Subsea Facilities Decommissioning –Selected Practical Optimisations and Considerations

- Subsea Tree Tooling Optimisations – Examples
- NORM
- Basker Manta Gummy Case Study – Deconstruction for NPP

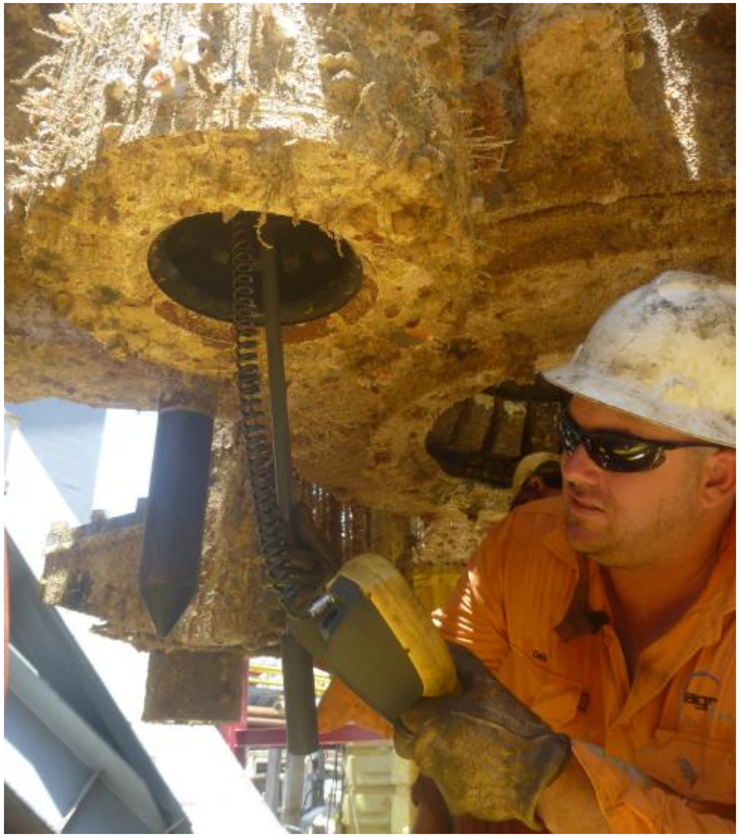
Subsea Well Abandonment

Subsea Tree System Tooling Optimisations

Typical Abandonment Activities

- Kill the well
- Plug the well with cement
- Possible use of Coiled Tubing
- Recover and dispose of subsea and downhole equipment

➢ ***Safe, environmentally compliant and cost effective execution***

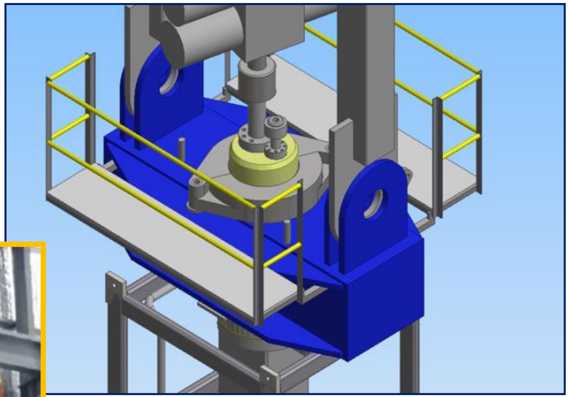


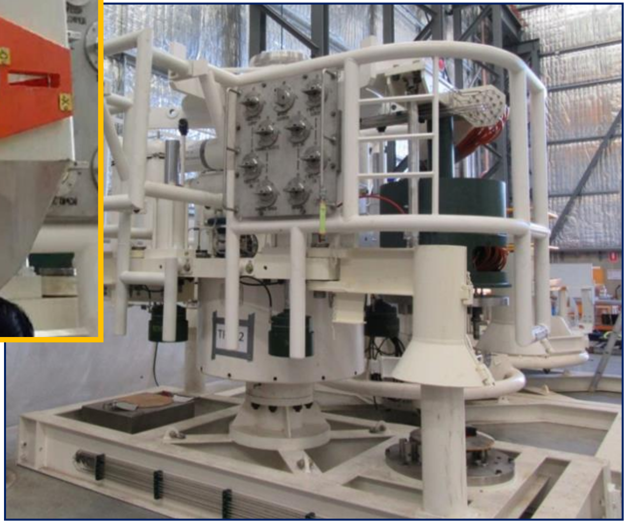
Typical Abandonment Challenges

- **Subsea equipment not fully functional**; mechanical failure, mechanical damage, corrosion, calcification of interface surfaces, marine growth
- **Integrity of well control barriers**; leaking tree valves, viability of tubing mechanical plugs
- **Availability and condition of original bespoke intervention/installation tooling**
- **Exposure to contaminated equipment**; people and environment

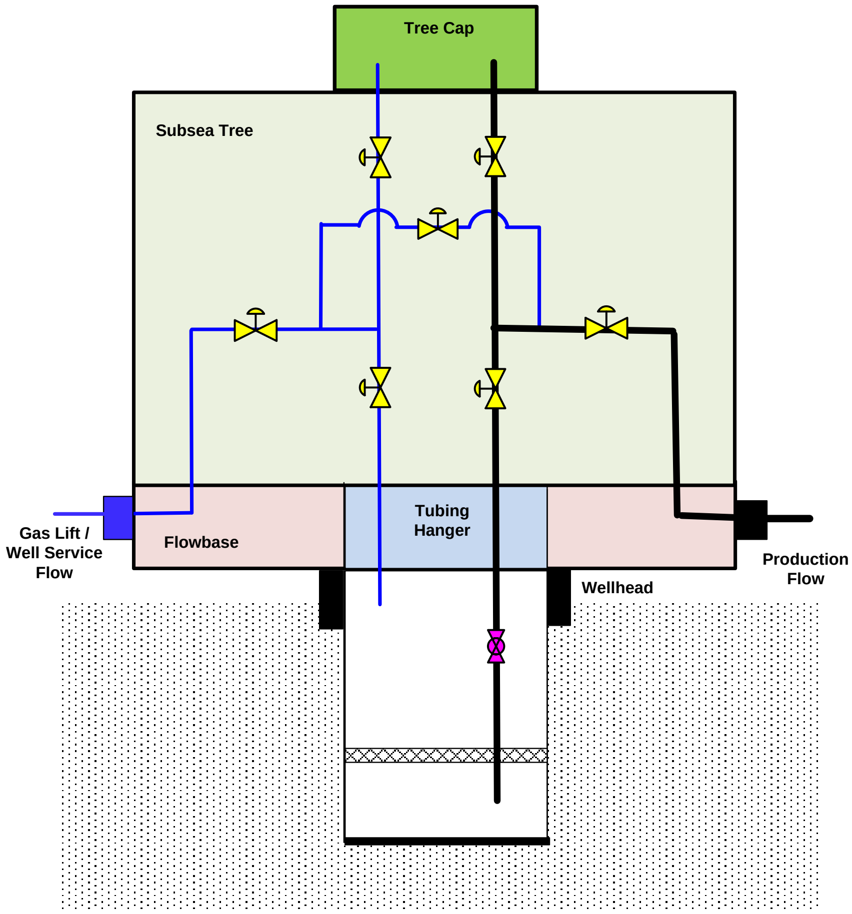
Tooling Optimisation Examples

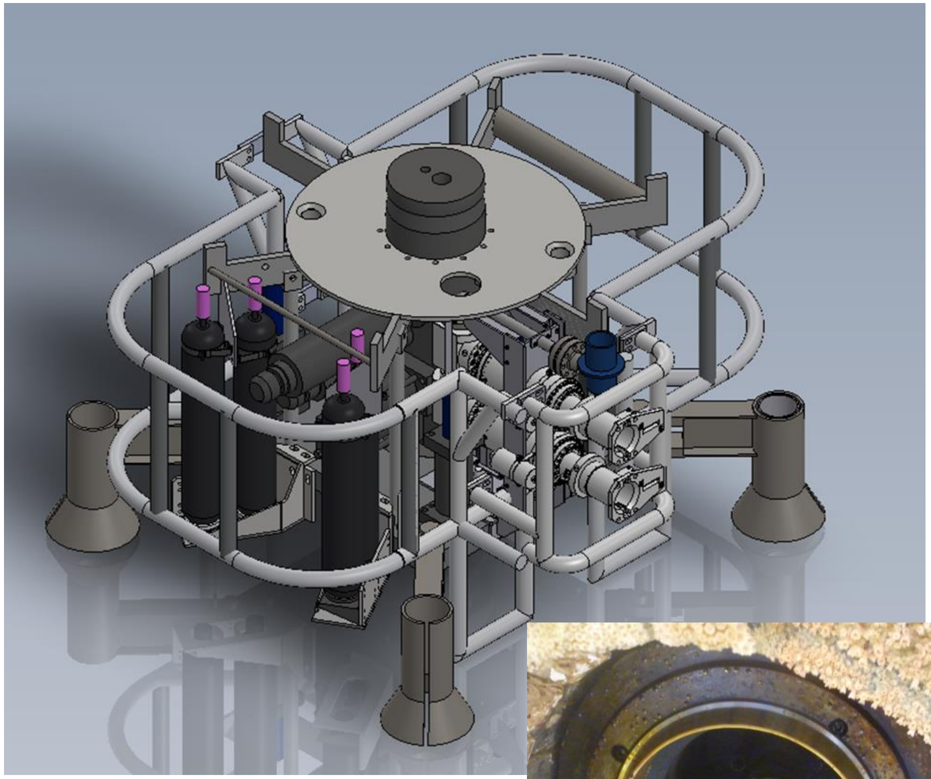
1. **Coiled Tubing Lift Frame Interface – Rotatable Collar**
2. **Tree Running Tool Cement Injection Port**
3. **IWOC Optimisation – Tree Running Tool ROV Panel**



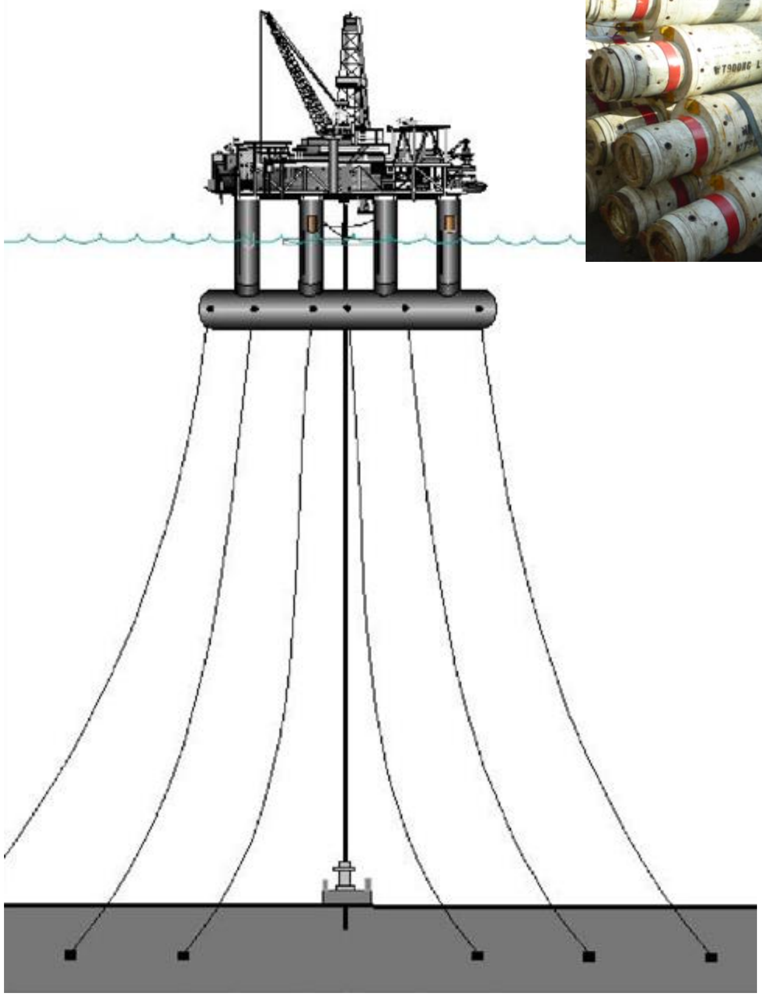


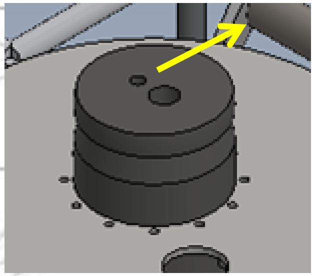
Vertical Dual Bore Subsea Tree



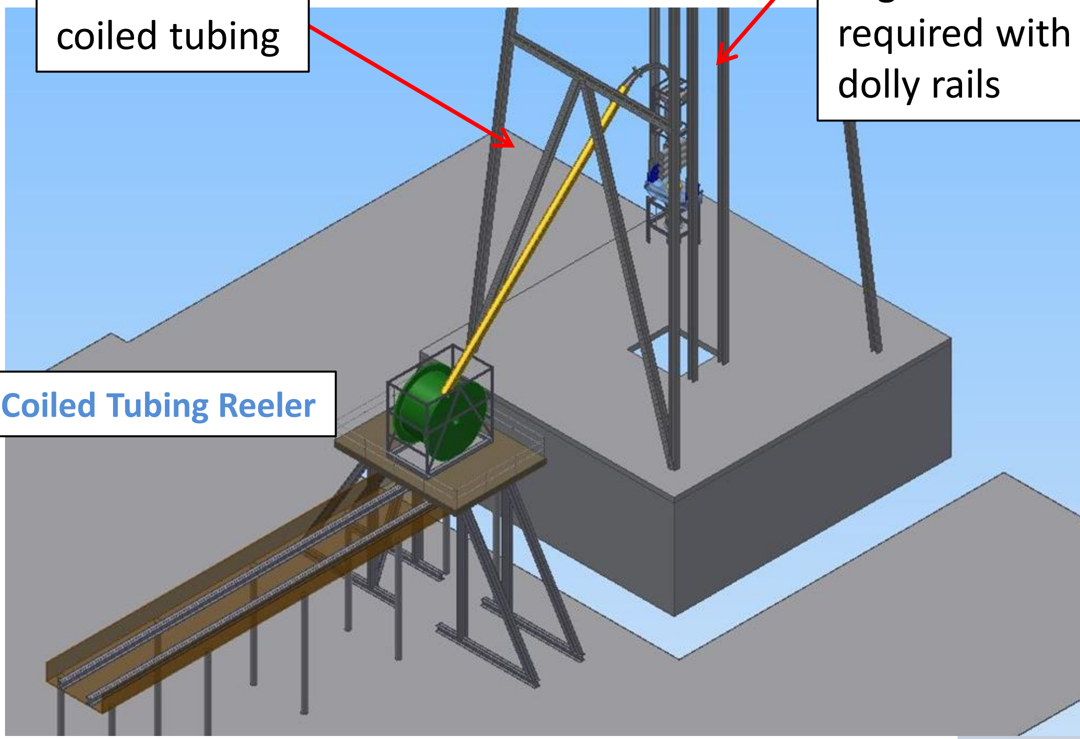


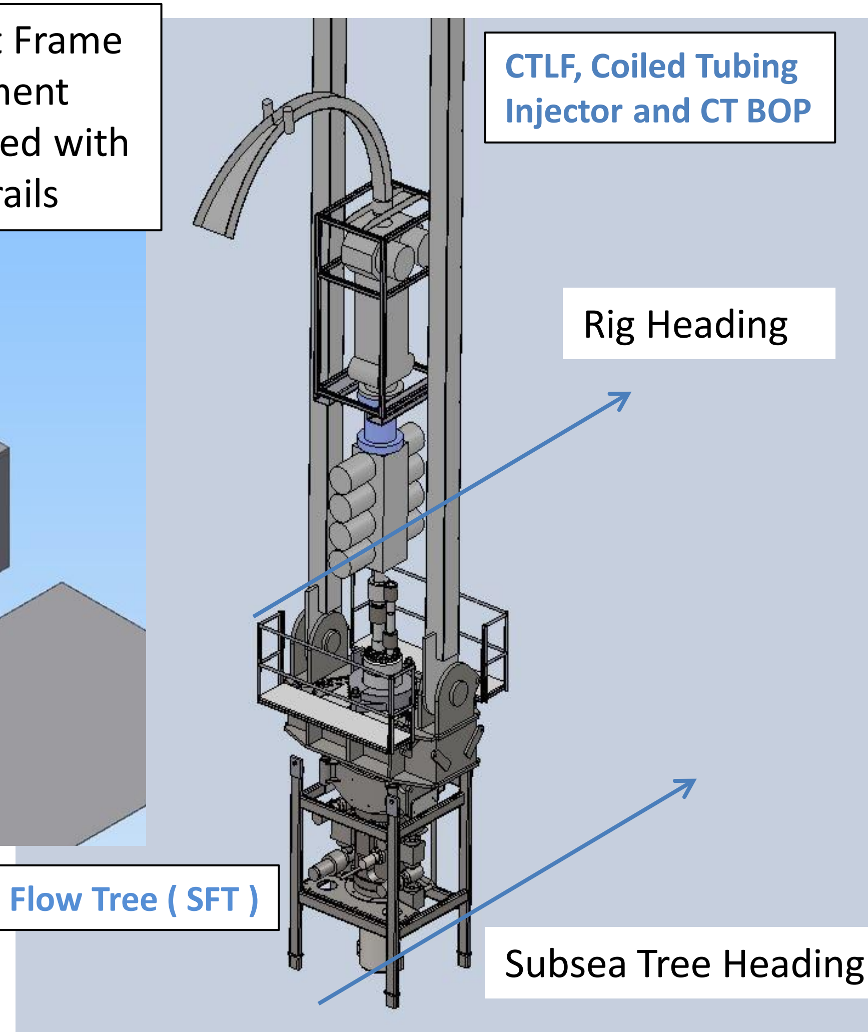
Dual Bore Tree System – Heading Considerations





Coiled Tubing Lift Frame (CTLF) Interface

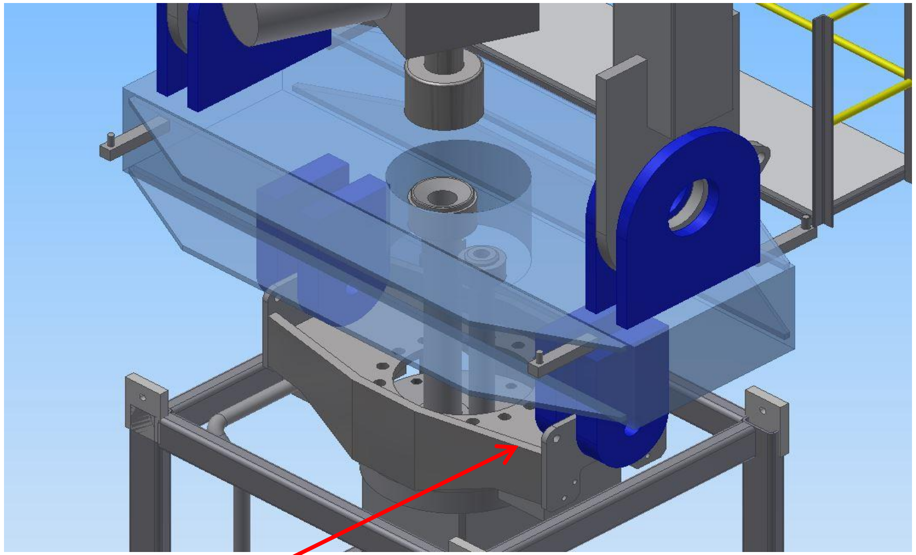




* Equipment Layout Constraints
* No torsion in completion riser

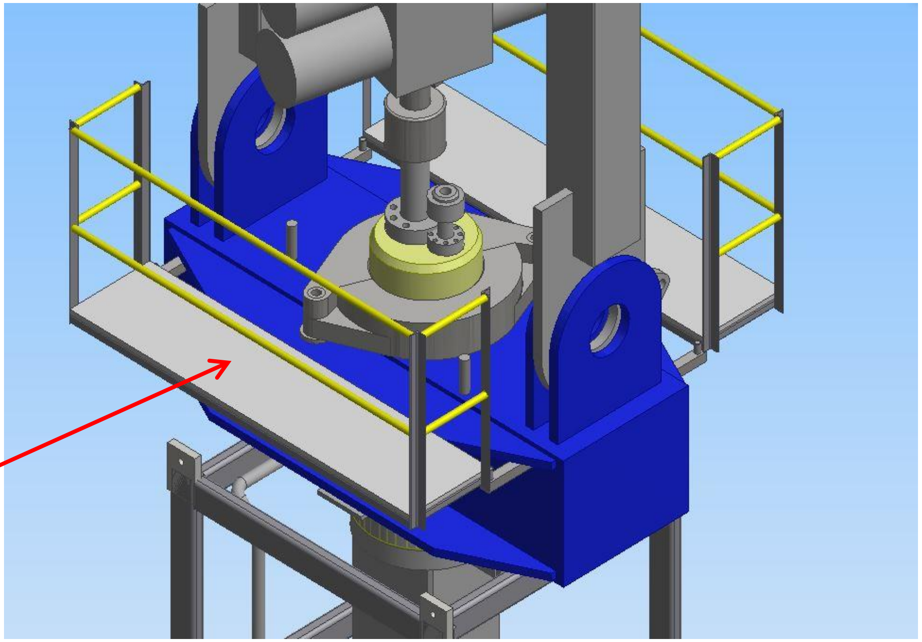
CTLF Interface – Rotatable Collar

ORIGINAL DESIGN – Fixed Orientation



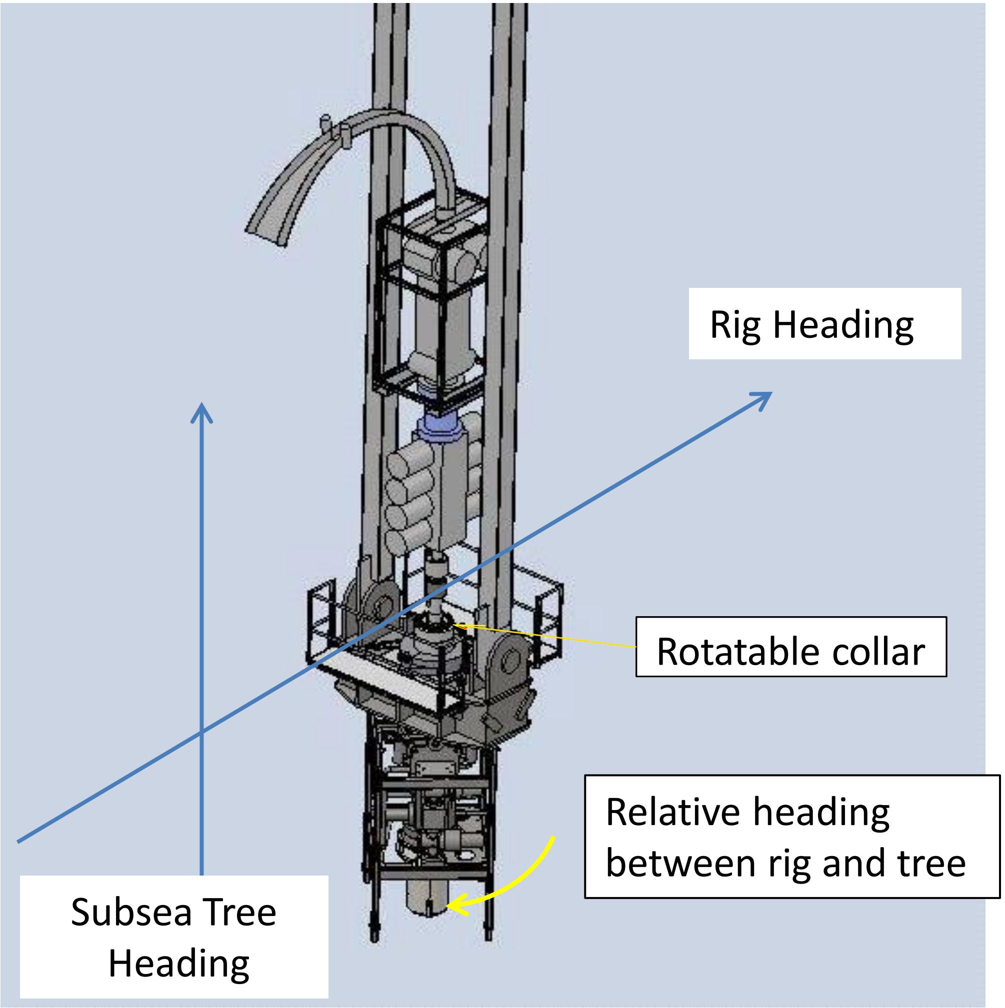
Padeye mounts fix the orientation of the CTLF to the heading of the Dual bore riser.

NEW DESIGN – CT Lift Frame padeye interface clamped to the body of the surface flow tree at any required orientation

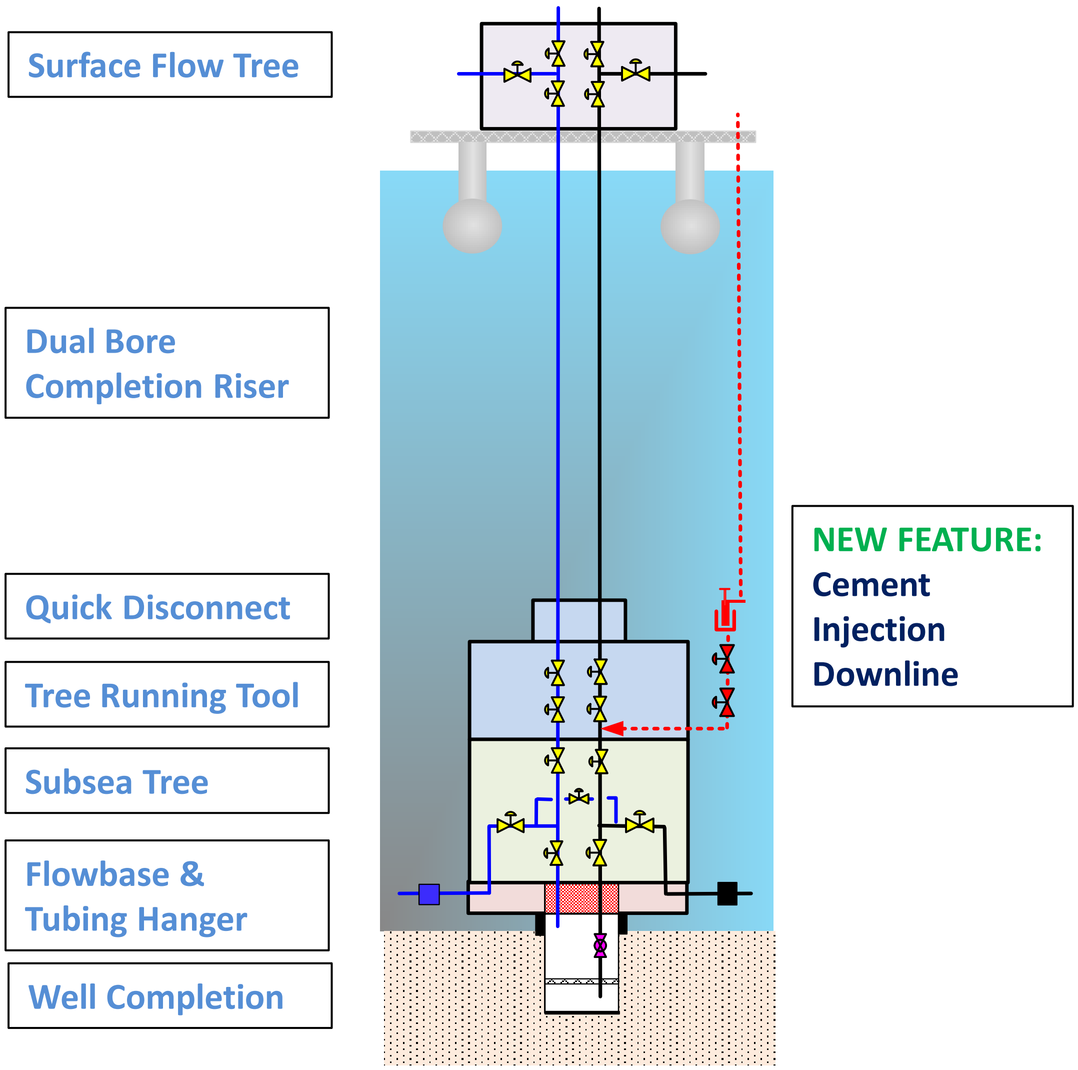


Spool bolted to SFT body and CTLF clamped with rotatable collar.

CTLF Interface – Rotatable Collar



Cement Injection



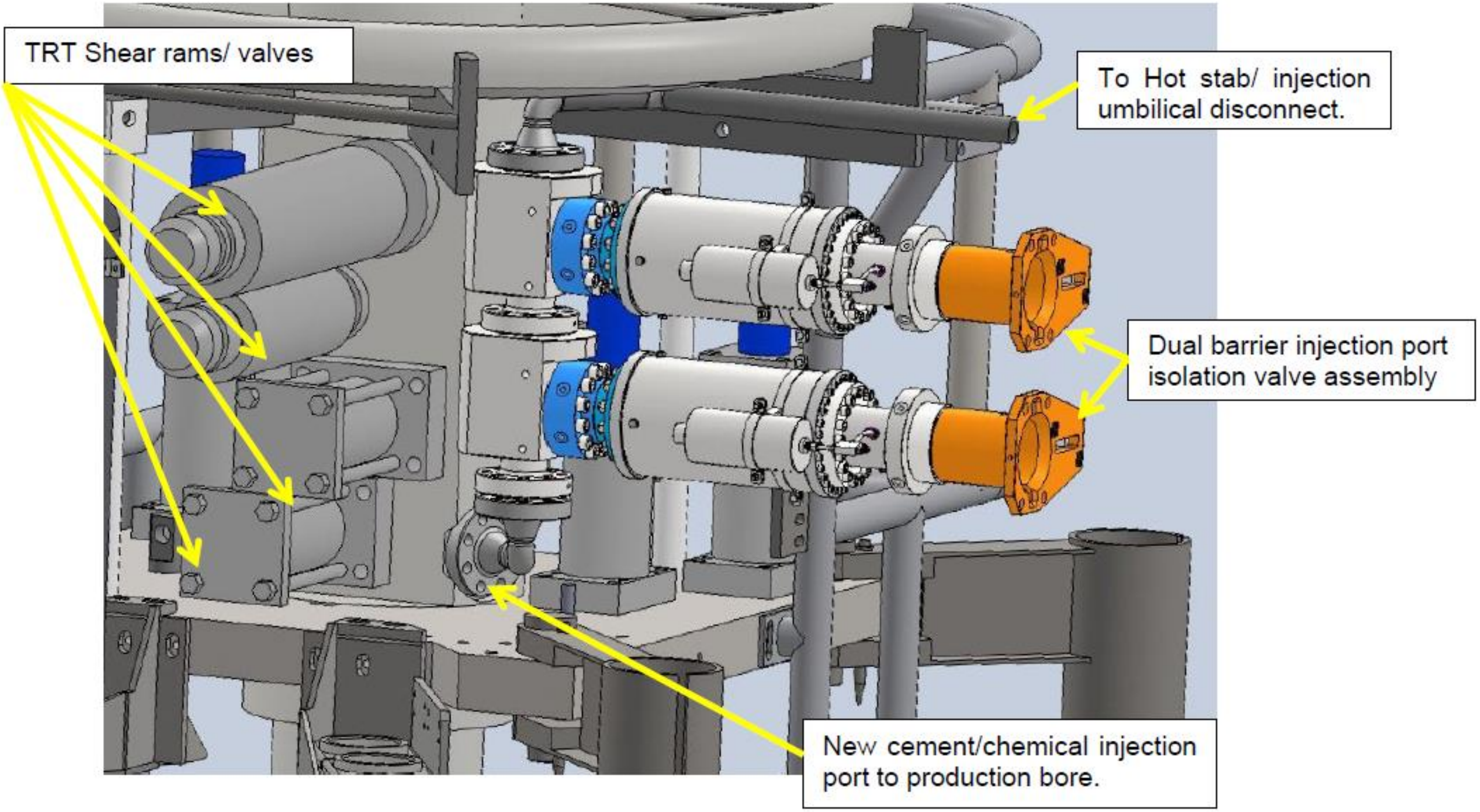
BASE CASE: Install cement plug with Subsea BOP installed for well control.
RISK: Integrity of mechanical plug barriers.

OPPORTUNITY: Install cement plug through the subsea production tree.
CHALLENGE: Preserving critical well isolation barriers.

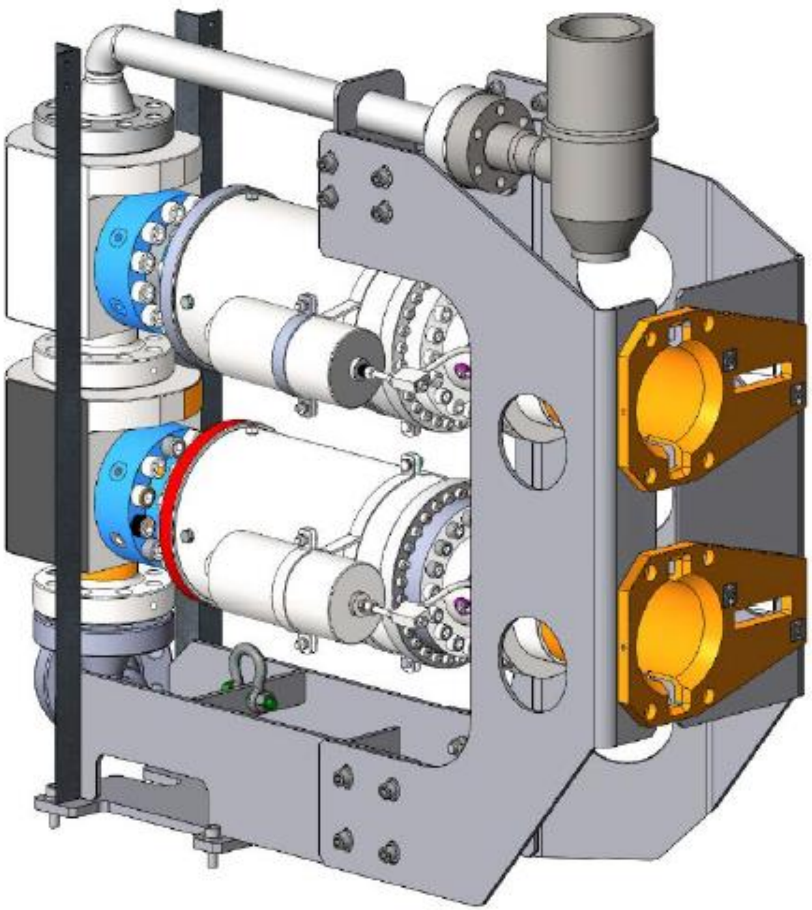
TOOLING OPTIMISATION: Cement injection port added to Tree Running Tool including:

- double valve isolation
- ROV Hot Stab connection for cement line

TRT – Cement Injection Port



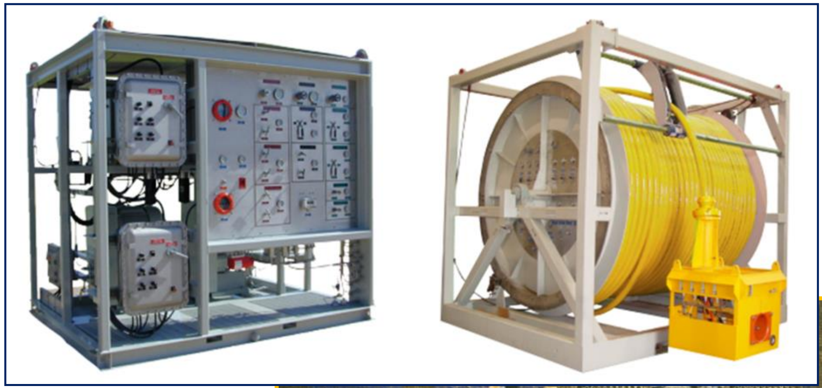
TRT – Cement Injection Port



TRT - IWOC Optimisation

ORIGINAL IWOC EQUIPMENT:

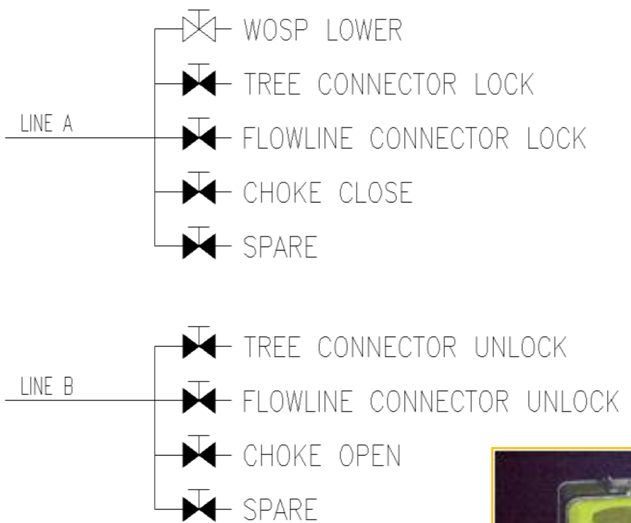
2 X 20 line hydraulic IWOC umbilicals

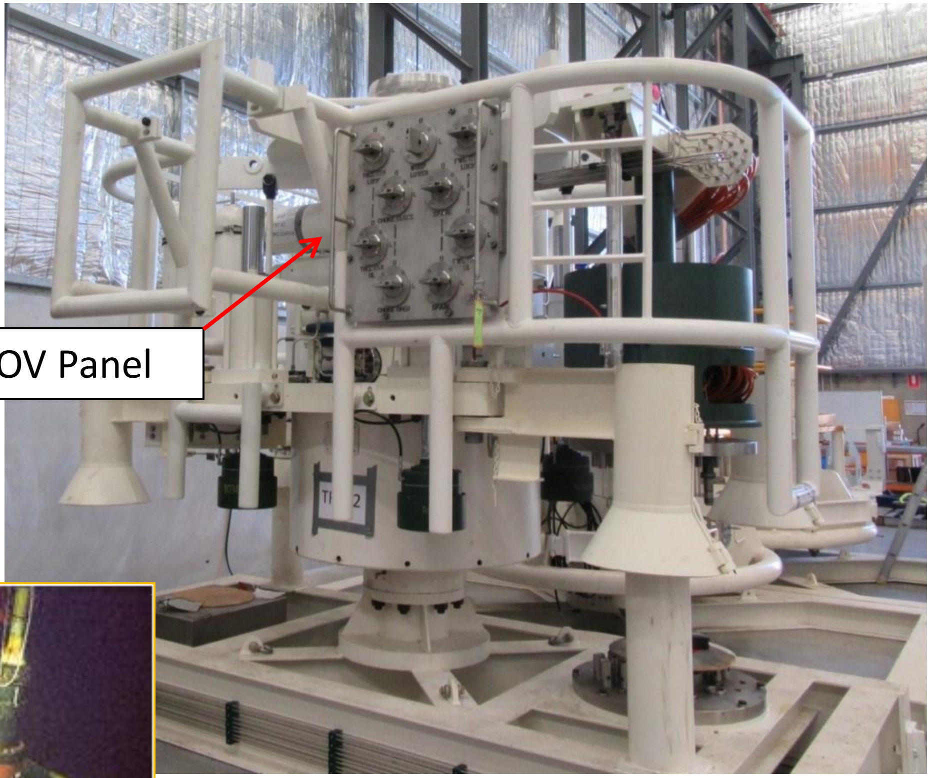


TRT - IWOC Optimisation

NEW IWOC EQUIPMENT:

1 x 32 line hydraulic IWOC umbilical PLUS ROV Panel installed on Tree Running Tool



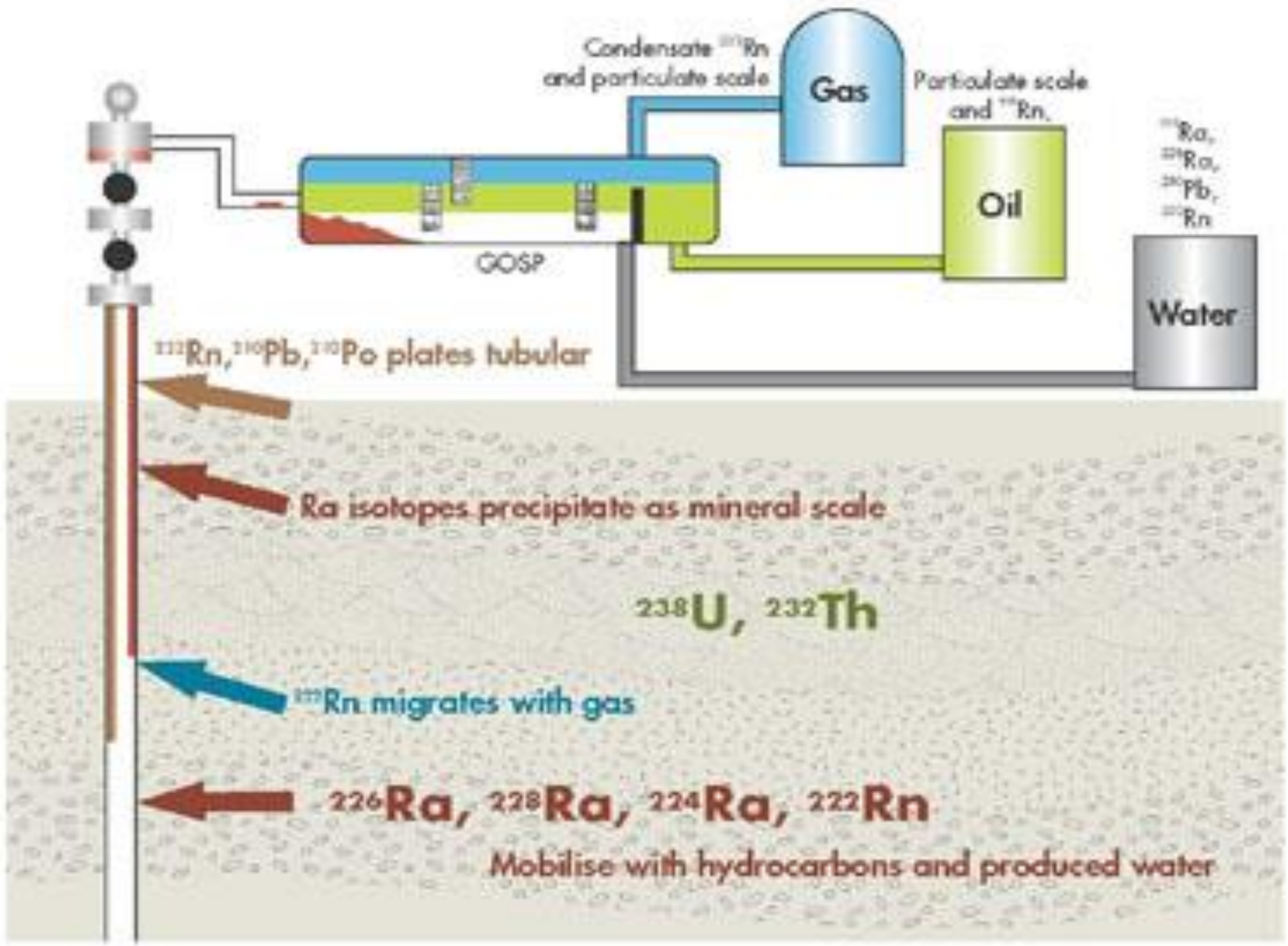


- ***Reduced equipment hire***
- ***Reduced rig time***

Naturally Occurring Radioactive Materials

NORM

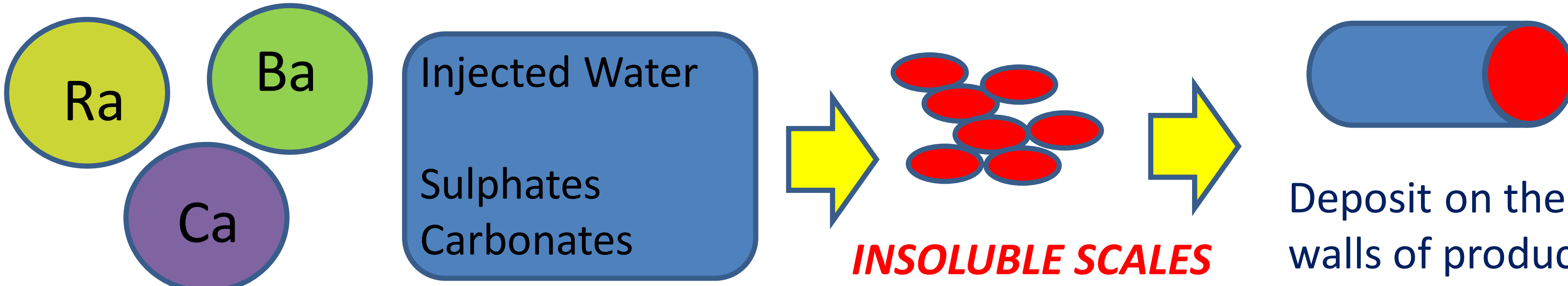
NORM in Oil and Gas



Radioactive sludge and scale and thin plating on metal surfaces (TENORM - Technically Enhanced NORM)

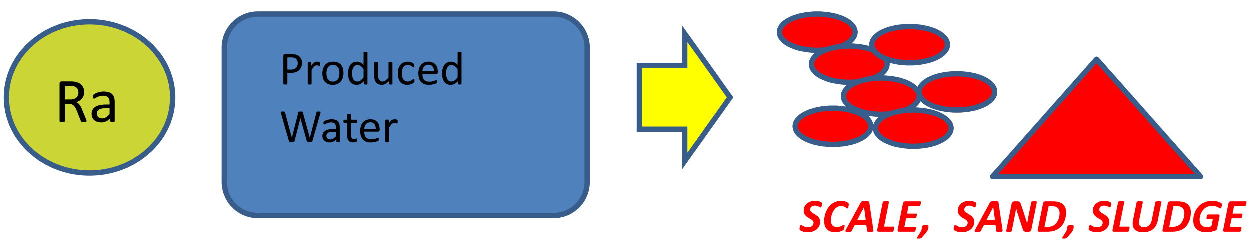
Naturally Occurring Uranium Thorium Radium

NORM in Oil and Gas



Deposit on the internal walls of production tubing, heat exchangers and manifolds as the temperature and pressure decrease

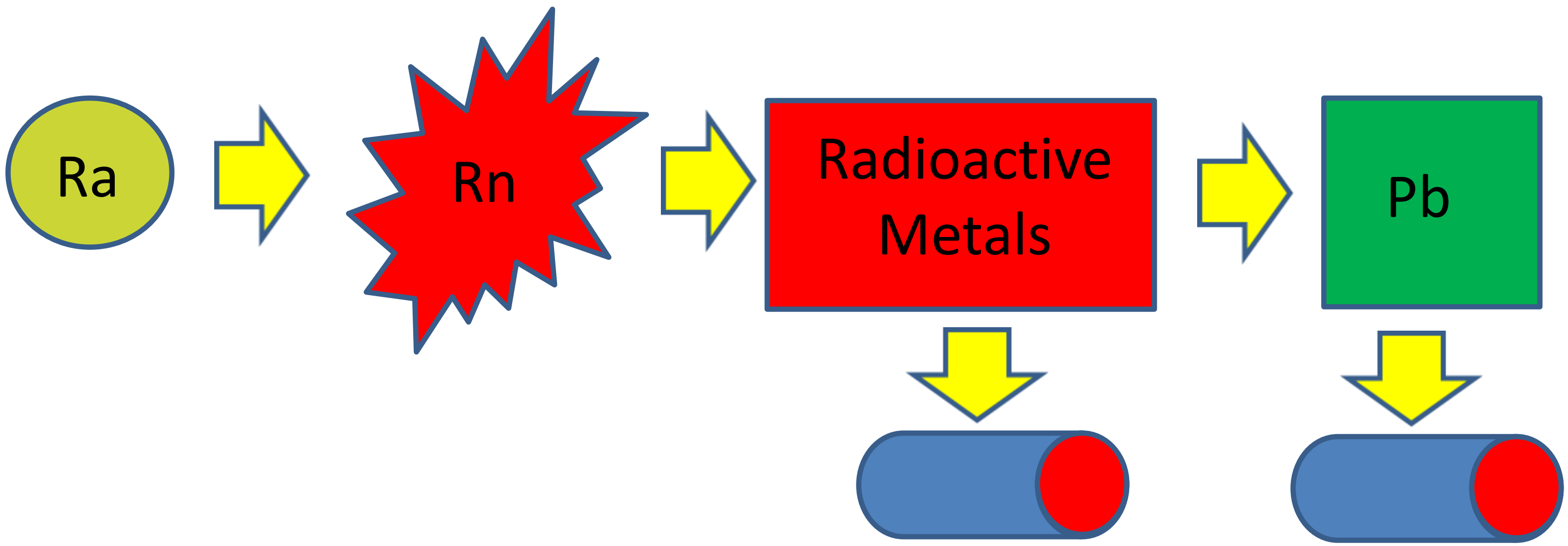
Radium (Ra) isotopes along with non radioactive barium (Ba) and calcium (Ca) anions form insoluble scales with sulphate and carbonate cations found in injected water.



Deposit in equipment

Radium compounds may be dissolved in the production water

NORM in Oil and Gas



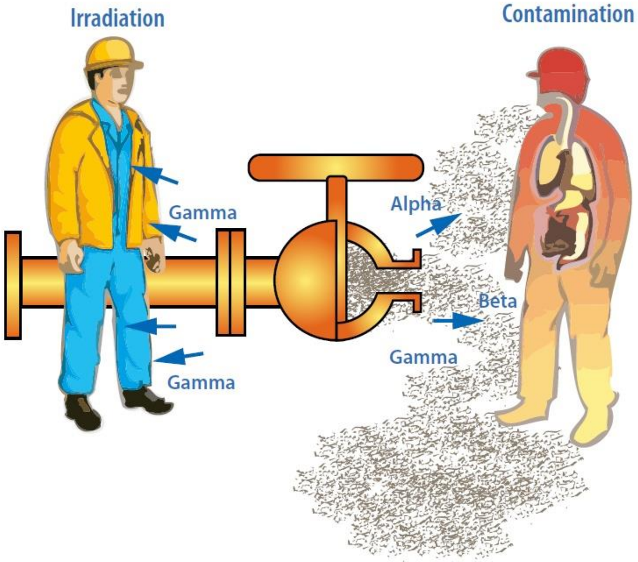
Radium decays to a radioactive gas, radon (Rn) which further decays into radioactive metals ending in non-radioactive lead.

These deposited metals are found on the gas production streams, contaminating the internal surfaces of equipment.

Regulatory Considerations

- Above specific concentrations, quantities of NORM are regulated requiring control, licencing and registration.
- Each State and Territory has its own legislation and regulation, but are generally consistent.
- Victorian Regulator – Dept. of Health, Radiation Act 2005 and Radiation Regulation 2007.
- In Victoria, concentrations of above 10 Bq/g for radium-226 and radium-228, are considered radioactive material and requires registration as a radioactive source.
- Exposure of personnel to radiation from NORM must be measured, and controlled to below annual radiation dose limits and As Low As Reasonably Achievable (ALARA).

Exposure pathways



- Exposure to radiation (irradiation) from NORM may be from an external source such as bulk NORM waste in drums, contaminated tubular or large vessels containing NORM contaminated sludge.
- Contamination (NORM where you do not want it) may be ingested or inhaled once equipment is opened and during handling operations.
- Ingested or inhaled NORM emits radiation directly to organs and tissue causing damage to cells.

Cleaning and Handling

- Production equipment and tubular can be decontaminated.
- Industry standard method utilises high pressure water jetting.
- Engineered filters collect the material.
- Collected NORM and sludges contain other hazardous substances which may require further treatment.
- Bulk quantities or NORM may be stored with regulatory approval while a suitable disposal option is determined.



Disassembling a sub sea heat exchanger for decontamination

Disposal

- Regulated NORM requires regulatory approval for disposal.
- Disposal options vary but include, down hole, sea dispersal, land farming, burial and overseas facilities.
- Technical and regulatory difficulties exist with each option.
- Other hazardous material also exist within NORM such as Volatile Organic Compound (VOCs) (eg Benzene), Semi-Volatile Organic Compound (SVOCs) and trace metals which may also require specialised disposal or treatment.

NORM Management Services

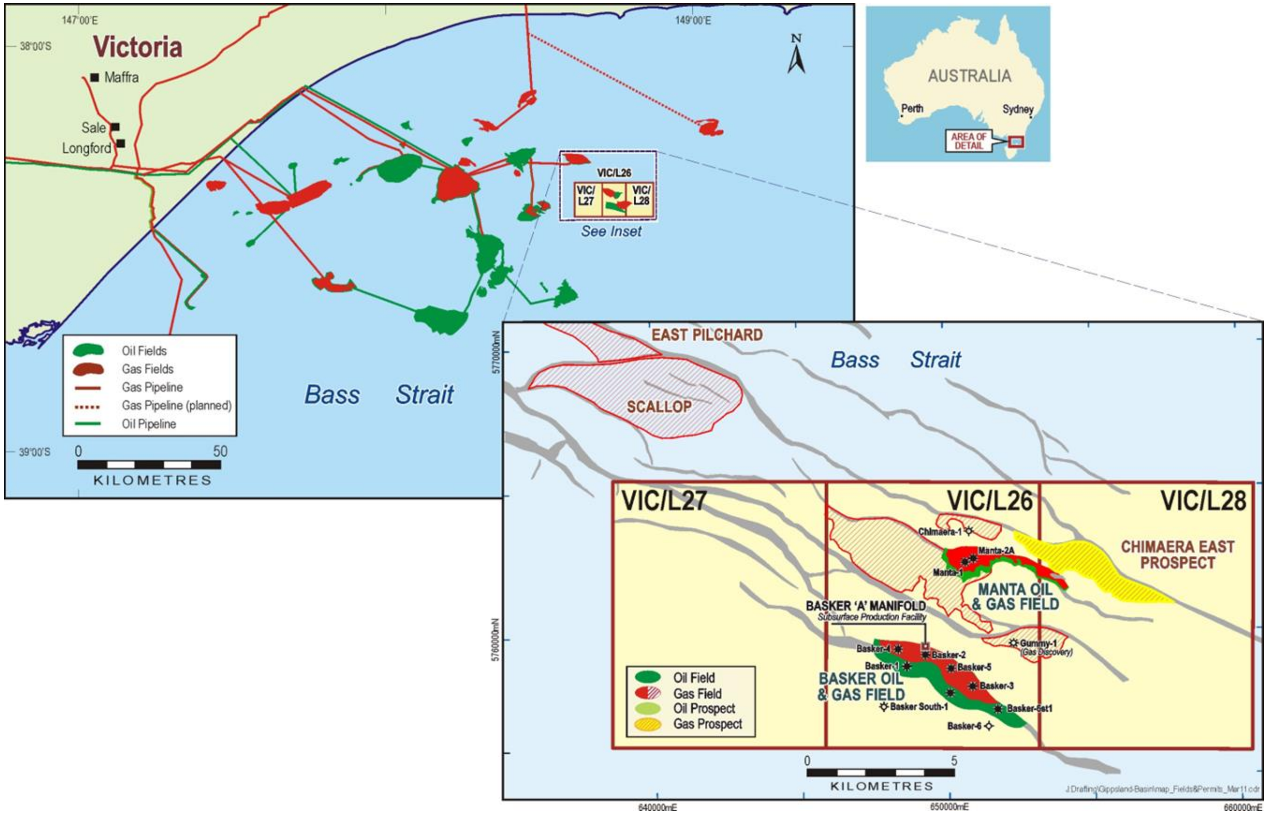
Oceaneering's NORM management services include:

- Radiation Safety Officers for NORM detection and monitoring surveys.
- ROV mounted NORM detection capability.
- Transportable decontamination equipment for use on client sites, including high pressure water pumps, specialised HP nozzles and filters.
- Cleaning and decontamination of equipment at Darwin base.
- An interim storage facility in Darwin whilst final disposal options are considered.
- Management and coordination of final disposal.

Basker Manta Gummy - Deconstruction for NPP

BMG Field

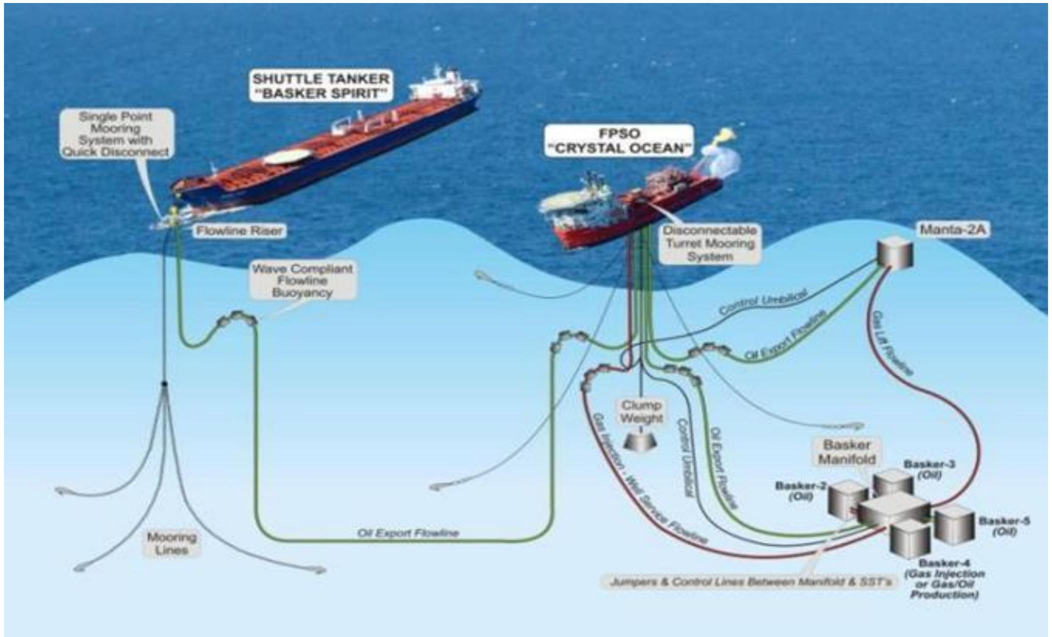
The BMG oil and gas fields are located in Production Licence areas VIC/L26, VIC/L27 and VIC/L28, which are situated in the Commonwealth waters of Bass Strait approximately 55km from the Victorian Coast and 15km east of the Flounder oil and gas field.



Basker Manta Gummy

The BMG Field Development consisted of:

- 7 subsea wells connected via a manifold to a stand-alone FPSO, the *Crystal Ocean*.
- The *Crystal Ocean* maintained its position on station via a Detachable Turret Mooring (DTM) system held in place by 3 drag anchors.
- Oil was exported from the FPSO to a shuttle tanker, *Basker Spirit*, connected to a Single Point Mooring System (SPM), maintained in position by 3 anchors and associated mooring lines. The *Basker Spirit* would periodically detach and delivered crude to onshore refineries for processing.



Phase 1 Complete

- In November 2010, ROC and its JVPs determined that BMG Phase 1 production under its current operational configuration was not commercially viable and a decision was taken to enter into a Non-Productive Phase (NPP) allowing for the definition, design and development of a possible BMG Field Phase 2 Gas Development.

- The *Crystal Ocean*, prior to leaving the field in 2011 de-pressured, flushed and preserved with inhibited water the BMG subsea equipment containing hydrocarbons.

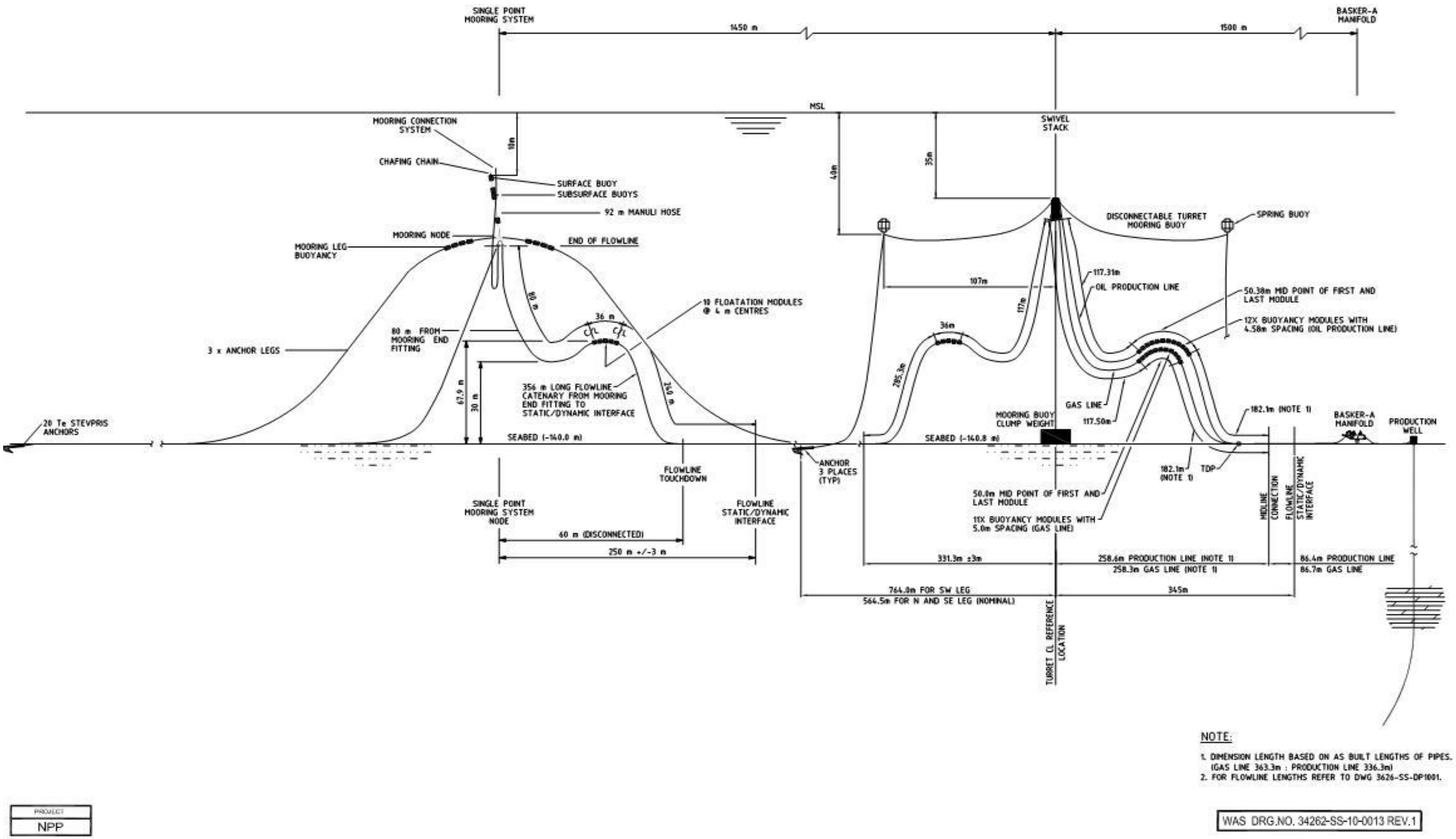
- Further deconstruction activity was performed in 2012 and included the removal of the mooring systems and all mid-water equipment (i.e. flowlines and umbilicals). The remaining subsea infrastructure was left under 'care and maintenance' pending a decision on the BMG Phase 2 (Gas) Development.

Preparation for NPP

Prior to the departure of the *Crystal Ocean* from the field in April 2011, the subsea infrastructure was subjected to a depressurization, flushing and inhibition program designed to meet the following objectives:

- All gas was vented from pipe work downstream of well wing valves.
- Moveable liquid hydrocarbon downstream of Subsea Tree (SST) production wing valves (PWV) were flushed from the system.
- Flowlines were flushed several times until hydrocarbon concentrations in the flush water reached limits of 30ppm or less.
- Vented and flushed pipe work was displaced with inhibited, depressurized freshwater.
- The SSTs were flushed with inhibited freshwater.
- All downhole barrier integrity and SST valve integrity was tested.

Mooring Systems & Risers



NPP Scope

The deconstruction scope to the BMG subsea facilities included:

- Removal of the Detachable Turret Mooring (DTM), Single Point Mooring (SPM) system, mooring chain and anchor systems from the field;
- Removal of the crude export flowline;
- Disconnection (cutting) of flowlines and umbilicals from the DTM Buoy;
- Recovery and removal of the dynamic sections and buoyancy of the 6” Basker production flowline, the 6” Basker gas injection flowline and the 4” M2A production flowline from the field;
- Laying down on the seabed and capping the static section of the flowlines with pressure retaining end caps;
- Trenching the B6 flowline and umbilical; and
- Additional isolation added to all umbilical lines connected to the process system and downhole controls (i.e. chemical injection supply lines, AMON lines and downhole control lines) at the subsea trees to ensure an additional barrier to environment on these systems.

Technical Issues

During the NPP risk assessment workshop conducted as part of the scope development, a number of technical issues were identified that would have an impact on the methodology for the deconstruction work, these included:

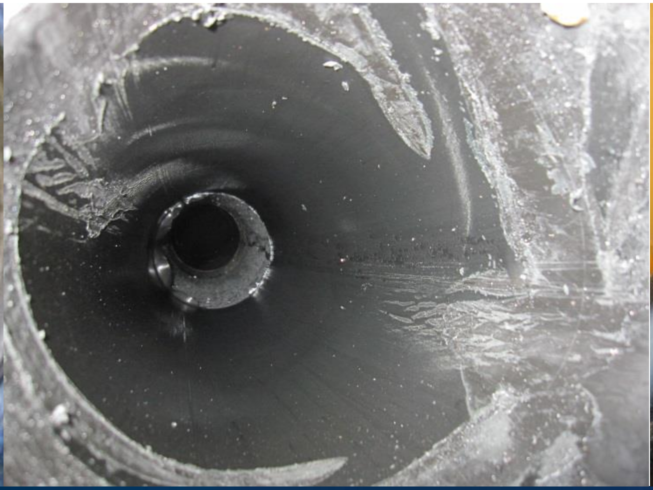
- Potential existence of NORM
- Potential for wax deposits and hydrocarbons in the flowlines/umbilicals
- Access at the DTM to release the flowlines and umbilicals
- Disposal of recovered materials
- Failed barrier on Basker 5
- Basker 6 barriers not fully tested

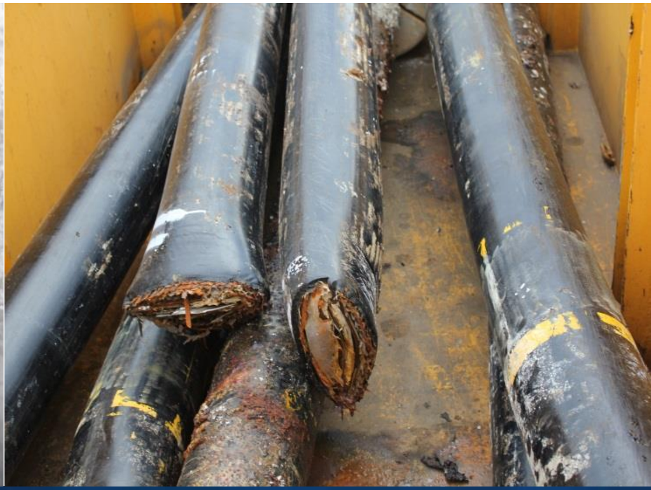
NORM and Wax Deposits

- During operation of the field, wax accumulation was identified within the production and export flowlines. However, quantitative measurements were not taken of the amount or the content of the wax build up in the lines.
- During de-commissioning of the *Crystal Ocean* and the *Basker Spirit*, the flowlines were cleaned by flushing the lines with hot water until the water returns reached a cleanliness level of 30ppm.
- In the absence of actual inspection data from the flowlines themselves, it was decided that caution must be applied to the Export lines and the Production lines during recovery. The assumption was made that some wax may exist on the flowline walls and therefore, hydrocarbons may also have been be present.
- To accommodate these unknowns the means to clean the internal surface of the flowlines and capture any wax deposits so that they can be disposed of in a controlled manner were made available on the vessel along with a testing procedure for NORMS.

NORM and Wax Deposits

- A cleaning and containment spread was mobilised on to the vessel.
- Hydrocarbon detectors were placed on the back deck.
- As each line was recovered and cut a sample section was inspected to confirm if wax build up was present in any sizable amount and to check for NORM.
- It was found that only trace samples of wax were present.
- Result being that cleaning was not required, saving considerable planned offshore time.



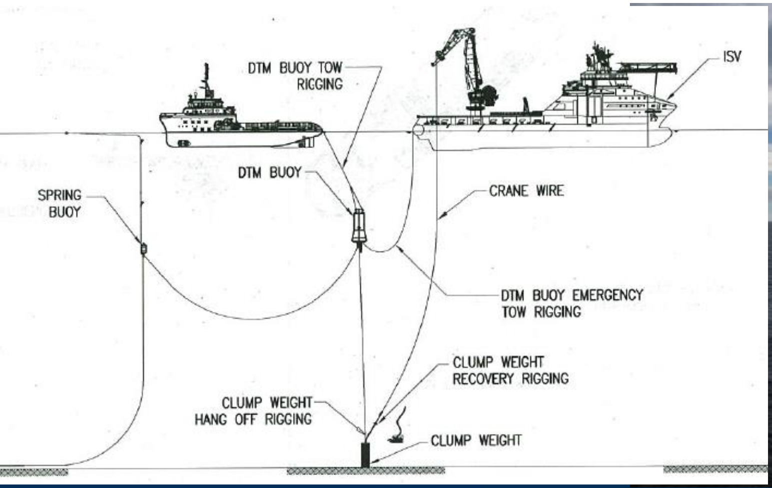


DTM Access

- Expected gas in the upper sections of the risers.
- Access to hang off arrangement was restricted and a high risk activity for divers.
- Solution was to release the gas in a controlled way and to then cut the flowlines and umbilical below the DTM.

DTM Solution

- A jig was made in order to operate the MIB valves by ROV.
- Each MIB valve was operated under controlled conditions with the vessel up wind of the DTM.
- Cutting tool was attached to the flowlines/umbilical and the line was supported at the hog bend by the crane.
- Buoy released by cutting the wire ropes below the buoy leaving the buoy attached to the clump weight and tied off to a tow vessel.



Disposal of Material

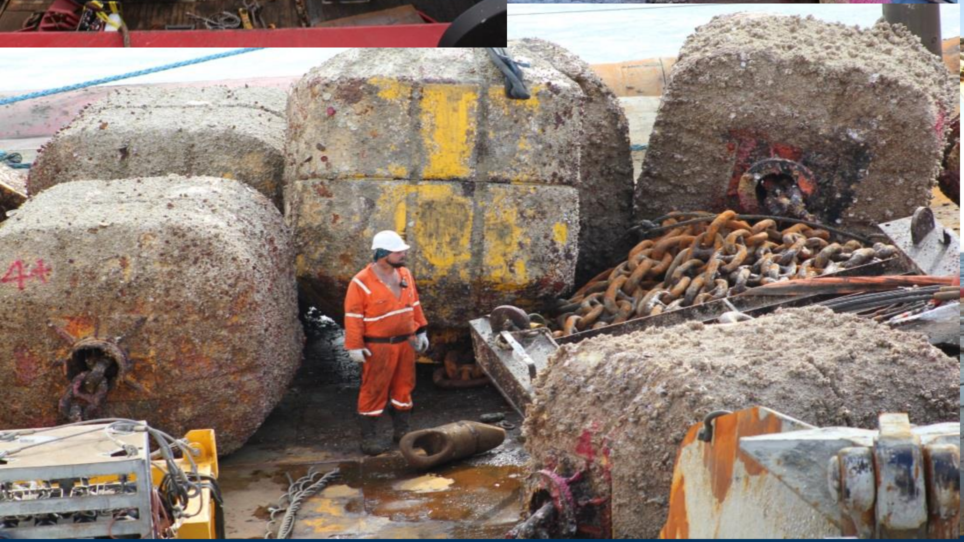
- 4 x flowlines (4” & 6”) totalling 2,778m (215 t)
- 600m umbilical (25 t)
- 96 x buoyancy modules (34 t)
- FPSO mooring (330 t)
  - 55Te clump weight
  - 380m of 76mm dia wire rope
  - 1,310m of stud link chain
  - 3 x 15 t anchors
- SPM Basker Spirit Mooring (530 t)
  - 2864m of stud link chain
  - Manuli hose guides (steel buoy, node, hose guides)
  - 3 x 15 t anchors
- DTM (125 t)

OCEANEERING

Recovered Equipment

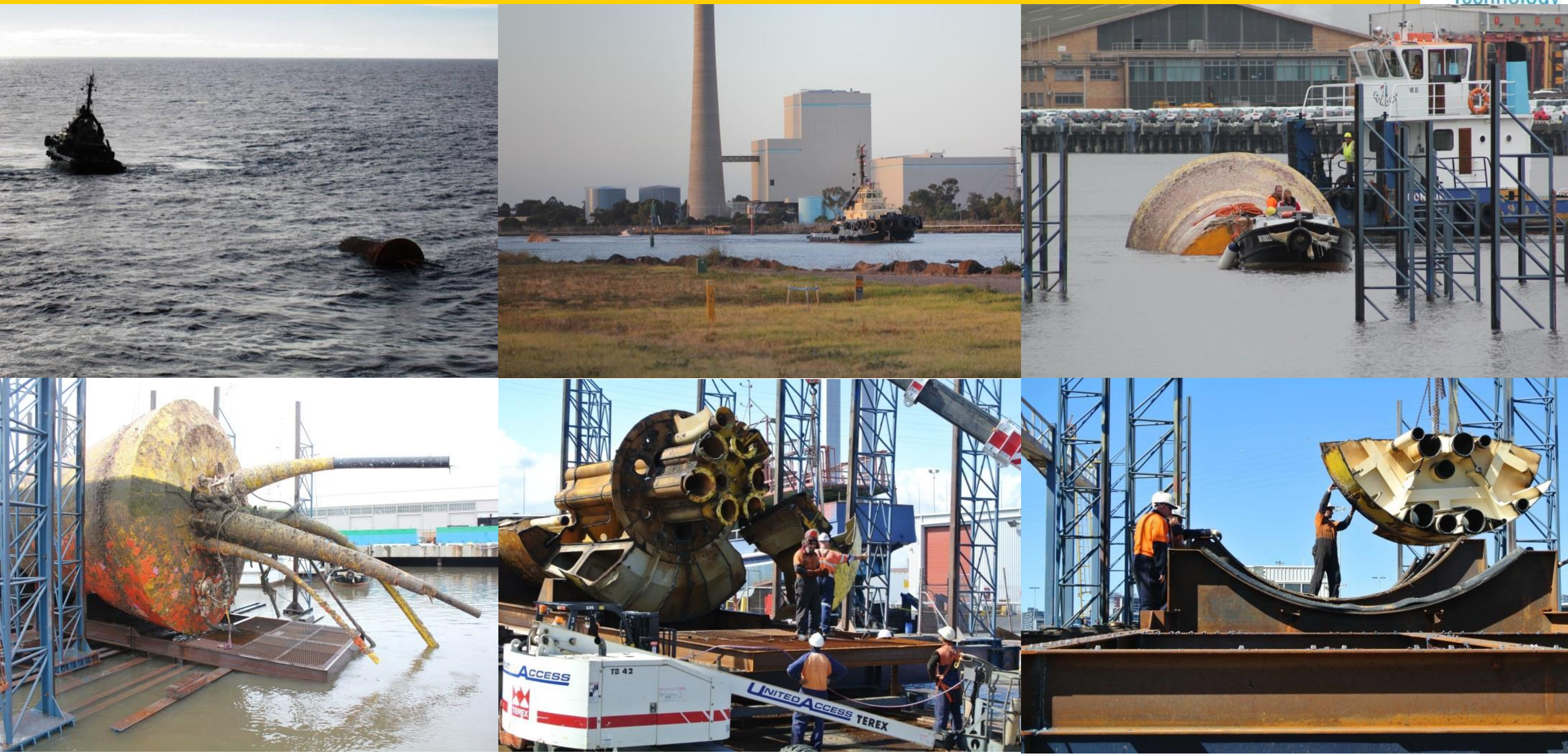
SUT Society for Underwater Technology




- Scrap metal $250/t
- Flexibles and umbilicals to landfill
- Anchors were sold
- Buoyancy to land fill

DTM Solution



- Tow vs Lift
- Minimum tow speed through the heads
- Containment of marine growth

Well Intervention

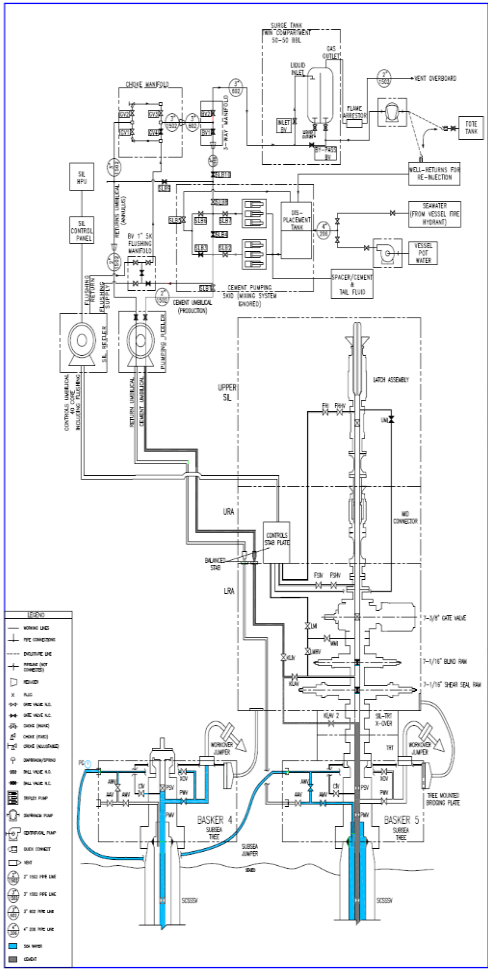
The well intervention scope of works included the following:

- Conduct a well intervention on the Basker-5 well to place cement plug barrier into the wellbore below and above the production packer; and
- Conduct pressure integrity tests on the Basker-6 well barriers at the subsea tree.

Well control was achieved through the deployment from the ISV of a Subsea Intervention Lubricator (SIL) which is a device that attaches to the subsea production tree to provide a pressure containing envelope for deployment of wire line conveyed tools into the well. The SIL includes blow out preventers and hydraulic connectors to contain well pressures at all times. The SIL was controlled from the surface via control umbilicals with design logic to automatically close in the event that control systems are compromised .

B5 – Plug and Test

- Pump brine into tubing and bullhead into formation to establish injection rates.
- Mix and pump cement down 1.5" hose into tubing and inject same to squeeze off perforations at the reservoir section below the production packer.
- Run a wireline tubing punch system to perforate the tubing above the production packer.
- Establish circulation pumping inhibited brine down the tubing taking returns up the annulus and then routed into the tubing on an adjacent well.
- Circulate cement down the tubing and displace to form a cement plug above the production packer in both the tubing and the annulus.
- Wait on cement and then pressure test the tubing and the annulus separately.
- Install the tree cap on the subsea tree.



B6 - Test

- Deploy ROV and attach Installation Workover Control System (IWOCS) to the tree.
- Conduct a series of pressure tests of the tree using the IWOCS.
- Disconnect IWOCS from subsea tree.
- Move off location with ISV.

Thankyou