Report of the investigation

of the grounding of

ARCO ARUN

off Broadness Point, River Thames

on 13 October 1998

FILE: MAIB 1/6/106

Marine Accident Investigation Branch
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Extract from
The Merchant Shipping
(Accident Reporting and Investigation)
Regulations 1999

The fundamental purpose of investigating an accident under these Regulations is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

CONTENTS

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

BST	British Summer Time (UTC +1)
cm	centimetre
DPC	Duty Port Controller
GPS	Global Positioning System (Satellite Navigation)
gt	Gross Registered Tonnage
kW	Kilowatt
m	metre
MAIB	Marine Accident Investigation Branch
MCA	Maritime and Coastguard Agency
PCL	Port Control London
PEC	Pilotage Exemption Certificate
PLA	Port of London Authority
SVTSO	Senior VTS Officer
SW	South-west
TBNC	Thames Barrier Navigation Centre
UTC	Universal Co-ordinated Time
VHF	Very High Frequency (Radio)
VRM	Variable Range Marker (Radar)
VTS	Vessel Traffic Services

SYNOPSIS (all times are UTC)

The accident was notified to the Marine Accident Investigation Branch (MAIB) by ARC Marine Ltd at 1615 on 13 October 1998. An investigation began on 14 October. MAIB Inspector, Captain Nick Beer, carried out the investigation.

Arco Arun, a suction dredger of 98.3m in length, was inbound on the Thames with a full cargo of aggregates, when at 1350 on 13 October, 1½ hours after low water, she momentarily grounded while rounding Broadness Point. She was holed beneath the waterline, and despite being manoeuvred first into the channel and then to a nearby anchorage, she capsized and foundered in shallow water 43 hours later. The MAIB investigation focused on what caused the initial grounding and on the actions of the crew immediately afterwards until the vessel was abandoned. The report identifies causal factors in the capsize and foundering of the vessel which are thought to have significance to other vessels in the trade.

The accident was caused by a navigational error due to poor bridge team management and the lack of a passage plan. With a draught of 6.6m, *Arco Arun* was navigationally restricted to a channel that was unmarked. The inquiry found that those on the bridge failed to use the radar, chart, or echo sounder to good advantage. The master, who was the pilotage exemption certificate (PEC) holder in charge on the bridge, had delegated the first responsibility for navigation to the newly qualified second mate.

In the minutes leading up to the grounding, *Arco Arun*'s radar echo on the vessel traffic services (VTS) screens at the Gravesend port control station indicated that she was moving into dangerously shallow water but this was not noticed by the VTS officers.

Recommendations have been directed at the shipmanager, the port authority and the Maritime and Coastguard Agency (MCA).

PHOTOGRAPH 1

Arco Axe - **Sister ship to** *Arco Arun*

Length	98.3 metres
Breadth	17.35 metres
Loaded draught	6.0 metres
Discharge gear	Drag scraper & conveyor 1000 - 1800 tonnes/hr
Speed	12 - 13.5 knots
Cargo capacity	4400 - 4500 tonnes
Position of boom conveyor	Port & starboard aft
Maximum outreach of boom conveyor	18.5 metres

SECTION 1 - FACTUAL INFORMATION

1.1 VESSEL AND ACCIDENT INFORMATION

Vessel (Photograph 1)

Name	:	*Arco Arun*
Type	:	Suction dredger
Official number	:	713645
Port of registry	:	Southampton, UK
gt	:	3,476
Length	:	98.3m
Place of build	:	Appledore, Devon. 1987
Propulsion	:	One Mirlees Blackstone Six Cylinder Diesel Engine Driving a Single Controllable Pitch Propeller
Propulsive power	:	2940kW
Class	:	Bureau Veritas
Owner	:	Lombard Lessors Ltd, Redhill
Operator	:	ARC Marine Ltd, Southampton (Now Hanson Aggregates Marine Ltd)
Crew	:	Ten: master, first mate, second mate, chief engineer, second engineer, third engineer, two able seamen, cook/steward and a deck officer trainee

Accident

Type of accident	:	Grounding
Date of accident	:	13 October 1998
Time of Accident	:	1350 (UTC)
Place	:	Off Broadness Point, River Thames
Weather	:	Overcast, Wind - SW 4
Sea conditions	:	Sheltered
Injuries	:	None
Damage	:	Bottom Holed, vessel foundered
Pollution	:	Minor pollution

1.2 BACKGROUND TO THE ACCIDENT

Arco Arun was one of 13 vessels operated by ARC Marine Ltd. She had three sister vessels. *Arco Arun* operated in and around the southern North Sea - and loaded at various dredging grounds. She discharged on the east coast of England or in other north European ports Complete voyages generally lasted between 24 and 36 hours. She frequently visited one of several discharging berths on the River Thames. Discharging ports and berths were not planned far ahead, but were chosen according to the commercial requirements at the time.

Twenty four hours before the accident, *Arco Arun* left Rochester for the dredging grounds off Great Yarmouth. She arrived and began to load at 2136 on 12 October. Once loading was completed, she sailed for Dagenham on the north bank of the River Thames, at 0335 on 13 October.

1.3 NARRATIVE OF EVENTS (All times are UTC)

After departure from the dredging ground, a fax message was sent to Port Control London (PCL) from *Arco Arun*, indicating her destination berth and notifying both the first mate's and the master's PEC numbers.

The first mate called PCL at 0818 when off Sunk Head Tower to report the vessel's entry into its area. He gave the vessel's destination as Dagenham, and registered his PEC number for the first part of the passage **(Figure 1 - plan of the river)**.

The first mate handed over the bridge watch to the second mate along with the master at 1100 (1200 BST) when the vessel was off South Oaze. PCL was not informed that the PEC holder in charge had changed.

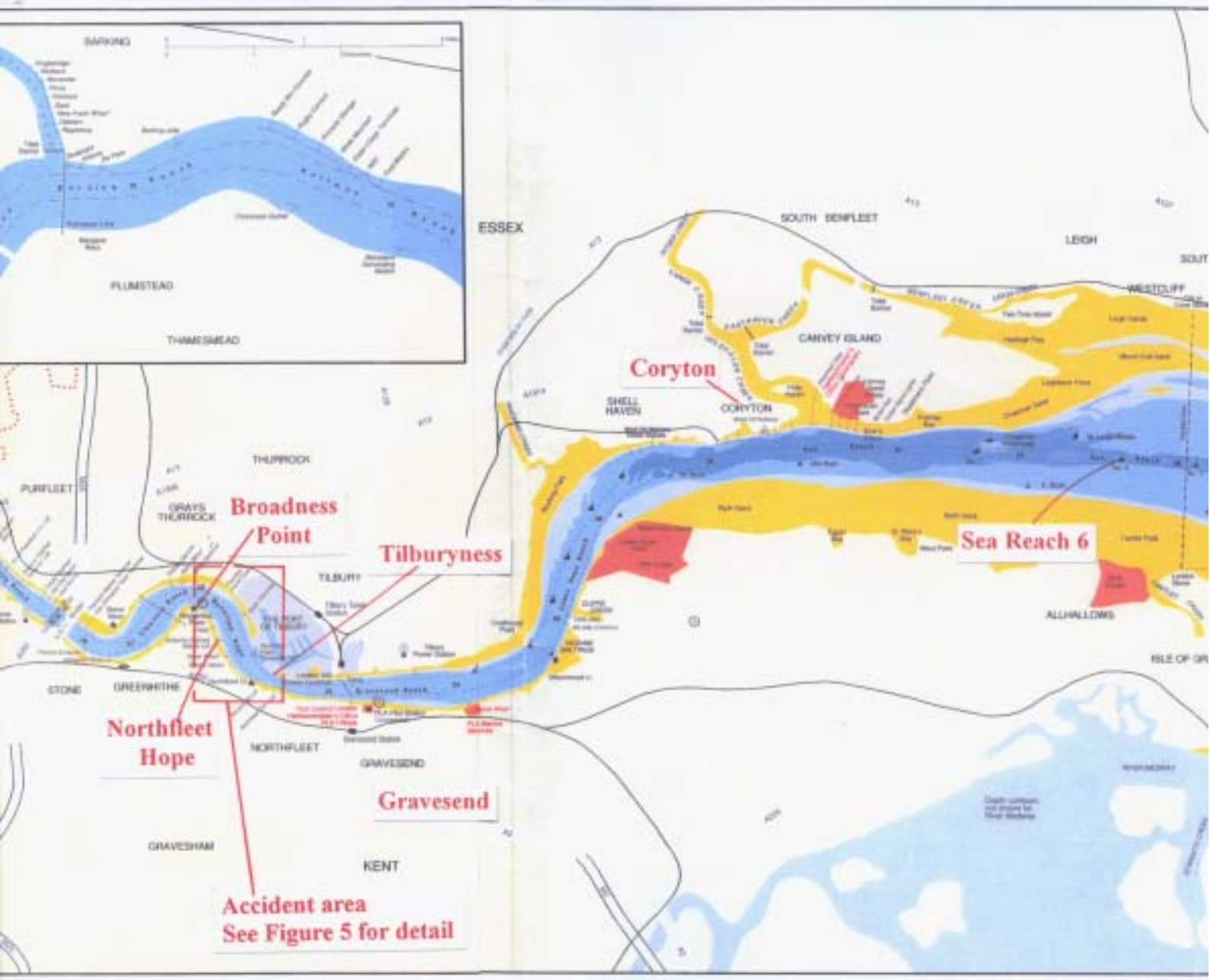
The master stayed on the bridge for about 20 minutes before going below to work in his cabin. Over the next hour the master returned to the bridge periodically to monitor progress and check that the second mate was happy with the navigation. At about 1220, when the vessel was passing Sea Reach 6 buoy, the master came to the bridge with the intention of remaining there until arrival.

As the vessel approached Tilburyness, hand steering was engaged, and the second mate began steering from the wheel position.

Arco Arun passed the outbound *Arco Bourne* at the southern end of Northfleet Hope. The master waved to his opposite number.

After passing the Tilbury Grain Terminal, both master and second mate used binoculars to look at some yachts moored on the north side of the river, and started to talk about them.

The River Thames



y courtesy of the Port of London Authority)

Shortly afterwards, the master left the wheelhouse to go to the bridge toilet as *Arco Arun* approached the bend off Broadness Point.

As *Arco Arun* began to turn off Broadness Point a scraping noise was heard and a juddering felt. The time was 1350. Very little way came off the vessel.

The second mate left the wheel and went to the wheelhouse door to shout for the master. On reaching the door he felt the vessel lurch violently. On this occasion there was a significant reduction in speed.

The master, who had been absent from the bridge for an estimated 30 seconds, was just emerging from the toilet as the vessel lurched. He reduced the pitch of the propeller, took the wheel and put it hard to port to bring the vessel into the centre of the river.

The second mate read off a position from the GPS and plotted it on the chart while the master increased the pitch in an attempt to reach St Clement's anchorage. PCL was informed and tugs were arranged.

Although the vessel remained on an even keel the bow was noticeably getting lower in the water. Initial damage reports indicated that water was entering the forward machinery space. The watertight doors to this space were closed.

As *Arco Arun* approached the anchorage the master shut down the main propulsion after being informed it was overheating. This report was made due to a high temperature alarm being activated. However, this was subsequently found to be false and due to short circuits in the alarm system caused by the flooding.

All electrical power failed as water reached the electrical flat in the forward machinery space.

As the way came off, she began to be affected by the counter-current that runs on the south side of St Clement's Reach towards Broadness Point. With no propulsive power, the master ordered the starboard anchor to be dropped and run out to one shackle. She anchored in a position just to the west of Broadness Point, to the south of and outside the main fairway.

The emergency cargo release valves were opened to reduce the displacement and increase the freeboard but without any apparent effect. The level of cargo in the hopper did not noticeably change.

As the vessel anchored, representatives of the Port of London Authority (PLA) arrived on board. Shortly afterwards, the harbour tug *Sun Mercia* came alongside.

Pumps from *Sun Mercia* were deployed into the forward machinery space through the foredeck hatch and through the accommodation.

A second tug, *Sun Essex*, arrived about 15 to 20 minutes later. By this time *Arco Arun*'s bow had settled on the bottom. She was still on an even keel but had started to develop a starboard list as she settled more heavily. When it had reached 10° (at 1556) all non-essential personnel (six out of ten) were transferred to *Sun Mercia*.

The list continued to increase. The hoses were taken out of the foredeck hatch which was then closed. The hoses were subsequently removed from the accommodation as well.

When the list reached 15°, all personnel left *Arco Arun* and boarded one of the vessels standing by. The time was about 1620.

The list continued to increase as salvage attempts, which by this time were under the control of a salvage master, continued.

At 2023, the cargo started to dump through the open release valves. The after port quarter of the vessel was seen to rise out of the water by 2 - 3m. The cargo was being released mostly from the port side which increased the angle of list further.

The vessel appeared to stabilise with a large list to starboard.

Despite salvage attempts, *Arco Arun* capsized at about 0830 on 15 October, 42½ hours after she had first grounded **(see Photograph 2)**.

At the end of November, salvors righted *Arco Arun* and towed her to Tilbury where she was handed back to her owner.

1.4 ENVIRONMENTAL INFORMATION

At the time of the accident the wind was from the south-west force 3 to 4, the sky was overcast and visibility was clear. Low water, measured at Tilbury Lock entrance, had occurred at about 1230 with a tidal height of 1.02m above chart datum. By the time of the grounding the tide had risen to a height of 1.5m, and the flood tidal stream was running at about 1 knot around Broadness Point.

1.5 COMPANY AND CAPTAIN'S STANDING ORDERS

Arco Arun is managed by ARC Marine Ltd (now Hanson Aggregates Marine Ltd) as one of 13 sand and aggregates dredgers operated by that company. The company was in the process of obtaining International Safety Management Code (ISM Code) accreditation with the aim of obtaining a document of compliance and safety management certificates for each vessel by the end of 1999.

The company had written and placed on board *Arco Arun*, in common with other vessels of its fleet, an operations manual and orders entitled Masters' Standing Orders. These company originated orders were complimented by Captain's Standing Orders which were

Arco Arun - capsized

specific to *Arco Arun* and which contained the particular additional requirements of the master.

These orders laid down specific watchkeeping and bridge operational requirements, and were required to be read and understood by the deck officers. The orders, and the government guidance and regulations to which they refer, comprehensively cover bridge watchkeeping requirements with the notable exception of operational guidance on pilotage by the master as PEC holder. Significantly, the orders make no mention of passage plans, and particularly passage plans in pilotage waters.

Of particular relevance to the accident, the master and officers are reminded, in the Masters' Standing Orders, that:

- *The officer of the watch should continue to be responsible for the safe navigation of the ship, until properly relieved by the master or other responsible officer.*

- *The officer of the watch should be thoroughly familiar with the electronic navigational aids carried, including their capabilities and limitations.*

- *The echo sounder is a valuable navigational aid and should be used whenever appropriate.*

The Captain's Standing Orders indicate that it is general practice for the duty officer to act as helmsman, and when the master is on the bridge, for the duty seaman to carry out preparations for berthing. On 13 October the bridge team was organised along these lines.

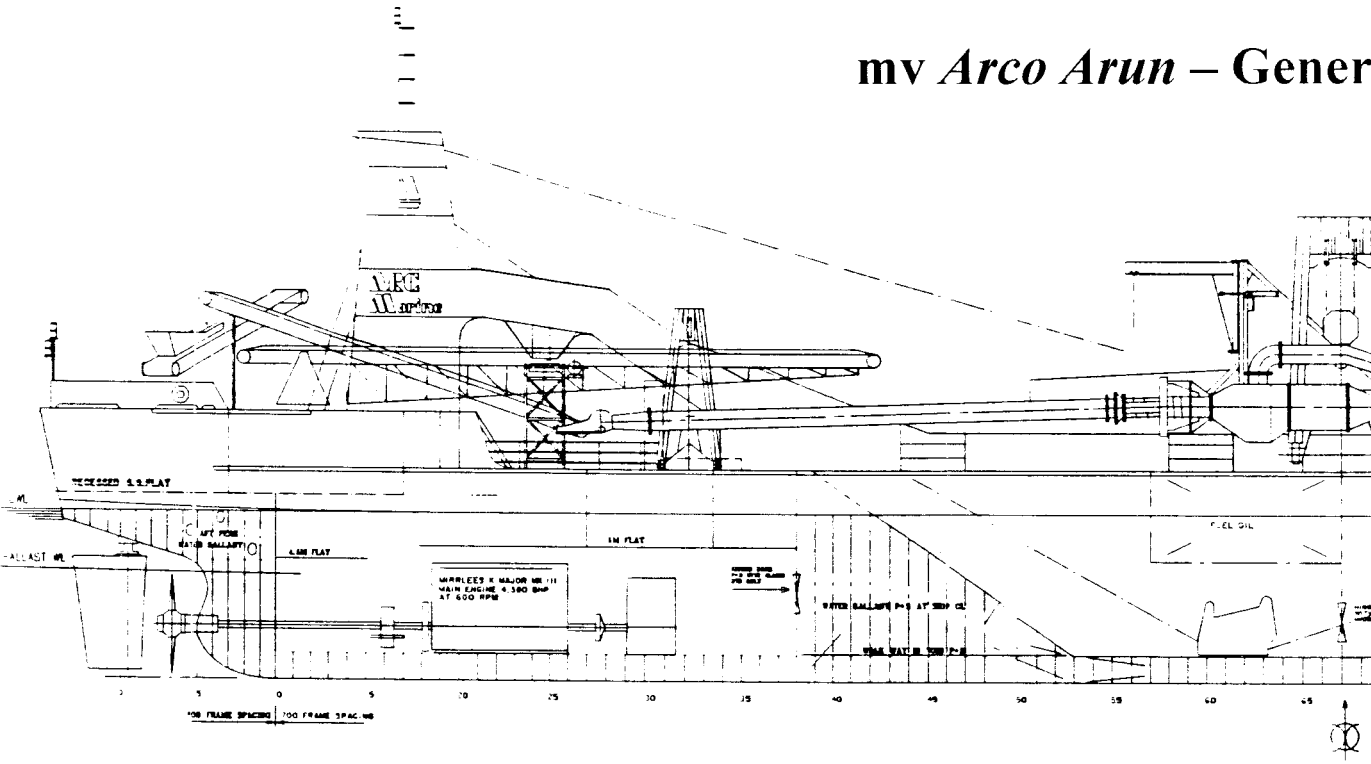
1.6 THE VESSEL (Figure 2 - General Arrangement)

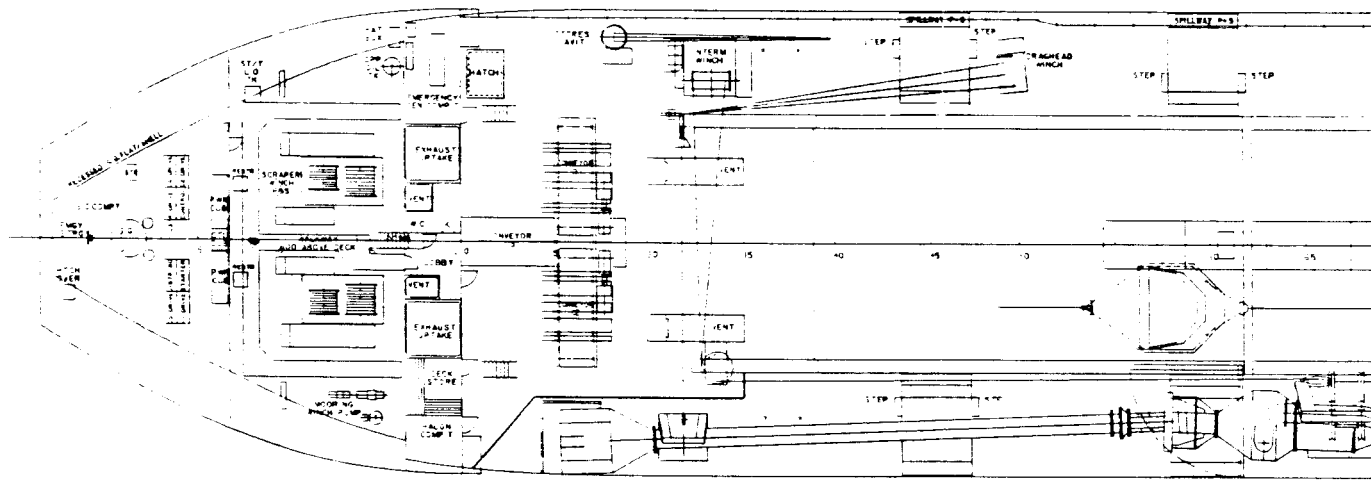
1. General Description

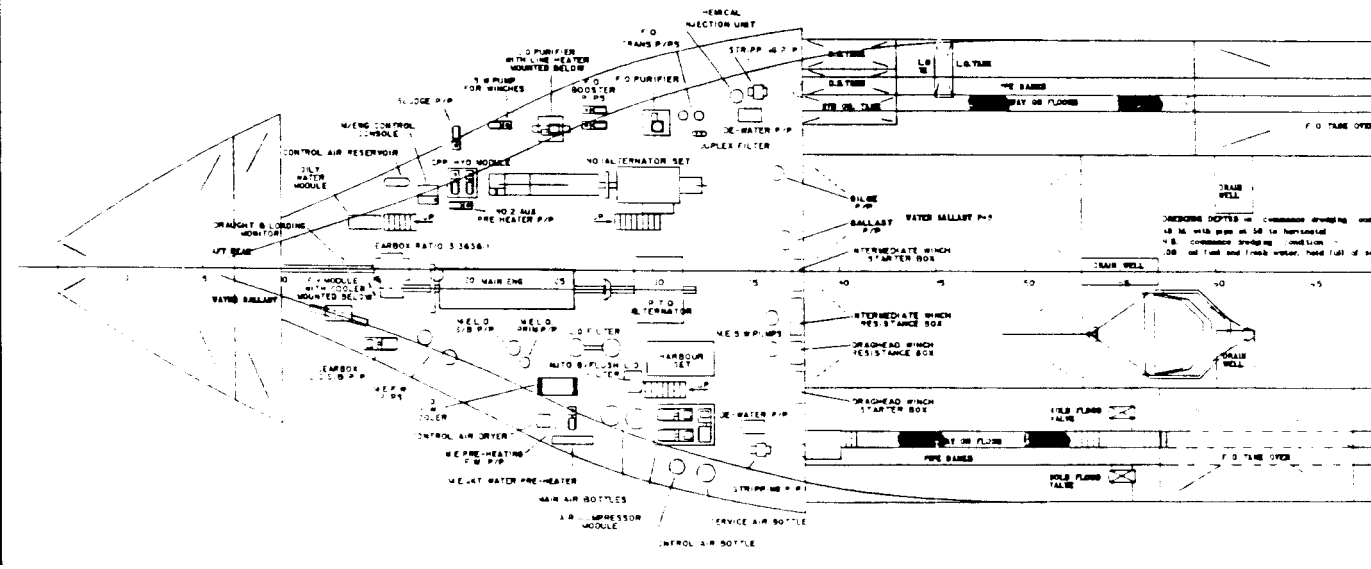
Arco Arun is a trailing suction dredger, designed and equipped to load sand and gravel from licensed dredging grounds, and to transport and discharge the cargo to shore cargo conveyors at designated and specially equipped berths in northern Europe.

She has a forward structure containing wheelhouse and crew accommodation, beneath which within the hull, is an auxiliary machinery space. This is referred to as the forward machinery space and is situated abaft the fore peak water ballast tank. A void space (containing pumping machinery) spans the full width of the hull of the vessel immediately aft of the forward machinery space. The main cargo hopper is positioned on the centre line with wing tanks on either side. Walkways, running at tank top level through the tunnels, connect the forward void space with the main machinery space which is situated aft of the cargo hopper. Above the main machinery space the funnel housing contains the winches used during cargo discharge. Cranes, winches and gantries necessary for deploying the suction arm and discharge equipment are sited on the main deck and on either side of the cargo hopper.

mv *Arco Arun* – Gener

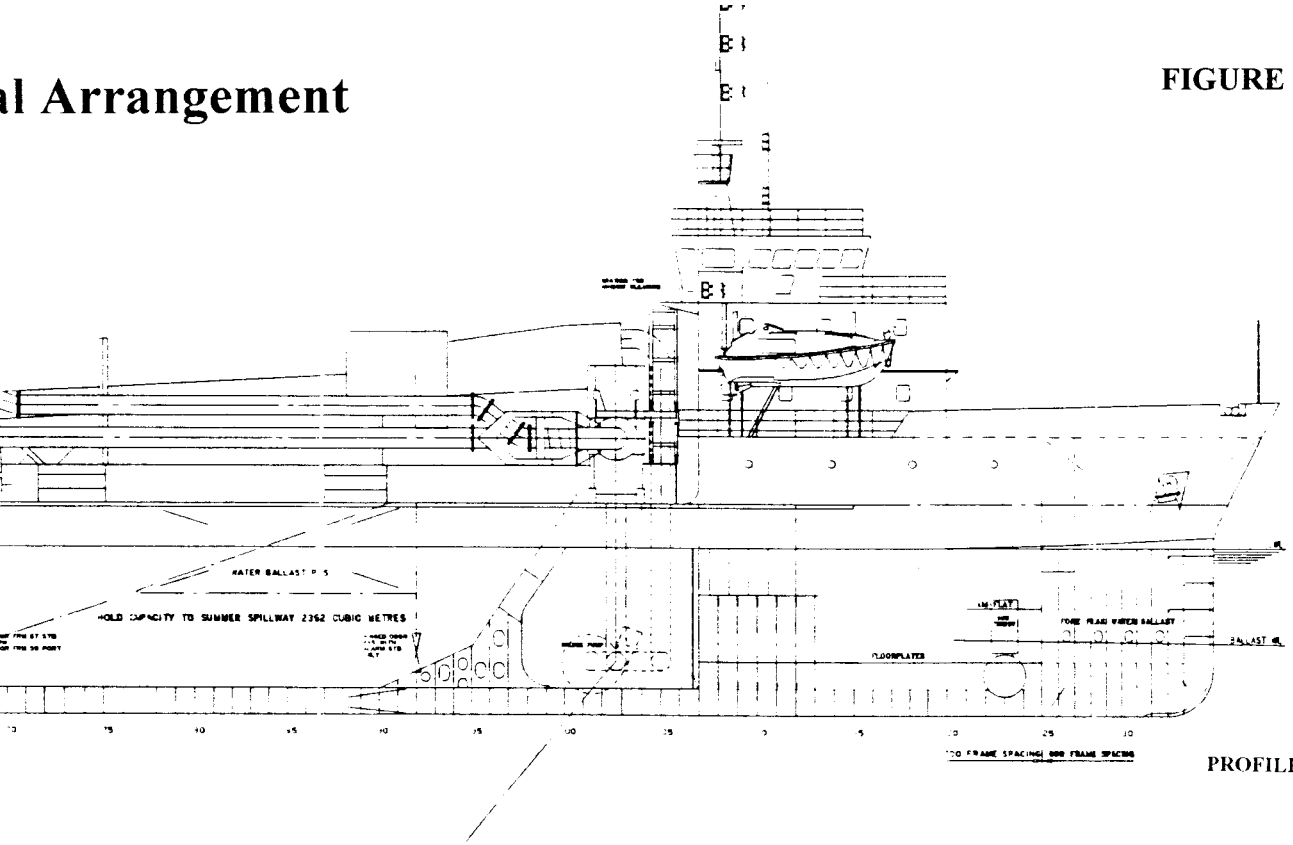




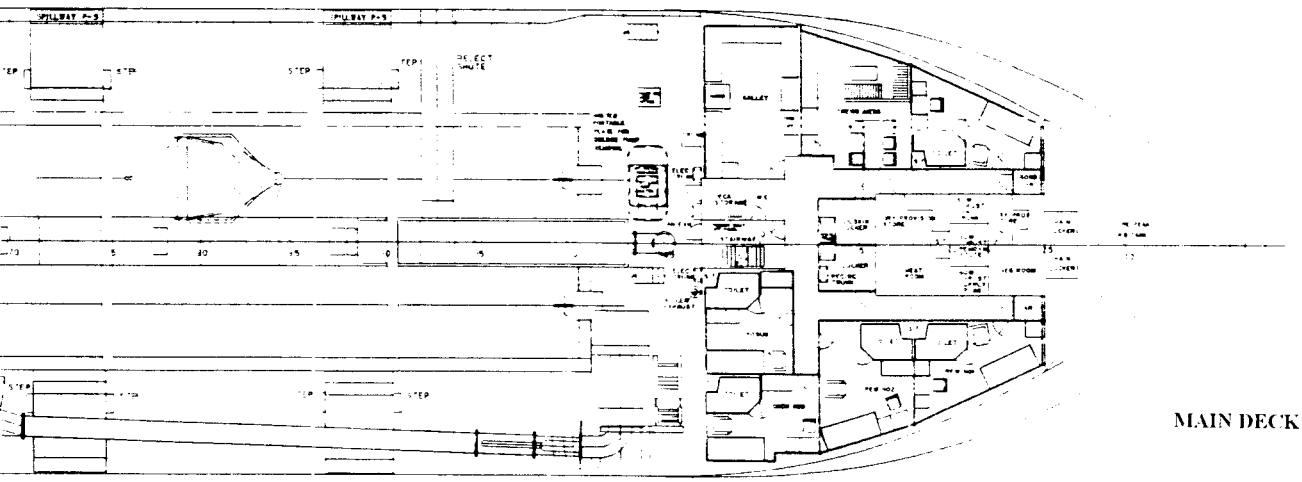


al Arrangement

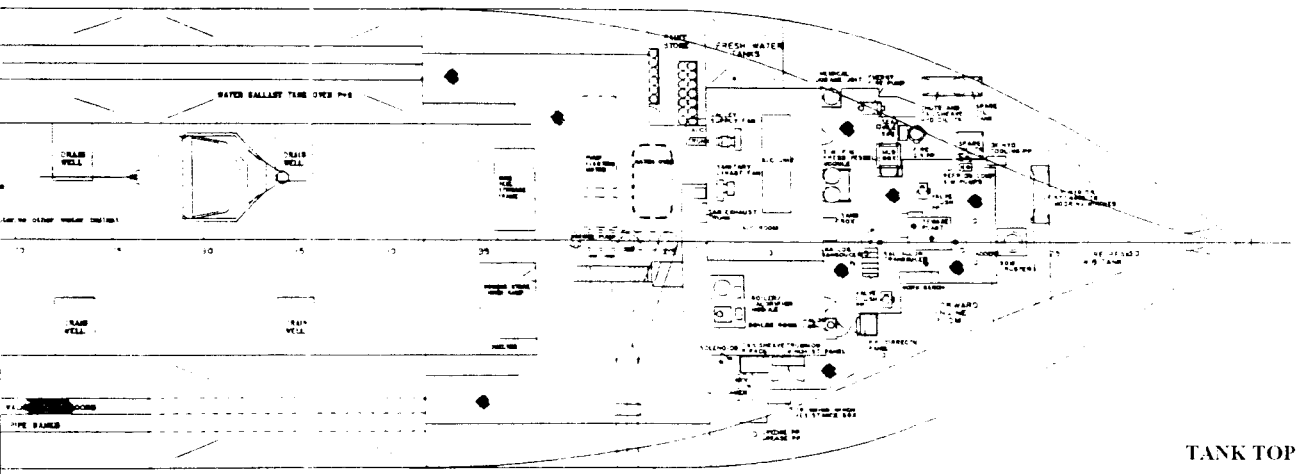
FIGURE 2



PROFILE



MAIN DECK



TANK TOP

2. The Wheelhouse

In addition to standard navigation, safety and control equipment, the wheelhouse **(Figure 3 - wheelhouse arrangement)** contains winch, gantry, and pump controls used during loading and discharge. These controls are positioned at two stations which are located aft in the space on port and starboard sides, overlooking the cargo working area.

The navigation and communication instrumentation is housed in consoles which are variously located within the wheelhouse. Two navigation consoles face forward; one on the port side and the other to starboard. A communications desk is sited on the port side of the space and a navigation workstation on the starboard side. There is a central steering position for both wheel and autopilot controls. There are manoeuvring control stations on each enclosed wing.

The main radar is on the opposite side of the wheelhouse to the chart table. Instruments such as the VHF radio, telephone, echo sounder, radar and engine controls, doppler log and GPS navigator are sited in different locations, necessitating the watchkeeper to move about the wheelhouse. None of the instruments can be reached, and only the radar can be monitored, from the steering position.

3. Vessel Certification

At the time of the accident *Arco Arun* was fully certificated to national and international regulations.

4. Emergency Cargo Release Equipment

During a refit, *Arco Arun* had been fitted with an emergency cargo release mechanism and associated control equipment which enabled the MCA to issue a Load Line Exemption Certificate on 5 February 1998 **(Figure 4 - Load Line Exemption Certificate)**. The release mechanism consists of three pairs of valves which are sited in the bottom of the cargo hopper, and which when operated open discharge pipes each of 750mm in diameter. In theory the open pipes will allow the cargo to rapidly drop through the vessel's hull thus increasing the vessel's freeboard in an emergency.

The load line exemption allows *Arco Arun*, under certain conditions, to load to deeper draughts. These conditions include favourable weather and the provision that the release arrangements must be maintained in efficient working condition. On 13 October *Arco Arun* had loaded to a mean draught of about 6.5m which is about 0.25m deeper than her summer load draught. Her precise draughts at the time of the accident were not known, but her after (deepest) draught was estimated to have been about 6.6m.

In an attempt to increase the freeboard, the emergency cargo release valves were opened on the orders of the master at about the time the vessel was anchoring. Although the valves opened correctly, little cargo was released at that time. However, a substantial amount of cargo was released through the open valves without warning some time later, after the vessel had developed a list and settled on the river-bed.

FIGURE 3

Wheelhouse Arrangement

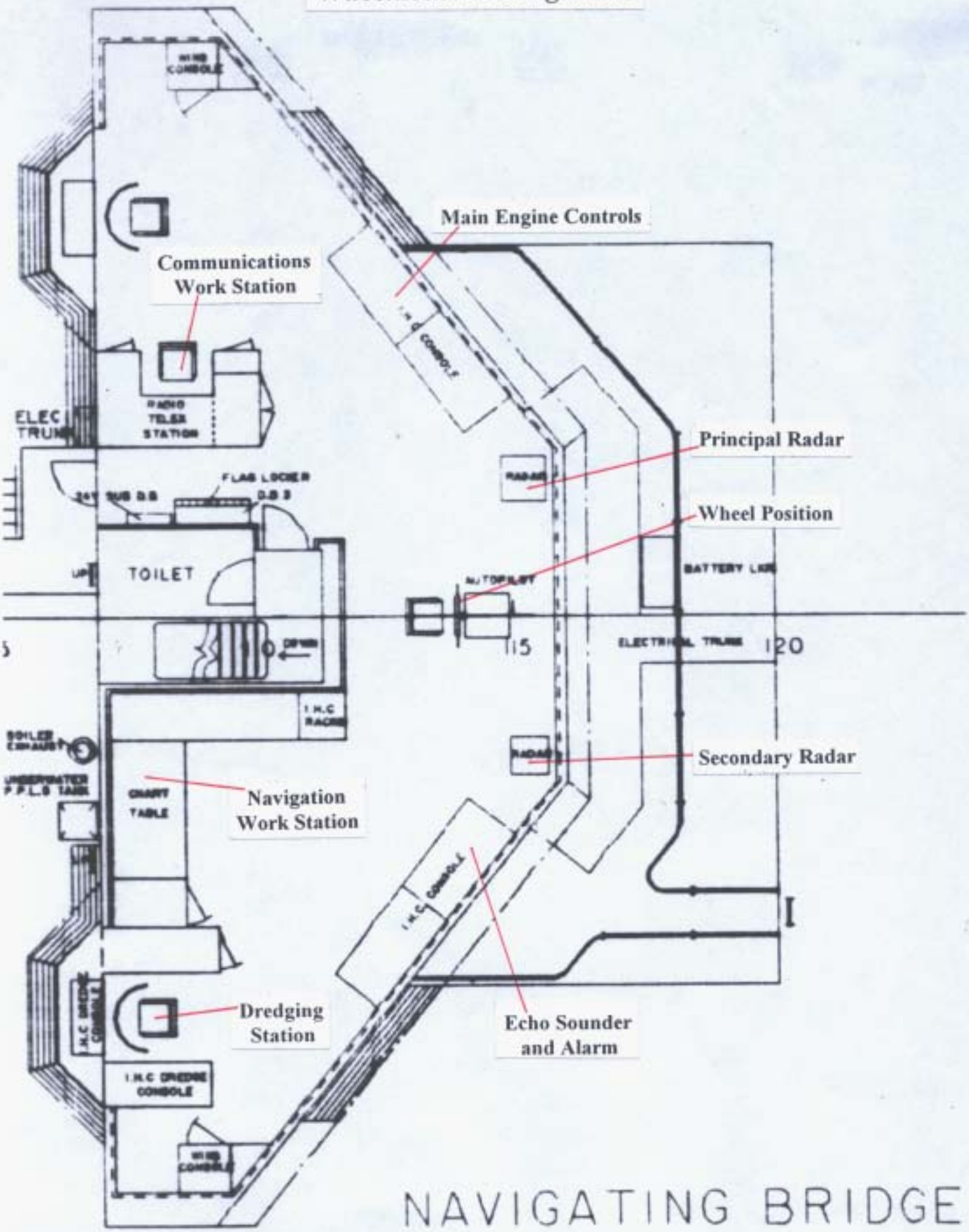


FIGURE 4

UNITED KINGDOM LOAD LINE EXEMPTION CERTIFICATE

Issued under the provisions of the Merchant Shipping Act 1995, under the authority of the Government of the United Kingdom of Great Britain and Northern Ireland by the Marine Safety Agency an Executive Agency of the Department of Transport

PARTICULARS OF SHIP

Name of Ship	**ARCO ARUN**
Distinctive Number or Letters	713645
Port of Registry	**SOUTHAMPTON**

THIS IS TO CERTIFY

That the above-mentioned ship is exempt under Schedule 3, paragraph 19(3) of the Merchant Shipping Act 1995 from- the following provisions of Schedule 3 of that Act and of the Merchant Shipping (Load Line) Rules 1968.

Section 4 of the Schedule and Rule 10(4)

Subject to the following conditions:

1. That the ship operates only when weather conditions and official weather forecasts are favourable.
2. That the ship operates up to 60 miles from land;
   - on national voyages from Machrihanish, Mull of Kintyre south, east, and north to the River Don Aberdeen.
   - on international voyages to France, Belgium and the Netherlands from Ushant, France in the west to the Dutch/German border in the east.
3. That the ship has been surveyed and freeboards have been assigned and Load Line marked in accordance with the Merchant Shipping (Load Line) Rules 1968 and that the ship carries a valid International Load Line Certificate.
4. That the release arrangements for quickly jettisoning the contents of the hopper in an emergency are maintained in an efficient condition.
5. That, in addition to the statutory marking, the ship is marked port and starboard with a load line mark complying with the requirements of Rules 15 and 20 of the Merchant Shipping (Load Line) Rules 1968 except that the centre of the ring is placed 762mm abaft the centre of the statutory load line mark and is painted in red on a contrasting background.
6. That the freeboard related to the red horizontal line is 829mm measured below the statutory deck line which is sited 200mm below the top of the steel freeboard deck at side.
7. That the ship is at no time so loaded as to submerge the horizontal line intersecting the red load line mark.
8. That no passengers are carried.
9. That the ship is surveyed in dry dock not earlier than two years nor later than three years after the survey date (i.e. initial survey date).

Date of initial or periodical survey	5th February 1998

This certificate is valid until 3rd May 2002 *subject, where appropriate, to periodical inspections in accordance with the Merchant Shipping (Load Line) Rules 1968.*

Issued at SOUTHAMPTON *on* 1st June 1998

MARINE SAFETY AGENCY SOUTHAMPTON

R. R. Dobson *Name* R.R. Dobson

An authorised officer of the Department of Transport

I hereby certify the above to be a true copy of the particulars on the original certificate.
This copy is issued for production on clearance
Dated this 1st day of June 1998
AN OFFICER OF THE MARINE SAFETY AGENCY

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1.7 BRIDGE RESOURCE MANAGEMENT

1. The Bridge Team

Arco Arun had a crew complement of ten: a master, first mate, second mate, chief engineer; second engineer, third engineer, two seamen, a cook/steward and a trainee deck officer. At the time of the accident there were two people on, or in the vicinity of, the bridge.

The master, aged 53 at the time of the accident, held a certificate of competency as first mate (foreign going) obtained in 1969, with a limited European command endorsement. After an initial career on deep-sea cargo ships he had served on aggregates dredgers since 1980. He was first made master in 1995 and had served on *Arco Arun* since that time. He held a current pilotage exemption certificate issued by the PLA valid for all pilotage zones up to Dagenham. He had rejoined *Arco Arun* on 23 September after a three week period of leave. He had been due to go on leave again on the day of the accident. He was familiar with the passage having undertaken it on numerous previous occasions.

The second mate, aged 22 at the time of the accident, held a certificate of competency class 4 which he obtained in August 1998. He first went to sea in 1995 as a deck officer trainee under the scheme operated by the Ship Safe Training Group (formerly Small Ships Training Group). His training had consisted of experience at sea on ships within the ARC Marine fleet interspersed with periods at college. During his training at sea he worked periods of 4 weeks on board ship, followed by 2 weeks leave. As part of a structured programme of on-the-job training, the last week in each 4 week period at sea was spent understudying one of the bridge watch officers. Having obtained his certificate, he was employed by ARC Marine, initially as a third officer for a 2 week voyage starting on 19 August. During this time he kept bridge watches with the first mate. After 2 weeks leave he returned to *Arco Arun* on 16 September where he kept watch with the first mate for 1 week before taking charge of his own watch as a second mate on 23 September. He had nearly completed his first tour of duty in this role and had been due to go on leave on the day of the accident. He had not previously had charge of a watch while on passage in the confined waters of the River Thames.

2. Working and watchkeeping routine

The officers and ratings worked a routine of 3 weeks on duty followed by 3 weeks leave. There were two full crews assigned by the shipmanager to *Arco Arun*. With the exception of the trainee officer the whole of each crew joined and left the ship on the same day.

The first and second mates alternated bridge watchkeeping, working eight hours on/eight hours off. This routine did not vary whether the vessel was loading, discharging or on passage.

The two seamen also worked an eight on/eight off watchkeeping routine. During daylight hours in good visibility the seaman watchkeeper generally carried out maintenance around the vessel. At night or in poor visibility he acted as lookout on the bridge. On the

afternoon of 13 October the visibility was good and the watchkeeping seaman had been employed washing down decks and clearing away the anchors. At the time of the grounding he was in the messroom having a tea break.

In addition to general administrative duties, the master carried out loading operations and pilotage work. He also took charge of the bridge watch if special circumstances or dangers dictated.

3. Navigation

The bridge superstructure on *Arco Arun* was sited right forward. This enabled the helmsman to get an unobstructed arc of view from right forward to about three points abaft the beam on each side.

Arco Arun was equipped with a modern daylight viewing radar which was sited about 2m to port of the steering position. From the wheel position, the helmsman had an oblique view of the radar screen and was close enough to read the radar information but was not able to adjust the picture or navigational functions.

In good visibility, navigation on the river was conducted by eye with occasional reference to the radar screen. Neither courses nor positions were plotted on the chart. Compass courses were not generally steered when in hand steering; the heading was chosen and adjusted according to the judgment of the officer of the watch. In some reaches, prominent landmarks helped in the selection of the heading to be steered. The radar was used to give a pictorial indication of the ship's position relative to the river banks and as a check on what could be seen outside. The range rings or variable range marker (VRM) facilities of the radar were not routinely used to confirm the information gained by these other methods. Parallel indexing or other radar pilotage techniques were not used. Although the echo sounder was generally left switched on to give digital depth indication which could be read when close to the main display on the starboard bridge front console, the echo sounder depth alarm was never used for navigation. The digital readout could not be read from the steering position.

The instrumentation in *Arco Arun*'s wheelhouse was not arranged to suit a sole watchkeeper who has to remain stationed at or near to the steering position.

1.8 PILOTAGE ON *ARCO ARUN*

PECs were held by both the master and the first mate for all pilotage areas in the PLA district up to Dagenham. When within the pilotage district to seaward of Sea Reach 7 buoy, the first mate would normally have pilotage responsibility during his watch, while the master would oversee the second mate at other times. When the vessel was above Sea Reach 7 the master always stayed on the bridge to monitor the actions of whichever mate was on watch while allowing that officer to have control of the vessel.

At these times the officer took the navigational decisions and the master corrected or countermanded them when necessary. Occasionally the master would, for instance, tell the

officer that he must "stay in the centre of the fairway", or "do not forget to call port control", but such directions apart, the master's actions were reactive. Once hand steering was engaged, usually from Tilburyness when inbound, the officer took the wheel and the master would handle VHF communications. The officer would continue to navigate and steer the vessel using his own judgment. Although on this occasion it was not specifically stated and agreed, this division of responsibilities was understood by both the master and the second mate.

For a passage in the PLA district no passage plan was made or thought necessary. Both master and first mate knew the waters well and had made the passage many times before. The chart, although laid out on the chart table, was not usually referred to for navigation. The mate on watch generally steered to keep the ship just to starboard of the centre of the fairway/river. This was achieved in the lower reaches by reference to the buoys, and on straight stretches, by knowing the courses to steer. In higher reaches it was achieved by sight of the river banks on either side. If opposing traffic was encountered, an appropriate course alteration to starboard was made to allow the vessels to pass before coming back to port to regain the centre of the channel.

1.9 ALCOHOL AND DRUGS

No toxicological testing was carried out after the accident. However, alcohol is not carried on *Arco Arun* and there is no indication that drugs, either illicit or medicinal, played any part.

1.10 FATIGUE AND OTHER MATTERS

The master and second mate were both sufficiently rested before taking over the watch at midday. There were no other personal circumstances that might have caused either officer to be distracted from their watchkeeping and pilotage duties.

1.11 THE PORT OF LONDON AUTHORITY

1. General Description and History

The PLA was established as a Public Trust under the Port of London Act of 1908 for the purpose of administering, preserving and improving the Port of London, and for other purposes including the conservancy of the Thames. The powers have been extended in subsequent Acts and Orders. Those of significance in this accident are:

(i) The Port of London Act of 1968, which gives wide powers to the PLA in the administration of the Thames, including *Regulation of navigation by means of Thames Bye-laws and Directions to vessels on the Thames*; and

(ii) The Pilotage Act of 1987, which empowers the PLA as a Competent Harbour Authority to make Pilotage Directions as the Pilotage Authority for the Thames.

The PLA has jurisdiction over the entire tidal Thames from Teddington in the west to the outer Thames estuary in the east.

2. Vessel Traffic Services

The PLA monitors the navigation on the river through to VTS centres at Gravesend and Woolwich. These VTS centres provide an integrated VTS to river users, and continuous radar and VHF monitoring of vessel movements. The centre at Gravesend, on the south bank of the river, is designated Port Control London (PCL) and that at Woolwich, Thames Barrier Navigation Centre (TBNC). PCL has general responsibility for traffic in areas seaward of Crayford Ness which include Northfleet Hope and Broadness Point, where the accident occurred.

PCL is manned by a duty port controller (DPC) and two senior VTS officers (SVTSO) during the night and a DPC and three SVTSOs during the day.

The DPC is a master mariner and a first class pilot for the London Pilotage District. He has the delegated authority of the harbour master to regulate and direct traffic in the river and estuary within the PLA area of responsibility. In addition he communicates between agents, ships and pilots to manage the day-to-day running of the pilotage service. The majority of his time on duty is spent on this latter area of his responsibility. The DPCs undergo VTS training along with the other VTS staff. DPCs alternate 5 weeks of work in PCL with 10 weeks active duty as a pilot.

SVTSOs are trained VTS operators many of whom have spent some time at sea. As well as having responsibility for VHF radio communications, SVTSOs monitor the radar screens, primarily to give information and advice to vessels in order to minimise the risk of collision. In addition, if the SVTSO notices a vessel making an unusual or unsafe course, he may inform the DPC and/or call the vessel to provide appropriate advice. Their role in such circumstances is reactive and their advice result orientated. In other words the SVTSO will say what end result is needed and not how to accomplish it. An SVTSO, or DPC, does not give precise navigational or manoeuvring directions unless requested to do so.

The equipment at PCL recorded both *Arco Arun*'s VHF radio traffic and her radar track during, and in the period preceding, the accident. At the time of the accident, the SVTSO who had responsibility to monitor the area of river which includes Broadness Point, was concentrating on another area within his responsibility, where a tanker or gas carrier was manoeuvring close to inbound vessels.

3. 'POLARIS'

The details of all vessels using, or intending to use, the river are entered into the PLA's computer data storage system, POLARIS, which records basic information about the vessel and her cargo, including dimensions (including draught), destination berth and departure/arrival times. It also records details of the PEC holder registered for each passage being undertaken.

4 Radar Surveillance

Shore radars enable the duty staff at either of the control centres to monitor the progress and position of vessels within the radar coverage area. When a vessel reports she is entering the PLA area inbound, or leaving her berth for the outbound passage, her radar target is "tagged" by VTS staff at either TBNC or PCL. The tag displays the vessel's name and voyage number extracted from the POLARIS data base. Once established, the tag tracks with the radar target and can be displayed on radar screens at both control centres. The radar system also computes the course and speed of any target and can display this information as a vector. When a vessel's heading and speed changes, the display will account for the change and show the new course after a short time delay.

PCL is charged with responsibility for radar surveillance of all areas to seaward of Crayford Ness. The control centre is equipped with six displays, arranged so that the two or three SVTSOs can divide the coverage area, each monitoring two or three displays. Each display has a variable range and split screen capability. To avoid clutter and to give a clear picture, the system suppresses the radar echoes from river banks and some other fixed objects on land. These key features, and some charted features such as the extremities of the fairway, are clearly depicted on the screens in the form of a computer generated and stabilised map. It is possible to select electronic channel boundaries, which will alarm whenever a vessel crosses them. Such boundaries, however, have to be positioned to ensure the safety of a deep-draughted vessel navigating the channel at low water. The boundary alarms cannot differentiate between one vessel and another, and will be triggered by any vessel crossing them, even though she has a shallow draught, or is navigating at higher states of the tide, and therefore not in danger. The result is a large number of alarm activations which has the potential for masking other alarms and reducing operator alertness. For these reasons, electronic channel boundaries are not normally selected.

At the time of the grounding the two SVTSOs on duty were each monitoring three radar screens; the third SVTSO on duty that day was taking a lunch break. Although one of the SVTSOs watched while *Arco Arun* and *Arco Bourne* passed, his attention thereafter switched to one of his other screens where a tanker was swinging off Coryton and might have come close to the path of inbound vessels. He did not notice *Arco Arun*'s target track moving steadily to the edge of the marked fairway and beyond.

The radar data is routinely recorded. On this occasion this facility provided the investigation with accurate track information for *Arco Arun*.

1.12 PILOTAGE

1 Compulsory Pilotage

The PLA, in exercise of its powers under the Pilotage Act 1987, has directed that vessels of the size of *Arco Arun* are required to either carry an authorised pilot, or be under the pilotage of a master or first mate possessing a valid PEC. Both master and first mate of *Arco Arun* held valid PECs for the pilotage areas up to Dagenham.

Before the master arrived in the wheelhouse at 1100, the vessel had been under the pilotage of the first mate who had registered the number of his PEC with PCL. PCL was not informed of the change in the registered PEC holder during the passage, as was required by the Pilotage Directions in force at the time.

2. Pilotage Exemption Certificates (PECs)

Under the Pilotage Act 1987 a competent harbour authority, in this case the PLA, shall: "*on application by any person who is bona fide master or first mate of any ship, grant a certificate* [PEC] *to him if it is satisfied (by examination or by reference to such other requirements as it may reasonably impose)-*

(a) that his skill, experience and local knowledge are sufficient for him to be capable of piloting the ship of which he is master or first mate (or that and any other ships specified in the certificate) within its harbour or such part of its harbour as may be so specified; and

(b) in any case where it appears to the authority to be necessary in the interests of safety, that his knowledge of English is sufficient for that purpose."

A later section of the Pilotage Act states that: "*A pilotage exemption certificate shall not remain in force for more than one year from the date that it is granted, but -*

(a) if the holder continues to be the master or first mate of a ship, may be renewed annually by the competent harbour authority on application of the holder if the authority continues to be satisfied as quoted above *and*

(b) on the application of the holder may be altered so as to refer to different ships from those to which it previously referred if the authority is satisfied as respects those ships."

The PLA, under its Pilotage Direction No 5, brings these rules into effect and in so doing makes a distinction between vessels over and under 100m in length. Pilotage Direction No 5 was the pilotage direction current at the time of the incident.

For vessels under 100m in length which do not carry dangerous substances, a master or first mate will normally be granted a PEC on written application to the PLA and without examination, provided the following:

- he or she is experienced in the navigation of the relevant area,
- holds a Certificate of Competency for the class of ship(s) concerned,
- is competent to communicate in the English language by radio,
- understands current local bye-laws and procedures, and
- is medically fit.

To satisfy the requirement that the applicant is '*experienced in the navigation of the relevant area*', it is necessary for the applicant to keep a "tripping log", which shows the number of times he has been on watch while the vessel has been navigating in the area concerned. On each occasion the log must be signed by the licensed pilot or PEC holder

who was on board at the time. For vessels under 100m in length, a specific minimum number of trips is not laid down, but it is widely accepted to be the same as required for a vessel over 100m in length, that is, at least twelve during the previous year involving six trips in and six trips out.

For vessels of this size the PLA usually accepts that the holding of an appropriate certificate of competency is sufficient demonstration of an applicant's '*skill*' as required under the Pilotage Act.

A PEC applicant for a vessel over 100m in length, in addition to the requirements stated above, must undergo a searching oral examination similar to that required for a licensed pilot.

Many of the aggregates dredgers which frequently visit berths on the Thames, like *Arco Arun*, have a length just short of the 100m demarcation.

A PEC must be renewed every 12 months. The PEC holder must apply to the PLA stating that he has carried out 4 acts of pilotage during the previous 12 months (2 inbound and 2 outbound) in the area(s) applied for, that he is aware of relevant changes affecting navigation in the area(s) concerned, and that he remains medically fit.

Whether for renewal or on first application, the accuracy of the information given must be attested by the vessel's owner or manager.

On receipt of a PEC first application or renewal application, the PLA will usually compare the information given with information stored in POLARIS to ensure that the data in the system matches that stated in the application.

1.13 THE VESSEL'S TRACK

The information gained from the radar recording the vessel's track before and immediately after the grounding has been plotted **(Figure 5 - chart extract)**. The track indicates that when *Arco Arun* passed *Arco Bourne* she was on the edge of the fairway. She stayed close to the limit of the fairway all the way up Northfleet Hope until at 1348 when, after she had passed Tilbury Grain Terminal, as the fairway bends further to port, she crossed the edge of the fairway heading for shallow water. This coincides with the period in which both the master and the second mate had used binoculars to look at yachts moored towards the north bank. It is apparent that she must have been very close to touching bottom for a full minute before she actually struck at 1350 in position 51°28.21'N 000° 19.25'E.

1.14 PROGRESSIVE FLOODING AND CAPSIZE

The initial grounding caused a hole in the vessel's underwater hull of about 2m by 0.10m through which the forward machinery space flooded. From this space, progressive flooding occurred through closed steel "watertight" doors into the main void space forward of the cargo hopper, and from there into the tunnels on either side of the hopper and eventually

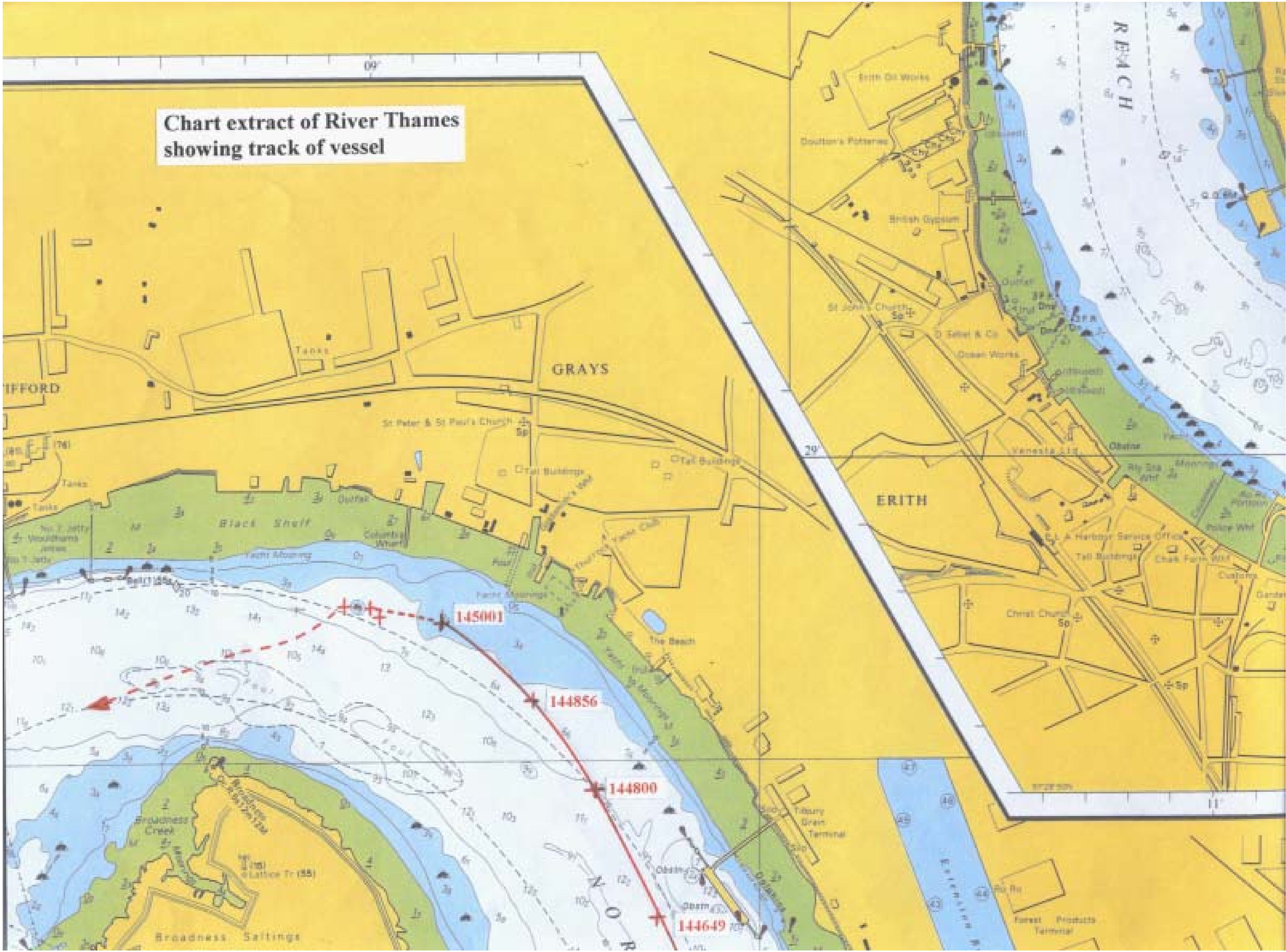
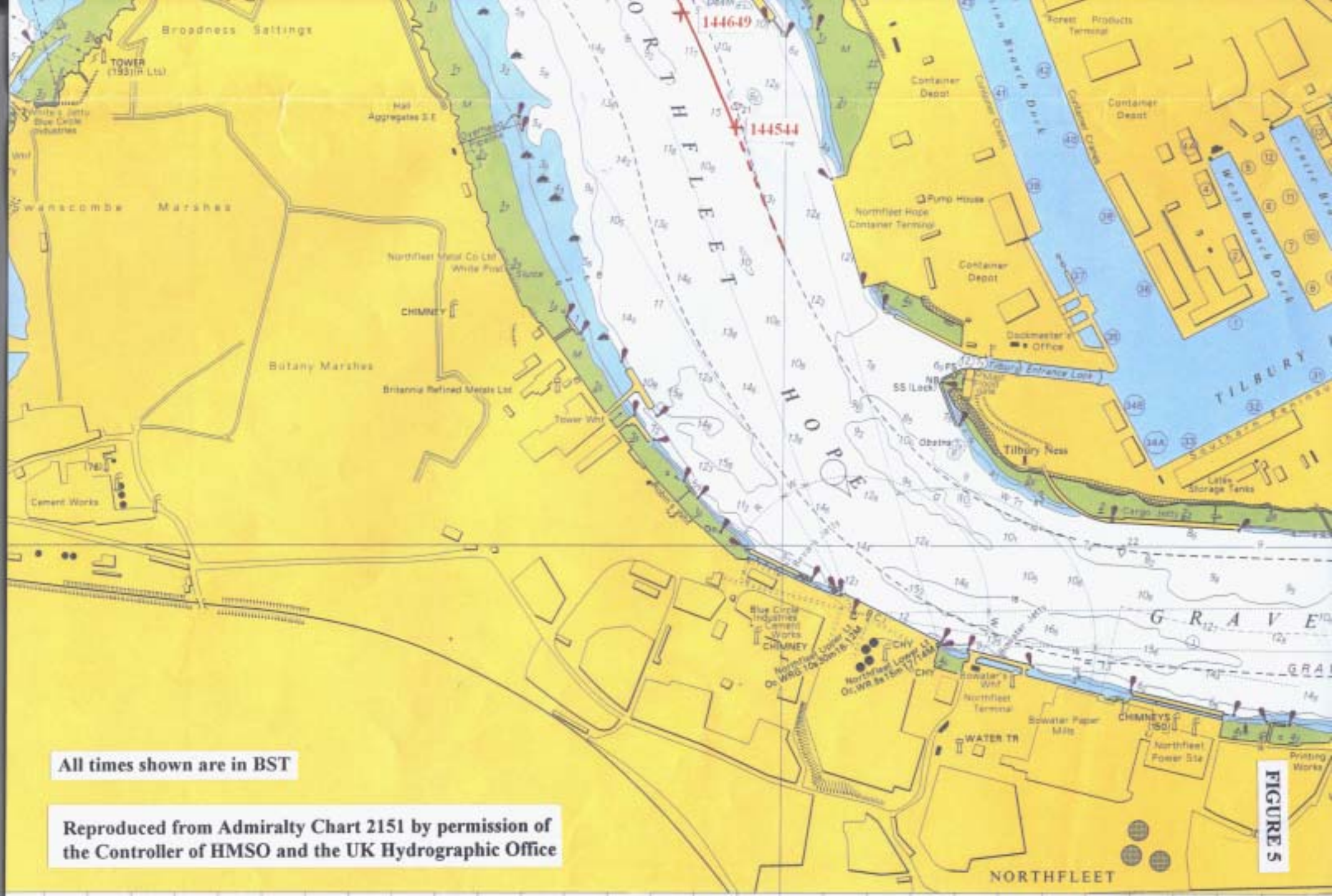


Chart extract of River Thames showing track of vessel



All times shown are in BST

FIGURE 5

into the aft machinery space. The flooding caused the vessel's list to progressively increase; which culminated in her capsize on the morning of 15 October. Salvage attempts were hampered because the volumetric capacities of void and machinery spaces were not known.

All the watertight doors in question are of a hinged type with a single handwheel controlling six dogs **(Photograph 3 - watertight door)**. This design achieves a degree of watertightness using a rubber seal pressed against the door frame as the dogs are hardened into position.

It can be seen from the general arrangement drawing **(Figure 2 - general arrangement)** that the watertight doors on *Arco Arun* were all hinged to open aft. This arrangement gives greater protection against progressive flooding from aft to forward, when hydrostatic pressure would act to press the door closed against its rubber seals. On this occasion the hydrostatic pressure acted in the other direction, causing the seals to be less effective. The doors allowed water to pass and progressive flooding to occur.

1.15 ACTIONS TAKEN BY THE COMPANY AND PORT AUTHORITY SINCE THE ACCIDENT

1. ARC Marine Ltd (now Hanson Aggregates Marine) has carried out an internal inquiry, and as a result of its findings, has dismissed the master from its service.

2. The PLA prosecuted the master successfully for navigating without due care and attention.

3. All vessels in the class have been provided with the volumetric capacities of all void and machinery spaces.

4. The watertight doors between the forward machinery space and the forward void space are in the process of being replaced with hydraulic sliding doors fitted with alarms on all vessels of the class.

5. The extreme end doors in the tunnels on each side of the cargo hopper are being reversed to open forward on all vessels of the class.

6. The PLA introduce new pilotage directions in September 1999 with an effective date of 15 October 1999, which, inter alia, introduced practical assessment of all PEC holders on application, and every three years thereafter.

7. The PLA introduced new general directions in September 1999, with an effective date of 15 October 1999, which, inter alia, made the preparation of a port passage plan by all vessel masters prior to navigating in the Thames, a legal requirement.

PHOTOGRAPH 3

Watertight Door

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine all the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future. This analysis will include:

1. The principal and underlying reasons why an apparently well found vessel, with a bridge manned by an experienced master and PEC holder, ran aground in familiar waters; and

2. The fundamental reasons why an apparently well found vessel capsized and sank after sustaining relatively minor damage.

2.2 ORGANISATION OF THE BRIDGE TEAM

Bridge team management is a fundamental function of safe ship operation. It is aimed at ensuring that a ship reaches its planned destination safely and efficiently through safe, well-planned navigation. *Arco Arun*'s bridge team management failed to fulfil this function.

There were only two people on or near the bridge at the time of the accident; the master and the second mate. The master knew the river well, was the PEC holder and was supervising an inexperienced second mate. The second mate had first responsibility for navigation and was steering. These two constituted the bridge team; it was a well tried system, common on small ships. On this occasion it allowed *Arco Arun* to run aground

The roles and responsibilities of master and second mate were not clearly defined. Both 'understood' what was required; the second mate would navigate and steer; the master would retain the overriding authority and exercise control if he saw a need. The second mate could never be entirely sure that the master was aware of each action taken and had approved it. The system allowed the chance of errors to go unnoticed.

The second mate was trying to both navigate and steer. Yet while steering, he was unable to refer to the chart, see the echo sounder, use the radar effectively, look aft or concentrate entirely on navigation. The bridge layout was not designed to allow an officer to navigate from behind the wheel. He was unable to do both jobs safely.

A third person could have been allocated the task of steering. There was an extra person available to do so; the seaman watchkeeper. At the time of the grounding he was in the mess room. Manning levels and maintenance requirements often mean that seamen must be employed in duties other than watchkeeping. On this occasion the seaman on watch had been assisting the bosun washing down and clearing away the anchors. A common denominator in many pilotage waters' accidents is the absence from the bridge of the rating on watch. Very often he has been stood down to rest, is

carrying out other duties, or is not being used as a helmsman because he does not have the necessary skills through lack of practice.

2.3 PASSAGE PLANNING

Arco Arun with a draft of 6.6m was restricted to using the deeper parts of the river. Broadly speaking her navigable channel consisted of the charted deep water channel **(see Figure 5)**. With a tidal height above chart datum of 1.6m at the time she grounded she would have been in danger of grounding anywhere where the charted water depth was less than, say, 5.5m after making an allowance for squat. Scrutiny of the chart reveals that *Arco Arun*'s safe water channel for this passage lay broadly in the centre of the river but was sometimes biased north or south, especially on rounding bends. At some places within the deep water channel shown on the chart, the water depth is less than 5.5m. Above Gravesend Reach, the deep water channel is not marked by buoys. These factors required particular care when navigating upriver on 13 October on *Arco Arun*.

Arco Arun's navigable channel in the river to the east of Broadness Point lies to the south of the centre of the river. The second mate was steering the vessel intending to maintain a position to starboard of the centre of the channel. He assumed the navigable channel lay in the centre of the river or, even, that it was slightly towards the north bank. The vessel first grounded in a position, which though well outside the channel, lies about two thirds of the way across the river from the south bank. The second mate's lack of knowledge of the precise position of the navigable channel within the river contributed to the accident.

A simple passage plan would have identified this as a danger area. In that case, when passing Broadness Point a variable range marker could have been quickly set up on the radar on a preplanned range to enable the master or navigator to confirm at a glance that the vessel remained in safe water. As a secondary information source the echo sounder's depth alarm could have been set to provide warning if the vessel approached dangerously shallow water.

There were no company or master's instructions or guidance on the production of passage plans.

2.4 NAVIGATIONAL METHODS

The investigation considered the river navigation methods on *Arco Arun*, and compared them with what might reasonably be expected of a pilot or PEC holder.

The primary method of navigating *Arco Arun* on 13 October was by eye. It is a technique used by pilots and those very familiar with the river. Navigating by eye to stay in, or close to, the centre of a channel can be safe if it is clearly marked. Where it is not, especially when the navigable channel is offset from the centre of the river, the situation is potentially hazardous and requires an effective back-up navigation system to guarantee safe passage. Even the most experienced pilots use radar, the echo sounder, natural transits and other navigational aids.

In *Arco Arun*, the master saw no need to use any of the established methods of navigation and did not produce a passage plan. He knew the river well, had made the passage many times before, and was confident of his ability to navigate by eye. He furthermore felt he could delegate the navigation to an inexperienced officer who was making the passage for the first time in charge of a watch. There is no evidence to indicate that he was any way concerned about his vessel's position in the few minutes before the grounding. He thought he knew where he was, and judged the vessel to be in safe water. He was wrong.

2.5 THE MASTER'S ROLE

There is every indication that the passage on 13 October was typical of those carried out by this master on *Arco Arun*. The master's actions, on this occasion, were not influenced by any extraordinary factors.

The master was monitoring the second mate's actions, and yet had been unaware that the vessel was standing into danger. Scrutiny of the track shown on the PLA's radar recording clearly indicates that the vessel had been close to the edge, or outside, the fairway, for a considerable time before he left the bridge to use the toilet. It can be concluded, therefore, that he either misjudged the position of the vessel in the fairway, or he was not concentrating on his monitoring role.

In considering the facts, a number of contributory factors which are relevant to the role of the master can be deduced:

- his reactive monitoring role was inappropriate for the person with pilotage responsibility;
- he had not considered all the risks; for instance, how the second mate would steer safely when the fairway was unmarked;
- he allowed his attention to stray at an inappropriate time, for instance, by looking at the moored yachts - he was not concentrating on his task;
- he had made the passage on numerous occasions and had become complacent about the hazards;
- his bridge resource management was poor in that he allotted the task of both helmsman and navigator to the second mate; a role that could not adequately be carried out by one person;
- communication on the bridge was poor, responsibility for control was not positively established;
- the bridge navigational equipment was not fully utilised;
- a passage plan indicating clearance distances and danger areas had not been established.

The fact that he saw no need for even a rudimentary passage plan; no need to give the new second mate special instructions or training; and no need to be specially vigilant in monitoring the second mate's navigation, indicates a casual approach to this area of his responsibilities as both master and pilot.

This casual approach meant that safeguards were not in place to identify errors.

2.6 THE SECOND MATE'S ROLE

The second mate was appropriately qualified and carrying out a task that his predecessors on *Arco Arun* had done safely on many occasions. Why then, on this occasion, did the vessel ground?

The investigation has shown that a number of factors, relevant to the role of the second mate, combined to cause the vessel to leave the fairway and ground. These include:

- his dual role as both navigator and helmsman was inappropriate;
- he was inexperienced in his role and in the geographical area;
- there was a general lack of pre-planning for the pilotage in that:
  - he did not appreciate that the centre of the fairway lay to the south of the centre of the river;
  - he did not appreciate the danger and extent of Black Shelf;
  - no clearing distances had been calculated;
  - the facilities on the radar including variable range marker and range rings were not utilised;
  - he was constrained by having to stay at the wheel position and unable to check chart, echo sounder or fully utilise the radar;
  - he was confident that his chosen course was correct. This may have been partly engendered by the presence of the master on the bridge and the fact that he was not directed to do otherwise;
  - his attention strayed to looking and talking about the yachts that were moored near the north shore; he was not concentrating on the task.

Some of these factors reflect a casual attitude to the conduct of safe navigation on the Thames.

This casual attitude, which was perhaps engendered by that of the master, allowed errors of judgment to be made and to remain undetected.

2.7 PILOTAGE EXEMPTION CERTIFICATES

The PLA does not usually require an applicant for a PEC on a vessel *of Arco Arun*'s size to show a safe passage plan or demonstrate an intimate knowledge of the river. It is sufficient to have had recent experience on the river and to hold the appropriate certificate of competency. Furthermore, at the time of the incident, there was no system in place for auditing the abilities of existing PEC holders. In the opinion of the MAIB, the process by which a PEC could be obtained and maintained to pilot a vessel the size of *Arco Arun* may have under-rated the difficulty of pilotage on the Thames, and:

(i) may have been an influence on the master's casual approach to pilotage; and

(ii) may have contributed to the likelihood of accidents occurring.

A tighter qualification system should reduce risks and improve safety.

The investigation looked at both the company's and master's instructions for guidance on how PEC pilotage should be conducted. There were none.

The traditional role of the pilot and his relationship to that of the master is well-known and forms part of the syllabus for the award of a certificate of competency. It is also included in the company's instructions. But the instructions are conspicuously silent about how the master should conduct pilotage, and how he should relate to other members of the bridge team. The relationship is just as complex and requires detailed attention. The lack of clear instructions was, in the opinion of the MAIB, a contributory factor in this accident.

2.8 THE ROLE OF PLA AND PCL

PCL does not undertake to monitor the navigation of every vessel. According to the PLA, VTS fulfils three functions: the transmission of navigational data, the provision of navigational assistance to specific vessels when required and practicable, and the organisation of vessel traffic where appropriate. This is in line with the IMO *Guidelines for Vessel Traffic Services*, Resolution A.857(20). The SVTSO's principal role was to give masters and pilots the information necessary to enable them to navigate their vessels safely.

In the period leading up to the accident, *Arco Arun* had passed *Arco Bourne*, the only other ship on that part of the river. The weather at the time was good and the master was experienced. Having satisfied himself that *Arco Arun* had safely passed *Arco Bourne*, the SVTSO had diverted his attention to another area where he had a more immediate role to play. This action was entirely understandable, but with the benefit of hindsight, it was unfortunate that *Arco Arun*'s divergence from the deep water channel was not noticed, despite it being clearly displayed on the video monitor next to the SVTSO. If this had been seen in the two minutes or so before the accident and precautionary measures taken, this serious accident may well have been averted. Although not a deep draught vessel at 6.6m, *Arco Arun* was, at that state of tide, constrained to navigate within an unmarked channel. This does not appear to have been fully appreciated by those on *Arco Arun*.

In this context it is relevant that the IMO Resolution A.857(20) referred to above states, in relation to the objectives of a VTS, that - *The quality of accident prevention measures will depend on the system's capability of detecting a developing dangerous situation and on the ability to give timely warning of such dangers.*

The PLA has neither the staff numbers, nor the equipment, to take responsibility for the safe navigation of every vessel; that lies quite properly with the vessel's master. The PLC radar surveillance system is capable of providing a warning whenever a vessel crosses a pre-determined electronic channel boundary. However, the boundary alarm cannot

differentiate between one vessel and another, and, therefore, has limited value. The potential for a large number of alarm activations masking other alarms and reducing operator alertness casts doubt on the ability to use the system safely when electronic channel boundaries are selected. Technological developments should be monitored with a view to incorporating an appropriate warning system as soon as it becomes practicable to do so.

A repetition of this accident could be avoided by marking the extremities of the channel close to Black Shelf. In this particular location the channel does not lie in the centre of the river, and the placing of a navigational mark would be of particular benefit to the larger river users to assist them in the safe navigation of their vessels.

2.9 THE CARGO RELEASE VALVES

In order to reduce the displacement, the cargo release valves were opened soon after the grounding as *Arco Arun* was approaching the anchorage position. The valves opened correctly, but the cargo did not release until some hours later. This is the second time in recent MAIB investigations that cargo has failed to release through open release valves on an aggregates dredger. When *Sand Kite* collided with the Thames Barrier in October 1997, her release valves were opened to dump her cargo rapidly. Like *Arco Arun*, nothing occurred initially but the cargo did dump later when it was not expected. Both *Arco Arun* and *Sand Kite* were inbound with cargoes of sand and gravel having nearly completed passages of several hours duration from their dredging grounds. In both cases it is possible the cargo had had time to settle and dry out making it not fluid enough to discharge through the valve openings. The cargoes subsequently released unexpectedly after water had entered the cargo hoppers. The purpose of the cargo release valves is to restore a vessel to her international freeboard, and it is possible that *Arco Arun* had returned to her summer load draught during the cargo settling and drying out process before the grounding.

2.10 THE CAPSIZE

Arco Arun grounded on a river-bed of compacted sand and stones, and was holed in one major compartment forward. That this should have led to her subsequent capsize and foundering is both surprising and of concern, and should not have happened. Although this investigation has not looked into the detail of the initial salvage attempt, it is apparent that it was hampered by, among other things, a lack of information on the volumetric capacities of void and machinery spaces.

Progressive flooding from forward to aft caused the vessel first to list and finally to capsize. The flooding occurred mainly through watertight doors that were designed principally to limit progressive flooding from aft to forward. The vessel capsized after the flooding had reached the aft engine room.

Since the accident, the owner has strengthened some of these doors and reversed others. The MCA and other owners should carefully consider the effectiveness of hinged and

dogged watertight doors, particularly their efficiency with respect to the most likely direction of flooding.

2.11 COMPARISON WITH THE *SAND KITE* ACCIDENT (MAIB Report 2/99)

Sand Kite collided with one of the piers of the Thames Flood Barrier, and sank in October 1997. Although different to this accident in many respects, there are a number of common factors.

These include:

- they were both suction dredgers falling below the 100m demarcation with respect to the requirements for PEC examination;
- both vessels sank quickly as a result of being holed beneath the waterline;
- both masters had chosen not to use the duty seaman to steer, preferring to use the duty mate for that purpose

and, on both occasions:

- the duty seaman had been in the messroom at the time of the accident;
- when a change in PEC holder had occurred in mid-passage PCL had not been informed;
- the PEC holder was on the bridge but not actually conducting the pilotage;
- the principal causal factors included a navigational error and poor bridge resource management;
- a passage plan was not being followed;
- the facilities of the bridge radars were not being fully utilised;
- the emergency cargo release mechanism was used in earnest and was ineffectual because the cargo was too dry;
- possibly a proportion of the cargo was later dumped unexpectedly and inadvertently.

The common factors of only two accidents cannot be considered as proof of widespread significance. However these two vessels are representative of numerous others that ply their trade around the coast of the United Kingdom and some of the factors are remarkably similar. Port authorities and dredger owners and operators should therefore consider the possibility that these factors might translate to other operations.

SECTION 3 - CONCLUSIONS

3.1 FINDINGS

1. *Arco Arun* was well found and manned by a total complement of ten in accordance with her safe manning certificate. All her statutory certificates were in force at the time of the grounding. [1.1, 1.6]

2. *Arco Arun* grounded on the north bank of the River Thames at 1350 on 13 October 1998 while attempting to round Broadness Point. [1.3]

3. The weather at the time of the grounding was overcast, fine and clear. The wind was from the south-west force 4. [1.1]

4. At the time of the grounding the second mate was the only person in the wheelhouse; the master had recently left to visit the toilet. [1.3]

5. After the initial grounding, *Arco Arun* was successfully manoeuvred close to St Clement's Anchorage before the bow settled on the river-bed. [1.3]

6. Although she had suffered only minor damage and despite salvage attempts, she capsized about 43 hours after the initial grounding. [1.3]

7. The second mate was recently qualified and carrying out his first River Thames passage in charge of a watch. [1.7]

8. The master held a Class II Certificate of Competency and a command endorsement. He also held a valid PEC for all Thames pilotage zones. [1.7]

9. The seaman on watch was in the mess room at the time of the grounding. [2.2]

10. Navigation on the river on *Arco Arun* was conducted by eye with occasional reference to the radar. [1.7]

11. Neither alcohol nor other drugs were factors in the accident. [1.9]

12. Fatigue was not a factor in the accident. [1.10]

13. Port Control London's recorded radar information shows the accident unfolding clearly. [1.11]

14. The vessel had been close to the edge of the safe channel for some minutes before the grounding. [1.13]

15. There are a number of common factors with those arising from *Sand Kite*'s collision with the Thames Barrier which might be relevant to other, similar, operations. [2.11]

3.2 CAUSES

3.2.1 The immediate cause of the grounding

The accident was caused by a navigational error which went undetected by the bridge team. [2.3, 2.4, 2.5]

3.2.2 Other factors and underlying causes

1. The bridge equipment was not arranged to allow an officer to both steer and navigate. In particular, from the wheel position: the radar was out of reach; the echo sounder could not be seen and the chart could not be consulted. [2.2]

2. Poor bridge team management on *Arco Arun* in that:
   - a passage plan had not been formed
   - there was no positive command
   - inappropriate roles were assigned to an inexperienced officer
   - neither the echo sounder nor its alarm was used
   - the navigational facilities of the radar were not used
   - there was little or no reference to the chart
   - the duty seaman was not used as helmsman as part of the bridge team
   - both master and second mate were distracted at a key moment. [2.2, 2.3, 2.4, 2.5]

3. The master's choice of a reactive monitoring role which is not considered suitable for the person with pilotage responsibility. The second mate was both steering and navigating and relying on the master to countermand any inappropriate action. [2.2, 2.4, 2.5]

4. The master showed a casual attitude to his responsibilities as pilot. This could have been due to his familiarity with the river, the process by which a PEC for the river could be obtained and maintained, and the company's lack of specific reference as to how that duty should be performed. [2.3, 2.4, 2.5]

5. Despite the fact that the main channel does not lie in the centre of the river as it rounds Broadness Point, it is not marked, which makes navigation more difficult on vessels confined to the channel by their draught. The second mate was not aware of the exact position of the navigable channel which, combined with a misjudgment, contributed to the accident. [2.3]

6. At a draught of 6.6m and with a tide 1½ hours after low water, *Arco Arun* was constrained to navigate within an unmarked fairway. The hazards posed by this fact do not appear to have been fully appreciated by either those on *Arco Arun* or those in PCL. [2.3, 2.8]

7. The process by which a PEC, for a vessel the size of *Arco Arun*, could be obtained and maintained may have under-rated the difficulty of pilotage on the Thames. [2.7]

8. The company's Operations Manual gives no guidance on the production of passage plans or on the roles and responsibilities during PEC pilotage. The roles and responsibilities of the bridge team on *Arco Arun* were inappropriate. [2.3, 2.7]

9. The information that could have alerted the VTS operator to the potential grounding of *Arco Arun* was available at the VTS control station. However, the operator did not notice it as he was monitoring other shipping movements. [2.8]

10. Progressive flooding through hinged watertight doors, which had been arranged against flooding from the opposite direction, caused the vessel to list and capsize after the grounding. [2.10]

SECTION 4 - RECOMMENDATIONS

Hanson Aggregates Marine is recommended to:

1. include standing instructions for the conduct of pilotage including passage plans and pilotage by the master as PEC holder.

2. consider introducing Bridge Resource Management training for all its masters.

The Port of London Authority is recommended to:

3. consider placing a mark on the southern extremity of Black Shelf.

4. monitor technological developments with a view to enhancing its radar surveillance system as soon as it becomes practicable to do so to give VTS operators warning that a vessel is standing into danger.

The Maritime and Coastguard Agency is recommended to:

5. consider, in the light of this accident, the effectiveness of hinged watertight doors, particularly their efficiency with respect to the most likely direction of flooding.

Marine Accident Investigation Branch
March 2000