WELLESLEY
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Wellesley Petroleum & Well Expertise Audit Report

PSW – Capping Stack

AUDITEE					
PSW GROUP					
AUDIT NO.					
EX-2017-06					
APPROVAL					
Rev.no	Date:	Auditors:	QA by:	Auditee:	Comments:
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2.0					

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1. Introduction

PSW Group are a subsea engineering and equipment supplier company. Their services are a combination of:

- Subsea & Drilling equipment; rental and sales, inspection, testing, maintenance and repair
- Engineering, Project Management and documentation
- Provision of capping stack and associated support services

The provision of capping stack and associated support services comes under the PSW Oilfield Services division and represented the core focus of the verification. Additional divisions within the PSW group provide supporting roles to the capping stack and for that reason are included in the verification. PSW Integrity have responsibility for the capping stack asset integrity and establishment of the associated maintenance system. **See Appendix 4 for PSW company structure.**

Wellesley Petroleum with support from Well Expertise performed a verification on the PSW capping stack and associated services as part of the initial verification prior to signing a contract for capping stack access.

Well Expertise provide a well incident team for Wellesley Petroleum and the relevant interfaces between PSW divisions and callout procedures for the stack were discussed and feedback provided to PSW on further deployment documentation to be prepared enabling the stack callout procedures to be formalised into a capping stack mobilisation and deployment plan.

2. Objectives

The following objectives were intended from the PSW verification:

1. Ensure the PSW capping stack complies with API RP17 W. **See Appendix 2**
2. Ensure PSW have systems in place for compliance with relevant legislation and standards, required certification and maintenance of capping stack and associated equipment.
3. Ensure plans and procedures are in place for mobilisation, transport, deployment and functioning and testing the capping stack. Verify most recent pressure tests
4. Verify PSW are ready for service delivery for well operations starting Q3, 2017
5. Verify personnel allocated to the functioning and logistical support of the stack are both available and qualified
6. Confirm storage conditions of stack ensures no longterm concerns for maintenance or functionality
7. Agree on procedures for ensuring well information relevant to deployment are communicated in time and included in call out information for the capping stack

The audit was based on the following documents:

- API RP 17W. **Appendix 2**
- PSW presentation attached and associated links. **Appendix 4**
- Norog – NCS Wells Capping Status Report 2016. **Appendix 3**
- Well Expertise standard relief well and capping plan

PSW are new to the provision of capping stack services and entered the market in 2016/17 following the purchase of the Shell Arctic Capping Stack. As recognised subsea experts, no concern existed about the ability to maintain and function the stack but the interface and expectations with deployment procedures and capping stack to operator expectations was intended to be checked and future testing of those plans agreed.

3. Deviations

Audit performed according to plan. No deviations

4. Warrant

The verification is warranted on the basis that the PSW capping stack is a new capping stack option not previously contracted on the NCS and therefore with no track record of status. Additionally, the associated support systems and competence were required by Wellesley and Well Expertise due to the potential criticality of the service if called out.

5. Participants

Role	Name	Position	Company
Auditor	Callum Smyth	Country Manager	Wellesley
Auditor	Trond Gravem	Senior Ops HSE Advisor	Wellesley
Auditor	Helge Hamre	HSE/Ops Manager	Wellesley
Auditor	Lars Lilledal	Drilling Advisor	Wellesley
Auditor	Morten Diesen	Ops Geologist	Wellesley
Lead Auditor	Mike Simpson	Operations Manager	Well Expertise
HSE Auditor	Silje Gjøse	HSEQ Manager	Well Expertise
Ops Auditor	Stig Seland	Rig Intake Lead	Well Expertise
Auditee	K.M. Wergeland	General Manager	PSW
Auditee	Marina Gullaksen	Project Manager	PSW
Auditee	D.K Baakind	VP Tech Ops	PSW

6. Audit Process

- Notification – sent 9th May 2017
- Audit – PSW Mongstad premises 30th May – PSW Group
- Summary verbal feedback – immediately after audit
- Report – issued 12th June 2017
- Follow up – continued updates on capping stack status and integration into Wellesley Well Incident Team

7. Categories of Findings

Findings are categorised as:

- Non conformance (NC)
- Observation (O)
- Improvement Suggestion (IMP)

Non conformances are classified as:

- Major (MA)
- Significant (S)
- Minor (M)

Identified non-conformances, observations and improvement suggestions are presented in the tables below.

Table 1 Non Conformances

NC No.	Description	Ref.	Responsible	Classification
	None			

Table 2 Observations

Observation No.	Description	Responsible
1	Original SAM modules still presented as default hydraulic energy source in presentations. Update to reflect new SAM module.	
2	Volume requirements for API RP17 W ram closures not included and associated remaining capacity	
3	New SAM functionality explanation including distance from stack requirements	
4	Opportunities to recharge SAM module not clear.	
5	PSW Operational procedures for capping stack need to be updated for stack modifications	

Table 3 Improvement Proposals

Improvement No.	Description	Responsible
1	Update documentation with new SAM module and associated functionality (ROV interface for flowmeter, onboard flow meter and capacity per bank of bottles)	
2	Prepare summary spreadsheet of volumes to perform all open/close functions on stack	
3	Prepare “incident seabed landing map” so optimised SAM deployment position, hydraulic hose lengths etc is clearly demonstrated	
4	Further document ability to use additional SAM modules for additional stack hydraulic	

	capacity in the event of an extended incident needing significant operations of the stack	
5	Prepare generic “deck layout plan” to optimise spotting of capping stack and associated equipment on transport vessel	
6	Prepare an equipment loadout checklist	

The reported non-conformances, observations or improvement proposals shall be followed up as soon as possible. All relevant actions and/or mitigating measures shall be identified (including action owner and due date) within 30 days after receival of report.

8. Topics & Findings

1) Compliance of the PSW capping stack with API RP17 W and deployment expectations

A technical presentation of the PSW capping stack and associated equipment was provided by PSW that enabled the audit team to assess compliance with API RP17 W with confirmation in the follow up tour of facilities, capping stack and associated equipment.

Element	Comment
Capping Stack	Category 2, 18 ¾'' 10K Capping Stack.
Water Depth	Maximum 10,000 ft.
Temperature Rating	Class P-U (-20 °F to 250 °F)
Dual Ram Assembly	NOV T3 Dual 10 Ksi 18 ¾" blind ram. Assembly Double Ram 6012 BOP 18 ¾'' 10K STD Bonnets FLG Top X FLG BTM with 4 1/16'' 10K FLG Outlets.
Diverter Spool	Two-way forged diverter spool for containment flow when rams are closed, two 5" valves per outlet. 18 ¾" axial bore with four 5 1/8" bores drilled radially with provisions for chemical or dispersant injection into the 18 ¾" bore and forged elbows. Bore pressure is read through pressure sensors on the diverter spool transmitting through an acoustic system.
Upper Mandrel	H4 10K flanged connection with an 18 ¾" bore, 58" long.
Top Connector / Tertiary cap	1 x 18 ¾" 10K Axon H4 type 90 connector VX gaskets fitted with 18 3/4" blind flange with certified lifting lug on top off flange
Bottom Connector's	1 x 18 ¾" 10K Axon H4 type 90 connector VX gaskets 1 x 18 ¾" 10K Cameron Mod 70 connector VX gaskets
Flowline Connections	Flexible flowlines will be interfaced to a 5 1/8" 15K psi API flange off the targeted elbow via the Trendsetter connector system. Attached to the outside flange of each valve coming from the diverter spool is a forged block elbow with sufficient wall thickness to address erosional concerns. · Attached to the elbow is a 5 1/8" clamp connection system with a 5 1/8" 10ksi manual ROV sacrificial valve and forged elbow mounted to it with side outlet for flexible flowlines via a 15 Ksi API flange. · The 5 1/8" connectors are subsea installable and retrievable and are designed to be modular to allow for various configurations on the connector package · The valve attached to each connector will be the sacrificial valve to be closed under full differential pressure since it is retrievable and replaceable
Chemical Injection	MeOH or glycol and dispersant through ROV hot stabs on Chemical Injection Panel. There are 4 connections in total. 2 will go directly to the 10K elbows located at the end of the 5" Isolation valves off of the diverter spool, and 2 will go directly to the diverter spool itself.
Valves & Connectors	ROV operated
Accumulator Banks	34 x 13 gallon accumulators.
Spacer Spool.	12 ft & 2,5 ft.

Figure 1 Technical Summary of PSW Capping Stack

Following technical discussion on the capping stack design and associated support equipment and facilities, the verification team concluded that the capping stack is in compliance with API RP17 W for both Category 1 (Cap) and Category 2 (Cap and Flow) capping stacks.

Interface connections supplied by PSW cover all expected scenarios and are in compliance with API RP17 W. Both H4 and HC connectors are available as part of the package with the default connector being H4 installed on the stack.

The new PSW SAM is set up with a precharge pressure of 1500 psi for functioning at depths of 500 m. Total capacity at
The SAM has the capacity to function closed all main bore and connectors as with the following capacities required.

2 x H4 connector – Lock = 2 x 4 US gallons = 30,2 litres
2 x H4 connector – Unlock=2 x 5 US gallons = 37,7 lites

1,5 x Lower Ram Close = 1,5 x 29,5 US gallons = 44,3 US gallons = 167,5 litres
1,5 x Upper Ram Close = 1,5 x 29,5 US gallons = 44,3 US gallons = 167,5 litres

Total Fluid Usage for above functions: 106 US gallons = 403 litres
Volume usable fluid remaining: 259 litres.

With specific reference to API RP17W, the following system requirements were verified:

All subsea capping stacks shall:

- Be equipped with the capability to monitor pressure below each vertical bore mechanical closure device. **Verified; Teledyne acoustic pressure and temperature acoustic system**
- Provide a means to inject hydrate inhibitors and chemicals into the main vertical bore, at a position below the divertor outlets. **Verified; Chemical injection manifold for Methanol or Glycol – 4 connectors**
- Contain one or more outlets for diverting flow from and/or pumping kill fluid into the main vertical bore. **Verified;2 x 5 1/8" outlets with dual gate valves. Detachable flowlines included in package**
- Follow the guidelines set forth by API 16 A, API 17 D and API 17G for design, qualification and validation of subsea equipment. **Verified in terms of equipment design and qualification with associated certification.**

In the event of a well control incident, PSW will mobilize and deploy the capping stack from PSW facility to the quay side at CCB Mongstad offshore base where it can be transported to the incident site via a supply vessel. The stack will then be deployed to the subsea well in one of three ways depending on operator preferences and vessel layout.

- On wire off the side of the vessel using a heave compensated crane
- On a wire from the stem of an anchor handling vessel using the A-frame
- Lowered from a drilling rig using a drill pipe or wire.

The capping stack can be installed on the well bore in three ways:

- Attach directly to the H4 wellhead
- Attach to the top of the blowout preventer (BOP)
- Attach to the lower marine riser package (LMRP)

A Remote Operated Vehicle (ROV) controls the 10k capping stack in either a cap only or cap and flow scenario. An acoustic system provides the operator with pressure and temperature readings on surface.

All equipment for the above deployment scenarios was included in the PSW capping stack equipment package.

2) Tour of Facilities and Capping Stack

A tour was made of the PSW Group facility at Mongstad both inside and out to inspect the PSW capping stack storage area and associated workshop facilities.

Figure 2 Capping Stack in PSW Workshop, Mongstad

At the time of visit, scaffolding had been erected around 2 sides of the capping stack for routine work and pressure testing. Additionally, the acoustic pressure and temperature transmitters were installed and connected to the surface read out device. Full access was made available to all areas of the capping stack and associated equipment.

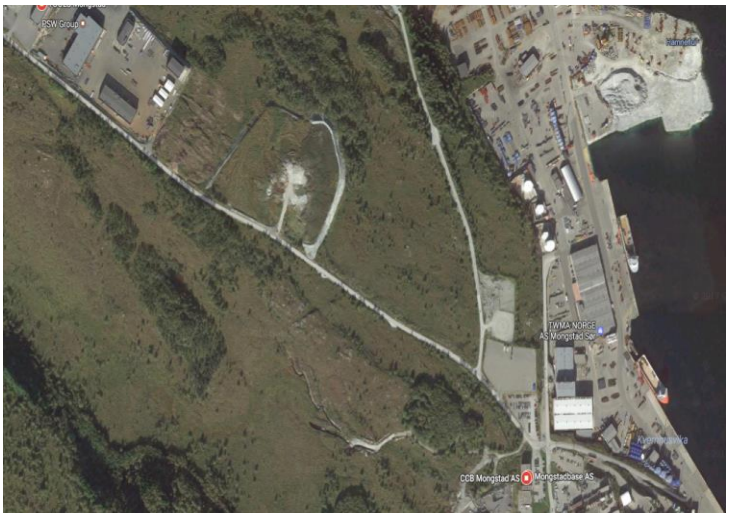
The capping stack is stored on a mobile flatbed trailer ready for immediate transit to the Mongstad quayside. The stack is stored in front of the workshop doors and is chained to the trailer for speed of response.

Figure 3 PSW Capping Stack on flatbed trailer ready for mobilisation

PSW have two options for mobilising the capping stack from the PSW base to Mongstad quayside. The inhouse trailer tractor below or access to the CCB larger equivalent is also readily available for immediate response in the event of a capping stack callout.

Figure 4 PSW Inhouse Tractor for towing capping stack flatbed trailer

PSW Facilities



Mongstad Quayside

Figure 5 Map of PSW proximity to Mongstad quayside via private road

The capping stack was originally purchased and planned to be operated with 2 x SAM (Subsea Accumulator Modules) which were designed to function both the capping stack and the BOPs of the rigs originally intended for use with the Shell Arctic capping stack. Both SAM modules were inspected.

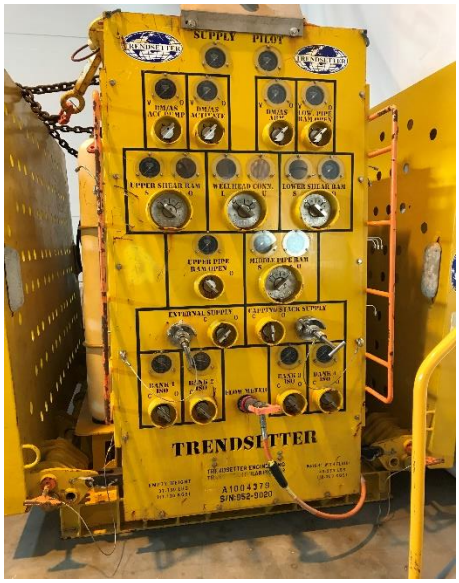


Figure 6 SAM Modules designed for both capping stack and BOP Intervention

Both SAM modules are fully functional and can be used to provide hydraulic energy to the capping stack. Apart from providing hydraulic energy to the capping stack, the SAM modules are also designed to provide BOP intervention capacity through a “Cobra Head” and Hydraulic Flying Lead (HFL). This option has not been considered as standard for services in Norway unless specifically requested and would need BOP interface modification.

Figure 7 Cobra Head and Flying Lead for BOP Intervention

The additional complications with the BOP intervention options has led PSW to consider the SAM modules as sub optimal for ease of deployment. Consequently, they have acquired an additional optimised SAM which provides easier access and less complicated procedures for deployment.

Figure 8 SAM Module intended as default SAM for operations in Norway

The new SAM exceeds API RP17 W stored energy requirements by 200% and has a very simple ROV interface. This SAM does not have folding mud mats as the original stack SAM modules have but the solid floor below the bottles ensures the SAM will not subside into seabed mud.

A live demonstration of the acoustic pressure and temperature transmitter was given allowing both temperature and pressure in the stack to be monitored remotely from a vessel within acoustic distance of the capping stack and having the appropriate receiver.

Figure 9 Acoustic Pressure and Temperature Outputs

Other key equipment items inspected and checked were:

Figure 10 Flowline frames and valves for flowing well

Figure 11 Test Pressure Cap

All the equipment demonstrated on the tour of the PSW facilities related to the capping stack is included in the maintenance system with valid certification. One exception to this is the “spreader bar” lifting device intended to lift the capping stack from a crane. This lifting device has expired certification which is in the process of being recertified and is thus not attached to the stack.

Figure 12 Spreader bar for deployment of stack by wire from vessel

The capping stack and all associated equipment and components that were intended for service in Norway were housed indoors and appropriately protected from corrosion. Condition of all components appeared very good and no concerns raised about longterm storage. The test bed and associated pumps were shown and clearly the capping stack is housed in the most appropriate location and condition for both maintenance, testing and rapid mobilisation to the quayside.

3) Status of Maintenance and Maintenance Systems on Capping Stack

PSW Integrity are in the final stages of including all of the paper versions of the capping stack original certifications into an electronic version that can be accessed via internet allowing both Wellesley and Well Expertise read access to the system.

All original manufacturing certification is present and the upload to the PSW Integrity electronic system is scheduled to be complete end June 2017. Dedicated resources from PSW Integrity will from that point be responsible for the ongoing availability of certifications, pressure tests, spare parts and criticality.

Remote read access to the maintenance system will be provided to Well Expertise and Wellesley for assurance on function and pressure testing.

A demonstration of the hierarchical maintenance system was provided. Examples of original equipment certifications was shown and the philosophies behind the system explained. The audit team were assured that the inventory control, spare parts, criticality and testing schedules would be complete by end June. Random verifications on equipment certifications were performed.

All periods of maintenance and pressure testing shall be scheduled in the maintenance system which shall be available to both Wellesley and Well Expertise in order that potential influence on schedule changes may be made if, for example, a Wellesley well is about to enter the reservoir or a planned emergency response drill is scheduled at the same time.

From initial purchase and transportation of the capping stack from Denmark (Munkebo) to Mongstad, a major scope of work in importing all of the original Trendsetter manufacturer and Shell supporting documentation has been performed.

4) Capping Stack Operational and Duty Teams and Competence

The PSW Capping Stack Operational and Deployment team has been built on the philosophy of having 6 offshore capping stack operators (split into 2 x 12 hr shifts) and 3 onshore team leaders. The nominated personnel are listed below with associated experience.

Onshore Team Leaders

Ingvald Øvretveit: Subsea Engineer – 25 years in technical subsea equipment roles. Senior technical responsible for the PSW Capping Stack
Klaus Wergeland: General Manager – 15 years Drilling and Well Operations
Marina Gullaksen: Project Manager – 5 years coordinating equipment, vessels and personnel

Offshore Capping Stack Operators

T. Torsvik – 9 years offshore experience as subsea engineer
C. Wilhelmsen – 10 years offshore as subsea engineer
K. Beheim – 6 years offshore as subsea engineer
Ø.Kvamme – 18 years offshore as subsea engineer
G. Skoglund – 10 years offshore as subsea engineer
A. Steindal – 8 years offshore as subsea engineer

In total, the PSW Group has 35 on/offshore subsea engineers available and the core capping stack operations and deployment team have extensive substitute personnel to cover holiday and leave of absence periods.

The capping stack operations and deployment team have been part of developing the logistics procedures for call out of the stack, the stack preparation procedures in transit to location and the capping stack installation procedures. They are responsible for mobilisation, preparation and all functions performed on the stack.

As part of the capping stack documentation and associated call out procedures, it was agreed with PSW that the relevant duty and vacation schedules would be shared so that Wellesley and Well Expertise would have access to the latest schedules. These will be linked in the capping stack call out procedures.

PSW have an established duty system and phone number which will be included in the Wellesley Emergency Response contact numbers and Well Expertise Well Incident Team's support service contact list. The duty system covers not only the callout of support personnel for the stack but the logistics team required to mobilise to the Mongstad quayside.

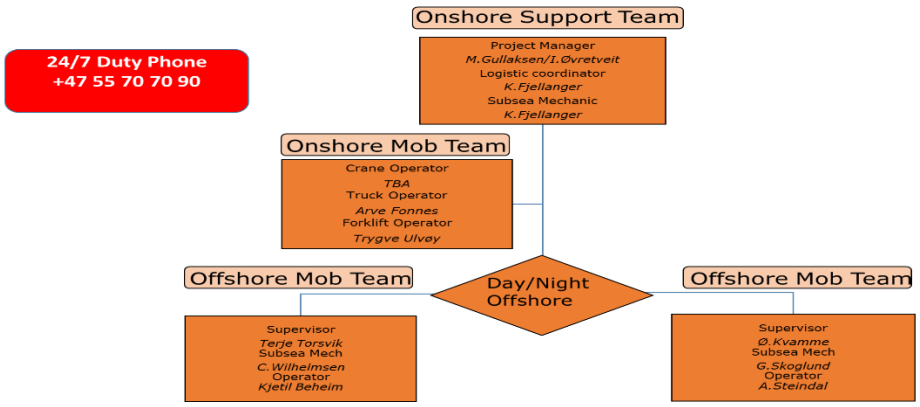


Figure 13 PSW Capping Stack Support Team and Duty Response

5) Capping Stack Deployment and Operational Procedures

PSW have procedures for all capping stack scenarios from mobilisation to recovery of the stack. The procedures are not designed to accommodate all well scenarios and should not be considered as well or well incident specific but the foundations for standard scenarios. The procedures are in place with regards to ram, valve and ROV positions for all of the following scenarios:

- Mobilisation
- Deployment and Installation
- Flow to Sea mode
- Test Well Integrity mode
- Containment Cap – double barrier mode
- Kill Well mode
- Flow to Capture vessel
- Recovery

The procedures and associated schematics are in the process of being updated to reflect the modifications made to the stack which include the following key changes:

- The original stack configuration had 8 koomey bottles contained on a spool below the stack. The spool and bottles have been removed in order to lower height, centre of gravity and reduce overall weight for ease of deployment.
- The new SAM module with additional capacity replaces the 8 koomey bottles and deployment and interface procedures are being incorporated

The ROV rotations to activate all functions are laid out in Appendix A of the PSW procedures.

Appendix E of the PSW procedures contains the Acoustic system positioning locations

The procedures have been read and verified against expected scenarios for water depth, well types and pressures, expected shut in scenarios and associated well integrity, functionality etc, etc. The procedures cannot be considered fit for adoption until the modifications for the deployment and attachment of the new SAM are in place which is planned completed by end July 2017.

An agreement between Wellesley and PSW has been made for final procedural verifications to be made by 1st August 2017 in a combined work group.

Equipment weights and dimensions for deck layout shall be updated as part of the mobilisation procedure. The original SAM modules shall be labelled as optional and not considered part of the initial load out unless specifically called upon.

The PSW procedures contain schematics of all manifolds for:

- Wellhead Connector ROV Panel
- Ram Control ROV Panel
- Chemical Injection ROV Panel
- Accumulator ROV Panel

The schematics and instructions for the installation of the flowlines in the event of flowing the well to a capture vessel are included in the operational procedures.

6) Emergency Preparedness Planning and Inclusion

In addition to the capping stack, associated equipment and personnel preparation in the event of call out, several topics were discussed with PSW for implementing in the emergency response planning.

Topics discussed were as follows:

Well Details Input Sheet

A one pager sheet with critical information for PSW to know and react to if called out will be prepared that contains all essential information including:

WELL INFORMATION CHECKLIST		
GENERAL		
☐	Water depth [meters]:	
☐	Estimated bottom hole pressure [bars]:	
☐	Estimated maximum wellhead pressure [bars]:	
☐	Estimated wellhead temperature [deg C]:	
☐	Known equipment limitations:	
☐	Latest well schematic:	
☐	Key interface information:	
☐	Potential attachment options:	
☐	Approximate production composition:	
☐	H2S, CO2	
☐	Expected flowrates	

The one pager will be issued to PSW once the final stages of the well planning are complete.

Scheduling Updates

It was agreed to include PSW operations manager and capping stack responsible on the daily timetracker when the well begins in order that expected entry into reservoir dates can be foreseen and any scheduled maintenance on the stack adjusted accordingly.

Emergency Response Contact Details and Associated Support Services

Wellesley Petroleum and Well Expertise will supply the relevant emergency response preparedness plan for PSW to be aware of the support systems and contact information. All contact details for support services including Safepath, Oceaneering, Add Wellflow etc, etc shall be incorporated into the capping stack deployment plans and shared with PSW. Inputs from PSW will be included.

9. Summary

The verification team were assured that the capping stack is supported fully from qualified technical personnel and with impressive facilities and resources to support it's maintenance, testing and deployment if required.

Considering the recent acquisition and mobilisation to Norway, the verification team acknowledge that final operational documents cannot be produced until adapted for the modifications made to the stack. However, establishing a time line when all supporting operational documents should be in place was agreed by 1st August 2017.

The proximity and ease of access to Mongstad base on a private road and inhouse PSW mobilisation resources assured the verification team that the PSW stack could indeed be mobilised far quicker than any other options available in Norway at the current time.

Continuing cooperation between PSW, Wellesley Petroleum and Well Expertise shall ensure the procedures are prepared and tested prior to the spud of the Wellesley Goanna well.

Contractually, the stack is considered able to be run in it's current condition but document familiarisation is not yet complete enough. The rate of progress with operational document support leaves the verification team in no doubt the procedures will be ready in time.

10. Appendices

Appendix No.	Description
1	Verification Attendance List
2	API RP 17W
3.	NOROG NCS Well Capping Status
4	PSW Company Presentation

11. Appendix 1

Meeting Sign In

PETRO SUPPORT WEST GROUP

Project: PSW Arctic Capping Stack
Facilitator: PSW
Place/Room: Mongstad

Date: 30.05.2017
Time: 09:00

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12. Appendix 2

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13. Appendix 3

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14. Appendix 4

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Company Presentatio