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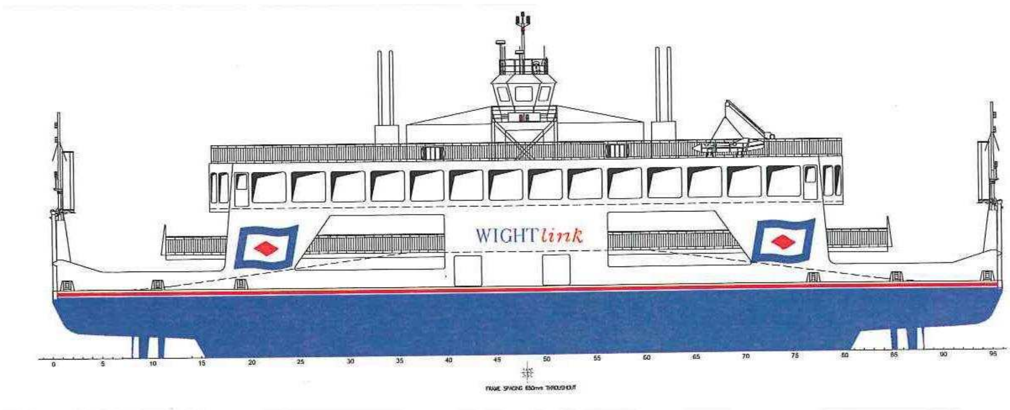
WIGHTLINK FERRIES

Lymington Harbour

Navigational Review

Report No: ELP-55272-1206-57219- Rev 1



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SUMMARY

1. An assessment has been made of the suitability of the proposed new class of ferries for the Lymington / Yarmouth route (referred to in this report as the R Class).

2. Although the initial intention had been to follow the format and terms of reference from a study undertaken in 1991 on behalf of Lymington Harbour Commissioners (LHC) when Wightlink was proposing to re-deploy the Saint Class vessels, the two day site visit rapidly identified that that would not be wholly possible.

3. This is because the 1991 study primarily sought to answer the question "*are the Lymington channels adequate*" ? (for the Saint Class). Given that the key physical dimensions of the R Class are very similar to the existing C Class ferries, the real issue now is "*what will be the <u>effect</u> of the R Class*" ?

4. This study therefore focuses on the changing profile in the range of hydrodynamic effects between the C Class and the R Class.

5. Given the considerable increase in displacement, block co-efficient, and windage area of the R Class, it is unavoidable that – for a given channel geometry, water depth and vessel speed – the R Class will have increased adverse effects of wash, drawdown and possibly surge.

6. The only way that this can be avoided is by:

   a) Building the new ferries in the same hull formation as the existing C Class vessels
   b) Deepening and/or widening the Lymington channels
   c) Reducing the speed of operation of the new R Class within Lymington River
   d) Some combination of the above.

7. As amplified in section 6, the recommendations from this study are centred around option c) above (the others being regarded as not acceptable to either Wightlink or LHC). The recommendations are:

   A. Wightlink should develop a programme for testing the effects of the R Class ferries upon their introduction to service. The key variable will be the vessel speed and tide height at different parts of the harbour. Implicit within this recommendation is the need to accurately measure the vessel speed.

   B. Consideration should be given by LHC to ceasing the practice of mooring freely swinging craft at the buoys on the west side of Short Reach and Long Reach, in order to maximise the navigable width and better allow the ferries to maintain their channel alignment by use of power, rather than setting large wind-drift angles.

   C. All of the above should be carried out in consultation with LHC.

7. Without pre-judging the outcome of the above process unduly, the following speed limits are regarded as a good estimate:

Tide	Area	Speed	Area	Speed
Existing Speed Limits				
All conditions	Above Harper’s	4 knots	Below Harper’s	6 knots
Anticipated Future Speed Limits				
Above half tide	Above Harper’s	4 knots	Below Harper’s	6 knots
Below half tide	Above Harper’s	3 knots	Below Harper’s	5 knots

8. The need to adhere to whatever speed limits are determined is a key part of ensuring the R Class works successfully in Lymington. Wightlink should ensure that any new speed limits adopted and adhered to have acceptable schedule implications for the Lymington / Yarmouth service.

1. BACKGROUND AND INTRODUCTION

1.1 Background

1.1.1 In 1991, the Lymington Harbour Commissioners (LHC) commissioned a study by Eagle Lyon Pope Associates to consider the navigational feasibility of Wightlink's proposals to introduce larger ferries on its route from Lymington to Yarmouth, Isle of Wight [Reference 1].

1.1.2 The proposed 1991 fleet renewal did not take place but Wightlink now has advanced plans to replace the existing C Class vessels (which are the same vessels as those operating in 1991). In anticipation of their introduction, Wightlink requires a similar study to assess the capability of the Lymington navigational channels to accommodate its new ferries, referred to in this study as the R Class. (Note – the R Class vessels due for delivery in 2008 are not the same as the vessels proposed in 1991).

1.2 Eagle Lyon Pope Ltd

1.2.1 Eagle Lyon Pope Ltd (ELP) is part of the Global Maritime Group of companies. It was established in 2000 following its acquisition of Eagle Lyon Pope Associates.

1.2.2 ELP is a specialist Port and Marine Consultancy which is experienced in undertaking marine feasibility, risk, and engineering studies for new port developments or when different vessels are being planned for an established facility.

1.3 Objective and Scope

1.3.1 The objective of the study is to review the suitability of the navigational channels at Lymington Harbour to accommodate Wightlink's proposed new ferries.

1.3.2 The Scope / Terms of Reference are as defined by Wightlink's Mr John Burrows by e-mail dated 3rd November. This is:

To consider the navigational and ship handling aspects of the proposed new ferries at Lymington, in terms of:

- *The river depths and widths necessary for the safe navigation of the new vessels, with particular consideration to be taken of the effects of the increased displacement,*
- *The radius of curvature of the river bends in relation to the overall length of the new ferry,*
- *The dimensions of the passing basin to allow two of the new vessels to pass each other.*

Due account to be taken of the methods of handling a vessel with two Voith Schneider propulsion units mounted on the centre line. Account will also be taken of the external forces of wind and current likely to affect the vessel during its river transit.

From the above to recommend any limitations if necessary on operations on the grounds of safety.

1.4 Limitations

1.4.1 The geographic area of the study is defined as the channel between the Jack In The Basket Pillar and the Wightlink Terminal.

1.4.2 The study is based on comparing the navigational needs of Wightlink's vessels to channel dimensions as defined in published sources of channel design (see references). No vessel manoeuvring simulation has been carried out for this study.

1.5 Instructions

1.5.1 In response to ELP's written proposal [Reference 2], instruction to perform the study was given by Mr. Burrows on 13th November 2006.

1.6 Report Structure

1.6.1 Section 2 describes the physical and operation aspects of Lymington in order to provide a further background for the study.

1.6.2 Section 3 provides a detailed comparison between the existing C Class vessels and the proposed R Class. Most of the information has been provided by Wightlink and its ship design naval architects, Hart Fenton. In order to carry out the study, some estimates and assumptions have also been made. For example, in order to quantify the ratio between the above water lateral area (windage) and the below water lateral area, the latter was derived simplistically by multiplying the vessel length at the waterline by the loaded draft.

1.6.3 Section 4 provides detail on the two day site visit undertaken as part of the study

1.6.4 Section 5 Examines in more detail the hydrodynamic effects caused by the existing and proposed ferries. As the key effects are wash and drawdown, which are directly related to squat, the squat of both the C Class and R Class has been calculated for two channel configurations and two speeds.

1.6.5 Section 6 Summarises the study and makes recommendations.

1.6.6 Section 7 Lists the references used in the study.

1.7 Acknowledgements

1.7.1 During the site visit which was a part of this study, information and support was provided by a number of sources including:

Ms. Janine Niven (Route Manager, Wightlink)

Captain Paul Nixon (Master "Cenred")

Captain Roy Nicholls (Master "Caedmon")

Mr, Graham Butler (Chairman, Lymington Harbour Commissioners)

Mr. Ryan Willegers (Harbour Master, Lymington Harbour Commissioners)

Mr. Colin Freeman (Harbour Operations Manager, Lymington Harbour Commissioners)

Mr. Mike Simpson (Managing Director, Hart Fenton Ltd)

The freely given assistance of the above has been greatly appreciated.

2. LYMINGTON HARBOUR

2.1 General

2.1.1 Lymington is a harbour which has evolved and successfully capitalised on its twin geographic advantages of:

- Its attractive position and proximity to the popular western Solent, which makes it a natural location for leisure craft activity
- It's location as the ferry port of choice for the western Isle of Wight and UK destinations west of Southampton.

2.1.2 Although there are other activities (commercial fishing, tourism related trips etc), the ferry and recreational craft are the dominant sectors of shipping in Lymington. Given the above, it is clear that the port can only operate successfully if it carefully balances the needs of these two key stakeholders.

2.1.3 The fact that both Wightlink and the recreational sector have thrived indicates that the correct balance has been achieved thus far.

2.1.4 The Wightlink Terminal comprises:

- a single linkspan* designed to accommodate any of the existing C Class ferries (see section 3)
- a single lay-by berth just upriver from the linkspan
- associated shore infrastructure of a terminal building and ticketing, parking, catering, and administrative facilities.

(* a slipway immediately north of the lay-by berth can be used if the linkspan is out of commission).

2.1.5 Apart from a few buoy moorings, the terminal is the only port facility on the eastern side of the Lymington River. The marinas, yacht clubs, Harbour Office, RNLI station and public slips are all on the western side, forming the waterfront of Lymington town itself.

2.2 Port Activity

2.2.1 The following gives a flavour of the Lymington Harbour activity:

Marinas	2
Marina Berths	900 to 1000
Buoy moorings	650 to 700
Ferries Operating	3
Ferry Crossings	22,500 per annum

Fishing craft	12 to 15 (mainly shellfish)

2.3 Approach Channels

2.3.1 The Wightlink Terminal is approached from the Solent by three separate Reaches as follows:

Long Reach

Is on an alignment of 139.5 / 319.5 degrees (T) and runs from where the Lymington River enters the western Solent (at the Jack In The Basket), to the Tar Barrel Pillar. Long Reach has a water depth varying from 2.6 metres to 3.8 metres below CD (on the centre line) but there are isolated 2 metre spots close to the outer end at Jack In The Basket. A recent bathymetric survey [Reference 3] confirms an opinion given by Wightlink's Masters that there is channel accretion in western side of Long Reach between Pillars No. 3 and No. 5.

The channel is approximately 55 metres wide between the 2 metre contour lines. Small craft moorings are sited along the west side for much of its length (although none was in use at the time of the visits on 20^{th} / 21^{st} November). The craft which use the mooring buoys are all on a single bow mooring and are therefore free to swing to wind or/and current, which results in the moored craft swinging into the channel with a resultant reduction in channel width of approximately 4 to 7 metres.

The Reach is marked by pairs of illuminated pillars (IALA system A). A set of transit marks / range lights are mounted on the shore in Lymington town, and this provides a very good visual check for inward and outward transits of Long Reach by night (although they are considerably obscured by yacht masts by day).

Short Reach

This Reach is actually a continuous curve which requires three bends to navigate – one (48^o) entering the Reach, one in the middle, and one (approximately 45^o) exiting the Reach.

The southern part of the Reach (in the vicinity of Bag of Halfpence Pillar) is the preferred location where an inward and outward ferry pass each other. Each ferry has a set of transit marks which facilitate a "green-to-green" passing. From Reference 3, the lateral separation between the transit lines is approximately 28 metres, which equates to less than 2 times the beam of the Wightlink ferries, as can be seen below.

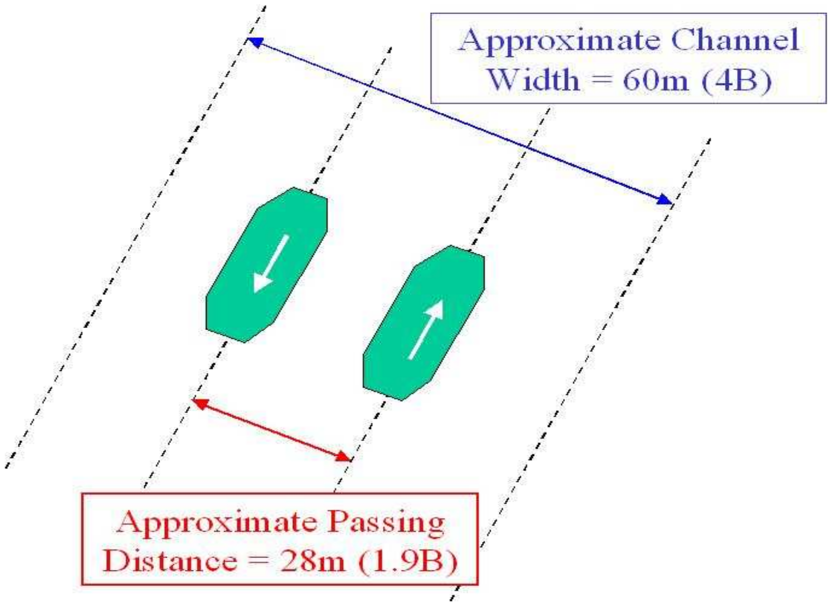


Figure 2.1 – Passing Off Bag Of Halfpence

Whilst the track record of successful ship passing clearly indicates that the Reach is wide enough for two ferries to pass, it cannot be considered as a generous width, especially when the distance is reduced further by:

- craft lying to their moorings on the western side, or
- ferries having to steer into the wind in order to make its track along the Reach, or
- a combination of the above.

Horn Reach

Upon exiting Short Reach, the final approach to the Wightlink Terminal is via Horn Reach. This area of the harbour is upstream from the Harper's Post / No. 11 Pillar wave screen and it is from this point that the LHC speed limit reduces from 6 knots to 4 knots.

LHC advise that a significant amount of capital dredging has taken place upstream of Harper's Post in recent years, with the twin objectives of providing:

- more channel space for the ferries and
- more yacht pontoons on the river side of the Yacht Haven wave screen.

It is understood that this is the only real capital dredging that has taken place near to the channel since the 1991 study ie the navigation channels can be regarded the same for both studies.

The dredging requirements for Lymington are approximately 30,000m^3 per annum, which is all deposited by the flood tides from the mud flats at the outer end of the Lymington River ie there is no alluvial deposit. LHC has a view that the dredging requirement is partly due to agitation of the river banks by speeding vessels, including the Wightlink ferries.

LHC further advise that the increased water “prism” above Harper’s Post has helped reduce the wash effect of ferries which navigate at (and, anecdotally, occasionally above) the 4 knot speed limit.

2.4 Tidal Regime

2.4.1 From nautical publications, the tidal range at spring tides is 2.3 metres, with MLWS being stated to be approximately 0.7m above chart datum (CD). Advice from LHC indicates that the tide level will fall below MLWS on approximately 10% of low waters, but very rarely will the water level fall to below chart datum.

2.5 Currents and Winds

2.5.1 No new data has been sought for this study but, for completeness, the following is replicated from the 1991 study [Reference 1]

2.5.2 Currents are believed to be co-axial with rates stated to be up to 1.5 knots in the river and across the outer channel at maximum of 3 knots. (Note, during the site visit, observations indicated that these harbour rates may be overstated).

2.5.3 Winds are predominantly from the south-west apart from the months of April and May when they are more north-westerly. Wind speeds exceed Force 6 (27 knots) for only about 1% of the time.

2.6 Marine Incidents

2.6.1 A brief review of Wightlink’s marine incident records was made to try and ascertain the nature and extent of problems caused by the ferries or visited on them by other Lymington port users. Given the level of shipping as described in section 2.2, the profile can be regarded as very low and serves to confirm that, for the most part, the ferries and the leisure sector co-exist very well.

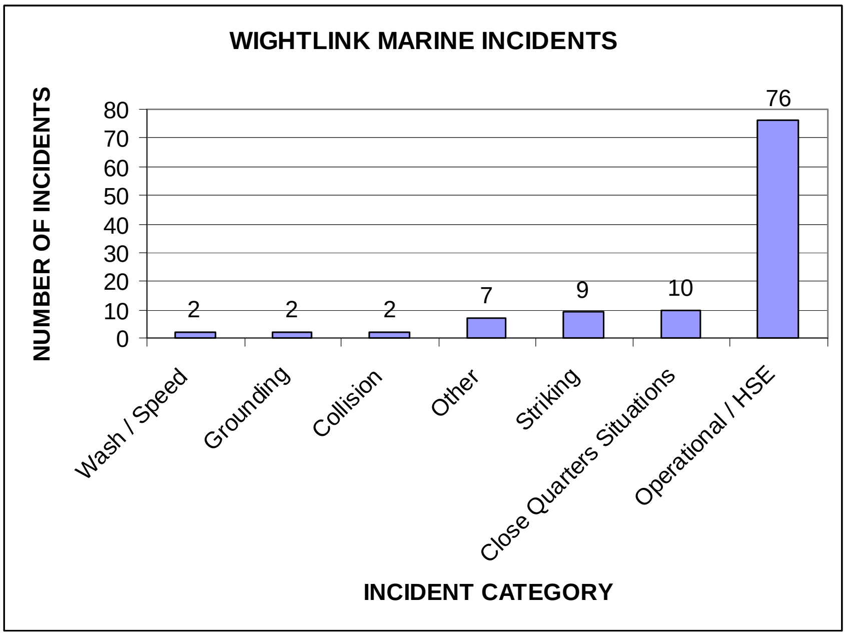


Figure 2.1 – Marine Incidents Involving “Cenred” (2003 to date)

2.6.2 The data is heavily dominated by what might be described as “domestic” ship-board issues such as damage reported to vehicles, minor injuries to passengers and crew, and assorted passenger-related incidents (eg antisocial behaviour).

2.6.3 The grounding incidents were both cases of “touching bottom” rather than hard groundings and, based on anecdotal comment of Masters, it is likely that this is an incident category which is heavily under reported as shallow water effects are an every day event.

2.6.4 The strikings related mainly to heavy landings on Wightlink property (Lymington or Yarmouth), with one incident involving contact with a pillar beacon.

2.6.5 The close quarters and collision situations were all involving yachts which (in the opinion of the incident reports ie the Wightlink Masters) were being poorly navigated.

2.6.6 The incident rate for wash and speed incidents is very low, given the presence of the necessary elements (time-driven ferries, yachts, narrow and twisting waterways, and a tidal range).

2.6.7 Even when examining the Lymington Harbour Commissioners data for the year 2004/2005, there were only 6 (out of 22) incidents categorised as “ferry” incidents. Of these, 3 were collision or near miss incidents and 3 were wash or handling incidents.

3. DESIGN SHIPS

3.1 General Particulars

3.1.1 The table below sets out the general particulars of the current C Class ferries and the proposed new R Class vessels.

Detail	**Existing C Class Ferries**	**Proposed R Class Ferries**	**Difference Between Ferries**
Length Over All (LOA)	58.0m	62.4m	plus 7.6%
Length At Waterline (LBP)	55.0m	56.1m	plus 2.0%
Moulded Breadth	15.2m	16.0m	plus 5.3%
Breadth At Waterline	12.2m	14.4m	plus 18.0%
Length / Beam Ration At Waterline	4.5	3.9	minus 13.3%
Draft	2.28m	2.30m	plus 0.88%
Load Displacement	850 tonnes	1500 tonnes	plus 76.5%
Displacement / Length^3 Ratio	0.00511	0.00850	plus 66.29%
Block Coefficient (CB)	0.517	0.650	plus 25.73%
Voith Schneider Propellers	2 x 16E	2 x 21G	
Combined h.p.	800hp (a)	2360hp (b)	see notes
Power / Weight Ratio (h.p. / displ.)	0.94	1.57	see notes
Maximum thrust available (tonnes) (c)	8.0	23.6	see notes
(Thrust / Displacement Ratio) x 100	0.94	1.73	see notes
Longitudinal Distanced Between Thrusters	34.5m	49.9m	plus 44.64%
Above Water Lateral Area (at loaded draft)	295m^2	544m^2	plus 84.41%
Below Water Lateral Area (at loaded draft)	125m^2	129m2	plus 3.2%
Above / Below Water Ratio	2.36	4.22	plus 78.8%
Maximum Speed	10.0kts	12.0kts	plus 20%

(a) This is as given in the 1991 report but its basis is not known and may well be incorrect.
Engine power value for existing C Class vessels is stated by Wightlink to be 793kw (1063 at 1kw = 1.341hp)
Engine power value for existing C Class vessels is stated by Lloyds Fairplay to be 618kw (828 at 1kw = 1.341hp)

(b) Based in information provided by Wighlink as follows:
4 engines each of 550kw = 2200kw
Assume 80% of power delivered = 80% of 2200 = 1760kw
Assume conversion at 1kw = 1.341hp = 1.341 x 1760 = 2360hp

(c) Conversion Factors as Follows:
C Class - 1.0 tonne of thrust per 100 hp to take account of thrust lost due to V/S units being offset from centreline
R Class - 1.1 tonne of thrust per 100 hp to reflect the more favourable centreline location of the V/S units

Table 3.1 – Principle Details Of Existing (C Class) and Proposed (R Class) Ferries

3.2 Comments

3.2.1 As can be seen, the main physical dimensions of the R Class ferries are not significantly different from the C Class ie the physical "footprint" is almost the same.

3.2.2 However, of particular concern are the much greater displacement, block co-efficient and thrust of the R Class, which all have the potential to increase the hydrodynamic effects of squat, wash and drawdown (for a given channel geometry, water depth and vessel speed).

3.2.3 Given the above, and observations gained during the site visit (see section 4), it is considered that:

- The proposed R Class ferries – being of almost equal size to the existing C Class vessels – ***will be capable*** of navigating within the existing Lymington waterways, but

- Their ***effect*** will be different to the effect of the existing vessels.

3.2.4 The greater emphasis in assessing the R Class in Lymington is therefore focussed on assessing the ***effect*** of the R Class ferries, rather than a straightforward assessment of their ***ability*** to navigate the Lymington River.

3.2.5 That assessment is given in section 5.

4. SITE VISIT

4.1 General

4.1.1 A two day visit was made to Lymington on 20th and 21st November 2006 in order to meet relevant personnel, gather data, observe local conditions, and consider the suitability of Lymington for the R Class ferries.

4.1.2 This section describes the observations from the visit.

4.2 Ferry Crossing (Monday 20th November)

4.2.1 On Monday 20th, a single round trip was carried out to gain an appreciation of the passage. The "Cenred" departed Lymington at 1215, approximately 2.5 hours after high water (predicted height 2.9 metres) and 3.5 hours before low water (predicted height 1.0 metres).

4.2.2 Winds were south westerly force 4 to 5, and conditions were fine and clear.

4.2.3 Given the "half tide" conditions on both the outward and inward transits, the Master was not unduly concerned about his under keel clearance and was able to devote time to pointing out the various aspects of note.

4.2.4 One aspect that came as something of a surprise was the way in which small craft, when lying to their single buoy mooring in Short Reach, swing into the Reach with the effect of reducing the navigable width. This is shown in the following photograph.

Figure 4.1 – Outward Bound Approaching Bag Of Halfpence Pillar. Yacht Is Wind-Rode At Its Buoy In A Westerly Wind, Causing A Narrowing Of The Channel

4.2.5 The Master concurred that this was an additional problem for him, but was unaware of any striking incidents between ferries and moored yachts.

4.2.6 The Master also felt that, whilst the freely swinging yachts are not welcome, the small craft mooring buoys in Short Reach and Long Reach are of value as they provide a readily visible indicator of where the channel edge lies.

4.2.7 The Master also felt that, although the buoys were generally advantageous as described above, caution had to be exercised during easterly winds when the buoys were lying away from the channel edge. Figure 4.2 illustrates a mooring buoy in:

a) its "neutral" position (marking the channel edge)

b) lying towards the channel (westerly winds)

c) lying away from the channel (easterly winds)

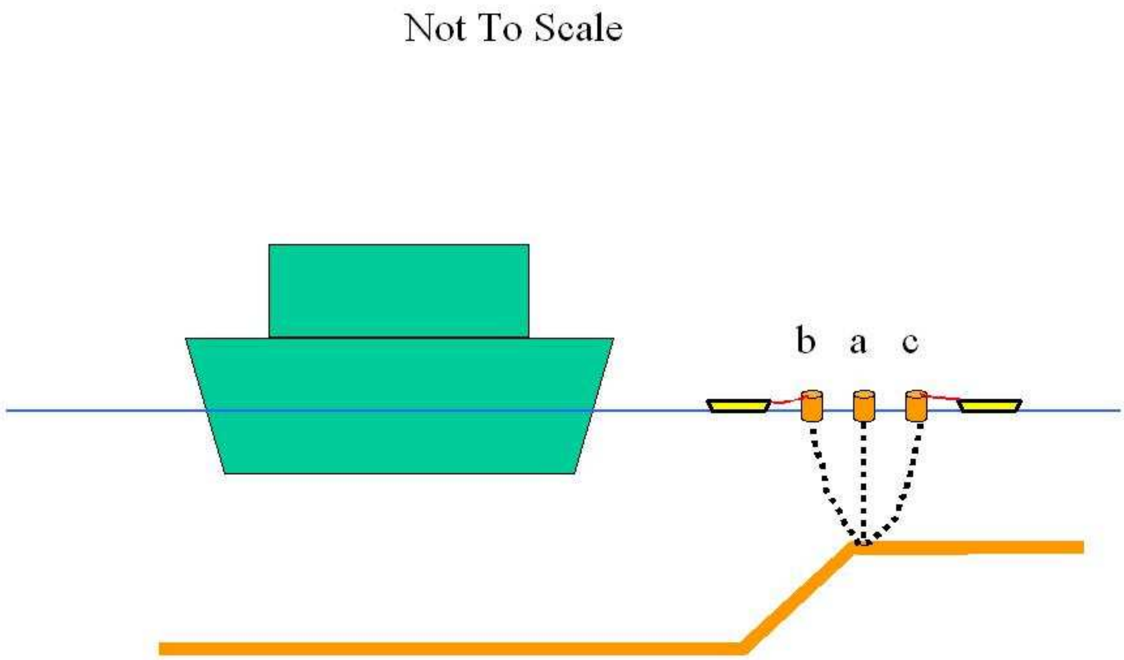


Figure 4.2 – Craft Mooring Buoys At Channel

4.2.8 As may be seen, these buoys have the potential to:

- Enhance navigation by marking the channel edge, when in position (a)
- Detract from navigation by restricting channel width, when in position (b)
- Distort the true edge of the channel, when in position (c).

4.3 Ferry Crossings (Tuesday 21st November)

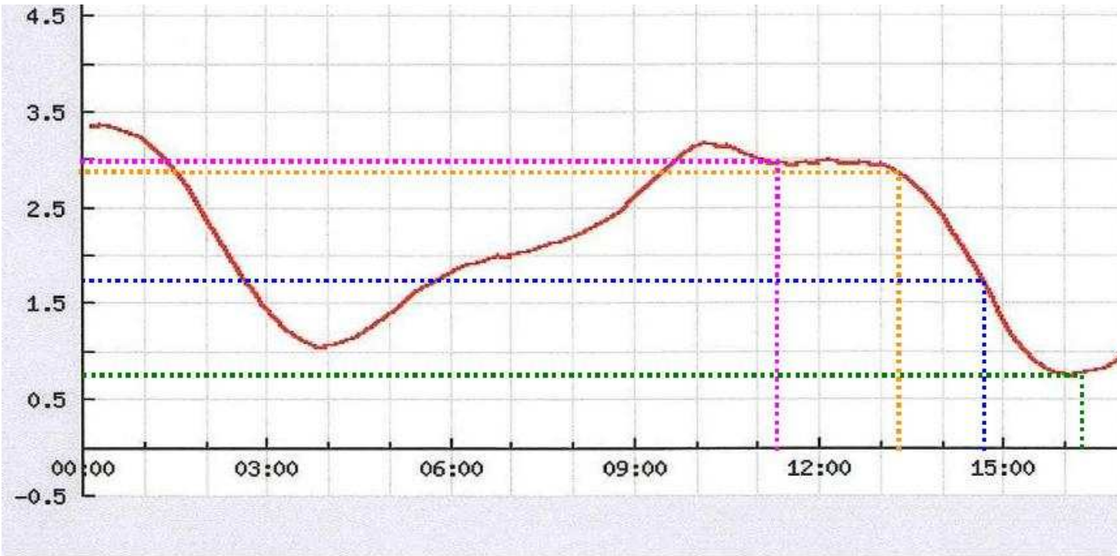
4.3.1 A total of four round trips were made on "Caedmon" to assess conditions at various tidal conditions by daylight and in darkness. These are summarised below.

Depart Lymington	Tide Time	Tide Height	Draft	
			Forward	Aft
1115	5.0h before LW	3.00m	Not noted	
1315	3.0h before LW	2.90m	2.10	2.12
1445	1.5h before LW	1.75m	2.22	2.20
1615	LW	0.75m	2.15	2.22

Table 4.1 – Summary Of Crossings On Tuesday 21st Nov

4.3.2 Figure 4.3 below is a tidal curve showing tide heights actually achieved on the 21st November, and figure 4.4 is an enlarged portion showing the tide heights stated in the above table (raw data downloaded from http://www.channelcoast.org)

Figure 4.3 – Tidal Curve For 21st November



Crossing	Tide Height
1115	3.00m
1315	2.90m
1445	1.75m
1615	0.75m

Figure 4.4 – Tide Heights On Crossings

4.3.3 Weather conditions were west to north westerly force 4 and, apart from some of the time on the 1115 crossing when moderate rain fell, conditions were dry, fine and clear. The return into Lymington from the 1615 crossing was in darkness, so the adequacy of lighted navaids was easy to assess.

4.3.4 In most of the transits in and out of Lymington, a passing of a ferry travelling the other way took place in the vicinity of the Pylewell and Bag of Halfpence Beacons in Short Reach.

4.4 Ferry Speed

4.4.1 During the crossings, the vessel speed was noted from the readout on the bridge GPS display, which gives speed over the ground as opposed to speed through the water.

4.4.2 The purpose of recording the speed was partly to validate the LHC view that speed limits are occasionally exceeded, and partly to observe the wash conditions at various speeds and different tidal conditions.

4.4.3 Tables below indicate the speed as read from the GPS display when passing different points along the channel.

Crossing - 1315 Ex Lymington	
Tide Height - 2.9m (3 hrs before LW)	
Abeam Of	**Speed In Knots**
Dredger	4.1
Yacht Club	5.9
No. 11	6.2
Harper's	6.2
Cocked Hat	6.5
Pylewell	7.4
Tar Barrow	7.6
No. 6	9.2
Cross Boom	9.2

Crossing - 1400 Ex Yarmouth	
Tide Height - 2.15m (2 hrs before LW)	
Abeam Of	**Speed In Knots**
Jack In Basket	8.0
No. 5	8.3
Tar Barrel	7.3
Cocked Hat	4.2
Harper's	5.7
No. 11	5.6
Yacht Club	5.4
Dredgers	3.5

Crossing - 1445 Ex Lymington	
Tide Height - 1.6m (1.5 hrs before LW)	
Abeam Of	**Speed In Knots**
Dredgers	3.6
Yacht Club	5.2
No. 11	5.9
Harper's	5.8
Cocked Hat	4.7
Tar Barrel	8.2
No. 3	9.1

Crossing - 1530 Ex Yarmouth	
Tide Height - 0.8 m (0.5 hr before LW)	
Abeam Of	**Speed In Knots**
Jack In Basket	7.9
No. 5	7.2
Cocked Hat	6.4
Harper's	4.8
No. 11	4.5
Yacht Club	5.1
Dredgers	2.3

Crossing - 1615 Ex Lymington	
Tide Height - 0.75m (LW)	
Abeam Of	**Speed In Knots**
Dredgers	4.3
Yacht Club	4.8
Harper's	4.9
Tar Barrel	5.9
Cross Boom	8.2

Crossing - 1700 Ex Yarmouth	
Tide Height - 1.05m (1 hr after LW)	
Abeam Of	Speed In Knots
Jack In Basket	8.7
No. 11	6.6
Yacht Club	6.2

Tables 4.2 – Ferry Speed, As Read From "Caedmon" GPS Display

4.4.4 Some of these transits were made with the current and some against the current. In the transits close to low water, the current streams were negligible. There may also be instrument errors in the GPS. However, it is clear that the ferries do not strictly adhere to the speed limits of 6 knots below the wave screen and 4 knots above the screen.

4.4.5 Figures 4.5 to 4.7, below illustrate the wash effect from the "Caedmon" when transiting outwards on the 1615 (low water) service.

4.4.6 No significant adverse effects resulted but the river was very quite and, in busier conditions, small craft would have been affected, but probably not endangered.

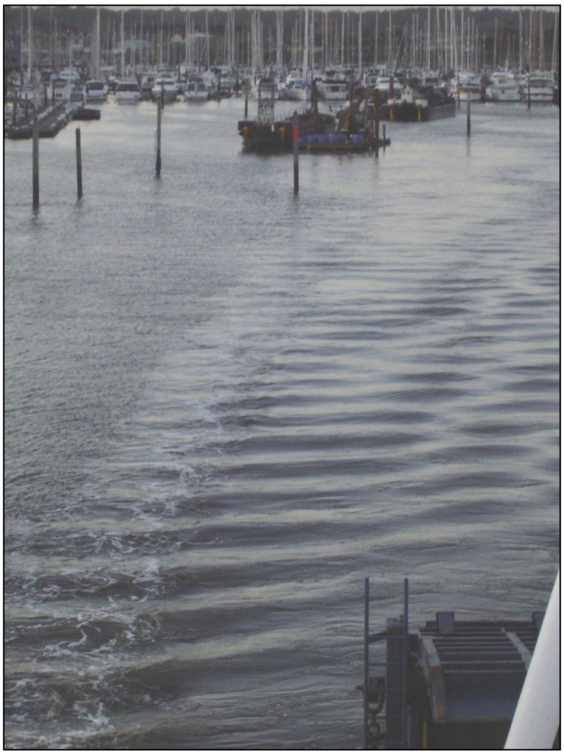


Fig 4.5 – Horns Reach

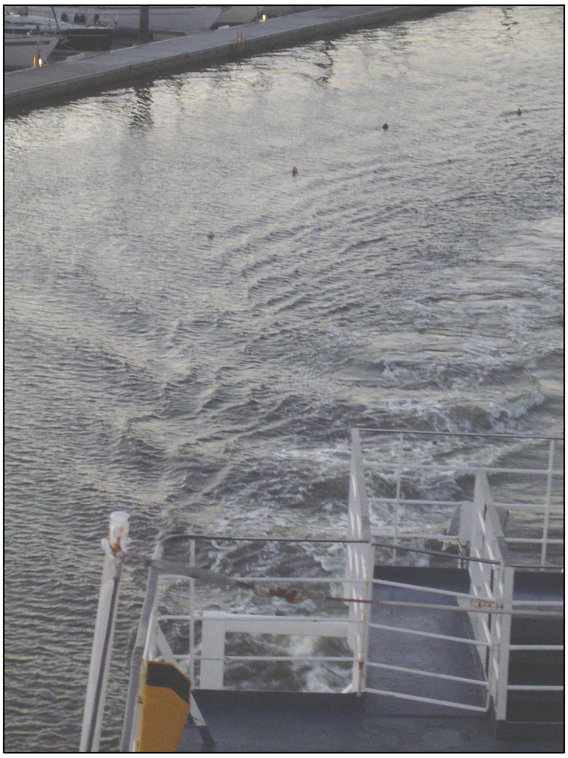


Fig 4.6 – Horns Reach

Figure 4.7 – Short Reach (Stern Wave Estimated To Be About 0.3m x 1.5m)

4.4.7 Figure 4.6, below, illustrates that flouting the speed limits is not exclusive to the ferries!

Figure 4.6 – Fishing Craft Inward Bound In Long Reach

4.5 Channel Adequacy

4.5.1 It is clear from:

- an examination of the Admiralty chart and Reference 3
- a review of the 1991 report
- a review of the various channel design guidance criteria used in the 1991 report, and again in this study (see references)
- observations gained during the ferry trips, and
- comments by the Wightlink Masters

that the existing channels are "at the limit" for the existing C Class vessels at low water.

5. HYDRODYNAMIC EFFECTS

5.1 Introduction

5.1.1 In this section, some comments are made on the hydrodynamic aspects that are relevant in the Lymington case and, indeed, whenever a vessel moves in restricted waters.

5.1.2 This section is particularly important given the comments made in section 3.2.3, in that the key issue is the ***effect*** of the proposed R Class vessels, rather than their ability to navigate the Lymington River.

5.2 Wash

5.2.1 When a vessel moves through water, the pressure systems over its hull create waves on the water surface. These may be classified into two broad types:

- The free wave system
- The local wave system

5.2.2 <u>Free Wave System</u>

The free wave system is seen with all ships. Comprising transverse and diverging waves, it typifies the wash pattern of all floating vessels. At high enough speeds, the transverse system disappears and a diverging system remains. Wave heights increase generally with increase of speed up to a critical value when height can become excessive and periods long. In some conditions so-called solitary waves, or solitons, may be created; they can travel for some distance and may be the source of “rogue waves” which can swamp a beach or riverbank for no apparent reason.

5.2.3 To help quantify the magnitude of the free wave, a measurement known as the Froude Depth Number (F_{nh}) is used. The Froude Depth Number is broadly a non dimensional ratio between speed and depth.

5.2.4 Solitons occur around a Froude Depth Number (F_{nh}) of one, where F_{nh} is defined as $v/\sqrt{(gh)}$ where v is the speed in m/sec, g is gravitational acceleration and h is water depth. For $F_{nh} > 1.0$ (i.e. supercritical speeds) only divergent waves exist, whereas for $F_{nh} < 1.0$ (i.e. subcritical speeds), both divergent and transverse waves co-exist.

5.2.5 Free waves are related to hull design and, generally, the greater the displacement/length ratio (displacement/length^3) the greater the height. As an example, a rowing eight (with a very low displacement/length ratio) makes very little wash, whereas a short rowing boat of the same displacement makes a good deal of wash at the same speed.

5.2.6 It may be seen from table 3.1 that the displacement/length^3 ratio of R Class is some 66% greater than the existing C Class.

5.2.7 To avoid large free waves, the range $0.6 < F_{nh} < 1.2$ should be avoided [References 5 and 6].

5.2.8 Local Wave System

The local wave system, while present in all water depths, is more apparent in restricted shallow waters. It comprises a crest at bow and stern and a trough in between. The trough represents a low-pressure region, a region where local velocities around the hull are increased to cause backflow and drawdown.

5.2.9 With some ships, such as tankers and bulk carriers, in shallow or restricted waters, it is the local system which dominates and contributes to their effect on the waterway itself.

5.3 Drawdown

5.3.1 Drawdown is a consequence of the local wave system. Due to the lowering of pressure over much of the hull, the ship settles into the trough so formed, thereby giving rise to squat. The magnitude of the drawdown is roughly equal to the squat of a vessel, so if the squat can be estimated, so can the drawdown. As a consequence, because the backflow is directly related to the drawdown (by Bernoulli's Theorem) then a rough idea of the amount of backflow, and how it varies with hull parameters may be obtained from an estimate of squat.

5.3.2 Drawdown and the magnitude of backflow increase with increase of block coefficient and increase of blockage (taken as the ratio of the midship section area to the cross-sectional area of the restricted waterway).

5.4 Squat

5.4.1 Squat describes the way a ship underway settles in the water and changes trim. It is caused by the same hydrodynamic phenomena that cause drawdown. In the case of the Wightlink ferries in the Lymington River, trim under way will usually be by the head, accompanied by a parallel sinkage due to the drawdown. Were the ship to be able to go fast enough, or the river narrow enough, then running trim could be by the stern but this is not likely with the vessels under consideration.

5.5 Bank Erosion

5.5.1 Drawdown pulls the water off the banks of a waterway and backflow erodes the banks. The latter usually occurs at the toe, thereby increasing the risk that the bank material will slump, resulting in a loss of water depth and a grounding hazard to vessels.

5.5.2 Once the vessel has passed, then the following wave can break in the shallow water high up the bank (due to its going supercritical), causing further erosion. The combined action of drawdown and following wave breaking can change the river cross-section by redistributing material from the higher regions of the bank to the toes.

5.5.3 Banks can be further eroded by the propulsion used on the vessel. Should the Voith thrusters come close to the banks, then their action could cause the bed and bank material to go into suspension, thereby causing further erosion. In the case of the new ferries, propulsion will be by Voith cycloidal propellers mounted on the centreline fore and aft instead of being offset, as is the case with the existing C Class.

5.5.4 This will have two positive effects:

- The fact that both thrusters are on the centreline will reduce the erosion effect, when compared to that of the C Class with their off set units

- The R Class will have improved directional stability, which will make them better able to navigate clear of the bank slopes.

5.5.5 Generally, the centrally-mounted thrusters on the new ferries should keep well clear of the banks of the river, but in a cross wind it may be necessary to adopt large drift angles to counter the wind. The lateral windage of the new vessels and its effect is discussed further in section 5.8 below, but suffice it to say that it is higher than that of the present ferries and may need larger drift angles than used at present, thereby placing the thrusters closer to the region of the bank toes.

5.6 Wash Nuisance

5.6.1 Excessive wave energy from the wash, whether it be from free or local wave systems, can cause nuisance to other waterway users in the following ways:

- By causing excessive motions on small craft on the trot moorings close to the navigation channel
- By endangering those in small craft from the action of the free wave wash
- Loss of wildlife environment due to bank erosion
- Change of the waterway geometry as a result of bank erosion

5.6.2 A further effect which may occur, and might be enhanced by the new vessels, is any tendency for the vessels to create a surge motion along the river. This could occur if the Froude Depth Number is too high (due to excessive speed through the water) which could cause low amplitude solitary waves to move along the waterway. The risk of this would increase with increase of blockage and loss of water depth, so would be most likely at low water. Such effects are present in canals and can affect other vessel moored in the waterway.

5.7 Squat Estimates

5.7.1 Squat estimates have been made for the present and proposed ferries using the methodology published in Reference 4. This has been done simply to demonstrate the effect of the change in underwater geometry, particularly that represented by the increase in displacement.

5.7.2 It must be stated that there are a number of methodologies for estimating squat values, but none is entirely appropriate in this case as:

- Most published research is based on open water conditions

- Most published research is based on larger block co-efficient values (typically the values of 0.75 to 0.85 that are found in oil tankers), and displacements well in excess of 2,000 tonnes

- All of the published research assumes a more conventional "ship shaped" vessel than is the case with the hull form found in the C and R Class ferries.

5.7.3 Given the above limitations, and accepting that the key need to estimate squat is to estimate the potential drawdown and backwash (rather than the squat, per se), the methodology used at Reference 4 is considered the most appropriate as:

- It is partly based on extensive tank model testing, including ships of low block co-efficient
- It does allow for the effect of channels

5.7.4 Using Reference 4, the following cases have been studied for both vessels:

- Single and passing (double) channel
- Mid-tide and chart datum (CD)
- Speeds of 4 knots and 6 knots.

5.7.5 The objective was to try and assess the squat in two key areas viz in Short Reach (where ferries are required to pass) and in Horn Reach (where the slowest speed is required). These two ship/channel scenarios are illustrated simply in figures 5.1 and 5.2 below.

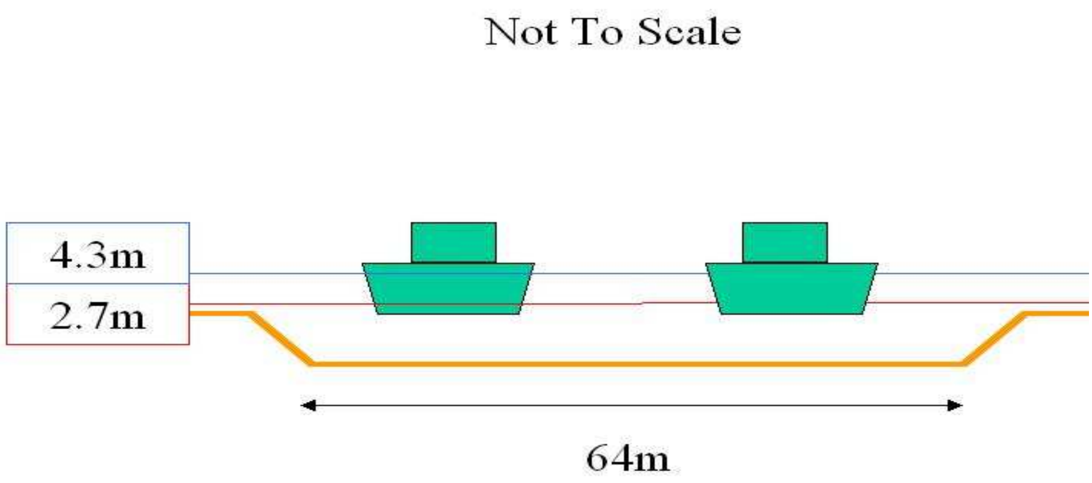


Figure 5.1 – Two Way Channel Showing Water Depth At CD (2.7m) and Mid Tide (4.3m)

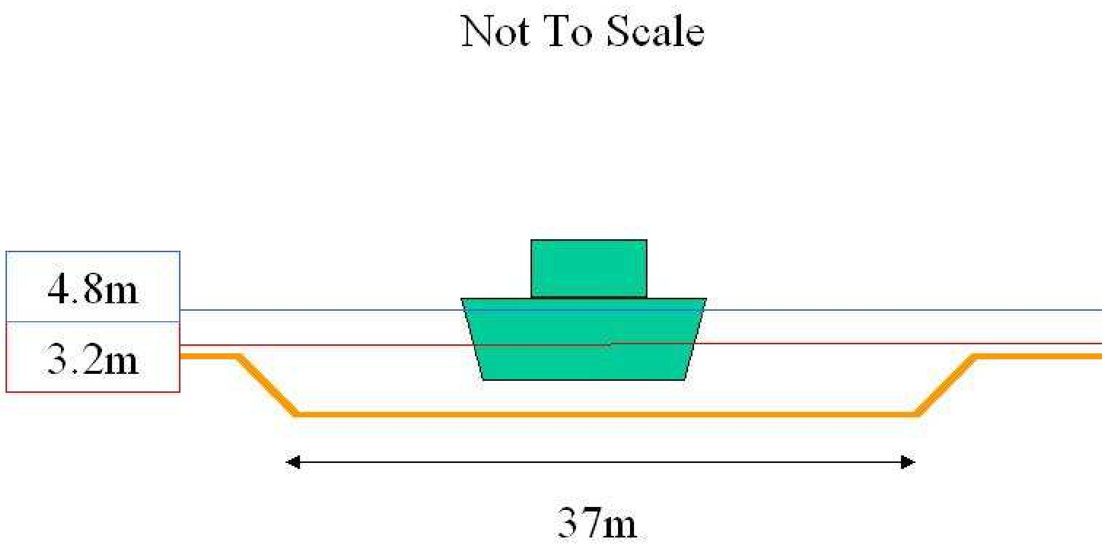


Figure 5.2 – One Way Channel Showing Water Depth At CD (3.2m) and Mid Tide (4.8m)

5.7.6 The results are shown in table 5.1 as maximum sinkage values (always at the bow) in metres:

CLASS	SPEED (knots)	SINGLE CHANNEL		DOUBLE CHANNEL	
		Mid Tide	CD	Mid Tide	CD
C	4	0.055	0.105	0.034	0.068
C	6	0.155	0.417	0.096	0.209
R	4	0.084	0.189	0.051	0.109
R	6	0.255	0.823	0.147	-0.537

5.7.7 It is seen immediately that the values for the proposed R class are greater than those for the C class, reflecting the increase in block coefficient from 0.52 to 0.65. If the block coefficient were to increase any more, then so would squat.

5.7.8 As squat is being used as an indicator of drawdown and backflow, Table 5.1 also serves to show that both these effects would be increased by the proposed vessels. In particular, attention is drawn to the increase in squat arising from an increase in speed from 4 knots to 6 knots for the R Class ships navigating a single channel at CD.

5.8 Windage

5.8.1 The lateral windage of the proposed R-Class vessels is some 84% greater than that of the existing C-Class vessels. In addition, the ratio of above to below water areas changes from 2.36 for the C-Class vessels to 4.22 for the R-Class, an increase of some 78%.

5.8.2 This ratio is a simple indication of the way in which a ship may behave in a beam wind, the above-water area representing the “driving” force and the underwater area representing the resisting force, all other things being equal. The increase on the new ship suggests that the R-Class will be more affected by beam winds than the earlier C-Class and further suggests that drift angles, possibly of greater magnitude, will still be needed to counter the effects of wind. This in turn suggests that the thrusters may come comparatively close to the river banks, with the consequences on erosion mentioned above.

5.8.3 The greater power in the thrusters should help to counter wind to some extent, but it is still likely that drift angles will need to be set. If there has been any slumping of the banks, the thrusters may be put at risk should large drift angles have to be used.

5.9 Discussion

5.9.1 It would appear from the above that the proposed R-Class could have an adverse impact on channel erosion. With the proposed increase in displacement, it is difficult to see any other outcome, even at the superficial level of investigation used in this study.

5.9.2 It must be mentioned however, that the discussion has been limited to just the two speeds of 4 and 6 knots being, respectively, the two harbour speed limits upriver and downriver of the Harper's Post wave screen.

5.9.3 As a matter of interest, if the speed through the water is as much as 8 knots, the squat estimates suggests that the C-Class vessels may just touch bottom at this speed in the single channel at low water; the R-Class, however, are estimated to touch bottom at the bow at less than 7 knots. Such speeds at low water give Froude Depth Numbers in the region of 0.7, suggesting that wash heights will be increased and may cause nuisance.

5.9.4 This again shows the additional constraints that may be placed on the shiphandler by the new vessel design.

5.10 Conclusions On Hydrodynamic Effects

5.10.1 As a result of this brief study, it is concluded that the proposed R-Class ferry will have a greater potential for channel erosion due to its increased drawdown and backflow, with the added possibility that the thrusters may come close to the banks in strong winds on the beam. This would cause further erosion and may put the thrusters at risk.

5.10.2 Speeds at or near 8 knots at low water are more likely to cause grounding at the bow with the R-Class than the C-Class; wash heights would also increase.

5.10.3 Wash from the free waves of the R-Class is likely to be a greater nuisance (due to greater height) than that from the present C-Class, although the extent of the increase cannot be determined without further more detailed study.

6. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

6.1.1 Given the similarities in the overall dimensions (length, beam and draft) between the existing C Class and the future R Class ferries, it can be readily accepted that the existing waterways are physically large enough to accommodate both vessel classes.

6.1.2 The key issue is therefore the ***effect*** that the greater displacement and fuller hull form of the R Class will have on a number of aspects, such as:

- Hydrodynamic effects (wave, wash, drawdown and surge)
- Bank erosion effects resulting from the above
- Impact on other craft, whether moored or under way
- Effect of increased windage and the consequential impact on navigation of ferries.

6.1.3 It is an unwelcome but inescapable fact that - for a given channel geometry and speed - the R Class ferries will have a greater adverse hydrodynamic impact than the existing C Class vessels. It is simply not possible to change the underwater form and expect the effects listed in 6.1.2 to remain the same.

6.2 Recommendations – General Description

6.2.1 The above pessimistic assessment is not without hope as the key factor in the level of adverse hydrodynamic effects is the vessel's speed.

6.2.2 LHC advise that ferry speed is an occasional problem with the existing C Class – hence their concerns regarding the R Class. The problem is (unsurprisingly) at low water, and is partly supported by anecdotal accounts of ferry speed in excess of the 6 knot and 4 knot limits.

6.2.3 It is therefore clear that the only way in which the hydrodynamic effects of the R Class can be maintained to acceptable levels is by reducing the ferry speed to either:

- The 6 and 4 knots that are meant to be followed at present or, possibly
- Some level below the 6 and 4 knots, particularly at low water.

6.2.4 The optimum speeds within Lymington River can be found in a variety of ways. It is not considered viable – or particularly accurate – to try and identify a wide range of vessel speeds and water depths and then determine the resultant hydrodynamic effects by calculation alone. The formulae and theorem for calculating wave effects are based generally on a vessel navigating a straight channel section and given that Lymington has many bends, differing bank gradients and a full range of wind effects, it is considered that the results achieved by calculation alone would not be sufficiently robust.

6.2.5 A more robust process would involve a structured programme of live “suck-it-and-see” tests involving the new ferries following delivery.

6.2.6 The live tests would essentially involve running the ferries at a range of speeds and tide heights in order to note the hydrodynamic effects. Whilst it is not possible to properly estimate the outcome of that process, a considered opinion from this report’s author is as follows:

Tide	Area	Speed	Area	Speed
Existing Speed Limits				
All conditions	Above Harper’s	4 knots	Below Harper’s	6 knots
Anticipated Future Speed Limits				
Above half tide	Above Harper’s	4 knots	Below Harper’s	6 knots
Below half tide	Above Harper’s	3 knots	Below Harper’s	5 knots

6.2.7 It may be unfeasible for LHC to have two limits for different tidal heights but, whatever is adopted, that speed should:

- Be based on the outcomes of the live trials
- Be adhered to in order to avoid an increase in wash related problems, particularly at low water

6.2.8 Clearly, whatever speed is established, it is important that the speed is adhered to. Therefore for both the establishment of the optimum speed during the live trials, and for ongoing verification, some form of accurately recording ferry speed should be agreed by Wightlink and LHC.

6.2.9 The increased windage area of the R Class ferries will have to be handled by a combination of:

a) Maintaining vessel alignment within the channel by use of the greater thrust available, and

b) Setting a course to counter the wind.

6.2.10 In both cases, the effect will be to impart energy on to the channel banks with resultant bank erosion, again most noticeably at low water.

6.2.11 In order to assist ferry Masters in maintaining their channel alignment, restoration of the full channel width would be helpful. This would mean refraining from mooring craft on the small moorings of the west side of Short Reach and Long Reach, although the buoys themselves are (on balance) helpful in providing positional awareness.

6.3 Recommendations – Listed

A. Wightlink should develop a programme for testing the effects of the R Class ferries upon their introduction to service. The key variable will be the vessel speed and tide height at different parts of the harbour. Implicit within this recommendation is the need to accurately measure the vessel speed.

B. Consideration should be given by LHC to ceasing the practice of mooring freely swinging craft at the buoys on the west side of Short Reach and Long Reach, in order to maximise the navigable width and better allow the ferries to maintain their channel alignment by use of power, rather than setting large wind-drift angles.

C. All of the above should be carried out in consultation with LHC.

7. REFERENCES

Reference	Description
Named References in report	
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4	"The Squat of Full Ships in Shallow Waters", I Dand and A.M. Ferguson, RINA Volume 115. page 237 onwards, 1973.
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Background sources and references	
7	Admiralty chart 2021
8	Hart Fenton drawing 633A013P4 dated 15/09/06
9	"Approach Channels – A Guide for Design" - PIANC, 1997
10	"Channel Design Parameters" – Canadian Coastguard, 1999
11	"Ship Behaviour in Ports and their Approaches" – Department for Transport, 1982
12	"Port Design, Guidelines and Recommendations", Carl A. Thoresen, 1988