MINES and ENERGY RESOURCES
SOUTH AUSTRALIA

ACCIDENT TO THE

MOBILE OFFSHORE DRILLING UNIT

MAERSK VICTORY

ON NOVEMBER 16 1996

by

T. Aust

Inspector under the Petroleum Act, 1940.

May 1997

Registered as MESA Report Book RB 97/24

MAERSK VICTORY AFTER THE ACCIDENT

Photographs taken on November 22 1996

DISCLAIMER

This report is written from the information available to the Inspector and is compiled from numerous sources. It should be noted that much of the information is recounted from memory of personnel involved in the accident, and not from recorded sources of data.

ACKNOWLEDGMENT

This report was prepared with assistance from the following organisations:

- Crown Solicitor’s Office and Government Investigations Office of the South Australian Attorney General’s Department
- Marine Safety Section, South Australian Department of Transport
- Mining and Petroleum Branch, South Australian Department of Industrial Affairs

ABSTRACT

On November 16 1996, on location in the Gulf Saint Vincent, South Australia, the mobile offshore drilling unit (MODU), or jack-up rig, *Maersk Victory* "punched through" a hard layer of sediment approximately 10 metres below the seafloor whilst undertaking preloading procedures. The rig sustained considerable damage to its three legs, and had to be severed from each leg prior to recovery of the rig. The legs were subsequently recovered independently of the rig. All personnel were evacuated from the rig without injury and there was no significant environmental impact.

The South Australia Department of Mines and Energy Resources commenced an investigation into the circumstances surrounding the accident, and interviewed a number of personnel directly and indirectly involved in the management and operation of the rig. This report details the history and management of the Campaign, and the opinion of an Inspector pursuant to the Petroleum Act 1940, as to the contributing causes of the accident and makes recommendations to the Industry to ensure that the risks of such an accident re-occurring are reduced to 'as

In summary, the findings are:

- that the foundation suitability, in particular the load bearing capacity, of the sub-sea sediments was not investigated to the degree required to reduce the risk of damage to the rig to as low as reasonably practical; and
- that the effectiveness of the Safety Case system to provide the framework for effective and safe management of the *Maersk Victory* was significantly reduced because the implications of the system were inadequately understood and not properly implemented by the responsible parties.

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DEFINITIONS

The following terms as defined below apply throughout this document.

Air gap	The minimum height to which it is considered safe to elevate the rig above the sea level to ensure that the rig will not be subject to varying tides, etc. This height varies according to the operations, the duration and the anticipated weather conditions
Campaign	A number of well operations conducted using a specified drilling rig
Fit for purpose	Able to achieve the purpose under the range of conditions which can reasonably expect to affect the operations.
Good oilfield practice [2]	Means all those things that are generally accepted as good and safe in the carrying on of exploration for petroleum, or in operations for the recovery of petroleum, as the case may be.
Harm [1]	A physical injury or damage to health, property or the environment.
Hazard [2]	A physical situation which may result in harm, including death or injury to people or damage to property.
Punch through	Punch through or rapid leg penetration occurs when one or more legs of a rig experience rapid downwards movement due to the sudden failure of a supporting sediment layer to continue to provide a secure foundation. The process undertaken to ensure a secure foundation exists below the rig's spudcans is termed 'preloading', and consequently it is intended that if punch through is going to occur, it will occur as the load on the supporting sediment layer is increased during this process. Prior to preloading though, an assessment of the capability of the sub-sea sediments to support the rig during all its operations and anticipated weather conditions is undertaken.
Risk [2]	The likelihood of a specified undesired event occurring within a specific period or in specified circumstances. It may be either a frequency (the number of specified events occurring in unit time) or a probability (the probability of a specified event following a prior event), depending on the circumstances.
Risk analysis [1]	The systematic use of available information to identify hazards and to estimate the risk to individuals or populations, property or the environment.
Risk assessment [1]	The overall process of risk analysis and risk evaluation.
Risk evaluation [1]	The process in which judgements are made on the tolerability of the risk on the basis of risk analysis and taking into account facts such as socio-economic and environmental aspects.
Risk Management [2]	The ongoing management process of identifying hazards, evaluating the consequences and probability of these hazards, then reducing the risk levels to as low as reasonably practicable.

Safety Management System (SMS) [2]

A comprehensive integrated system for managing safety at a facility which sets out:

- the safety objectives;
- the systems and performance standards by which these are to be achieved;
- the performance standards which are to be met; and
- the means by which adherence to these standards are to be maintained.

Safety Case [2]

The presentation of a justification for the safety of an installation.

1) The objectives of the safety case are to demonstrate via a written description that an operator of a facility has:

- an SMS that is capable of continually and systematically identifying hazards, assessing the likelihood and consequences of the hazard and, in so far as is reasonably practicable, eliminating or controlling the risk to personnel at the facility. the SMS must be capable of managing risk to facility personnel generated over the life of the facility, from design, construction commissioning, operations to abandonment;
- carried out a detailed and systematic risk assessment that has identified potential hazards which may, over the life of the facility, lead to an MAE (major accident event); and
  - has assessed the likelihood and consequences of these potential MAEs, and;
  - has reduced the risk to as low as is reasonably practicable by hazard elimination, or implementation of technical and/or other measures that minimise the likelihood or consequence of the MAE;
  - in so far as is reasonably practicable, provided for safe evacuation, escape and rescue in the event of a major emergency, and where appropriate provided an adequate TR (temporary refuge) to ensure the safety of employees until they can be evacuated from the facility to a place of safety.

2) The safety case will form the basis of a co-regulatory regime. The safety case once accepted by the regulator becomes a set of recognised legal standards against which operators are assessed.

spudcan

'Foot' at the base of each leg which is a hollow hexagonally shaped can.

System [1]

A composite, at any level of complexity, of personnel, procedures, materials, tools, equipment, facilities and software. The elements of this composite entity are used together in the intended operational or support environment to perform a given task or achieve a specific objective.

Toolpusher

The person in charge of the drilling operations, and other duties may include being in overall charge of the vessel and responsible for the safety, health and welfare of all personnel on board.

TowMaster

The person in charge of the rig during moving and jacking operations.

1 AS/NZS 3931(Int):1995 Risk analysis of technological systems - Application Guide
2 DPIE Guidelines for Preparation and Submission of Safety Cases

SECTION 1: FINDINGS AND RECOMMENDATIONS

INTRODUCTION

The accident to the *Maersk Victory* occurred because one leg experienced a sudden rapid penetration of the sub-sea sediments, or punch through. Punch through will always be a potential hazard to a jack-up rig when locating on a site especially in previously unexplored areas. The investigation of the accident to the *Maersk Victory* therefore was to establish whether effective management systems and procedures were in place to ensure that the risks of, and consequences of, punch through were as low as reasonably practical.

In outline, the procedure leading to a decision as to whether the sub-sea sediments will provide an adequate foundation is:

A decision is made on the extent of site specific geotechnical operations (shallow seismic survey, soil sampling, coring, etc) required to enable the evaluation of the load bearing capabilities, heterogeneity, and other characteristics of the seabed sediments. The need for a particular operation would be judged against the criteria of reducing the risk to the rig to as low as reasonably practical.

The geotechnical operations are then carried out.

The geotechnical data obtained from the operations is then evaluated as to whether or not:

- the sub-sea sediments are capable of providing a secure foundation for the rig during its operations; and
- the sub-sea sediments are unlikely to fail in such a manner as to pose an unacceptable risk to the rig (eg a marginal load bearing layer is not underlain by a much weaker layer).

On the basis of this evaluation the decision is taken whether or not to locate the rig, or whether more geotechnical data is required to properly evaluate the risk to the rig.

Once the rig is located at the nominated well site, preloading is carried out. Preloading is undertaken to ensure adequate foundation capacity is developed in the sub-sea sediments, and is done by the controlled application of load by pumping seawater into tanks adjacent to each of the three legs. The increased load on the legs subjects the sub-sea sediments to a controlled increase in stress to above that which will be experienced during drilling operations. There are various ways of carrying out the preload. The choice of a particular way being, in part, dependent upon the perceived risk of punch through.

If during preload the actual load bearing performance of the sub-sea sediments is different from that predicted by the previously obtained site specific geotechnical information, the location attempt can be aborted, or, the preload can be interrupted whilst more data is obtained, or, the preload can be continued. Once commenced, the preload procedure itself can also be varied to take account of changes in the perceived risk of punch through.

FINDINGS

1. In the opinion of the Inspector, the investigation found no evidence to doubt Maersk's opinion that there was no immediate cause for the damage to the rig other than the failure of the sub-sea sediments to support the weight of the rig.

2. In the opinion of the Inspector, the investigation found evidence that insufficient attention had been paid to evaluating the risks to the rig inherent in undertaking operations in an area where a jack-up rig had not previously been used. Therefore steps to ensure the management of risks to as low as reasonably practical had not been undertaken.

3. In the opinion of the Inspector, the investigation found evidence to support the view that errors of judgement were made in not evaluating what geotechnical information was necessary to reduce the risk to the rig to as low as reasonably practical. This error led directly to a lack of geotechnical information, which could have been used to assess the suitability of the sub-sea sediments as an adequate foundation, in particular the load bearing properties. In the opinion of the Inspector, good industry practice required in the circumstances in which the *Maersk Victory* was to drill Frijole #1, the taking and geotechnical evaluation of cores obtained by drilling to a depth of at least 30 metres, in conjunction with the evaluation of seismic and other geotechnical data. The significant circumstance being that the load bearing properties of the sub-sea sediments relevant to the Frijole #1 site had not previously been evaluated.

4. In the opinion of the Inspector, the investigation found evidence to support the view that errors of judgement were made in not assembling, or in not ensuring the assembly of, available, relevant geotechnical information on the sub-sea sediments.

5. In the opinion of the Inspector, the investigation found evidence to support the view that there were deficiencies in management systems and procedures relevant to the establishment of the *Maersk Victory* on location and because of these deficiencies the risk to the rig was not reduced to as low as reasonably practical. Specifically, there were deficiencies in:

a) the provision of written descriptions of the scope of work and responsibilities of the various parties involved in the gathering of information, assessment/validation of the information, and decision taking process associated with characterisation of the sub-sea sediments at the Frijole # 1 location;

b) the processes for ensuring that professional services received were of a quality required to achieve a risk as low as reasonably practical;

c) the provision of procedures to ensure that the TowMaster had access to 'fit for purpose' information; and

d) the provision of procedures to guide the TowMaster's exercise of judgement in the event that actual performance of the sub-sea sediments departed from that predicted.

6. In the opinion of the Inspector, the investigation found evidence that there were errors of judgement and deficiencies in the reporting, and, if a validation process was carried out, in the validation of the data obtained to characterise the sub-sea sediments.

7. In the opinion of the Inspector, there is evidence to show that the Safety Case and associated documentation accepted by Mines and Energy Resources South Australia, if effectively implemented, would have prevented some, if not all, of the above listed deficiencies arising. In general all parties had management systems, procedures and access to expertise sufficient to reduce the risk to the rig to as low as reasonably practical. It appears to the Inspector that a degree of complacency had developed at a number of points in the total system which reduced its effectiveness to below that required to achieve a risk level as low as reasonably practical.

8. In the opinion of the Inspector, there is evidence to show that there were a number of procedures undertaken on the rig that were not covered in the Safety Case and associated documentation, and other procedures required by these documents were not undertaken. In the opinion of the Inspector, the Safety Case and associated documentation should document all procedures and the associated risks, and that any deviation from the documented procedures should be considered as an exception rather than the rule, and should only be done in accordance with a deviation procedure.

9. RECOMMENDATIONS

1. All parties to the accident should immediately review their management systems and procedures and institute changes where needed to make them 'fit for purpose' within a Safety Case regulatory regime, ie. a regime based on an objective achieving, management system approach. (The objective being to reduce the risk to the rig to as low as reasonably practical).

2. All parties, as part of their management review, should ensure that there is more effective documentation of the responsibilities of all parties/contractors in a Campaign. In particular the contracts should incorporate the requirements of the Safety Case approach.

3. All parties operating under a Safety Case should be apprised of the relevant features of the Safety Case applicable to them. The detail

imparted should enable all parties to take an informed decision as to the conduct required of them. This will require effective communication tools to facilitate the development of a Safety Case culture, which requires a good understanding of the objective achieving, management system approach.

4. All parties assigned the responsibility for managing risk to the rig during one or more operations should:

a) have in place management systems which ensure that an effective formal assessment of the hazards to the rig during the operation or operations, and their causes and consequences is carried out. The results of the assessment should be effectively responded to by those in the company(ies) responsible for managing the risks to the rig. This applies to identifying the hazards, causes and consequences of management decisions as much as to any other operation which affects the rig.

b) have in place management systems which ensure that all contracts for services which are identified as being a potential cause of a hazard to the rig or affect the consequences of a hazard are 'fit for purpose'. For example, as a guide should:

i) have effective descriptions of the work and services to be carried out and the responsibilities of the contractor to the party receiving the work or services;

ii) be awarded only after pre-qualifying contractors against criteria necessary for effective management of the risks to the rig (this may include assessment of protocols used to guide professional judgement where professional judgement is the essence of the contract); and

iii) where the major purpose of a contract is the exercise of expert judgement the contract should have clauses which require; (adapted from the 'The Valmin Code', The Australasian Institute of Mining and Metallurgy, 1995)

a) the identification, relevant qualifications and experience of the expert who exercises the judgement and of all specialists whose work is used by the expert in making the judgement;

b) the expert or specialist stating in the report the purpose of the report and the purpose of any subsidiary report, its terms of reference or scope of work and any limitations on its use;

c) the expert and specialists stating in the report the endeavours they have taken to obtain and assess all relevant information and draw attention to any significant lack of information;

d) the report being written recognising the extent to which it may be used by readers having different interests and depths of technical knowledge;

e) the report to contain all information which potential users of the report would reasonably require and reasonably expect to find in the report for the purpose of making an informed decision in respect of the subject of the report;

f) the report to contain a balanced, objective and concise statement of the expert's review and conclusions so that potential users can have a clear understanding of the conclusions of the report and the attendant risks; and

g) the report to contain sufficient information to allow a validator or assessor to understand how the conclusions were reached. This information should include summary details of any models used and sensitivity to any changes in assumptions with respect to material technical parameters and the significant risks arising from these assumptions.

5. Where a Safety Case claims 'good oilfield practice' will be used, the relevant company should have in place management systems and procedures which identify industry practices and assesses them for use as criteria of 'good oilfield practice'. The company will then be able to substantiate their claim to be following 'good oilfield practice'.

6. Where a professional judgement is to be made that impacts significantly on safety, protocols should be established to guide the application of judgement. Such protocols should in particular address the need to identify the significant factors affecting the decision and to identify the assumptions used in reaching the decision.

7. Care should be taken to ensure the availability of relevant contingency response personnel and the good working order of communications systems when carrying out operations with significant risk.

In the opinion of the Inspector, the recommendations above (or their operational equivalents) are required if the objectives of the 'Safety Case Regulatory Regime' is to be achieved. It should be borne in mind that the recommendations are generalisations from the findings of the inquiry. In general, systems were in place, but were not fully effective. The Inspector also believes that recommended practices, codes of practice, guidelines etc. already exist which give adequate guidance in the matters addressed in the above recommendations.

In the opinion of the Inspector, industry needs to develop effective means of monitoring the degree to which effective implementation of the Safety Case is being achieved.

SECTION 2: DESCRIPTION OF CAMPAIGN

CAMPAIGN

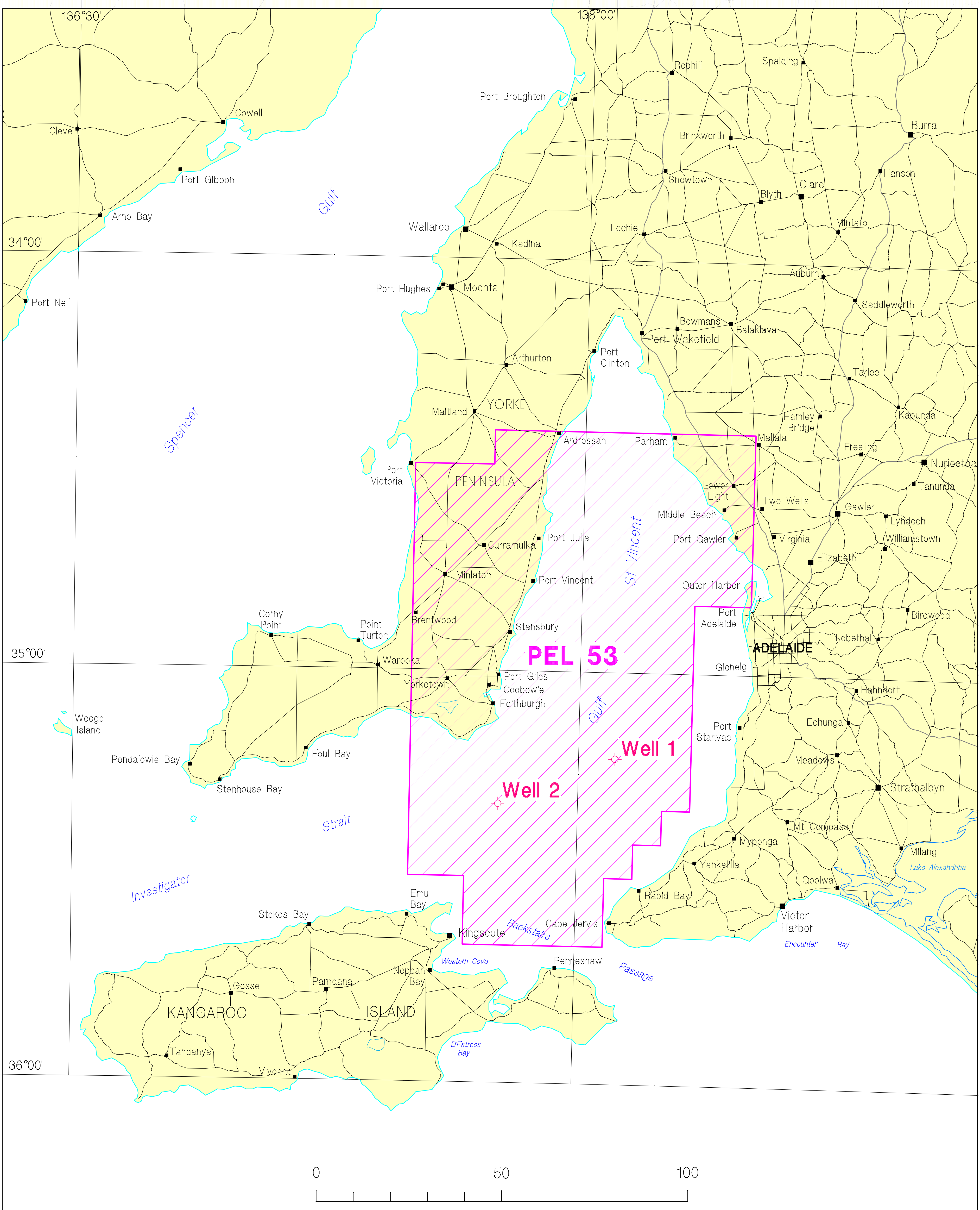
Drilling Objective

The Licensee of Petroleum Exploration License 53 (PEL 53), Canyon (Australia) Pty Ltd, an affiliate of Wagner & Brown of Texas, USA had a licence obligation to drill two wildcat wells in Gulf St Vincent, South Australia during late 1996.

The two wells were to be drilled to target Cambrian age sediments of the Stansbury Basin. These rocks have not been targeted for their petroleum potential since Beach Petroleum drilled three wells on Yorke Peninsula in the late 1960's.

The Campaign plan was to drill Frijole #1 first, followed by Enchilada #1 with the locations as detailed below and shown on Figure 1 :

Well	Frijole #1 (Well #1)	Enchilada #1 (Well #2)
Location from Adelaide	50 km SSW	88 km WSW
Target total depth of well	1450 m	1650 m
Water depth	40.0 m	32.5 m



Plan projection is simple conic
Tenement data correct as at 25th September 1996

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Petroleum Exploration Licence PEL 53 and proposed well locations

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Documentation

The operations were carried out pursuant to the following documentation required under the Petroleum Act 1940:

Declaration of Environmental Factors (DEF)
This document summarises the significant features of the environment in the area which may be impacted by the drilling operations and includes a description of the natural environment, location of sensitive areas, evaluation of environmental impact, and measures proposed to avoid/minimise and monitor impacts.

Code of Environmental Practice (CEP)
The CEP sets out the objectives, derived from a consultation and assessment process, which are to be met in managing impacts on the environment. Ideally they are expressed in quantitative terms but where necessary qualitative objectives are defined.

Drilling Program
The Drilling Program details the information relevant to the well, including design of the well and calculations used, density and composition of the drilling mud, and the testing program to be carried out if oil or gas is encountered.

Safety Case and Contingency Manual
These documents evaluate the risks involved in the drilling operations, and demonstrate how the risk has been reduced to as low as reasonably practical. It covers all aspects of operations including under tow, elevating/lowering of the drilling platform ("jacking up and jacking down"), drilling and logging operations, as well as emergency response procedures to manage hazards to the rig and personnel. The Safety Case is a rig specific study, and is amended to be operator and site specific by the preparation of a Bridging Document, which analyses and summarises the relevant aspects of the Safety Case that are pertinent to the specific Campaign.

Emergency Response Manual (ERM)
Procedures, including responsibilities of supervising staff and external resources, to deal with emergencies affecting the drilling rig, helicopters and support vessels are detailed in the ERM.

Oil Spill Contingency Plan (OSCP)
The OSCP defines State, company and personnel responsibilities, lines of communication and equipment required to manage and clean-up any oil spill, as well as the resources that can be called upon to assist. It details any considerations that must be taken into account before any decisions are made, and the personnel that must be consulted.

MANAGEMENT

Relevant Parties to the Campaign

The main parties involved in the Campaign and their roles were:

Company	Role (in brief)
Canyon (Australia) P/L	Licensee of PEL 53, and the party funding the Campaign.
Apache Energy Ltd	Petroleum exploration and production company operating in North West Shelf of Western Australia. Campaign Manager for Canyon and provider of drilling services personnel.
Maersk Contractors	Wholly owned subsidiary of A.P. Moller of Copenhagen, Denmark. Owner of drilling rig *Maersk Victory* and provider of drilling crew, including Tow Master.
Fugro Survey P/L	Worldwide consulting company which acquires relevant soil, water & air data for offshore activities and interprets that data. Conducted seismic and site surveys within PEL 53 for Canyon.
London Offshore Consultants (WA) P/L	Insurance Warranty Surveyors who prepare the ‘Certificate of Approval’ and monitor the rig operation on behalf of the rig owner’s insurance company during rig move, jacking & preload procedures.
Tidewater Port Jackson Marine	Provider of rig support vessels, “Massive Tide” and “Canning Tide”, including crews.
Q SEA Innovations	Quality supervisor of position surveyors of the site location.
Racal Survey Australia Ltd	Position surveyors of the site location.
American Bureau of Shipping (ABS)	Conduct routine vessel surveys, inspect the vessel and advise whether observed or reported damage means the rig is still within ‘class’.
Department of Mines and Energy Resources South Australia (MESA)	Lead Government agency responsible for ensuring legislation is complied with and being a facilitator for Licensee-Government issues.

Government's role

The Government, through MESA - Petroleum Division, has the objective of ensuring that petroleum resource exploration and development meets the Government's environmental, resource management and public safety objectives. Therefore in this Campaign, MESA was tasked to ensure that the State's assets were protected and that all activities complied with the relevant legislation and Government objectives.

The role of the Government in a regulatory system which places full responsibility upon industry for achievement of management of risks to 'as low as reasonably practical' (ALARP) is:

- to ensure the integrity of the system;
- to give an assurance to all stakeholders that the system will and is achieving ALARP; and
- to determine whether prosecutions for breaches of the Petroleum Act are warranted.

MESA in conducting the investigation of the accident deliberately limited it to:

- determining the circumstances of the accident;
- assessing whether or not the management systems in place were deficient in allowing these circumstances to arise and remain uncorrected;
- to determine whether or not it was likely or not that the accident was one within the ALARP criteria; and
- developing recommendations that identify improvements that can be made in industry practices to minimise the risk of this type of accident re-occurring to ALARP.

This investigation has been conducted by interviewing a number of personnel who were both directly and indirectly involved in the accident, and who had a range of roles and responsibilities. Industry sources of information and publicly available documents were also consulted in order to establish industry practices and 'best practice' guidelines.

Campaign Management Structure

Canyon, the Licensee, knowing they had no expertise in offshore exploration drilling, contracted Apache Energy to provide planning and supervision services for the PEL 53 drilling operations. This included the provision of the drilling rig, *Maersk Victory* and the various specialised drilling service consultants, as well as management of the drilling operations of the two wells. Apache Energy had a long term contract with Maersk Contractors for the provision of the *Maersk Victory* to drill wells under Apache's direction.

Apache apparently did not formally assess Maersk's management systems nor assess their level of implementation. Apache also did not formally assess the risks of operating in South Australia.

Canyon contracted the Perth office of a worldwide survey company, Fugro Survey Pty Ltd, to undertake seismic and site surveys of PEL53. The first seismic surveys were completed in 1994, and once availability of a drilling rig was confirmed for late 1996, Canyon again contracted Fugro to conduct a "Bathymetric and Geohazard Site Survey" of the Frijole #1 and Enchilada #1 well sites.

Apparently the primary role of London Offshore, as the Insurance Warranty Surveyor required by Maersk's underwriters, is to ensure that the interests of the underwriters and the insurance company(s) are protected, by preparing a 'Certificate of Approval' for each well and to be present during specific rig operations. Maersk pay for the services of the Insurance Warranty Surveyor. It appears that London Offshore take the information presented in the site survey report and generally available marine documents, review the information to the extent of their capability, and then make recommendations based on their personnel's experience. (Note that in the case of Frijole #1, they did not undertake a professional geotechnical review). These recommendations form a 'Certificate of Approval', which includes details such as anticipated leg penetrations, air gap between rig and sea surface, rig heading, and any other marine recommendations considered relevant to ensure the safety of the rig. A London Offshore representative is present on the rig during the rig move, preloading, and jacking operations, to ensure that

- the TowMaster and other Maersk personnel follow, and that their actions are in compliance with, Maersk's standard operating and safety procedures;
- the requirements of the 'Certificate of Approval' are complied with;
- the rig is at the nominated location; and
- no action is taken that will endanger the rig or personnel.

The London Offshore representative was present during the loading and offloading of the *Maersk Victory* from the *Super Servant 3* to ensure that the rig was safely handled at both times. He was not present during the journey from Dampier to Adelaide, when the operations were the responsibility of the TowMaster and Master of *Super Servant 3*. The TowMaster has ultimate responsibility for the rig and operations undertaken, however the London Offshore representative has the right to make his views known to the TowMaster.

There are various operations that involve the rig during which responsibility for the rig and its operations changes between different parties. However, the overall responsibility for the rig and its safety lies with the owners of the rig, Maersk Contractors and its delegated representatives.

When the rig is being transported by heavy lift vessel, the rig is the responsibility of the TowMaster until it is within the fifty metre range of the heavy lift vessel, when it becomes the responsibility of the heavy lift vessel company, and vice versa when it is offloaded.

There is a senior management position on the rig known as the ‘Person in Charge (PIC)’, who is in full control of all the operations that are conducted once the rig leaves the responsibility of the heavy lift vessel company. The holder of this position on Maersk rigs varies according to the operation underway at the time, whereas elsewhere in the industry it appears that the PIC is the Senior Tool Pusher at all times. On Maersk rigs, the TowMaster, as the PIC, manages the rig move and jacking-up operations, until the cantilever containing the drilling equipment is ready to be skidded out and secured, when the operations are handed to the Senior Tool Pusher who becomes the PIC. Likewise once drilling operations have been completed, the TowMaster again becomes the PIC and manages the jacking-down and rig move operations.

Site Survey and associated documents

The Fugro Survey Pty Ltd "Report on Bathymetric and Geohazard Site Survey PEL-53 Frijole Step-Out Site, Gulf of St Vincent, South Australia" consisted of side scan sonar, sub bottom profiling using seismic boomer surveying, and seabed sampling techniques (dredge and grab samples) that penetrated less than one metre into the seabed. The report states

"The seabed across the surveyed site appears from the side scan sonar to be smooth and featureless and essentially flat varying between 39.9 and 41.5 metres deep. Sandy sediments, which should afford good lateral stability to the rig legs vary between 0.8 and 1.2 metres thick across the site, and the underlying more consolidated stratum appears to be suitable as a secure foundation."

"In the absence of geotechnical information, the usual preload tests are recommended to confirm foundation stability."

Canyon provided one copy of the site survey to Apache Energy, who passed it on to Maersk Contractors, who forwarded it to London Offshore, who apparently then kept it. Canyon also instructed Fugro to provide any further information to Apache Energy that was requested, including survey reports, however it is reported that no further information was requested.

London Offshore issued a 'Certificate of Approval' based in part on the Fugro site survey and there were no areas of concern highlighted. This 'Certificate of Approval' was presented to Maersk. However, it appears that no geotechnical expert assessed or reviewed the site survey.

A 'Letter of Instruction' was issued to the TowMaster, which detailed all the specific requirements and instructions for each rig move as decided by Maersk Marine Department in Copenhagen. The TowMaster also had to complete a checklist listing all the documents required to be in his possession prior to commencing any operations, which included the site survey.

Fugro carried out the seismic and site surveys, whereas RACAL undertook the rig positioning on the Frijole #1 location. It is noted that industry practice seems to be that one company will undertake both the surveying and the positioning functions, probably due to contractual agreements being easier to manage, which also means that the company usually has their own copy of the site survey on the rig for their own reference and information. In this case, Canyon contracted Fugro prior to the determination of the drilling rig, whilst Apache had an existing contract with RACAL to provide rig positioning services for the *Maersk Victory*.

The contract documents for Fugro and London Offshore made available to MESA do not contain a description of the Scope of Work to be carried out.

MAERSK VICTORY

Selection of the MODU *Maersk Victory*

The selection of the *Maersk Victory* for this Campaign apparently was made for the following reasons :

- availability of rig and personnel;
- marine environment (eg water depth, wind, wave height, etc.) was suitable for a jack-up rig of this class;
- cost due to the rig already operating on the North West Shelf of Western Australia minimising mobilisation costs; and
- ease of use, as the rig already had an Australian operating record and had submitted, and received provisional approval of, a Safety Case and associated documents.

The *Maersk Victory* is a 'mobile offshore drilling unit (MODU)' jack-up rig of type MODEC 300C-35, classified by the American Bureau of Shipping (ABS) as "ABS Maltese Cross A 1 - self-elevating drilling rig without circle E". It was constructed by Mitsui Ocean Development & Engineering Co. Ltd. (MODEC), Japan and delivered in August 1981.

History of *Maersk Victory*

After commissioning in 1981, the *Maersk Victory* operated in the offshore waters of United Arab Emirates and Qatar, drilling on 55 locations. In October 1986, during the Iran/Iraq war, the rig was attacked by aeroplanes and sustained damage due to explosions and the ensuing fire. It is reported that the aft port corner of the hull, and legs #2 and #3 were damaged. The rig was satisfactorily repaired and returned to service.

The *Maersk Victory* entered Australian waters in April 1996, and commenced operations with Apache Energy operating in the North West Shelf of Western Australia. During the April to October 1996, the rig was engaged on 12 locations in this area.

In November 1996, a routine vessel inspection was begun in Dampier by the American Bureau of Shipping (ABS) including a spudcan survey, which was undertaken on the heavy lift vessel prior to leaving Dampier, and completed in South Australia on November 15 1996. There was some damage reported to two braces at the top of leg #2 and some slight damage to the tip of the spudcan on the same leg. This damage was not considered by the ABS representative to put the rig out of 'class', and plans were made to conduct the repairs before June 1997.

SECTION 3: DESCRIPTION OF ACCIDENT

EVENTS PRIOR TO AND DURING THE ACCIDENT

It has been reported that at no time during the operations were weather conditions a significant influence on operations.

On Friday November 15 1996, the *Maersk Victory* entered the Gulf St Vincent, South Australia on a dry-tow aboard the heavy lift vessel, *Super Servant 3* after a voyage from Dampier, Western Australia. It is reported that during the voyage, the maximum pitch of the vessel was 3-4 degrees, which was within the acceptable criteria. It moored at a location north of the well site to offload the rig due to weather conditions in the lower Gulf area. During the afternoon, a meeting was held on the *Super Servant 3* to plan the offloading of the rig and the rig move to the first well location. This meeting was attended by the Masters of the support vessels and *Super Servant 3*, TowMaster, and London Offshore representative. Subsequently the *Super Servant 3* was ballasted down, and the rig offloaded at 2000 hours using the support vessels *Massive Tide* connected to the main bridle forward, and the *Canning Tide* to the starboard aft. Supervised by the TowMaster, once the rig was clear of the heavy lifter, the *Canning Tide* was released, and the *Massive Tide* then towed the rig on a 1800 foot tow wire attached to the main bridle at full power generating a speed of approximately 4 knots during the 40 kilometres to the well location, Frijole #1. The *Canning Tide* remained in close vicinity to the rig and towing vessel to provide assistance if required. During the tow, the three spudcans were lowered into the water, filled, checked, retrieved and manhole covers closed. This procedure was undertaken to provide the weight in the spudcans necessary for the secure positioning of the rig on its location.

During the tow to Frijole #1, it was identified by the Q Sea representative, that a copy of the site survey was not on board the rig at this time, and a request was made to have one brought out by the next helicopter. However due to weather conditions, the helicopter due on the rig later that night was cancelled. There has been no reason given to satisfactorily explain the absence of copies of the site survey report from the rig, which according to procedures and common industry practice should have been in the possession of a number of the personnel aboard the rig. The Q SEA representative then contacted the Apache representative in the Canyon Operations Office (in Adelaide) and requested advice regarding whether the report contained information indicating that there were any circumstances out of the ordinary, and received a response that there were no concerns cited in the survey report. It was also confirmed during this conversation that the rig would be positioned facing north-west, and it is noted that the 'Certificate of Approval' recommends a rig heading of west-north-west, which would allow for supply boat operations on the port side and the prevailing winds for well testing.

At 0218 hours, as the rig approached the Frijole #1 location, the *Massive Tide* shortened up its tow wire to 900 feet in order to prevent it dragging on the bottom as the vessel's speed was reduced to steering speed. At 0400 hours, the rig was at the one kilometre distance from the nominated location. At 0430 hours, jacking down of the legs commenced to engage the seabed and soon after bottom contact was noted. The tow wire between the *Massive Tide* and the *Maersk Victory* was maintained in a sagging condition, almost to the sea floor, with the intention of avoiding inducing any tension in it. Shortly thereafter the *Maersk Victory* stopped and became fully engaged on the seabed with a minor penetration. A position check undertaken by the Racal personnel found the rig to be approximately 68 metres from the nominated Frijole #1 well location.

To reach the well location, the TowMaster decided to reposition the rig by a procedure known as 'walking'. This required the slight jacking up of leg #1 and one of the other legs, and then the *Massive Tide*, being still attached to the main bridle at leg #1, pulling the rig around by applying low power which caused the rig to pivot alternatively on legs #2 and #3, which were still engaged on the seabed. (The procedure follows these stages: the rig is pinned on the starboard leg, lifts the port leg, and TowMaster instructs "Starboard 30% power" or suchlike, and the towing vessel pulls the rig around spinning on the pinned leg, TowMaster says "Stop", and then pins the port leg and lifts the starboard leg, and the towing vessel goes the other way and the rig follows that way as well.) The catenary tow wire is attached to the main bridle and hence is forward of the direction in which the rig is being towed, because the combined weight of the tow wire and the towing vessel is required to move the rig. The *Maersk Victory* has 'stress' indicators on the control room console to indicate the amount of stress being induced in the legs, which if excessive the TowMaster would then stop the operation and 'shake out' the stress by raising the affected leg. The 'walking' process was undertaken at least three times to cover the distance to the nominated well location. It was reported that the pivoting was very easy, which meant that the spudcans had a very soft seabed on which to skid. There were no reported difficulties and the London Offshore representative was not reported as objecting to the conducting of this manoeuvre. A subsequent position check revealed that the rig was 2.4 metres from the target, which was within the 25 metres acceptable limits for this well and was subsequently accepted by Q SEA, as the representative of the Operator. Leg #3, being the last leg pivoted on, was jacked up slightly to reduce any induced torque, and all three legs were lowered to the seabed in preparation for preloading.

Subsequently, the TowMaster discharged the *Massive Tide* from towing duties, which then paid out the tow wire to 2000 feet, and moved away from the rig and anchored as per normal procedures. At this time, the *Massive Tide* was not involved in any process with the *Maersk Victory*, and was only attached via the tow wire lying on the sea floor in case anything went wrong and the rig had to be suddenly towed away.

It is reported that the TowMaster decided to jackup the rig to reach the two metre preload airgap to allow the helicopter to land on the rig, which would bring the site survey report and permit personnel transfer. Jacking was commenced at 0630 hours to raise the hull free of the water. Experiencing greater penetration than the predicted 2.0 to 2.5 metres nominated in the ‘Certificate of Approval’, Q SEA requested the Canyon Operations Office for the relevant pages of the site survey to be faxed out to the rig, in particular the boomer surveys. Personnel on the rig, including the TowMaster, who reviewed this data had no professional qualifications or expertise in seismic interpretation. It was also later questioned when the full site survey was viewed on the rig, whether the information transmitted by facsimile was for the actual site where the rig was located. Zero air gap (ie. hull left the water) was attained at 0712 hours, with initial penetration on all legs of :

Leg #1	9.4 metres
Leg #2	7.2 metres
Leg #3	9.2 metres

Within a short time of reaching zero air gap, leg #2 settled a further approximately two metres, thereby reaching a similar penetration to the other two legs. This was counteracted with the standard procedure of lowering the hull by jacking down on leg #1 and leg #3. There was no indication of any other concerns. During the jacking operations, it is reported that the TowMaster attempted to contact Maersk’s Copenhagen office for advice, but was unable to receive any assistance in obtaining further information or guidance on the situation encountered.

Once the rig was level, jacking recommenced to again achieve zero air gap and to continue to the final preload airgap of 2.0 metres. This airgap is determined by the expected tide and sea conditions, as the preload continues for a number of hours. The leg penetration at the preload air gap was :

Leg #1	9.9 metres
Leg #2	9.6 metres
Leg #3	9.6 metres

Preloading was then delayed to await the arrival of the helicopter from shore at 0825 hours bringing the complete Fugro site survey and supervisory personnel, and to disembark other redundant personnel from the rig. There were now 33 people on board the rig. Examination of the Fugro site survey report by a number of personnel, including the TowMaster and other Maersk senior rig personnel, Apache, London Offshore, Q SEA and RACAL representatives, could find no reason within the report to suspend or modify operations even though the penetration was significantly greater than that predicted. It is noted that none of these personnel were professionally qualified to interpret seismic data in any form, although some had previous exposure to seismic reporting. It is reported that none of the personnel involved in the discussion relating to the site survey and the penetration voiced overriding concerns and it was accepted that preload could commence. The interpretation that a ‘harder’ layer existed at approximately 10 metres appeared to be borne out by the fact that the legs had settled at this depth, and the TowMaster decided to continue normal operations and begin preload.

Preloading of a jackup rig requires the intake of seawater into tanks located around each leg well, which is similar to ballasting a ship. The intention is to simulate the maximum loading on the rig that could be attained during drilling operations to ensure that any settling or movement that could be induced by drilling is already undertaken. It was anticipated that a total of 3800 metric tonnes of preload water would be added to the rig, which was the full allowable preload, and it was planned that it would be held for a duration of 6 hours. The TowMaster instructed that the preload operation was to be carried out maintaining a very even load on all three legs, which was achieved by regulating the flow of water to each preload tank through valving. The *Massive Tide* was still attached to the rig via the tow wire which was slack, and the *Canning Tide* was in attendance some distance away.

During the preload, at a coffee break, a safety meeting was held with the majority of onboard personnel to discuss the preloading procedure, penetration situation and other safety issues. A number of personnel did not attend, including those who had been conducting work during the night and were asleep in their cabins.

At 1000 hours, the load on each leg (preload water plus rig static load) was calculated at :

Leg #1	3000 metric tonnes
Leg #2	3000 metric tonnes
Leg #3	2900 metric tonnes

It was reported that the wind had increased during the morning from 10 knots at 0400 hours to 25 knots at 0700 hours, however by 1200 hours it had dropped to 5 knots. The sea state was 3, which is about one and a half metres of wave height, which apparently does not impede rig operations.

At 1032 hours, one third of the way through preload, the starboard quarter of the hull suddenly listed downward and water washed onto the deck. After undergoing two or three surges, the rig stabilised. It was conjectured that leg #2 had experienced a 'punch through', which means that the spudcan had broken through the supporting layer on which it was sitting, and had 'pulled' the rig down where leg #2 was connected to the rig hull. Standard operating procedures dictated that to counteract the list, lowering the hull at the port leg was attempted by jacking down, which was unsuccessful. The TowMaster initiated an inspection of all three legs, which were subsequently reported as severely damaged. Leg #1 and leg #2 were diagnosed as damaged along their full length and within the jacking unit structure/legwell, and leg #3 below the hull. There has been no evidence presented to suggest that there was any structural failure of any of the legs or any part of the rig.

At 1035, the TowMaster decided to evacuate all personnel from the rig via the support vessels - this was reported to be the most expeditious method and due to the list of the rig, some of the life boats were inaccessible. However, neither the 'Abandon Rig' alarm nor the P.A. system were used to advise of the evacuation for fear of creating unnecessary panic amongst personnel. In the meantime, most personnel had assembled on the high side of the rig, port side of the main deck, and donned life jackets in preparation for evacuation, however one person had entered the water. A 'Man over Board' alert was raised, a dye marker was released into the water to indicate his location and a scramble net lowered over the rig's hull to allow the person to return to the rig's deck - which he promptly did.

It is reported that a roll call was then undertaken, and the first count noted two missing people, who were identified as the Racal personnel who had previously been sent to their cabins by the TowMaster for rest. Two supervisory personnel went immediately to the appropriate cabin and woke these people, who were still asleep. It is noted that there was an alarm speaker located almost directly outside the cabin where these personnel were sleeping.

A watertight integrity check was conducted by senior Maersk personnel to ensure no water ingress would occur.

In its role as support vessel, the *Canning Tide* was monitoring the *Maersk Victory* and visually noted the change in status of the rig. Both support vessels were aware of the man overboard alarm and the request to the *Canning Tide* to mobilise the "Fast Rescue Craft" (FRC). However the man overboard had returned to the rig via the scramble net, and the FRC was utilised to evacuate the rig. Immediately after the FRC was launched, the *Canning Tide* began to weigh its anchor, which took approximately 15 minutes before it could move closer to the rig. Personnel alighted from the rig via the scramble net into the FRC and were then transferred to the *Canning Tide* five at a time. To evacuate all personnel required approximately seven trips, with the TowMaster and Barge Engineer being the last to evacuate at 1115 hours. Just prior to completion of the evacuation, the positioning equipment showed that a horizontal shift of 20.5 metres in a 054 degrees direction had occurred, in conjunction with a change of heading to 5 degrees to the starboard.

The support vessels use the same radio channels as the rig during the rig move, and hence the support vessels can hear the dialogue aboard the rig by the preloading personnel. It is assumed this is how the support vessels initially became aware of the rig's predicament. The *Canning Tide* master indicated that he would go alongside the rig and disembark people straight onto his vessel, however the rig personnel advised that they wanted to do it by FRC. This was the first that the support vessels knew of the rig's greater than anticipated penetration, and the status of the preload - apparently it is common practice for the support vessels not to be informed of the expected operations of the rig during preloading, and so would have no knowledge of any situation of unexpected penetration.

Meanwhile, the *Massive Tide* although monitoring the radio channel that had previously been in use for the rig/support vessel communication, was unaware that an evacuation was taking place, and unable to determine what was happening, moved around the rig to gain a better vantage point in order to appraise the situation. At this time, the tow wire was still connected between the *Maersk Victory* and the *Massive Tide,* although it was slack.

A new aluminium FRC was also located on the *Massive Tide*, but the offloading crane had been defected by Australian Maritime Safety Authority (AMSA), as it suffered a bent jib during a routine test loading in Adelaide. AMSA issued instructions that the FRC was to be launched over the stern if it was to be deployed. The *Massive Tide* was requested to launch its FRC, and it was decided to utilise the crane to launch the FRC without any people in it over the side of the vessel. This was because the *Massive Tide* Master assessed the risk of launching the FRC over the stern as being too dangerous due to the presence of the tow wire to the *Maersk Victory*, and the possibility that the FRC could fill with water after being dropped the few metres into the water, which would then require it to be bailed out before being able to assist in the accident response. It was also considered that the person operating the crane would be well clear of the crane load and would be placed at minimal risk if the jib failed. Once launched, a crew member of the *Massive Tide* manoeuvred the FRC over to the *Maersk Victory*. However, once near the rig, the outboard engine failed and it was unable to provide assistance in the evacuation (this engine had previously been used on the inflatable dinghy that was replaced by the aluminium FRC and had not had previous problems). This FRC was later retrieved by the *Canning Tide*'s FRC and towed to the *Massive Tide*. The *Massive Tide's* FRC was considerably smaller than the *Canning Tide's*, and was only certified for four people including the driver, as well as not being a dedicated high speed FRC. It was also reported that the TowMaster did not know that the *Massive Tide* FRC was restricted in its launching ability.

It was reported that the *Massive Tide* Master was instructed by the Apache Energy representative to let go of the tow wire, and subsequently checked the instruction with and had it confirmed by the TowMaster. The tow wire was let go, and wound in aboard the *Massive Tide* - the wire is circular and is connected with a shackle so that it is unnecessary to release it from towing bridle on the rig, and all operations are done from the towing vessel.

At 1305 hours, twenty eight non-essential personnel were transferred to the *Massive Tide* and returned to shore. The TowMaster, Barge Engineer, Rig Engineer, Senior Toolpusher and London Offshore representative remained on the *Canning Tide* to secure and monitor the rig. A visit was made to the rig and a line attached from the *Canning Tide* to the *Maersk Victory* at 1400 hours. Further visits to the rig were made during the afternoon to dump the preload water, check the water tight integrity, and organise power supplies. At 1920 hours, the *Massive Tide* tow wire was again connected to the main tow bridle and a watch mounted from the *Canning Tide*.

RECOVERY OPERATION OF THE *MAERSK VICTORY*

Extensive damage to all three legs below the rig hull, and to leg #1 and leg #2 above the hull prevented the legs and attached spud cans being jacked up out of the seabed by the rig. Subsequently the rig was freed from its legs on November 28 1996 and towed by the *Massive Tide* accompanied by the South Australian State Emergency Response Vessel *mv Gallantry* to a safe anchorage off Port Adelaide. At this location, the rig was further stabilised and the protruding sections of legs below the hull were trimmed and secured. The rig was then towed to the Australian Submarine Corporation dockyard at Osborne, and work commenced to prepare the rig for repairs. All the recovered leg sections were stripped of their bracing and the valuable leg chords retained. Subsequently the rig and salvaged chords were loaded back onto the *Super Servant 3,* which sailed on December 20 1996. Meanwhile, Maersk were negotiating the contract for conducting the repairs and other necessary maintenance work, which was awarded to the Far East Levingston ShipBuilding company of Singapore.

The heavy lift vessel *Dock Express 10* was mobilised from overseas and began to lift the cut leg sections from the sea floor on December 23 1996, which continued until January 2 1997.

On January 8, the *Dock Express 10* began its attempt to lift spudcan #1 which had penetrated to a depth of 9.6 to 9.9 metres, and after damaging and repairing lifting equipment, the spudcan was finally freed and lifted out of its footprint on January 13. The weight of the mud attached to the spudcan proved to be excessive for the lifting equipment, and had to be removed by washing the spudcans with compressed air, prior to final lifting into the vessel's hull on January 25 1997.

Concurrently, preparation of spudcan #3 which was at the same approximate penetration as spudcan #1, was commenced on January 17, culminating in the first attempt to pull it out on January 26. Once again the load was borderline and damage occurred to the lifting equipment, requiring more mud to be removed to reduce the weight. Then the spudcan was removed from its footprint, and washed until light enough to lift into the *Dock Express 10* on February 3 1997.

It is assumed that spudcan #2 punched through a hard layer, which is shown on the shallow seismic survey at approximately 10 metres below the mudline. Spudcan #2, consequently penetrated deeper than the other two spudcans to a depth of 15 metres at an angle of 15 degrees. At the time of writing, resolution of the abandonment of spudcan #2 is still being sought.

SECTION 4: REFERENCE PAPERS AND DOCUMENTATION

Government Issued Guidelines

"Guidelines for Preparation and Submission of Safety Cases"
Petroleum and Energy Policy Division
Department of Primary Industries and Energy, Canberra, Australia
January 1995

"Guidelines for Mobile Offshore Drilling Unit Safety Case Submission - Bridging
Petroleum Operations Division
Department of Minerals and Energy, Western Australia
15 March 1996

Jack-up rigs and site surveys

"Offshore Installations: Guidance on design, construction and certification"
Section 14 - Site Investigations and Section 20 - Foundations
Department of Energy, London, Fourth Edition, 1990

"The Marine Operations of Self-Elevating Platforms"
Noble Denton International Ltd / Aberdeen College of Further Education
Revision 3, March 1992

"Recommended Practice for Site Specific Assessment of Mobile Jack-Up Units"
First Edition, May 1994, Society of Naval Architects and Marine engineers

"Jack-up Moving" Volume 2, "Oilfield Seamanship" Series
Michael Hancox
Oilfield Publications Limited, Homend House, PO Box 11, Ledbury,
Herefordshire, HR8 1BN, England, Tel: (0531) 634563 Fax: (0531) 634239

Risk Management

"Dealing with Risk - Managing Expectations"
Australian Council of Professions Ltd, 1996

"HAZOP & HAZAN: Notes on the Identification and Assessment of Hazards"
Second Edition
Trevor A. Kletz
The Institution of Chemical Engineers, England, 1986

"Approach to Risk Management in Pipeline Design"
K Bilston
Australian Pipeline Industries Association Risk Management Forum, Adelaide,
August 1996.

Interim Australian / New Zealand Standard AS/NZS 3931(Int):1995 "Risk analysis of technological systems - Application guide"

"Guidelines for Hazard evaluation Procedures"
Battelle Columbus Division
The Center for Chemical Process Safety, American Institute of Chemical Engineers, 1985

Contract Management

"Qualification Based Selection for the Procurement of Engineering and Management Services - Embracing World's Best Practice"
Association of Consulting Engineers Australia

"Qualification Based Selection: The Probity Perspective"
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Australian Standard AS4121 - 1994 "Code of ethics and procedures for the

Interim Australian Standard 4122 (Int) - 1993 "General conditions for engagement

"Code and Guidelines for Assessment and Valuation of Mineral Assets and Mineral Securities for Independent Expert Reports (The Valmin Code)"
The Australasian Institute of Mining and Metallurgy, June 1995

"The Heart of the Enterprise - (The Managerial Cybernetics of Organization)"
Stafford Beer
John Wiley and Sons, 1990

"Beyond TQM"
Robert L. Flood
John Wiley & Sons, 1993

"Rational Choice in an Uncertain World"
Robyn M. Dawes
Harcourt Brace Jovanovich College Publishers, 1988

"Uncertainty: A Guide to Dealing with Uncertainty in Quantitative Risk and Policy

M. Granger Morgan and Max Henrion ; with a chapter by Mitchell Small
Press Syndicate of the University of Cambridge, England