

**Report on the investigation
of the foundering of the narrow boat
Drum Major
with the loss of four lives at Steg Neck lock
near Gargrave, North Yorkshire
on 19 August 1998**

Marine Accident Investigation Branch
First Floor
Carlton House
Carlton Place
Southampton
SO15 2DZ

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

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.

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Glossary of Abbreviations and Acronyms

BW	:	British Waterways
CPR	:	Cardiac Pulmonary Resuscitation
DETR	:	Department of the Environment, Transport and the Regions
ft	:	foot
in	:	inch
HSE	:	Health and Safety Executive
m	:	metre
mm	:	millimetre
MAIB	:	Marine Accident Investigation Branch
UK	:	United Kingdom
UTC	:	Universal Co-ordinated Time



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SYNOPSIS

The accident occurred at the Steg Neck lock on the Leeds and Liverpool canal on Wednesday 19 August 1998. The Marine Accident Investigation Branch was informed of the incident by the Health and Safety Executive at 1620 that day but did not take over primacy for its investigation until 20 August. It was investigated by Captain P Kavanagh.

Four carers and four disabled people with learning difficulties were taking a week's holiday on board the narrow boat *Drum Major* on the Leeds and Liverpool canal. They had started their holiday at Silsden on Sunday 16 August and had travelled as far as Foulridge where they turned round and started their return journey on 19 August.

The holiday had been mainly uneventful and the transit of Steg Neck lock should have been like many others they had already undertaken. The carers were handling the boat while the four disabled passengers were seated inside the accommodation.

Drum Major entered the lock as normal but before the top gate was shut, a second narrow boat, *Dan's Drum*, approached, wanting to share the lock and descend together. With both boats in the lock the top gate was shut and the routine of opening the bottom gate paddles to drain the water in the lock started.

Very shortly afterwards it was realised that *Drum Major*'s bow fender had caught between the top of the bottom gate and the balance beam above it and, as the water-level began to fall, the bow remained suspended while the stern dropped to such a degree that it started to take water on board. Steps were taken to try to arrest the situation by shutting the bottom gate paddles and opening a top gate paddle. In opening the top gate paddle, however, water started to pour into the stern of *Drum Major*, and the paddle was quickly closed.

Suddenly the bow came free of the bottom gate. The boat dropped heavily and created a large wave that surged through the lock and swamped *Drum Major*, causing her to fill with water and sink. Attempts to rescue the four disabled people trapped inside were unsuccessful. All four were declared dead at the scene.

The cause of the foundering was an uncontrolled ingress of water into *Drum Major* while she was descending in the lock. A main contributory cause was that she was positioned too far forward in the lock, contrary to the advice provided in the *Waterways Code for Boaters*, which is issued by British Waterways.

The report makes a number of recommendations addressed to British Waterways with respect to the reporting and analysis of accidents and hazardous incidents, the adequacy of narrow boat emergency escape routes, and the fitting of weak securing arrangements to bow fenders of the type on *Drum Major*.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS

1.1.1 *Drum Major*

Owner	:	Silsden Boats
Length	:	18.88m
Breadth	:	2.07m
Draught	:	0.55 m
Berths	:	10/12
Persons on board	:	Eight

1.1.2 Accident Details

Injuries	:	Four deaths
Damage to boat	:	Waterlogged throughout
Date and time of incident	:	19 August 1998 at 1430 (UTC + 1)
Location of incident	:	On the Leeds and Liverpool canal at Steg Neck lock near Gargrave, North Yorkshire

1.2 SCOPE OF INVESTIGATION

This investigation and report deals with the immediate circumstances and causes of the accident. The Health and Safety Executive (HSE) investigated the health and safety management issues while British Waterways (BW) carried out its own investigation.

1.3 BACKGROUND INFORMATION - INLAND WATERWAYS

1.3.1 History

The inland waterways of Britain have been used for the carriage of people and cargoes since Roman times. Until the construction of weirs on rivers and the building of canals, such trade was confined to the carriage of goods in large timber-built sailing vessels in estuarial waters as far as wind and tide could take them. By 1660 there were about 700 miles of navigable rivers but it was not until the 18th century that canals started to be constructed. They became vital arteries to the development of trade in the country.

Canalised rivers accommodated vessels of barge dimensions but those constructed further inland were, with one or two exceptions, built to conserve water and were much narrower. Their locks were 2.13m (7 ft) wide. The Leeds and Liverpool canal was one of the exceptions.

The arrival of the railways in the 19th century presented competition to the canal cargo-carrying companies. Many railway companies bought the canals and left them to decline. Although commodities such as coal, grain, wool, cement and sugar continued to be carried, many inland waterways fell into a state of disrepair. It was not until the middle of the 20th century that their potential for pleasure use was realised.

Britain's inland waterways are now enjoying a new lease of life and hundreds of miles of canals have been extensively improved. British Waterways owns, or is the navigation authority for, an extensive network of navigable canals and rivers and every boat using them must have a British Waterways licence or certificate.

1.3.2 The Leeds and Liverpool canal

Construction of the Leeds and Liverpool canal began in 1770 and was completed in 1816. It is 127 miles long, is the longest canal in the country and crosses the Pennines near Nelson and Colne with its summit 148m (487 ft) above sea level. It links Liverpool, Wigan, Blackburn, Burnley, Skipton, Bingley and Leeds. The revolution in textile manufacture centred on these towns and all raw materials and finished products were carried by canal. Cargo transport ceased in 1964.

The canal now comes under the jurisdiction of the North West Region of British Waterways.

1.3.3 Locks

The locks of the Leeds and Liverpool canal were built to take the size of the broad boat in use on both sides of the Pennines in the 18th century and had a maximum length of approximately 20.5m (67 ft 4in) and a breadth of 4.36m (14 ft 4in).

They were designed to accommodate one broad boat but are wide enough to take two narrow boats lying alongside one another. This has the advantage of retaining water in the canal, and decreases buffeting water, especially when ascending.

Because of its breadth a broad boat's bow fender snubs up against the two heavy central vertical timbers of the bottom gates when descending. The bow fender of a narrow boat can, however, enter the space between the top of a gate and the balance beam above it.

The paddles can be locked against misuse and vandalism by 'handcuff' locks, which are operated by keys issued to boat users.

A metal ladder is recessed into the side of each lock.

A description of lock operation is given in Annex A.

1.3.4 Steg Neck lock

Steg Neck lock is number 35 on the east side of the summit of the canal and is one of six carrying the canal through Gargrave.

Like other locks on the canal it has two gates at either end. They were installed in 1986. The water-level difference between the upper and lower pounds is 3.15m (10ft 7in). It normally takes about 3½ minutes for the water to drain from the lock when full.

Each top gate has a ground paddle which is operated by raising or lowering a large wooden lever which, when raised, allows water to flow in an underground culvert from the upper pound to the bottom of the lock. The top gates also have sluices in them which are sealed by gate paddles operated by a portable windlass and winding gear on top of the gates.



A view of the windlass for the top gate paddle (in foreground) and the wooden lever for the ground paddle (behind).

The two bottom gates are fitted with gate paddles.

A bridge crosses the canal immediately downstream of the bottom gates.

1.3.5 Narrow boats

The width of canals and their locks dictated the size of the boats using them and the concept of the narrow boat came into being. They were originally built of wood but steel took over in the 20th century. The usual form of motive power was provided by horses, donkeys and mules until the arrival of engines in the late 19th century. Steam engines were used in some boats but they took up a large amount of space and needed a three-man crew to operate them. The arrival of the internal combustion engine led to greater efficiency, smaller spaces for the engine and greater cargo-carrying capacity.

The greater part of a typical narrow boat was given to the carriage of cargo with a short foredeck right forward and a small accommodation section situated aft with a steering platform at the stern.

Today there are four types of narrow boat; traditional with accommodation occupying the space formerly taken up by the cargo hold; cruiser with a modern cabin and plenty of open deck space; semi-traditional combining features of the two; and the tug type.

Narrow boats for leisure have been built since the mid-nineteen sixties and can vary in length from 5.48m (18ft) to 21.93m (72ft) but are never over 2.18m (7ft 2in) wide. They are constructed from steel plates welded together to form a strong and resilient hull and superstructure.

Drum Major was a traditional narrow boat 18.88m (61.94ft) long.

1.4 THE CARERS AND THE DISABLED PERSONS

1.4.1 The manager

The man in charge of the *Drum Major* holiday was highly experienced in the care and management of people with learning difficulties. He had a teaching diploma and was manager of a centre run by Cumbria Care for those with learning difficulties at Walney Island, Barrow-in-Furness. The patients at the centre were known as 'clients'.

He had been running narrow boat canal holidays for a number of years, had about 20 years experience on the canals and owned his own boat. He had previously been on three or four working holidays with clients on the Leeds and Liverpool canal.

1.4.2 The care assistants and day service officers

The manager was supported by a male care assistant and two female day service officers (DSOs). They were all employees of Cumbria Care and had experience working with clients with learning difficulties. They all had previous narrow boat experience.

1.4.3 The clients

Before the holiday, clients were selected on the basis of physical and mental health, and the personal choice of the carers. On this occasion they were aged between 33 and 49, were in varying degrees of physical health and either had learning difficulties or a learning disability.

1.5 BACKGROUND TO THE ACCIDENT

On Sunday 16 August 1998 four carers employed by Cumbria County Council and four mentally disabled people set off from Barrow-in-Furness, Cumbria, for a week's holiday in a narrow boat on the Leeds and Liverpool canal.

Their craft was *Drum Major*, which was hired from Silsden Boats at Silsden. The person in charge of the party, the manager, had hired *Drum Major* on previous occasions and the other carers had had narrow boat experience. Because of this overall experience and knowledge, no specific instruction or advice was given to the party by the boat owner on this occasion.

The group's intention was to head towards Liverpool as far as Foulridge and then return.

No lifejackets were carried.

The trip to Foulridge was uneventful and the return leg started on Wednesday 19 August. The group planned to have lunch that day at the canalside Anchor Inn on the outskirts of the village of Gargrave.

Before reaching Gargrave they had to transit Steg Neck lock, which is about a third of a mile to the west of the Anchor Inn.

1.6 NARRATIVE OF EVENTS

1.6.1 The accident

On approaching Steg Neck lock, *Drum Major* drew in to one side of the canal to disembark the manager and the care assistant to enable them to prepare the lock for the forthcoming descent. The boat was being controlled by DSO(1) while DSO(2) was forward. The four disabled passengers were seated in the lounge area at the aft end of the accommodation.

Before *Drum Major* could enter the lock it was necessary to equalise the water-levels. Once achieved and the right-hand top gate opened, *Drum Major* was moved forward and secured to the right-hand side of the lock. As the top gate was being closed behind her, another narrow boat, *Dan's Drum*, approached from astern, wanting to join *Drum Major* and descend together. This was agreed and *Drum Major* was moved to the left-hand side of the lock to allow the other boat to enter. Once she was in, the top gate was shut.

The water-level in the canal was high on 19 August and reached the top of the bottom gates.

With two boats lying alongside each other in the lock, the manager told those on board *Dan's Drum* that they would not have to use restraining ropes. His reason was that the two boats would provide mutual support and could not swing round while descending in the lock. One person from each boat then opened the two bottom gate paddles and water started to drain from the lock. Having opened the left-hand bottom paddle, the care assistant from *Drum Major* remained on the lockside by *Drum Major's* bow while at the stern, her colleague, DSO(1), had put the engine in neutral ready to engage it ahead to ensure the stern and rudder remained clear of the sill. At this time, the manager was on the lockside by *Dan's Drum* and DSO(2) was on board *Drum Major*.

Very shortly afterwards, DSO(2) noticed that the boat was unusually trimming by the stern and listing to starboard. She told DSO(1), who was still at the control position aft. The latter, on looking aft, saw water on the cockpit deck. Her warning shouts alerted the manager, who crossed the bridge to *Drum Major's* side of the lock. Seeing what was happening he went towards the top gate with the intention of opening the gate paddle to allow water into the lock to equalise the outflow. He was unable to do so as he did not have the key with which to undo the handcuff lock.

The care assistant, who was also alerted by the warning call, saw the bow fender in the gap between the balance beam and the top of the lock gate. A man who was sitting by the lock, heard the warning and saw the care assistant try to twist the shaft of the winding gear with his hands. The care assistant shouted for the windlass, which was lying on the grass. The man picked it up, inserted it in the square end of the winding gear, and shouted that he did not know which way to turn it. Not hearing a reply, he turned the windlass and saw the metal hook rise and disengage from the sprockets. The paddle then appeared to close under its own weight.

Three members of the family in the adjacent *Dan's Drum* closed the bottom right-hand paddle.

The care assistant boarded *Drum Major* and tried to prise the fender off the lock gate. He was unsuccessful and disembarked. The manager called for the key to unlock the top gate paddle. DSO(2) remembered that the care assistant had the key, fetched it and gave it to the manager. The manager opened the top gate paddle but, when the water flowed into the cockpit of *Drum Major*, he realised that it was making the situation worse and closed the paddle.

DSO(1) saw a gush of water come into *Drum Major* from astern. She left the tiller and went into the accommodation. On making her way forward, the disabled people grabbed her arms. The water was rising rapidly and she made her way towards the forward doors.

The manager jumped onto the accommodation roof, made his way forward and, with the care assistant, gained access to the accommodation through the forward

doors. The manager saw DSO(1) and one of the disabled people making their way forward whereupon the care assistant made his way aft to find the others.

Suddenly *Drum Major's* bow fender came free of the bottom gate and the boat dropped heavily into the water. She moved astern and was arrested by the rudder hitting the sill.

The displaced water from the fall created a large wave which swept through the accommodation. Alarmed by the sudden rise of the water-level, the care assistant managed to get clear but the sudden surge pushed the manager and DSO(1) out of the accommodation and into the lock where they were pulled from the water. Only when they were rescued was it realised by other people on the lockside that four disabled passengers were still on board the narrow boat which was, by then, fully submerged.

1.6.2 The rescue attempt

The water-level in the lock continued to fall until it had equalised with the lower level of the canal, leaving *Drum Major's* accommodation roof exposed. As soon as they were able, the father of the family in *Dan's Drum*, the care assistant and DSO(2) entered the accommodation from forward. The water-level was high and debris was everywhere; they failed to find anyone.

Meanwhile the son from *Dan's Drum* was attempting to enter the accommodation from aft, so his father and DSO(1) went to assist. With the water-level up to his chin, the son groped around inside the cabin and found a slightly-built man underwater. He was dragged out of the accommodation and, showing no signs of life, was laid on the accommodation roof.

By now several other people had become involved either in raising the alarm or in the rescue attempt. These included two lock-keepers who, among other things, attempted to drain as much water from that stretch of the canal as possible.

A second body and then a third was found but the search was complicated by the amount of debris in the accommodation. As bodies were found they were taken onto the roof where attempts to revive them using cardiac pulmonary resuscitation (CPR) were made. An ambulance crew arrived at the scene and took over CPR on two of the disabled persons, and the fire brigade recovered the body of the fourth. Eventually a doctor declared all four dead.

1.7 DRUM MAJOR

1.7.1 The boat

Drum Major was a typical narrow boat used for pleasure. The accommodation spread throughout most of her length with small cockpits at each end. The only means of access were through doors at either end. There was one door internally separating a lounge, galley and dining area at the aft end from the sleeping accommodation

Drum Major was fitted with two half-round 50mm rubbing bands designed to prevent damage or scratching. They ran the full length of the boat on each side.

Drum Major had a valid licence issued by British Waterways. Under the British Waterways Act 1995 this licence is issued when the boat complies with the Boat Safety Scheme, and has a Boat Safety Certificate and an insurance policy. The Safety Certificate is only issued once the boat meets the Boat Safety Scheme standards.

1.7.2 The fender

Drum Major, like all narrow boats, was fitted a bow and stern fender to reduce or prevent damage in the event of her colliding with lock gates, structures or other boats. Fenders are traditionally made of rope and designed to be soft enough to cushion the impact of, perhaps, 30 tonne or more coming to a dead stop. The British Waterways bye-laws require all vessels using the canals to use fenders whenever there is a risk of contact.

Two basic designs of bow fender exist; a round pudding or 'button' type, and one with ears or a wrap-around version which extends to both sides of the stem. *Drum Major* was fitted with the 'button' type, held in place by chains.



A view of the stem of DRUM MAJOR, showing the securing points for the fender chains

On *Drum Major* there were four chains; two leading vertically down from securing points on either side of the snub nose, and two lower ones leading horizontally aft to securing points on the hull, with connection bolts as little as 5mm in diameter. The lower chains were of unequal length, allowing the fender to swing to starboard of the stem. The fender arrangement was designed to take loads in the horizontal plane, not the vertical.

1.8 SILSDEN BOATS

Drum Major, which was one of 15 in the Silsden Boats' fleet, was owned and managed by a husband-and-wife team. The company employed four full-time staff and a number of part-time staff, and was affiliated to the British Marine Industries Federation, Inland Waterways and the Tourist Board.

The company's insurance covered the employees, the boats and third party liability. All boats in the fleet had British Waterways licences and were surveyed every four years. The survey covered water-worthiness, safety equipment, fire extinguishers, gas systems and ventilation.

The boats were cleaned after each hiring and a thorough check was made on the inventory, the engine and systems, including the gas bottles. Diesel and fresh water tanks were filled ready for the next customers and any damage to the boats, including the fendering system, was repaired.

When customers booked a boat, an instruction booklet was forwarded together with a booking form on which they could indicate whether or not they required lifejackets.

Before anyone set off on a hiring the owner or one of his employees normally took them through the instructions and established what previous experience they had of narrow boats, lock operation and the Leeds and Liverpool canal. Newcomers were shown how to use locks with the aid of a model and were instructed in the use of paddles, gates, handcuff lock keys, and general guidelines, including keeping the boat forward in the lock away from the sill when descending. Those without previous experience of the Leeds and Liverpool canal were informed of the differences with the wider locks, which can take two narrow boats at a time, and that the water is more turbulent than in other canal systems.

Because the Cumbria Care manager was known to Silsden Boats and had previously hired *Drum Major*, and the three other carers were known to have previous narrow boat experience, no instructions were given at the start of the hire on this occasion.

1.9 BRITISH WATERWAYS

British Waterways (BW) is responsible for keeping some 2000 miles of waterways open for cruising, for arranging essential maintenance work and for the general standards of boats and the safety of those using the canals. It is one of 30 separate bodies having responsibility for inland waterways and is a member of the Association of Inland Navigation Authorities.

BW, the National Rivers Authority (now the Environment Agency) and other authorities have harmonised technical standards to apply on waterways within their jurisdiction. This is known as the Boat Safety Scheme.

Under the British Waterways Act 1995 a licence for a boat is issued when the boat complies with the Boat Safety Scheme standards, has a Boat Safety Certificate and an insurance policy. To be issued with a certificate the boat has to have a place where she can be reasonably kept, or lawfully left, unless she is cruising continually.

All boats require a Boat Safety Certificate before a licence can be issued. BW requires all owners to ensure that a boat is properly maintained so that she continues to meet the required standards. The Act allows BW to withdraw a boat's licence if the conditions are not met.

Boat surveys are carried out by inspectors who meet BW standards and are authorised to issue Boat Safety Certificates.

BW issues a booklet called *Waterways Code for Boaters* which gives advice about safety procedures and the general conduct of boats on the canals. The *Code* contains specific advice about the use of locks. In the section on descending a lock it advises:

Keep the rear of your boat clear of the sill, and also the front end clear of the bottom gate timbers.

BW also issues a supplement to the 'Code', the *Waterways Code for Boaters on the Leeds and Liverpool Canal*. This booklet gives general advice on navigation and manning and says:

To ensure your journey is as smooth as possible through the large locks of the Leeds and Liverpool Canal and many swing bridges, we recommend a crew of two persons on the craft and two on shore (or share with another craft).

The supplement gives advice on the handcuff security locks on the paddles, general information on locks including the sharing of locks to conserve water, and the operation of the various types of paddles found on this canal.

1.10 POST ACCIDENT RE-ENACTMENT AND SURVEYS

1.10.1 Lock Survey

Following the accident BW carried out a full and detailed survey of the lock, using an electronic theodolite. No defects were found and all operating mechanisms were functioning correctly.

Fresh damage was observed on the coping stonework at the top edge of the lock and there was a large splinter on the balance beam of the bottom left-hand gate.



The snub nose against the balance beam with the fender in the gap.



A view showing the port side rubbing bands in relation to the coping stones when the lock was full.

1.10.2 *Drum Major* Survey

An inspection of *Drum Major* revealed scrape marks on the starboard face of the snub nose. No visible signs of strain were found in respect of the fender securing arrangement.



The Damage to the starboard side of the snub nose, which probably caused the splinter to the balance beam.

1.10.3 Accident re-enactment

After the accident the water-level in the canal was restored to normal and *Drum Major* refloated. To understand better what had actually occurred it was decided to re-enact the incident. This was carried out on 21 August in the presence of representatives of various agencies including the police and BW, and inspectors from the HSE and the MAIB.



The top paddle gate was opened to show the force of the water entering into the lock. Note the cill beneath and the police yellow chalk marks on the coping stones to the right.

- *Drum Major* was placed in the lock in the same position as at the time of the accident. It became apparent that in this position her bow fender could not rest on top of the balance beam.

The water in the lock was slowly drained in a controlled manner and it became evident that the top rubbing band coincided with the fresh damage marks on the lock edge coping. It was also noticed that the splinter on the balance beam matched the position of the snub nose.

When sufficient water had been drained *Drum Major* was edged forward so that her fender passed between the top of the gate and the balance beam.

As the water continued to drain away, weight came onto both the fender and the snub nose resting on top of the gate.



The water level in the lock was dropped and the fender was allowed to become caught in the gap between the balance beam (top) and the top of the gate (below).

1.11 PREVIOUS INCIDENTS

Inland waterway accidents are not normally reported to the MAIB and no records are therefore kept on incidents affecting this type of boating. The MAIB was informed however that about ten boats founder each year, but there was no record of a previous incident where a bow fender had snagged and caused an accident on the scale of the *Drum Major* incident. It is also the first instance known to the MAIB when four people have died in a single accident on a canal.

Because the *Drum Major* accident attracted nationwide publicity, a number of people wrote to the HSE, Craven District Council and Cumbria County Council reporting accidents that had occurred in the past.

Some of those reports concerned narrow boats negotiating locks.

- *While ascending in a lock, the inrush of turbulent water through the paddles made this long boat surge back and forwards, which caused the forward fender to become caught under a cross beam on the gate. When it was realised what was happening, a bottom paddle was opened to allow water to flow out of the lock. If the paddle had not been opened in time the bow would have probably been held down by the cross beam. This would have allowed water to flow over the bow and into the accommodation, and caused the boat to founder. The lock gate had to be lifted off its hinge by a crane and resealed.*

- *While descending in a lock and being controlled by two people, a small narrow boat surged forward. The bow of the boat became wedged in the extreme corner between the wall and the gate. The stern swung out so that the boat lay diagonally across the lock and the boat quickly trimmed by the stern to about 45°. They closed the paddle to stop the water to stop the water going out of the lock and cautiously opened a paddle to allow the water in the lock to rise.*
- *While descending in a lock, the rope bow fender of a narrow boat became caught on a projection on the gate. The bow rose quickly out of the water as the level dropped. The paddles were closed and the snag freed itself causing the boat to fall heavily into the water.*
- *While descending a lock near Steg Neck, the rubbing strake of the boat caught on the stones lining the side. The stern of the boat dropped and she heeled to one side. The boat fell off, to confine damage to crockery on board. The hirer was concerned that the engine space vent would submerge and that the ingress of water would sink the boat.*

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations with the aim of preventing similar accidents occurring in the future.

2.2 *DRUM MAJOR*

Drum Major was licensed, satisfied the Boat Safety Scheme standards and, as far as can be judged, was defect free.

2.3 THE ACCIDENT

The accident re-enactment on 21 August, and the inspection of the gates and the lockside after the event, gave a clearer understanding as to what probably occurred on 19 August.

Drum Major entered the lock as normal and was joined by *Dan's Drum*. The bottom gate paddles were opened and the water-level started to go down. From the BW lock emptying flow rate graph at Annex C, it is known that the time taken for the water to reach the lower level is about 3½ minutes. On first opening the paddles the initial draining rate is slow but once they are fully opened after about 20 to 30 seconds, the water-level difference causes the flow rate to increase to its fastest rate over the next 90 seconds before slowing again until the water reaches the bottom level.

With *Drum Major* lying alongside the lock on her port side, the rubbing band was directly above the coping stone. As the water started to drain away, the rubbing band descended on to the stone, and was momentarily suspended to list the boat to starboard.

As the descent began to accelerate the rubbing band slipped off the coping stone to cause the bow to move to starboard and splinter the balance beam. This interpretation is supported by the fresh damage found on the coping stonework and the scrape marks found on the starboard face of the snub nose of *Drum Major*.

Drum Major moved forward in the lock. There were no restraining ropes and she moved, either because of water movement in the lock or because the engine was moved slightly ahead to ensure the rudder remained clear of the sill, or a combination of both. Evidence indicates that her stem was lying hard up against the bottom gate.

About 35 seconds after the bottom gate paddles were first opened the bow fender came level with the gap between the top of the bottom gate and the balance beam above it. With *Drum Major* pushed forward, the bottom fender entered the gap and

stayed there and the boat began to trim by the stem. It is uncertain what proportion of the load was taken respectively by the fender securing arrangement through the medium of the fender, and by the stem at its point of contact with the top of the lock gate.

By the time the level had dropped about 2m *Drum Major* had taken up an angle of 6° to the horizontal and water poured over the stern and into the accommodation.

This interpretation is supported by the calculations shown at Annex D, which also indicates a total load of 2.9 tonne at the point of contact with the top of the lock gate.

At this juncture water from the now opened top gate sluice started to flood the stern to aggravate the situation and very shortly afterwards the bow fender came free of the top of the bottom gate. The boat fell heavily into the water to cause a large wave to surge through the lock and completely swamp the after end and the accommodation through the open aft doors. Two carers, neither of whom were wearing lifejackets, were swept into the lock.

With the amount of water now on board, *Drum Major* sank to the bottom of the lock. Once the lock had emptied to the bottom level the accommodation roof emerged to leave a very small air gap under the roof.

2.4 THE PEOPLE

The owner knew that the manager was very experienced in narrow boats and in cruising canals, and that the other three carers had had some previous experience.

Therefore there was no need to reassure himself, under the provisions of the hire boat licence, that the carers were competent to navigate the waters to be cruised, that they had knowledge on how to use the locks and bridges, and that they were familiar with the safety equipment on board.

The boat was manned in accordance with existing advice, and the distribution of carers was suitable for operating a lock. The disabled people were kept clear of handling operations and, for their own safety, were seated in the aft end of the accommodation while transiting the lock.

Normal procedures were carried out for entering the lock and preparing to descend. DSO(1) was familiar with the need to keep the stern and rudder clear of the sill.

The precise reason for *Drum Major* moving ahead once the water-level started to go down has not been determined. It is possible the engine was engaged ahead or the boat moved forward by water movement in the lock. DSO(1) would not have been able to see the bow from where she stood and recalls keeping the engine in neutral as she saw no reason to move the boat ahead on this occasion.

Nobody recognised that the boat was too far forward in the lock. The boat was allowed to make contact with bottom gate, contrary to the advice provided in the *Waterways Code for Boaters*.

When it was realised the bow fender had snagged, the initial reaction was positive. All involved appreciated the need to stop the outflow immediately to prevent the stern dropping further. Shutting the bottom gate paddles and opening the top gate paddle to reverse the situation was sensible. However, a lack of knowledge by a bystander as to which way to turn a windlass; a delay in locating a handcuff lock key; and the late realisation that opening the top gate paddle resulted in water pouring into the stern cockpit, all combined to make matters worse. It would have been better had the ground paddle been opened first, as this would have allowed water to enter the lock underneath the boat.

It was not until the boat had foundered that the carers told the others around that four disabled people were still inside the boat. This was probably because they had become totally involved in trying to stabilise the situation and prevent the incident escalating.

2.5 LIFEJACKETS

No lifejackets were carried on board. However, had the disabled people been wearing lifejackets, it is doubtful the outcome would have been different, as they were eventually trapped in the confines of the accommodation.

2.6 THE FENDER

It is uncertain what proportion of the load was taken by the fender securing arrangement before the boat came free of the lock gate, and no visible signs of strain were found following the accident. It is possible that a weaker securing arrangement would have enabled the bow to break free of the lock gate at an earlier stage, thereby avoiding the consequences seen on this occasion.

2.7 ESCAPE ROUTES AND ACCESS POINTS

As the *Drum Major* predicament began to unfold in Steg Neck lock, only the carers knew that four people were inside the accommodation. Several people witnessed what was happening but thought the four people they could see were all those involved and saw they were accounted for. It was not until the boat had sunk that the presence of the others on board became known. The problem any rescuers then faced was trying to obtain access very quickly with only two points of entry, the doors fore and aft.

Because they were disabled, it is unlikely the four people sitting in the accommodation would have been able to escape without assistance. The situation was aggravated by water pouring in through the nearest escape route, the doors at the after end.

If a narrow boat as long as *Drum Major* sinks and people are caught in the accommodation spaces the nearest exit could be several metres away. Some narrow boats have a side-door or a hatch in the centre of the accommodation and

this could have advantages as an alternative or quicker escape route for the disabled, elderly or young. No recommendation is made for all narrow boats to be so fitted, but the provision of escape routes or points of access must be a consideration when selecting a suitable boat for carrying anyone less than normally mobile.

2.8 ACCIDENT REPORTING

This was a very unusual accident, which had not been foreseen. A key feature in developing a safety awareness is for all accidents or 'near misses' to be reported, so that all the lessons can be absorbed and improvements made in an attempt to prevent something similar happening again.

While owners who hire out boats must maintain a log of all breakdowns and emergency calls, these incidents are not required to be passed to British Waterways. It should be a requirement for British Waterways to be informed of all accidents and hazardous incidents affecting canals and navigations under its control, and for these to be entered on a central database. This would allow trend and risk analyses to be undertaken, so that consideration could be given to how best to manage those risks.

SECTION 3 - CONCLUSIONS

3.1 CAUSE

The cause of the foundering was an uncontrolled ingress of water into *Drum Major* while she was descending in the lock.

3.2 CONTRIBUTORY CAUSES

- .1 *Drum Major* was positioned too far forward in the lock, contrary to the advice provided in the *Waterways Code for Boaters*, which is issued by British Waterways. (2.4)
- .2 The boat moved forward when the lock began to empty, either by the engine being engaged ahead, or by the forward movement of water caused by the bottom paddles being opened, or a combination of both. (2.4)
- .3 The stem was pushed against the top of the lock gate and the bow fender became snagged in the gap between the top of the lock gate and the balance beam above it. (2.3)
- .4 The design of the lock gate and the fender allowed the snagging to occur. (2.3)
- .5 Nobody recognised that the boat was too far forward in the lock. (2.4)
- .6 Although experienced in narrow boats and lock operations, the manager opted to open the top gate paddle, rather than the ground paddle, in his urgency to remedy the emergency situation. (2.4)
- .7 There was a delay in locating the handcuff lock key before the top gate paddle could be opened. (2.4)
- .8 The bottom left-hand paddle was allowed to close only partially under its own weight by someone who was unfamiliar with the normal operating procedure. (2.4)

3.3 OTHER FINDINGS

- .1 It is probable that the metal rubbing band caught on top of the coping stonework, before the boat freed herself, causing the snub nose to splinter the balance beam prior to the fender becoming snagged. (2.3)
- .2 The rapid rate of rising water prevented the disabled people from reaching the forward accommodation doors, even with the assistance of others. (2.7)
- .3 Because of their disabilities, these people were probably unable to escape without assistance. (2.7)

- .4 No lifejackets were carried on board. However, it is doubtful that the outcome would have been different had the disabled people been wearing lifejackets. (2.5)
- .5 The absence of any requirement for accidents and hazardous incidents to be reported to British Waterways prohibits comprehensive trend and risk analyses being undertaken. (2.8)
- .6 It is possible that a weaker fender securing arrangement would have enabled the bow to break free of the lock gate at an earlier stage. (2.6)

SECTION 4 - RECOMMENDATIONS

British Waterways is recommended to:

1. Require all owners of boats using canals and navigations under its control to inform British Waterways of all accidents and hazardous incidents.
2. Consider modifying lock gates/narrow boat bow fendering arrangements to prevent similar accidents in the future if database trend and risk analyses so indicate.
3. Review the adequacy of existing emergency escape routes on board narrow boats, with particular regard to the carriage of disabled, elderly and young persons.
4. Encourage boat owners to fit weak securing arrangements to bow fenders of the type fitted to *Drum Major*.

Marine Accident Investigation Branch
May 1999

Operation of Canal Locks

British inland waterway canals are made up of different levels of water, and locks are used to carry the canal over high ground. The stretch of water between locks is known as a pound and can be anything from a few metres to several miles. When a particularly steep gradient is being traversed, the series of closely spaced locks is known as a flight.

A lock is a stone or brick-built chamber in which the water-level can be raised or lowered. Each has a by-pass weir, which channels excess water around the lock from the upper level pound to the lower pound and maintains the water-level in the canal.

Gates at either end of the lock can be opened one end at a time to let boats in and out. They are angled to resist the water pressure above them and a difference of only a few centimetres in water-levels between one side of the gates and the other can prevent them being opened. Each gate is surmounted by a balance beam which acts as a counterweight to facilitate opening and shutting.

In each gate is an aperture known as a sluice and these are sealed by paddles. When lifted, water flows through the sluice to empty or fill the lock. A gate can only be opened when the water-level on either side of it is the same.

Before entering a lock somebody must check the water in the lock is level with the water in the pound being used by the approaching boat. If not, the levels must be equalised. If they are level, the gate can be opened by pushing on the balance beam. The boat then enters and the gate shuts behind it. A check is made to ensure the paddles in the entry gate are closed.

For descending, the bottom gate paddles are opened and the water drains from the lock into the lower pound. It is then essential that the boat is kept forward in the lock and well away from the upper gate and the sill lying beneath it. The sill usually extends about 1m into the lock and is identified by white paint markings on the side of the lock. Once the water in the lock is the same level as the lower pound, the bottom gates can be opened and the boat is clear to leave.

For ascending, the sequence is almost the same except it is performed in reverse. The boat enters the lock from the lower pound once the levels have been equalised and the bottom gates opened. Once secured in the lock, the gates are shut and the paddles in the bottom gates checked shut. The ground paddles at the top end of the lock are opened first, followed by the top gate paddles when they are submerged. When the water-level in the lock is the same as the upper pound, the top gates can be opened and the boat is clear to leave.

British Waterways - Safety Advice

BRITISH WATERWAYS

British Waterways recommend the following essential equipment is carried on a boat:

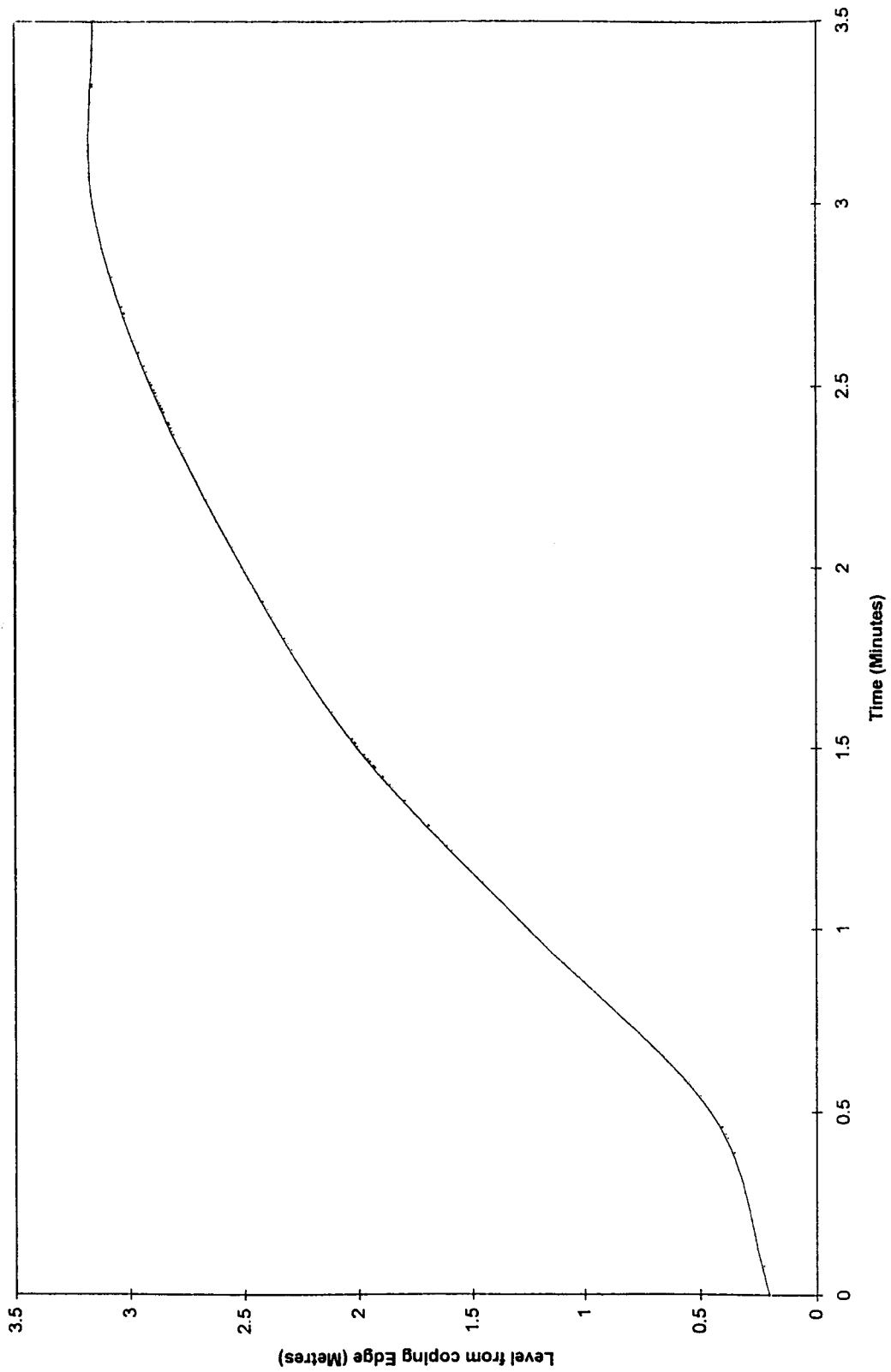
- *a lifebuoy to meet the Department of Transport (now DETR) standards;*
- *a way of getting on and off the boat people can use safely;*
- *a shaft or boathook that is strong enough and long enough for the waterways;*
- *enough mooring ropes of appropriate length and strength;*
- *at least two mooring stakes or pins and a hammer to drive them in;*
- *where the boat is used on rivers, an anchor and chain or rope of adequate length and strength; and*
- *an adequate first aid kit.*

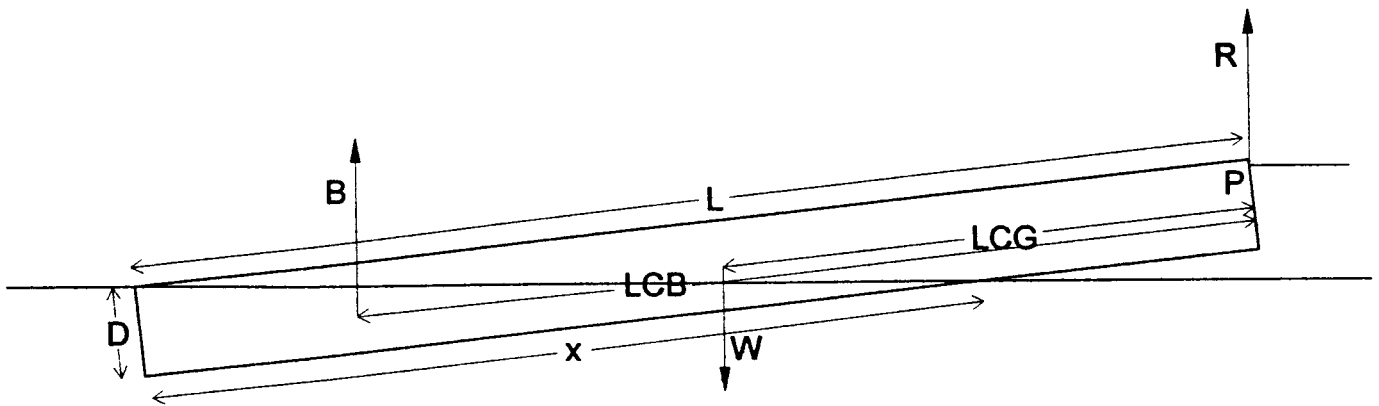
British Waterways also grants a Hire Boat Licence which allows the use of a boat for hire or reward or a promise of payment, and recommends that the equipment above is carried and in addition requires:

1. *Each time a boat is let out, the owner must ensure that the user and at least one other member of the party are:*
 - *competent to navigate the boat safely on the waterways they intend to use;*
 - *told (and, where practical, shown) how to use locks and bridges safely and properly. The owner should warn them about potential dangers of not following these instructions; and*
 - *aware where the safety equipment is on the boat and how to use it.*
2. *The boat must have on board a clearly marked and easily accessible set of documents containing up-to-date:*
 - *safety advice (including British Waterways' Waterways Code for Boaters booklet);*
 - *instructions on how to use the boat and its equipment;*
 - *daily maintenance instructions;*

- *guidance on navigation; and*
 - *emergency contact details.*
3. *The owner must ensure that there is a method for hirers to contact him/her 24 hours a day, including a facility to take messages, if a breakdown or emergency occurs that affects them. The owner must respond within a reasonable time.*
 4. *The owner must maintain a log of all breakdown or emergency calls.*
 5. *The owner must offer the hirer, and everyone in the hirer's party, free use of properly maintained buoyancy aids or lifejackets.*
 6. *The owner must keep a record for the boat of the inspections of it and its equipment or gear and of any work to maintain or repair since the licence was last issued.*

British Waterways' Lock Emptying Rate



DRUM MAJOR - CALCULATION FOR TRIM

R	=	Force holding bow up	
L	=	Length of narrowboat	= 18.5m
W	=	Weight of narrowboat	= 16.0 tonne
ρ	=	Density of water	= 1000 kg/m ³
B	=	Buoyancy force from water	
b	=	Breadth of boat	= 2.07m
θ	=	Angle of trim	
D	=	Depth to top of cockpit	= 1.16m

Taking moments about P, the pivot point.
(Neglecting $\sin \theta$ terms)

$$W.LCG \cos \theta = B.LCB \cos \theta \rho$$

$$W.LCG = \underbrace{\left(\frac{1}{2}.D.x.b. \right)}_{\text{upward force from buoyancy}} [(L-x) + \frac{2}{3}x] \rho$$

$$= \frac{1}{2}.D.x.b. (L-x/3) \rho$$

$$\text{Also } x = D/\tan \theta$$

$$\Rightarrow W.LCG = \frac{1}{2}.D. D/\tan \theta.b. (L- D/3\tan \theta). \rho$$

By achieving a balance between both sides of the equation $\theta = 6.0^\circ$

$$R = W-B$$

$$= 2.9 \text{ tonne}$$