Navigation Act 1912

Navigation (Marine Casualty) Regulations

investigation into the sinking of the off-shore supply vessel

BOA FORCE

on Saladin No.3 wellhead

off Thevenard Island, Western Australia

on 24 February 1994

*

conducted in conjuction with the

Western Australian Department of Transport

and the

Western Australian Department of Minerals and Energy

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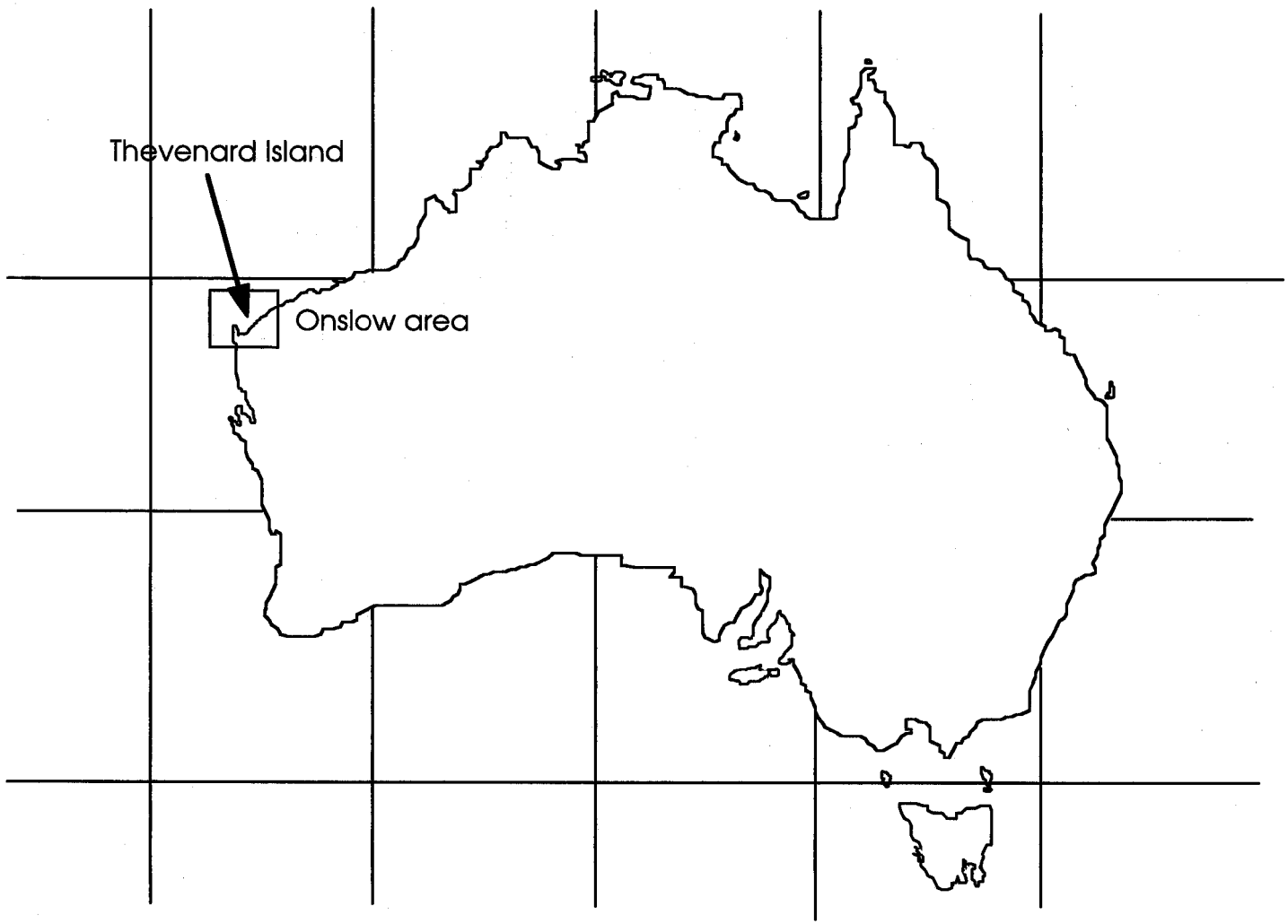


Area of incident

Boa Force after grounding near Thevenard Island

Summary

In the early hours of 24 February 1994, the Norwegian flag (NIS) off-shore anchor handling and supply vessel Boa Force was engaged in deploying anchors from the off-shore construction barge, Support Station III, about half a mile south of Thevenard Island, 11 miles north-west of Onslow, Western Australia.

Anchor handling vessels do not navigate in the accepted meaning of the term, but are directed to go in directions determined by the person controlling the operation on board the parent vessel, in this case, using a differential global positioning system and monitor.

In the immediate area of Boa Force's operation, there was a pipeline, marked at regular intervals with temporary buoys and an unmarked subsea wellhead, standing about 3m high in a general seabed depth of under 8m of water. The well itself was not active and had been capped and suspended for some time. To the west, and about 70m from the wellhead, a new pipeline had been laid, running from oil production platforms to Thevenard Island.

At about 0220 Western Australian Standard Time, Boa Force recovered the barge's number one anchor from close to the wellhead. Those on the barge were concerned with the proximity of the wire to the wellhead. Boa Force was ordered to go in a northerly direction to ensure that the wire was clear, before the barge recovered the wire prior to repositioning the anchor.

At about 0250, while moving stem fnst towards the barge, Boa Force hit the wellhead and holed the engine room space in the only area where the vessel did not have a double hull.

Despite efforts by the Chief Engineer, the Second Engineer and an Integrated Rating, the vessel's pumps could not keep up with the ingress of water. A launch was sent from the Support Station III to stand by Boa Force. A little before 0345, the Master ordered the crew to abandon Boa Force and by 0345 the complement of eleven were on board the launch.

The vessel sank, to the seabed partially supported by the wellhead. A boom was deployed to combat any pollution.

An operation to raise and dispose of Boa Force was completed on 6 April. This involved lifting Boa Force clear of the wellhead, patching the breach in the hull, and recovering all oil and other pollutants. The vessel was then towed beyond the continental shelf and scuttled.

The incident occurred in Western Australian State waters, where shipping is administered by the Western Australian Department of Transport, and the general operation, connected with the petroleum industry, came under the provisions of legislation administered by the Western Australian Department of Minerals and Energy. Boa Force was a "declared vessel" under the provisions of the Navigation Act 1912 and its Australian Master and crew held Commonwealth

qualifications. Therefore, in addition to the flag State, three Australian administrations had jurisdiction to investigate the incident (Commonwealth Department of Transport, Western Australian Department of Transport and the Western Australian Department of Minerals and Energy), however, by mutual agreement the authorities agreed to conduct a joint investigation in accordance with the provisions of the Navigation (Marine Casualty) Regulations.

Sources of Information

The Master and crew of Boa Force

Tidewater Port Jackson Marine Pty Ltd

West Australian Petroleum Pty Ltd

SubSea Diving Services International Australia Inc

Staff of the barge Support Station III

The Hydrographer, Royal Australian Navy

United Salvage

The Australian Maritime Safety Authority

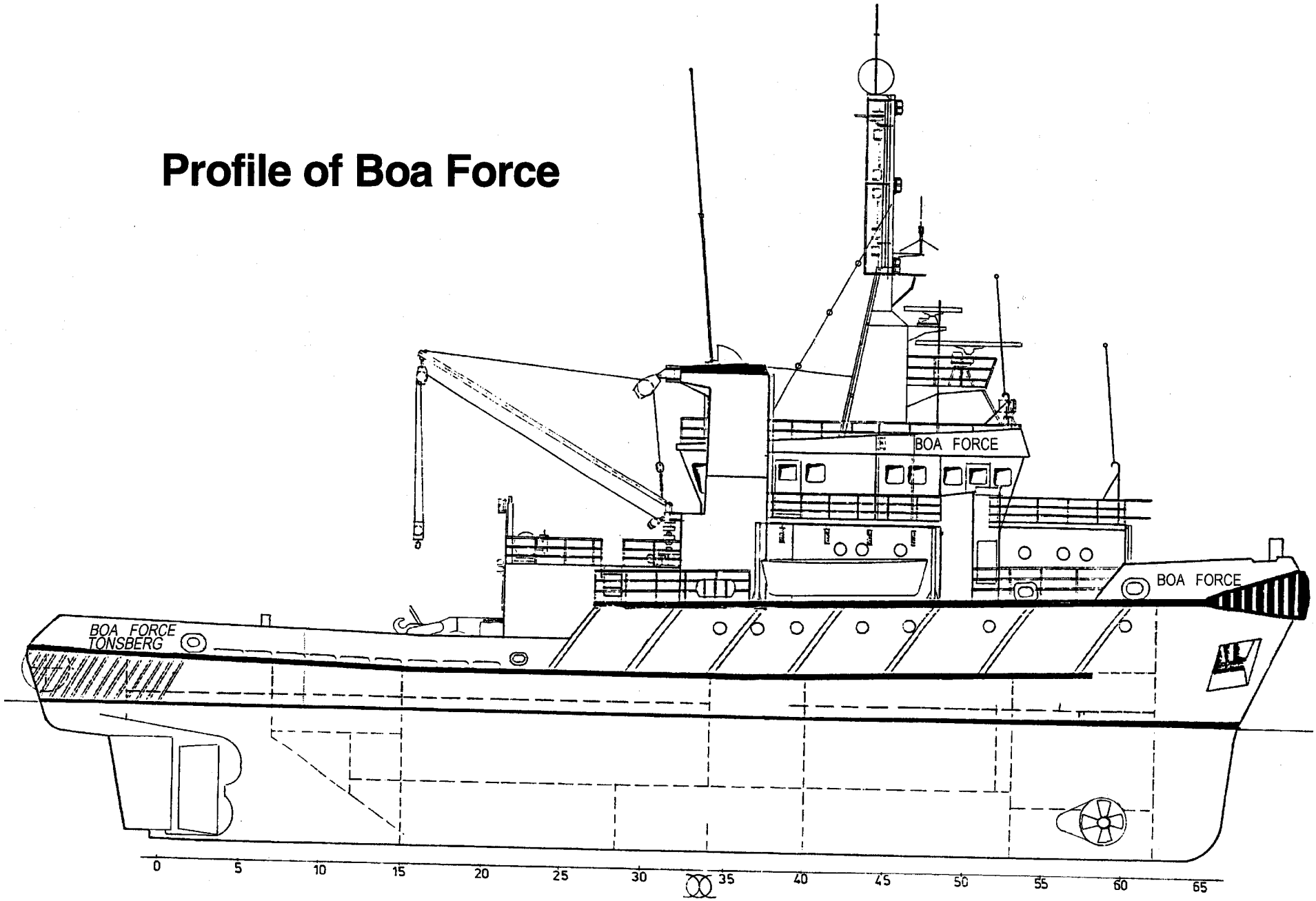
Det Norske Veritas

Australian Surveying and Land Information Group

Acknowledgement

Tidal data is taken from the Australian National Tide Tables and predictions are computed by the Ministry of Defence Hydrographic Office, United Kingdom, Tidal Prediction System, ''Tidecalc''.

Profile of Boa Force



Narrative

Boa Force

Boa Force was built in 1978 by Stort Verlt A/S in Stord, Norway, and launched as Tiwaz for AB Bohus-Tug Ltd, Udevalla, Sweden. It has operated under five different names for five owners. At all times it has been classed with Det Norske Veritas.

As Boa Force, it was owned by WS Leh IX A/S under the Norwegian flag (NIS), and carried an Australian master and crew. It had been on bareboat charter to Tidewater Port Jackson Marine **Pty** Ltd for about three years and it had operated in Australian and South-East Asian waters.

Boa Force was an off-shore tug/supply vessel of 499 gross tonnage, designed for handling the anchors of off-shore drilling rigs and construction barges. It was 43.39m in length, it had a beam of 12.25m, a moulded depth from the main deck of 6.02m and a maximum draught of 4.961m. Propulsion was by twin variable pitch propellers in Kort nozzles, driven by two sixteen cylinder diesel engines with a continuous output of 5 180kW. The engine room was designated an unrnanned machinery space (UMS).

As part of its complement of deck machinery for anchor handling, the vessel was equipped with a hydraulic towing/anchor handling winch, with a bollard pull of about 120 tonnes, and four hydraulically operated towing pins. These were normally operated from the after end of the vessel's bridge.

The wheel house of the Boa Force was about 10.5m in length, with engine control positions at the forward end of the wheelhouse, and on the bridgewings (for normal navigation) and at the after end. For anchor handling operations, the engines, steering, hydraulic towing winch and hydraulic pins, could all be controlled from the after end. The engines and the hydraulic controls, operating the winch and hydraulic towing pins, were normally controlled by a person sitting in a chair on the centre-line, at the after end of the wheelhouse.

With the exception of one gyro compass repeater, all the navigation equipment (radars, gyro compass, echo sounder etc) was at the forward end of the bridge, variously 6m to 10rn from the after conning position. The chart table was about 5.5m forward of the after conning position.

Boa Force operated on a two crew system, each crew of eleven, working about one month on and one month off. To ensure continuity, the Master and Chief Engineer joined together at a different time to the remainder of the crew.

The Master first went to sea in 1959 and had extensive seagoing experience. He first joined the off-shore industry in 1968 for a period of about two years and he rejoined the industry in 1976. He had 16 years command experience in the off-shore industry and held a certificate of competency as Master Class 1. He had sailed on Boa Force as Master before August 1993 and had

sailed regularly on the vessel since September 1993, completing three swings. He rejoined Boa Force on 28 January 1994 with the Chief Engineer. Most of his experience was in anchor handling and off-shore construction work.

The Chief Engineer had 16 years seagoing experience and held a Class 1 Engineer's Certificate. He had been a Chief Engineer for five years and had been Chief Engineer on Boa Force since January 1993.

The Mate held a certificate of competency as a Master Class 2 and had extensive commercial shipping experience. He joined the off-shore industry in 1974 in the North Sea working on tugs, crew boats and rig tenders. He entered the Australian Merchant Marine in 1986 and worked as tug master in various ports around Australia and in the off-shore industry. He joined Tidewater Port Jackson Marine in 1989, sailing as Mate and relieving Master. He had sailed on the Boa Force in 1993 and had rejoined the vessel on 7 February 1994.

The Second Mate held a Master Class 1 Ce cate, had eleven years seagoing experience and spent some time ashore as a marine surveyor for private marine consultants. He had undertaken limited operations off-shore, with two rig moves and a delivery voyage. Boa Force was his first off-shore vessel engaged in construction work, deploying anchors and towing pipelines.

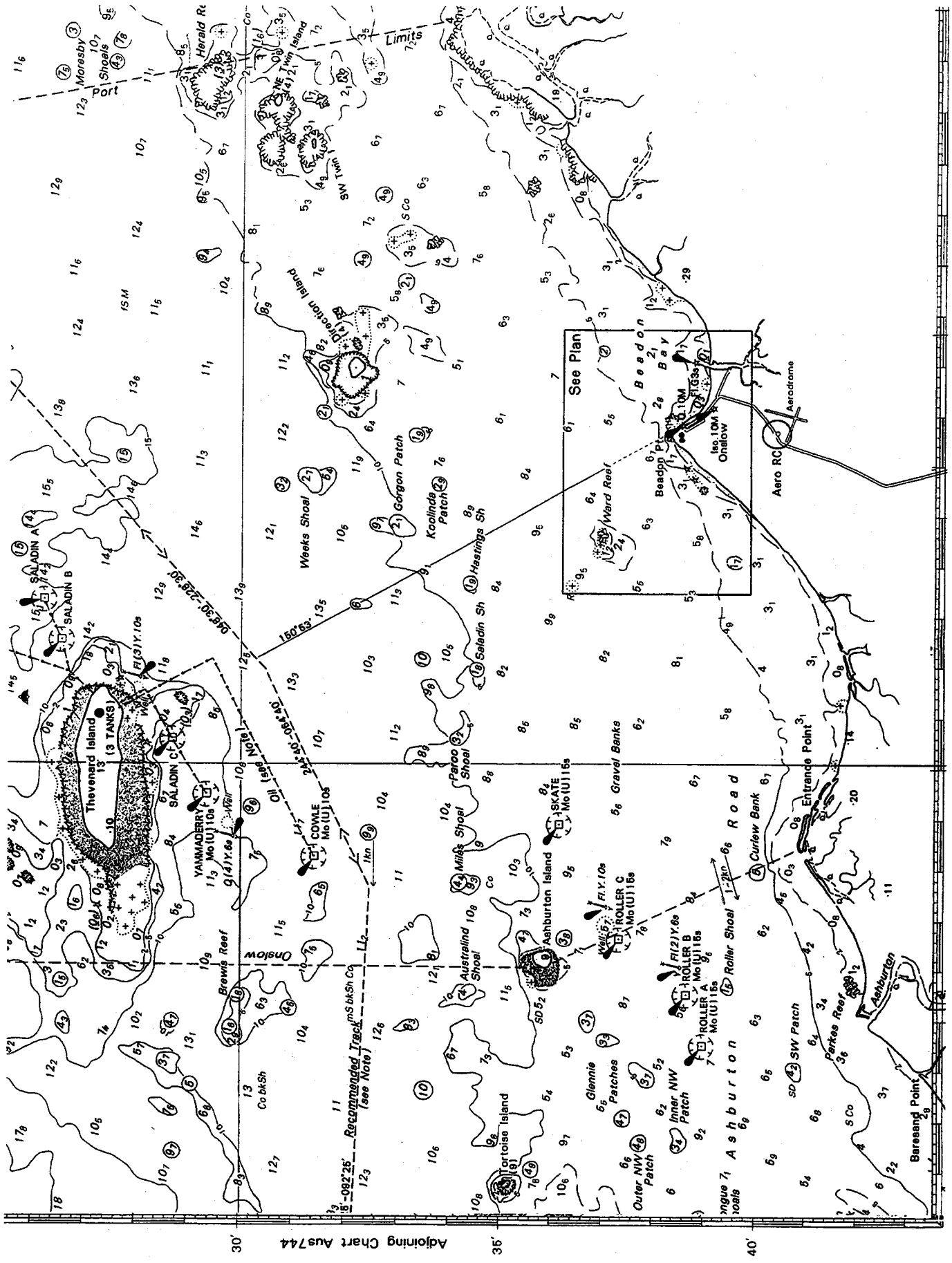
The Second Engineer held a certificate as an Engineer Class 2, he had extensive engineering experience as rig mechanic and second engineer in the off-shore industry. He had over six months experience on Boa Force.

The remainder of the crew involved in this incident, comprising of four integrated ratings and a cook, joined on 8 February 1994. Two of the ratings had considerable experience in the off-shore industry and the Boa Force in particular. The three new ratings proved enthusiastic and proved that they were capable of handling the specialised deck work with wires and anchors.

Off-shore support vessels normally service one geographic area of the off-shore industry for prolonged periods. Their voyages are essentially within State jurisdiction and hence are on intra-state voyages, under State or Northern Territory jurisdiction. However, to allow flexibility in their operation it is open to the operator to apply for a declaration under Section 8A of the Navigation Act 1912, to bring a vessel under the provisions of the Act.

Tidewater Port Jackson Marine Pty Ltd applied to the Australian Maritime Safety Authority (AMSA) for a declaration under Section 8A of the Act, to bring Boa Force under the provisions of the Navigation Act 1912. The declaration was issued with effect from 14 January 1992, following an inspection of the vessel by an AMSA surveyor on 7 January 1992. The declaration was in force on 24 February 1994, and all statutory certificates were valid.

Boa Force had been supplied with West Australian Petroleum Pty Ltd's



Extract from chart Aus 743 showing area of operation.

(WAPET) safety manuals relevant to the operation and their requirements for anchor handling. The Master stated that he read the manuals and had taken the relevant parts in the four manuals, creating a single document for the officers and crew.

The Operation

WAPET had contracted MSJ Joint Venture, on a fixed price contact, to develop the pipeline system from two oil fields, Roller and Skate, situated between 7 and 11 nautical miles west of Onslow, Western Australia, to Thevenard Island and the mainland. The Roller/Skate project includes four unmanned monopod well-heads. The operation involved a number of phases, including the construction and stabilisation of the pipeline system.

Boa Force was chartered to MSJ Joint Venture on 11 January 1994 under the terms of "Supply Time 89" Uniform Charter Party for Off-shore Service Vessels. SubSea International Inc., one of the joint venture partners who had operational control of the construction and stabilisation phase of the pipeline, coordinated the operation from the construction barge Support Station III (SSIII).

A Barge Master was in charge of SSIII and was responsible for construction operations, including the anchor deployment. The Barge Master had 22 years experience in the marine construction industry world wide, in deep and very shallow sea areas and in conditions of extreme tide and current. For 16 years he had direct responsibility for anchor handling from off-shore construction vessels from 50m to over 18Om in length.

Boa Force was involved in towing the off-shore barge SSIII and working with Maersk Supporter. This work included the two vessels working in tandem, dragging the pipeline route with a heavy chain sweep, to remove obstructions, and towing lengths or "strings" of prefabricated pipeline from a construction site near Onslow to the allotted position. The pipe strings were towed at the seabed, attached to special flotation collars which provided neutral buoyancy.

Boa Force also towed SSIII to various locations, where divers from the barge bolted the lengths of pipe together. This involved using an anchor wire from the barge for towing and deploying the anchors as directed by the barge master. The positions of the anchors on the seabed were marked by barrel buoys joined to the anchor by a 50m wire pennant. The wire pennant passed through the anchor buoy (in a "suit-case" system) and ended in an eye. When recovering the anchor, the pennant eye was secured by a messenger and led to the working winch and pulled through the buoy, which remained afloat until the top of the anchor shank engaged the buoy. Both buoy and anchor were hove to the stern roller, and either left there ready for dropping, or brought on deck (decked).

Under the terms of the charter party, specific provision was made to allow the owner, master and crew discretion regarding the safety of any operation that they might have been directed to undertake.

"If Owner determines it is not safe to perform any services as requested under any given conditions, Owner shall immediately notify the Charterers of such unsafe condition, and shall not engage in any activity which may cause damage or loss of life or property. Owner, its Master and Crew have the sole discretion, authority and last word as to whether any request of the Charterers should or should not be carried out. Owner, its Master and Crew, shall not under any circumstances, undertake any task or request of the Charterers which it or they shall deem unsafe; and Owner, its Master and Crew shall have the responsibility not to undertake any task which it shall deem improper or unsafe."

The Roller/Skate operation involved work in shallow water off both Onslow and Thevenard Island, requiring detailed bathymetric surveys of both the pipeline route and any towage route where it was necessary to tow clear of existing pipelines and subsea obstructions. The towing and positioning of the pipeline was co-ordinated by specialist "tow masters" operating from Maersk Supporter.

Once the bolting together of the pipeline strings had been completed on the seabed, the pipeline had to be "stabilised" by burying it in a trench to an approved depth. This operation, "sledging", is undertaken by equipment that straddles the pipe. Very high pressure water is forced through the "runners" of the sledge on either side of the pipe, creating a slurry of the bottom material and a trench into which the pipeline subsides.

As far as possible, pipelines are run adjacent to other pipelines, so as to minimise the area of hazard and enhance safety. Where pipelines are laid adjacent to other lines, they are laid 5m apart. In the case of the Roller/Skate project the pipeline was being laid adjacent to the Saladin "C" pipeline and the Cowle pipeline, which meant that the Roller/Skate pipeline was laid adjacent to at least one other "live" oil pipeline for a distance of 3000m South-south-east from Thevenard Island.

When operating on off-shore construction projects and positioning pipelines or anchors, great precision and careful planning is required. Accurate positioning is obtained through a differential global positioning system (DGPS) utilising the United States military Navstar GPS. Both the barge and support vessels were equipped with DGPS. In the case of the Boa Force, the DGPS position was configured to show the position of the vessel's stern roller, whereby the position of the barge's anchor, carried at the stern, could be monitored and an accurate position of where the respective anchors were dropped could be obtained.

Masters of anchor handling vessels do not navigate in the normally accepted terms of the word. Navigation, as practised by trading vessels, would be impracticable given the scale of charts,

the relative coarseness of standard ships' position fixing equipment, the lay-out of the wheelhouse and the need to respond immediately to directions from the parent vessel.

In the construction operation, the barge master and surveyors pre-planned the anchor positions and patterns, which had to be approved by WAPET. The support vessel was directed to place anchors in the pre-planned positions. The master or officer conning the support vessel usually operated from the after control position, away from the normal navigation aids such as radar, navigation charts and echo sounder. The support vessels were directed, as to the direction in which they had to go and when they were to drop the anchor, by the person controlling the operation from the parent vessel, usually the surveyor or barge master. Although support vessels may be equipped with survey charts and DGPS, while engaged in anchor handling they do not usually have any detailed knowledge of the anchor or pipeline position, but rely overwhelmingly on the directions given by the surveyor or other people on the parent vessel and, to a lesser extent, on marker buoys and DGPS monitor screens which provide a visual reference or display of the position of the support vessel.

Under WAPET's operating procedures, no construction or anchor laying operations were allowed to be carried out within 200m lateral distance or within 5m vertical distance of any pipeline or subsea structure. Also, when anchors were carried over pipelines or subsea structures, there was a requirement for the anchor to be carried on deck to prevent accidental release and danger to the subsea installation. On-the-spot exemptions from this requirement could be given by WAPET through their representative working with the Contractors, but in any event no work was allowed within a lateral distance of 10m. Detailed surveys of the areas of operation, including the position and depth of subsea constructions, were therefore an integral part of any specification for conducting such work.

The navigation charts of the area issued by the Hydrographic Office of the Royal Australian Navy, chart Aus 743 Barrow Island to Onslow and chart Aus 744 Exmouth Gulf and Approaches, are on a scale of 1: 150,000 and do not contain sufficient detail for the specialised operation.

The WAPET project team co-ordinated a detailed survey of the pipeline routes on a scale of 1:10,000 and had in their possession a bathymetric survey of the area on a scale of 15000. These were conducted by survey companies engaged by WAPET and included drawing B-72201-L ''Offshore - Thevenard Island Subsea Pipelines Alignment Sheet'', at a scale of 1:5000.

SubSea International commissioned their own survey of the the pipeline routes, completed by a private contractor. This included the survey on a scale of 1:10,000 ''Roller Skate Tow Out Route Survey'' which included composite chart 5, drawing A 2166-6.

The tenderers were provided with the WAPET surveys in September 1993.

Contractually, it was the successful tenderer's responsibility to check the data given and undertake such other surveys as required to safely undertake the operation. It was therefore the responsibility of MSJ Joint Venture to ensure that the necessary information for the project was available and that the Sub-contractors, including Boa Force, also had accurate information concerning the operation. By the same token it was WAPET's responsibility to endeavour to ensure that the information they provided to the contractors was correct.

The Contractors marked the position of the existing pipelines and subsea well-heads associated with the Roller/Skate project with temporary buoys, as required under the conditions of the contract.

Operations 11 January to 0001 on 21 February 1994

The initial operation was under the direction of the Tow Masters, experts engaged from Smit Engineering of Rotterdam. They were part of the complement on board the Maersk Supporter and directed the pipelaying operation.

The general area of work lay in shallow water of less than 10m, between Urala Beach, south of the Ashburton River, and the shoal water surrounding the Roller/Skate monopods and Thevenard Island.

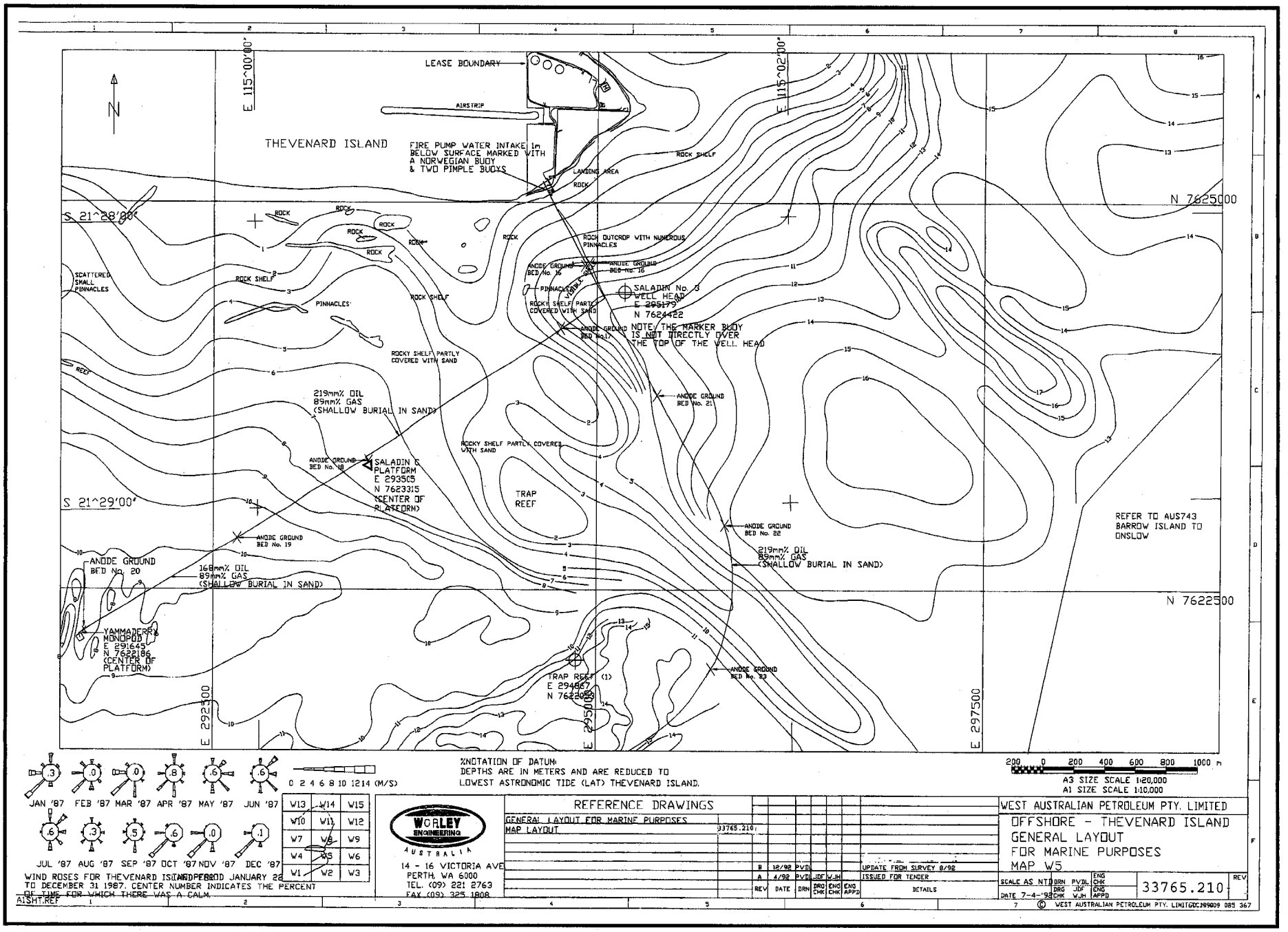
Boa Force, at a deepest draught of between 4.5m and 4.8m, operated with the larger Maersk Supporter (draught about 6m). When necessary, the two vessels operated in tandem, sweeping the pipeline route with a heavy chain and deploying strings of pipeline, some as long as 4km in length, from a site on the mainland at Urala Beach, to the planned position. Boa Force, being of shallower draught than Maersk Supporter, was able to operate in marginally shallower water.

Between 11 January and 8 February, Boa Force was involved in a number of potential or actual incidents.

In late January, the vessels were sweeping the pipeline route, when the Second Mate on Boa Force saw a wave-rider buoy ahead on the sweep path. The Tow Master, overseeing the operation on board Maersk Supporter, ordered that the sweep be aborted as they were concerned that the buoy may have been marking an uncharted wellhead. In the event it was established that it was not a wellhead and the operation resumed.

Also, on 28 January, a small fire in the Boa Force's bow thrust compartment, (resulting in the loss of the bow thrust motor for about three weeks), delayed bottom sweeping operations for eighty five minutes.

There were also a number of incidents in which Boa Force "touched" bottom, while picking up the pipe strings and while delivering the string to the beach at Thevenard Island. Maersk Supporter also touched bottom on at least one occasion. These incidents reflected the restricted water depth close to the pipeline construction site and close to Thevenard Island, in which the vessels had been operating for seven weeks. A further incident,



Survey drawing 33765.210

when Boa Force was alongside the SSIII and fouled an anchor wire pennant, made it necessary for divers from the barge to cut the wire free of the vessel's Kort nozzle. This coincided with a time when the bow thruster was inoperative. The incidents were noted in the vessel's log book, copies of which were sent routinely to Tidewater Port Jackson Marine.

These incidents and the mechanical performance of the vessel caused the Barge Master to facsimile MSJ Joint Venture on 3 February, complaining about the handling of Boa Force while engaged in anchor and tow work, and while alongside SSIII.

SubSea International sent a number of facsimiles to Tidewater Port Jackson Marine relating to personnel and mechanical problems, which resulted in a meeting between the two companies. This meeting did not address the specific issues raised by the Barge Master, but related to issues of lost time injury to the crew aboard Boa Force. The officers, ratings and cook were changed on 7 February as part of the routine "swing" system, and the vessel under the new swing operated apparently without incident until 24 February, although the bow thruster unit remained inoperative until about 16 February, when new electrical breakers were fitted.

On 18 February, the laying of the pipeline was finished and Maersk Supporter completed its charter and left the operation.

The engineers on Boa Force, together with the ratings, were constantly involved in maintenance of equipment. On 19 February, the ballast pump, with a capacity of about 40 tonnes per hour, was sent ashore for repairs to the electrical motor, which could not be completed on board. This left three other engine room pumps, each rated at about 40 tonnes per hour, which adequately covered the required pumping capacity on board.

On Saturday, 19 February, both the Barge Master and WAPET's representative were particularly concerned that the barge did not have detailed soundings of the area of Trap Reef, where the pipeline passed close to shoal water, as drawing B 772201-L gave insufficient detail of that particular area. They did not have a suitable survey drawing on board with which to plan the deployment of the anchors in the area of Trap Reef, as anchor wires could extend about 500m or more from the barge. The route drawing (A 2166-6) showing the tow routes to position the pipeline, detailed an area no more than 150m either side of the projected pipeline position, did not show the position of Saladin No.3 wellhead and was unsuitable for laying out anchors from SSIII during the stabilisation operation.

As it was a Saturday afternoon, the WAPET representative telephoned a colleague, who lived near to Perth's city centre, and asked him to go to the office and find a suitable drawing for the operation. The colleague secured a survey drawing on a scale 1:10000, with the bathymetric datum stated to be based on lowest astronomical tide (LAT). This was the only drawing that he could find and it was sent by facsimile to Thevenard Island, together with the explanation that his access was limited to the floor on which he worked.

Later on that day at 1730, a meeting was held on board SSIII, which included the, the Barge Master and the Master of the Boa Force, but did not include the Contractor's surveyors. The forthcoming stabilisation operation and safety issues were discussed in accordance with WAPET's "job safety analysis" procedure. The Master was given a copy of the drawing facsimile from Thevenard Island to south of Trap Reef wellhead.

Once back on the Boa Force, the Master highlighted all critical depths on the drawing, using orange for any area of 6m and bounding in red all areas less than 5m datum, as he had done with his other working drawings and plans. The drawing showed that Saladin No.3 wellhead was just inside the 9m depth contour in a depth of about 8.8m. He had been told that the well was 2.5m in height.

Just after midnight on 20 February, Boa Force recovered SSIII's no.1 anchor, decked and secured it, then used the anchor wire to tow the barge to a new position. The tow lasted about four and a half hours after which the anchors were re-deployed on the seabed. At 1005, Boa Force again recovered no.1 anchor, secured it on deck and towed SSIII for a further hour to a position about 1200m to the south-south-east of Thevenard Island jetty, in about 9.6m of water, over or adjacent to the newly laid pipeline, to allow the testing and subsequent stabilisation (burying) of the pipeline to start.

At about 1055, Boa Force dropped no.1 anchor, at the direction of the Barge Master and Surveyor*, to the east of the subsea wellhead, Saladin No.3. The WAPET representative reviewed the position of the anchor in relation to the wellhead and he considered that the operation of deploying the barge over the pipeline could bring the anchor wire to no.1 anchor in contact with the wellhead. Although the anchor position accorded with the agreed plan, at the verbal request of WAPET representative, the Barge Master directed Boa Force to recover the anchor and reposition it south and west of Saladin No.3 wellhead.

Boa Force lifted the anchor at 1122 and followed the directions from SSIII to the new position. Boa Force's log book contains a notation for 1135;

"TOUCHED BOTTOM RUNNING No 1 ANCHOR

No.1 Anchor was dropped at 1139. According to the DGPS monitor on SSIII it was just 30m south and west of the wellhead and 68m from the pipeline. The wind at the time was from the south-west at about 4 knots, with calm conditions and no swell.

The anchor handling operation was completed at 1420, after which Boa Force went to anchor.

The start of the stabilisation of the pipeline and other preliminary work was delayed, over the next few days, by strong winds.

On 23 February, Boa Force was engaged in anchor handling for a little under three hours from about 1115 to

* A number of surveyors were engaged for the project, and different surveyors were involved at different times of the operation.

about 1400, and again from about 1800 to 1845. Otherwise the vessel remained at anchor.

Operations on 24 February

At about midnight on 23/24 February the barge was ready to reposition and start the sledging operation.

A little after 0001 on 24 February, the rating on watch on Boa Force was called by a foreman on SSIII. He was asked to ready the vessel for anchor operations and prepare to pass two 85 tonne safe working load shackles (each about 40kg in weight) to a work boat. The Second Mate was called, who in turn called the duty engineer and the Master. The wind at that time was west by north averaging about 13 knots, with wind gusts of 19 knots and there was a swell of 0.3m. It was overcast and drizzling.

Upon request from SSIII, the Second Mate looked up the Onslow tidal predictions and relayed them to the surveyors on the barge.

Boa Force weighed anchor at 0024 and, after what seemed to the crew to be some indecision on the part of those on SSIII, the vessel was ordered to go alongside and deliver the anchor shackles to the barge. This was completed at 0100. At 0150, Boa Force was instructed to reposition no.2 anchor. By 0154 the anchor was secured at the stern roller and, following the directions of the Surveyor working from the DGPS monitor, the anchor was successfully repositioned at 0206. Boa Force was then directed to reposition no.1 anchor, the anchor that had been repositioned south and west of Saladin No. 3 wellhead on the morning of 20 February, to move it closer to the barge.

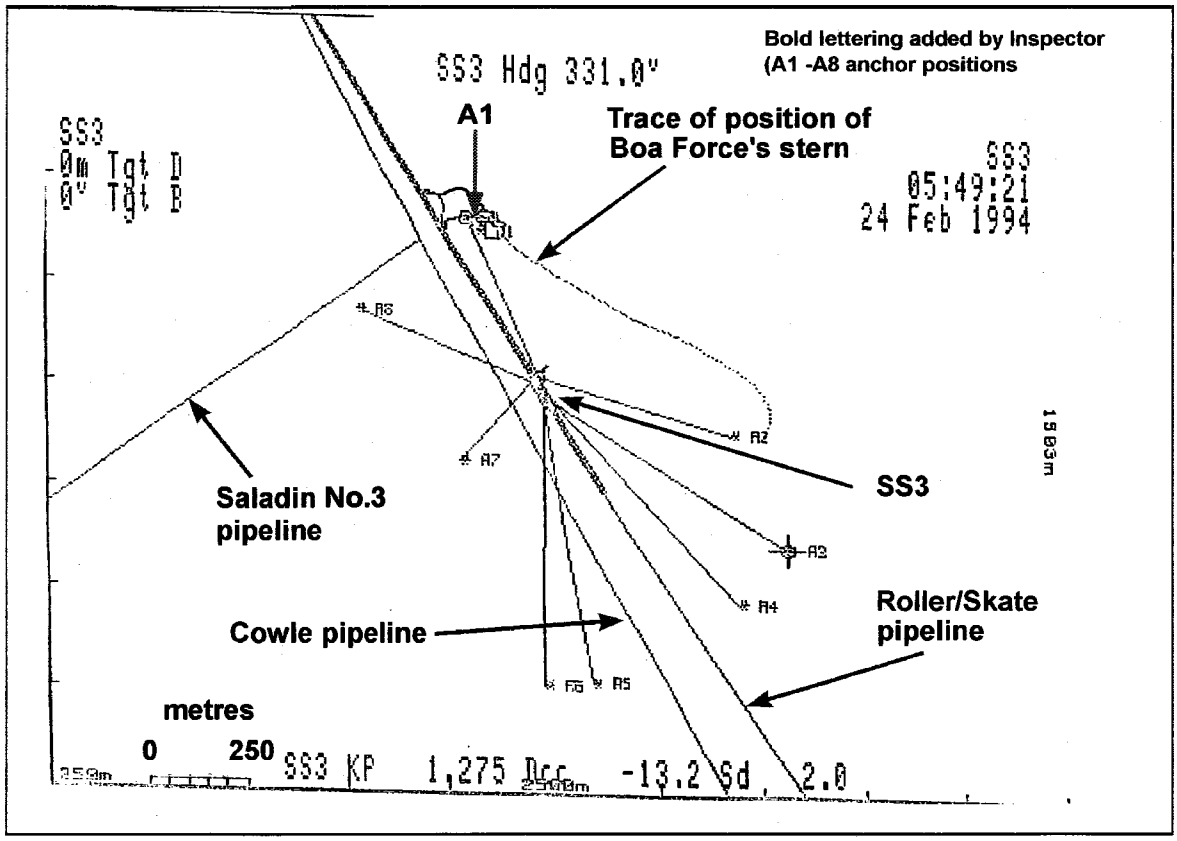
Boa Force approached the anchor buoy stern first from the south and east. The two rudders had been locked, angled toward the centre line at about 30 degrees, the Master was seated at the after engine controls steering the vessel with the pitch of the propellers and, where necessary, the bow thruster. The Second Mate stood on his left hand side controlling the winch.

Working in what was, according to the working survey drawing (33765.21), about 9m of water, the 50m wire anchor pennant was secured to the working winch and the slack taken in. At 0218, the anchor was on the stern, together with the anchor buoy. From the weather records monitored by Thevenard Island weather station, situated about 1500m to the north, the wind at the time was averaging 14 knots gusting to 18.8 knots. High water at Thevenard Island (Saladin Terminal) was predicted at 2056 on 23 February (2.1m) and low water at 0400 (0.8m), the tide was ebbing to the south-west at about 0.3 knots. At 0220 the height of tide above datum was 0.95m.

The Surveyor on SSIII, stationed in the control room, was able to track the position of Boa Force's stern on the DGPS monitor. While the anchor was being recovered, the Surveyor estimated from the monitor that the vessel's stem was only 10m from the wellhead and he was concerned that, with the slackening of the anchor wire

Printout from SSIII DGPS monitor

Showing deployment of anchor from SSIII and route followed by Boa Force



and lifting the anchor, the vessel had drifted to the east and the anchor wire may have fouled the wellhead.
Boa Force was informed that the wire might be around the wellhead. The Barge Master, stationed on deck at the anchor winch, and the surveyor combined to direct Boa Force, in a generally anti-clockwise direction, to the north-west to ensure that the anchor wire was clear of the wellhead, before the anchor and Boa Force were winched back towards the SSIII.

Both the Master and Second Mate stated that Boa Force followed a steady stream of instructions from the barge, directing Boa Force north-west, then to the north and finally to the west. Boa Force at this time was about 550m to the north and west of SSIII. Boa Force was then told to back down towards SSIII as the wire was clear and that the pull back to the barge would start. By this time Boa Force was close to the pipeline and was instructed to go to starboard, so that the vessel would not cross any pipeline with an undecked anchor. This instruction was followed and Boa Force came slowly south as SSIII took up the slack anchor wire.

The Master of Boa Force had limited points of reference, having one unlit "Norwegian" buoy marking the pipeline, which could be seen by those on Boa Force and the barge itself. He endeavoured to keep Boa Force aligned fore and aft with SSIII. Boa Force had backed about 150m towards SSIII, and was just north and west of Saladin No.3 wellhead,when it was directed to go to starboard, as the DGPS on the barge indicated that Boa Force was again closing with the pipeline. Boa Force was then told to go to port as it was closing the Saladin III wellhead. According to the Barge Master and the Master of Boa Force, shortly afterwards the Master was informed by SSIII that Boa Force was clear of the wellhead and the barge would pull Boa Force back to the barge.

At this time the Master felt a slight bump, similar to a slight bottom contact. Thinking that the vessel may be touching the bottom, he told SSIII to keep recovering the wire and, after about two or three minutes, the anchor wire broke the surface so the Barge Master, who had remained on deck by the winch, commented "that you could walk across without getting your feet wet." This showed that the wire was not fouled on the wellhead, the vessel however, had not moved and was firmly lodged on an obstruction.

At 0257, the Second Engineer, who was sitting in the mess room having just returned from answering an alarm in the engine room, was alerted by the bilge alarm. He went to the engine room and found water entering the space apparently from below the starboard engine. He immediately informed the Master and called the Chief Engineer, started the bilge pump and stopped the starboard engine. The Master reported the incident to SSIII and he was instructed to put the anchor on the bottom and attend to his emergency. This he did.

The Chief Engineer went straight to the engine room when telephoned by the Second Engineer. On arrival he found the water was already rising round the starboard engine gear box. He rang the Master and told him that they had a serious problem.

At about 0305, the Master instructed the Second Mate to go to each cabin and call those crew that were sleeping and tell them, together with the remainder of the crew, to muster on the bridge with life jackets.

As there were only five crew known to be off duty, the proximity of the cabins and the fact that the full extent of the emergency was not known, he did not use the emergency alarm. The Second Mate went to call the crew and told one of the duty ratings to assist. All the crew, with the exception of the Chief and Second Engineers and the Integrated Rating assigned to the engine room, mustered on the bridge with their life-jackets.

The Master and those on SSIII realised that the vessel may have struck the Saladin No.3 wellhead. The Master called SSIII to request the diving launch Dolphin Diver to stand by in case it was necessary to abandon ship.

The three engine room staff were in the engine room trying to bring pumps into action to counter the ingress of water. The engineers were able to start the fire pump and the fire and deck wash pump, in addition to the bilge pump.

The Chief Engineer collected all the pipeline diagrams and, assisted by the Second Engineer and rating, explored ways of bringing other pumps to draw from the bilge, particularly the two high capacity fire monitor pumps. They were hindered to a degree, as all the plans were in Norwegian. To utilise the two fire monitor pumps would have meant breaking the line from the foam tank and cutting a hole in the pipe system so that they could draw from the bilge. The engine room rating went to the starboard side and marked the water level on the gear box. The rate of ingress was such that there was not time to improvise pumps and, as the water rose, the Second Engineer first stopped the starboard electric generator, shortly after he stopped the centre of the three generators.

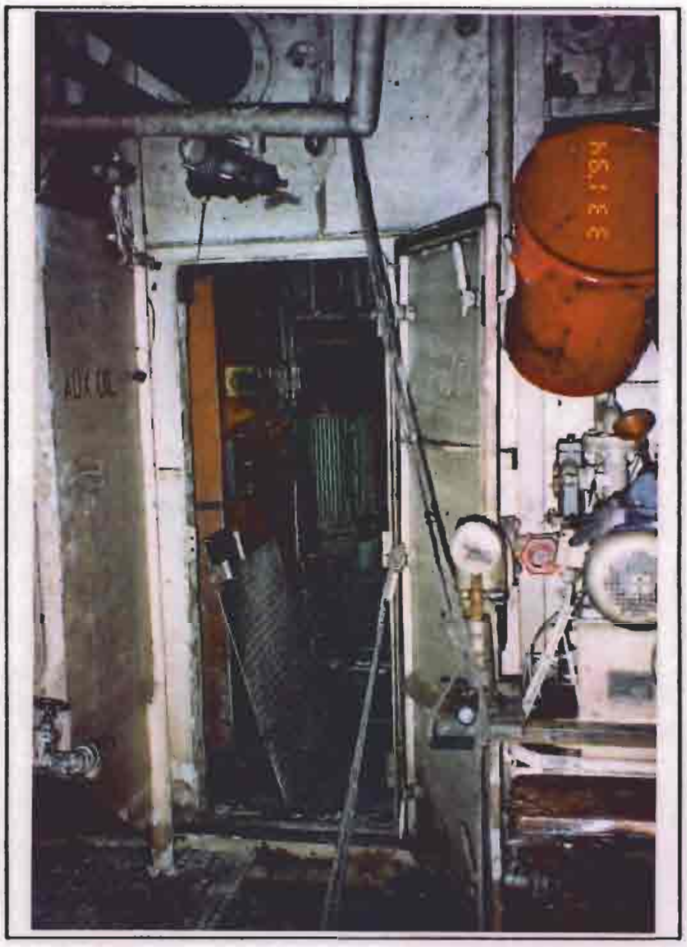
So as not to distract the engineers in their efforts, the Master sent the Mate to the engine room to make an up-to-date assessment of the emergency. He returned to the bridge and reported that the water level was rising rapidly. At 0320, the Master instructed all the crew to gather essential personal belongings. Both those on the bridge and those in the engine room went to their cabins and secured essential items. The deck crew returned to the bridge within three minutes and the engineers returned to the engine room.

The vessel took a significant list. The Chief Engineer was concerned for the safety of life and rang the Master, telling him that the water could not be contained. The Master called in the launch and instructed the crew to abandon ship. Those in the engine room went to the deck, leaving the starboard generator running, to provide light for the abandonment. By this time the launch, was alongside Boa Force.

The crew of the launch were concerned that the wellhead might be "live" and urged the crew to hurry. At 0345, all crew left the ship safely and without any panic, by stepping from the starboard side of Boa Force onto the launch. They were all taken to SSIII.

Subsequent examination by divers established that the Saladin No.3

wellhead had punctured the port side of the bottom plating of Boa Force, in way of the engine sump between frame **18** and 19,10.20m forward of the port rudder stock. They also reported to the Barge Master that the anchor was about 30m south of the wellhead, about 15m from Boa Force's stern. At the time of the incident Boa Force had 241,500 litres of light diesel oil and 1910 litres of lubricating oil on board in double bottom and side tanks.



Forward bulkhead door, showing six securing dogs

Aft bulkhead door showing two securing dogs

Well-head Cap

Comment and Analysis

Performance of Personnel

Following the incident, various parties raised doubts relating to the performance and effectiveness of some of those involved.

The Barge Master had many years experience and his appointment by MSJ Joint Venture was testament to his ability. Those on Boa Force found him professional and easy to work with.

Similarly the Surveyors had wide experience in off-shore construction operations and there seems to be little doubt on their competence or effectiveness. However, the sweeping operation of late January, when the operation was suspended after the Surveyors suspected the presence of a wellhead, caused some comment on Boa Force, as to the thoroughness and quality of the survey.

The Master of Boa Force was involved in two incidents which led to the Barge Master reporting on the competence of the Master and crew and the reliability of the vessel itself; the fouled propeller on 2 February and the incident off Urala Beach of 3 February.

Boa Force's Master had wide experience and was well thought of as a highly competent off-shore operator. It is not unusual for relatively minor mishaps to occur from time to time and in the case of the fouled propeller, this may have been such an incident. There were limited areas for vessels to come alongside, given that only certain areas of SSIII's hull protected by fendering, and that Boa Force's bow thruster was inoperative. Also, the Master of the Boa Force attributed the incident to the crane operator, who reportedly lowered the pennant into the water after being instructed to keep it clear.

The second incident involved an operation under the direction of the Tow Master on Maersk Supporter, when in extreme shallow water and securing a pipe string tow line from the shore. This was typical of the task in hand and does not reflect on the Master's competence.

Of greater concern to the Inspector, was the failure of the Master to check the survey drawings available to **him** after Boa Force had apparently touched bottom on 20 February. The Master dismissed this contact as one of ''touching'' a coral pinnacle, which could be expected to collapse with such a contact. He did not report the incident to the staff on board the barge and, other than noting it in the log book, took no other action. Had he checked, he would not only have established that Boa Force had probably come into contact with the wellhead, but also that the chart datum was inaccurate. However, rather than an issue of competence, this relates more to the conditioning of masters of off-shore vessels and their reliance for proper directions from the parent vessel.

The Master worked long hours on the bridge, recognising that the Mate's experience in anchor handling was limited, and the Second Mate had none. Up until 24 February, Boa Force was under the direction of SSIII, some days working 18 or more hours, other days less hours, depending on what was required. Recognising that once the stabilisation phase was started the vessel would be operating on a 24 hour basis the Master had arranged a system whereby either he or the Mate would be on the bridge at all times while manoeuvring.

On 23 February, Boa Force had remained at anchor until 1117 and had anchored again at 1845. The ratings took the watch and the Master and Mates were able to rest. The Master stated that he went to bed at about 2100, realising that he may be required early in the morning. He was called three hours later.

It is recognised that a seagoing life usually involves long hours of duty. This is particularly true of the off-shore industry, particularly in construction work, which can involve a disruptive sleep pattern. The Master accepted the routine as "part of the job". However, the Inspector cannot rule out the possibility of fatigue, as one of the many elements that contributed to the incident, and particularly of chronic fatigue as a possible explanation for the Master failing to investigate why Boa Force apparently touched bottom at 1135 on 20 February, in an area where, according to his base data, there should have been sufficient water.

Position of Saladin No.3 Wellhead

The co-ordinates of Saladin No.3 wellhead were recorded on a "Well Location" form, dated 25 August 1988, based on Australian Geodetic Datum 1984 (AGD84), giving a position in Eastings* 295178.618 and Northings* 7624422.541. This equated with a position of 21°28' 15.589"s 115" 01' 23.672"E.

The Eastings and Northings used by the surveyors to fix the position of the wellhead, obtained from earlier surveys, were within 0.5m of the true position of the wellhead.

To fix the position of the barge and support vessels relevant to the survey drawings, SSIII was fitted with a satellite based global positioning system (GPS) which uses World Geodetic System 1984 (WGS84) as datum. To achieve the required accuracy, a supplementary shore based station was set up at a known position so that the differential between the actual position and the satellite position could be computed, thus creating a DGPS system, accurate to plus or minus 3m, providing that the distance between the local differential station and known geographic points were absolutely accurate. Two differential stations had been set up for the operation, one on Ashburton Island and the other on Thevenard Island. For the operations in the area of Saladin No.3 wellhead, the station on Thevenard Island was in use. The

* Eastings and Northings refer to map projection co-ordinates of the "Universal Grid Reference.

positioning obtained should have been within the plus or minus 3m required.

The support vessels were also fitted with DGPS and their position relative to the barge and the survey drawing could be monitored by the surveyors on the SSIII, with updates every three seconds.

However, WGS84 and AGD84 do not have a common datum and a correction of about 90m in latitude and 160m in longitude must be made to the incoming GPS signal. This adjustment can be made by programs within the computer software of a GPS receiver, based on known local datum points, to convert GPS latitude and longitude to AGD84 datum. However, the accuracy of the conversion may vary, depending on the distance of the receiver from the common local datum.

The transformation parameters used by SubSea International to transform from WGS84 datum to AGD84 were the standard transformation parameters supplied to SubSea International by the Geodetic Office of the Department of Land Administration, Perth (Attachment 2). No evidence was presented to suggest that the transformation parameters were in any way inaccurate.

Minor variations in GPS positioning may also arise through a change in the satellite constellation "visible" from SSIII. Although the GPS constellation between 1100 and 1200 on 20 February and between 0200 and 0300 on 24 February involved different satellites, there were sufficient available at a reasonable altitude on both occasions to provide an accurate GPS position, any variation in the satellite positions would have been nullified by the differential station on Thevenard Island.

There does seem to be some evidence that there was uncertainty as to wellhead plotted position. Those in control of the anchor operation on SSIII on 20 February, allege Boa Force over-ran the no.1 anchor target position to the east and north, and this made it necessary to redeploy the anchor, yet they did not detect that Boa Force may have made contact with Saladin No.3 wellhead while repositioning no.1 anchor, or appear concerned during the repositioning. The Master of Boa Force maintained that the anchors were dropped when instructed as soon as the order was given at the end of a count-down received from SSIII.

Again, on the morning of 24 February, they found that the stem of Boa Force, while lifting the anchor, was only 10m from the wellhead, indicating that the vessel had again overrun the target anchor position. This is supported by the perceived uncertainty of the position in which the anchor was dropped as well as the initial uncertainty of the actual distance of the vessel's stern from the wellhead when it subsequently struck on 24 February. It cannot be determined with absolute certainty whether or not the positioning system was giving variations in the position of Saladin No.3 wellhead.

Charted Depth

The Australian Hydrographic Office chart Aus 743 Barrow Island to Onslow and chart Aus 744 Exrnouth Gulf and Approaches, are on a scale of 1:150,000 and did not have sufficient detail for either the pipe laying or stabilisation operation.

WAPET had undertaken surveys of the area as part of the pre-operation planning; however, under the terms of the contract with MSJ Joint Venture, there was a responsibility on the Contractor to ensure that the survey was correct and that any other survey necessary to complete the operation safely was undertaken. It was therefore the responsibility of SubSea International to supply working plans, or drawings, or charts showing accurate bathymetry and the location and depth of hazards, including pipelines and well-heads. SubSea International completed surveys of the tow out routes and submitted them to WAPET for acceptance.

Boa Force had three sets of bathymetric data, relevant to this investigation, provided by the Contractors.

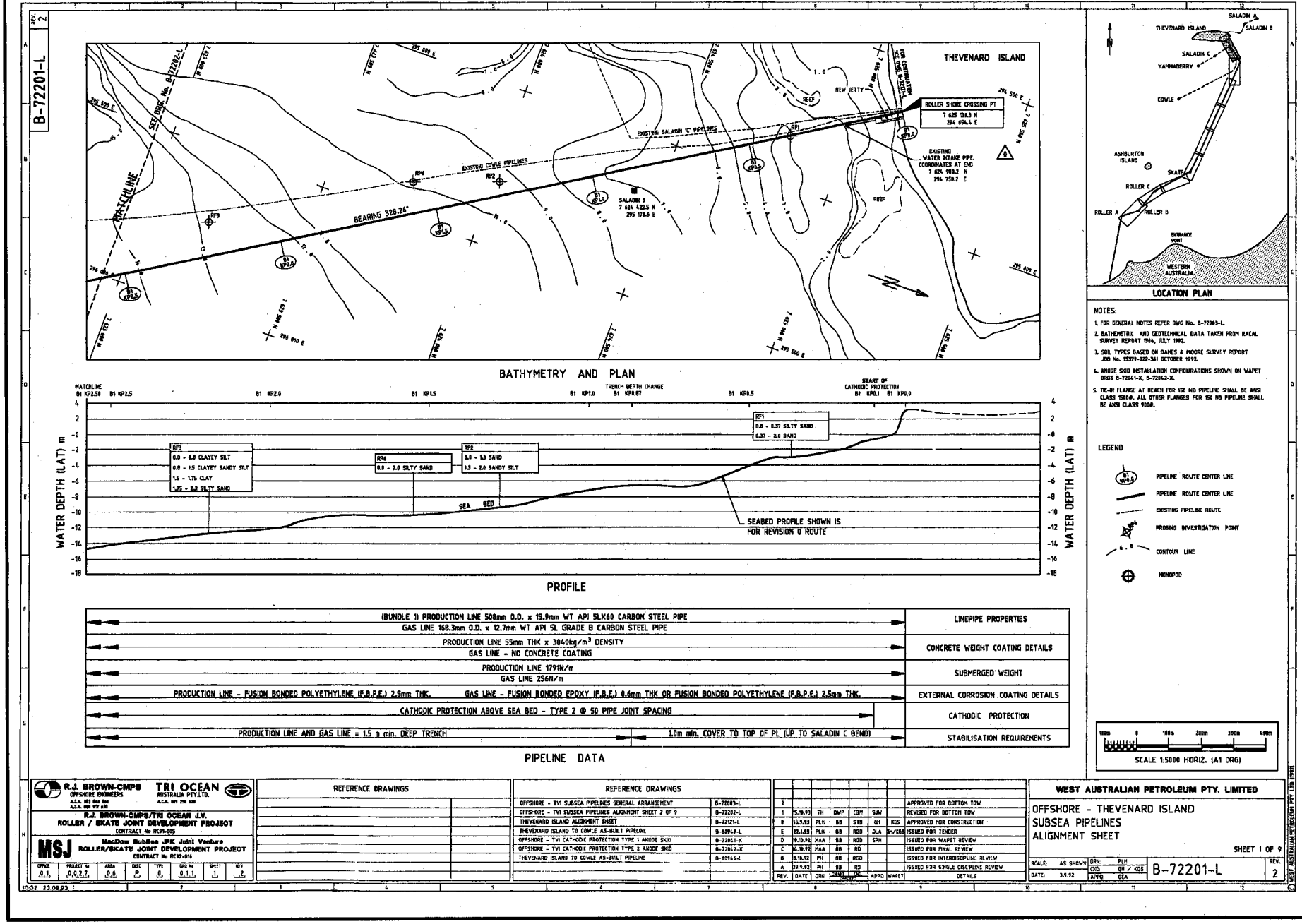
The first was the ''Roller Skate Tow Out Route Survey'', composite chart 5 (A 2166-6) on a scale of 1:10,000. This drawing showed only the details of the tow out routes to a width of about 300m, it did not show Saladin No. 3 wellhead.

The second, was a series of 10 drawings issued by West Australian Petroleum Pty Ltd, ''Off-shore - Thevenard Island, Subsea Pipelines Alignment Sheet'' (B-72201-L), on a horizontal scale of 15000. These drawings had been on board Boa Force and Maersk Supporter throughout the pipeline laying operation. Sheet 1 showed the bathymetry in plan and profile of the area about 2500m south-south-east of Thevenard Island jetty and the pipeline terminal. The Master had marked his limiting depth on both the plan and the profile. On this drawing, Saladin No.3 wellhead is shown to be in between 7 and 7.2m of water based on a datum of lowest astronomical tide (LAT).

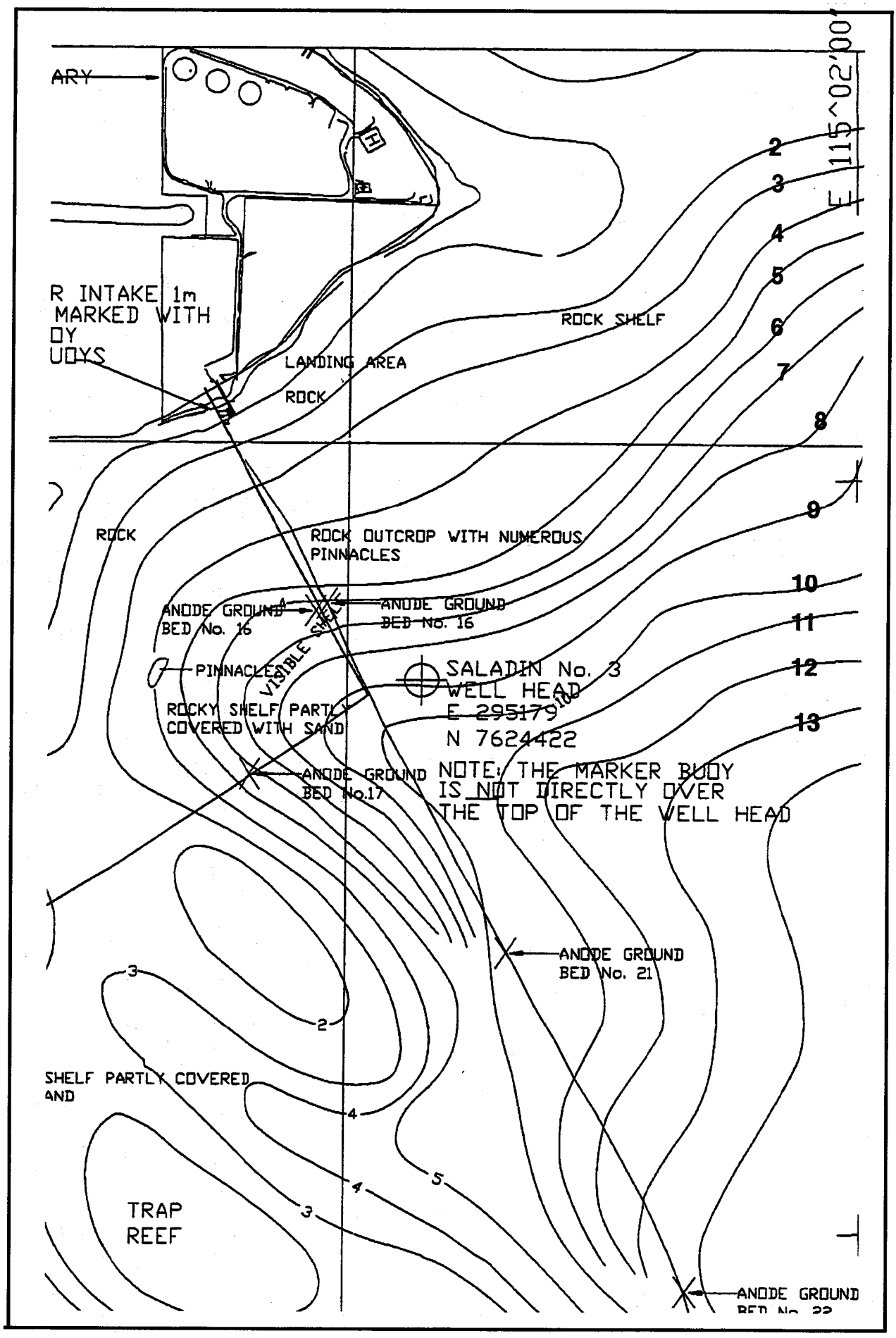
The third, was a drawing also issued by WAPET, ''Off-shore - Thevenard Island, General; Layout for Marine Purposes Map W2'' (33765.210) on a scale of 1:10,000. This was also a plan bathymetric drawing, the depths also stated to be based on LAT, showing Saladin No.3 wellhead in about 8.8m of water. This drawing was provided to the Master of the Boa Force on 19 February and was used by the staff of the SSIII for its bathymetric information from 20 February onwards, although specifically acquired by the WAPET representative for operations in the area of Trap Reef.

Other than establishing that it carried the legend that the bathymetry was based on LAT, the Master did not check the information further. Neither did the Mate or Second Mate.

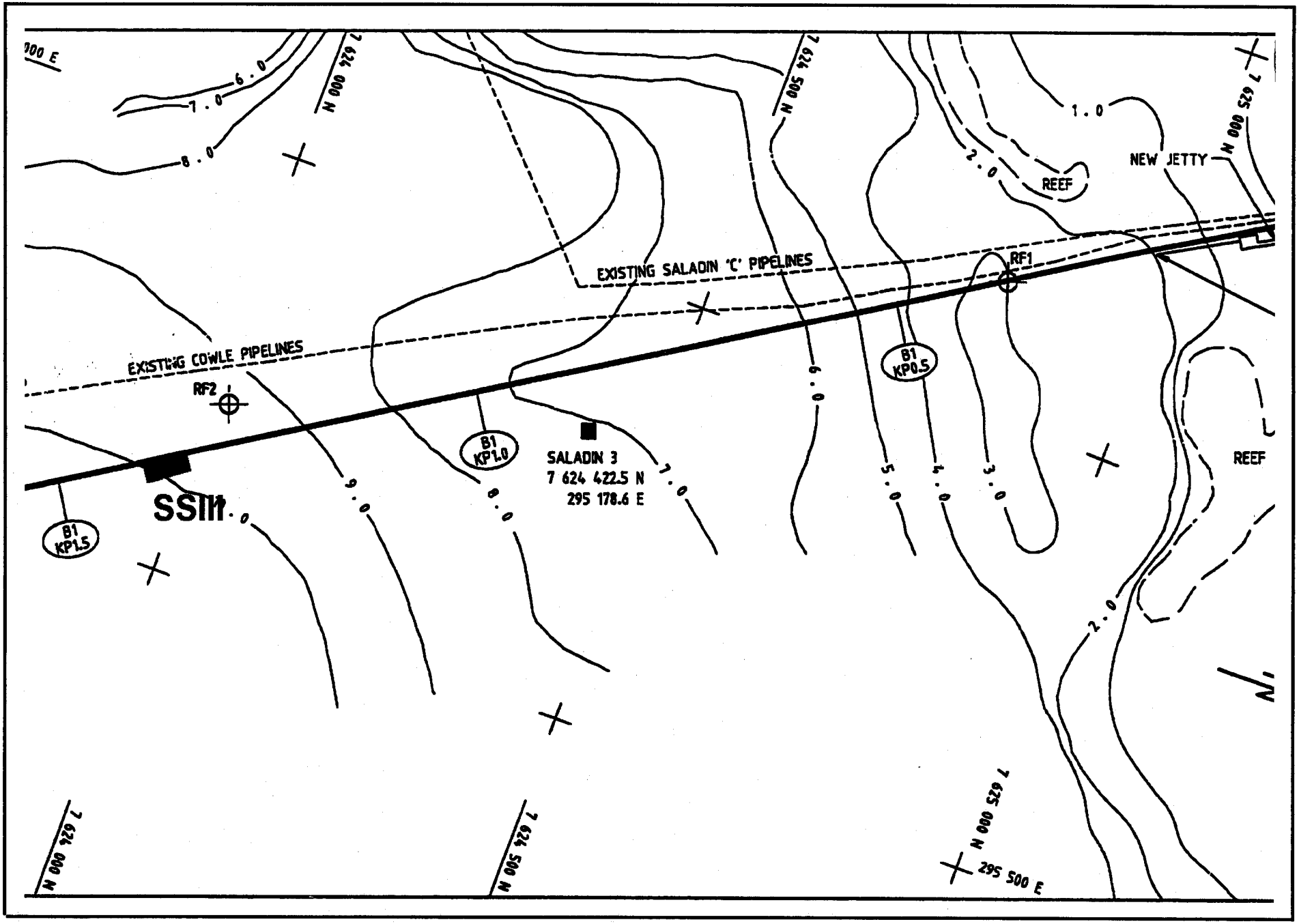
A document produced during the investigation, ''Saladin No.3 - Suspension Status'' shows the depth of the seabed in the area of the wellhead as 8.3m below mean sea level (MSL). Allowing that LAT is 1.5m below



Survey drawing B-72201-L



Enlargement of survey drawing 33765.210



Enlargement of survey drawing B-72201-L

MSL, a depth to the seabed of 6.8m would be indicated.

This depth is consistent with the depth recorded on the "Well Location" form of 25 August 1988, which also showed the water depth to be 6.8m based on LAT, Thevenard Island.

Examination by divers on the morning of 24 February, between 0945 and 1100, found that the seabed around the casing was scoured away, however away from the scoured area the general depth of water was 8.56m. Given a height of tide at 1000 of 1.7m, the general depth in the area of the wellhead was about 6.9m.

The Inspector consulted the Hydrographer of the Royal Australian Navy with regard to the soundings, LAT datum and the bench mark. The Hydrographic Office advised that, based on bench mark B934 and observations between 7 July 1985 and 30 July 1987, LAT was determined as being 1.5m below MSL. Based on the survey grid coordinates (Easting 295178.6 and Northing 7624422.5) on the Hydrographic Office's survey "fairchart" (scale of 150,000, with 200m between sounding lines) Saladin No.3 wellhead is in water between 6.1m and 7.2m.

The Inspector is satisfied that the actual depth of water at LAT was in the region of 7m and not greater than 7.2m and the bathymetry of drawing B-72201-L showed the more accurate information.

This drawing had been used as the operational drawing by the Tow Masters on Maersk Supporter and by the Master of Boa Force. The drawings were apparently not transferred to SSIII when Maersk Supporter completed its operation on 18 February and left the area on 19 February. It was stated by barge staff, that no copy was available on SSIII.

On balance, given the nature of the relationship between masters of support vessels and those supervising the operation on parent vessels in the off-shore industry, the Inspector considers that it was not unreasonable for the Master to accept the drawing 33765.210 at face value at the time of the job safety analysis meeting of 19 February. However, had he compared the depths he would have found a significant discrepancy in depth of about 1.6m.

Height of Wellhead

In estimating the risk posed by Boa Force to Saladin No.3 wellhead the Barge Master and surveyors assumed that the wellhead was 2.5m in height. This seems based on verbal advice that was not checked against any historic data.

However, in the contractual document "General Specification, Roller/Skate Joint Development Project, Anchor Handling Procedures, Specification No. RWGS20.02-3", issued for tender in May 1993, under paragraph 5.2 (e) it is stated that:

"Unless otherwise advised by the Company, all subsea well-heads shall be assumed to be 3 metres above seabed".

According to the document "Saladin No.3 - Suspension Status" the wellhead casing stood 2.9m above the seabed, with a central cap of 0.15m, making a total height of 3.05m.

On the morning of 24 February, divers measured the depth of water at the base of the wellhead to the surface as 9.815m and from where the wellhead entered the hull as 5.913m. However, because of the scouring at the base this does not reflect the height of the wellhead from the general seabed adjacent to the wellhead. This depth was 8.656m, making the height above the seabed, including the 150mm cap, about 3m.

Boa Force - Draught and Under Keel Clearance

Boa Force was drawing a maximum draught of between 4.5 and 4.8m. This was an estimation based on the diesel oil, lubricating oil, and stores on board.

The Master highlighted his limiting depths based on the survey information provided to him and, based on the information supplied to him on 19 February on drawing 33765.210, considered that he would have at least one metre clear water depth over Saladin No.3 wellhead. Although the Master appreciated undecked anchors should not be carried over the wellhead, he was not concerned that Boa Force would strike the wellhead, only that any anchor wire from SSIII might foul the obstruction.

The Barge Master, Surveyor and WAPET representatives were concerned to keep Boa Force clear of the pipelines and the wellhead, particularly in view of the operating procedures prohibiting undecked anchors passing over subsea installations. Their operating procedure was designed not to allow Boa Force to pass over the wellhead, although they considered there was sufficient water to do so.

In repositioning the anchor to the west of Saladin No.3 wellhead at about 1135 on 20 February, the Master felt Boa Force apparently touch bottom and duly made an entry to that effect in the log book, but made no report to the barge. Given a general depth as shown on the working survey drawing (33765.210) of 8.8m below datum in the immediate area of the wellhead and a height of tide above datum of 1.4m, Boa Force (with a draught of 4.8m) would have had a theoretical clearance of about 2.3m over the wellhead and 5.4m over the seabed in that general area. However, if the predicted height of water for 1135 is taken as 8.4m (based on the actual LAT) the under keel clearance would have been 0.5m.

The wellhead was the only obstruction in that immediate area that the vessel could have encountered.

In calculating the depth over the wellhead on 24 February, the staff on SSIII requested information on the tides at Onslow which predicted low water at 0413 with 0.9m of water. Thevenard Island is a standard tidal port and predictions for the area of operation could have been taken directly from the tide tables.

At a draught of 4.8m in salt water, with a tonne per centimetre immersion of

4.06 and a moment of 11.00 tonne/metres to change trim by 1cm, a weight of 7 tonnes placed at the stern roller, 23.3m from the longitudinal centre of flotation will increase the stern draught at the after perpendicular (18.3 m aft of the centre of flotation) by 0.09m, giving a draught of 4.89m*. This does not take into account the weight of the wire, but may be assumed to approximate the deepest possible draught.

On the morning of 24 February, low water was at 0402, with 0.82m of water above datum (LAT). At 0250, a little after Boa Force struck Saladin No.3 wellhead, the level of water was 0.89m above datum, with a swell of about 0.3m. Assuming the seabed was 8.8m below sea level as shown on survey drawing 33765.210, there should have been a minimum under-keel clearance of 2.1m.

However, the seabed was not more than 7.2m below datum (as shown on survey drawing B72201-L 5). At 0250, there would have been only 4.89m clear water over the wellhead and Boa Force was bound to make contact if it passed over the top of it.

The estimation of the under-keel clearance by the Master of Boa Force and the staff on SSIII was based on false information (See table below).

Marking the Wellhead

The Saladin No.3 wellhead had been marked by a navigation aid, a yellow spar buoy, shown on navigation chart Aus 743. There is some dispute as to the date on which the wellhead became unmarked. The best evidence is that this buoy had been displaced in bad weather at some time before October 1993 and a decision was taken not to replace it, either temporarily or permanently, the reasoning being that it was close to the prohibited area of the pipelines and only small local vessels bound for Thevenard Island used these waters. This decision had not been conveyed to the Hydrographic Office, who were unaware that the navigation buoy had been removed.

Further, the navigation buoy was not placed exactly by the wellhead and it had a scope of chain 2.5 times the maximum depth, which meant that the buoy had a circle of rotation about its

* Length between perpendiculars 36.95m

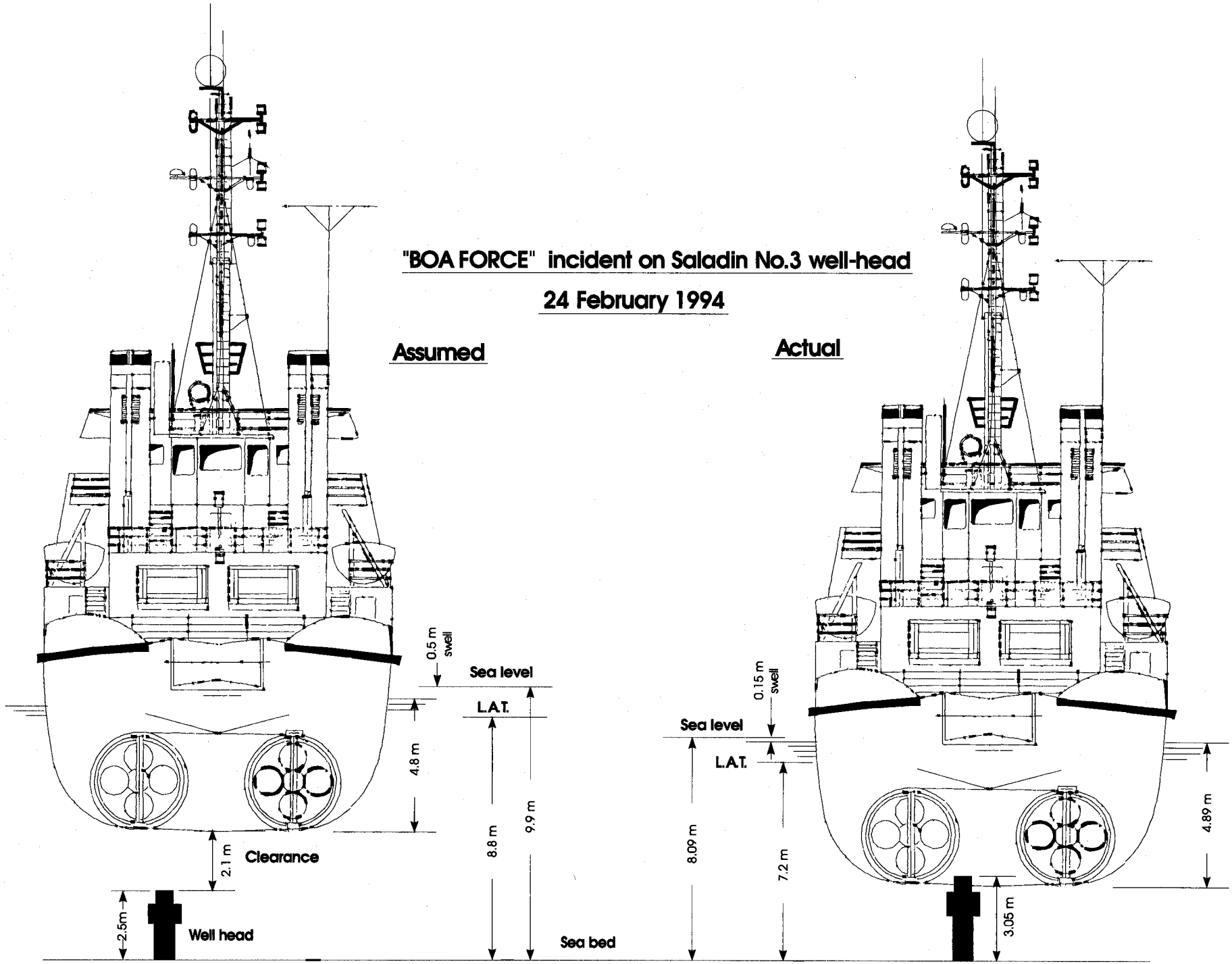
Table 1

Calculations on clearance over Saladin No.3 Wellhead

Assumed 24 Feb 93		Actual (Estimated)
8.8m	Depth of sea bed below LAT	7.20m
1.1m	Sea level above LAT	0.89m
0.5m	Less swell	0.15m (half swell)
2.5m	Less Height of wellhead	3.05m
6.9m	Water over wellhead	4.89m
4.8m	Boa Force Draught	4.89m
2.1m	Under-keel Clearance	0.00m

"BOA FORCE" incident on Saladin No.3 well-head

24 February 1994



mooring of about 20m. It was considered that such a buoy would not mark the wellhead with sufficient accuracy for the pipeline laying and stabilisation operation.

However, the contract agreement between WAPET and the Contractor stated that:

> "Any existing pipelines or facilities in the vicinity of the Works shall be located and marked with temporary buoys by the Contractor. The Contractor shall provide the company with the surveyed location of all buoys."

Temporary buoys were placed to mark the route of the pipeline and on subsea well-heads. However, no temporary buoy was placed at Saladin No.3 wellhead to provide a visual point of reference.

The Barge Master stated that, up until the barge started operation in proximity to Saladin No.3 wellhead on 20 February, he thought that Saladin No.3 wellhead was marked and there seems to have been a break down in communications within and between SubSea International and WAPET. It would have been a relatively simple matter to mark the wellhead with a temporary buoy. Given the limited time of operation in the area and the known range of tide over the period, a buoy with a light line and light could have marked the position of the wellhead accurately, indicating the hazard to the support vessel.

Positioning Equipment

As required by the contract, the Contractors installed a DGPS transceiver in Boa Force, consisting of a digital read out of the vessel's position in latitude and longitude, so aligned that the position given was that of the stern of the vessel, thus giving an accurate position of the anchor. SSIII was equipped with DGPS and plotter to monitor its own position, relevant to the pipelines and any other relevant hazard, and the position of Boa Force's stern. The plotter updated its position every three seconds.

According to the contract, the Contractor was obliged to submit details of the positioning equipment, personnel and procedures governing the survey works associated with the positioning of anchors, to WAPET for approval.

When the DGPS equipment was fitted to Boa Force in Exmouth some time after 11 January, the then Master asked those fitting the equipment why no monitor screen was fitted to the vessel; equipment, which in his experience, was normally supplied to anchor handling vessels. He recalls that the reason offered was based on minimising costs. The Master did not formalise his query by contacting Tidewater Port Jackson Marine, or the Contractors to express concern.

The provision of a monitor was not a requirement under the charter party between Tidewater Port Jackson Marine and the Charterers.

The equipment supplied to Boa Force was the standard equipment supplied to the Contractors vessels world wide. It was their policy not to supply monitors as experience had shown that ship operators tended not to look at them, but listen to the instructions from the parent vessel. The anchor handling procedures were written specifically to exclude visual monitors.

A digital printout of latitude and longitude is of virtually no practical value while manoeuvring in very close proximity to hazards, when the master's concentration is on handling the vessel and following the instructions from the parent vessel. It is not practical to transfer positions to charts or drawings under such circumstances, nor are radars sufficiently accurate. In any case both the chart table and radar were about 5.5m from the conning position.

The monitor has the advantage that information about all known hazards may be entered onto the screen, with accuracy to within 3m and the position information is updated every three seconds. By using the scale facility an enlarged picture can be obtained when working close to hazards, which acts as a visual prompt and point of reference for the Master when following instructions from the barge.

incident of Touching Bottom

The construction operation, since its inception, had involved Boa Force in navigating shallow waters and the vessel had touched bottom on a number of occasions. Maersk Supporter had also touched bottom on at least one occasion, on 15 January. These incidents were noted in the log book of the respective vessels and forwarded to Tidewater Port Jackson Marine.

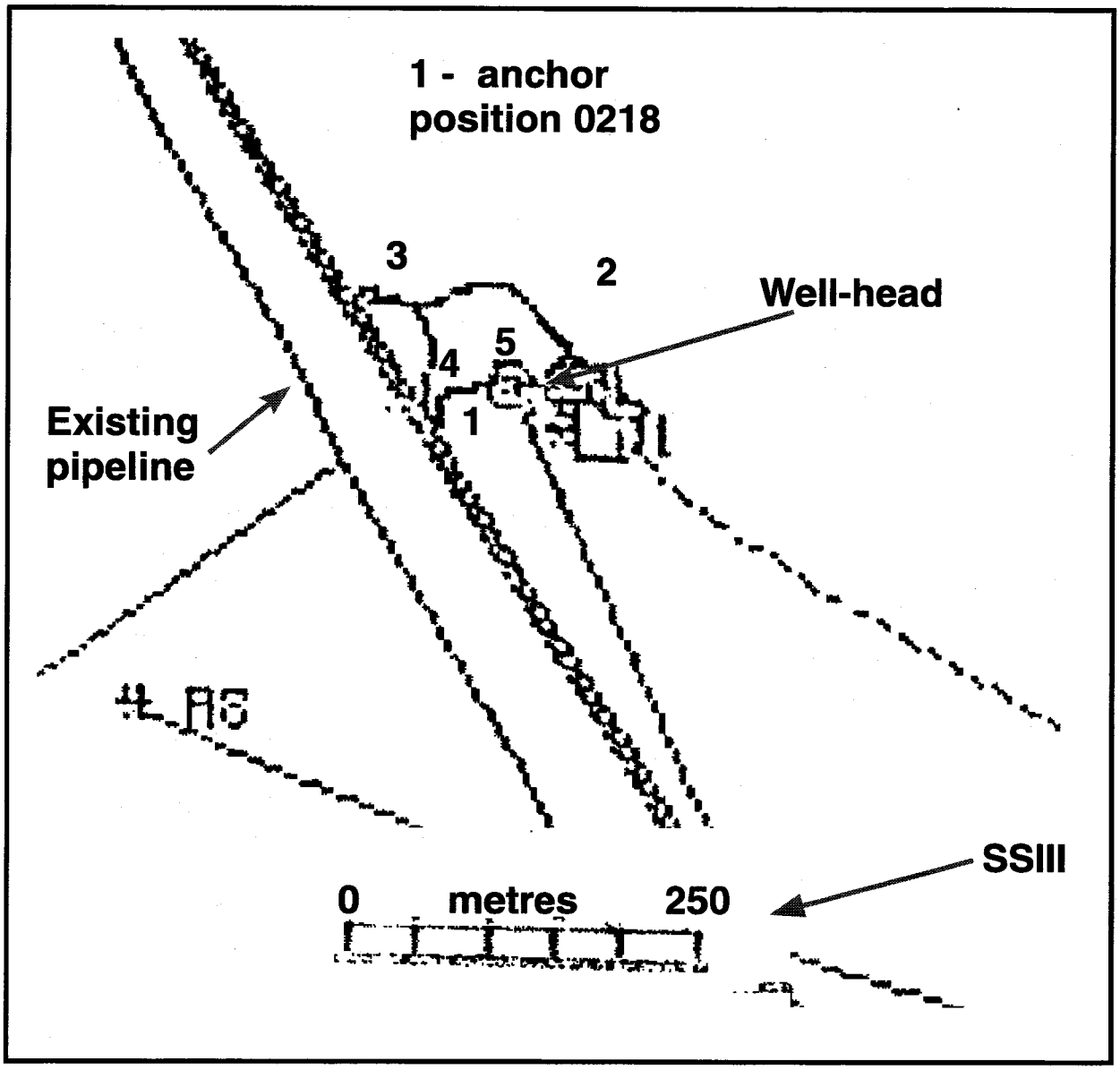
However, neither the Master nor Tidewater Port Jackson Marine felt compelled to exercise their prerogative under the charter party and notify the charterers of unsafe conditions during the operation. The speed of the vessels while engaged in shallow water was minimal and the incidents involved the vessels "resting" gently on the bottom with little risk. The incidents of grounding were not seen as serious or "unsafe" by the vessels' masters.

On 20 February, the Master of Boa Force noted that it touched bottom at 1135, when repositioning no.1 anchor from SSIII. The Master, who was following directions from SSIII, received no indication from the barge to indicate that Boa Force was over the wellhead. The Master accepted that the contact, which was very slight, was with a coral pinnacle, however he was very close to the known position of Saladin No.3 wellhead. If, after the event, he had checked against his working drawing (33765.210) he would have seen that there should have been about 4m under-keel clearance at LAT with no allowance for tide and the contact could well have been the wellhead.

The Sinking

Boa Force was involved in the repositioning of no.1 anchor when it struck Saladin No.3 wellhead. At the time, it was carrying the anchor at the stern of the vessel with about 450m to

Enlargement of DGPS monitor printout



Enlargement showing movement of Boa Force from 0218 to 0255, from position 1 anti-clockwise to position 2, then north-west and west to position 3, then south to position 4 and grounding position 5.

500m of anchor wire extending to the starboard forward corner of SSIII and was manoeuvring under the direction of the Barge Master and Surveyor.

On the morning of 24 February, it was dark, overcast and there was a light drizzle. The wind was from the west, or just north of west, averaging about 14 knots with gusts of 18 to 20.5 knots. There was no buoy on the wellhead and Boa Force had no survey monitor to work from.

No. 1 anchor had been repositioned from east, to a position west of Saladin No.3 wellhead on 20 February 1994, when SSIII was within 250m of the wellhead. The wind at the time of repositioning the anchor (1120,20 February) was from the south-west at 5 knots. The anchor was dropped 30m south and west of the wellhead and about 70m from the pipeline.

At the time no.1 anchor was picked up at 0218 on 24 February, it was stated that the position of the anchor was within 20rn of the wellhead and the assumption was made that Boa Force had over-run the anchor position. However, there was no suggestion that the normal anchor routine had been breached and nothing unusual was recalled to suggest that the anchor was positioned other than required by the barge. At 0220, the westerly wind was gusting to 18 knots from a mean of 14 knots. Boa Force approached the anchor buoy from the south-east (with its bows to the south-east). After the anchor was lifted the vessel headed, bow first, to the north and north-west, altering the heading initially by 135 degrees. It is possible that in lifting the anchor, with the 50m anchor pennant wire and while bringing the anchor to the stern, Boa Force did drift marginally from the anchor position.

Because the anchor was so close to the wellhead, the Surveyor was concerned that the anchor wire may have been in a position to foul the wellhead. He advised that Boa Force should first go north-west, to ensure that the wire was clear of the wellhead, and that there was no danger of fouling the subsea structure with the wire.

From 0218 to a time between 0245 and 0250 (a time lapse of about 30 minutes), Boa Force was manoeuvring in a box about l00m wide and 150m long. The vessel received a constant stream of instructions to clear the pipeline and then to keep clear of the wellhead. The Master was totally reliant upon directions from SSIII in manoeuvring the vessel and to pass through a gap less than twice the length of Boa Force.

An enlargement of the DGPS monitor printout, taken at 0549 on 24 February 1994 (about three hours after the incident) shows the track of Boa Force from the time it picked up no.1 anchor to the contact with the wellhead, a period of about 35 minutes. The Surveyor on SSIII indicated that Boa Force had followed a generally anti-clockwise route under the direction of the Surveyor and the Barge Master. Although the printout does not actually indicate the direction that Boa Force moved, the anti-clockwise direction agrees with the recollection of both the

Master and Second Mate on Boa Force.

It would seem that the anchor was recovered from position 1 and the vessel then moved due east before the vessel moved north-east, then north and then north-west at position 2. At positions 3 and 4 the stern was almost vertically over the pipeline, while at position 4 the vessel passed just north of the original anchor position and then in a southward direction over the well- head.

The pipeline, about 70m to the west of the wellhead, was marked by unlit "Norwegian" fibre glass buoys at 250m intervals. One of these buoys was close to the west of Saladin No.3.

The Master of Boa Force was therefore holding his vessel in a limited area without any adjacent points of reference to show where the hazards lay, with the exception of one Norwegian buoy over the pipeline which had been fixed in the vessel's searchlight. To assist SSIII, Boa Force was required to back towards the barge so that the barge winch did not have to take any weight. The problem of the time spent in proximity to hazards was exacerbated by the slow recovery rate of the winches on SSIII. When the anchor wire was clear to be recovered the winch speed on the SSIII could only retrieve at 24m/min.

However, nobody on SSIII had any direct experience of actually handling anchor support vessels, nor did they appreciate the difficulties of maintaining station in a gusting wind, or in a tidal stream, or current without any effective point of reference.

Great reliance was placed on the ability of Boa Force to respond immediately to directions when working in close proximity to hazards.

No.1 anchor was recovered after the incident from a position reportedly 15m from Boa Force's stem towards the position of SSIII. In submission, the Barge Master stated that he was of the opinion that the vessel drove bow first over the wellhead. He considered that the contact with the wellhead was made after the bilge alarm had sounded and he had advised the Master to drop his anchor and deal with the bilge alarm. In his view this was the only way to explain the 15m distance between the stern of Boa Force and the position from which the anchor was later recovered.

The Master's description of events and the timing of the bilge alarm, together with the Barge Master's written report and subsequent interview would suggest that Boa Force in fact backed over the wellhead. Evidence from the salvage team, relating to marks on the vessel's hull running from about frame 15 to the breach in the hull, seem to support the Master's view. The vessel was not holed at the extreme depth of the hull and if the vessel had driven over bow first it is almost certain that it would have holed in the fore part of the hull rather than in the after part of the vessel in way of frame 18. The probability is that the wellhead had passed between the keel and the port propeller shaft fairing, first making contact at about frame 15 and scoring the hull to the point at which the hull was punctured at frame 20, about 15.5m forward of the stem roller.

The Inspector is satisfied that Boa Force backed over Saladin No.3 wellhead. The distance of the anchor from the stern can be explained by tension on the anchor wire when it was dropped from Boa Force, after hitting the wellhead.

Flooding and Abandonment of Boa Force

The engine room staff on Boa Force were able to bring 3 pumps into operation to try and hold the water. The fact that the dedicated ballast pump was out of commission and had been sent ashore, did not render the vessel unseaworthy. There was more than enough pumping capacity to meet the flag State requirements for emergency pump capacity.

Whether or not the ballast pump had been operational, the initial ingress of water would have been in the region of 1 cubic metre a second, far in excess of the capacity of all the pumps.

Under Det Norske Veritas class notation rules, Boa Force was required to comply with intact and damage stability requirements equivalent to the International Maritime Organization Resolution A. 469(XII), "Guidelines for the Design and Construction of Off-shore Supply Vessels", adopted on 19 November 1981.

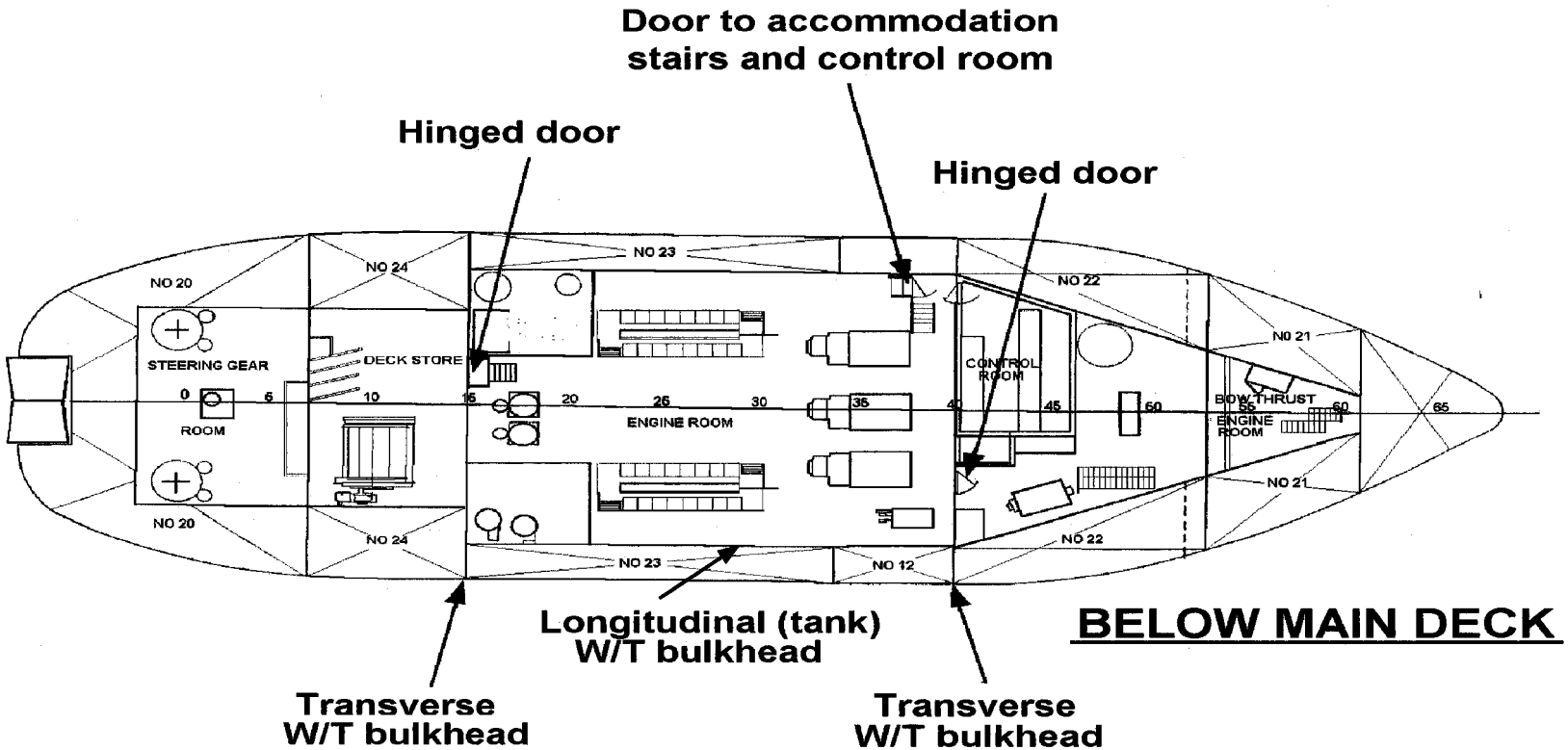
Under the terms of Resolution A.469, the damage stability conditions are predicated on a transverse extent of damage assumed to be 760mm, measured inboard from the side of the vessel and perpendicular to the centre line. Therefore a transverse watertight bulkhead extending inboard 760mm from the shell plating, joining a longitudinal bulkhead may be considered to be a watertight bulkhead. This assumption is based on penetration of the hull from the side, such as in the case of collision, and does not take into account stranding or other contact with the vessel's bottom.

As a vessel declared under Section 8A of the Navigation Act 1912, the provisions of the Act apply to Boa Force. Although built in 1978, and defined as an "existing vessel", under the provisions of Marine Orders, Part 46 (Off-shore Supply Vessels) the orders applied to Boa Force. These reflect the recommendations of Resolution A.469.

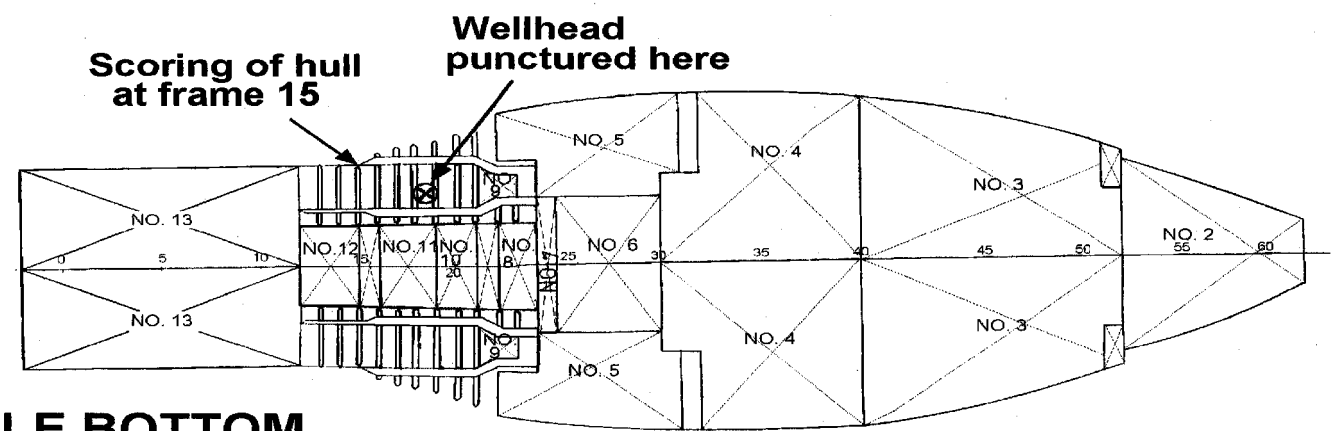
The engine room was protected by a longitudinal side tank about 1.3m in width (in excess of the 0.760m required by the Resolution). Double bottom tanks extended over the bottom of the vessel between frames 12 and 61 and protected the engine room space, except at the after end of the machinery space, where there are centre double bottom tanks and side tanks, but a single skin under the port and starboard engine gear boxes.

The damage stability book for Boa Force does not consider the possibility of flooding of either the engine room or the spaces forward and aft of it, despite the single skin in way of the engine sumps, either side of the centre tanks.

The forward and after engine room bulkheads were designated "watertight". But for the purposes of



BELOW MAIN DECK



DOUBLE BOTTOM

damage stability compliance, the doors in the forward and after bulkheads were not required to be watertight, nor were they required to be kept closed, or closed as part of the emergency procedures and they were habitually left open for access. Neither of the doors could be closed remotely. The door to the space forward of the engine room, although not rated as watertight, had six dogs (three on the hanging stile and three on the shutting stile). In addition the forward bulkhead was pierced by a vent trunking, approximately 350mm square. The door between the after store room and the engine room was secured by two dogs, at the top and bottom of the shutting stile.

Further, both doors opened outward from the engine room, and in this case the head of water would have tended to force the doors open.

Access to the forecastle accommodation from the main deck was limited to a weather tight door on the starboard side, which led to a "store" room and thence to the accommodation. There was no equivalent access on the port side. With a list to starboard and the main deck immersed, water was able to enter the accommodation area.

However, in the absence of any instructions to the contrary and despite the lack of watertight doors, it would, in the Inspector's opinion, have been sensible to try and confine the area of flooding to the maximum extent possible and close the doors at the forward and after bulkheads. While there is no certainty that this would have been effective in preventing the egress of water to the adjacent compartments, it would have been consistent with good seamanship to **try.** The Master could have ordered them closed as soon as he became aware of the ingress of water, providing he was satisfied that the engineers had a means of escape to the deck other than the emergency escape through the after store room. The Mate actually went to the engine room, but did not consider closing the bulkhead doors and the Second Mate, although having limited experience in the off-shore industry, was in a position to advise the Master, based on his general seagoing experience. Although the Engineer Officers were busy with the pumps and exploring alternative means of pumping water from the engine room, they also should have considered closing the doors.

The engine room escape is reached from the engine room through the after store room and by way of a hatch on the starboard side in way of frame 14. The Class Society advises that:

> "As part of openings exposed to the sea it is kept closed at **all** times".

Although the engine room was ventilated by forced air ventilation, given the age of the vessel and the time spent by engineers and ratings out of the control room and in the machinery space, the adequacy of ventilation (especially for operation in hot climates) was inadequate. The engineering staff stated that temperatures of 50 degrees centigrade were not uncommon, and the escape hatch was left open to allow the hot air some escape, unless there was danger

of an anchor wire fouling the raised hatch lid. In general it was left open. While the Inspector understands the reasons for leaving the hatch open, there was no attempt to close it before the vessel was abandoned. It does seem however, that it was closed after the vessel had sunk.

The other possible point of flooding on the main (shelter) deck was the weathertight door on the port side at frame 29, which led to the accommodation and general forecastle space. It seems that this door was not secured before the vessel was abandoned.

At the request of the Inspector, naval architects from the AMSA, assessed the damage stability condition of Boa Force based on four flooding scenarios:

1. Engine room only,
2. Engine Room and after store,
3. Engine Room, after store and forward work shop,
4. Engine room, after store, forward workshop and steering gear flat.

In the absence of a lines plan to adequately define the hull form and its appendages, the direct calculation method, using a semi spreadsheet approach, was adopted.

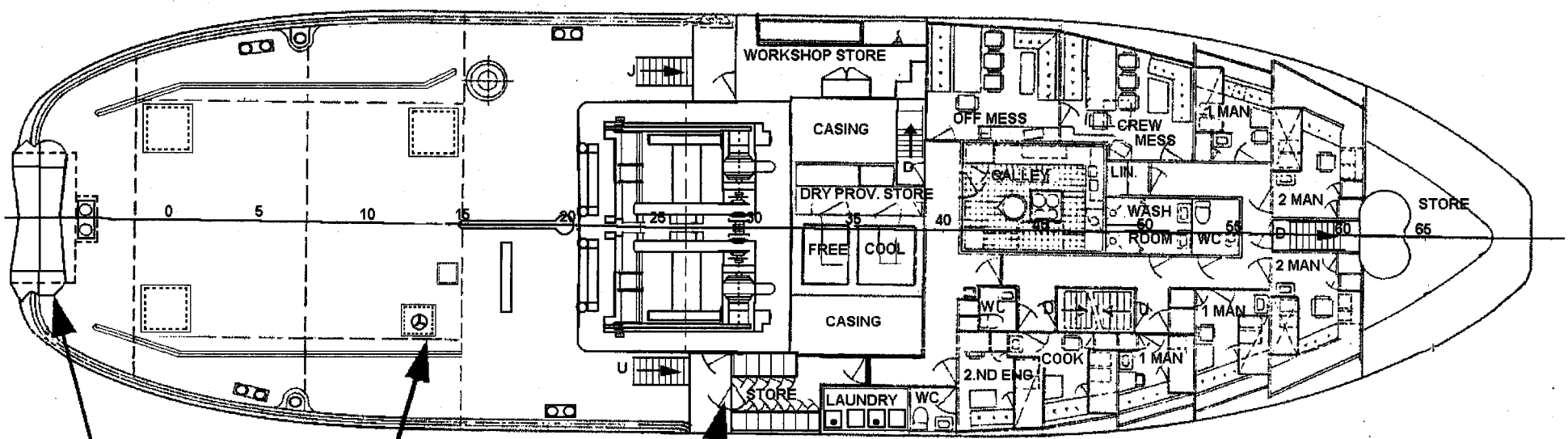
This concluded that with the four spaces flooded the vessel would have retained positive residual stability, initially up to about 25 degrees of heel, provided the forecastle structure could be assumed to be watertight. The main deck would have been under about 100mm of water, but the large forecastle structure would have provided sufficient reserve buoyancy to stop the vessel sinking. In the event, the sill of the weathertight door on the port side of the main deck at frame 29 would immerse at about 5 degrees of heel, and the vessel was listed to starboard. Therefore to retain the positive buoyancy this door would have to have been closed and, while weathertight, would have to have acted as a watertight door.

It may be, that in this specific instance, the wellhead would have been put at greater risk by a partially buoyant vessel. However, neither the Master nor officers knew what effect the flooding of the engine room space would have on the stability of the vessel and they should have attempted to limit the extent of progressive flooding and possible down flooding from the main deck.

It is apparent that the effects of flooding and the possible ways of limiting the spread of flooding were not taken into account in either Boa Force's damage stability data or emergency plans. The Inspector regards such emergency plans as essential on any ship, but particularly where vessels are operating in shallow water or servicing off-shore structures.

Job Safety Analysis

WAPET operates a safety regime that involves a "job safety analysis" of all operations. It is conditional upon all people working under the Company's general umbrella that all contractors



Stern Roller

Engine room escape (via store room)

Weathertight door access to accommodation

SHELTER DECK (MAIN DECK)

and subcontractors comply with the practice of conducting such an analysis for each operation.

The general procedures for deploying anchors are detailed in WAPET's operating instructions. There was an emphasis on safe operation in the region of pipelines and other structures.

It is stated that the job safety analysis meeting of 19 February, involving representatives of, SubSea International and the Master of Boa Force, discussed the presence and issue of Saladin No.3 wellhead. WAPET representatives, although present on the barge, state that WAPET was not represented at the meeting. It is difficult, therefore, to understand, in view of the ethos of safety and the requirement of job safety analysis, how the meeting did not recognise that Saladin No.3 wellhead was not marked by a buoy, as required by the contract, and that it would have a little more than 4m of water covering it at low tide.

Each meeting was required to be minuted in an approved format, however the record of the meeting of 19 February could not be produced.

The Barge Master stated that on 19 February he thought that the wellhead was marked. However, after the meeting and between 19 and 24 February, he realised that there was no buoy. He discussed the absence of the buoy with a representative from WAPET and yet it seems that neither SubSea International nor WAPET regarded it as necessary to mark the wellhead, notwithstanding the agreement between the companies and the job safety analysis where it was an acknowledged and accepted hazard which it was important to avoid.

The job safety analysis meeting failed to establish that drawing 33765.210 was intended for use close to Trap Reef and it was used, by both SSIII and Boa Force, as the working drawing when close to Thevenard Island, between 20 and 24 February.

The failure to mark the wellhead, together with the acceptance of drawing 33765.210, indicates a haste to complete the operation, consistent with a fixed price contract, resulting in incompatible goals to the detriment of a considered safety analysis. This should be seen in the light of the very high costs involved in the operation and the consequential monetary penalty brought about by delay.

No account seems to have been made for any limitations of the support vessels, particularly when operating close to subsea structures, or operating in winds of various strengths. On 20 February, when the anchor was repositioned, no thought was given to the fact that the anchor was dropped up-wind of Saladin No.3 wellhead and, in any significant wind, Boa Force would be blown down on to the hazard leaving very little margin for error.

This must be considered in the light that, on a dark and overcast night, while actually controlling his vessel the Master of Boa Force did not know, nor had he any realistic opportunity or means to check his position relative to the hazard with any accuracy and was dependent upon accurate instructions

from the parent vessel. Although Boa Force was equipped with an echo sounder, this would not have given advance warning of an isolated pinacle of rock or coral or the wellhead. An echo sounder is a highly effective navigation aid in showing shoaling water and indicating the actual depth of water below the keel. However, echo sounders do not provide any pre-warning of isolated rocks or obstructions and in areas of uniform depth do not indicate a vessel's position. For want of a better analogy, Boa Force was like an obedient, sightless dog on a lead.

Boa Force - 26 February 1994

Photograph shows Boa Force with SSIII in background. The gap between orange "Norwegian" buoy and Boa Force shows the extent of clear water between Saladin No.3 well-head and the Roller\Skate pipeline.

Conclusions

These conclusions identify the different factors contributing to the accident and should not be read as apportioning blame or liability to any particular organisation or individual.

The sinking of Boa Force was the result of a series of factors which combined to cause the vessel to make contact with Saladin No.3 wellhead. These were:

1. The failure to temporarily mark the location of Saladin No.3 wellhead with an adequate buoy.
2. The failure to use adequate and accurate charts, or drawings, or plans to enable the anchor laying operation close to the south of Thevenard Island to be conducted in safety.
3. The provision of bathymetric data which was in error by about 1.6m.
4. The failure to supply a differential global positioning system monitor to Boa Force to provide the Master with a display of the operation upon which known hazards could be plotted.
5. The lack of appreciation on board Support Station III of the problems in manoeuvring an off-shore anchor handling vessel in a relatively confined area for a prolonged period without an effective point of reference.
6. The failure of the job safety analysis to properly take into account the operational safety issues of an unmarked subsea well.
7. The lack of local marine knowledge and expert marine advice in the planning and operational stages to address the above issues.
8. The failure of the Master of Boa Force to check known depths on 20 February, following an apparent bottom contact, particularly as it was known that the vessel would have to operate in the same area to retrieve the anchor at a later time.
9. The possibility of fatigue, resulting from the operational program, cannot be ruled out

Other Conclusions

10. Boa Force met the requirements of the Navigation Act 1912 and subordinate regulations and orders. All certificates were valid.
11. The provision of plans and documents in the Norwegian language did not facilitate the effort by those on Boa Force to control the emergency.
12. The Master, Deck Officers and Engineer Officers should have considered trying to restrict the extent of the flooding by closing all doors and hatches, consistent with the safety of the engineers in the engine room. Any decision not to close doors should have been based on known effects of flooding of the vessel.
13. The damage stability characteristics of the vessel met the relevant criteria for an offshore supply vessel under the provisions of Marine Orders Part 46 and IMO Resolution A. 469(XII), but the criteria did not allow for penetration of the hull inboard of the line of the inner bulkheads of the side tanks.

Details of ship

Name	BOA FORCE ex Tiwaz, ex Scan Force, ex Tender Pull, ex Bob
Flag	Norway (MS)
Call Sign	LCKA3
Lloyd's Number	7625990
Owners	K/S Leh IX A/S
Managers	Taubatkompaniet A/S, Trondheirn, Norway.
Operators	Tidewater Port Jackson Marine Pty Ltd, Melbourne
Classification	Det Norske Veritas
Type	Anchor handlinglsupply, off-shore support
Year	1978
Builder	Stord Verlt MS, Stord, Norway
Length	43.39m
Breadth	12.25m
Depth	6.02m
Maximum Draught	4.961m
Gross tonnage	499
Net tonnage	145
Deadweight	529 tonnes
Engines	2, Nohab Polar Diesels F216-D825 Vee Oil 4SA, 16 cylinder
Engine Power	5181kW
Propellers	2, controllable pitch Ka-Me-Wa in 2800mm Kort nozzles
Bollard Pull	Approximately 87 tonnes
Crew	11 (Australian)

Offshore survey and positioning

Geodetic Parameters

Datum:	**Australian Geodetic Datum 1984**
Spheroid:	Australian National
Semi-major Axis (a):	6 378 160.00m
Semi-minor Axis (b):	6 356 774.719m
Eccentricity Squared: (e2):	0.006 694 542
Flattening (l/f)	298.25
Datum	**WGS44**
Spheroid	WGS84
Semi-major Axis (a):	6 378 137.000m
Semi-minor Axis (b):	6 356 752.3142m
Eccentricity Squared: (e2):	0.006 694 380
Flattening (l/f)	298.257 223 563
Projection:	**Universal Transverse Mercator**
AMG Zone:	50
Central Meridian:	117"East
Scale Factor on CM:	0.9996
False Easting:	500 000m
False Northing:	10 000 000m
Latitude of Origin:	0° (Equator)
Unit of Measure:	International Metre

GPS Datum Transformation - WGS 84 to AGD 84

The following seven parameter datum transformation values will be used to convert WGS 84 co-ordinates to AGD 84 co-ordinates:

Dx	+116.00m
Dy	+50.47M
Dz	-141.69m
Rx	+0.230"
Ry	+0.390"
Rz	+0.344
Scale (k)	-0.0983 ppm