relatively infrequently during the sailing season.

6.7 Effects of Ferry Draught/Loading

It is shown in Section 5.4.4 that the effect of deadweight on the draught of a W-class vessel is comparatively small over the likely operating range. The changes of draught shown in Figure 1 for a deadweight range of about 170 tonnes would not have any significant effect on handling behaviour on the river, even allowing for the change in windage they represent.

As mentioned in Section 5.4.4, it was agreed at the outset that a draught representing a realistic maximum load condition likely to be met in service would be used for the trials and the results would not be expected to change significantly at other draughts in the deadweight range of Figure 1.

Some later trials were run at a level keel draught of just over 2.0 metres compared to about 2.18 metres used for most of the trials. No difference in behaviour could be discerned at a given water depth, water depth itself providing a more testing parameter for ship behaviour.

It is therefore concluded that the trials draught represented a robust test of the system giving results, and allowing conclusions, which may be used for all other operating draughts.

Summary

It was noted that, although two draughts were used in the trials, observations and measurements indicated that the effect of the difference was negligible. It was concluded that the draught used gave a robust test of the W-class ferry behaviour in the river.

6.8 Effects of Ferry Speed

6.8.1 Ferry Speed

Ferry speed affects handling as well as hydrodynamic effects; it therefore affects safety. In Section 6.1.4 it has been shown that speed through the water can have a significant effect on both handling and the amount of space used at the seaward end of Long Reach (south of numbers 5 and 6 posts) when a strong cross wind combines with a strong cross tidal stream in a location which no longer enjoys the protection of the salt marsh. It was shown that an increase in speed in such conditions (from 6 to 8 knots) had the benefit of better control and a narrower swept track as a result. However it was also noted in Section 6.1.5 that a similar result can be achieved by through increasing thruster power instead of increasing vessel speed although this has the downside of increasing water turbulence.

In the river the 6 knot mandatory limit south of the wave screen was adhered to in all the W-class trials; indeed in many cases inbound the overground speed was less than this. However, effects such as drawdown and squat depend on speed through the water so an overground speed on the 6 knot limit in the Short Reach Lay-by area may well be closer to 7 knots through the water if the ship is inbound against a strong ebbing spring tidal flow, bearing in mind, of course, that such streams occur in this area for only a few per-cent of the tidal cycle time and relatively infrequently throughout the sailing season. From a safety perspective, such a speed increase may have the benefit of greater control allied with the disadvantages of increased hydrodynamic disturbance and a more turbulent wake. In Horn Reach it has been shown in Reference 1 that tidal stream velocities are low throughout the tidal cycle.

However, too high a speed is not beneficial for scheduling, especially with a three ship operation. If a speed is used which is not compatible with the schedule, the schedule will slip or a need to wait in the river will prevail. Neither is to be encouraged and indeed the question of waiting in the river will be addressed separately in Section 6.10 below.

It may be that environmental considerations indicate the need for a lower speed in the river; such considerations are outside this study, but it should be remembered that too low a speed on the river will compromise handling in some weather conditions. It will also lead to bunching of other river traffic astern of an inbound ferry, for example, which is undesirable, especially if uncertain overtaking manoeuvres are attempted by unskilled river users. It may also lead to increased wind shadow duration, a further undesirable outcome. Some users, of course, have enough power in their craft to pass at will; indeed examples of leisure users operating at speeds in excess of the 6 knot limit were measured by the BMT team.

6.8.2 Monitoring and Enforcing Speed on the River

The monitoring of speed on the river is carried out for reasons of safety for all users and for the protection of the river environment. This applies to all vessels and the wash of vessels smaller than the ferries has been shown in this report to be significant, and often worse than that of the ferries themselves. Speeds in excess of 30 knots have been reached in the river by those planing vessels capable of such values.

However, it is the ferry speeds that are monitored remotely using a system that takes information from the AIS transducers on board each vessel and measures speed over the ground. A tolerance is set and, once the ship speed over the ground exceeds this tolerance, a warning is triggered in the software.

From what has been seen in the trials, the speed limits on the river are suitable from a safety perspective. Although it would be preferable if these were taken as speeds through the water, rather than over the ground, it is accepted that practical problems of remote monitoring of through-water speed will prevent this although, as already mentioned, for all of the neap and most of the spring tidal cycle, speed over the ground is reasonably close to speed through the water. However, in the 5% of the spring ebb tide cycle when the tidal stream is just over one knot, the ferries have the potential to make their highest speed through the water (stemming an ebb tide inbound), they are unlikely to breach the overground speed limit, but could produce their greatest hydrodynamic effects; conversely, when they are outbound on the ebb, they may breach the monitored overground speed limit while at the same time producing smaller hydrodynamic effects due to their lower speed through the water. Although large spring tides, and their associated strong ebb flows, occur comparatively infrequently throughout the sailing season (see Section 6.6), it would be prudent for inbound ferries to reduce their speed in the Short Reach Lay-by area at mid-ebb to minimise the hydrodynamic effects they create when the tidal stream is at its strongest. Voluntary speed reductions are already the norm with regard to excessive ferry wash at low water and it is suggested that these be extended in mid-ebb inbound as indicated.

There is a tolerance set in the speed monitoring equipment of 2 knots. When this is exceeded an alarm is triggered, signifying a breach. This seems a reasonable tolerance; maintaining an exact speed within tight tolerances on a ferry is not easy, although BMT observations on the trials showed that the speed holding was good in the generally benign conditions experienced at the time.

It is noted that, in exceptional circumstances, the master may have to exceed the speed limit in order to maintain control and/or reduce drift angles (See Section 6.1.4) and that this is more likely south of No 5 & 6 marks where the combined influences of strong winds and cross tides are greater. The COLREGS and LHC Byelaws 4 and 5 provide for all masters to use their discretion in exceeding the speed limit in circumstances where not to do so would endanger life or obstruct or impair the navigation of vessels. However, BMT accepts that a breach of the speed limit, measured on remote monitoring equipment, gives no information as to the reason for the breach and agrees with the LHC Safety Committee that ferry masters should make a deck log entry, by exception, to explain those occasions when the speed limit has been exceeded, or is thought to have been exceeded on safety grounds.

Summary

The appropriate speeds for the W-class ferries in the river were discussed and it was concluded that the present mandatory and advisory speed limits should continue, but recognising the provisions within the COLREGS and LHC Byelaws 4 and 5 that to use their discretion in certain circumstances if life is in danger or the navigation of their ferry or other vessels was likely to be impaired. The 2 knot tolerance level should remain and breaches of speed limits should be logged by exception on the ferries by way of explanation for "justified" breaches.

6.9 Effects of Traffic

The fact that the trials were unavoidably carried out at, and beyond, the end of the sailing season, was unfortunate. It meant that the full effects of busy traffic could not be seen at first hand by the BMT team, although some amends were made for this by special trials.

On the one day when trials were run with a "medium" amount of river traffic, the winds were light so that, at the end of the afternoon when most of the traffic was inbound, most vessels were under power. Lookouts were posted on each bridge wing of the W-class vessel and they showed great diligence throughout the day by keeping whoever was in control of the ship continually up-dated with the location of nearby vessels and developing situations. Ship speed was also called out at frequent intervals for the information of the shiphandler so that he/she was fully informed at all times of the traffic situation. On occasions when races are taking place in the river or just outside its entrance in the Solent, additional lookouts may be posted to inform the shiphandler of the behaviour of the fleet.

In passing it may be mentioned that the need to start races across the entrance to the river when one ferry was entering was unfortunate and could perhaps be reviewed. Such a situation was noted more than once by the BMT team.

The impressions of the sailors who took part in the sailing trials have already been presented and, although all of them coped well with the presence of the ferry in the lower reaches river, several commented that most of the traffic problems, from their perspective, occurred in Horn Reach rather than Short Reach. On the other hand, the ferry masters felt that most incidents occur in the river between the wave screen and Tar Barrel (confirmed by the 2008 statistics), so it would seem that care needs to be taken, by all parties, along the whole river when it is busy. This is done at present and is greatly helped if all obey the International Regulations for the Prevention of Collisions at Sea: the ColRegs.

On the day of the "traffic" trial, all users assiduously kept to this discipline, helped, it was believed by bridge team, by the presence of the Harbour Master's RIB escorting the W-class ferry in the river. Figure 75 shows disciplined inbound traffic at the time.

The Harbour Master's RIB can be seen ahead of the ferry near the starboard hand navigation post and the well-disciplined vessels in line astern may be noted. It would therefore seem advisable in future to allow a Harbour Master's RIB to be visible in the river on busy days; its mere presence may improve ColReg discipline, rather in the way police patrol cars keep speeds down simply by their presence on a highway.

Finally, traffic density will affect the ferry schedules, especially if a ferry has to stop or go to the aid of a river user. This will in turn affect the need to wait in the river.

Figure 75: Inbound Traffic during Trial

Summary

The trials would have benefitted from the availability of more traffic on the river, but, on the one day when there was a reasonable density, it was clear that there would be some benefit in a presence on the river of the Harbour Master and/or his staff. Observations showed that such a presence improved the traffic's discipline considerably and most people observed the ColRegs as they are required to do.

6.10 Waiting in the River; Thruster Slipstreams

Several trials were carried out with the ferry waiting in the river and the Section on stop-and-hold manoeuvres (Section 6.1.4) has described those in a wind. The main effect of interest from a safety perspective relates to the disturbance created in the river by the thruster slipstreams and their effect on small craft.

Accordingly measurements of the slipstream velocities were made for both the W- and C-classes. The only way these could be carried out in safety was with the ship berthed at the North End jetty with the appropriate thruster operating. This necessitated temporary closure of the river local to the ferry for the duration of the trials due to the cross-currents created.

For both W- and C-class ferries the thrusters were caused to operate to port or starboard so that the slipstream velocities could be measured in one direction and any upstream suction near the hull in the other. Velocities were measured at distances up to 24 metres from the side of the ferry local to the thruster and at depths of 250mm, 500mm, 750mm and 1000mm. The maximum depth was limited by the length of the current meter probe, but was felt to be adequate to cover the draught range of small boats most likely to be seriously affected by the thruster slipstreams. Measurements of flow velocity, averaged over 30 seconds, were made from a RIB moored to the ferry by a line calibrated at 2 metre intervals and maintained in position in the middle of the slipstream by the mooring line and judicious use of the outboard unit.

The propeller-type current meter used for the measurements is described in Appendix 5 and was hand-held from the RIB for all of the measurements. For each trial the thrust vector was set at 90° to the ship centreline and the power set, as a percentage value, to the equivalent of 4 or 6 knots through the water when moving ahead. For the W-class, these were taken as 40% and 60% power settings, with an additional 20% used to complete the picture, all at "operational" rotor speeds. In addition, the "idle", as well as the "operational", setting was used. For the C-class, power settings for 4 and 6 knots were used.

Early inspection of the results showed that slipstream velocity at a given depth and distance off varied linearly with power setting over the range so, to simplify the plots, a dimensional "velocity coefficient" was used. This was defined as $100V_S/P$ where V_S is the measured slipstream velocity in metres/second and P is the power setting as a percentage. In order to compute the velocity, the velocity coefficient should be multiplied by the percentage power setting.

The results are shown in Figures 76 to 78.

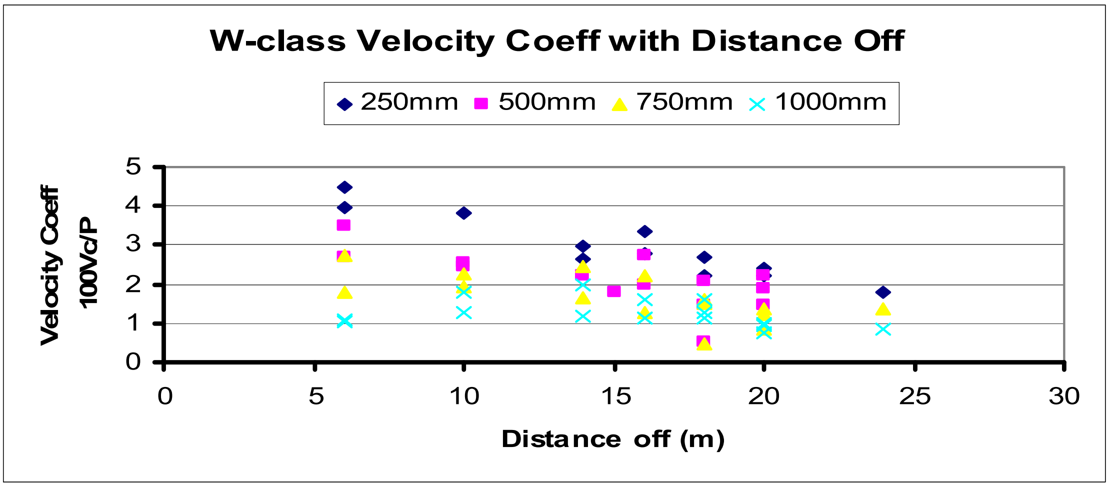


Figure 76: W-class: Measured Slipstream Velocity Coefficients at "operational" Setting

The following observations may be made with regard to the structure of the slipstream:

- The velocity reduces with distance off in the upper layers, staying roughly constant with distance off at the greater depths.
- Slipstream velocity is at its greatest in a comparatively shallow layer in the top 250mm or so of the slipstream. If this applies to the slipstream issuing from the stern of the vessel under way, this may help explain the existence of the standing waves astern when the "operational" thruster settings were used. A high speed jet acting near the surface could induce standing waves in the manner of a strong current in a shallow stream.
- The C-class slipstream has lower velocities than the W-class when used at the "operational" setting, although the difference is more marked in the slipstream closest to water surface.

- The "idle" setting significantly reduces the slipstream velocities of the W-class thruster: at 10 metres off the reduction is of the order of 50%. This may explain why no standing waves were present in the wake of the ferry when the "idle aft" setting was used.

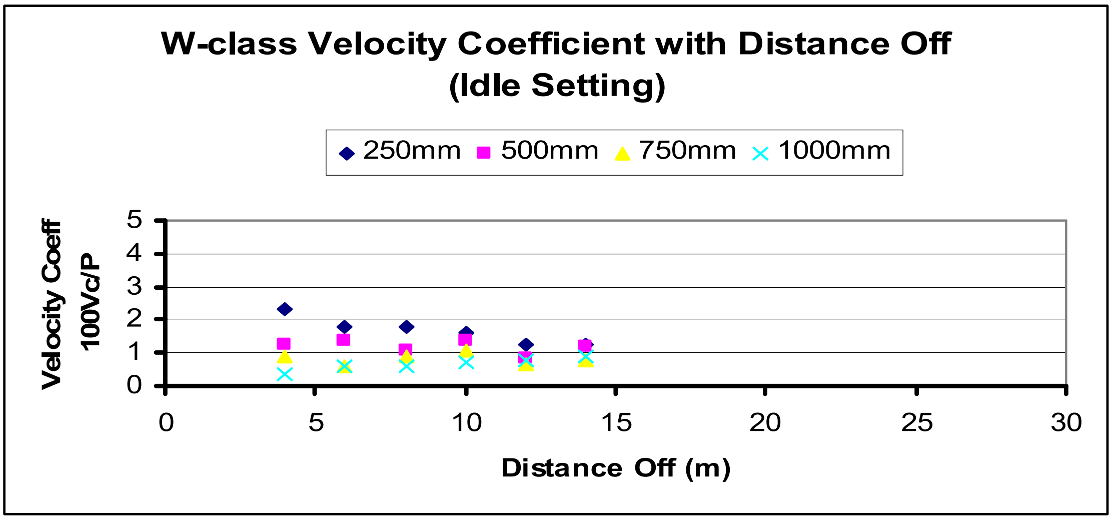


Figure 77: W-class: Measured Slipstream Velocity Coefficients at "idle" Setting

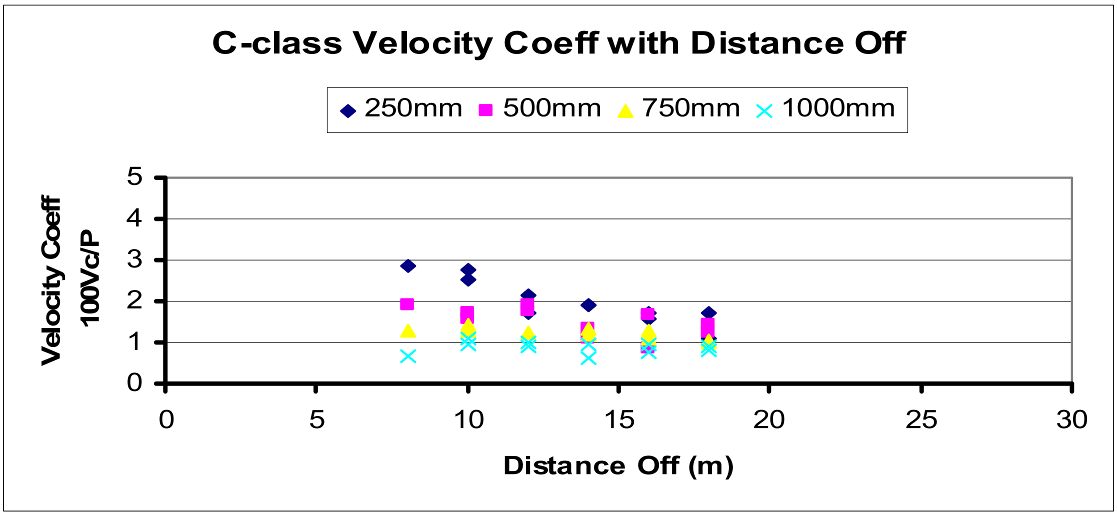


Figure 78: C-class: Measured Slipstream Velocity Coefficients

- Although the velocity diminishes with distance off, there is still a noticeable velocity some 25 metres off and there is a much reduced influence of depth in this region where, it is assumed, the slipstream flow is much more mixed.

There is some scatter in the results, largely due to the eddying flow at the greater depths causing large fluctuations in flow velocity. The power of this eddying flow made it quite difficult to hold the current meter in position; this became more of a problem as the current meter was taken closer to the ferry and explains why some of the measurements were curtailed while some distance off. Indeed at some points it became impossible to hold the RIB on a fixed location in the slipstream due to the induced velocities.

For the W-class measurements a regression fit was made to all the "operational" results so that values could be interpolated (and, if required, extrapolated) at other locations in the slipstream. As an example a velocity of 2.75 metres/second (5.34 knots) is predicted at 250mm depth, 4 metres from the side of the ferry at 60% power with the "operational" thruster setting.

When the W-class thrust vectors were reversed in order to see if there was any evidence of suction near the water surface on the upstream side, the RIB was taken up to the side of the vessel at the thruster location to observe any movement at the water surface or to find any other evidence of suction. No evidence whatsoever of suction was found. A key indication of suction in way of the operating thruster would have been a local drop in water level at the hull side, but there was none. Indeed, small pieces of seaweed, stirred up by the thrusters and passing along the hull side in the tidal stream, were not affected in the slightest by the fact that the thrusters were at 60% power on the "operational" setting. In addition no flow of any type, inflow or otherwise, was found at depths down to a metre at the side of the hull.

The same could not be said for the C-class thrusters where slight evidence of upstream disturbance was noted at the hull side. However, the location of the C-class thrusters did lead to a distinctive result when the slipstream was checked for the thruster acting on the other side of the hull. The measurements in Figure 78 relate to the port forward thruster thrusting to starboard with its slipstream to port. However, when the starboard aft thrust vector was also set to thrust to starboard, no evidence of any slipstream could be found on the port side at the 40% setting while, at the 60% setting, some flow eventually became visible, but its direction was highly variable and its strength weak. It was noted that most of the slipstream did not pass under the hull, but took the route of least resistance, leaving the hull astern on the starboard side. This asymmetry of thruster operation fore and aft no doubt helps to explain the unique handling qualities of the C-class. On the W-class the slipstreams resulting from thruster action are intuitively obvious; the behaviour of the thrusters is therefore predictable, a necessity for good control. This was demonstrated in the low speed handling of the W-class vessel and especially in any stop-and-hold manoeuvres.

However, the powerful slipstream velocities induced in the river when the W-class ferry has to stop-and-hold in a strong beam wind are intolerable for the safety of any small craft which may have to pass through them. For this reason, the recommendation made in Reference 1 that waiting in the river should be the exception rather than the rule is further endorsed as a result of the measurements described above and considerations given in Section 6.1.4 *Stop-and Hold Manoeuvres*.

Summary

Measurements of the flow velocities in the slipstreams of the W- and C-class thrusters were obtained when the ships were moored alongside. It was shown that the highest velocity was in a layer just below the water surface and that at the lowest measurement location, one metre below the surface, velocities showed little variation with distance off.

No evidence of upstream suction on the water in way of the thruster was found, even after taking a RIB up to the hull sideshell.

6.11 Trials with MOB Dummy

In late August 1979 a fatality occurred on the Lymington/Yarmouth route. As far as can be ascertained, this is the only fatality involving a ferry on the route. There were several reasons for the fatality but prime among these was that the casualty was in a small boat near the bows of a ferry about to leave the slipway at Yarmouth which was not seen by those on the bridge as the ferry left. The boat was run down and it and its occupant entered the forward thruster on the port side with catastrophic results.

While it is not the purpose of this section to dwell on this accident, it has assumed quite a high profile with some stakeholders and it deserved consideration in the overall assessment of risk. The following observations may be made:

- The accident happened nearly 30 years ago at Yarmouth and not on the Lymington River. As far as can be determined, there has been no other fatality or injury involving a ferry on the route since then and certainly not in the past 11 years.
- The small boat and its occupants were near the bow of the ferry and in the blind spot ahead of the ferry ramp. Consequently, they were not seen by those on the bridge as the ferry departed.
- Since this accident the C-class crew now does a 360^{o} check around the ship, including in the ramp blind spot, before leaving, following a recommendation of the Isle of Wight coroner after the accident.
- The boat was pulled in to the forward thruster on the port bow, a thruster which is placed on the deadrise of the hull in this region and closer to the water surface than the W-class thrusters.
- The W-class has a wide blind area due to the sun deck when looking ahead from the bridge. This is offset, to a certain extent, by a CCTV camera on the foremast and visibility from the bridge wings, but this still leaves a blind spot ahead of the ramp.
- The chance of anyone being run down by a W-class ferry on the Lymington River is extremely remote if all the risk control measures are applied: the Wightlink bridge team are diligent in their lookout duties, are able to pick up developing situations rapidly and can act before anyone in the water passes into any blind spot ahead of the ferry. The ability of the W-class to stop rapidly in around a ship's length has been well demonstrated and masters adjust their speed to suit the traffic density.

However, there remains a possibility that a small boat, or a person in the river, could enter the ramp blind spot when the ferry is berthed. This is a time when bridge manning during loading/unloading operations is minimal and it is possible that leisure craft in the blind spot could still be there when it is time for the vessel to sail. It is therefore essential that a good check is made of this blind spot before sailing (or before moving off after having stopped in the river for any reason) and a report made to the bridge that it is clear to move away. Direct and routine observation of the blind spot by a crew member is a suitable solution and, because of the impossibility of observing the blind spot from the terminal pier when the W-class is berthed at Lymington, Wightlink have installed permanent access to the focsle at the true bow (the "Yarmouth end") of the vessel for a crew member; ships will not sail or move off until the blind spot has been visually checked by this crew member and reported to the bridge that all is clear. Once this message is received, the master is clear to move off. However, tests with one of the W-class ferries at Lymington revealed that a limited area of the blind spot under the bow is still out of sight from the focsle. Further checks from water level showed that it was necessary for a person there and on the port side of the bow to be some 2 metres out before being seen from the focsle. It is therefore recommended that steps be taken to improve blind spot visibility from the focsle.

Possible alternatives include, where possible, visual observation from the shore (the method currently used at Yarmouth), a camera fixed to either the bow or a fixed location ashore to cover the blind spot. An on-board camera would be vulnerable to salt spray covering the lens and is not a practicable option, while visual checking by a crew member on board removes the need for an on-shore camera.

For the special case of ships berthed at the Freshwater and North End Jetties, checks of the blind spots should still be made, with either the ship's or the shore crew checking the blind spot under the ramp before giving clearance to the master that the ship is allowed to leave the berth.

It may also be useful, when the river is busy, for the master, at his discretion, to post a lookout on the focsle, able to observe both the blind spot and the traffic ahead. However, to be able to do this inbound on the river as well as outbound would require ladder access to the "focsle" deck at the true stern of the vessel, as well as the true bow. It is recommended by BMT that such an addition be made to the vessel.

In order to see whether, if all these risk control measures fail, a casualty in the water run down by a ferry would be likely to enter a thruster or be swept aside by the hull, a separate trial was carried out. This involved the use of a redundant "Man Overboard (MOB)" dummy, as used by the RNLI for training purposes. This was placed in Short Reach Lay-by and a W-class ferry master was asked to run it down deliberately in a series of runs, each at an increased speed, starting from 2 knots. Observations were made at river level on both sides of the ferry and all runs were videoed.

It should be stressed that this is, in many ways, a rather artificial situation; the master was asked to run down the dummy, the opposite of his normal reaction in such circumstances. Lookouts are posted on the bridge whose prime purpose is inform the master of hazards ahead, among which clearly a person or persons in the water would be classed as major; a stopping manoeuvre would be the natural outcome before the ferry got close to the casualty. Observations on the river have shown that the very action of stopping produces flow from the bow thruster out ahead of the bow which would tend to push anyone in the water away from the hull, rather than sucking them in.

In the trial itself, the first run at 2 knots saw the dummy struck by the ferry about 300mm off the bow centreline to port. The dummy drifted down the side of the hull without being sucked into either the bow or stern thruster. Indeed there was not the slightest indication that any suction existed to pull the dummy or anything else on the water surface into one or other of the thrusters. (see Section 6.10)

On the second run, a similar glancing blow caused the dummy to pass down the starboard side of the ferry without being sucked into either thruster or being affected by the wash of the bow thruster when it was used to stop the ferry for the next run.

On the third run, the dummy was hit by the ferry at 4 knots square on the bow. The water pressure held it in place for about 100 metres, after which observers lost sight of it; it had not been sucked in to the bow thruster before it disappeared from view. The ferry then commenced its turn to port to pass round the Tar Barrel post, leaving the dismembered dummy in its wake. It is not clear what happened, but it could have been that, as the ferry turned, the dummy, drifting down the starboard side of the vessel, was swept in to the aft thruster, helped by the lateral movement of the stern. Alternatively, it might have been swept into the forward thruster, once dislodged from the bow.

It has to be said that such an outcome could have occurred with a conventionally powered vessel, but it was a clear reminder that, unlikely as any run-down may be, and as unlikely it was that any casualty in the water would be struck in exactly the way as in the third run, the possible outcome is such as to demand continual vigilance on the part of the bridge teams on the ferries. The excellent safety record on the river, with no fatalities to date, indicates that this is in fact the norm, and BMT observations confirm this.

Nevertheless, the blind spot ahead of the bow needs to be checked before sailing as mentioned above and to minimise any chance, no matter how slight, of someone in the water being swept along the side of the ferry and possibly under the hull, it is further recommended that grab lines be attached to the hull in the region of the bow, as is the case on the Voith-propelled Red Funnel vehicle ferries.

It is important to note that no evidence was found in any of the trials to suggest that the way in which a casualty was run-down by a ferry in the river was any worse with a W-class than a C-class; for example, there was no evidence of the concern expressed by stakeholders of W-class thrusters pulling the casualty in by suction on those occasions when it drifted clear of the bow. Indeed the overhanging decks on the C-class probably constitute a greater hazard to any small boat caught under them; these are not present on the W-class vessels. If the risk control measures mentioned above are adopted, then BMT considers that the risk of a run-down has been reduced to a value as low as is reasonably practicable and that this risk may in fact be lower with the W-class than the C-class.

Finally, the fact that no casualty in the river has been run down by a ferry contrasts with the number of casualties caused by craft striking people in the waters of the Solent and surrounding waters. This further emphasises the high level of safety on the river.

Summary

Three trials were conducted with an RNLI MOB dummy. The W-class ferry was instructed to run it down at a speed which started at 2 knots and was increased to 4 in the third run. In the first two runs the dummy was deflected by the bow and drifted down the side of the ferry without showing any tendency to be sucked into either the bow or stern thrusters. In the third run the dummy was hit square on the bow, was held there by water pressure and subsequently dismembered.

This showed the need to be sure that there is no risk of anyone in the river being run down, a very unlikely event (it has never happened with a ferry in the river) but possible if a person is in the blind spot ahead of the bow before a ferry moves off. It was therefore concluded that this blind spot must be checked before each sailing and before moving off after stopping in the river. Grab lines should be fitted to aid people in the water.

6.12 Behaviour on the River

In this Section the overall behaviour of all river users is discussed, based on observations by BMT. Naturally, these depend heavily on the observations of the two experienced master mariners in the team.

The Regulations

First, the regulations governing movement of all vessels on the Lymington River are addressed. These are subject to the International Regulations for the Prevention of Collisions at Sea (Colregs) and the Lymington Harbour Byelaws. Those Colregs which are particularly relevant are Rule 9 - Narrow Channels; Rule 13 – Overtaking; and Rule 18 – Responsibilities Between Vessels. (See Appendix 8)

Rule 9 states that vessels of less than 20 metres, or a sailing vessel, shall not impede the passage of a vessel which can navigate only within a narrow channel or fairway. Rule 13 states that any vessel overtaking shall keep out of the way of other vessels. Rule 18 states that a power driven vessel shall keep out of the way of a sailing vessel except where Rules 9 and 13 otherwise require.

Byelaw 6 states the master of a small vessel which is not constrained by its draft to navigate only in the fairway shall not make use of the fairway so as to cause obstruction to other vessels which can navigate only within the fairway.

There is also a note at the end of the byelaws (though it does not form part of the byelaws) which draws attention to the risk of interaction when small craft pass close to larger vessels and gives advice on minimising the risks. This topic is also covered in the MCA Marine Guidance Note MGN 199(M)

In addition to the above, the Lymington Harbour website and Harbour Guide has a section titled "River Safety – Small Craft Beware Ferries". This gives very clear guidance to operators of small craft and states that "Every effort should be made by skippers of small craft to avoid close quarters situations [with Wightlink ferries]."

Observance of the ColRegs and Bye Laws

In a situation such as the Lymington River which is a relatively confined waterway and there are two distinct users, namely the Wightlink ferries and leisure craft, it is important that both appreciate the needs of the other. Taking the Colregs, the byelaws and other guidance into account, it might appear that everything is in favour of the Wightlink vessels and that leisure craft users take second place on the river. However, during the BMT presence on "Wight Light" there was no untoward attitude of "We have the right of way" by those in control of the vessel. While abiding by the Colregs, the Wightlink masters appear to appreciate that the leisure craft under sail do not necessarily have total control over their speed and manoeuvrability and take this into consideration while handling the ferry.

Unfortunately, from what was observed by BMT, some of the leisure craft users do not appear to abide by the Colregs, the Byelaws or the guidance given by the Lymington Harbour Commissioners in their Harbour Guide. In failing to do so it gives the impression that they do not understand the needs of the ferries with regard to safe navigation. On a number of occasions it was observed that leisure craft users got themselves into very close quarter situations with the ferry when a bit of forethought on their part could have prevented such an occurrence.

6.13 Other Observations

Professionalism of Wightlink Staff

As mentioned above, BMT was impressed with the professionalism of the Wightlink staff; their concern that all aspects of operational safety should be properly dealt with was obvious and it was apparent that they took safety on the river very seriously. It was also apparent that they were satisfied with the W-class with regards to safe navigation and there was nothing that BMT observed that gave rise to alarm regarding the safe operation of either the C- or W-class.

Wednesday Junior Sailing

Observations of the Junior Sailing Day took place on Wednesday 24th September. All that needs to be said is that it passed off without any problems and it was apparent that, in at least one aspect, the W-class vessels in fact present less of a hazard to small boats than the C-class. This is because there is no extension of the ship's side outwards above the waterline causing an overhang which has potential for small craft to become trapped if they come alongside the vessel. As a result of this exercise there would seem to be no reason, from a safety perspective, to change the advisory 4 knot speed limit in Horn Reach.

Communication of Intent

One aspect that was clear throughout the trials was that routine communication of intent from the ferry to other river users was lacking. This was especially true if traffic had bunched astern of a W-class ferry when it proved very difficult for the ferry to communicate with them. The bridge is completely enclosed and high above the water so that reflections from the bridge windows meant it was difficult for someone at river level to perceive any hand signals from anyone on the bridge "waving them through". The C-class ferries have open bridge wings and it is not uncommon for a member of the bridge team to go out on the wing and, by gesture, communicate intent with those on the river. The difficulty of communicating in this way on the W-class ferry can lead to confusion in the following craft and, in some cases, frustration, as witnessed when a yacht decided to overtake a slow-moving inbound W-class ferry about to pass an outbound C-class by moving between the two ferries without warning. Further confusion may arise were the ferry to wait in the river and begin to back down on small craft bunched astern, a manoeuvre which occurs if the waiting vessel wishes to gain some more space before continuing along the river. Using a crew member on the "focsle" astern could be a suitable way of communicating with any bunched traffic astern which could be "waved through" from that location if necessary.

However, because of the general problems of communicating intent to those on the river from the W-class bridge, a greater use of sound signals would be beneficial (see Appendix 8 for the ColRegs sound signals). Sound signals on the W-class are supplemented by synchronised signals on the mast lights; they were used during the trails, but infrequently and generally only for stopping. ColReg sound signals are used for communications on the Thames but they are supplemented by additional signals for "I am turning around with my bow swinging to starboard/port" and "I am about to get underway". The last of these is observed on the Lymington River when the ferries are about to leave the linkspan, although this is an action usually reserved for the Wednesday Junior Sailing events. Additional sound signals (a single blast) when an inbound ferry is rounding the Cocked Hat bend would alert river users to an impending ferry presence so that sailing operations, movement on deck, mooring manoeuvres and entry into the channel in Horn Reach from the slipway can be judged accordingly.

Finally, in regard to communicating intent, it should be remembered that flying the Red Ensign at the stern of the vessel is important with a double-ended ferry so that all are aware of the direction in which the vessel is about to move. For vessels in service, observations on the ferries showed that this discipline was generally poor with the ensigns being changed too early, some time before the ferry had actually berthed.

Communications and Schedule

Communications between the trials ship and other Wightlink vessels on the route was poor in the early trials, but this was largely due to the trial vessel having an incomplete set of hand-held VHF equipment. This was remedied and good communication was possible between ships. This was important because, when the schedule drifted (as it frequently did) the masters needed to communicate with each other to ensure that passing was carried out in the right place and speeds were adjusted accordingly. These ad hoc corrections, made in an attempt to maintain schedule, appeared to be commonplace and, although during the trials they were no doubt caused by the intrusion of the trials vessel into the service schedule, it did seem to load the masters with the responsibility of maintaining the schedule in all circumstances. If no computer-based system ashore can be developed to determine ferry speeds in certain parts of the route required by all ships to restore the schedule, then good and frequent communications between ships and between ship and shore would seem to be essential.

Navigation Light Visibility

A number of river users brought to BMT's attention that it was not possible to see the W-class masthead navigation lights from the river level in certain locations. Figure 79 illustrates this.

It is apparent that one of the two masts is not visible at river level in the close quarters situation of Figure 79. However, it should be mentioned that at other alignments, and at greater distances, the top of the hidden mast does become visible; indeed, the vessel complies with the requirements of the ColRegs in that the aft masthead light is visible at sea level about 313 metres from the bow, well within the required 1000 metres. With the C-class, both masts and their attendant navigation lights are more readily visible, even from close quarters, as shown in Figure 80.

This matter is simply an observation, but one that river users should be aware of if linked sound and light signals are used more extensively on the river.

7. Discussion

7.1 Marine Risk with the C- and W-class Ferries

In this Section, the results of the study are discussed in relation to the marine risk on the Lymington River leading ultimately to a revision of the Risk Register of Reference 1 and recommendations for risk management.

First, the incident data for the river is re-visited as it has been updated for incidents reported in 2008, some of which concern the W-class. This data is confined only to incidents in which a ferry was involved to a greater or lesser degree: in some cases it may have been the cause of the incident, in others it may simply have witnessed an incident and then stood by to give assistance.

Figure 79: W-class from River; One Mast Invisible

Figure 80: C-class from River; Both Masts Visible

In the whole of 2008 there were no reported fatalities or injuries in any of the ferry-related incidents, but reported events rose from 58 in the 10 years to the end of 2007 to 175 for the 11 years to the end of 2008. This does not reflect an increase in marine risk so much as an increase in reporting, especially of breaches to the speed limits for which there were a total of 71 recorded by the AIS monitoring system from January to 5 November 2008 alone. However, while these were all technically breaches of the limits, many were justified on the legitimate grounds of shiphandling in strong cross winds and currents when additional speed was required. (See Sections 6.1.3 and 6.8). In the event, the ferry company was issued with three speed warning notices dealing with 71 of the breaches up to November 2008, about half of which related to speeds in the outer reaches of Long Reach where strong cross tides occur, as discussed in Section 6.1.4.

These now dominate the statistics as can be seen from Figure 81:

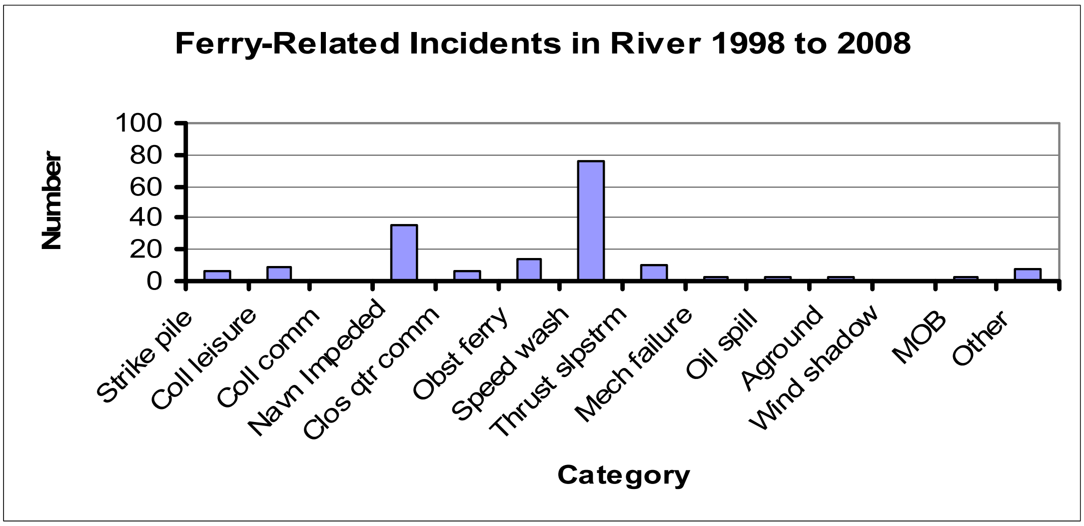


Figure 81: Updated Ferry-related Incidents on the Lymington River

An additional category – that of Man Overboard (MOB) – has been added to the plot and a small number of these incidents were recorded. A new category has been added to cover those instances where a ferry or other vessel constrained by draught has been impeded by other craft; it is shown in Figure 81 as "Navigation Impeded". There were no reported incidents due to wind shadow, the most numerous after speeding being in the "Navigation Impeded by Other Vessel" category in which 19 of the 23 incidents reported were of a ferry being impeded, the remaining 4 being cases where a ferry impeded leisure craft.

Taking all of the speed limit breaches into account, the incident rate rises to 0.71 per 1000 ferry movements which is more in line with other well-run ports as indicated in Table 8 of Reference 1. The difference, however, may be that incidents for other larger ports result in injuries and fatalities whereas those for Lymington contain no such data, reflecting the very safe record of the port.

This raises the issue of marine risk in a port such as Lymington. Coupled with the natural concern over the safety of life is the consequence of an incident on the environment (Reference 6), a concern which is outside the scope of this study. Therefore marine risk in this report should be understood as confined primarily with the safety of life but also with the safety of artefacts such as boats and yachts as well as the more nebulous concept of the overall sailing facilities, for which the river is famous, as well as the conveyance of passengers and goods to and from the Isle of Wight.

At the heart of these considerations is the effect of the W-class operations on the port and its river. Several stakeholders have raised the issue of "perceived risk" in relation to these ferries with an extension to the idea that, because they are bigger in several respects than the C-class, it follows that they are less safe. Indeed a view has been expressed by some interested bodies that, because they are bigger, they are therefore more dangerous than the C-class. This would seem to be a good example of the perceived risk associated with the W-class, a perception which is understandable, but needs to be subject to some rigour before it can be accepted.

While accepting that risk may be perceived as high with the new vessels, it is necessary to determine what, if any, risk management measures are available to reduce it to acceptable levels and that is the task of this Section. It has been stated above that the experienced and independent master mariners in the BMT team are satisfied with the capabilities of the Wightlink crews to handle the new vessels competently and observations have shown that they can be navigated along the river without grounding or losing control in the weather and tidal conditions met in the trials. Indeed, observations also suggest that control of the new vessels is in many ways superior to that of the C-class, but it is nevertheless the case that they occupy more water space than the old ferries and their windage is, to scale, more akin to that of a cruise liner than a conventional ferry. As a rough measure of this, a coefficient based on the ratio of maximum loaded windage area to the waterline length times the draught gives an idea of how much inherent underwater resistance there is to a beam wind. For the C-class this ratio is about 2.9 which compares to about 3 to 4 for conventional ferries. For the W-class it is about 4.8 which compares to 4.2 to 4.8 for cruise liners. The W-class may therefore be expected to be sensitive to wind, but trials carried out in quite strong beam winds showed that the amount of control they possess, allied to the skill of the Wightlink masters, allowed the vessel to maintain a good track along the river, even though the aft thruster was constrained to operate at the so-called "idle" setting. (See Section 6.1.4 above)

In terms of handling, therefore, it became clear on the trials that the W-class vessels were superior to the C-class. While both have to possess a degree of inherent directional instability to navigate the bends in the Lymington River, the W-class was better-behaved than the C-class in this regard and some low-speed manoeuvres, possible with the W-class, would have been difficult, if not impossible, with the C-class.

However, one aspect which caused considerable concern with the new vessels was the disturbance created in the river by the thrusters, especially that located at the stern. When used in the "operational" setting the aft thruster disturbance was quite intolerable and would have posed a significant hazard to small boats in its vicinity. Measures were found, however, to reduce thruster disturbance to an acceptable level, a level in fact which resulted in reduced wash compared to other settings and the wash produced by the C-class. However, as mentioned in Section 6.2.1 above, the wake astern of the ferry, while quite flat, contains large eddies below the surface with vertical shear layers of more intense and concentrated vorticity at its boundaries. Whereas these components of the wake when the "idle" setting was in operation were manageable by small craft (provided they were not too close to the stern of the ferry), when the "intermediate" setting was used, their effect on small craft was more evident. The impression gained in the sailing trials was that the wake with this thruster setting had a more noticeable effect; small boats navigating close to the stern of the ferry had their handling affected and allowances had to be made for its effect on the fin keel and rudder. However, as the "intermediate" setting is only to be used in winds above 25 knots, those sailing vessels still out in such conditions will have more power to deal with the wake disturbance.

Nevertheless, it is fair to say that most sailors were able to deal with the wake effects arising from the "idle" and "intermediate" settings, but seemed to find wind shadow more challenging. From a safety perspective, the twin effects of wake and wind shadow on the smaller sailing dinghies caused inconvenience, but did not prove to be significant hazards. However, the dinghy sailors and others who took part in the sailing trials were, in the main, experienced and accomplished sailors whereas novices or less skilled sailors could be caught unawares by these effects from the ferry. Observation showed that both wind shadow and wake effects were most evident near the ferry; keeping about a ship's length astern puts a small vessel in an area where the wake effects are less noticeable and keeping as far away from the ferry as practicable reduces wind shadow effects. It is also true that wind shadow is an inevitable consequence of the wind blowing around a large ship, a feature which is experienced frequently by sailing vessels of all types who share water space with larger commercial vessels.

As mentioned above, the sailing trials were carried out by experienced and skilled sailors, familiar with the river. Several stakeholders have pointed out that, whereas local users of the river are familiar with the local environment and the way operations are organised, visitors also use the river during the sailing season and their abilities and competence are unknown. The implication is that marine risk is compromised by their presence especially with regard to dealing with the presence of the ferries. Views have been expressed by some ferry masters that visitors to the river are sufficiently wary of the ferries that they keep well clear of them; some locals, acting on the "familiarity breeds contempt" basis can be more of a problem. It is difficult to see how the presence of the W-class on the river is going to change this situation. The responsibility for control of any risks posed by those unfamiliar with the river, and/or those who simply break the rules, must lie jointly with the harbour authorities (by means of their patrols, Harbour Guide and byelaws) and the ferry masters (dealing with the risks posed by others, keeping a good lookout to see and deal situations as they develop, using an appropriate speed for the situation, stopping and giving assistance as required). As far as BMT has been able to observe, this is common practice at present and there is no reason why it should not continue with the W-class on the river using the risk control measures given below.

Fortuitously, over the years and as far as is known, there has been no loss of life or serious injury on the river as a result of the ferries' activities. Indeed in several incidents the ferries have been able to help and prevent escalation. But there has been one tragic fatality as described in Section 6.11. This occurred in Yarmouth and not the Lymington River, but its component elements could be repeated on the river if nothing were to be done to prevent it; there are blind spots around the ferries in which small boats, or people in the water, would be hidden from the view of those on the bridge. These need to be recognised and the associated risks managed; recommendations are given in this report.

The overall impression gained by BMT as a result of the trials was that, purely from a marine safety perspective, the W-class ferries themselves had many good qualities. Their handling (See Section 6.1) in a range of conditions is such that they are able to deal with the challenges posed by the river itself and the weather conditions. They can stop well in an emergency, stop-and-hold satisfactorily in strong beam winds, deal with passage in the Solent and arrival/departure at

Yarmouth and low speed control is good. The crews are competent and experienced in the river, and the navaids on board are excellent.

However, this ignores the fact that the ferries share the river with leisure users and, because of the increased size and power of the new ferries, therein lies the potential for increased marine risk, a potential which has had to be investigated and suitable risk control measures for its management recommended.

These are now considered by reference to evidence provided in Section 6 above.

7.2 Risk Control Measures for the W-class Ferries

In this Section a number of risk control measures are recommended for the safe co-existence of W-class vessels and leisure users on the Lymington River. Their purpose is to reduce risk to a level which is not only no worse than the present situation, but make risk as low as is reasonably practicable. This is then tested in Section 7.3 by revisiting a revised version of the Risk Register of Reference 1.

The majority of the recommendations flow from the discussion above and reference is made here, and in the Risk Register of Section 7.3, to the appropriate Sections of the report for the supporting evidence derived from the trials and measurements. It should be noted that the recommendations apply to both the ferry and leisure craft operations.

In what follows, the risk control measures are grouped together under suitable headings.

7.2.1 Ferry Handling; On Board

In this Section, control measures associated with operations on the bridge of the ferry are recommended.

- Handover from one conning position to another is to be carried out according to the procedures developed during the trials, but these should be kept under review to verify that the hand-over is entirely reliable. In the longer term, the possibility of synchronising all conning locations on the bridge, as is the case with the Saint class, should be explored. (see Section 6.1.2)
- In the longer term, explore the possibility of ganging the thrust vector controls as presently implemented on the C-class. (See Sections 6.1.2, 6.1.3 and 6.1.7)
- When in the river, lookouts should be posted to cover both bridge wings for a centre con, and the other bridge wing and centre bridge (for assessment of whether the ship is on the transit marks) for bridge wing con. (see Section 6.9). This requires a minimum of three people on the bridge and it is understood from the MCA that the ISM Code has been amended to reflect this minimum manning level.
- Ensure that the blind spot under the bow is checked before the ship is allowed to move off. A crew member should check visually for unseen small craft there prior to getting under way from the berth or after any stopping manoeuvre on the river. He may also be useful there as a lookout (at the Master’s discretion) when the river is busy or when otherwise required. (see Section 6.11)
- Ensure that steering consoles in the bridge wings are suitably located for all crew to be able to reach the controls while conning the W-class vessel (see Section 6.1.7).

- When the river is busy and the traffic density high, masters should use the thrusters at their discretion while keeping within the recommended rotational speed settings, to reduce drift angles as much as possible, thereby releasing more space for leisure users.

7.2.2 Ferry Handling; On the River

In this Section, risk control measures related to the way the ferry behaves in the river are recommended.

- The ferries should use the Transit Marks inbound and outbound, whether or not there is a passing manoeuvre, to allow sufficient space for leisure craft. (see Section 6.1.6)
- When conning from the bridge wings, the temptation to pass very close to any moored vessels alongside the navigable waterway should be resisted as this results in disturbance to the moored vessels and reduces the space available for leisure craft. (see Section 6.1.7).
- In Horn Reach in particular and elsewhere in the river when practicable, the W-class should keep near to the centre of the channel, if practicable and while conforming with the ColRegs, to allow passing room for leisure vessels. (see Sections 6.3.2 and 6.4)
- When on passage on the river, the thrusters should be on "operational" setting forward and either "idle" or "intermediate" aft according to the following Safe Operating Profile (see Section 6.1.4):
    - "idle" for wind speeds up to 20 knots, gusting 25 as measured at the RLymYC Starting Platform in the interim, changing to 25 knots, gusting 30 once all helmsmen have sufficient experience in strong winds. The change to the higher limit should be the subject of a formal application by the operators demonstrating "river experience" - for example through evidence of transits and master "sign off" for adverse weather operation. In the light of this declaration, the risk assessment should be reviewed.
    - "intermediate" for wind speeds from 25 knots, gusting 30, to 30 knots, gusting 42 as measured at the RLymYC Starting Platform.
    - The only exceptions to these settings and their limits are in case of emergency or if the ship would otherwise be endangered having already committed to the river passage within the wind speed limits given above.

7.2.3 Ferry Thruster Usage

This section considers the use of the ferry thrusters in the river with a view to minimising risk to other river users.

- Ensure that thrusters are stopped by de-clutching when the ferry is securely berthed, or when attending an emergency involving a person(s) in the river near the ferry. (see Section 6.1.5 and 6.10)
- Avoid large changes of thrust vector direction combined with increases of power; a more gentle, "little and often", approach to control is preferred. The effect on small craft near the stern of rapid changes of a "kick ahead" thrust vector slipstream carries the potential risk of swamping. (see Sections 6.1.2, 6.2.1)
- Use the lowest aft thruster setting compatible with the conditions at all times. This applies not only when on passage, but also when standing by an incident, berthing, moving between berths and accelerating and

decelerating. It is very difficult to determine from the bridge the severity of the thrust slipstream and its effect on leisure craft, so care should be exercised at all times.
- Where practicable, ferry masters should witness the effects of the thruster action at river level; such effects are largely invisible from the bridge and are relevant to the safety of leisure vessels in their vicinity.
- When using the "intermediate" setting on the aft thruster, acceleration should follow the approach suggested in Section 6.1.2 above.

7.2.4 Ferry Passing and Waiting

- Passing should always be undertaken on the Transit Marks. (Section 6.1.6)
- Waiting in the Short Reach Lay-by should not occur, as recommended in Reference 1. This is especially desirable in strong beam winds when the resultant thruster slipstream disturbance is intolerable for small craft in the vicinity. It is recognised, however, that there will be exceptional occasions when waiting in the river cannot be avoided, and these should be recorded in the deck log. (Section 6.1.4)
- When a ferry passes a leisure craft it should ensure that ColRegs Rule 13a always applies (See Appendix 8)
- The safe operating wind profile applies to passing as well as general navigation in the river.

7.2.5 Adherence to the Collision Regulations

- All river users must obey the ColRegs with no exceptions. (Section 6.12)
- To help in this it is recommended that on days when the river is busy, the Harbour Master increase the number of patrols in the river. The presence of the Harbour Master's RIB had an entirely beneficial effect in this regard in the trial conducted with river traffic. (Section 6.9)

7.2.6 Speed Discipline

- The speed limits on the river, whether advisory or mandatory, should remain and always be adhered to by all craft. (see Section 6.8)
- Although the hydrodynamic effects of squat, drawdown and wash, not to mention ship handling behaviour, depend on speed through the water, the difficulty of remotely monitoring speed through the water suggests that the speed limits should remain as speeds over the ground. (see Section 6.9). For most of the time tidal stream values are low enough to assume that ground speed is an adequate measure of through-water speed.
- In Long Reach, from Post 6 to Jack in the Basket where strong cross-tides occur, the speed of 6 knots overground should be maintained by the ferries, unless an increase in speed is warranted by the tidal and/or wind conditions in compliance with LHC Byelaw 4 and the ColRegs. (see Section 6.1.4). In such cases the increase should be reported by exception in the ship's deck log; it is recognised that in very strong wind conditions in the river, speed limits may be exceeded for short periods but efforts should be made in such circumstances to adhere to the limits.
- At low water, care should be taken to avoid the production of large waves over the shallow berms at the outer end of Long Reach.
- Ferry speeds on the whole route from Lymington to Yarmouth should be commensurate with the schedule and arranged in such a way as to avoid waiting in the river.
- At low water and when the river is busy, ferry speed should be adjusted to suit the conditions.

- Speed monitoring should continue. For the ferries this should continue to use AIS data and ground speed with a 2 knot tolerance; for small craft monitoring should be done as at present from the Harbour Master RIBs with, as necessary, the continued use of portable GPS units.

7.2.7 Operations in Horn Reach

- The 4 knot advisory speed limit in Horn Reach should remain (see Section 6.13)
- Ferries should manoeuvre with due regard for space for small craft on either side. For this reason, it is recommended in Section 7.2.2 that ferries take a course close to the centre of Horn Reach if circumstances, such as moored boats or local regattas, allow.
- Extra care should be exercised by all vessels at the traffic crossing point near Harpers Post.
- Operational procedures presently in place for Wednesday Junior Sailing should continue as they are, but taking account of the larger wind shadow from the W-class ferries.
- Shut down the W-class thrusters when the ferries are berthed

7.2.8 Communication of Intent

- Sound signals in compliance with the ColRegs (Appendix 8) should be used by the ferries on the river to inform other users of intent. The current requirement whereby a single blast is sounded when leaving the berth at Lymington and when inbound rounding Cocked Hat bend should continue and not be restricted to Wednesday Junior Sailing occasions. (Section 6.13)
- Access to the "focsles" at each end of the ship by a member of the crew will be useful in allowing visual communication with any bunched traffic astern, but the presently limited visibility of the blind spot from the focsle platform should be improved. (see Sections 6.11 and 6.13)
- It is further recommended that access to the "focsle" at the true stern, as well as the true bow, be facilitated. (See Sections 6.11 and 6.13)
- Wightlink, LHC and interested stakeholders should discuss the need for further visual or aural communication with the ferry regarding intent. This would be used should the ferry have to stop or proceed very slowly for some reason

7.2.9 Wind Shadow

- The W-class wind shadow is bigger than that of the C-class and more turbulent. Leisure users should be aware of this and avoid sailing close to the leeward side of the ferry, if possible. It is in this region, and very close to the windward side, that wind will be lost in a beam or nearly beam wind. (See Section 6.3)
- Where practical to do so leisure craft should keep well to windward of a ferry should it be waiting in the river, unless there is sufficient water to leeward to keep clear.
- When passing a moving ferry be aware that the wind shadow effect can last up to 50% longer than with the C-class. (see Section 6.3.1)
- A W-class ferry coming up astern will take the wind of a yacht on a run in the river; with the wind astern, sailors should be aware of vessels, especially ferries, astern of them and, if practicable, move over into less disturbed wind or, if they have auxiliary power, consider using it to move to areas of less disturbed wind.

7.2.10 Sharing the River

- The water space available on the river is shared by a range of vessel types with a range of sizes. All should be aware of the needs of the others, but ferry masters should continue to take particular account of the space needs of some sailing craft at low water.
- Very low water spring tides occur comparatively infrequently at busy times in the sailing season, (see Section 6.6) but when they do, ferries should ensure that they continue to pass on the Transit Marks to leave space to starboard for small vessels.
- Sailing dinghies and other small craft should be aware of the wash when deciding to cross astern of a W-class ferry; they should be aware that its effect reduces with distance astern and navigate accordingly.
- All small craft should avoid sailing along the edge of the wake from the W-class ferries; there is concentrated vorticity here which can affect control and it is especially intense when the ferry is turning (see Section 6.2.1).
- All leisure users should be aware that the ferry wake consists of a smooth central area, about as wide as the ferry, beneath which large eddies cause water movements which can affect a small boat. This centre portion is bounded by vertical shear layers of vorticity. (see Sections 6.2.1 and 7.1).
- Ferries should avoid navigating close to moored boats.

7.2.11 Aids to Navigation

- The aids to navigation on the river should be reviewed, as suggested in Reference 1, so that they better define the navigable channel. As some of these posts are used as sighting marks by ferry helmsmen, they should be relocated after discussion with Wightlink.
- Relocating the navigation posts should be done in such a way as to make navigation of the river easier, especially in restricted visibility. For example, gated pairs of posts could be considered with marks at Tar Barrel and Cocked Hat bends located in such a way as to aid turning in poor visibility. With this in mind, it should be remembered that the radars on the W-class have no parallel indexing capability, so turning on a radar-conspicuous mark at the centre of bend curvature in poor visibility would not be possible.

7.2.12 Moored Boats

- Boats are moored on single point moorings alongside the navigation channel at the northern end of the Short Reach Lay-by area and on Short Reach between the wave screen and the Cocked Hat Bend; fore-and-aft moorings are used on the east and west banks of the channel in Horn Reach. While the single point moorings south of the wave screens provide good visual cues for the ferries and other river users, encroachment of moored boats, in certain winds, into the northern end of the Short Reach Lay-by area and the inside of the Cocked Hat bend should be stopped by not allowing vessels to moor in these areas. (See Section 6.5.1). The buoys themselves could remain as they form a valuable visual cue for vessels navigating in the river.
- The spacing of the mooring buoys between the wave screen and the Cocked Hat Bend should be increased to allow small craft better access to the "escape routes" behind.
- Boats moored near the ferry route will experience enhanced hydrodynamic interaction effects as the ferry passes. These should be expected and anticipated and movement on deck should be avoided when the ferry is

about to pass. (See Section 6.5.2) Similar remarks apply in bad weather when the moored vessels can move around in the wind and, in less sheltered areas, the ambient waves.

7.2.13 Grab Lines

Grab lines, fixed to the hulls near the waterline, should be fitted in an appropriate location to the W-class as an aid to anyone in the water.

7.2.14 Continuous Review

These recommendations should be the subject of continuous review, in line with paragraph 2.1.11 of the Port and Marine Safety Code. As a result, some may change as experience of operations on the river builds.

7.3 Risk Assessment

7.3.1 The Requirement

As mentioned in Section 1, the study brief included a requirement for a risk assessment to define any necessary and reasonably practicable risk mitigation measures needed to enable the LHC to meet the requirements of the Port Marine Safety Code.

In Phase 2 of the study, the approach to satisfy this requirement has been to re-visit the risks and proposed mitigation measures for W-class operation, assumed in Phase 1, but this time with the benefit of the trial results. This allows the risks associated with operating W-Class ferries to be assessed relative to C-Class ferries, and enables additional practicable risk reduction options to be proposed where necessary.

7.3.2 Risk Assessment Approach

As shown in Reference 1, and confirmed in Section 7.1 above, operation of C-Class ferries has been a ‘Low risk’ activity for many years, and the risk assessment of W-Class ferries has, of course, to be considered against this benchmark in a low-risk context. Key considerations are whether the risk of identified incident scenarios will be increased or decreased, and how the overall level of risk is likely to change when operating W-Class ferries rather than the C-Class.

Table 9 of the Phase 1 report provided an initial assessment of risk associated with areas of operation and/or circumstances that can influence operational safety with C-Class vessels, as well as providing initial direct assessments of particular incidents (e.g. Grounding). This was appropriate in order to review the risks and risk-influencing factors associated with operation of the older vessels, bearing in mind the existing risk control measures.

This information has now been used, together with objective information from the trials, to focus attention on those operational, design and other characteristics of the W-Class vessels that could affect, or “drive”, marine risk, including those that were of particular concern to Stakeholders. This provides the best possible objective assessment of the differences in risk that arise from:

- specific hazardous scenarios;

- marine operations on the river with the W-Class ferries operating on the route.

In order to assess the potential difference in safety risk between operations involving C-Class and W-Class ferries, the material from the Phase 1 report was taken forwards into a detailed Risk Assessment developed to provide:

- a detailed objective comparison of safety risk, based on the evaluation of specific hazardous scenarios in the light of the trials data, trials experience and extensive stakeholder consultation;

- a clear reference to the initial risk assessment made during Phase 1;

- the clearest possible link to the recommendations of the study, in order to show how the specific risks under consideration would be further reduced by implementation of those risk control measures needed in addition to those already in existence;

- an assessment of whether overall residual risk would be increased or decreased if W-Class ferries were introduced to the river. In this context, residual risk is defined as the risk that would remain once any additional risk control measures had been introduced over and above those existing at the moment.

The approach focused on the way in which safety risk varies for the two vessel types by examining and presenting evidence in respect of the probability and consequence of a number of key incident scenarios, directly related to stakeholder concerns. The relationship between safety risk and the underlying issues that drive it (whether by affecting the probability or the consequences of these incidents) was clarified, thereby showing a clear link to the trials evidence, and therefore ensuring a high degree of objectivity.

The detailed risk assessment spreadsheet, with explanations and showing all working, is given in Appendix 10; a summary table, incorporating the key results, is given below as Table 6. This shows the key incident scenarios and assessments of their relative risks. The latter are shown before and after the application of risk control measures whether these already exist or are proposed in this report. Colour coding in "red-amber-green" highlights whether the relative risk of operating the W-class instead of the C-class is likely to be greater, the same or less. Finally a score for the relative risk is shown, derived from the evidence in the worksheet supplemented by the judgement of the independent master mariners on the BMT team; this is used in the overall assessment of relative risk.

7.3.3 Risk Assessment Results

Analysis of the Risk Associated with Hazardous Scenarios

From the summary table (Table 6) it is seen that, of the 18 scenarios considered, the assessment predicts that before adoption of the recommended additional risk control measures.

- 7 scenarios would give an increased risk with the W-class operating, rather than the C-class (red)
- 4 scenarios would give a reduced risk (green)

- 7 scenarios would give a level of risk that may be higher or lower or similar, depending on particular variables such as weather conditions (amber)

These are summarised in Figure 82.

After adoption of the additional recommended risk control measures, the assessments predict that:

- 3 scenarios would give an increased risk with the W-class operating, rather than the C-class (red)
- 9 scenarios would give reduced risk (green)
- 6 scenarios would give a level of risk that may be higher or lower or similar, depending on particular variables such as weather conditions (amber)

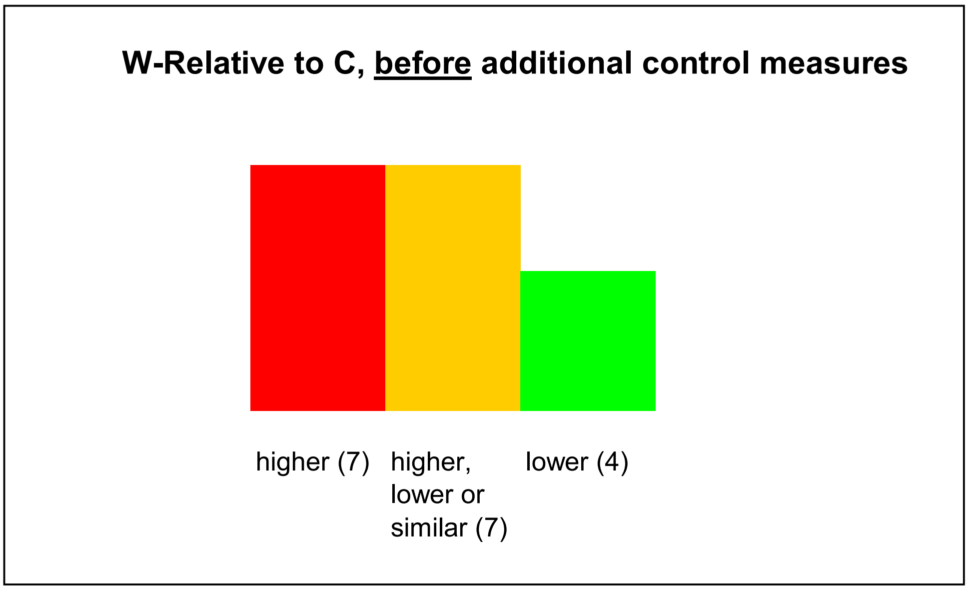


Figure 82: Relative Risk Before Additional Control Measures Applied

These are summarised in Figure 83 and a comparison of Figures 82 and 83 implies a reduction in relative risk (more green and less red) with still a significant number of risks which could be lower or higher (amber). It is therefore of interest to appeal to the numerical score derived from expert judgement.

Numerical Estimate of Residual Risk of Individual Scenarios

Where the incidents are applicable to both C-Class and W-Class ferries, the residual risk after both sets of the required control measures have been applied is assessed to be similar or slightly less than the equivalent C-Class assessment in all cases, but in scenario 2, the residual risk has been (cautiously) assessed as being higher than that for the C-Class, recognising the increased wind shadow of W-Class and a need for additional vigilance.

Scenario 13 is specific to the W-Class ferries, and, as mentioned in Sections 6.1.2 and 7.2.1 should be mitigated by procedural control and training in the short term, with consideration being given to a design modification in the longer term.

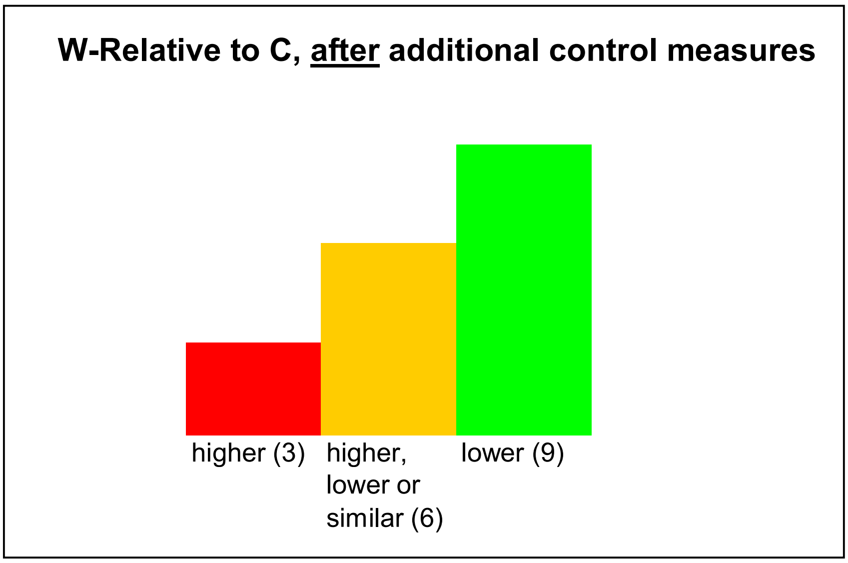


Figure 83: Relative Risk After Additional Control Measures Applied

Indication of Overall Residual Risk

The overall sum of the master mariners' numerical indications of the residual risk is used to indicate the level of overall risk by operating the W-Class ferries instead of the C-class. Overall summation of the indicators shows that the net effect is a slightly reduced level of overall marine safety risk on the river; the numerical values in the Summary Table, when summed, yield a value of -7. This may be compared with a value of -90 which would result if every scenario showed a significantly reduced residual risk (i.e. if each had a score of -5).

It should be noted that introduction of the W-Class vessels will result in reduced safety risk in open water. Compliance of the W-Class ferries with the latest IMO/MCA damage stability regulations means that the W-class is potentially much safer than the C-class for the Solent part of the route, and although this cannot be taken into account in respect of the evaluation of risk in the Lymington river, it is a risk-based consideration that acts in favour of operating the W-Class in place of C-Class ferries, and relates to potential events that are of the highest scale, potentially involving multiple fatalities and a catastrophic scale of loss.

It is concluded that, as the risks relevant to the river passage are similar, operating W-class ferries on the river should be at about the same level of (low) risk as the present operations with the C-class, on the assumption that the reasonable risk control measures recommended in Section 7.2 to secure ALARP are adopted by both the ferry operator and leisure users.

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)
	Operational scenario	Hazard and potential accident scenario description			
1	2 ferries passing at layby	Collision of 2 ferries, resulting in multiple injuries, grounding, blockage of navigation channel, loss of cargo	Lower	Lower	Lower
2	ferry transiting area with sailing vessels present	Loss of control/capsize as sailing vessel passes into ferry wind shadow in river; Loss of control/capsize as Junior sailors pass into wind shadow in Horn Reach	Higher	Same	Higher

Ref no.	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
1	Ferry damage stability and survivability to conform to IMO/MCA requirements; operation of the ferry to conform to ISM/STCW requirements Adhere to ColRegs, use Transit Marks in good visibility, also use the master's judgement as to whether to pass at all in bad visibility or strong winds	Use radar/ECDIS in poor visibility (6.1.6, 7.2.5, 7.2.8)	Lower	0		Low due to compliance with latest IMO/MCA damage stability regulations Collision on passing would occur only at layby area.
2	Keep clear of ferries as advised in LHC Harbour Guide; Compliance with ColRegs Juniors moved to sides of water space as ferry passes. (5.4.3, 6.3, 7.2.9)	Additional Harbour Master presence would reduce probability by stimulating good and compliant behaviour of leisure craft. Anticipate wind shadow (6.3, 7.2.9, Appendix 5)) Sail only vessels should have another means of propulsion (e.g. a paddle(s) for dinghies)	Higher	3	Junior sailing is moved clear of ferries, and this practice should continue	Low to medium due to greater windage. Low for Junior sailing

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	**Hazard and potential accident scenario description**				**Existing/ Planned Risk Control Measures for W-Class ferries**	**Required Additional Risk Control Measures to achieve ALARP**				
3	ferry transiting area with sailing vessels present	Small vessel sailing near waiting ferry loses wind due to wind shadow, could cause small boat to move towards the ferry and collide with it; could cause sailing vessel to capsize	**Higher**	**Same**	**Higher**	Keep clear of ferries as advised in LHC Harbour Guide; anticipate wind shadow (6.3, 7.2.9, Appendix 5)). Compliance with ColRegs Juniors moved to sides of water space as ferry passes. (5.4.3, 6.3, 7.2.9)	Sail only vessels Should have another means of propulsion (e.g paddle(s) for dinghies)	**Higher**	1		Low to medium due to higher windage
4	ferry transiting area with sailing vessels present	Too low a river speed results in reduction in control, ferry grounding, contact or collision Longer occupation of the river if speed low so greater chance of bunching and impeding sailing activities	**Same**	**Higher**	**Higher**	Ferry to maintain a safe speed (minimum whilst maintaining control). W-class hull design has low wash at river speeds W-class has better inherent controllability (6.1, 6.1.3, 6.2) maintain existing speed limits (6.8,7.2.6)	Use recommended thruster settings (7.2.2) Improve ferry/river communications	**Similar**	0		Low with existing advisory and mandatory speed limits
5	ferry transiting area with any *(commercial or leisure)* vessel underway or moored	Sinking/ swamping of other vessels (including moored vessels) due to wash Wash swamps/ inconveniences other vessels	**Lower**	**Higher**	**Could be Lower or Higher**	Control speed and adhere to limits, low wash hull form, use appropriate thruster settings, be aware of other users on the river. (6.2, 6.8, 7.2.2, 7.2.6)	Run at reduced power settings New handlers to have close and continuous supervision in winds and when manoeuvring close to leisure traffic or moored vessels Use of correct through-water speed for the conditions, use of recommended thruster speed settings, use of more power if necessary, training in high winds, especially from SW, E and S (6.1.3, 6.1.4, 7.2.2)	**Lower**	0		Low

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	Hazard and potential accident scenario description				Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
6	ferry transiting area with any vessel underway	Ferry capsizes rapidly in Solent (seaward of Jack in the Basket mark) after sustaining damage with heavy loss of life	Lower	Lower	Lower	Ferry damage stability and survivability to conform to IMO/MCA requirements; operation of the ferry to conform to ISM/STCW requirements	None	Lower	-3		
7	ferry transiting area with any vessel underway or moored	Boat (moored or moving) hit by ferry Restrictions on bridge field of view results in collision with leisure vessel	Similar	Similar	Similar		Stop single point mooring on inside of Cocked Hat Bend and western side of Short Reach Lay-by area; keep good lookout on ferries; ferries keep to middle of river when possible; keep clear of ferries (6.5.1, 6.5.2, 7.2.2, 7.2.12) Maintain lookout, use extent of bridge wings on ferries, check around ferry	Lower	0		Low

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	Hazard and potential accident scenario description				Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
8	ferry transiting area with any vessel underway	Collisions between or grounding of small craft because of lack of space during busy periods	Same	Same	Similar	All craft to comply with ColRegs (6.9) Small craft to adhere to Cops to limit boat numbers Small craft to keep out of the main channel if possible	Ferries to keep to centre of channel where possible and pass on Transit Marks. Extra HM patrols at busy times. Adopt greater use of sound signals to inform users (6.13, 7.2.8 and Appendix 8) Use Transit Marks for passing, adhere to ColRegs and Byelaws, use appropriate speed, use radar/ECDIS in poor visibility, keep good lookout, follow safety advice in LHC Harbour Guide. Follow guidance in MGN 199(M), harbour launch patrols, adhere to CoPs for organised events. (6.1.6, 7.2.5, 7.2.1, 7.2.8)	Similar	0	Physical signalling from open bridge wings is possible on C Class but not on W Class. However, signalling from focsle at either end is possible on W-class if access to foclse at true stern provided	Medium. The associated hazard probability is highest during low tide
9	ferry enters area where vessels are moored	Interaction pulls moored vessels into main channel and collision ensues	Same to Higher	Same to Higher	Higher	Maintaining effective lookout making full use of bridge wings Limit speed in accordance with the Byelaws and the advisory limit in Horn Reach	Ensure boats moored near the channel cannot swing into the path of passing ferries and other large vessels; be aware of ferry proximity and avoid moving on deck when ferry passes (6.5.2, 7.2.12). See also Ref 7 - vessels should not be moored on Cocked Hat bend.	Lower	-1		Low if Cocked Hat bend mooring measures applied, otherwise low to medium The associated hazard probability is highest during low tide and strong winds

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	Hazard and potential accident scenario description				Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
10	ferry is underway	Ferry loses power, resulting in grounding and blocking of river	Lower	Higher	Could be lower or higher	Ensure navigation marks correctly positioned; on ferry maintain lookout, ship handles well in river, echo sounder to be working, especially at low water; ferry proceeds with caution at low water; use visual tide height gauges on navigation posts; ensure river does not silt; regular surveys and make bathymetry plots available. (6.1.6, 7.2.11, Reference 1)	None	Could be Lower or Higher	0	Redundant, reliable machinery reduces likelihood of mechanical failure	Low
11	ferry is underway	Severe weather results in loss of control, damage to other vessels and damage to navigation posts	Lower	Higher	Could be Lower or Higher	W-Class has greater reserves of power and control Good ferry control, use radar and ECDIS; conspicuous and "handrail" visual navigation marks which clearly define the channel; masters to cease ferry operations if they consider situation unsafe; use appropriate thruster settings (6.1, 7.2.2, 7.2.11)	Use W-class safe operating procedures: - For winds up to a mean value 25knots, gusting 30, thrusters at "operational"/"full" forward and "idle"/"slow" aft - For winds greater than a mean value of 25 knots, gusting 30 to a mean value of 30 knots, gusting 42, thrusters at "operational"/"full" forward and "intermediate"/"half" aft - All wind speeds are to be measured at the RLymYC Starting Platform. - Masters' competence at higher wind limit should be the subject of a formal application by the operators demonstrating "river experience" - for example through evidence of transits and master "sign off" for adverse weather operation.	Could be Lower or Higher	-1	Use of ECDIS will reduce likelihood of contact and collision in fog	Low
12	ferry is underway	Grounding due to navigation marks being unrepresentative / main channel migration	Same	Same	Similar		Ensure navigation posts correctly located. (6.1.6, 7.2.11, Reference 1)	Similar	0		Low
13	ferry is underway	Grounding or collision due to loss of control during change of con location on bridge	Higher	Higher	Higher	N/A - Hazard is specific to W-Class	Use recommended handover procedures; training; recommend synchronising control positions in the long term. (6.1.2, 7.2.1) Only handle ships from central con	Higher	2		Medium at present reducing to low if synchronised control positions adopted

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	Hazard and potential accident scenario description				Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
14	ferry enters area where persons are in the water	Person in water hit by ferry	Same to Lower	Same	Lower	Keep clear of ferries as advised in LHC Harbour Guide; Ferries keep lookout with a minimum of 3 crew on bridge, two of which are lookouts in bridge wings. No swimming/diving in river	Ensure blind spot under bow checked before sailing and moving off (6.11, 7.2.1) Increased Harbour patrols, especially in the lower reaches and at times of peak leisure use	Lower	-4	The safeguards would be less effective after dark, when there is also likely to be reduced probability of persons being in the water Propulsion system is designed for rapid stops (by reversing thrust to avoid impact) Ferries able to stop rapidly under control; People in the water are considered to be at greatest risk from leisure craft	Low due to good visibility and surveillance cameras, but blind spot must be checked before sailing
15	ferry enters area where persons are in the water	Person in water sucked into thruster. This accident scenario requires that someone is in the water adjacent to the thrusters, and that they are then pulled towards the thrusters, and that they are then impacted by them.	Lower	Same	Lower	Thusters can be de-clutched on the W-Class ferries. Compliance with Notice to LHC Mariners 10 2008 further reduces the consequences of this accident (i.e. wear life-jackets)	Grab lines should be attached to the hull in the region of the bow, as is the case on the Voith-propelled Red Funnel vehicle ferries. (Para 6.11, para 7.2.13)	Lower	-1		Low
16	Ferry arrival / departure	Thrusters' slipstream impacts nearby leisure vessels	Lower	Higher	Could be lower or higher		Stop thrusters when berthed (6.10, Appendix 7, 7.2.3)	Lower	-2		
17	ferry transiting area with any vessel underway	Swamping of leisure craft impacted by aft thruster slipstream disturbance and sudden vectoring	Higher	Higher	Higher	ColRegs Keep clear of ferries as advised in LHC Harbour Guide (6.3.2, 7.2.4)	Use of appropriate power setting on aft thruster (6.1, 6.1.4, 6.2, 6.8, 7.2.2, 7.2.6)	Lower	1		Low if additional risk control measures applied, otherwise significantly higher

Ref no.	Hazard		Probability	Consequence	Relative Risk (See Appendix 10)	Risk Control Measures		Risk After (Further) Control Applied (relative to C-Class).	Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Notes on risks based on BMT's Master mariners' judgement	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L)
	Operational scenario	Hazard and potential accident scenario description				Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP				
18	ferry waiting at layby	Inconvenience to other craft; grounding of leisure craft	Higher	Higher	Higher	ColRegs Keep clear of ferries as advised in LHC Harbour Guide (6.3.2, 7.2.4)	No waiting in the river	Same	-2	No waiting in the river	Risk would be low if no waiting, otherwise medium in light winds and high in strong winds

Table 6: Summary Risk Register

7.4 Compliance with PMSC

This Section indicates compliance of the study with the requirements of the Port and Marine Safety Code (PMSC). The results of a comparison with the relevant requirements of the PMSC are shown in Table 7

Code Paragraph	Nature of Compliance
1.5.21	The study provides appropriate engineering advice for the port's Safety Management System
2.1.1D / 2.1.12	The recommendations of the study have been made with a view to assisting LHC in ensuring that all risks associated with the operation of W-class ferries on the Lymington/Yarmouth route are tolerable and as low as reasonably practicable.
2.1.10	The study has adopted a positive, analytical, approach by considering past events and accidents and examining potential dangers and the means of avoiding them.
2.1.11	The study has identified and assessed new hazards and changed risks
2.2.5 to 2.2.6	Information in this report and Reference 1 support the port's Safety Management System
2.2.13 and 2.2.14	Consultation has been carried out with the stakeholders listed in Appendix 9
2.2.15 to 2.2.17	Risks have been assessed and analysed using the existing operations in the river as a benchmark. (see Reference 1). Qualitative risk assessment has been used, with judgements informed by measurements and relevant nautical experience.
2.2.18	Suitable risk control measures have been recommended
2.4.3	The Collision Regulations have been considered in this study
2.7.11	Moored vessels have been considered in the study

Table 7

8. Conclusions and Recommendations

8.1 Conclusions

Due to concerns voiced in Lymington over the increased size and power of the W-class ferries proposed for the Lymington/Yarmouth route, a study has been carried out in connection with the safety of operations, and the resultant marine risk, on the river.

As a result of both phases of the measurement study and risk assessment, the following conclusions are drawn:

- The level of marine risk on the Lymington River is very low, with suitable risk management measures in place for operation of the C-class vessels in conjunction with sailing and other activities.
- The introduction of W-class ferries to replace the C-class will slightly reduce the overall level of risk to safety on the Lymington River, provided the risk control measures recommended in this report are adopted by the ferry operators and all users.
- Commercial ferries and leisure users have been able to co-exist on the river satisfactorily for a large number of years. However, the power

needed to operate the W-class ferries in strong winds has led to the recommendations in this report made to ensure that this co-existence will remain.
- The maximum tidal stream occurs in an ebbing spring tide and is of the order of 1.2 knots in the vicinity of the channel at the Pylewell Boom navigation post. Tidal streams in the Short Reach Lay-by are likely to be between 0.5 and 1.2 knots for about 16% of the cycle of a large spring tide, a tide which may occur less than 5% of the time when the river is likely to be busy (i.e. between 0800 and 2200) in the sailing season. Tidal streams in Horn Reach are unlikely to exceed 0.4 knots.
- The W-class vessel has a hull which creates low wash at the speeds used in the river. However its thrusters when used on the "operational" settings produce intolerable flow aft. To provide an acceptable wake, the aft thrusters must be run at the "idle" or "intermediate" settings, depending on wind speed, as defined in Section 7.2.2.
- Drawdown, and hence hydrodynamic interaction, squat, backflow and over-bank velocities are greater with the W-class than the C-class.
- The inherent manoeuvrability and control of the W-class are superior to those of the C-class both in the Lymington River and the Solent.
- More water space was used by the W-class in the familiarisation trials than the C-class. This was probably due in part to the fact that the crew were undergoing familiarisation trials while measurements were being made.
- The wind shadow of the W-class is greater than that of the C-class and its effects can be felt on the windward as well as the leeward side of the ship. That on the leeward side is stronger and there is more turbulence in the wind wake than on with the C-class
- Many sailors appeared to deal with the W-class wind shadow well when they were passing the W-class ferry. When the ferry is waiting, the wind shadow is more of a problem for small sailing craft.
- Slipstreams from the thrusters when the ferry is waiting in the Short Reach Lay-by in a strong beam wind are intolerable for leisure craft.
- Strong easterly winds combined with a peak ebb flow in the outer parts of Long Reach seaward of Post 6 may cause ferries to adopt drift angles (and hence use more water space) if the speed limit of 6 knots is adhered to. Higher ferry speeds or the use of more power on the thrusters would reduce drift angle in these circumstances. Trials showed that the W-class have less need to adopt large drift angles than the C-class as they have increased thruster power available.
- While visibility from the bridge is in general good, there is a blind spot under the loading ramp.
- Natural ambient waves in the river can be markedly higher than waves induced by the W-class ferries. The free wave systems of RIBs and some other leisure vessels on the river are often worse than those of the W-class.

8.2 Recommendations

Following from these conclusions, the following recommendations are made for safe W-class operation on the Lymington River.

- Adopt the Risk Control Measures described in Sections 7.2
- Ensure that waiting in the river does not occur, except in exceptional circumstances when the event should be entered in the deck log.

- Explore the possibility of synchronous control at all conning positions on the bridge of the W-class to avoid the need for the present handover procedure.
- All users to make more use of the ColRegs on the river as they are required to do.
- When the river is busy, increase the number of Harbour Master patrols to improve adherence by leisure users to the ColRegs.
- The ferries should make more use of the ColReg sound signals to communicate intent on the river.
- Ensure that the navigation posts on the river correctly mark the navigation channel.
- All vessels should comply with the existing advisory and mandatory speed limits. In the event that masters need to exceed the speed limit to safeguard the navigation of their own or other vessels, and to ensure compliance with Bye-law 4 and the ColRegs, this should be reported by exception in the ship's deck log.
- Ensure that the blind spot under the W-class bow ramp is checked before the ferry is allowed to sail and before getting under way after stopping in the river.
- Review the risk control measures on a regular basis (See PMSC paras 2.1.11 and 2.2.10) and modify as experience builds.

9. References

1. "Ferry Operations at Lymington, Phase 1: The Present Situation and Future Predictions" Report by BMT SeaTech Ltd for Project C13537, March 2008

2. Final trials schedule, Project C13537.01, BMT SeaTech Ltd, 23 July 2008

3. "Bathymetric Survey of Lymington Harbour" Shoreline Surveys Ltd, June 2008

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5. Dand, I W "Hydrodynamic Aspects of the Sinking of the Ferry 'Herald of Free Enterprise'" Transactions of the Royal Institution of Naval Architects, Vol 131, 1989, p145

6. "Approach Channels: A Guide for Design" Final Report of the Working Group of PIANC and IAPH, in co-operation with IMPA and IALA. Supplement to Bulletin 95, June 1997

10. Acknowledgements

Acknowledgement is made to the Lymington Harbour Master, Ryan Willegers, and his staff for all the assistance they gave throughout the study and to the various Wightlink masters, especially Captain Baker, for the help and assistance they provided during the trials and the round trips undertaken on C-class vessels by the BMT team. The help given by a number of stakeholders is also gratefully acknowledged, with particular thanks to all those who took part in the two sailing trials.

The BMT team comprised Capt John Noble, Capt Peter Marriott, Mr Julian Lockett and Dr Ian Dand who was also Project Manager.

APPENDIX 1

Terms of Reference for Phase 2

Lymington Harbour Commissioners

Terms of Reference for Ferry Operations Risk Assessment

Introduction.

This document is intended to provide a set of terms of reference for an independent consultant with relevant experience in marine risk assessment to be employed to undertake a full risk assessment of the operation of the new ferries proposed by Wightlink for the Lymington to Yarmouth route. The assessment shall include the verification of the ELP Report (December 2006), the provision of an appropriate agreed methodology for measuring impacts during live sea trials, and a risk assessment to define any necessary reasonably practicable risk mitigation measures that may be required to enable the LHC to meet the requirements of the Port Marine Safety Code. The work will require liaison with all river user groups. The exercise will necessarily be conducted in several parts.

Part 1. Review of Previous Study Work

As part of their own investigations, Wightlink have had two reports produced, one relating to the navigational characteristics of the new vessels within the river, and the second to consider possible environmental impacts.

The appointed consultant shall review the Navigation Report (Ref 1), and following a new analysis of the existing data, provide an opinion regarding the likely accuracy of its conclusions. This information (in combination with that developed from Part 2) will then be used to inform the Appropriate Risk Assessments in Part 3.

The framework for any further assessment of environmental impacts is currently being considered by the Marine Fisheries Agency, Natural England and the Environment Agency. We understand that these regulators are taking legal advice on how/if any further assessment should proceed. LHC will be guided by the outcomes of these considerations which must be set within the legal framework for assessing projects of this nature. Hydrodynamic data captured to help inform this study will be available to help inform environmental considerations.

Part 2. Provision of Methodology for Measuring Impacts during Live Sea Trials

LHC and Wightlink have developed a draft methodology (Annex 1) to quantify the present and potential future hydrodynamic effects of both the existing and proposed larger ferries through a series of “live” sea trials. The appointed consultant will be required to review this methodology and offer an opinion on whether it is fit for purpose, can reasonably be achieved, and where necessary provide reasoned recommendations for improvement. The appointed consultant will be responsible for sourcing the necessary equipment and for monitoring and recording the results of the trials in co-operation with LHC personnel. LHC will provide the necessary marine logistical support.

Part 3. Risk Assessment

The objective of Part 3 is firstly to attempt, based on the validated conclusions from Ref. 1, and further desk/field based work, to undertake a full risk assessment that will meet the requirements of the PMSC. This assessment will have regard for the safety of all craft using or moored on the river including the ferries themselves. The assessment will include (but not be limited to); an assessment of bridge operating procedures on the new vessels - to include an assessment of bridge visibility; an assessment of manoeuvrability; an analysis of historic incident records; an assessment of the impact of the hydrodynamic effects including some quantification of what those effects are (see Annex 1); an analysis of the navigation of the new vessels including the effect of windage, thruster power and direction when transiting the reaches of the river in all operating wind speeds and direction; an analysis of passing in the river; and an analysis of the effects of increased wind shadow on sail powered boats. Based on the assessment of risk, the consultant will need to identify reasonable and practical risk mitigation measures that may be required to enable LHC to meet the requirements of the PMSC. This may also require the suggestion of mitigation and control measures for leisure users.

Once the sea trials (Part 2) are complete, the consultant will be required to verify the earlier (desk based) risk assessments and proposed mitigation measures against the trial results. At this stage it may be necessary to modify the control measures predicted from the theoretical work.

Methodology

The consultant will be required to liaise in detail with all the interested user groups, to include (but not necessarily limited to) the Yacht Clubs, Rowing Club, Sea Scouts, Lymington Sailability and Wightlink. The objective of these meetings will be to allow the consultant to understand from each group what activities they consider are likely to be impacted by the proposed ferries. The Lymington Harbour Commissioners will also be represented at these discussions.

Reporting and Implementation

The Consultant will prepare a report for the consideration of LHC and a draft will be circulated to all participating groups for comment/discussion prior to publication of formal conclusions.

The final decision regarding any necessary mitigation measures will rest with LHC, in accordance with the Port Marine Safety Code.

Where appropriate, LHC will then seek to codify any new measures within existing or a revision of the Harbour Byelaws.

06/11/07 ver 3
Ref 1. Wightlink – Lymington Harbour Navigational Review
Report No. ELP-55272-1206-57219-Rev 1
Annex 1. Attach Risk Identification and Measurement Criteria.

APPENDIX 2

Original Trials Programme

ORIGINAL TRIALS PROGRAMME

In this Appendix the original trials programme is listed in its entirety. In the event, as discussed in the main report, it did not prove possible to adhere precisely to the planned programme due to weather, ship and crew availability, the need to train crew and the need to interleave the trials with the regular C-class service operating at the time.

It was the last of these that restricted the number of runs possible in a day and, in spite of the best efforts of the Wightlink masters, some waiting in the Solent was inevitable to avoid excessive disruption to the commercial services.

In addition to this, the trials programme was conducted at the end of the sailing season so that only a limited number of runs in river traffic could be carried out. As described in the main report, the runs that were done were supplemented with sailing trials carried out with the co-operation of the Lymington Town Sailing Club and the participation of the Royal Lymington Yacht Club.

In the event, it was accepted, after in excess of 80 trial runs, that sufficient data had been obtained. These were then supplemented with simulation runs and the experience of the BMT master mariners to make the required assessments, as described in the main body of the report.

Phase 2 Trials

Runs 116
Days 8
Runs/day 14.5

Speed : Shown for downstream (South) of breakwaters only. All Horn Reach Transits at 4 knots
Speed for Low Water Transit not set but determined on day based on low water conditions (will be limited by squat)

Trial	Day No	Ship Draught	Tide	Wind Speed	Wind Dirn	Trial v/l In/out?	Content	Speeds	Location	Waiting?	Passing?	Traffic?	Field Measure?
1	1	largest load	HW	calm	calm	out	Familiarisation runs for river; single ferry	4	Pylewell & Horn	no	no	none	wash, wind, tide
2	1	largest load	HW	calm	calm	in	Familiarisation runs for river; single ferry	5	Pylewell & Horn	no	no	none	wash, wind, tide
3	1	largest load	HW	calm	calm	out	Familiarisation runs for river; single ferry	6	Pylewell & Horn	no	no	none	wash, wind, tide
4	1	largest load	HW	calm	calm	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	6	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
5	1	largest load	HW	calm	calm	out	Familiarisation runs for river; single ferry	8	Long Reach & Pylewell	no	no	none	wash, wind, tide
6	1	largest load	HW	calm	calm	in	Familiarisation runs for river; single ferry	8	Long Reach & Pylewell	no	no	none	wash, wind, tide
7	1	largest load	mid	calm	calm	out	Familiarisation runs for river; single ferry	4	Pylewell & Horn	no	no	none	wash, wind, tide
8	1	largest load	mid	calm	calm	in	Familiarisation runs for river; single ferry	5	Pylewell & Horn	no	no	none	wash, wind, tide
9	1	largest load	mid	calm	calm	out	Familiarisation runs for river; single ferry	6	Pylewell & Horn	no	no	none	wash, wind, tide
10	1	largest load	mid	calm	calm	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	6	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
11	1	largest load	LWS	calm	calm	out	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
12	1	largest load	LWS	calm	calm	in	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
13	1	largest load	LWS	calm	calm	out	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
14	1	largest load	LWS	calm	calm	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	note	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
15	1	a load	HW	calm	calm	in or out	Emergency stop - C	6	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
16	1	a load	mid	calm	calm	in or out	Emergency stop - C	6	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
17	1	a load	LWS	calm	calm	in or out	Emergency stop - C	note	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
18	2	largest load	HW	calm	calm	out	Passing C / W Class	4	Pylewell only	no	yes	none	v,wnd,tde,track + space,
19	2	largest load	HW	calm	calm	in	Waiting & Passing C / W Class	n/a	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
20	2	largest load	HW	calm	calm	out	Passing C / W Class	5	Pylewell only	no	yes	none	v,wnd,tde,track + space,
21	2	largest load	HW	calm	calm	in	Passing C / W Class	6	Pylewell only	no	yes	none	v,wnd,tde,track + space,
22	2	largest load	mid	calm	calm	out	Passing C / W Class	4	Pylewell only	no	yes	none	v,wnd,tde,track + space,
23	2	largest load	mid	calm	calm	in	Waiting & Passing C / W Class	n/a	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
24	2	largest load	mid	calm	calm	out	Passing C / W Class	5	Pylewell only	no	yes	none	v,wnd,tde,track + space,
25	2	largest load	mid	calm	calm	in	Passing C / W Class	6	Pylewell only	no	yes	none	v,wnd,tde,track + space,
26	2	largest load	LWS	calm	calm	out	Passing C / W Class	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,
27	2	largest load	LWS	calm	calm	in	Waiting & Passing C / W Class	n/a	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
28	2	largest load	LWS	calm	calm	out	Passing C / W Class	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,
29	2	largest load	LWS	calm	calm	in	Passing C / W Class	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,
30	3	largest load	HW	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	4	Pylewell & Horn	no	no	none	wash, wind, tide
31	3	largest load	HW	BF5 to 6	SW	in	Familiarisation runs for river; single ferry	5	Pylewell & Horn	no	no	none	wash, wind, tide
32	3	largest load	HW	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	6	Pylewell & Horn	no	no	none	wash, wind, tide
33	3	largest load	HW	BF5 to 6	SW	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	6	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
34	3	largest load	mid	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	4	Pylewell & Horn	no	no	none	wash, wind, tide
35	3	largest load	mid	BF5 to 6	SW	in	Familiarisation runs for river; single ferry	5	Pylewell & Horn	no	no	none	wash, wind, tide
36	3	largest load	mid	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	6	Pylewell & Horn	no	no	none	wash, wind, tide
37	3	largest load	mid	BF5 to 6	SW	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	6	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
38	3	largest load	LWS	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
39	3	largest load	LWS	BF5 to 6	SW	in	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
40	3	largest load	LWS	BF5 to 6	SW	out	Familiarisation runs for river; single ferry	note	Pylewell & Horn	no	no	none	wash, wind, tide
41	3	largest load	LWS	BF5 to 6	SW	in	Familiarisation runs for river; single ferry + Long Reach emergency stop	note	Pylewell & Horn	no	no	none	speed, trk rch, wind tide
42	3	a load	HW	BF5 to 6	SW	in or out	Emergency stop - C	6	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
43	3	a load	mid	BF5 to 6	SW	in or out	Emergency stop - C	6	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
44	3	a load	LWS	BF5 to 6	SW	in or out	Emergency stop - C	note	Pylewell	N/A	N/A	none	speed, trk rch, wind tide
45	4	largest load	HW	BF5 to 6	SW	out	Passing C/W	4	Pylewell only	no	yes	none	v,wnd,tde,track + space,
46	4	largest load	HW	BF5 to 6	SW	in	Waiting & Passing C/W	n/a	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
47	4	largest load	HW	BF5 to 6	SW	out	Passing C/W	5	Pylewell only	no	yes	none	v,wnd,tde,track + space,
48	4	largest load	HW	BF5 to 6	SW	in	Passing C/W	6	Pylewell only	no	yes	none	v,wnd,tde,track + space,
49	4	largest load	mid	BF5 to 6	SW	out	Passing C/W	4	Pylewell only	no	yes	none	v,wnd,tde,track + space,
50	4	largest load	mid	BF5 to 6	SW	in	Waiting & Passing C/W	n/a	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
51	4	largest load	mid	BF5 to 6	SW	out	Passing C/W	5	Pylewell only	no	yes	none	v,wnd,tde,track + space,
52	4	largest load	mid	BF5 to 6	SW	in	Passing C/W	6	Pylewell only	no	yes	none	v,wnd,tde,track + space,
53	4	largest load	LWS	BF5 to 6	SW	out	Passing C/W	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,
54	4	largest load	LWS	BF5 to 6	SW	in	Waiting & Passing C/W	note	Pylewell only	yes	yes	none	jet vels, wind, tide, eddy
55	4	largest load	LWS	BF5 to 6	SW	out	Passing C/W	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,
56	4	largest load	LWS	BF5 to 6	SW	in	Passing C/W	note	Pylewell only	no	yes	none	v,wnd,tde,track + space,

Trial	Day No	Ship Draught	Tide	Wind Speed	Wind Dirn	Trial v/l In/out?	Content	Speeds	Location	Waiting?	Passing?	Traffic?	Field Measure?
57	5	largest load	HW	calm	calm	out	Familiarisation runs for river plus passing C/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
58	5	largest load	HW	calm	calm	in	Familiarisation runs for river plus passing C/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
59	5	largest load	HW	calm	calm	out	Familiarisation runs for river plus passing C/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
60	5	largest load	HW	calm	calm	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
61	5	largest load	mid	calm	calm	out	Familiarisation runs for river plus passing C/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
62	5	largest load	mid	calm	calm	in	Familiarisation runs for river plus passing C/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
63	5	largest load	mid	calm	calm	out	Familiarisation runs for river plus passing C/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
64	5	largest load	mid	calm	calm	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
65	5	largest load	LWS	calm	calm	out	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
66	5	largest load	LWS	calm	calm	in	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
67	5	largest load	LWS	calm	calm	out	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
68	5	largest load	LWS	calm	calm	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
69	6	largest load	HW	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
70	6	largest load	HW	BF5 to 6	SW	in	Familiarisation runs for river plus passing C/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
71	6	largest load	HW	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
72	6	largest load	HW	BF5 to 6	SW	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
73	6	largest load	mid	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
74	6	largest load	mid	BF5 to 6	SW	in	Familiarisation runs for river plus passing C/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
75	6	largest load	mid	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
76	6	largest load	mid	BF5 to 6	SW	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
77	6	largest load	LWS	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
78	6	largest load	LWS	BF5 to 6	SW	in	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
79	6	largest load	LWS	BF5 to 6	SW	out	Familiarisation runs for river plus passing C/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
80	6	largest load	LWS	BF5 to 6	SW	in	Familiarisation runs for river plus waiting & pass C/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
81	7	largest load	HW	calm	calm	out	Passing W/W	4	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
82	7	largest load	HW	calm	calm	in	Passing W/W	6	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
83	7	largest load	HW	calm	calm	out	Familiarisation runs for river plus passing W/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
84	7	largest load	HW	calm	calm	in	Familiarisation runs for river plus passing W/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
85	7	largest load	HW	calm	calm	out	Familiarisation runs for river plus passing W/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
86	7	largest load	HW	calm	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
87	7	largest load	mid	calm	calm	out	Passing W/W	4	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
88	7	largest load	mid	calm	calm	in	Passing W/W	6	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
89	7	largest load	mid	calm	calm	out	Familiarisation runs for river plus passing W/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
90	7	largest load	mid	calm	calm	in	Familiarisation runs for river plus passing W/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
91	7	largest load	mid	calm	calm	out	Familiarisation runs for river plus passing W/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
92	7	largest load	mid	calm	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
93	7	largest load	LWS	calm	calm	out	Passing W/W	note	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
94	7	largest load	LWS	calm	calm	in	Passing W/W	note	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
95	7	largest load	LWS	calm	calm	out	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
96	7	largest load	LWS	calm	calm	in	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
97	7	largest load	LWS	calm	calm	out	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
98	7	largest load	LWS	calm	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
99	8	largest load	HW	BF5 to 6	calm	out	Passing W/W	4	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
100	8	largest load	HW	BF5 to 6	calm	in	Passing W/W	6	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
101	8	largest load	HW	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
102	8	largest load	HW	BF5 to 6	calm	in	Familiarisation runs for river plus passing W/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
103	8	largest load	HW	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
104	8	largest load	HW	BF5 to 6	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
105	8	largest load	mid	BF5 to 6	calm	out	Passing W/W	4	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
106	8	largest load	mid	BF5 to 6	calm	in	Passing W/W	6	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
107	8	largest load	mid	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	4	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
108	8	largest load	mid	BF5 to 6	calm	in	Familiarisation runs for river plus passing W/W	5	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
109	8	largest load	mid	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	6	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
110	8	largest load	mid	BF5 to 6	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)
111	8	largest load	LWS	BF5 to 6	calm	out	Passing W/W	note	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
112	8	largest load	LWS	BF5 to 6	calm	in	Passing W/W	note	Pylewell only	no	yes	Controlled	v,wnd,tde,track + space,
113	8	largest load	LWS	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
114	8	largest load	LWS	BF5 to 6	calm	in	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
115	8	largest load	LWS	BF5 to 6	calm	out	Familiarisation runs for river plus passing W/W	note	Pylewell & Horn	no	yes	yes	wash, wind, tide (observe effects & space)
116	8	largest load	LWS	BF5 to 6	calm	in	Familiarisation runs for river plus waiting & pass W/W	n/a	Pylewell & Horn	yes	yes	yes	wash, wind, tide (observe effects & space)

APPENDIX 3

Simulation Model

PCOD: A SIMULATION MODEL FOR SHIPS PROPELLED BY PODDED PROPULSORS OR VOITH THRUSTERS

A3.1 INTRODUCTION

PCOD is a PC-based Ship Manoeuvring Simulation Model developed in-house at BMT SeaTech Ltd. Originally developed to simulate the behaviour of ships fitted with podded propulsors, it has been modified to deal with a double-ended ferry fitted with Voith cycloidal propulsors fore and aft. Making use of a number of computer models arising from basic research carried out by the Company into the behaviour of ships in deep and shallow water, it has been used to help illuminate a number of points regarding the dynamic behaviour of ferries proposed for the Lymington/Yarmouth route. This appendix focuses on the Voith application, relevant to the W-class Wightlink ferries.

A3.2 THE SIMULATION MODEL

The simulator itself uses a four-degree of freedom model shell for ship dynamics which allows for

- variations in ship type
- variations in water depth
- the effects of wind, waves and current
- bank effects
- tug action
- mooring line and fender forces
- variations in tide height.

Its modular construction allowed separate hull and Voith thruster models to be developed and combined for a number of simulated runs in the Lymington River.

A3.3 OPERATION

The simulation model was run in an interactive mode with control of both thrusters. Control was via a mouse and allowed the thrust vector and power (i.e. the eccentricity) of each thruster to be varied as required. Both thrusters could be ganged together if required, or operated individually.

Key information such as heading, rate of turn and speed through the water is displayed on the screen. The track of the ship is shown in plan on the screen with the channel and a number of salt-marshes indicated, together with representations of the local coastlines. Aids to navigation are shown on the screen, together with the leading lines from the two pairs of transit marks.

Along the track of the ship, tidal heights and streams as well as wind speed and direction vary both temporally and spatially.

Figure A3.1 shows the screen in which the plan view of the area and the control panel can be seen. A zoom facility allows close-up views of selected parts of the play area to be used during a simulation run.

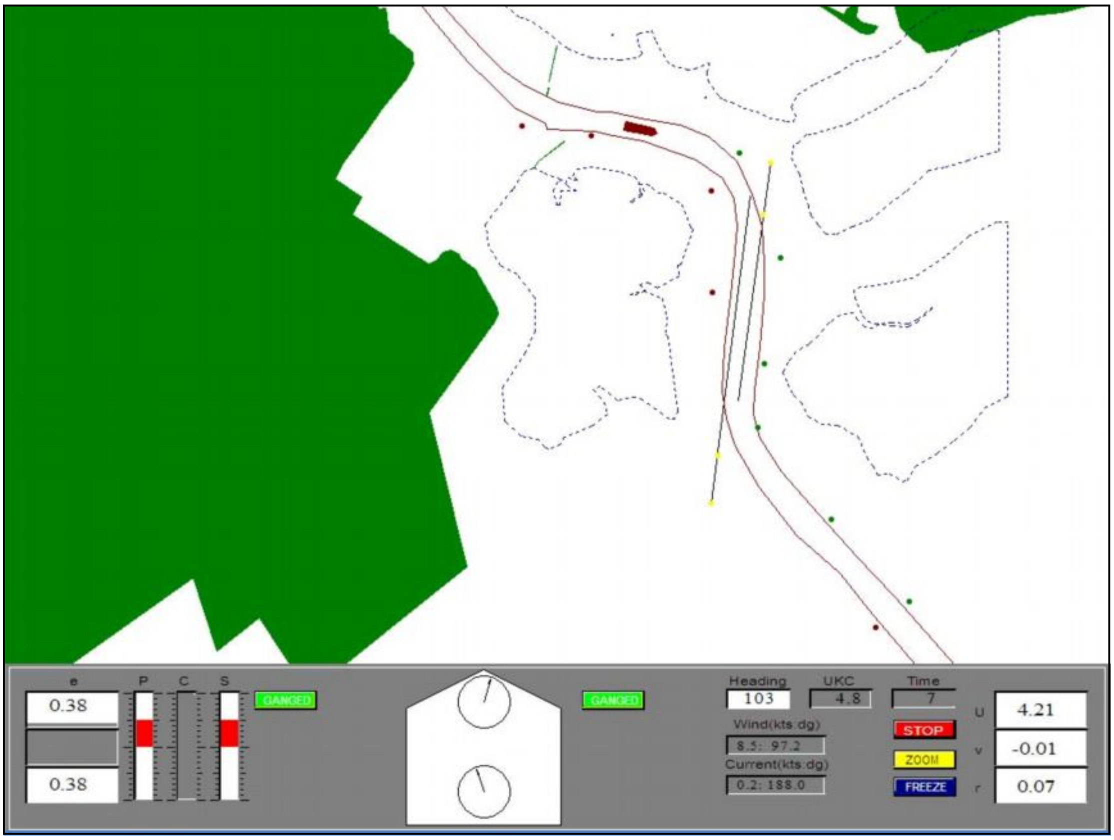


Figure A3.1: PCOD Simulation Screen Display

A3.4 MODELLING AND VALIDATION

Hull hydrodynamics were modelled from a representation of the hull in a Body Build Up program developed at BMT SeaTech. This uses known force coefficients for a number of body shapes and orientations to the flow and provided an initial estimate of the forces and moments acting on the hull as it moved through the water in the three degrees of freedom of surge, sway and yaw. This information was then fitted to the regression model used in the basic PCOD model and modified to match the tracks determined from the ECDIS system on board the W-class ferry. For rotary motion, a match was obtained against pure rotation manoeuvres carried out on a W-class ferry in the Solent. Adjustments for the effects of shallow water were made using in-house data derived from research based on model experiments carried out by BMT.

Basic information for the characteristic performance curves for cycloidal (Voith) thrusters was obtained from References A3.1 to A3.3. The eccentricity of each thruster was adjusted on the screen using the controls at the left-hand side of the control panel (see Figure A3.1) and effectively changed the speed of the vessel. To turn, the azimuth angles of the thrust vectors were controlled by dragging the vector arrows in the mimic diagram in the centre of the control panel; the thrusters were ganged or not according to the button sitting to the right of the mimic. Similarly the eccentricity of the thrusters could be adjusted together or separately according to the button sitting close to the eccentricity controls.

A standard diesel engine model was used, with its controller set to give constant rotor baseplate rotation, in “idle”, “intermediate” or “operational” modes as required.

A3.5 REFERENCES

A3.1 Van Manen, J D: "Ergebnisse systematischer Versuch mit Propellern mit annähernd senkrecht stehender Achse" Jahrbuch der Schiffbau-Technischen Gesellschaft, 1963, pp 377 to 397

A3.2 "Principles of Naval Architecture", The Society of Naval Architects and Marine Engineers (SNAME), New York, 1967, Chapter VII, pp 431 to 433.

A3.3 Mueller, H F: "Recent Developments in the Design and Application of the Vertical Axis Propeller" Transactions SNAME, 1955, pp 4 to 30

APPENDIX 4

Final Schedule of Phase 2 Trials

FINAL SCHEDULE OF PHASE 2 TRIALS

This Appendix contains the final schedule of the Phase 2 Trials after discussion with stakeholders.

1. Introduction

This note outlines suggested Phase 2 trials for the new W-class ferries. It also includes, where necessary, measurements on any C-class vessels which will be operating on the river at the same time.

2. Suggested Trial Outlines

The trails are now outlined in broad terms.

2.1 Handling (no traffic)

- Behaviour without traffic on an ebbing spring tide in calm water at HW, mid tide and LW; no passing or waiting; inbound and outbound (perhaps in the early morning or, if this is not possible, mid-week afternoons – excluding Mondays – from September)
- Behaviour without traffic on an ebbing spring tide with wind (ideally SW) at HW, mid tide and LW; no passing or waiting; inbound and outbound (early morning or, if this is not possible, mid-week afternoons – excluding Mondays – from September)
- Speeds through water should go up to 8 knots to allow for effect on wash to be determined which should help in deciding on whether speed limits/monitoring should be based on OG or TW speeds.
- Measure (at Pylewell, Horn Reach and below No 6 Mark):
    - Wash and drawdown,
    - tidal stream - and other flow velocities, such as thruster slipsteams, in river (if possible),
    - speed (OG and TW),
    - Heading, lat/long, thruster settings (rpm and angle)
    - Wind speed and direction on Pylewell Boom, Cocked Hat, Harpers and the Red (off RLYC) posts. A limited number of later trials will be located at Number 6 post. These wind measurements will be supplemented by hand-held anemometers in the Harbour Master's launch, together with vessel proximity measurements, all of which will give some information on wind shadow effects
    - Atmospheric pressure, wind speed, wind direction and tide height from Coastal Observatory, and other, web sites

- Observe:
    - Handling, especially on bends
    - Handling and speed at low water
    - Low speed handling in cross wind
    - Bank effects
    - Local flow in river
    - Master's feedback
    - Visibility from wheelhouse
    - Thruster effects

2.2 Handling (with traffic)

- As for 2.1 but with normal sailing traffic in river, obeying the ColRegs, Harbour Byelaws and the LHC Harbour Guide. Still with no passing in river until the master is confident in his handling of the vessel. (Note that LWS tides are too early or too late through the summer season for peak traffic levels to occur)
- Observe behaviour of small boats near the ferries and the effect of the ferries, both C and W classes, on them

2.3 Passing

In these trails W-class/C-class and W-class/W-class passing would be studied. Ships would pass with and without sailing traffic and would use the leads in Short Reach as at present. Measurements would be made at Pylewell and all the parameters mentioned in Section 2.1 would be obtained. Special attention will be paid to low water manoeuvres.

Observations will be made of those items mentioned in 2.1, with, in addition:

- Ship behaviour on C-class/C-class passing, to see if ship-ship interaction effects are felt. This would be used as a base case and would supplement observations already made.
- Ship behaviour on W-class/W-class passing, to see if ship-ship interaction effects are felt.
- Ship behaviour on W-class/C-class passing, to see if ship-ship interaction effects are felt and, if so, whether they differ from those in W-class/W-class passing.
- Ship behaviour when a strong cross wind blowing.
- River disturbance, after passing especially at low water springs.
- Any wave breaking on banks on recovery after passing drawdown.
- Additional master's feedback on behaviour when passing. Their views on the adequacy of the channel width for passing would also be sought.
-

2.4 Stopping

In these tests an emergency stop would be carried out in the river with both the C-class and W-class vessels. For the W-class this should pose few problems in principle because there would be only a trials crew on board, but on the C-class arrangements would have to be made to ensure there are either no passengers on board, or all passengers have been suitably briefed and will not be injured during the stop. This trial could take place when a C-class ship does its safety drill.

As usual this trial should be done on the spring ebb, if possible, at HW, mid tide and LW, with and without a cross wind. It is suggested that it would best be done with no traffic in the river, for safety reasons. (Unless, of course, the manoeuvre has to be made in earlier trials with traffic, as the result of a real emergency.)

This trial would be carried out in Short Reach only with a start speed of about 6 knots through the water or, for low tide conditions, at the maximum safe speed. Some trials should be done with only one thruster operating from a lower initial speed.

- Measure (mainly on board):
  - speed (OG and TW),
  - Heading, lat/long, thruster settings (rpm and angle, if possible)

- Observe:
  - Ship behaviour, especially during stopping (does it remain under control?) and when drifting after stopping. Note how well the ships are able to hold station after stopping, especially in a cross wind.
  - Deceleration severity
  - Master's feedback

2.5 Waiting

These trials should be done because there will be occasions when waiting has to occur, in spite of the requirement to avoid waiting. Waiting trials at low water will be of special significance because they should be able to confirm if waiting must be avoided because of the limited space available, the local disturbance the ferry makes in the river and the longer term disturbance resulting from any low speed eddies that are set up.

Such trials will also provide an opportunity to measure flows local to the vessel, especially those caused by the thrusters. Ideally, measurements of thruster slipstreams should be done when traffic numbers in the river are low because it would be useful for the river trials crew boat to be unimpeded in order to be able to get in close to the waiting ferry to measure flows etc.

These trails should be done in both calm water at low, mid and high water conditions in a strong cross wind and should include both W- and C-class vessels.

- Measure:
  - Speed (OG and TW)
  - Heading, lat/long, thruster settings
  - Flow downstream of thrusters (flow markers?)
  - Flow upstream of thrusters (suction?)
  - Wind "shadow" effect, if waiting can be carried out near one of the fixed anemometers. A hand-held anemometer would also be used and proximity of the ferry to the Harbour Master's (trials) launch would be measured.
  - Space available around ferry (from track reconstructions)

- Observe:
  - Space available round ferry, particularly at low water springs
  - Disturbance in river downstream
  - Ferry movements
  - Ease of control when holding station
  - Master's views
  - Thruster effects

2.6 General

2.6.1 Timings

While on board the ferry, it would be useful to keep a record of the timings as the vessel passes known locations during each trip. This was done for a few runs on the C-class vessels, the timings and locations from Lymington being

- Ramp up time
- Time leaving terminal, as the ship starts to move.
- Time passing wave screen
- Time passing Pylewell
- Time passing starting platform
- Time stopping at Yarmouth
- Ramp down time

2.6.2 Trials Draught

It would seem to be appropriate to run the trials vessel at a fixed draught throughout. It is therefore proposed to run all trails at a realistic maximum load condition, likely to be met in service. This may or may not correspond to the value of 2.3 metres used as a basis in Phase 1, but would have to be achievable and maintainable for the duration of the trials.

It would be determined from the ships' hydrostatic particulars once

- The actual lightship weight is known accurately
- The realistic maximum load has been determined from operational information

It is suggested that BMT, Hart Fenton and Wightlink work jointly to determine this condition. This could possibly involve an assessment of actual freight vehicle loads compared to their stated manifests.

Such a load condition would provide a severe, but realistic, test of wash, drawdown, backflow, handling, stopping, station-keeping while waiting, and passing when in service.

2.6.3 Logistics Matters

It would be useful to have a de-briefing for the trials crew, and it will be necessary to download data from the measurement sites on both the river and the trials vessel, at the end of each trials day. Access to the sites on the river is straightforward, but access to the W-class ferries may not be, unless they are able to berth at Lymington without using the linkspan. If the linkspan is out of action due to shore-works, presumably the normal ferry service will be operated, using C-class vessels, from the slipway. Would the W-class be able to berth alongside the layby berths or would this sterilise slipway access?

As mentioned above, the W-class should be run at a loaded condition for all the trials and another condition for some. It is assumed that a suitable load can be obtained (and maintained) for the duration of the trials to provide the necessary draughts.

2.6.4 Speed near Entrance to River

It is proposed to run a number of speeds in Long Reach below No 4 Mark, near the entrance to the river in the belief that by so doing information will be obtained which will be useful in determining operational aspects associated with avoidance of waiting in the river. Wash and drawdown will be measured at No 4

Mark and wash will be compared with natural waves and the vessel impacts in this location.

2.6.5 Stakeholders' Concerns

It is believed that the trials as outlined above will cover the remaining safety concerns of the river users. In summary these are:

- *Wind Shadow Effects*. These will be covered by use of an anemometer suitably located on a navigation post close to the ferry track which will measure changes in wind speed and direction as the ferry goes past. Naturally such measurements will be dependent on the wind on the day and it is to be hoped that the SW or WSW winds will prevail because it is believed that these winds, on the beam in the lower reaches of the river, will provide the severest test of wind shadow effects. (Weather forecasts will be used in advance of trials to determine suitable conditions). Any other wind directions will naturally be included as they arise. These trials will be supplemented with an independent assessment on the water by an experienced sailor. The use of wind tunnel tests is not believed to be justified on the grounds that without a suitable criterion for the effect of wind shadow it will be difficult, if not impossible, to use the results obtained in a way meaningful for the risk assessment. It is also believed that the expense of such tests, their analysis and interpretation, will not be justified on the ALARP principle. The proposed trials measurements, together with experience of wind shadows in a sailing boat on the water, will be used to make a judgement as to the extent of risk to which small sailing boats will be exposed with both C- and W-class ferries. Particular attention will also be paid to the effect of wind shadow on each ferry during a passing manoeuvre, with especial interest in W-Class/W-Class passing.
- *Thruster Effects on Safety*. It is proposed to measure thruster efflux effects on both sides of the ferry during the waiting trials. These will be done as close to the ferry as possible, consistent with safety requirements. Some attempt will be made to measure flow effects while the ferries are on the move, but safety considerations may rule out measurements close to them.
- *Handling and Water Space during Passing*. Passing trials will receive close attention, especially at low water. As a result of these a decision will be made regarding the safety of W-class passing at certain states of the tide. Use of the on-board measurements should enable track reconstructions which will indicate track envelopes in the river.
- *Emergency Stopping*. This is the subject of a particular trials segment.
- *General Handling Behaviour*. An independent BMT master mariner will be on the bridge for all trials to provide an independent assessment of the way the W-class behave in the river and any effects this may have on risk. Particular attention will be paid to times of traffic congestion.
- *Junior Sailing.* Verify that operating speeds in Horn Reach do not need to vary from the current practice and verify the prediction of no impact on Junior Sailing which would have arisen if a speed limit lower than 4 knots had become necessary. Increased adverse impact may still arise from wind shadow and side thrust, part of the general risk assessment of the interaction between the ferries and all small boat users.

3. Deliverables

In this section, an indication is given of the deliverables on completion of the Phase 2 trials. In essence it is a first draft of the contents to be expected in the final Phase 2 report, but, as these may change depending on the outcome of the trials, this must of necessity be regarded as preliminary and subject to change.

3.1 Preliminary Table of Contents for Phase 2 Final Report

1. Introduction
2. Aims and Scope
3. Summary of Phase 1 Findings
Brief recap of the Phase 1 findings, conclusions and recommendations.

4. Purpose of the Trials
Discussion on what the trials were aimed at achieving, within the ALARP principle.

5. The Phase 2 Trials
5.1 Scope
What was included and why, what was not included and why
5.2 Planned and Achieved Schedule
The reason for this section is that it will indicate the effects of the weather obtained on the trials compared to that desired, the amount of traffic encountered and the problems faced.
5.3 Measured Parameters
Description of the parameters measured, the location of the probes, the measuring apparatus used and any corrections/calibrations used.
5.4 Operational Aspects of the Trials
Trials ship condition, de-briefings (purpose and execution), safety issues, bridge team,
5.5 Metocean Conditions Experienced
Winds, currents, tides, natural wave activity – typical measurements etc
5.6 User Operations
Purpose, operations, methodology

6. Results Obtained
6.1 Behaviour of W-class Ferries
Handling, passing, waiting, stopping, comparison with C-class; subjective impressions and measurements, masters' feedback, users' feedback, independent consultants' feedback, track envelopes
6.2 Wash and Drawdown
Comparison with C-class and natural waves, effect of TW ferry speed, effect of distance off, amount of drawdown on banks, compare with wash of other craft
6.3 Wind Shadow Effects
Measurements and subjective impressions from users and consultants, obtained from the river and on-board the ferry. Effects on the ferries as well as on small craft
6.4 River Space Availability with W- and C-Class
Track envelopes superimposed on chart/bathymetry plots, assessment
6.5 Effects on Moored Vessels
Subjective impressions, observations and video records
6.6 Effects of Tidal State
Shallow water effects
6.7 Effects of Ferry Draught/Loading

Assessment of effect of draught on squat, drawdown and wash. Effect on stopping of increased displacement - and increased resistance to go with it. All these effects discussed in relation to water depth effects.

6.8 Effects of Speed

Include discussion on ferry speed monitoring, speed of other river users.

6.9 Effects of Traffic

Impressions of bridge team, impressions of users, impressions of trials team on the river, video/photographic examples. Traffic mix and numbers observed. Ferry schedules and timings.

6.10 Hydrodynamic Disturbance in the River

Slipstream measurements, convection of slipstream downstream, eddies etc

6.11 Behaviour on the River

Adherence to ColRegs, ferry handling and behaviour, leisure craft handling and behaviour.

7. Discussion

7.1 Marine Risk with the W- and C-Class Ferries

General discussion of the extent to which marine risk on the river is affected by the introduction of the W-Class ferries. Show how conclusions fit in with Port and Marine Safety Code. Perceived risk.

7.2 Risk Register Re-Visited

Discussion of the Phase 1 Risk Register, risk by risk, with amendments and additions where necessary

7.3 Safe Operations on the River with the W-Class Ferries

Speed monitoring, operations in Horn Reach (WJS etc), recommendations of any restrictions/rules necessary to manage risk.

8. Conclusions and Recommendations

9. References

10. Appendices

3.2 Other Deliverables

Copies of videos and photographs taken during the trials will be made available to LHC, collected and stored on suitable media. If required, the raw data can be made available, or obtained from BMT SeaTech Ltd on request.

Ian W Dand
23 July 2008

Regarding trials below Number 6 Mark, a run at 8 knots was carried out in Long Reach and no adverse wash effects were noted. It was decided that, once below Post 4 the ferry is effectively in the open Solent and there was little point in measuring drawdown there. Consequently it was decided, in consultation with LHC, not to proceed further with the measurements below Post 6 mentioned in 2.1 above. (IWD, 9/2/09)

APPENDIX 5

Field Measurements and Equipment

FIELD MEASUREMENTS AND EQUIPMENT

A5.1 INTRODUCTION

In this Appendix, field measurements made on board and on the river are presented and discussed, as is the instrumentation used in their capture.

A5.2 EQUIPMENT

The following instrumentation and software was common to both Phases of the study and has been described in Reference 1 of the main report; it will not be discussed further here.

- Capacitive water level probes and analysis software
- Acoustic doppler current profiler (ADCP)

The following equipment was used in addition to that used in Phase 1:

- Propeller-type hand-held current meter
- ECDIS system on-board W-class ferries Wight Light and Wight Sky
- GPS system on board C-class ferry Caedmon
- Wind anemometers on Navigation Posts
- AIS speed monitoring system in Harbour Office
- Sundry hand-held devices including still and video cameras, an anemometer and radar gun, all used from on-board the ferry, one of the Harbour Master's launches or a Harbour Master's RIB.

These are described briefly in turn.

Propeller-type Hand-held Current Meter

This comprised a strut-mounted propeller which rotated in any flow into which it was placed. Rotations were sensed by the passage of a small magnet in a housing on the propeller shaft past a sensor on the support strut. The resulting pulses were counted over a known time period on a digital counter.

The original support strut was made of plastic and proved to be unsatisfactory. Its lack of rigidity was dealt with by replacing it with a steel tube just over a metre in length. To this was added a splitter plate some 5 tube diameters in chord to reduce the drag arising from the vorticity shed by the cylindrical strut, thereby making it easier to hold by hand. (See Reference A5.1). The strut terminated at its upper end with a hand-grip which allowed control of the incidence angle of the propeller to the flow. This was done by slowly rotating the strut until the minimum drag/lift angle was found.

The length of the strut was determined by the ability to hold it steady in some of the disturbed flows in which measurements were made, but it was nevertheless considered adequate to cover the area of flow of most interest to the study:

- that encompassing the hulls of many of the smaller leisure craft most likely to be affected by the ferries and also
- that encompassing much of the submerged torso of anyone in the river.

In the measurement of flow, both in the thruster slipstreams and in peak ebb tides near the bank at the Cocked Hat bend, counts over thirty seconds were used. For the peak flow measurements of backflow in the inter-tidal regime, a 10 second period was used.

Flow velocities, in metres per second, were computed from the calibration supplied with the current meter, assumed to have been unaffected by the strut modifications. No opportunity arose during the trials period to re-calibrate.

W-class ECDIS System

A Raytheon ECDIS (Electronic Chart and Display System) is carried on each W-class ship. It consists of two monitor screens on the bridge, one displaying a heading relative to the Lymington/Yarmouth leg while the other displays the heading for the return leg. A typical screen display is shown in Figure A5.1.

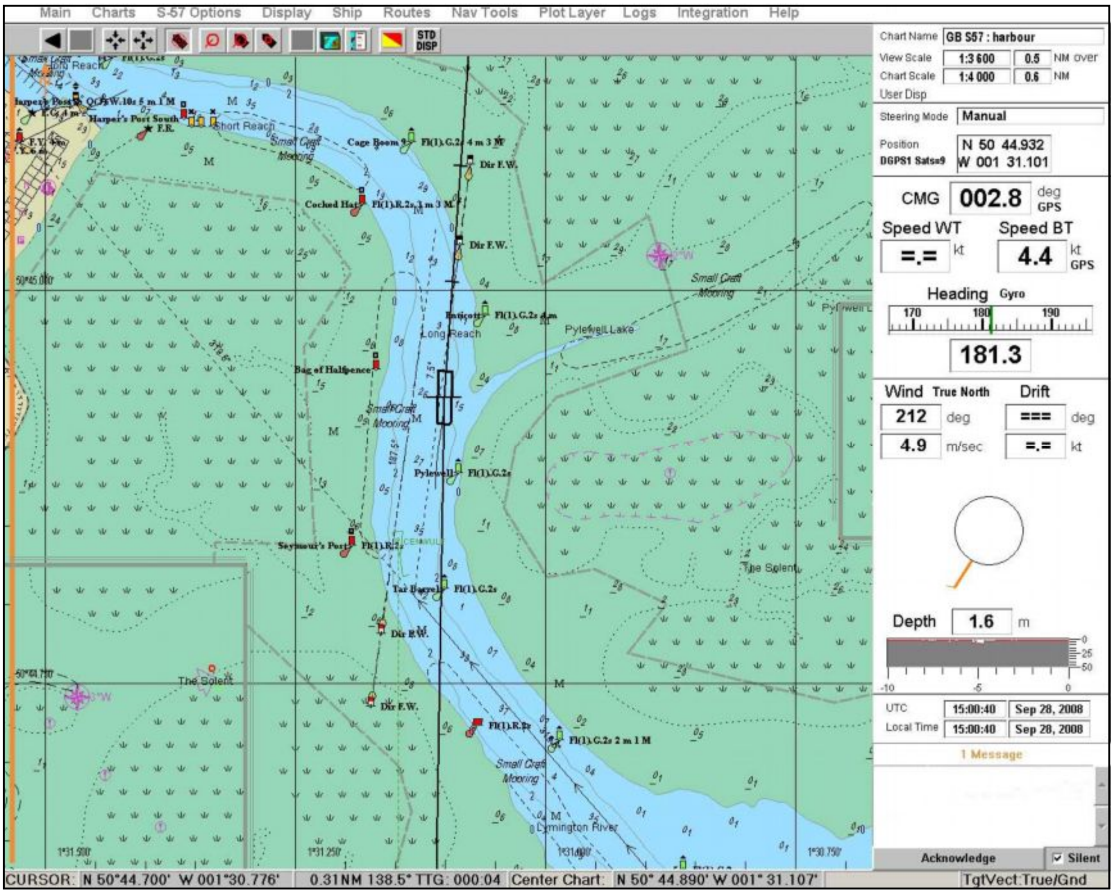


Figure A5.1: Typical Screen Display from ECDIS

When early plans to obtain data direct into a computer from the ECDIS system proved impossible to realise, it was decided to use the system's ability to dump a screen display into a bitmap file. By doing this at intervals during a trial, and saving all the screen dumps from each run to a memory stick, the data shown on the screens was available on a time base. Taking the required data off each screen manually at each time step, and analysing it in a purpose-built spread-sheet, gave the track, ground speed, location and ship-based true wind data used in the main body of this report.

In general screen dumps at 30 second time intervals were the norm, but occasionally these were reduced to 20 seconds to give better resolution in the bends. For the stopping trials much lower values were used.

GPS Monitor on C-class Vessels

Each C-class vessel has a GPS monitor on the bridge and this was used to obtain location and heading data at 30 second intervals. It did not prove possible to log this information electronically, so it was logged manually on a standard sheet and manually transferred to the analysis spread sheet.

This proceduren gave information on track, ground speed and location, but not true wind speed and direction local to the ship.

Wind Anemometers

Cup-type anemometers were fixed to the following four navigation posts:

- Pylewell
- Cocked Hat
- Harpers South
- The Ferry Post

A typical installation is shown in Figure A5.2.

Figure A5.2: Anemometer and Arm on Pylewell Boom Navigation Post

The devices were fitted to arms temporarily attached to the navigation posts 2 metres above high water springs. By so doing, the possibility of interference from flow round the navigation post was minimised and the danger of their being submerged at high water was eliminated. More importantly, it allowed them to serve the purpose for which they were deployed. This was to give an idea of the extent of the wind shadow experienced by a range of sailing craft. Assuming that wind effects would be concentrated on the centre of pressure of the sail plan of such craft, by placing the anemometers as described, they covered a range of centre of pressure heights from 2 metres to about 5 which should cover most of the sailing vessels using the river on a regular basis.

Wind speed was sensed by the rotation of the cups, logged as a stream of pulses. Purpose-built software was developed to count the pulses and convert them in to wind speeds. In the event it was necessary to log the pulses at a high sampling rate (about 500 Hz) which gave very large files, so wind speeds were logged in this way on only one windy day. In the plots, wind velocities are meaned over one second (i.e. after 500 samples) to capture details of the wind shadow. Wind direction was logged as an analogue value, and converted to a 0^{o} to 360^{o} scale.

Harbour Office Speed Monitoring System

For all runs, the timing and speeds of vessels were required at certain locations. For the trials vessels this was done using the ECDIS, but others (mainly the C-class) had not necessarily been logged on the day because members of BMT staff were elsewhere on the river and not able to log the appropriate information. Some cross-checks against logged speeds, vessels and locations were also needed.

All of this was accomplished by means of the Ground Speed Monitoring and Logging system based in the Harbour Office.

Sundry Hand-Held Devices

These devices simply served for backup and recording purposes. The radar gun was used sporadically and served to back up the other speed measurements, results from the hand-held anemometer were not used in the analysis presented in the report and several of the still photographs have been used above to illustrate various points. The extensive video record is available for further analysis; it was used as a comprehensive record of most runs as well as providing frame-by-frame detail of the MOB dummy tests and visual records of water movements over the inter-tidal area of the banks.

A5.3 MEASUREMENTS

A5.3.1 Water Level Changes

Changes in water level were measured using wave probes, described in Reference 1, located on the following navigation posts to cover the Short Reach Lay-by, Short Reach and Horn Reach areas of the river:

- Pylewell Boom
- Enticott
- Cocked Hat
- Harpers South
- Red Post
- Ferry (Green) post

In the course of events, the probe on the Ferry Post inadvertently fell into the water and was damaged beyond repair. It was decided not to replace it, but rely on the Red Post measurements to represent conditions in Horn Reach; as a result there were no wash measurements from the Ferry Post from 1 October 2008 onwards.

Many of the wash measurements have been presented in the main report and a sample of the remainder is given here for information.

Short Reach Lay-by Area

The traces for both the C-class and W-class ferries are characterised by drawdown and wash from the free wave system and thruster slipstream. The measures taken to reduce the wash from the thruster slipstreams have been discussed in the main report and Figures 53 to 55 indicate the reductions in free wave amplitude obtained in the Short Reach Lay-by area.

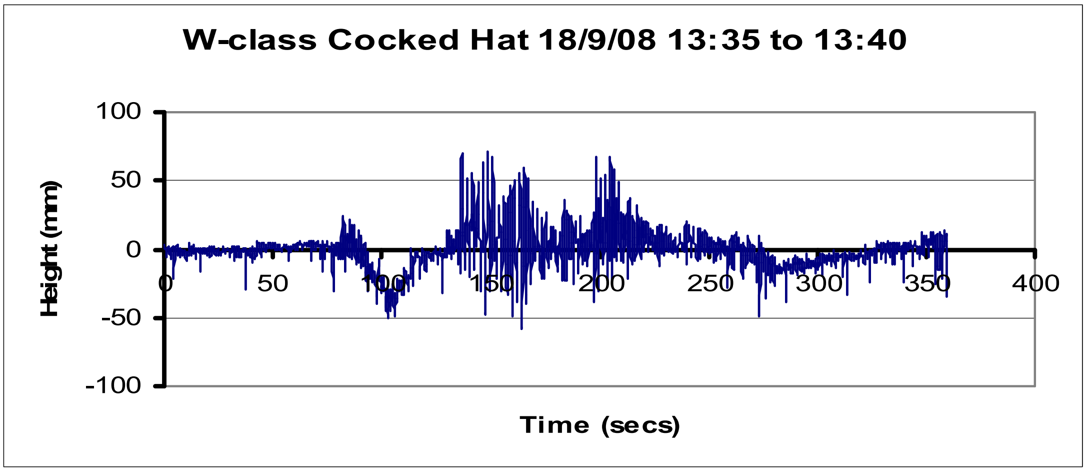
Drawdown has been discussed in some detail in Section 6.2.2 and examples in the Short Reach Lay-by area have been shown in Section 6.2.1.

Measurements of ambient waves in the Short Reach Lay-by area have been shown in both Reference 1 and this report, as have free wave traces from boats of various kinds and sizes. In general, the amplitudes of the latter are at least as great as those from the W-class ferries running in the "operational"/"idle" or "operational"/"intermediate" modes; they are often much bigger. Ambient waves in windy conditions in the Short Reach Lay-by area can be significantly bigger than the free waves from the W- or C-class ferries.

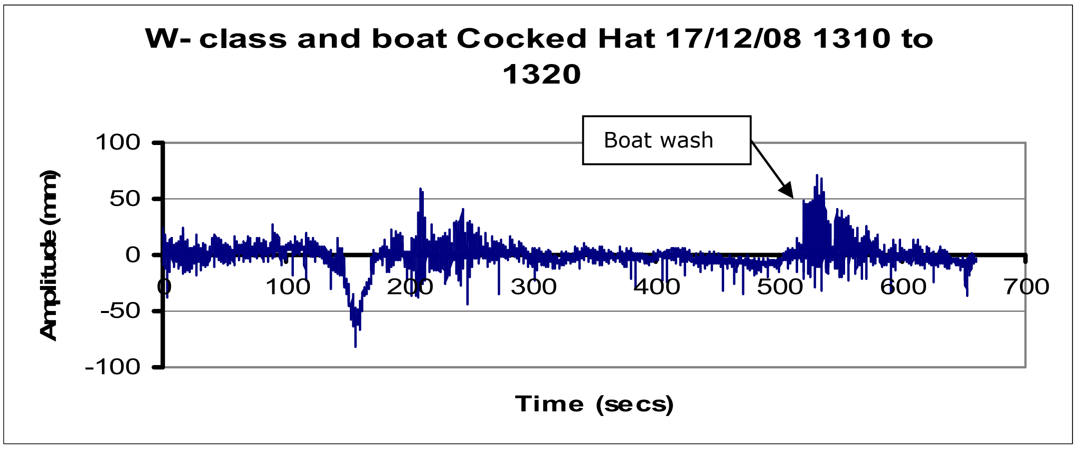
Short Reach

Measurements in Short Reach are of interest because those at Cocked Hat allow some assessment to be made of water level changes due to the ferries on the inside of a bend, while passage past Harpers South post by all vessels is characterised by a much more narrow range of speeds and distances off than those in the Short Reach Lay-by area. Accordingly, further comparisons of wash between the ferries and between different operational modes of the W-class thrusters can be made.

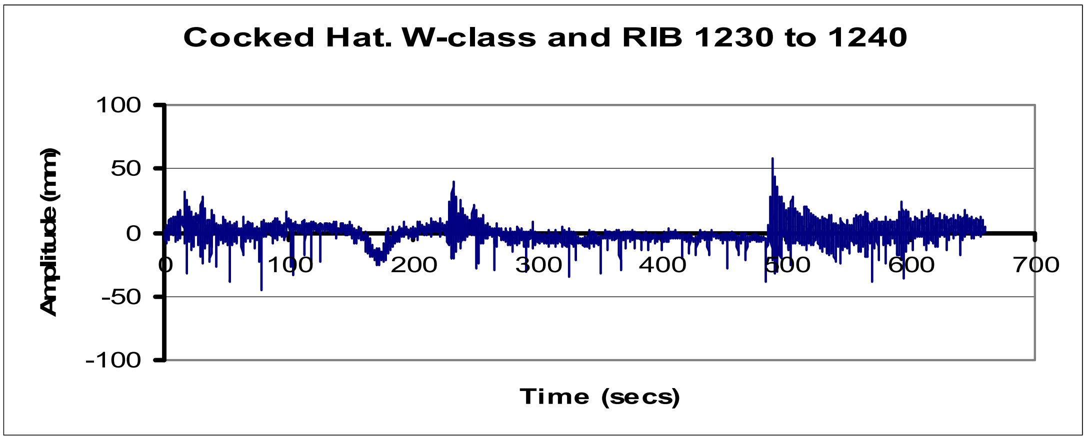
Figure A5.3 shows comparisons at Cocked Hat between results obtained with W–class vessels on "operational", "intermediate" and "idle" settings on the aft thruster. High water values are shown because the speed and free wave wash both tended to be higher at that state of the tide.



"Operational" Setting, Overground Speed 5.8 knots, tidal height 2.91m,outbound



"Intermediate" Setting, Overground Speed 5.3 knots, tidal height 2.84, outbound

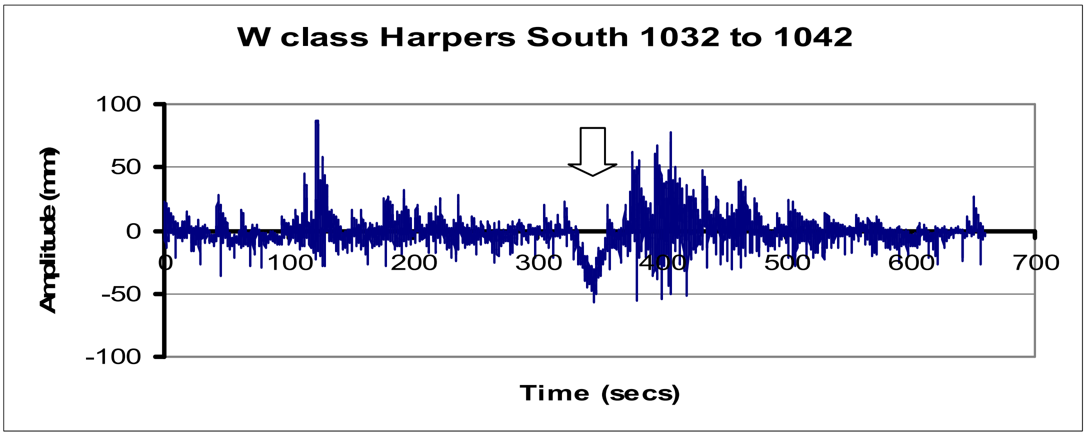


"Idle" Setting, Overground Speed 5.0 knots, tidal height 3.01m, outbound

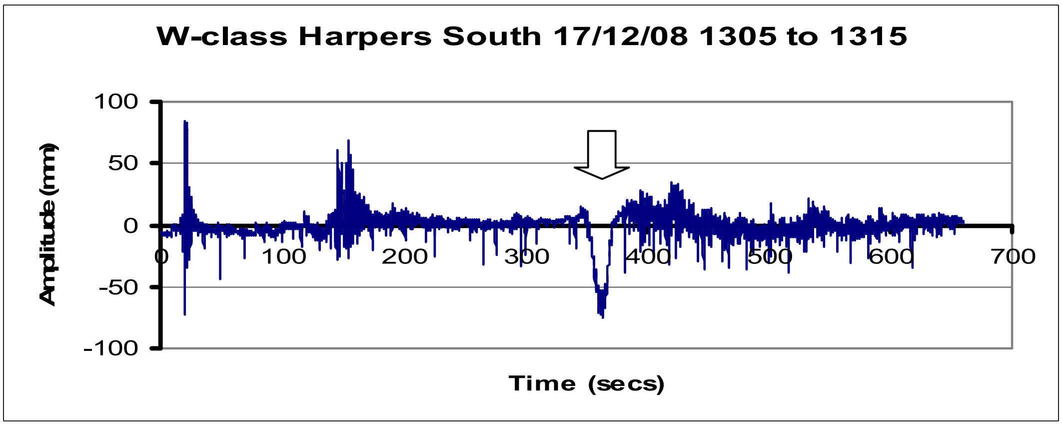
Figure A5.3: W-class Wash at Cocked Hat

The reduction in free wave amplitudes resulting from changes in the thruster settings may be seen, as can the wash from a passing boats (probably RIBs) in two of the plots.

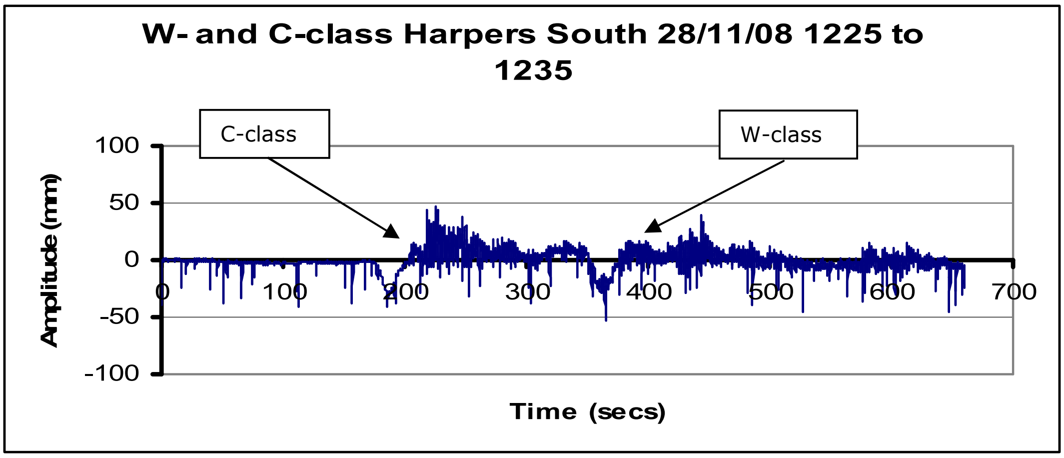
At Harpers Post South, similar results were obtained, as shown in Figure A5.4:



"Operational" Setting, Overground Speed 3.8 knots, tidal height 2.45m, outbound



"Intermediate" Setting, Overground Speed 5.3 knots, tidal height 2.8m, outbound

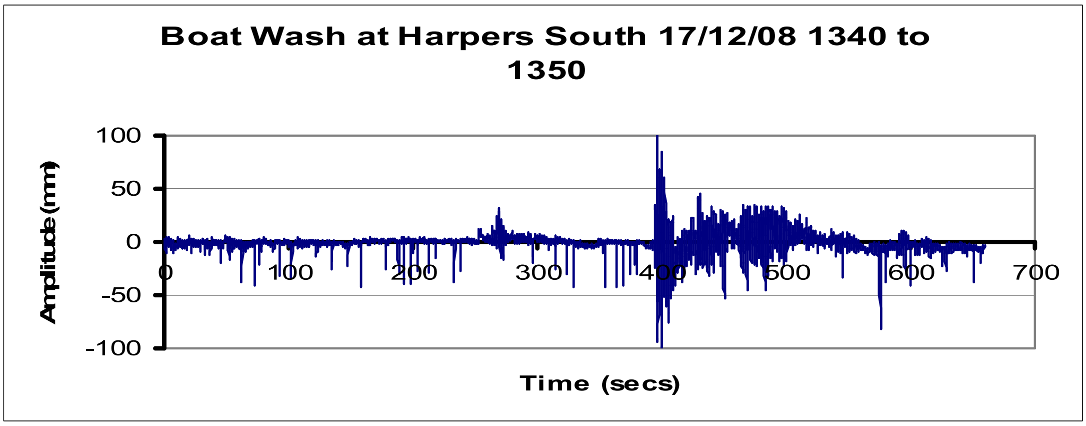


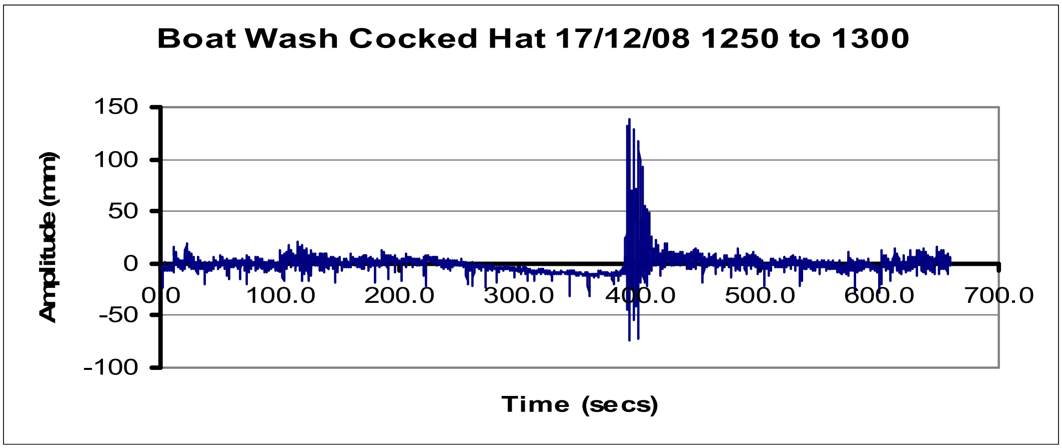
"Idle" Setting, Overground Speed 4.2 knots, tidal height 3.01m, outbound

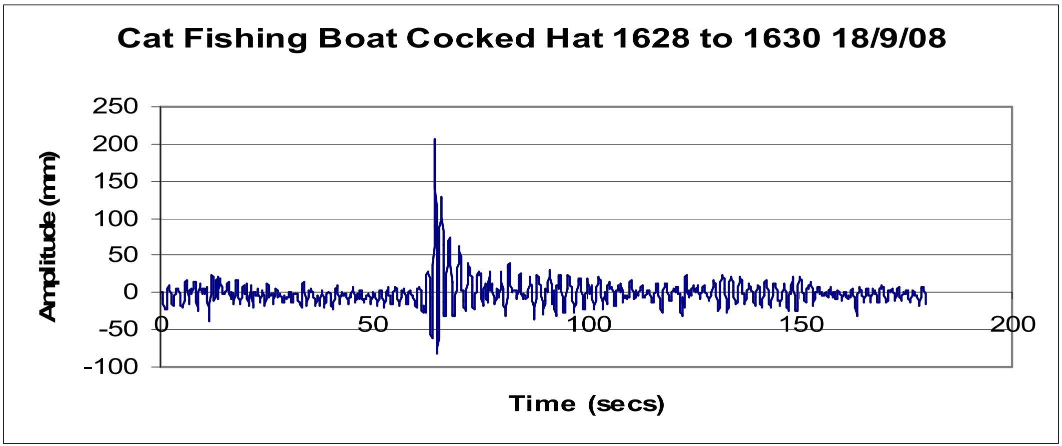
Figure A5.4: W-class Wash at Harpers South

Of interest in the "idle" result is the comparison that can be made between the drawdown and wash of a W- and C-class ferry as the W-class followed the C-class outbound. It is seen that, at high water, the W-class wash with the aft thruster on the "idle" setting is less than that of the C-class.

Traces from various small craft passing Cocked Hat and Harpers South were obtained; a selection is given in Figure A5.5.







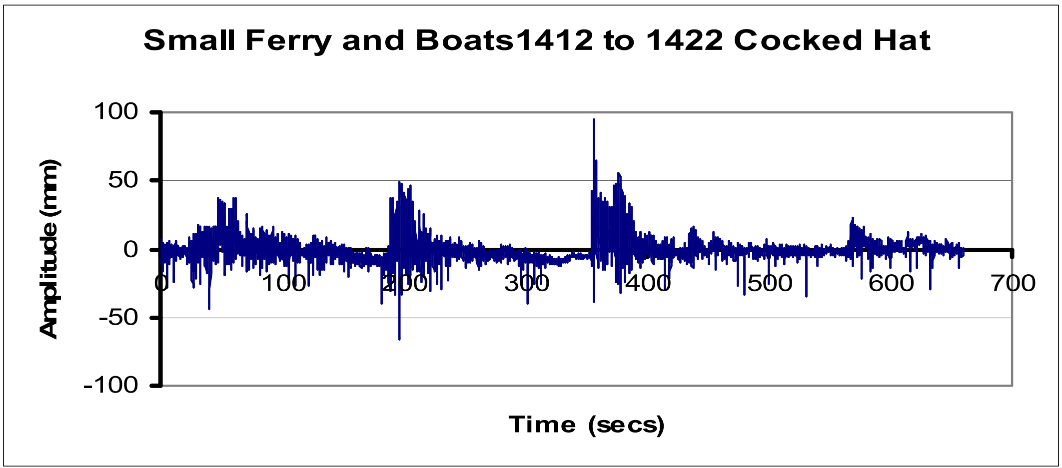
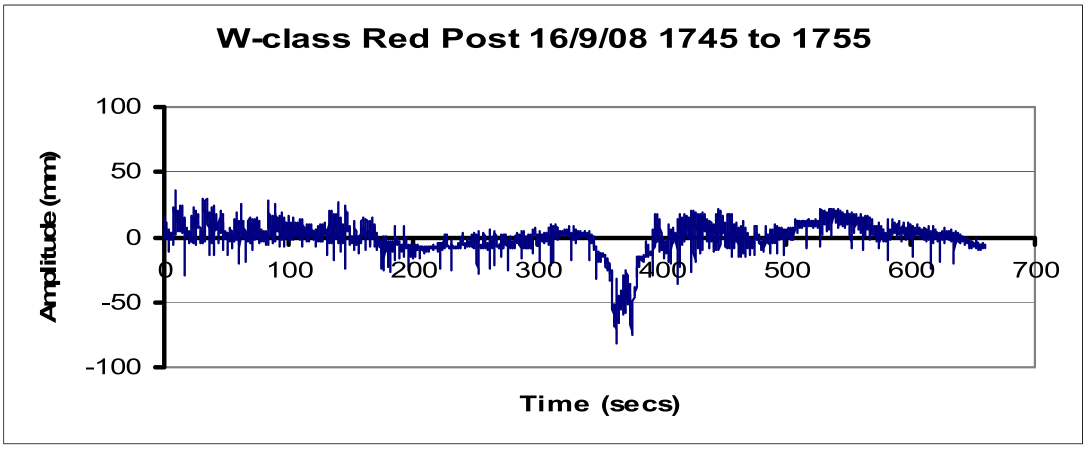


Figure A5.5: Boat Wash in Short Reach

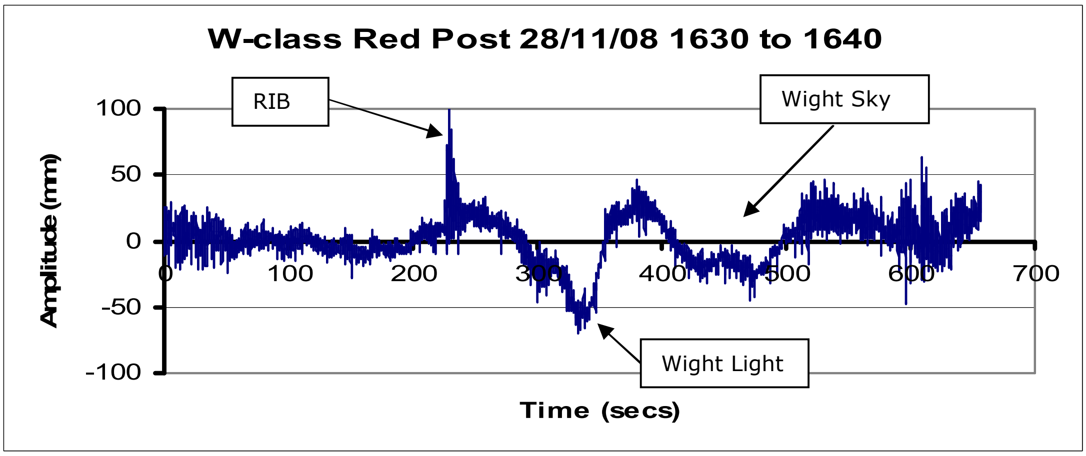
Horn Reach

All the wash and drawdown traces shown here are for the "Red" post off the RLymYC. No measurements were made at this post when the W-class was operating with its aft thruster on its "intermediate" setting.

Figure A5.6 shows a comparison of wash at low water:



"Operational" Setting, Overground Speed 3.3 knots, tidal height 0.53m, outbound



"Idle" Setting, Overground Speed 3.4 knots, tidal height 0.97m, inbound

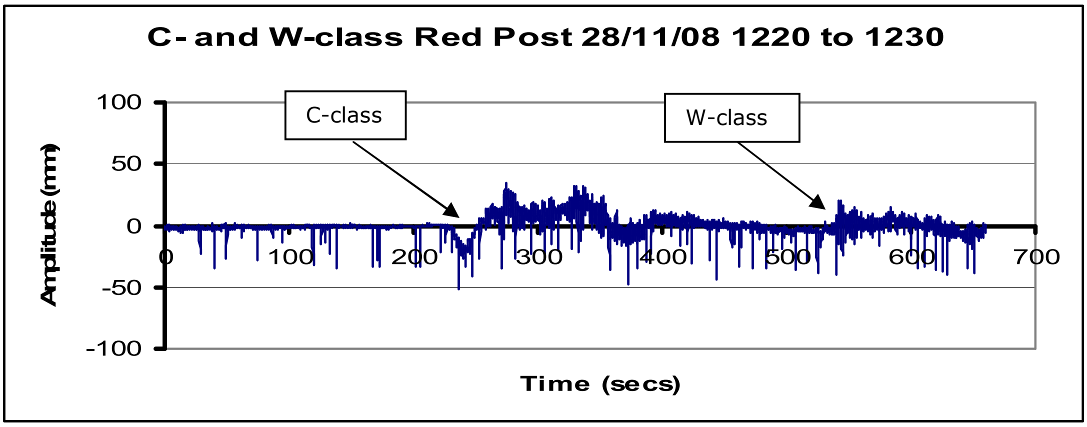
Figure A5.6: W-class Wash in Horn Reach at Low Water

Both these plots refer to low speed, low water conditions in which case the free wave wash is low, due to the low speed, so differences due to thruster setting are not so large. However, it may be noted that, as well as the high frequency wash, there is also evidence, especially for the run on 28 November, that long period motions were in evidence in Horn Reach. Two W-class ferries were inbound at the time, a few minutes apart, and it would appear that the first caused a swell-up of water, starting some 2 minutes before the maximum drawdown from Wight Light arrived at the probe and thereafter the Wight Sky, following astern, maintained a low period motion of the water prism.

This, combined with drawdown from the vessels themselves, would cause moored vessels to move in a vertical plane, together with movement in a lateral plane due to hydrodynamic interaction effects. Such effects will be greater than those presently experienced with the C-class.

The W-class wave wash is, however, generally reduced by use of the "idle" setting aft, especially at high water as Figure A5.7 shows. In this run, the W-class followed a C-class out; the C-class drawdown and wash is obvious, whereas that from the W-class is very much smaller with little evidence of drawdown.

This evidence suggests that wash disturbance in Horn Reach will be no more, and often less, then the present situation with the C-class vessels. Drawdown and interaction effects will be greater, however, and there may be long-period movements induced in the water prism at low water.



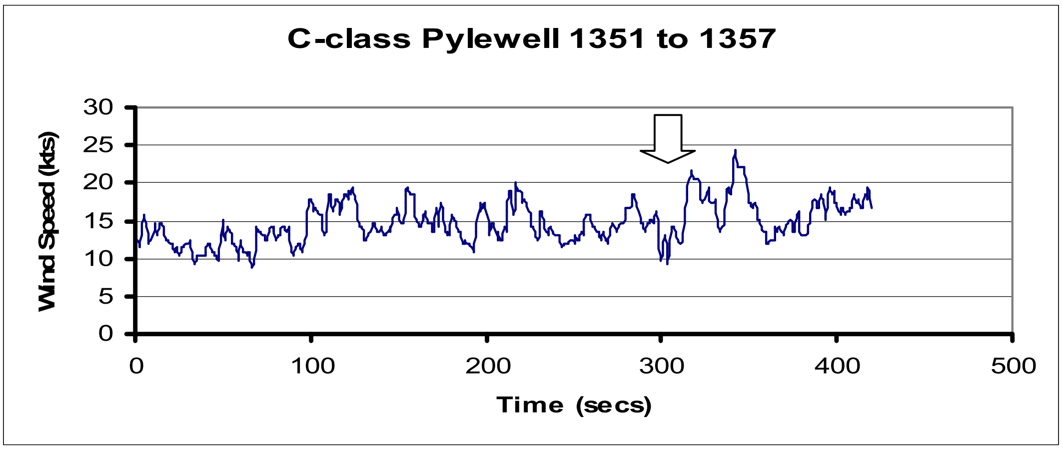
"Idle" Setting, W-class Overground Speed 3.3 knots, tidal height 3.01m, outbound

Figure A5.7: W-class Wash in Horn Reach at High Water

A5.3.2 Wind

Wind measurements on board ship and the accompanying tracks have been discussed in Section 6.1.4 above. Also shown in Section 6.3 were measured results of the effects on wind speed and direction of a passing ferry – the wind shadow.

Figures A5.8 to A5.11 show additional measurements as ferries passed the Pylewell Boom navigation post.



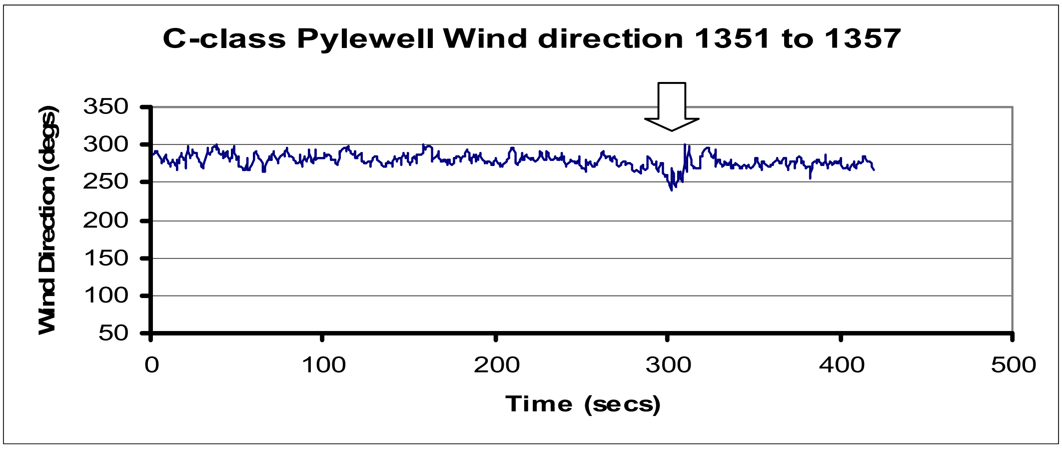


Figure A5.8: C-class passing Pylewell Outbound; Effect on Wind (Tide height 2.95m)

The outbound C-class, on the other side of the river, had very little effect on the wind at Pylewell in Figure 5.8. However, a more significant effect occurred when an inbound C-class passed, as shown in Section 6.3.1 in the main report (Figure 63). When two C-class passed each other at Pylewell, the resulting effect on wind speed and direction is shown in Figure A5.9.

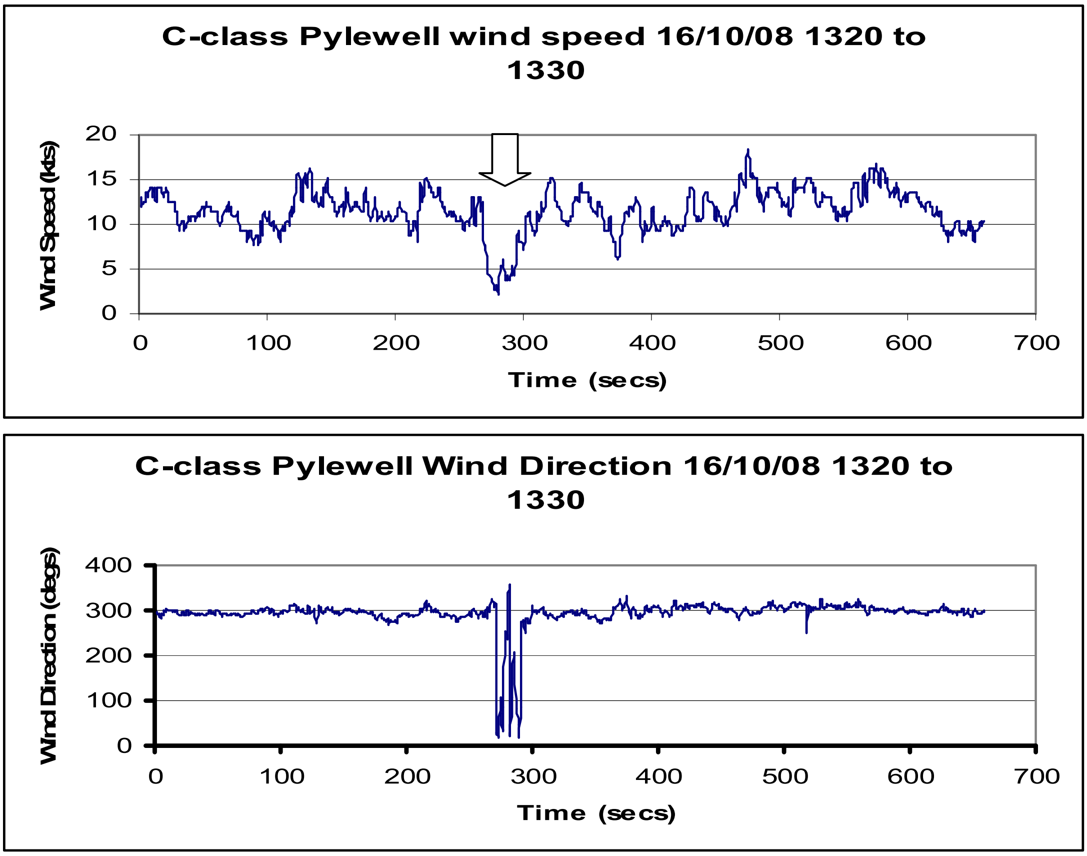
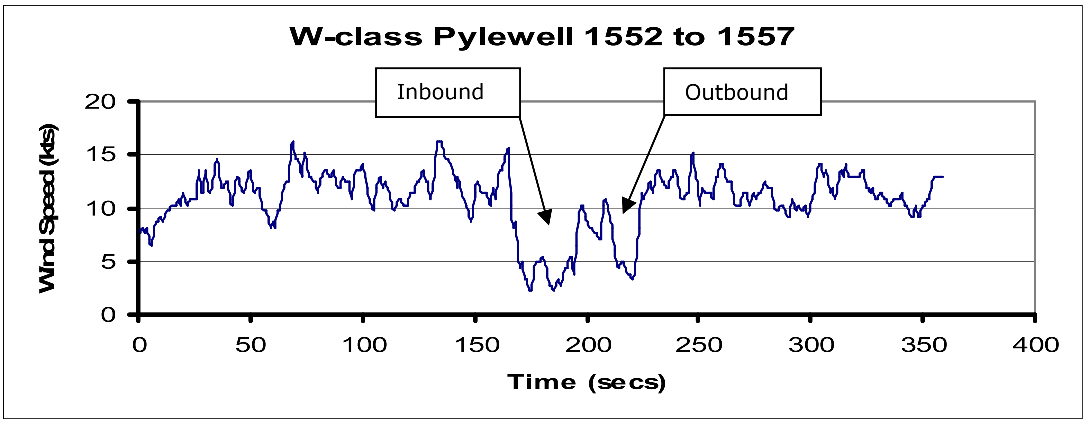


Figure A5.9: Two C-class passing at Pylewell; Effect on Wind (Tide height 3.2m)

The last two Figures show results at mid-tide (in the ebb) and low water, both showing the effect of two W-class passing at Pylewell.



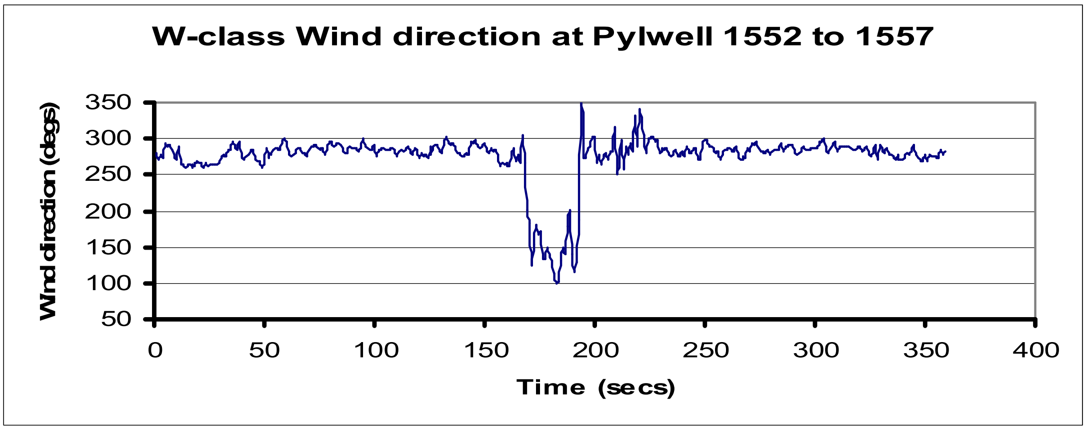
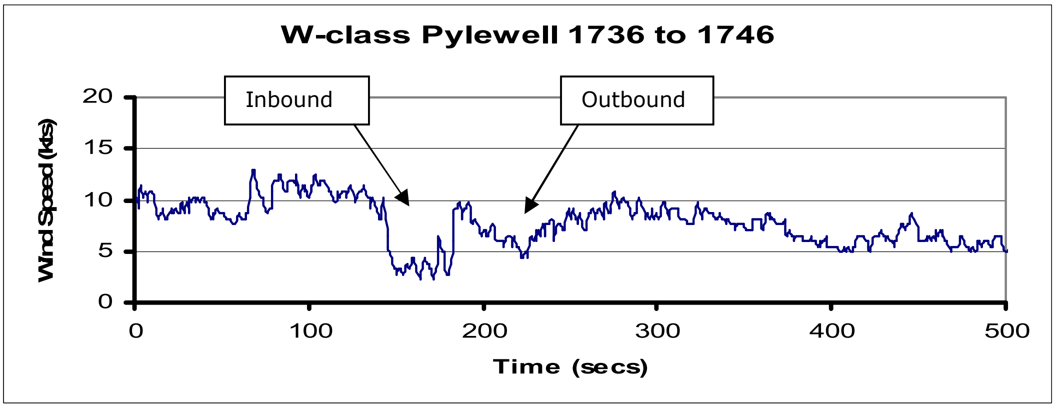


Figure A5.10: Two W-class passing Pylewell; Effect on Wind (Tide height = 1.43m)

It may be seen in Figure A5.10 that the outbound ship had some effect on wind velocity, but little effect on wind direction, with Figure A5.11 showing a similar result.



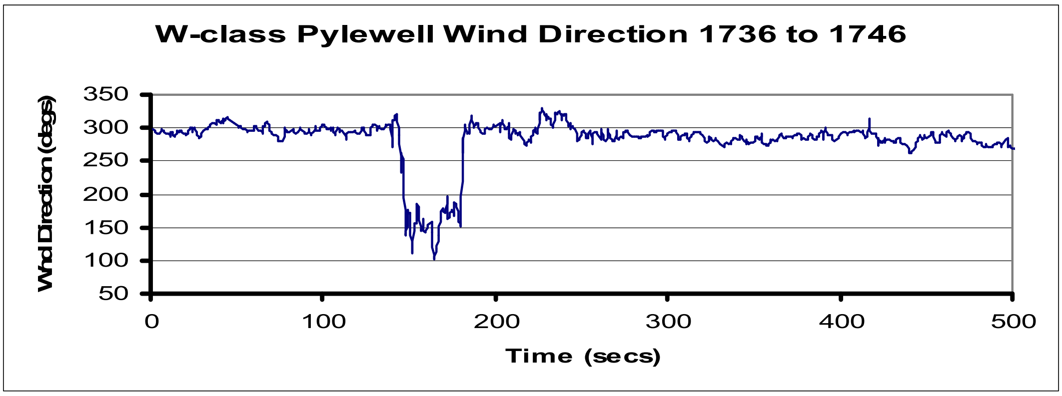
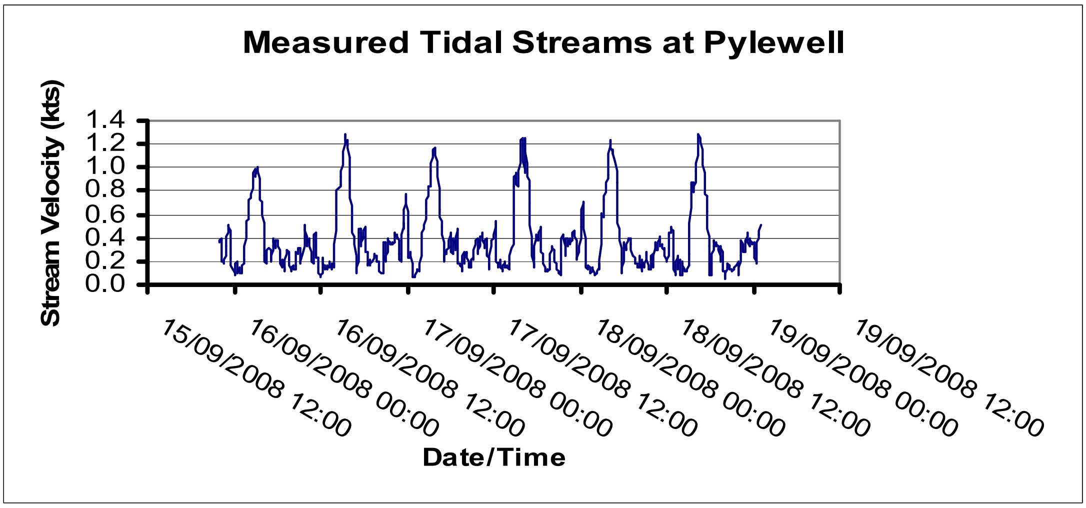


Figure A5.11: Two W-class passing Pylewell; Effect on Wind (Tide height = 0.63m)

Comparing the results for two W-class passing with those for two C-class it is seen that the effect on wind direction appears to be roughly the same for the inbound and outbound C-class unlike the case with the W-class. However, due no doubt to the longitudinal distribution of the windage of both classes of vessel, the effect on wind direction appears to be shorter-lasting with the C-class compared to the W-class. The magnitude of the change in speed and direction appears to be roughly the same for both classes, however.

A5.3.3 Tidal Streams and Other Flow

Tidal streams were measured in the same location as those obtained in January 2008, using the same equipment. The results were obtained over a period from early September to early October 2008 and the spring tidal stream results were very similar to those obtained in January. Examples are given in Figure A5.11.



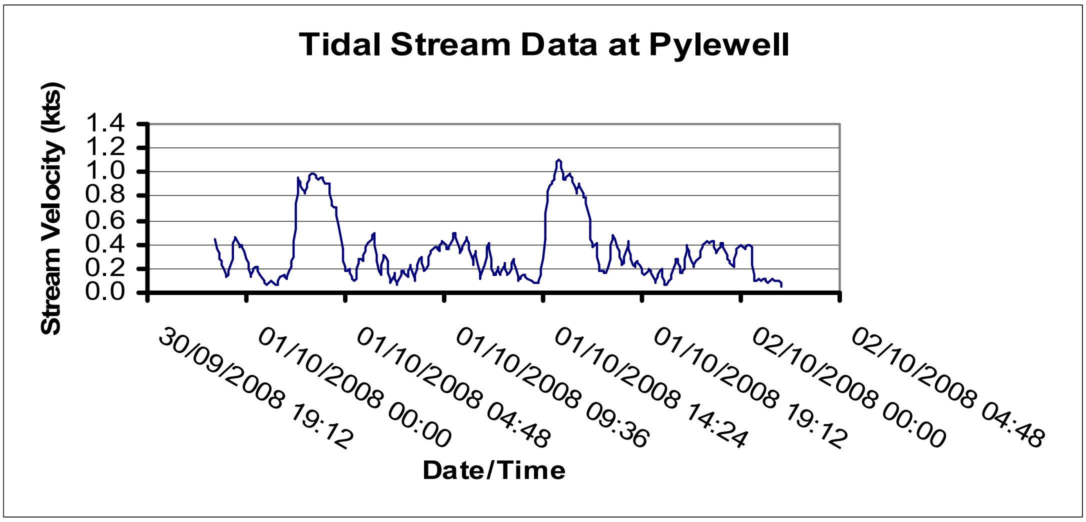


Figure A5.11: Tidal Stream Measurements near Pylewell Boom Post

Other flow measurements have been presented and discussed in Appendix 7.

A5.4 REFERENCE

1. Hoerner, S F: "Fluid-Dynamic Drag" Published by the Author, 1958

APPENDIX 6

Track Analysis

TRACK ANALYSIS

A6.1 INTRODUCTION

In this Appendix the analysis of the composite track plots for the C- and W-class vessels is discussed. The method derives from Reference 6 of the main report and simply concentrates on the statistics of the tracks at a number of gates in the Lymington River, placed as shown in Figure A6.1.

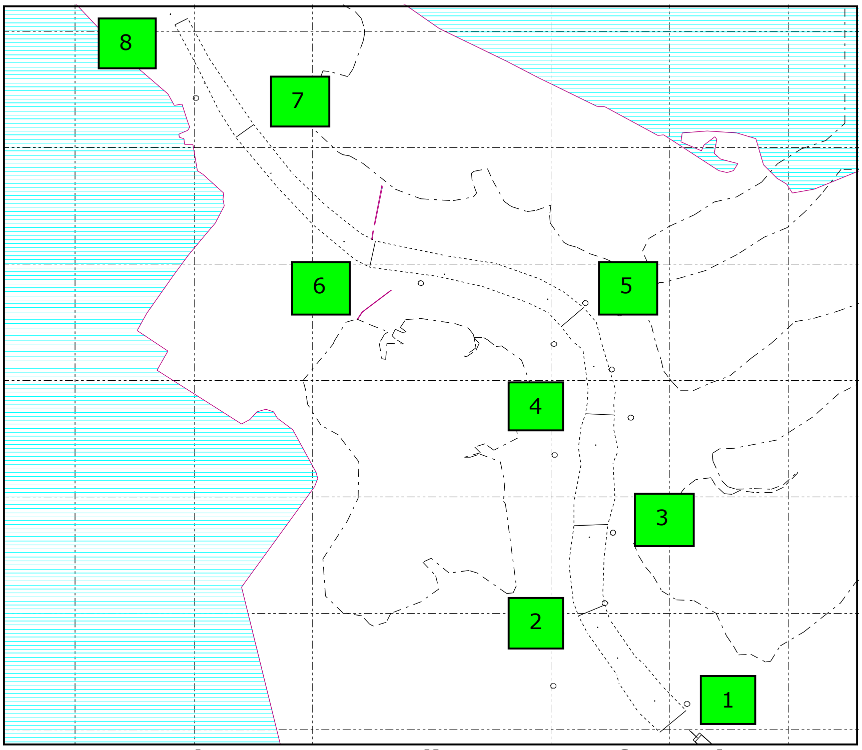


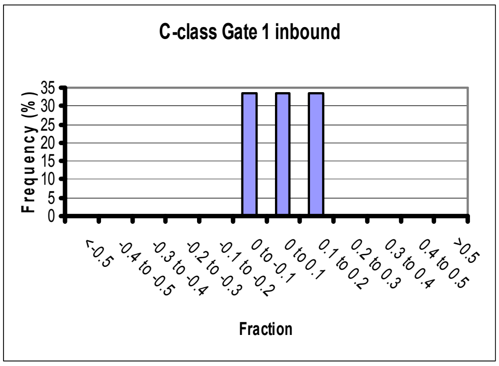
Figure A6.1: Gates and 2 metre Sounding Contour from Chart BA2021

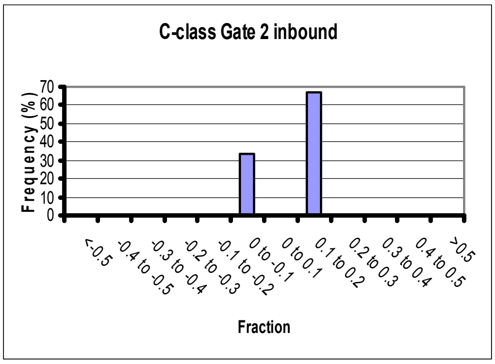
From the composite tracks for both the C-class and W-class measured runs, the location of the ship centre as it crossed each gate was computed as was its location (as a fraction of the gate width) from the centre of the gate. These were then used for the frequency plots shown below, together with the computed mean values and standard deviations, again relative to the centre of the gate.

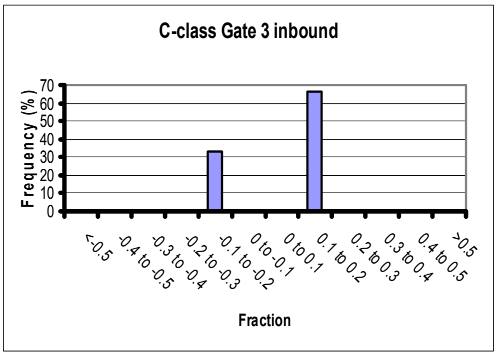
For all plots, whether the track is inbound or outbound, the western end of the gate is the left hand end of the plot.

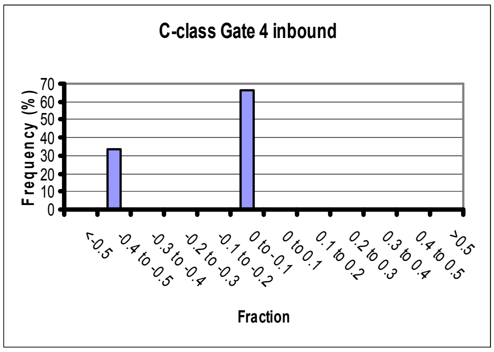
A6.2 GATE FREQUENCY PLOTS

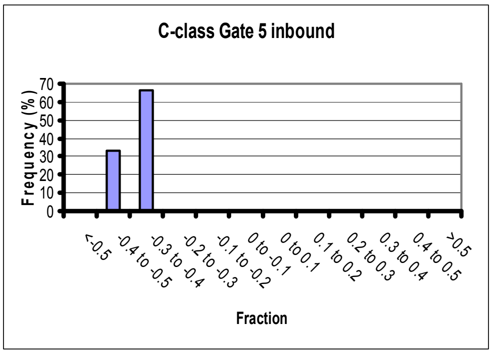
***C-class Inbound*.**

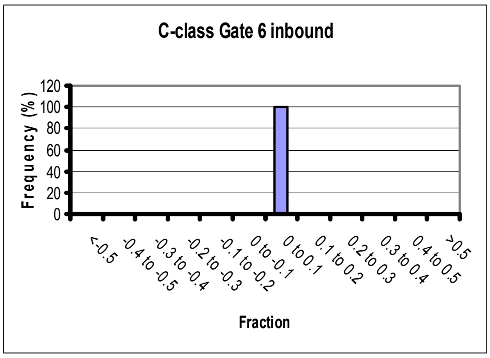


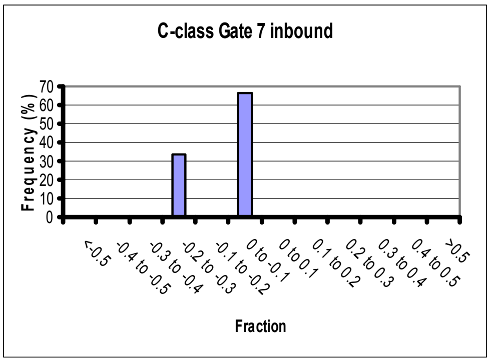


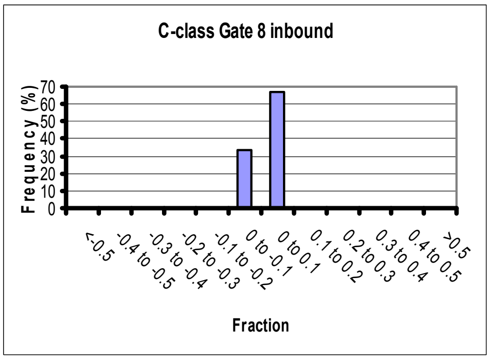




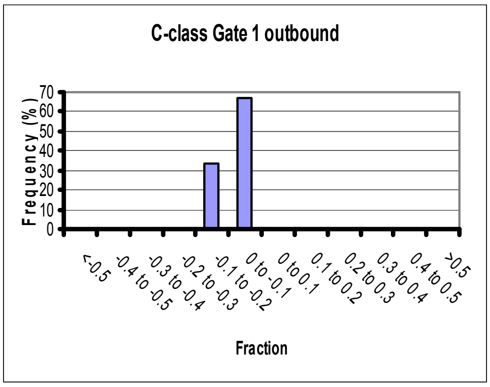


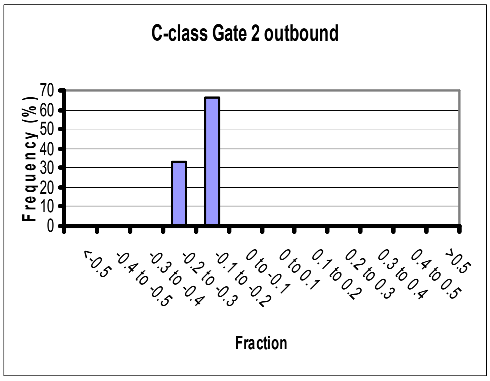


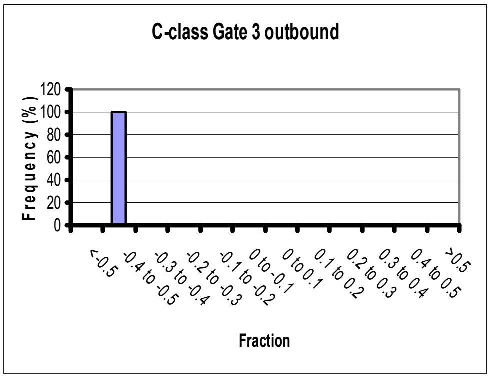


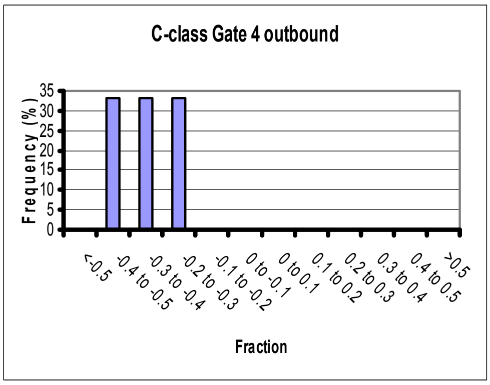


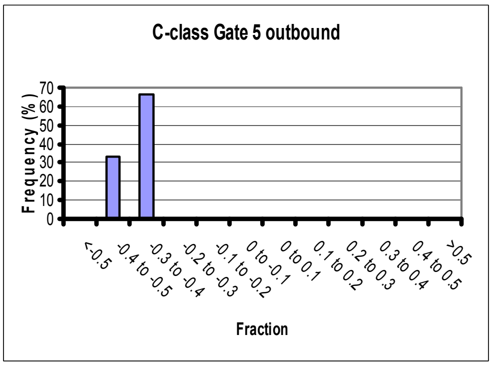
C-class Outbound

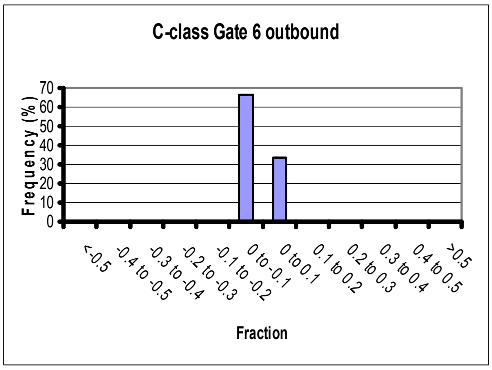


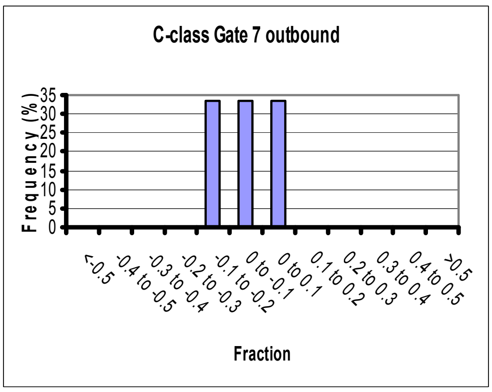


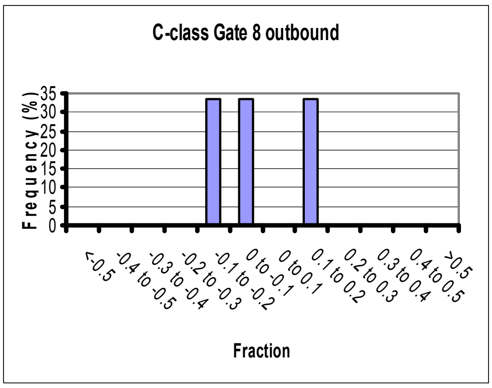










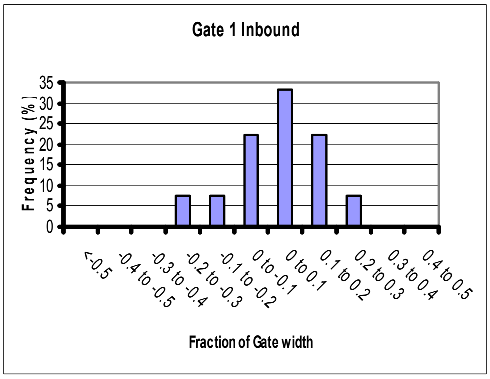


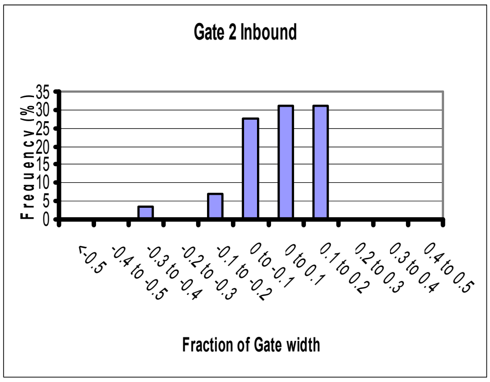
Mean values and standard deviations for all the above frequency plots are given in Table A6.1.

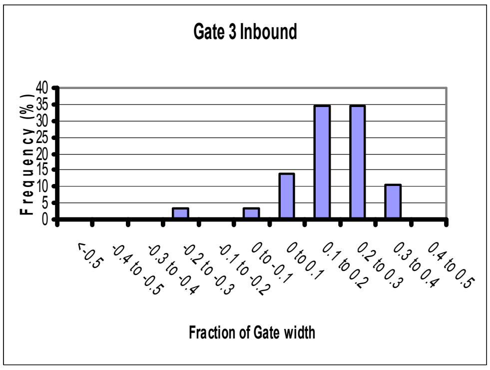
Gate	In/out	Mean	Standard Deviation
1	In	0.039	0.083
2	In	0.115	0.117
3	In	0.060	0.153
4	In	-0.167	0.206
5	In	-0.387	0.051
6	In	0.052	0.040
7	In	-0.105	0.154
8	In	0.007	0.080
1	Out	-0.071	0.031
2	Out	-0.170	0.044
3	Out	-0.442	0.025
4	Out	-0.338	0.074
5	Out	-0.382	0.051
6	Out	-0.005	0.090
7	Out	-0.061	0.075
8	Out	-0.003	0.109

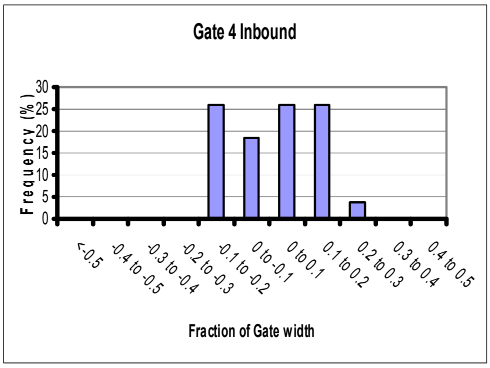
Table A6.1: C-class Measured Runs: Means and Standard Deviations.

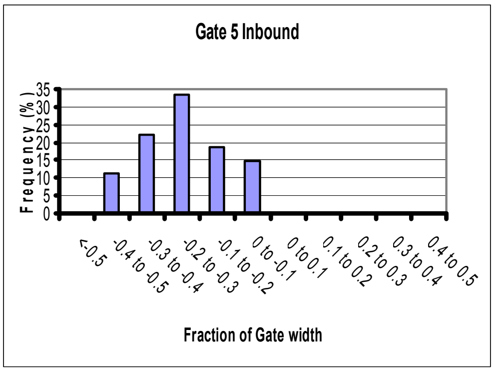
W-class Inbound

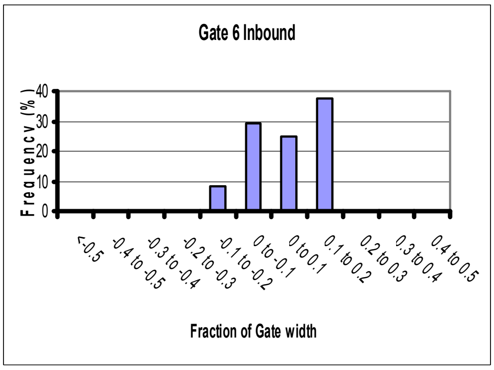


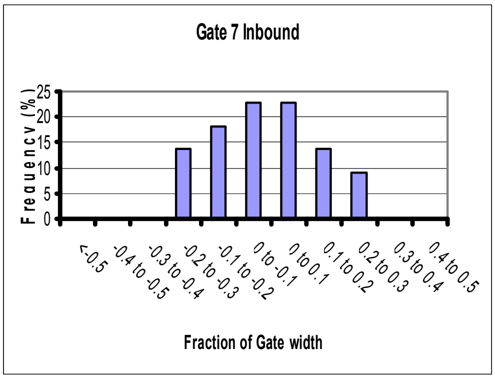


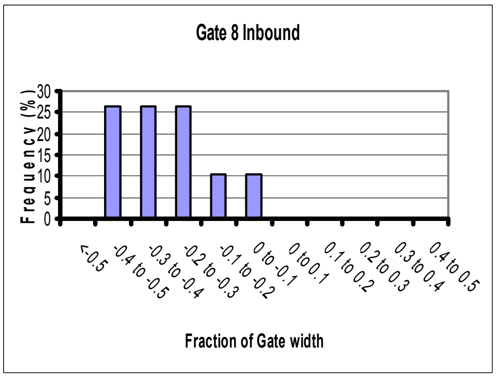




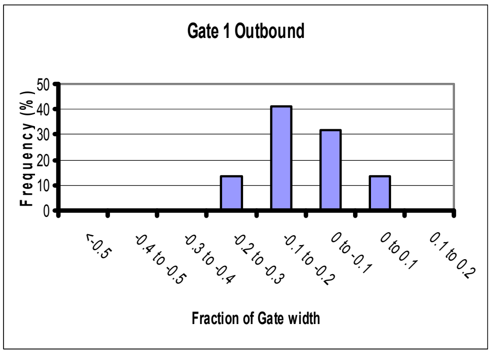


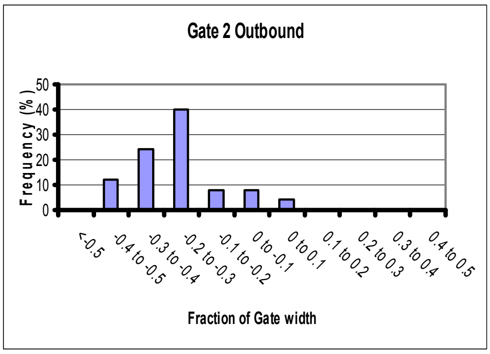


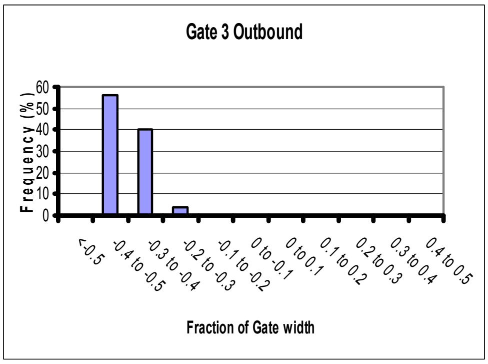


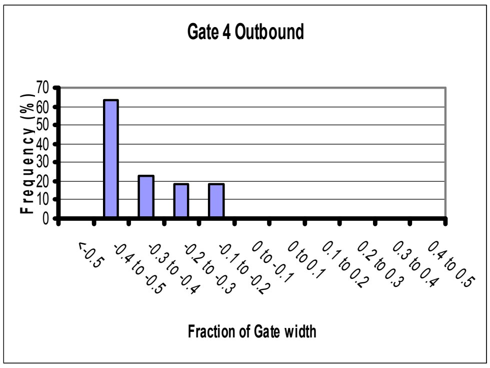


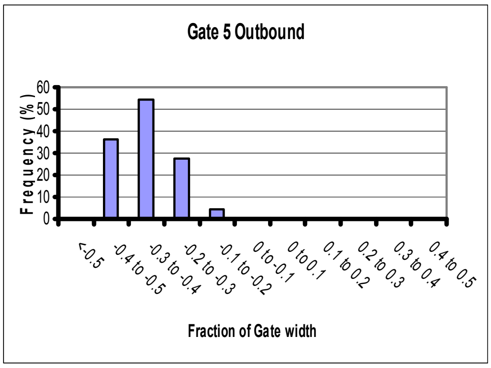
W-class Outbound

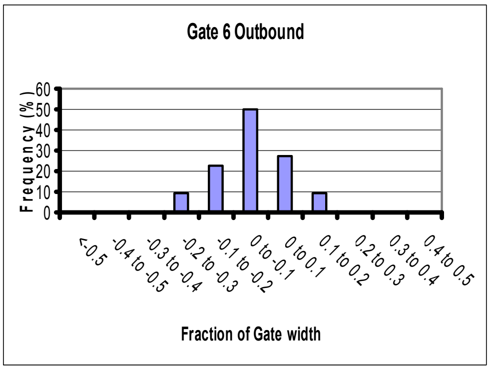


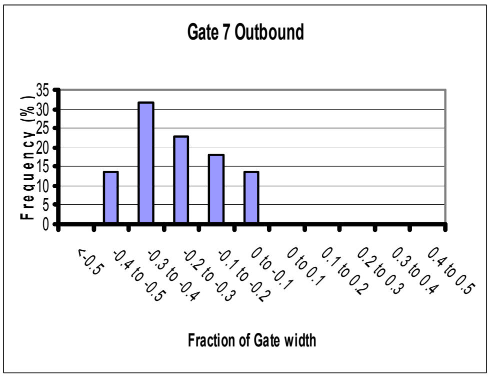


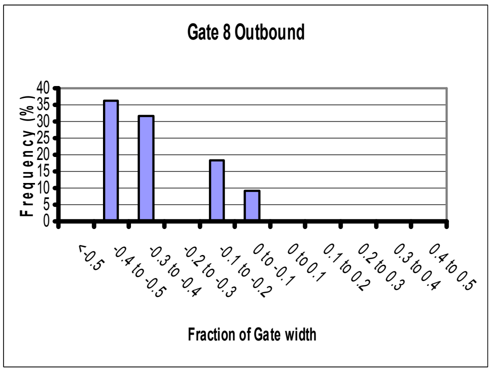












Mean values and standard deviations for all the W-class frequency plots are given in Table A6.2.

Gate	In/out	Mean	Standard Deviation
1	In	0.031	0.129
2	In	0.020	0.120
3	In	0.194	0.196
4	In	0.018	0.110
5	In	-0.244	0.123
6	In	0.059	0.132
7	In	-0.022	0.142
8	In	-0.309	0.127
1	Out	-0.102	0.094
2	Out	-0.264	0.128
3	Out	-0.417	0.058
4	Out	-0.353	0.117
5	Out	-0.348	0.080
6	Out	-0.041	0.098
7	Out	-0.261	0.127
8	Out	-0.321	0.146

Table A6.2: W-class Measured Runs: Means and Standard Deviations.

APPENDIX 7

Drawdown Analysis

DRAWDOWN ANALYSIS

A7.1 INTRODUCTION

The contents of this Appendix are based on notes provided for Natural England to give them an indication of the disturbance caused on the Lymington River by the W-class ferries. Information was provided for the drawdown caused by the ferries and the across-bank flow induced by this and other effects. In addition to this, some along-bank flow measurements in the vicinity of the Cocked Hat and Harpers South posts were given, together with some measurements of the natural tidal flow in the bank inter-tidal region in the vicinity of the Cocked Hat Bend.

All measurements were obtained from either the wave probes mounted on the navigation posts, or a hand-held propeller-type current meter, as described in Appendix 5.

A7.2 DRAWDOWN

Drawdown is the reduction in water level local to the ship as it moves through the water. It is a consequence of the pressure field around the hull which is manifest, in shallow water, as a depression in the water surface around the ship (the "drawdown"), combined with surface "swellings" at bow and stern. The depression is at its greatest near the midships region of the vessel and usually increases for increases in ship size and speed and reductions in water depth and proximity. Therefore, the closer the ship is to some feature in the river, the lower the water depth and the higher its speed through the water, the greater the drawdown.

It may be assumed that drawdown extends unchanged for some distance from the vessel (Reference A7.1) so that, when close to one side of the river, it is seen as a lowering of the water level over the banks. If the bank slope is small, the change in water level will induce a flow velocity across the bank, roughly perpendicular to the track of the vessel. At the same time, the whole disturbance will move along the bank at about the same speed as the vessel itself giving a loss then recovery of water level over the banks as the ship passes. The longitudinal flow along the banks may be accompanied by so-called undular activity (Reference A7.1) at the shallowest depths, when waves begin to form. At greater speeds the undular activity may give way to what is in effect a hydraulic jump if the speed is great enough and the water depth small enough. In extreme cases the recovering "wave" may break at the upper limit of the water coverage causing some disturbance over the bank.

Finally, passage of the ferry close to the banks induces a "backflow" or "return current" (see Reference A7.1) which induces further along-bank flow. Measurements of this are discussed below.

In addition to these effects, which arise from the so-called "local" or Bernoulli wave system around a moving ship, there is the more familiar system of free waves on the water surface common any moving surface vessel. For the purposes of these notes these waves are referred to as "wash" and will be dealt with in the next two Sections.

Figure A7.1 shows a plot from the W-class vessel passing the Pylewell Boom navigation post at low water with the tide at 0.52 metres above datum. The drawdown is indicated, as is the free-wave wash astern of the vessel. The rise in local water level as the vessel approaches the measurement location is also of interest.

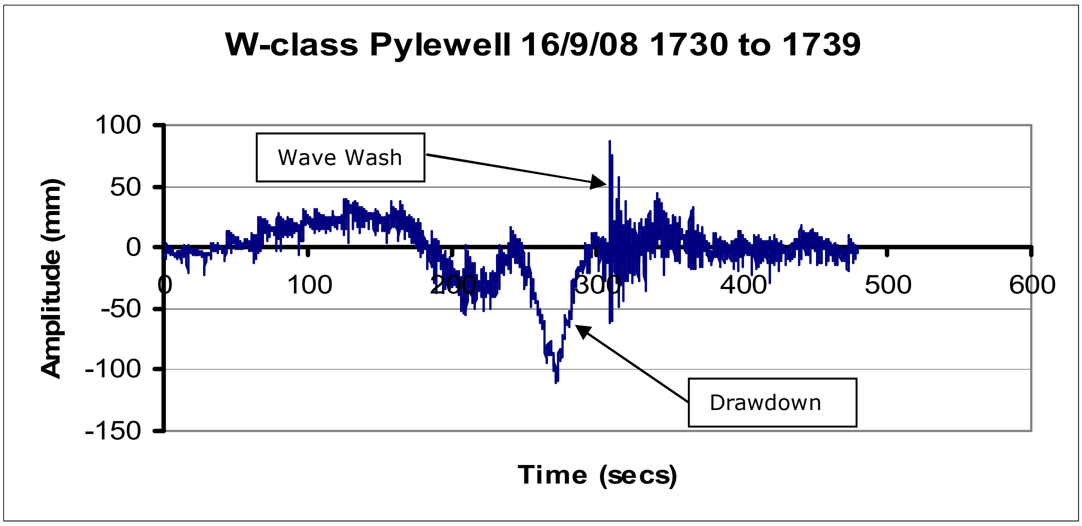


Figure 1: Wave Probe Record on Pylewell Boom Navigation Post; Wight Light Passing about 25 metres off (clear water distance).

Knowing the rate of change of water level due to drawdown, together with the local bank slope, it is possible to compute the flow velocity across the bank surface roughly perpendicular to the path of the ferry. Initially this was done numerically from the measurement data, but the noise in the data from surface wavelets resulted in very inaccurate results. To overcome this, it was found that a cosine-type function fitted the drawdown measurements well, thereby allowing the implied across-bank velocities to be calculated from the sine function representing its first derivative. The maximum values of these across-bank velocities are given in Table A7.1.

In this Table the following nomenclature applies:

Depth BCD = the assumed mean sounding in metres at the location
Tide Height = the height of tide at that location and time, estimated from Reference 2
Vog = ship speed overground in knots
Vtide = the deduced tidal stream at Pylewell taken from measurements made in January 2008. No tidal stream information was available for the other locations, so the overground speed was used.
Vtw = ship speed through the water in knots
D = the maximum measured drawdown value in millimetres.
T = the time taken, in seconds, for the drawdown to pass
Vleft = the cross-bank velocity in metres per second computed from the drawdown for the western bank of the channel. For the Pylewell location, no results are given because the western bank is too distant from the measurement location
Vright = the cross-bank velocity in metres per second computed from the drawdown for the eastern bank of the channel.

Post	Depth BCD	Tide ht(m)	Ship	Vog(kts)	Vtide(kts)	Vtw(kts)	D(mm)	T(secs)	v left(m/s)	v right(m/s)
C Hat	3.8	2.81	C	2.2	-0.6	1.6	10	66.50		
Harpers S	3.7	0.53	C	3.1	0.2	3.3	33	73.50	0.077	0.086
Harpers S	3.7	0.53	C	3.1	0.2	3.3	47	79.00	0.103	0.114
C Hat	3.8	1.35	C	4.3	-0.9	3.4	38	46.00	0.085	0.146
Harpers S	3.7	0.59	C	4.0	0.2	4.2	81	50.75	0.274	0.302
Pylewell	3.7	0.71	C	4.5	0.4	4.9	95	39.02		0.204
C Hat	3.8	2.94	C	4.7	0.6	5.3	25	34.00		
C Hat	3.8	0.72	C	4.5	0.8	5.3	55	58.45	0.121	0.151
C Hat	3.8	2.94	C	6.5	-0.9	5.6	23			
C Hat	3.8	0.72	C	5.1	0.6	5.7	154	62.25	0.318	0.396
Pylewell	3.7	0.66	C	5.4	0.4	5.8	26	49.12		0.041
Pylewell	3.7	0.82	C	6.0	0.2	6.2	92	23.75		0.343
Pylewell	3.7	1.13	C	6.0	0.3	6.3	100	28.94		0.305
Pylewell	3.7	2.86	C	5.8	0.6	6.4	34	24.09		
Pylewell	3.7	1.07	C	5.8	0.6	6.4	98	22.00		0.393
Pylewell	3.7	2.35	C	5.6	0.9	6.5	52	29.98		
Pylewell	3.7	0.59	W	2.5	0.2	2.7	38	59.50		0.050
Harpers S	3.7	0.53	W	3.1	-0.2	2.9	93	62.00	0.257	0.284
Harpers S	3.7	2.50	W	4.0	-0.4	3.6	48	32.00		
C Hat	3.8	2.81	W	4.3	-0.6	3.7	50	42.50		
C Hat	3.8	0.52	W	3.8	0.2	4.0	71	70.00	0.174	0.148
Pylewell	3.7	0.52	W	3.8	0.2	4.0	97	43.00		0.176
Harpers S	3.7	0.59	W	4.3	-0.3	4.0	111	66.00	0.288	0.319
Pylewell	3.7	0.83	W	4.0	0.6	4.6	78	46.20		0.150
Pylewell	3.7	0.82	W	4.7	0.2	4.9	190	39.00		0.433
Pylewell	3.7	2.95	W	5.2	0.6	5.8	33	18.01		
Pylewell	3.7	1.33	W	4.9	1.0	5.9	121	25.25		0.424
Pylewell	3.7	1.43	W	5.0	1.2	6.2	215	22.52		0.840

Table A7.1: Drawdown Parameters

As can be seen, results were obtained for a number of locations and for both ferry types. The locations chosen for the Table were those (such as Harpers Post South or Cocked Hat) where the inbound and outbound ferries passed at approximately the same (relatively close) distance off, thereby removing one variable from the mix. The other location, the Pylewell Boom post, was chosen as representative of the lower areas of the river close to the banks of the saltmarsh; both outbound and inbound runs are included in the Pylewell data shown.

It should be noted that at low water, safety considerations limit the speeds to around 4 knots or less; speeds at higher tidal levels may attain 6 knots in Short Reach, the layby area and Long Reach.

Figures A7.2 and A7.3 summarise the key results to give an impression of the effects of tide height and speed through the water on cross-bank velocity and drawdown for both types of ferry. Figure A7.2 shows drawdown and Figure A7.3 the velocity.

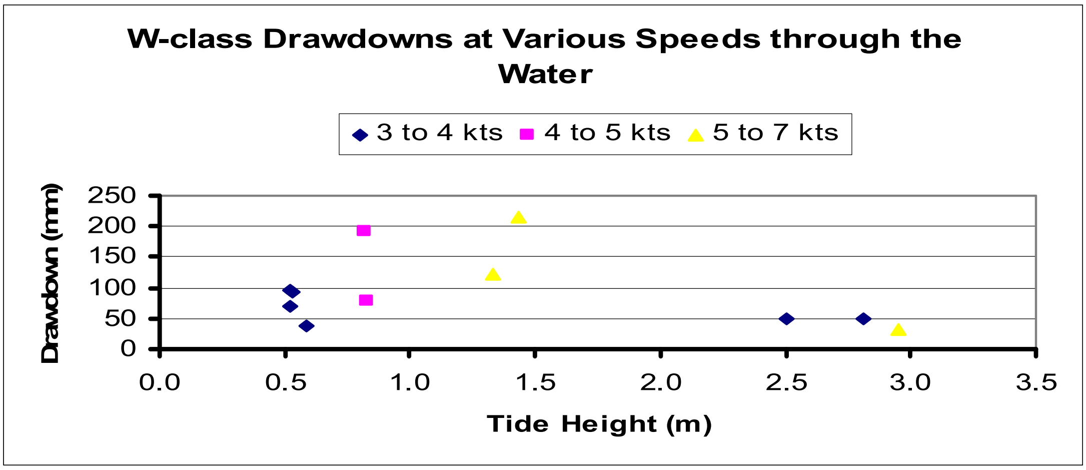


Figure A7.2a: W-class Maximum Drawdown

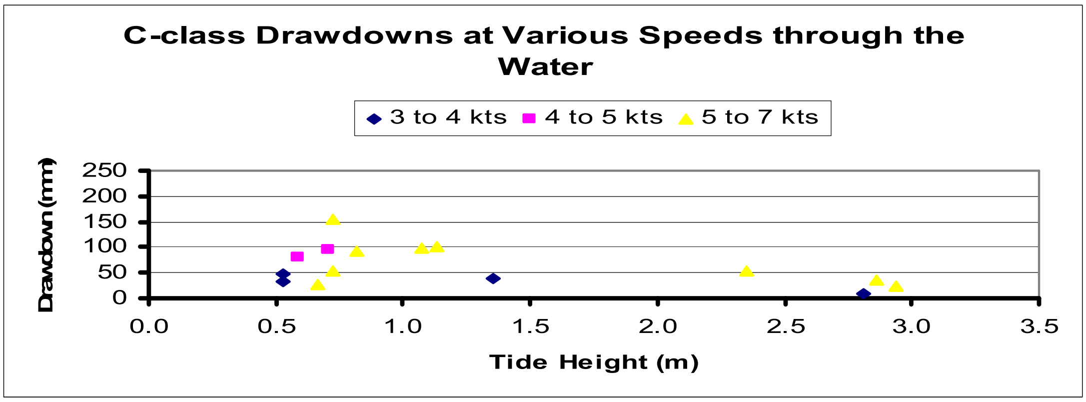


Figure A7.2b: C-class Maximum Drawdown

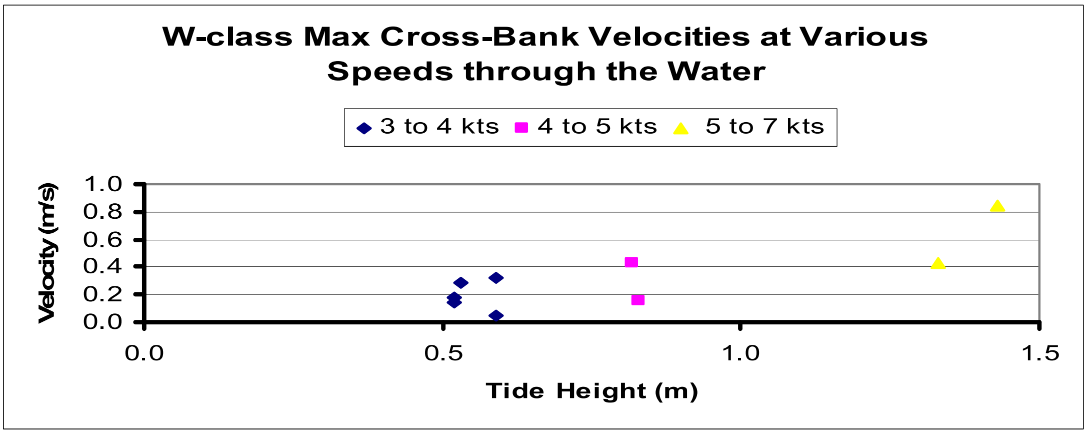


Figure A7.3a: W-class Cross-Bank Velocities

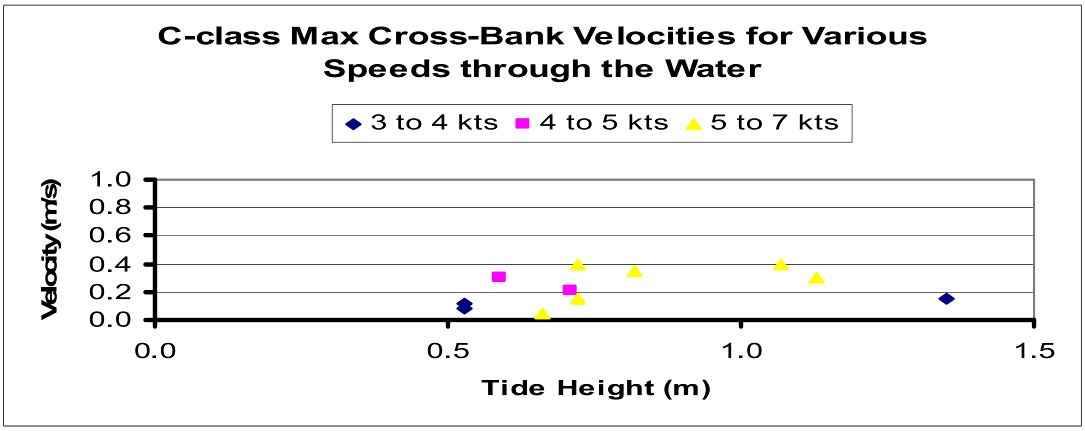


Figure A7.3b: C-class Cross-Bank Velocities

These Figures show that many of the results are confined largely to low, or nearly low, water. This is because it is in such conditions that the banks are exposed; at high water they are not and, in any event, as the local bathymetry plots were used to deduce bank slopes, it was impossible to obtain bank slope data for high water. Slopes were obtained on both sides ("east" and "west") of the channel at each location and the maximum computed across-bank velocities are therefore shown in the Table for both channel banks; in the plots only values for the east bank are shown for clarity. No velocities are shown for high water or for the west bank at Pylewell which are sufficiently far away for the assumption of constant drawdown with distance to break down.

A comparison may be made between the effects of the C- and W-class vessels and it is seen that, whereas in general there is not much difference in magnitude between results for the two vessels, the greatest individual drawdown and cross-bank velocities were obtained with the W-class; indeed the highest cross-track velocity of 0.84 m/sec was obtained for a W/W passing, exactly at Pylewell, made in the strongest ebb current where the inbound vessel (Wight Sky) was close to the measurement location and whose speed through the water, while stemming the current, was consequently high. Indeed, the larger drawdowns tended to be associated with passing (especially W/W passing) in the river. In the passing manoeuvres included in the data above, the ships were well separated and tracked close to the channel banks in the Pylewell region while there was a tendency to hug the inside of the bend when outbound at Cocked Hat. Both undoubtedly have increased the local drawdown values.

Figure A7.4 shows a direct comparison of drawdowns measured for W- and C-class ferries following each other at Harpers Post South; the greater value from the W-class can be seen.

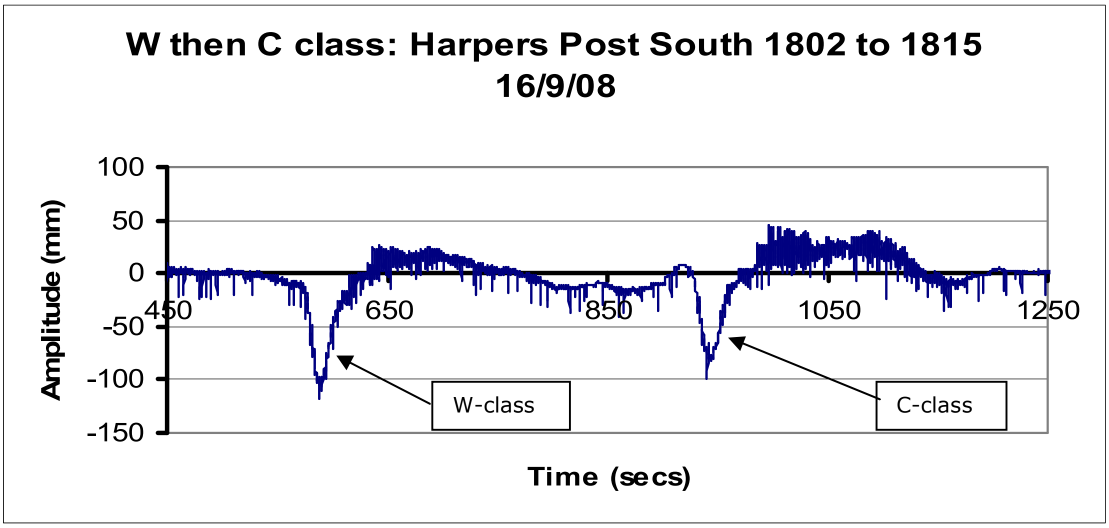


Figure 4: Drawdown; W-class followed by C-class at Harpers Post South. Height of tide 0.54m to 0.67m during period.

The powerful effect of speed on drawdown at low water is shown in Figure 5. This was the largest C-class drawdown measured and was obtained as a result of a request, as part of the trials programme, for a ferry to pass the Cocked Hat post at a speed of about 6 knots; in the event a speed around 5 knots was achieved. The normal speed at this location is about 4 knots in compliance with Byelaw 4 (relating to prudent navigation and keeping wash down), giving a maximum measured drawdown from the W-class of about 100mm and from the C-class around 70 to 80mm; these may be compared to the maximum value of 154mm shown in the Figure. It is of interest to note the existence in the trace of a second smaller drawdown some 4 minutes ahead of the large C-class example. The cause of this is not known, but it was not Wight Light which was in Yarmouth at the time.

A7.3 ALONG-BANK FLOW MEASUREMENTS

Some measurements were made of the backflow (return current) induced by the ferries in the intertidal mud on the west bank near the Cocked Hat post; they were 10 second mean values and are summarised in Table A7.2.

It is seen that the natural tidal ebb flow was similar or, in many cases, greater than, the backflow induced by the ferry at a range of speeds and similar distances off.

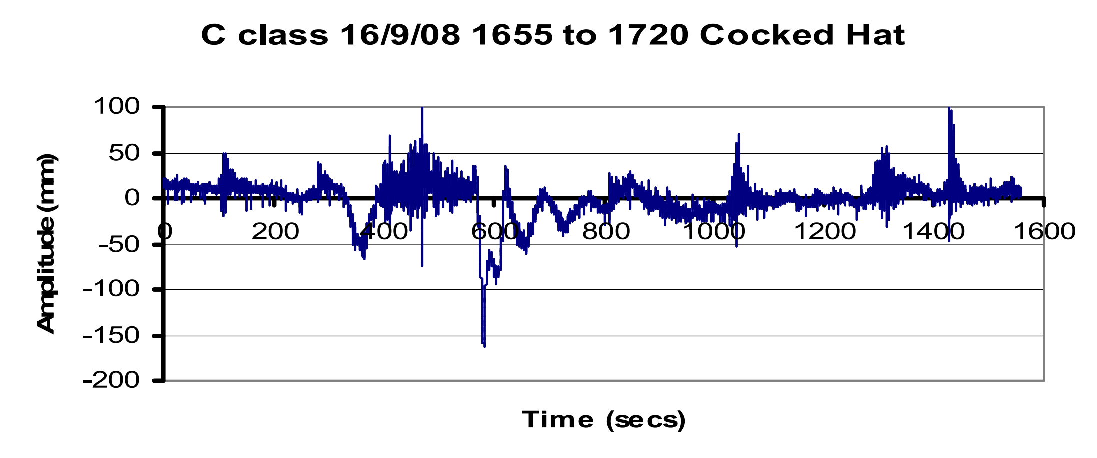


Figure 5: C-class Vessel drawdown at about 5 knots

Source	Ferry Direction	Time (BST)	Tide Height	Ferry Speed (knots)	Flow Rate (Meters per Second)	Notes
Wight Light	Inbound	16:22	2.8	6.2 (3 engines)	0.127	
Natural (Ebb Flow)	n/a	17:02	1.8	n/a	0.173	
Natural (Ebb Flow)	n/a	17:03	1.8	n/a	0.183	
Wight Light	Outbound	17:09	1.8	5.5	0.199	Natural flow stopped just before backflow
Caedmon	Outbound	17:25	1.8	5.8	0.178	Natural flow stopped just before backflow
Natural (Ebb Flow)	n/a	17:40	1.3	n/a	0.460	Measured rate on bank where 0.4m tide line forms (marked)
Wight Light	Inbound	17:45	1.2	4.1	0.429	
Natural (Ebb Flow)	n/a	17:46	1.2	n/a	0.250	
Cenwulf	Outbound	18:00	1.1	6.5	0.465	RIB Grounded due to drawdown
Caedmon	Inbound	18:30	0.6	5.1	see note	HM asked for 6 knot trial speed (more than master would normally do at this tide state - effects too significant to measure and run aborted
Caedmon	Outbound	19:00	0.3	4	0.511	HM requested HM do 4 knots outbound
Cenwulf	Inbound	19:05	0.3	4.5	0.209	
Wight Light	Inbound	circa 19.30	0.5	2.7	0.275	
Natural (Ebb Flow)	n/a	as WL	0.5	n/a	0.086	

Table A7.2: Backflow Measurements in the Intertidal Regime on the west bank near Cocked Hat.

Further measurements were made of the along-bank natural flows in the intertidal regime near the Cocked Hat, Cross Boom and Transit posts. Measurements were made with the propeller current meter close to the bank at the LAT level in the peak flow of an ebbing spring tide; they are shown, in metres per second, in Table A7.3.

Bank	Location	Time	Tide	v (m/s)
West	50m NE Cocked Hat	13:07:00	HW+4h6m	0.354
East	Cage Boom	13:12:00	HW+4h11m	0.274
East	Black + White Transit	13:16:00	HW+4h15m	0.486
East	Cage Boom	13:21:00	HW+4h20m	0.342
West	30m S Cocked Hat	13:25:00	HW+4h24m	0.504
East	Black + white Transit	13:29:00	HW+4h28m	0.484

Table A7.3: Measured Natural Along-bank Flows at Cocked Hat Bend

It is clear from these results that the maximum flow velocities are about 0.5 metres per second or 0.97 knot. This may be compared with the maximum tidal stream of about 1.2 knots measured on the edge of the channel near the Pylewell Boom post and shown in Figure 2 of the main report.

APPENDIX 8

Sound and Light Signals

The International Regulations for Preventing Collisions at Sea: Sound Signals

The sound signals for manoeuvring and warning are given in Rule 34 of the ColRegs. However, Rule 9, dealing with Narrow Channels, and Rule 13, dealing with overtaking, are also relevant for operations on the Lymington River.

The sound (and the accompanying light) signals in Rule 34, relevant to the Lymington River, are summarised here; for a complete listing and explanation the ColRegs themselves should be consulted.

Rule 9

(a) A vessel proceeding along the course of a narrow channel or fairway shall keep as near to the outer limit of the channel or fairway which lies on her starboard side as is safe and practicable.

(b) A vessel of less than 20 metres in length or a sailing vessel shall not impede the passage of a vessel which can safely navigate only within a narrow channel or fairway.

(c) A vessel engaged in fishing shall not impede the passage of any other vessel navigating within a narrow channel or fairway.

(d) A vessel shall not cross a narrow channel or fairway if such crossing impedes the passage of a vessel which can safely navigate only within such channel or fairway. The latter vessel may use the sound signal prescribed in Rule 34(d) if in doubt as to the intention of the crossing vessel.

(e) (i) In a narrow channel or fairway when overtaking can take place only if the vessel to be overtaken has to take action to permit safe passing, the vessel intending to overtake shall indicate her intention by sounding the appropriate signal prescribed in Rule 34(c)(i). The vessel to be overtaken shall, if in agreement, sound the appropriate signal prescribed in Rule 34(c)(ii) and take steps to permit safe passing. If in doubt she may sound the signals prescribed in Rule 34(d).

(ii) This Rule does not relieve the overtaking vessel of her obligation under Rule 13.

(f) A vessel nearing a bend or an area of a narrow channel or fairway where other vessels may be obscured by an intervening obstruction shall navigate with particular alertness and caution and shall sound the appropriate signal prescribed in Rule 34(e).

(g) Any vessel shall, if the circumstances of the case admit, avoid anchoring in a narrow channel.

Rule 13

(a). Notwithstanding anything contained in the Rules of Part B, sections I and II, any vessel overtaking any other shall keep out of the way of the vessel being overtaken.

(b). A vessel shall be deemed to be overtaking when coming up with another vessel from a direction more than 22.5^{o} abaft her beam, that is, in such a position with reference to the vessel she is overtaking, that at night she would be able to see only the sternlight of that vessel but neither of her sidelights.

(c). When a vessel is in any doubt as to whether she is overtaking another, she shall assume that this is the case and act accordingly.

(d). Any subsequent alteration of bearing between the two vessels shall not make the overtaking vessel a crossing vessel within the meaning of these Rules or relieve her of the duty of keeping clear of the overtaken vessel until he is finally past and clear.

Rule 34

(a) and (b) *"I am altering my course to starboard" – one short blast/flash*
"I am altering my course to port" - two short blasts/flashes
"I am operating astern propulsion" - three short blasts/flashes

(c) When in sight of one another in a narrow channel or fairway:
(i) a vessel intending to overtake another shall, in compliance with Rule 9 (e)(i), indicate her intention by the following signals on her whistle:
- *"I intend to overtake you on your starboard side" – two long blasts followed by one short blast*
- *"I intend to overtake you on your port side" – two long blasts followed by two short blasts*

(ii) the vessel about to be overtaken when acting in accordance with Rule 9(e)(i) shall indicate her agreement by the following signal on her whistle:
- One long blast, one short blast, one long blast, one short blast in that order.

(d) When vessels in sight of one another are approaching each other and from any cause either vessel fails to understand the intentions or actions of the other, or is in doubt whether sufficient action is being taken by the other to avoid collision, the vessel in doubt shall immediately indicate such doubt by giving *at least five short blasts/flashes on the whistle/lights*.

It is relevant to note that Rule 33(b) states that vessels less than 12 metres (40 feet) in length are not obliged to carry sound signalling appliances appropriate to larger ships, but, if they do not, they must be provided with some other means of making a sound signal.

APPENDIX 9

Consultation

CONSULTATION

The following bodies were contacted by, or were in contact with, BMT during the course of the whole study. Those marked * were stakeholders:

Lymington Harbour Master and Staff*
Lymington Harbour Commissioners*
Lymington Harbour Advisory Council*
Wightlink*
Maritime and Coastguard Agency*
Natural England
Royal Lymington Yacht Club*
Lymington Town Sailing Club*
Solent Protection Society*
Sailability*
9th Lymington and Barton Sea Scouts (through LTSC)*
The Lymington Society*
The Lymington River Association
HR Wallingford
Lymington Marina Operators*
ABPmer

The Lymington Rowing Club was invited to participate, but declined as the club had no real safety issues with the ferry operations.

Meetings were held with stakeholders during Phase 1 of the study to understand their concerns. In Phase 2, the trials scope and programme was discussed and adjusted on the basis of stakeholders' comments in order to address as many of their concerns as was possible and reasonable in the prevailing weather and river traffic during the trials period.

It was emphasized to stakeholders that members of the BMT team were always available for discussion and full contact details were made available. Some of the bodies were therefore in contact during the study by both e-mail and telephone.

APPENDIX 10

RISK REGISTER WORKING TABLE

RISK REGISTER WORKING TABLE

In this Appendix the full workings behind the Summary Risk Register in Table 6 are provided.

The Register considered a number of incident scenarios which reflected the concerns of the stakeholders. The component parts of risk – probability and consequence – were then addressed for each scenario to give an overall assessment of the *relative* risk (with W-class compared to C-class) before any control measures were applied. As an aid, a red-amber-green colour-coding was used to indicate if the relative risk was greater, the same or less with the W-class compared to the C-class.

Various control measures were then assessed and ultimately an overall assessment of the relative risk was made making use of the professional judgement of the experienced master mariners on the BMT team.

The key results from this detailed risk assessment worksheet were then extracted and summarized in Table 6 in the main report.

Details of the methodology for the detailed worksheet, forming the basis of the risk assessment, now follow.

Objective Assessment

The way in which the detailed Risk Assessment Worksheet in this Appendix was filled in is shown in the first row. The overall approach has been based on objective assessment wherever possible in order to show the way in which the risks associated with the identified incidents would be affected by introducing the W-Class ferries. This used the informed judgement of the BMT team to assess the probable extent of that change, supplemented by an additional judgement of the level of residual risk present for each of the scenarios.

Firm evidence from the trials themselves, together with measurements and observations made on the river, has been used to inform the relative risk assessment wherever possible, allowing the BMT team to provide a firm, objective, view of the way in which changing from C-class to W-Class operation would affect the risks associated with incidents relevant to either class.

The matrix approach of Figure A10.1, and consequent colour coding, high-lighted the effects on each scenario's risk, depending on whether the probability or consequence from W-Class operation would be Lower than (L), the Same as (S), or Higher than (H) the equivalent probability or consequence for C-Class operation.

Master Mariners' Assessment

In order to clarify the amount by which the risk changed, the informed judgement of BMT's master mariners was also used in this exercise, based on their exposure to:

- Stakeholder consultation, and all related evidence, direct and anecdotal, supplied to the study team
- Trials and measurements

- Direct observation, both on-board and on from the river, made during a large number of vessel transits
- Their extensive relevant marine expertise.

RISK ASSESSMENT TABLE - USED TO LOOK UP WORDS AND SHADING FOR RELATIVE RISK ASSESSMENT

Overall Probability Ranking (a) of W-Class relative to C-Class \ Overall Consequence Ranking (b) of W-Class relative to C-Class	Lower (L)	Same (S)	Higher (H)
Higher (H)	Could be Lower or Higher	Higher	Higher
Same (S)	Lower	Similar	Higher
Lower (L)	Lower	Lower	Could be Lower or Higher

Figure A10.1: Matrix used to Determine Relative Risk of Identified Scenarios

A numerical estimate of the change in residual risk caused by the introduction of the W-class was made for each incident. This was evaluated on a scale of -5 to 5, with the boundaries of that range defined as follows:

5	Significantly increased residual risk, requiring additional mitigation
3	Moderately increased residual risk, after the implementation of reasonably practicable risk-reduction options
0	Similar level of residual risk
-3	Moderately reduced residual risk, after the implementation of reasonably practicable risk-reduction options
-5	Significantly reduced residual risk, after the implementation of reasonably practicable risk-reduction options

Consistent with the above, a further indication of the level of residual risk associated with each identified scenario has been provided, based on BMT's master mariners' judgement as to whether the level was High (H), Medium (M) or Low (L). It must be emphasised that this assessment set against a background of the overall low level of marine risk experienced on the river to date, and the desire to maintain or reduce the level of risk associated with ferry operations at Lymington.

Summary of the Approach

The overall stages in the main Risk Assessment process were:

1. A detailed objective comparison of the risks associated with identified hazardous incident scenarios followed by recommendations of additional practicable risk control measures. This involved:

    a) The identification and clarification of specific, and potentially hazardous, scenarios to form the basis of the risk assessment, based on available evidence;

    b) Consideration of the factors that would affect the probability and/or consequence of the identified scenarios;

    c) The provision of all available evidence (trials information, stakeholder comments, anecdotal information etc) to inform the assessment as to how the probability and/or consequence of the scenarios would differ with W-class vessels in service;

    d) From the above, make an objective assessment, based on the evidence, of whether the risk associated with the particular incident with W-class operations would be higher than, the same as, or less than the risk with the same or equivalent incident with C-class operations;

    e) Where the risk of specific incidents was deemed to be higher with W-Class operation compared to that of the C-Class, identify additional risk control measures and assess their effect.

It may be mentioned here that LHC has overall responsibility for ensuring that the safety of navigation risk is reduced to a level that is As Low As Reasonably Practicable (ALARP), consistent with meeting the requirements of the Port Marine Safety Code (PMSC); it is the ultimate arbiter of what will be effective and practicable in the overall context of Lymington Harbour and the existing marine operations. A number of risk control measures are permanently in place and others are introduced from time to time, consistent with other existing risk assessments and the various Codes of Practice (CoPs) for events in the river. Consistent with this, BMT has identified those practicable additional specific risk control measures that the Company believes will be required in respect of W-class ferry operation in order that levels of risk are reduced and maintained ALARP overall.

The numbers in parentheses in the "Risk Control Measures" column of the Table in Appendix 10 are the Section numbers in the main text where further relevant information can be found.

2. Comparison of how the overall level of residual risk would be affected by operating W-class, rather than C-class, ferries on the route. This involved:

    a) Analysis of the implications of operating W-class rather than C-class vessels on the risks all the identified hazardous scenarios;

    b) An indicative numerical estimate of residual risk for each of the potential hazardous scenarios. This involved consideration by the BMT master mariners as to how the residual risk of each of the scenarios will vary from C-Class to W-Class. It was done by allocating a value of between -5 and 5 (see above) to the level of residual risk estimated for each case with existing and additional recommended control measures in place. While this final level of assessment is necessarily subjective, it is informed by all available data, the experience of the BMT master mariners, and their broad nautical experience;

c) An indication by the master mariners as to whether they felt the residual risk associated with each scenario is High, Medium or Low, in the context of the known low-risk environment on the river (i.e. "High" risk is used as a relative term, rather than an absolute level of risk);

d) Summation of the residual risk indicators for a further indication to show how residual risk would change with the W-class ferries operating in place of the C-Class.

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	Operational scenario	(Hazard and potential accident scenario description)	Accident Probability Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Probability Ranking relative to C-Class (a)	Accident Consequence Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Consequence Ranking relative to C-Class (b)		Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP		Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement
			What could affect probability?	Assessment of drivers and supporting evidence	Higher (H) Lower (L) Same (S)	What could affect consequence?	Assessment and supporting evidence	Higher (H) Lower (L) Same (S)						
1	2 ferries passing at layby	Collision of 2 ferries, resulting in multiple injuries, grounding, blockage of navigation channel, loss of cargo	Current and wind conditions Controllability of vessels Vessel width Channel width Vessel speed	S: Current and wind conditions are not affected by which ferry type is operating L: There is potential for reduced control with C or with W Class, especially outbound on ebb tide in strong winds. However, controllability of W Class is better than C-Class despite additional windage (6.1.2, 6.1.3, 6.1.4, 6.1.5, 6.1.6, 6.1.7) S: Overall width (including overhangs) is similar for C-Class and W-Class S: Channel width affects this hazard in the same way for C Class and W Class, as they are of similar width. S: Speeds in the lay-by are likely to be similar for C and W-classes for most tidal conditons. At very low water, they may be lower for W-class	L: To date this has never happened on the river. In spite of this,the overall probability of this event occurring is considered to be reduced, due to the improved control of W-Class across the range of anticipated weather and tidal conditions	Passenger numbers at risk Ability to remain afloat Ability to retain control	L: Passenger numbers on W-class likely to be less on C-class as demand has changed in favour of vehicle rather thasn passenger transportation L: Survivability of W Class is improved over C Class as a result of complying with latest IMO/SOLAS regulations (See Phase 1 report) L: W-class has better navaids and controllability.	L: The consequence of a collision would be reduced due to fewer people being carried, improved survivability and greater potential to retain control	Lower	Ferry damage stability and survivability to conform to IMO/MCA requirements; operation of the ferry to conform to ISM/STCW requirements Adhere to ColRegs, use Transit Marks in good visibility, also use the master's judgement as to whether to pass at all in bad visibility or strong winds	Use radar/ECDIS in poor visibility (6.1.6, 7.2.5, 7.2.8)	Lower	0	Low due to compliance with latest IMO/MCA damage stability regulations Collision on passing would occur only at layby area.
2	ferry transiting area with sailing vessels present	Loss of control/capsize as sailing vessel passes into ferry wind shadow in river; Loss of control/capsize as Junior sailors pass into wind shadow in Horn Reach	Wind direction and strength Ferry superstructure Congestion/ proximity of leisure traffic Experience of leisure users	S: wind direction and strength unaffected by ferry type H: W Class have a greater wind shadow whose effect is worst when the ferry is waiting in the river and relative passing speeds are low. S: congestion unaffected by ferry type S: Users with experience of ferries will tend to keep well clear. Inexperienced users may stray too close to the ferry and became more affected. Objective evidence gathered comprises: - Sailing trials. Trials stakeholders indicated a greater wind shadow for W Class than C Class, the main difference being one of duration (6.3). The Wednesday Junior Sailors appeared to cope well with wind shadow in a special trial (5.4) - Wind shadow measurements indicate that the main differences are in duration of the change of wind direction (6.3 and Appendix 5) - Independent observations by stakeholders in sailing trials indicated a greater wind shadow for W Class than C Class, but they were generally able to deal with it satisfactorily (6.3).	H - On balance, a marginally higher probability is likely, as a consequence of the extended duration of wind shadow.	W-class has increased windage	S - no change in the experience of river user expected	S	Higher	Keep clear of ferries as advised in LHC Harbour Guide; Compliance with ColRegs Juniors moved to sides of water space as ferry passes. (5.4.3, 6.3, 7.2.9)	Additional Harbour Master presence would reduce probability by stimulating good and compliant behaviour of leisure craft. Anticipate wind shadow (6.3, 7.2.9, Appendix 5)) Sail only vessels should have another means of propulsion (e.g. a paddle(s) for dinghies)	Higher	3	Low to medium due to greater windage. Low for Junior sailing

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	**Operational scenario**	**(Hazard and potential accident scenario description)**	**Accident Probability Risk Drivers and comparison with existing ferries** (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		**Overall Probability Ranking relative to C-Class (a)**	**Accident Consequence Risk Drivers and comparison with existing ferries** (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		**Overall Consequence Ranking relative to C-Class (b)**		**Existing/ Planned Risk Control Measures for W-Class ferries**	**Required Additional Risk Control Measures to achieve ALARP**		**Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)**	**Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement**
			What could affect probability?	**Assessment of drivers and supporting evidence**	**Higher (H) Lower (L) Same (S)**	**What could affect consequence?**	**Assessment and supporting evidence**	**Higher (H) Lower (L) Same (S)**						
3	ferry transiting area with sailing vessels present	Small vessel sailing near waiting ferry loses wind due to wind shadow, could cause small boat to move towards the ferry and collide with it; could cause sailing vessel to capsize	Wind direction and strength Ferry superstructure Thruster slipstream Congestion/ proximity of leisure traffic Leisure user behaviour	S: wind direction and strength unaffected by ferry type H: Wind shadow of W-Class is greater than C-Class and eddies probably stronger due to superstructure height (6.3 and Appendix 5) H: slipstream effects can be greater in medium to strong winds (6.3.2) S: congestion likely to be the same regardless of ferry type Sailing trials indicate the overall effect is slightly worse, especailly if sailing vessels approach too close to the windward side of the ferry.	H: if sailing vessels move very close to ferry otherwise S:	W-class has increased windage	S: if river users follow advice of Harbour Guide and keep clear of ferries	S	Higher	Keep clear of ferries as advised in LHC Harbour Guide; anticipate wind shadow (6.3, 7.2.9, Appendix 5)). Compliance with ColRegs Juniors moved to sides of water space as ferry passes. (5.4.3, 6.3, 7.2.9)	Sail only vessels should have another means of propulsion (e.g. a paddle(s) for dinghies)	Higher	1	Low to medium due to greater windage
4	ferry transiting area with sailing vessels present	Too low a river speed results in reduction in control, ferry grounding, contact or collision Longer occupation of the river if speed low so greater chance of bunching and impeding sailing activities	Environmental conditions are more difficult to combat at low speed.	L: W Class ferries have better low speed control than C-class (6.1) H: W-class ferries have greater squat then C-class, but still low values at low speed (6.2.2) S: slow speed will cause these problems regardless of ferry type	S	W-class have greater momentum and inertia due to greater displacement Poorer communications between river users and W-class lead to uncertainty in bunched traffic	H: due to greater displacement H: poor communications create uncertainty	H	Higher	Ferry to maintain a safe speed (minimum whilst maintaining control). W-class hull design has low wash at river speeds W-class has better inherent controllability (6.1,6.1.3,6.2) maintain existing speed limits (6.8,7.2.6)	Use recommended thruster settings (7.2.2) Improve ferry/river communications	Similar	0	Low with existing advisory and mandatory speed limits

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	Operational scenario	(Hazard and potential accident scenario description)	Accident Probability Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Probability Ranking relative to C-Class (a)	Accident Consequence Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Consequence Ranking relative to C-Class (b)		Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP		Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement
			What could affect probability?	Assessment of drivers and supporting evidence	Higher (H) Lower (L) Same (S)	What could affect consequence?	Assessment and supporting evidence	Higher (H) Lower (L) Same (S)						
5	ferry transiting area with any *(commercial or leisure)* vessel underway or moored	Sinking/ swamping of other vessels (including moored vessels) due to wash Wash swamps/ inconveniences other vessels	Wash from hull or thrusters Loss of control	L: Wash is reduced compared to C-class (and some leisure craft) provided W-class aft thruster is at correct power setting (6.2.1) H: Recovery from loss of control may need large thruster forces, due to greater inertial effects leading to enhanced wash (6.1.3)	L: If correct thruster settings and control actions are used	W-class capable of producing more powerful wash and thruster slipstreams	H: If Operational power setting applied H: Slipstream and wash unacceptable at operational setting (6.2.1) L: Wash if reduced if recommended power settings applied to aft thruster	H	**Could be Lower or Higher**	Control speed and adhere to limits, low wash hull form, use appropriate thruster settings, be aware of other users on the river. (6.2, 6.8, 7.2.2, 7.2.6)	Use SOP New handlers to have close and continuous supervision in winds and when manoeuvring close to leisure traffic or moored vessels. Use of correct through-water speed for the conditions, training in high winds, especially from SW, E and S (6.1.3, 6.1.4, 7.2.2)	**Lower**	**0**	Low
6	ferry transiting area with any vessel underway	Ferry capsizes rapidly in Solent (seaward of Jack in the Basket mark) after sustaining damage with heavy loss of life	Current and wind conditions Controllability of vessels Navaids Use of ColRegs Vessel statical stability and subdivision	L: Handling of W-class in wind and tidal streams and in Solent is good from observations on trials. (6.1.3) L: Controllability of W-class is good (6.1.3); emergency stopping good (6.1.5) L: Excellent navaids on W-class; superior to those on C-class L: Masters are familiar with ColRegs and adhere to them L: W-class complies with latest SOLAS/IMO regulations; C-class do not	L: W-class comply with latest survivablity requirements and should survive long enough to get passengers off	Passenger numbers at risk Ability to retain control	L: Passenger numbers on W-class likely to be less than C-class as demand has changed in favour of vehicle rather than passenger transportation L: Survivability of W Class is improved over C Class as a result of complying with latest IMO/SOLAS regulations (See Phase 1 report) L: W-class has better navaids and controllability.	L	**Lower**	Ferry damage stability and survivability to conform to IMO/MCA requirements; operation of the ferry to conform to ISM/STCW requirements	None	**Lower**	**-3**	Low
7	ferry transiting area with any vessel underway or moored	Boat (moored or moving) hit by ferry Restrictions on bridge field of view results in collision with leisure vessel	Tide and weather conditions Controllability of vessels Use of ColRegs by all users Vessel size Hydrodynamic interaction	S: Tide and weather conditions independent of ferry type L: W-class controllability better than that of C-class (6.1) S: Adherence will be unchanged by ferry type. Generally good adherence by ferries, generally poor by leisure users (7.2.5, 6.12) H: W-class more mass and inertia than C-class H: Greater interaction with W-class L: Better overall view from W-class bridge, but blind spot under bow bigger than C-class (6.1.5, 6.11, 7.2.1) L: If boats not placed on single point moorings at Cocked Hat Bend (6.5.1, 7.2.12)	S	The number of impeding vessels and the number of occupants	S: No reason to anticipate a behavioural change.	S	**Similar**		Stop single point mooring on inside of Cocked Hat Bend and western side of Short Reach Lay-by area; Ferries keep to middle of river when possible; keep clear of ferries (6.5.1, 6.5.2, 7.2.2, 7.2.12) Maintain lookout, use extent of bridge wings on ferries, check around ferry before departure; use on-board CCTV cameras; check bow blind spot (6.1.5, 6.11, 7.2.1)	**Lower**	**0**	Low

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	Operational scenario	(Hazard and potential accident scenario description)	Accident Probability Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Probability Ranking relative to C-Class (a)	Accident Consequence Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Consequence Ranking relative to C-Class (b)		Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP		Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement
			What could affect probability?	Assessment of drivers and supporting evidence	Higher (H) Lower (L) Same (S)	What could affect consequence?	Assessment and supporting evidence	Higher (H) Lower (L) Same (S)						
8	ferry transiting area with any vessel underway	Collisions between or grounding of small craft because of lack of space during busy periods	Communications Traffic density Tracks taken by ferries, especially in lay-by area on leading lines State of tide Use of ColRegs Type of mooring	H: The bridge on the W Class ferries is more isolated from external traffic than C Class making it more difficult to communicate with other vessels. Use of the ColReg sound signals is limited (Appendix 8, 6.13) S: Traffic density - the same for both vessels. H: W-class tends to keep to edge of channel (6.4) S: Space in river most restricted at low water springs S: Not all users adhere to ColRegs (6.12) S: single point moorings on edge of channel restrict navigation space for both C_ and W-class ferries	S	The number of small craft and the number of occupants	S: No reason to anticipate a change in the number of occupants per vessel or the number of small craft.	S	Similar	All craft adhere to ColRegs; Small craft adhere to sailing CoPs to limit boat numbers. Small craft keep out of the main channel if possible Use appropriate speed, use radar/ECDIS in poor visibility, keep good lookout, follow safety advice in LHC Harbour Guide. Follow guidance in MGN 199(M)	Ferries to keep to centre of channel where possible and pass on Transit Marks. Extra HM patrols at busy times. (6.9, 7.2.6) Adopt greater use of sound signals to inform users (6.13, 7.2.8, Appendix 8) Use Transit Marks for passing, (6.1.6)	Similar	0	Medium. The associated hazard probability is highest during low tide.
9	ferry enters area where vessels are moored	Interaction pulls moored vessels into main channel and collision ensues	Speed Proximity to moored vessels Water depth Location of moored vessels	H: The W-class ferries will induce more interaction due to their increased displacement H: if the W-class ferries pass unnecessarily close to moored vessels at too high a speed S: interaction effects stronger at low water depths and greatest at LWS S: vessels moored in certain locations, such as the Cocked Hat bend, are more vulnerable (6.5) S: Single point moorings more vulnerable (6.5)	S to H	The number of moored vessels and the number of occupants	S to H: No reason to anticipate major change in behaviour, but interaction from W-class will have a greater effect.	S to H	Higher	Maintaining effective lookout making full use of bridge wings and focsle (the last at master's discretion) (6.11) Limit speed in accordance with the Byelaws and the advisory speed limit in Horn Reach	Ensure boats moored near the channel cannot swing into the path of passing ferries and other large vessels; be aware of ferry proximity and avoid moving on deck when ferry passes (6.5.2, 7.2.12). See also Scenario 7 - vessels should not be moored on Cocked Hat bend.	Lower	-1	Medium / Low if Cocked Hat bend mooring measures applied. The associated hazard probability is highest during low tide.
10	ferry is underway	Ferry loses power, resulting in grounding and blocking of river	Mechanical failure	L: new ferries have redundant and more reliable machinery; they can also be controlled in "get you home" mode with one thruster in benign conditions (6.1.2)	L	Vessel momentum and windage: number of other vessels at risk Damage to Voith thrusters	H: Refloating after grounding is likely to be more difficult for a vessel with a greater wind area. Release of oil is less likely than in C Class because of use of more modern / more highly proven Voith thrusters, but these thrusters are more vulnerable than those of the C-class due to their location under the hull.	H	Could be Lower or Higher	Ensure navigation marks correctly positioned; on ferry maintain lookout, ship handles well in river, echo sounder to be working, especially at low water; ferry proceeds with caution at low water; use visual tide height gauges on navigation posts; ensure river does not silt; regular surveys and make bathymetry plots available. (6.1.6, 7.2.11, Reference 1)	None	Could be Lower or Higher	0	Low

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	**Operational scenario**	**(Hazard and potential accident scenario description)**	**Accident Probability Risk Drivers and comparison with existing ferries** (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		**Overall Probability Ranking relative to C-Class (a)**	**Accident Consequence Risk Drivers and comparison with existing ferries** (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		**Overall Consequence Ranking relative to C-Class (b)**		**Existing/ Planned Risk Control Measures for W Class ferries**	**Required Additional Risk Control Measures to achieve ALARP**		**Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)**	**Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement**
			What could affect probability?	**Assessment of drivers and supporting evidence**	**Higher (H) Lower (L) Same (S)**	**What could affect consequence?**	**Assessment and supporting evidence**	**Higher (H) Lower (L) Same (S)**						
11	ferry is underway	Severe weather results in loss of control, damage to other vessels and damage to navigation posts	Weather conditions Controllability of vessels Familiarity of the masters with the vessel in strong winds Vessel width Channel width	S: Weather conditions unaffected by ferry type L: Controllability of W-class vessels is good and better in wind than C-class (6.1.3) S or H: Masters need familiarisation of the new W-class vessels in strong winds from a range of directions L: Excellent navaids on W-class vessels will improve navigation in fog S: W-class and C-class widths similar S: Channel width same for both C- and W-class	L	Vessel momentum and windage; number of other vessels at risk	H : Although loss of control is less likely, once control is lost the consequence is likely to be greater	H	**Could be Lower or Higher**	W-Class has greater reserves of power and control Good ferry control, use radar and ECDIS; conspicuous and "handrail" visual navigation marks which clearly define the channel; masters to cease ferry operations if they consider situation unsafe; use appropriate thruster settings (6.1, 7.2.2, 7.2.11)	Use W-class safe operating procedures: - For winds up to a mean value 25knots, gusting 30, thrusters at "operational"/"full" forward and "idle"/"slow" aft - For winds greater than a mean value of 25 knots, gusting 30 to a mean value of 30 knots, gusting 42, thrusters at "operational"/"full" forward and "intermediate"/"half" aft - All wind speeds are to be measured at the RLymYC Starting Platform. - Masters' competence at higher wind limit should be the subject of a formal application by the operators demonstrating "river experience" - for example through evidence of transits and master "sign off" for adverse weather operation.	**Could be Lower or Higher**	-1	Low
12	ferry is underway	Grounding due to navigation marks being unrepresentative / main channel migration	Channel navigation marks out of position	S: Hazard independent of ferry type	S	None	S	S	**Similar**		Ensure navigation posts correctly located. (6.1.6, 7.2.11, Reference 1)	**Similar**	0	Low. The associated hazard probability is highest during low tide.
13	ferry is underway	Grounding or collision due to loss of control during change of con location on bridge	The W class ferries can be conned from one of four locations on the bridge. Transferring the con from one location to another requires strict observance of operating procedures or control can be lost temporarily.	H: Not a feature of C-class bridge operations H: If vessel not conned from only one location for all transits. H: Possible to lose control during transfer	H: because C-class have no such facility	Only on W-class	H	H	**Higher**	N/A - Hazard is specific to W-Class	Use recommendaed handover procedures; training; recommend synchronising controls in the long term. (6.1.2, 7.2.1) Only handle ships from central con	**Higher**	2	Medium with present situation, Low if control locations synchronised
14	ferry enters area where persons are in the water	Person in water hit by ferry	Controllability of vessels and look-out especially in blind spot Ferry speed Design of bow	S or L: View from W-class bridge generally very good; blind spot under bow needs checking on both ferry types (6.11) S: Stopping ability of W-class very good and similar to that of C-class (6.1.5) L: Better control of W-class (6.1) S: speed of ferry types similar L: Design of bow on W-class is more likely to deflect casualty down side of	S or L	Ferry speed Bow design of W-class Thruster location	S: speeds likely to be similar	S	**Lower**	Keep clear of ferries as advised in LHC Harbour Guide; Ferries keep lookout with a minimum of 3 crew mwmbers on the bridge with two on bridge wings. No swimming/diving in river	Ensure blind spot under bow checked before sailing and moving off (6.11, 7.2.1) Increased Harbour patrols, especially in the lower reaches and at times of peak leisure use	**Lower**	-4	Low due to good visibility and surveillance cameras, but blind spot must be checked before sailing
15	ferry enters area where persons are in the water	Person in water sucked into thruster. This accident scenario requires that someone is in the water adjacent to the thrusters, and that they are then pulled towards the thrusters, and that they are then impacted by them.	Thruster proximity to water surface Thruster power in use Area of suction near the thruster	L: W-class thrusters on centreline and lower than C-class H: Power on forward thruster higher on W-classthan C-class (6.1) L: No evidence for suction at or near water surface in vicinity of W-class thrusters (6.10, 6.11)	L	Thruster location	S: Both C-Class and W-Class ferries have Voith thrusters with similar consequences	S	**Lower**	Thusters can be de-clutched on the W-Class ferries. Compliance with Notice to LHC Mariners 10 2008 furgther reduces the consequences of this accident (i.e wear life-jackets)	Grab lines should be attached to the hull in the region of the bow, as is the case on the Voith-propelled Red Funnel vehicle ferries. (Para 6.11, para 7.2.13)	**Lower**	-1	Low

	HAZARD		PROBABILITY ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			CONSEQUENCE ASSESSMENT (W-CLASS RELATIVE TO C-CLASS)			RISK [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	RISK CONTROL MEASURES		Risk After (Further) Control Applied (relative to C-Class). [Function of (a) and (b)] (with existing / planned Risk Control Measures) Relative to C-Class	Relative and Residual Risk (in context of existing risk levels, as demonstrated through operational experience)	
Ref no.	Operational scenario	(Hazard and potential accident scenario description)	Accident Probability Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Probability Ranking relative to C-Class (a)	Accident Consequence Risk Drivers and comparison with existing ferries (H - Higher than existing ferries; S - No Difference; L - Lower than existing ferries)		Overall Consequence Ranking relative to C-Class (b)		Existing/ Planned Risk Control Measures for W-Class ferries	Required Additional Risk Control Measures to achieve ALARP		Estimate of Change in Residual Risk with W-Class as opposed to C-Class (-5 to +5)	Indication of level of residual risk based on BMT's Master mariners' judgement (H, M, L) / Notes on risks based on BMT's Master mariners' judgement
			What could affect probability?	Assessment of drivers and supporting evidence	Higher (H) Lower (L) Same (S)	What could affect consequence?	Assessment and supporting evidence	Higher (H) Lower (L) Same (S)						
16	Ferry arrival / departure	Thrusters' slipstream impacts nearby leisure vessels	Thrusters in operation when ferry berthed	L: C-class keep thrusters rotating in zero pitch; W-class stop thrusters when berthed.	L	Power of slipstream	H - More distubance from W-class thruster slipstreams	H	Could be Lower or Higher		Stop thrusters when berthed (6.10, Appendix 7, 7.2.3)	Lower	-2	Low
17	ferry transiting area with any vessel underway	Swamping of leisure craft impacted by aft thruster slipstream disturbance and sudden vectoring	Control actions Training Thruster power settings Excessive wash and wake disturbance	H: Control response more rapid in W-class so over-control possible in some situations (6.1.2) H to L: Rapid vectoring associated with early training and difference in response of W-class compared to C-class. Should improve with familiarity	H	Location of leisure vessels near stern of W-class	H: if thrusters on "operational" setting, slipstream could seriuosly affect small craft	H	Higher	ColRegs Keep clear of ferries as advised in LHC Harbour Guide (6.3.2, 7.2.4)	Use of appropriate power setting on aft thruster (6.1, 6.1.4, 6.2, 6.8, 7.2.2,7.2.6)	Lower	1	Low if additional risk control measures applied, otherwise significantly higher
18	ferry waiting at layby	Inconvenience to other craft; grounding of leisure craft	Thruster slipstream Wind shadow Traffic bunching Lack of space at low water	H: Slipstream effect can be unacceptable in stop-and-hold in medium to strong winds (6.1.3) H: Wind shadow longer duration (6.3) S: Traffic bunches due to lack of space and uncertainty as to ferry's intentions (6.13)	H	Density of nearby vessels Greater windage of W-class W-class thruster slipstream	S: ferries do not affect density of river traffic; H: greater windage will affect more craft H: slipstream could endanger nearby small craft if thrusters in "operational" settings	H	Higher	ColRegs Keep clear of ferries as advised in LHC Harbour Guide (6.3.2, 7.2.4)	No waiting in the river.	Same	-2	Risk would be low if no waiting , otherwise medium in light winds and high in strong winds

Complete Working Risk Assessment Table

APPENDIX 11

W-CLASS STRONG WIND TRIALS ON 3 MARCH 2009

APPENDIX 11

This Appendix contains the report of the strong wind trials carried out on the W-class ferry Wight Light on 3 March 2009. It was carried out after the main trials had been completed, no suitably strong winds having been encountered during that period. It is included here for completeness and is referenced in the main text of the report.

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W-CLASS STRONG WIND TRIALS ON 3 March 2009

A11.1. Introduction

In Reference 1 it was noted that the Phase 2 trials for the overall risk assessment for operating W-class ferries on the Lymington River had not seen very much in the way of strong winds. It was agreed that additional trials would be carried out, as the opportunity presented itself, in order to explore the behaviour of the W-class vessels in strong winds both in the whole river and in W-class/W-class passing manoeuvres in the Short Reach Lay-by. Allied to this was the need to set an upper safe operating wind speed limit for the "operations"/"intermediate" ("full"/"half") thruster settings.

This additional report describes operations on a day of strong winds when two W-class vessels were operating. The results obtained are presented and discussed, conclusions drawn and recommendations made.

A11.2Aims and Scope

A11.2.1 Aims

The main aims of the study were as follows:

- To observe and record W-class behaviour when passing in the Short Reach Lay-by in strong winds
- To determine an upper wind speed limit for safe W-class operations on the Lymington River when the "operational forward"/"intermediate aft" ("full"/"half") thruster settings were in use.
- To observe and note any other relevant matters for safe W-class operations in strong winds.

A11.2.2 Scope

The scope was necessarily limited to the following:

- The winds on the day
- The masters on duty on the day
- The ship draught condition for each run; as the ships were in service during the trials, this depended on the cargo carried from run to run
- The crew rostered for each run.

A11.3 Background Information

A11.3.1 Conduct of the Trials

The trails took place between 10:30 and 21:00 on 3 March 2009 with the BMT team on the bridge of the Wight Light throughout. The other ship on the service was Wight Sky.

The ship's crew changed at 15:00, the second crew staying on until the Wight Light was routinely taken out of service for the day at approximately 21:15.

The BMT team consisted of one of the two independent master mariners who had attended most of the Phase 2 trials, and the project leader. The team observed from the bridge and downloaded screen dumps from the ECDIS as described in Reference A11.1.

Members of the Harbour Master's staff were on the river throughout the period of the trials to provide visual observations of the conditions and the behaviour of the ferries.

A11.3.2 Ship Condition

The ship conditions varied slightly from run to run depending on load. Observations of the draught sensor reading on the bridge showed that the static trim was close to level for all runs although there was a slight (about 0.5^{o}) heel to starboard indicated for some runs.

Draughts were only slightly affected by load (see Reference A11.1) and remained around 2.2 metres for the day, a value close to that used in most of the other Phase 2 trials.

A11.3.3 Metocean Conditions

A11.3.3.1 Tide Conditions

The predicted tide might be described as of medium magnitude, being part way between spring and neap. It had a predicted range varying between 1.8 and 1.9 metres during the period of the trial with the relevant predicted low waters in the river at 07:50 and 20:07 with high water at 14:48.

Unfortunately no measurements of tidal levels were available on the web site of the Channel Coastal Observatory (Reference A11.2), the source of such information in the main body of the Phase 2 trials. No measurements of the barometric pressure were available either, so it was not possible to check how the tidal levels were affected by the significant drop in barometric pressure which occurred in the evening. In view of this a "standard" tidal curve was used to give rough estimates of the tidal elevations during the day, thereby allowing some idea of the water depths in the channel to be obtained.

A11.3.3.2 Wind and Waves

Wind speeds increased gradually through the day as Figure A11.1 shows.

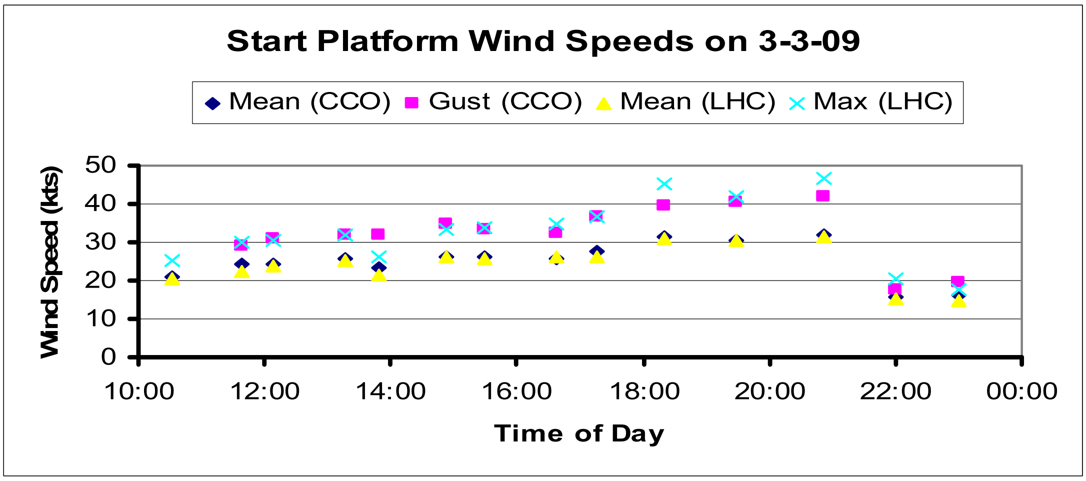

Figure A11.1: Wind Speed Measurements from the RLymYC Starting Platform.

Shown in this Figure are 10 minute mean wind speeds, together with a "gust" speed from the Channel Coastal Observatory (CCO) and "maximum" from information on the Lymington Harbour Commissioners' (LHC) web site (Reference A11.3). There is a reasonable degree of agreement between measurements from the two sources and it is clear how both mean and gust speeds increased from 10:30 to about 21:00, after which the wind dropped quite rapidly; peak wind speeds occurred in the early evening.

Wind direction changed through the day as shown in Figure A11.2:

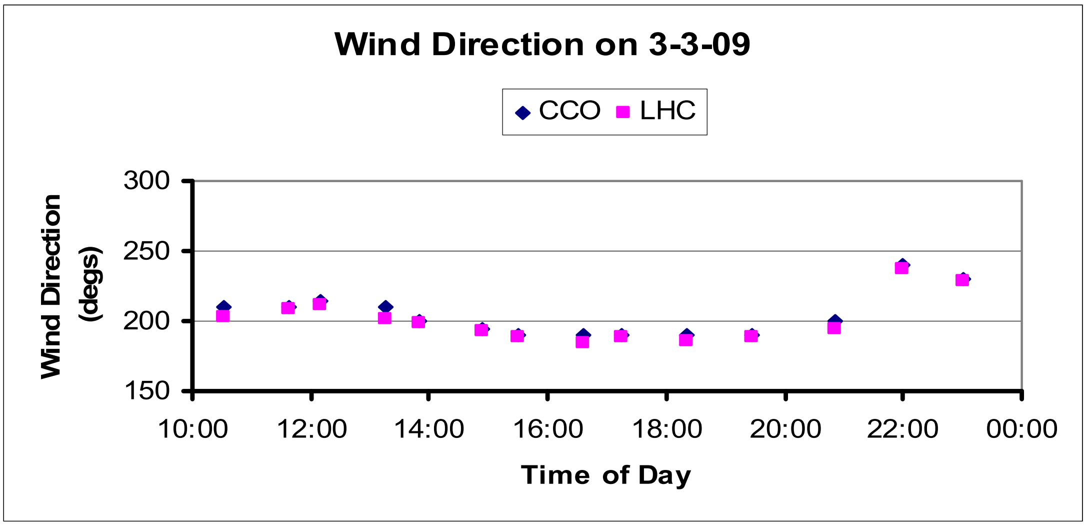

Figure A11.2: Wind Direction Measurements from the RLymYC Starting Platform.

Starting in a south-westerly direction, the wind backed to a more southerly direction in the afternoon, staying there for the period of the highest wind speeds before veering back to a south-westerly direction once the wind had dropped.

No wave measurements were made, but observations at river level showed that in the early part of the trials waves in the river were comparatively small and, as the wake from the ferry was visible, it was possible to judge its effect on the Harbour Master's RIB. As the wind strength developed, however, and once the wind had backed to the south, minimal shelter in the Short Reach Lay-by area resulted in sizeable waves there, making it very difficult to discern the ferry wake.

A11.3.4 Measurements

All measurements, other than those of the reference wind, were made on board the Wight Light. These comprised:

- Wind speed and direction as 2 minute means, up-dated every second
- Overground speed
- Heading
- Position, given as latitude and longitude
- Passing and other distances, as required.

All of these were obtained from ECDIS screen dumps, described in Reference A11.1, the first four measurements being captured about every 30 seconds.

A11.3.5 Other

There was no traffic on the river when the wind was at its strongest; otherwise, at the lower wind speeds earlier in the day, two yachts, one under sail and one under power, were observed.

A11.4 Results Obtained

Altogether 6 round trips, Lymington-Yarmouth-Lymington, were witnessed, making 12 runs in all. These are described by reference to their reconstructed tracks, after which some aspects of the handling challenges posed by the weather are presented.

A11.4.1 The Trial Runs

Tracks for the first round trip (Runs 79 and 80) are shown in Figures A11.3 and A11.4. In the Figure captions, the first figure for wind speed is the 10 minute mean, the second the gust, as given on the CCO web site at the RLymYC Starting Platform.

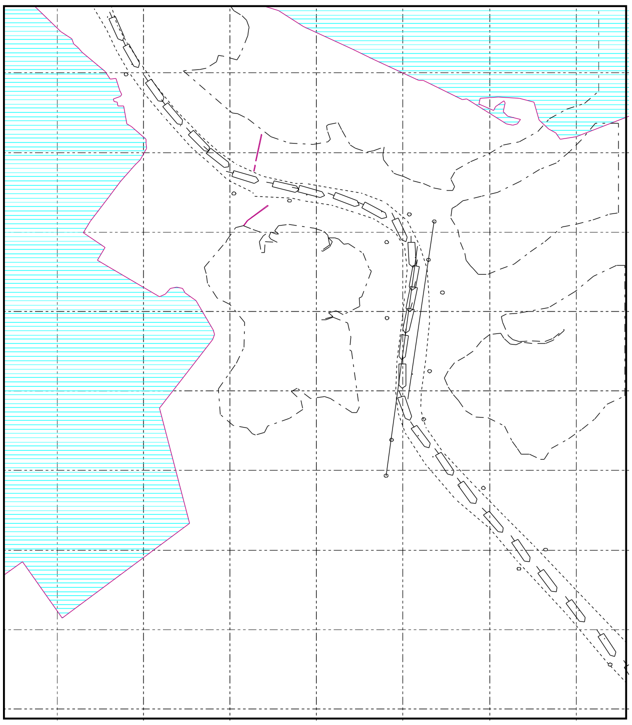

Figure A11.3: First outbound run; wind 20/25 kts from 210°, tide about 1.8m

In the first run (Run 79) Wight Sky was passed in the Short Reach Layby with Wight Light on the Transit Marks as shown and Wight Sky slightly to the east of the marks. No problems were experienced in passing and there was no obvious sign of interaction or wind shadow effects on either vessel. The drift angle needed in Long Reach is quite modest although the vessel was taken to the port side of the channel by the wind on leaving the Tar Barrel bend.

The thruster settings were "operational"/"idle" ("full"/"slow") and the majority of the river transit was conned from the centre of the bridge. Bridge wing control was used for berthing at which time the thrusters were set to "intermediate"/"intermediate" ("half"/"half").

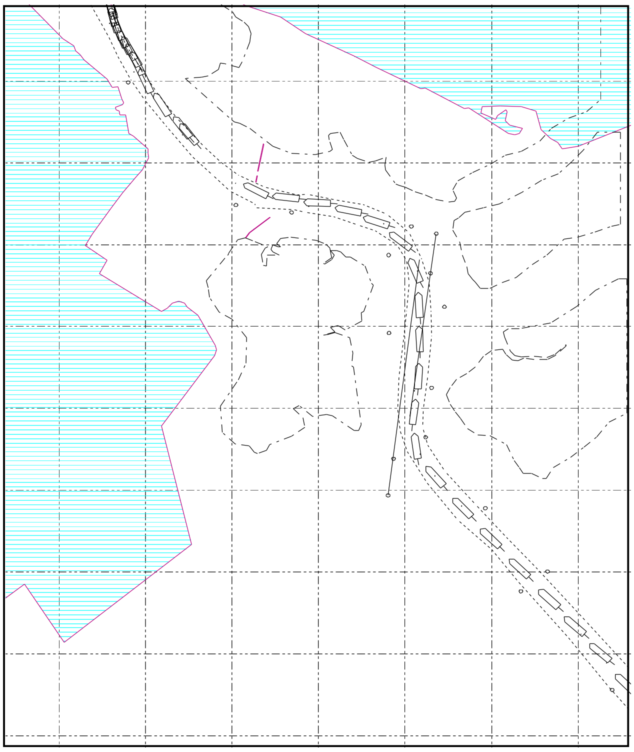

Figure A11.4: First inbound run; wind 24/29 kts from 210°, tide about 2.0m

Inbound (Run 80) the thrusters were kept on "operational"/"idle" ("full"/"slow") and the con was once again from the centre of the bridge; no passing occurred. The aft thruster, on the "idle" setting, was placed on "full ahead" pitch and kept there while the vessel speed was adjusted with the forward thruster on its "operational" setting.

A problem occurred when handing over the con from the centre to the starboard bridge wing position and this led to a brief period when control was compromised. It occurred shortly before reaching the Ferry Post at the Lymington Terminal and the ship, moving at around 2 knots, began to drift to the east on the wind. However, control was regained in sufficient time to achieve a satisfactory berthing.

The next outbound run (Run 81) was uneventful and similar to that shown in Figure 3 with another successful W-class/W-class passing. However, by the time the next inbound run (Run 82) was carried out, the wind had begun to back to a more southerly direction and the track of Figure A11.5 resulted.

It is seen that the more southerly wind took the vessel rather more to the north than usual after rounding the Cocked Hat bend and the recovery took it close to Number 11 post at the wave screen. The ship was conned from the centre of the bridge with the thrusters on "operational"/"intermediate" ("full"/"half") and, apart from being taken wide at the Cocked Hat bend, the rest of the river passage was acceptable. The wash was also found to be acceptable for the Harbour Master's RIB, impressions of its effect being very similar to those described in Reference 1.

No passing occurred on this run.

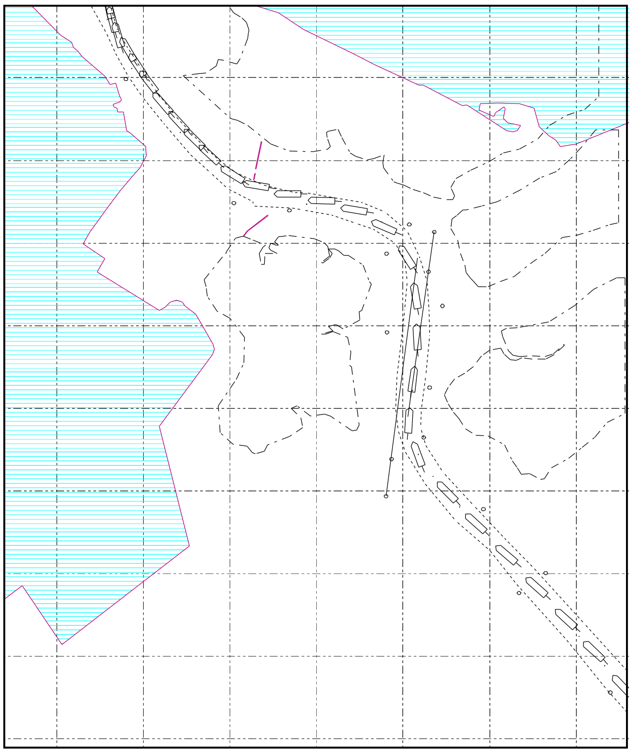

Figure A11.5: Inbound run; wind 25/32 kts from 202°, tide about 2.4m

In the next run (Run 83), thruster settings of "intermediate"/"intermediate" were tried as an experiment. This combination had been used by the Wightlink masters for berthing at Lymington and Yarmouth who found it to give a better balanced feel to the control. Extending its use to a complete river transit resulted in the track of Figure A11.6.

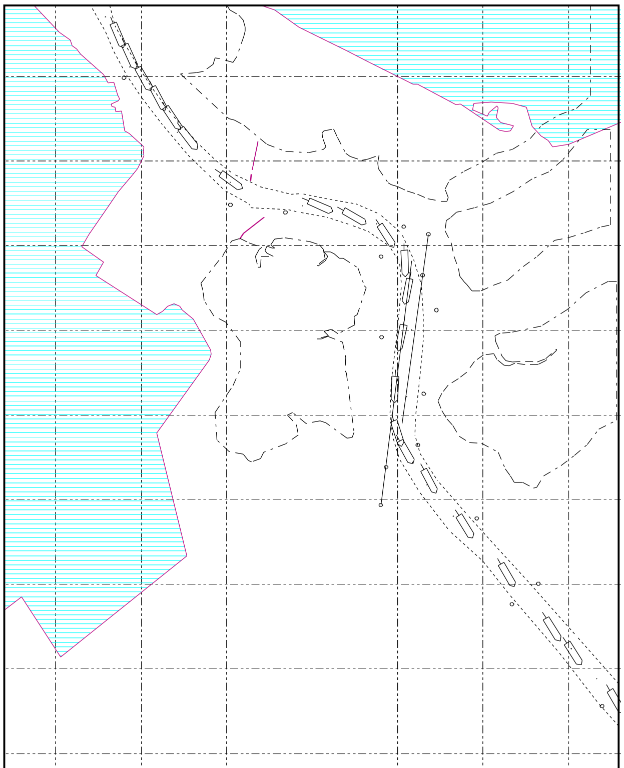

Figure A11.6: Outbound run; wind 23/31 kts from 200°, tide about 2.6m

This was a generally successful run down to the Tar Barrel bend, including a satisfactory passing manoeuvre in the Short Reach Lay-by. However, the wake was not as acceptable as that with the "operational"/"intermediate" settings because some evidence of the return of the standing waves was seen as shown in Figure A11.7.

Figure A11.7: Outbound run of Figure 6; wash in Horn Reach showing Standing Waves

Further problems were encountered on rounding cocked Hat bend from the vorticity at the boundary of the wake as shown in Figure A11.8.

Figure A11.8: Outbound run of Figure 6; wash at Cocked Hat bend

A further problem arose in Long Reach when it proved impossible to proceed at a speed much greater than 5 knots with the chosen thruster settings. As a result, they were abandoned and the forward thruster returned to an "operational" setting.

The following inbound run (Run 84), on the "operational"/"intermediate" thruster settings, was successful and, although the wind had strengthened slightly and the Cocked Hat bend was again taken wide, recovery was improved and Number 11 post was passed without difficulty.

The crew changed at this juncture and the next outbound run (Run 85) was carried out with a helmsman having no experience of the W-class in strong winds under the close supervision of the master. A number of thruster settings were used, but the run from the wave screen to near the Starting Platform was undertaken using the "operational"/"idle" combination. Its track is shown in Figure A11.9.

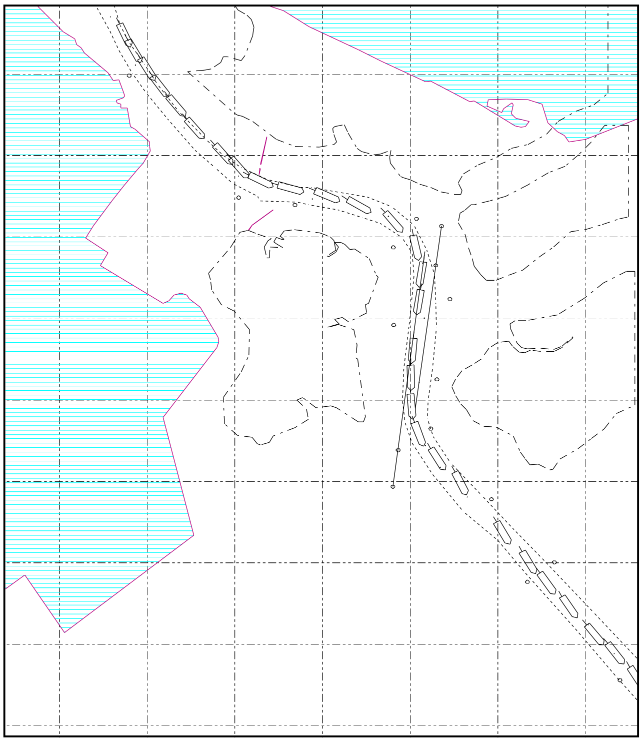

Figure A11.9: First Outbound run after Crew Change; wind 26/33 kts from 190°, tide about 2.7m.

The run included a passing manoeuvre in the Short Reach Lay-by and was generally satisfactory, although the lateral drift due to the wind is apparent on the approach to Number 11 post and on entry to Long Reach. Control was from the centre of the bridge while in the river.

The following inbound run (Run 86) was the first of three consecutive inbound runs conned by the master. The winds by this time (about 16:30) had taken a more southerly direction and were strengthening with gust speeds measured at the Starting Platform in excess of 30 knots. Figure A11.10 shows the track and Figure A11.11 the measurements from the anemometer on-board the Wight Light; no passing took place and the "operational"/"intermediate" ("full"/"half") thruster settings were used.

It is seen that the track was in general satisfactory, although the vessel left the Cocked Hat Bend rather more to the northern side of the channel than normal as it moved toward the wave screen, in spite of an early entry to the bend. The tide was high giving adequate water space to allow the drift to be corrected and the turn round number 11 post was executed satisfactorily. The wind measurements show a good deal of scatter, as might be expected in a gusty wind, and the shielding of the anemometer by the superstructure when in the Short Reach Lay-by is highlighted.

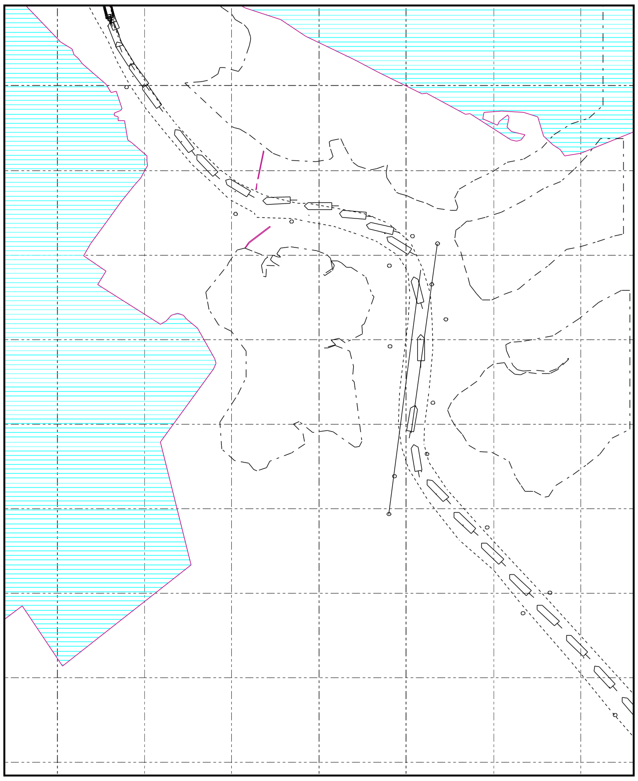

Figure A11.10: First Inbound Run conned by Master. Wind 26/32 kts from 190°, tide about 2.7m

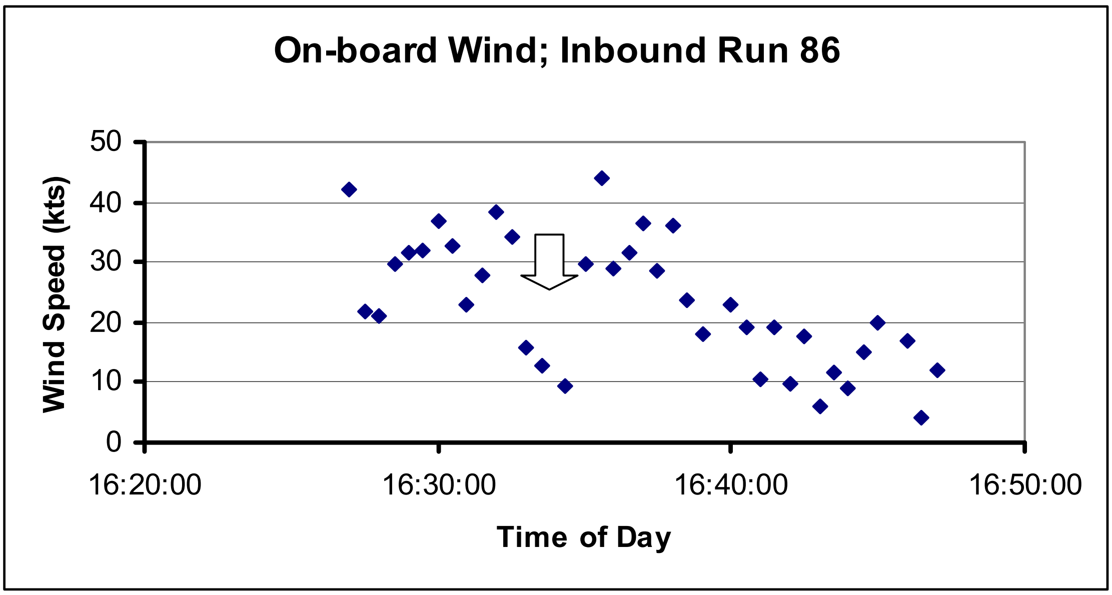

Figure A11.11: On-board True Wind Speed Measurements for Run of Figure A11.9

The expected reduction in wind speed in Horn Reach is clear, enabling berthing to be done in more benign conditions than those encountered elsewhere in the river. The vessel was conned from the centre of the bridge for the whole river transit until berthing which was then carried out from the starboard wing. It may be mentioned that the approach to the Cocked Hat Bend was made at overground speeds of around 6 to 6.5 knots, augmented by the following wind, and this, coupled with strong winds on the beam, may have caused the ship to run wide.

The next run (Run 87 outbound) was also conned by the master from the centre of the bridge in winds which had continued to strengthen; thrusters were set once more to "operational"/"intermediate" ("full"/"half"). The track is shown in Figure A11.12 with the on-board wind measurements in Figure A11.13.

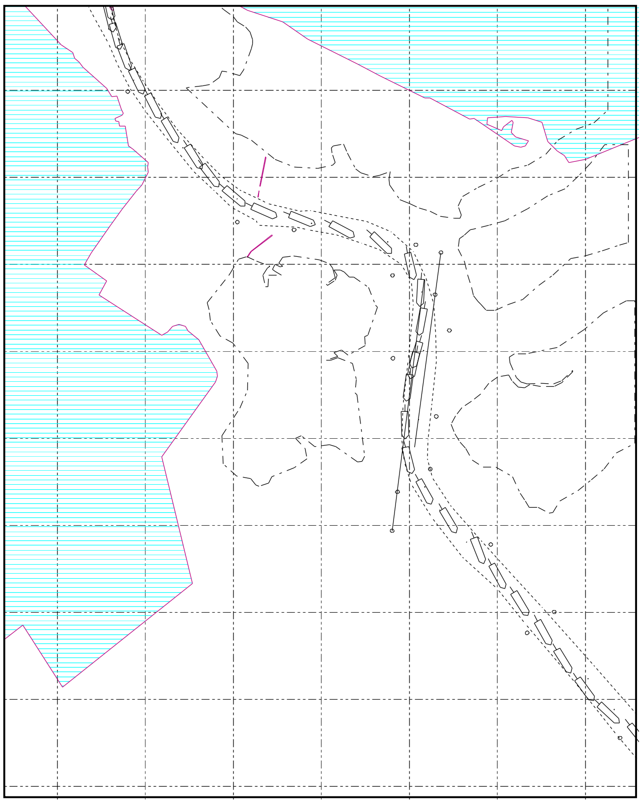

Figure A11.12: Outbound Run. Wind 27/36 kts from 190°, tide about 2.7m

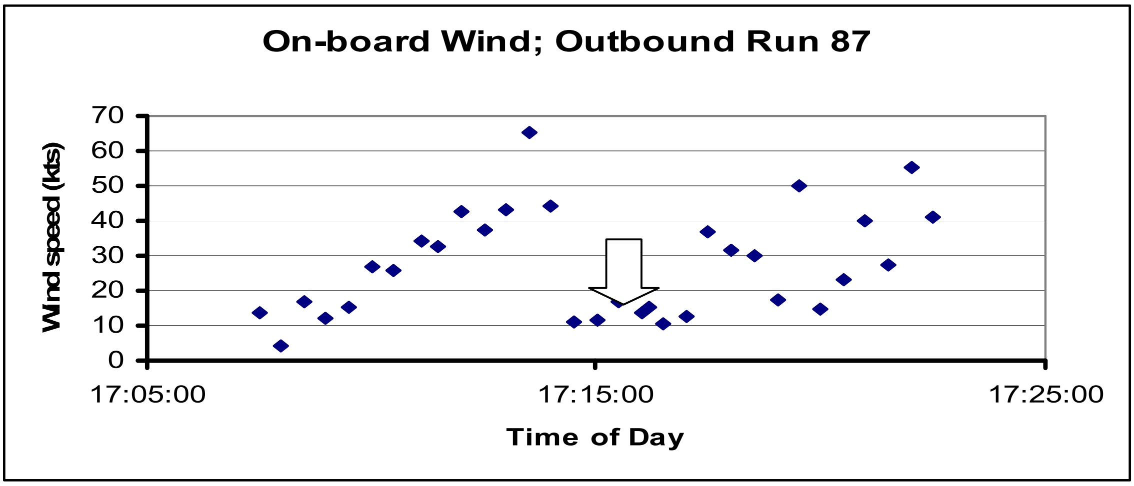

Figure A11.13: On-board True Wind Speed Measurements for Run of Figure A11.12

A passing manoeuvre took place in the Short Reach Lay-by and, as can be seen from the close spacing of the ship icons in this region in Figure A11.12, the head wind, combined with some adjustment of speed to comply with the required passing speed, caused the overground speed to drop to just over 4 knots from just over 6 on exit from the Cocked Hat Bend. The on-board wind measurements in this region are again affected by superstructure shielding, but in general the short term wind measurements on board are somewhat higher than the mean and gust values from the Starting Platform of 27 and 36 knots. This is especially true in the approaches to the Cocked Hat Bend when the wind speeds were high and felt to be so on board as the wind was "funnelling" up the river.

For the next inbound run (Run 88), the master reduced speed in the approach to the Cocked Hat Bend to make allowance for the effect of the strong following wind. The resultant track is shown in Figure A11.14 and the onboard winds are given in Figure A11.15.

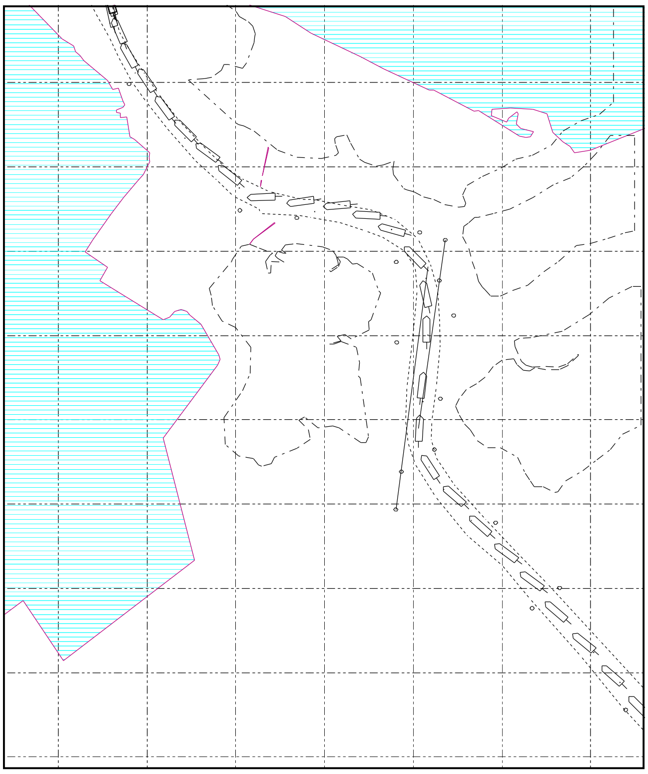

Figure A11.14: Master's Second Inbound Run. Wind 31/39 kts from 190°, tide about 2.1m

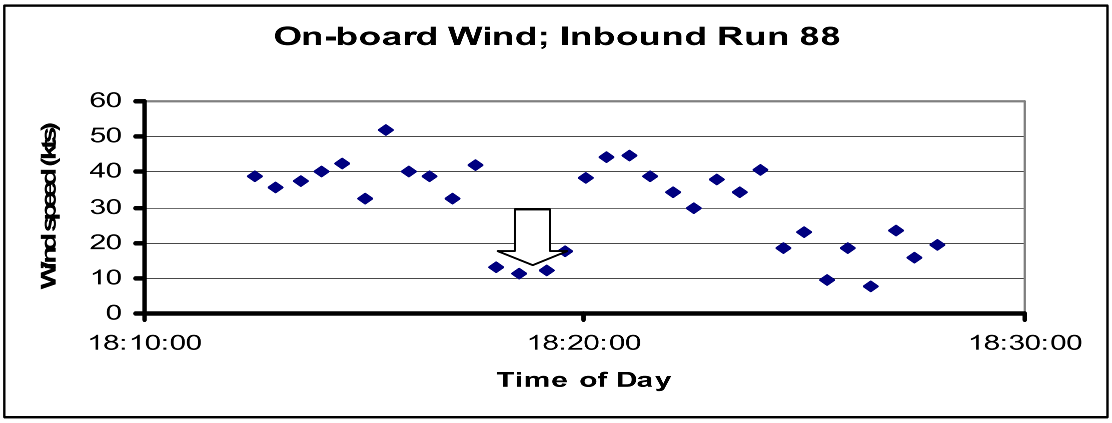

Figure A11.15: On-board True Wind Speed Measurements for Run of Figure A11.14

The superstructure shielding is once again highlighted in Figure A11.15.

The on-board measurements suggest that the wind maintained speed from Long Reach until past the wave screen. However, an attempt to reduce overground speed on the approach to Cocked Hat Bend was made by using an "intermediate"/"intermediate" ("half"/"half") thruster combination from Long Reach. In spite of this, the following wind raised overground speed to a value in excess of 6.5 knots as the bend was approached, although this dropped rapidly in the turn. The need to retain control coming out of the bend required more power and the forward thruster setting was increased to "operational" ("full") in conjunction with a heading just south of west to counter the sideslip; the increased power at the new thruster setting was then needed for the starboard turn past Number 11 Post and in to Horn Reach. By this time the wind speed had reduced and the run up Horn Reach was accomplished satisfactorily at around 4 knots, reducing all the time from 4.7 knots at the wave screen.

The next round trip (Runs 89 and 90) was carried out in perhaps the most challenging conditions of the day, but with satisfactory results. The tide was ebbing and the outbound run (Run 89), carried out in about mid-ebb with the wind still strong, is shown in Figure A11.16. The thruster settings were "operational"/"intermediate" ("full"/"half") throughout.

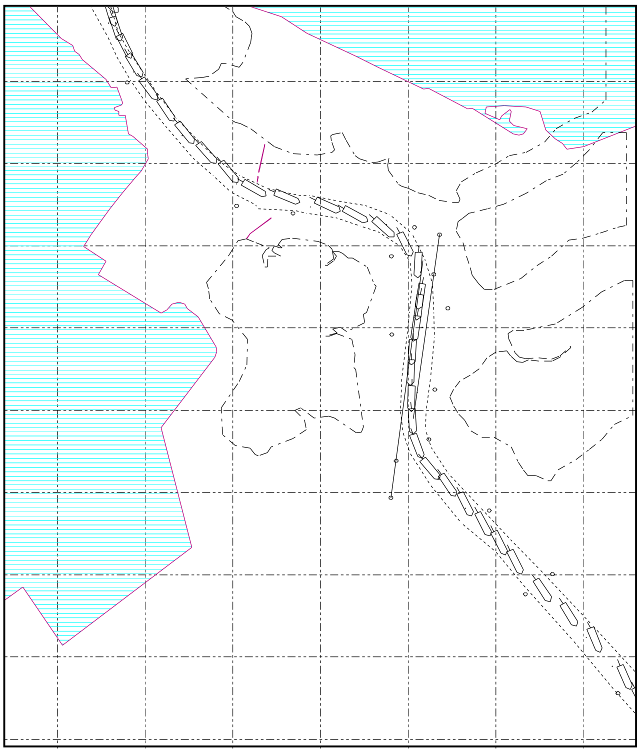

Figure A11.16: Outbound Run. Wind 30/40 kts from 190^o, tide about 1.1m

It is seen that, in spite of passing close to Number 11 post to allow the required heading to be achieved in Short Reach, the track was in general good. There was no passing in the Short Reach Lay-by area and the effect of the wind on the beam on exit from the Tar Barrel bend is clear. This situation was corrected, although the large drift angles needed in Long Reach (and the amount of water space used) may be noted.

The next run (Run 90) was the last in the master's trio of consecutive inbound runs. Winds were still strong and the river level at or near low water. Thrusters were set to "operational"/"intermediate" ("full"/"half") and the centre con was used in the river; no passing manoeuvre took place. The track is shown in Figure A11.17 and the on-board wind measurements in Figures 18 and 19.

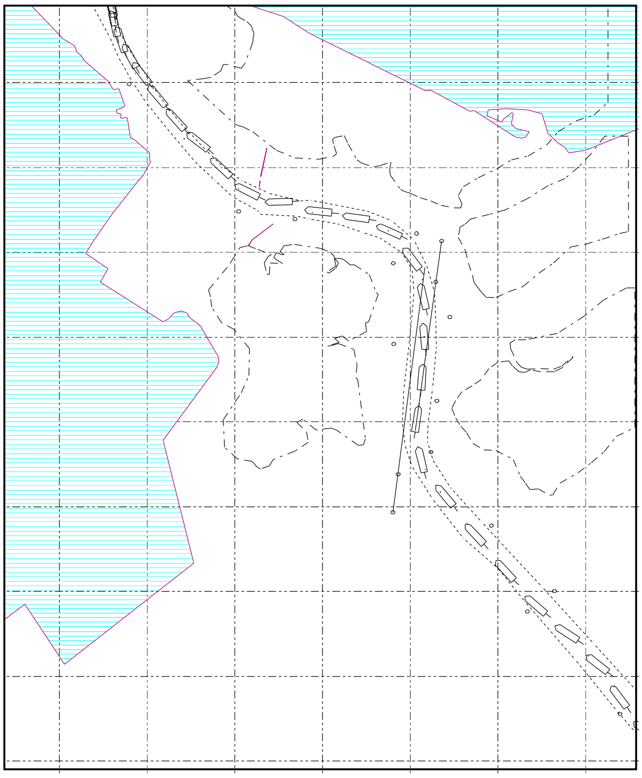

Figure A11.17: Master's Third Inbound Run. Wind 31/42 kts from 200°, tide about 0.96m

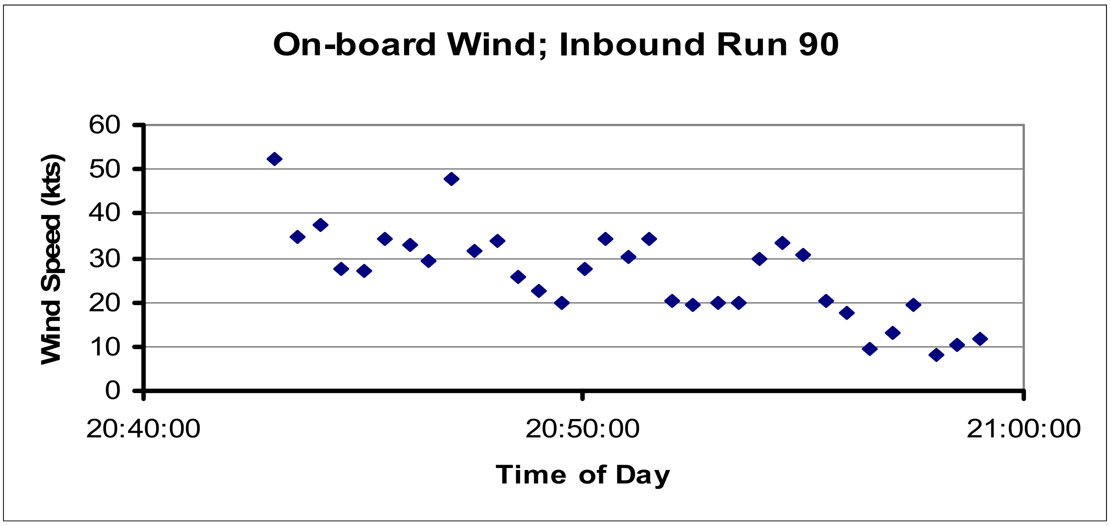

Figure A11.18: On-board True Wind Speed Measurements for Run of Figure A11.17

Wind direction measured on board is shown in Figure A11.19 from which it is seen that the true wind experienced by the ship veered from southerly to south-westerly as the run progressed, perhaps accounting for less obvious shielding by the superstructure when the vessel was in the Short Reach Lay-by area.

In Run 90 there was no passing required in the run up the river, passing having taken place outside the river mouth. It is seen that a good track up the centre of the river was made once round the Tar Barrel bend, and speeds on the approach to Cocked Hat were just in excess of 6 knots, lower than in the previous two inbound runs. The Cocked Hat bend manoeuvre was more in the middle of the river with less drift to the outside of the bend leading to a satisfactory passage through the wave screen, in spite of a severe hail squall at this point accompanied by a failure of the bridge window wipers.

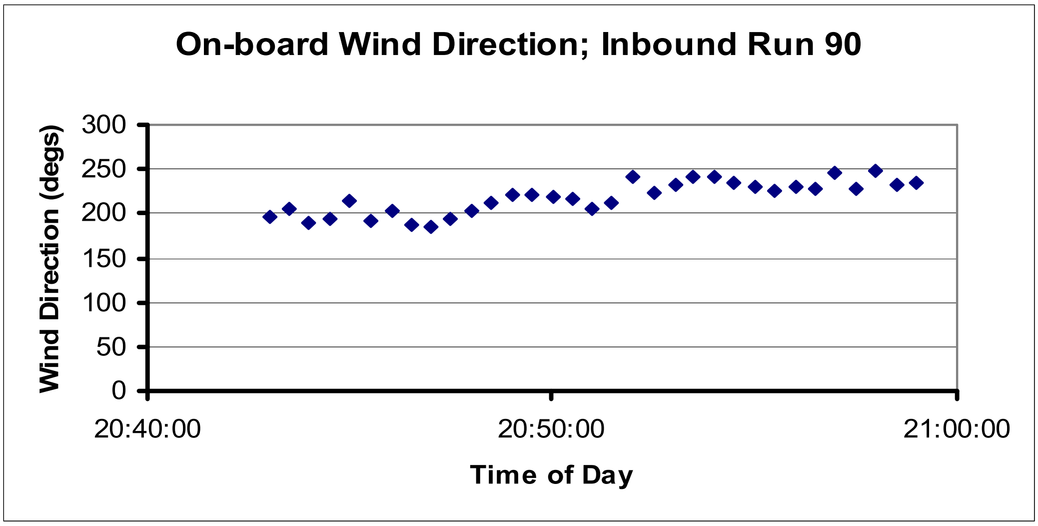

Figure A11.19: On-board True Wind Direction Measurements for Run of Figure A11.17.

On completion of this inbound run the wind dropped to around 15 knots as shown in Figure A11.1. No further trials were carried out.

A11.4.2 Speed and Handling

In this Section, the measured overground speeds on all trials are presented and discussed and some general comments are made on the handling of the W-class in strong winds.

A11.4.2.1 Overground Speed

Figure A11.20 shows the measured overground speeds for all outbound runs on the day while Figure A11.21 shows values for all inbound runs.

Regarding the outbound runs, it is seen that speeds were in excess of the advisory 4 knots in Horn Reach, but in the conditions this was perhaps understandable for reasons discussed in Reference A11.1. Later in the day, and especially in run 89, speed was increased prior to entering the Cocked Hat Bend (around 400 seconds into the run) to compensate for the drop in speed due to both turning and meeting a strong head wind in the Short Reach Lay-by. After that, speeds in Long Reach were around 6 knots.

The speed in Long Reach (after 600 seconds) for run 83 may be noted. In this run the "intermediate"/"intermediate" thruster settings were used, resulting in insufficient power in the strong head wind to achieve more than about 5 knots overground. The same comment applies to run 85 when the "operational"/"idle" ("full"/"slow") combination was used.

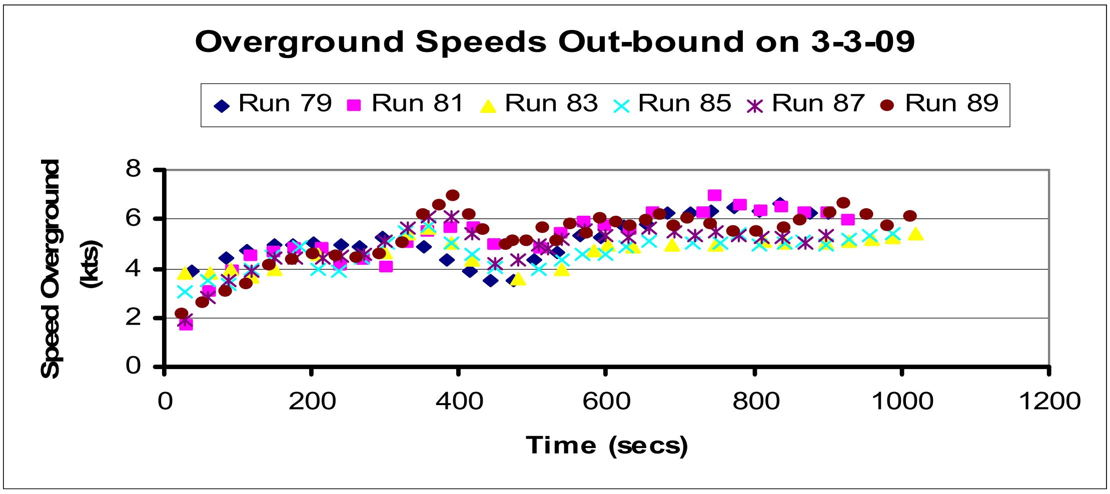

Figure A11.20: Measured Overground Speeds for All Outbound Runs

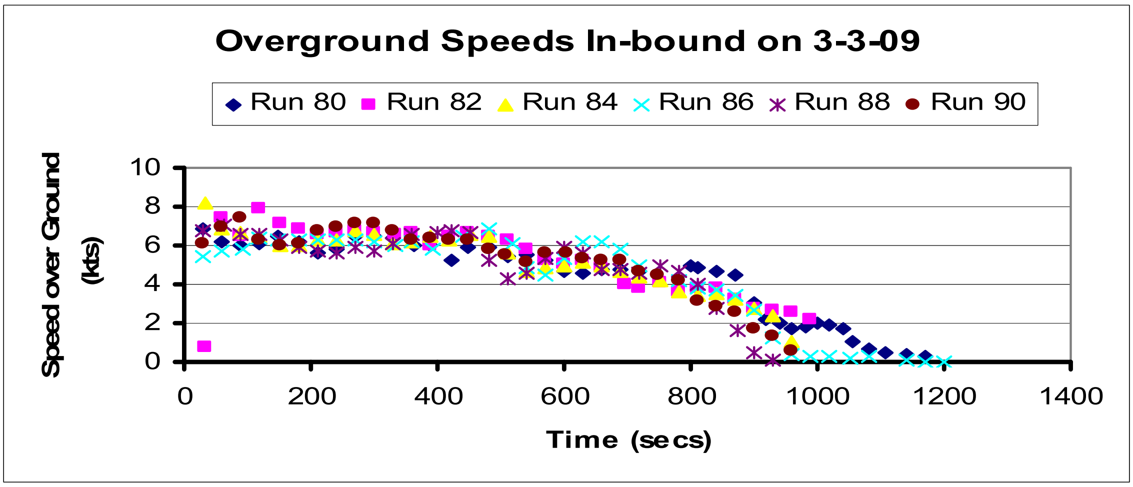

Figure A11.21: Measured Overground Speeds for All Inbound Runs

Inbound runs show very similar speed profiles in the river, Tar Barrel bend being rounded at about 330 seconds in to the measured run and Cocked Hat at about 450 to 500. The drop in speed in run 88 once round Cocked Hat bend as large drift angles were set may be noted. Number 11 post was rounded at about 650 seconds at around 5 knots and it is seen that the technique was then to allow speed to fall away gradually all the way up Horn Reach to the berth.

A11.4.2.2 Handling

The W-class vessels are characterised by increased windage and it is therefore to be expected that handling in strong winds requires a learning process to determine the best way to deal with not only wind speed effects, but also wind direction. The day of the trials saw the wind build through the day and back from a south-westerly direction to one that was almost due south. This was useful in that it appeared to high-light some handling issues in southerly winds not met in quite the same way in the south-westerly winds which prevail in the area.

It became clear that the crews were comfortable with handling south-westerly winds with gusts up to 30 knots or more when the thrusters were on the "operational"/"idle" ("full"/"slow") settings. It then became clear that it was possible to handle these vessels in more testing conditions as the masters evolved the appropriate handling techniques.

While these were being developed, however, overground speeds occasionally exceeded the advisory and mandatory limits on the river. It appeared to BMT that this was part of the learning process and it was clear from the three consecutive inbound runs conned by the same master in the strong winds of the latter part of the day that learning was swift. No doubt speed limits can be met once more familiarity with these new vessels in strong winds has been obtained.

A further example of the need to adapt occurred as the ship left the Tar Barrel bend when outbound. In the runs shown in Figures A11.3, A11.6, A11.9, A11.12 and A11.16 the vessel left this bend on the port side of Long Reach after which the correct drift angle was set to bring the ship to the starboard side of the channel for the remainder of the transit. This may be because, in such conditions it was difficult to achieve the correct drift angle for the Long Reach transit at the same time as the swing is killed on exit from the bend, and it is assumed that as experience builds this will improve. It is recommended that attention be devoted to this in future runs in strong winds to prevent the vessel spending time on the wrong side of the channel outbound on exit from the Tar Barrel bend.

An example of the outcome of the learning process in the last three inbound runs of the day is shown in Figure A11.22. It should be remembered that a master with no previous experience with the W-class in wind conned all three runs.

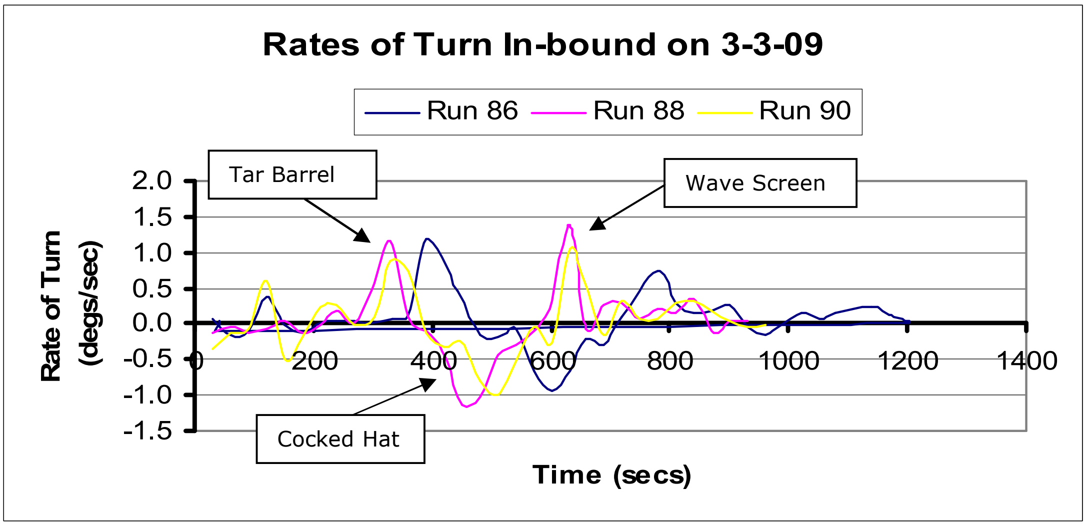

Figure A11.22: Rates of Turn for Last Three Inbound Runs

The three main bends in the river are marked on the plot. Taking run 86, the first of the trio, the rate of turn shows a little over-correction on leaving the Tar Barrel bend after which the Cocked Hat bend was taken with the lowest rate of turn seen in all three runs. There was further over-control as the turn to starboard at the wave screen was negotiated, after which there was further control action as the vessel moved along Horn Reach. For the second run, run 88, there was less evidence of over-control at Tar Barrel but, because speed on entry to Cocked Hat was high and it was necessary to increase power on the forward thruster at the bend, rather more rate of turn was required to get round; this led to the highest rate of turn at this location. This run showed that learning had helped, but there was still some improvement to be made. This came in run 90, the last of the three. It is seen that the rates of turn used in two of the three bends were less than those of the other two runs and the rate used at Cocked Hat was about the same as that of the first run in the trio. The track showed that a satisfactory run resulted with the ship generally well located in the river.

When the river was empty and there were no passing manoeuvres to be made, masters trended to keep in the centre of the river. This was recommended in Reference 1 and will be a positive outcome in terms of overall river safety if the same also occurs in more benign conditions. Also apparent was the fact that for most of the runs where passing in Short Reach Lay-by occurred, both ships were on, or nearly on, the leading lines from the Transit posts.

A11.4.3 Other Observations

Other observations made on the day included the con hand-over problem mentioned above. This was resolved quickly and no incident resulted.

Also noted was the fact that several of the bridge windows misted up during the day, significantly restricting the otherwise excellent 360^{o} visibility from the bridge. It became apparent that, although window warmers are fitted, they apply only to those windows close to the conning locations in the centre of the bridge and on the wings. This allows the intervening windows to mist up and, on one occasion when the ship was waiting in the Solent, it was very difficult for the helmsman to see what the other ferry was doing in an "outside the river" pass.

A further problem arose when the bridge window wipers and washers would not work on the last inbound run, their loss being felt most keenly just as a hail squall hit the vessel at the wave screen on the last run. This considerably reduced the master's vision at a key point in the run and the fact that the vessel was well-positioned to pass through the wave screen helped avoid an incident.

Although the "intermediate"/"intermediate" thruster setting was not successful in the river, it may well have some benefit in berthing and when moving the vessels from one berth to another. For the latter, ahead/astern ship movements are necessary and the advantage of having the same thruster setting at both ends of the ship is clear. When leaving the berth in conditions when the aft thruster is to be set to "Intermediate" ("half"), it is recommended that, in order to minimise wash nuisance, acceleration up to speed be carried out using the technique described in Reference A11.1 at the end of Section 6.1.3 "Ferry Behaviour in the River".

Finally, it was clear that some of the situations dealt with satisfactorily by the helmsmen in the W-class on the day would have caused more problems had the vessel been one of the C-class. This was stated on a number of occasions by the masters and served as a testament to the better handling qualities of the W-class.

A11.5 Discussion

The primary purpose of this day of trials was to determine a safe upper limit for the "operation"/"intermediate" ("full"/"half") thruster settings. These settings come into play at the "25 knot, gusting 30" upper limit for the "operational"/"idle" ("full"/"slow") settings and an upper safe limit for their use was sought.

The trials were also, of course, a test of the W-class themselves in strong winds something which, in view of their increased windage, was important; it was also a test of the masters' ability to adapt to handling these ships in such conditions. They themselves need to develop a feel for the inherent safe limits of the new ships, for it is the master who must ultimately decide if it is safe to operate at all in a given set of conditions.

Although, in the masters' views, the conditions met on the day may not have been as severe as some that can be met, it was accepted that more severe conditions are comparatively rare and it was felt that both ships and crews were well tested.

Turning to the safe upper limit for the "operational"/"intermediate" setting, it is apparent from Figure A11.1 that the maximum mean wind speed, as measured at the RLymYC Starting Platform datum location, was of the order of 30 knots with a gust/maximum speed of around 42 knots. Clearly the W-class and the masters were able to cope with these conditions and maintain control, in spite of sometimes trying (and avoidable) conditions on the bridge when windows misted up and wipers failed to work. This gives confidence that an upper mean wind speed limit of 30 knots, gusting 42 knots would be safe, in the judgement of BMT, for the use of the "operational"/"intermediate" settings.

It is therefore recommended that such a limit be used, but that, as required by the Port and Marine Safety Code (PMSC), it should be reviewed on a regular basis as masters and helmsmen gain more experience operating W-class in severe weather. It is recommended that reviews are made at a periodicity of 6 months.

A note of caution should be sounded, however. Two wind directions were seen on the day of the trials and each posed its own handling challenges. There are other wind directions which have not been experienced and, although these may be less frequent, they should be treated with caution until enough experience has been gained. Although it is not expected that strong winds from the north will pose problems for the shiphandler in those parts of the river north of Tar Barrel because of sheltering, but an outbound vessel might tend to run wide on exit from the Tar Barrel bend in such a wind. A strong wind from the east could pose more significant challenges to the ship handler, especially if combined with a strong ebb tidal stream as discussed in Reference A11.1. Finally, operations in such winds at low water on a spring tide with a large range could be problematic due to the lack of water space available, especially on the bends, although it is understood that the exposed salt marshes have an effect, from sheltering or otherwise, of reducing the severity of the wind in such conditions. Naturally, the decision as to whether to run at all in such conditions would, of course, rest with the master.

It is recommended therefore that the mean wind speeds and directions, together with the gust values as measured at the RLymYC Starting Platform be included in the bridge deck log as this will build a picture of the strong wind conditions experienced by both master and crew. Before operating in wind conditions with mean values above 25 knots, a formal procedure should be developed between Wightlink and LHC to demonstrate that masters are competent to handle the ship at the next level of wind speed which is recommended should be set to 30 knots gusting 42 knots. One way that could be considered derives from pilot development when, in order to move from one level of experience to a higher level, a pilot is assessed as competent by another who is qualified at that level. In the case of the W-class, it is suggested that the Senior Master or Training Master could assess competence in this way and sign off personnel when satisfied. This avoids the requirement for a fixed number of trips in strong winds and recognises the fact that some personnel may take longer than others to gain the required competence. However, it is recommended that a minimum of one shift should be worked in winds with mean values of 20 to 25 knots before moving to the next wind speed level.

A11.6 Conclusions and Recommendations

As the result of a series of trial runs in strong winds with W-class ferries a number of conclusions have been dawn and recommendations made. These now follow.

A11.6.1 Conclusions

- The W-class can be handled in south and south-westerly winds with mean speeds up to 30 knots gusting 42 knots, as measured at the Royal Lymington Yacht Club Starting Platform.
- The masters, experienced in handling the C-class in strong winds, are able to adapt to the W-class in strong winds
- Strong head winds have a significant effect on the speed of the W-class.
- Strong beam winds cause the W-class to sideslip rapidly; it is assumed that this will be resolved after sufficient experience in strong winds has been gained.
- The W-class can be handled well from the control position in the centre of the bridge. Berthings at both Lymington and Yarmouth can also be carried out successfully from the centre con position.
- Control hand-over problems can still occur

A11.6.2 Recommendations

- The lower wind speed limit for operation of the "operational fwd"/"intermediate aft" thruster settings should be 25 knots mean, gusting 30, as measured at the Royal Lymington Yacht Club Starting Platform.
- The upper wind speed limit for operation of the "operational fwd"/"intermediate aft" thruster settings should be 30 knots mean, gusting 42, as measured at the Royal Lymington Yacht Club Starting Platform.
- These wind speed limits should be reviewed on a regular basis as experience builds and new masters arrive.
- Acceleration away from the Lymington Berth with the "operational fwd"/"intermediate aft" thruster settings should be carried out with regard to reducing wash using the technique described in Reference 1 at the end of Section 6.1.3 "Ferry Behaviour on the River".
- The thruster settings within the recommended wind speed limits should only be changed from the recommended values during passage in the river if not to do so would endanger the ferry and/or other river users.
- The tendency to drift to the port side of the channel on exit from the Tar Barrel bend should be addressed and eliminated as experience in strong winds is gained.
- A formal procedure should be developed between Wightlink and LHC to show that masters can demonstrate sufficient experience in mean wind speeds of 20 to 25 knots and are able to move up to the next wind speed level. Use of the Senior Master or Training Master to assess competence after a minimum exposure to such winds of one shift is recommended.
- The bridge window misting problem should be resolved
- All window wipers and washers should be operational at all times, especially in bad weather.
- To avoid control hand-over problems when operating in the river, either synchronisation of the control stations should be explored or the vessels should be controlled and berthed only from the centre control position, unless exceptional circumstances compromising safety arise.

A11.7 References

A11.1. “Ferry Operations at Lymington: the W-class Ferries” BMT SeaTech Ltd Report document number C13537.01.R01.V4 March 2009

A11.2. Channel Coastal Observatory web site on www.channelcoast.org

A11.3. Richard Paul Russell Ltd web site providing RLymYC Starting Platform wind data accessed through Lymington Harbour web site address at www.lymingtonharbour.co.uk