Sea Eagle DPA Surface Lines Chemical De-Scaling Report

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EXECUTIVE SUMMARY

Mineral scale deposition in Sea Eagle DPA flowlines and production headers have led to production deferments due to constricted flow lines. Pin hole leaks due to under deposit corrosion has been reported and flowline vibrations have raised concerns on risk of process safety incidence. The Production Chemistry Discipline with support from EA Operations carried out technical studies and proposed chemical de-scaling of DPA surface lines, including 21 flowlines as well as the HP, LP and test headers, to remove deposited scale followed by installation of a scale inhibition system to mitigate further scale deposition.

Production Chemistry led execution of the de-scaling activity, with support from EA Asset Management Team, and in collaboration with an integrated Team comprising of EA production operations and maintenance, Production Programming and subsurface Field Management Team (FMT). This document presents a comprehensive documentation of the de-scaling activity, outcomes and commercial implications.

Observation made during and post de-scaling execution led to the following conclusions;

- Proffered chemical solution for EA DPA surface lines descaling, was effective and resolved production constriction due the scale
- Over 3kbopd production gain was achieved.
- An annualized ROI of >US$65million is expected from F$500k invested in chemical descaling.
- Chemical de-scaling project was delivered safely, on schedule, within budget and flawlessly

The following recommendations are proposed;

- Deploy scale inhibition system, with injection points downstream of the culprit wells flow control valves.
- Re-assess for repeat de-scaling of flow lines, post scale inhibition system deployment, if deployment tarries beyond 12months post this descaling (i.e. May 2024)
- Secure regulatory approval for increasing Technical Allowable Rates (TAR), to enable maximization of production gains from de-scaling activity

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1 INTRODUCTION

1.1 Background

In recent years, and as water production increased, inorganic scale deposition has been observed on some Sea Eagle Drilling Platform A (EA DPA) surface lines. Solid deposits recovered from these lines were investigated and confirmed to be predominantly (ca. 90%) carbonate scale [1, 2, 3, 4]. This led to chemical descaling of 8oo21 DPA flowlines and HP header manifold in June 2021 [5], unlocking >2.1kbopd. The Multi-Phase Flow Metering package on DPA was also chemically descaled in September 2022 [6]. Both descaling activities were successfully executed using Amsolv6920 and Amsolv6100, engineered chemicals technically qualified for EA DPA scale [7] and earlier successfully deployed in other SPDC operations [8].

Observations in Q3 2022 indicated severe scale deposition on DPA with need for chemical descaling of all surface lines and manifolds. The observations include;

- Stuck open flow line valves, which includes valves descaled in H2 2021, indicative of flowlines scale deposition
- Increased FTHP & FLP on EA54 post well intervention in August 2022, with higher production when opened to both LP & HP headers, indicative of constriction on the headers
- Actual scale deposits on the LP header manifold (Fig1) sighted during descaling of 8 flow lines and HP header manifold in 2021

Figure 1: EA DPA LP header west manifold (scale deposits at the unboxed EA26 flow line tie-in point)

To manage the observed scaling, a chemical descaling proposal [9] was signed off and budget secured to chemically de-scale all surface lines on DPA. A Production Chemistry TA1 assured chemical de-scaling program [10] was signed off and resources mobilized to site to execute chemical de-scaling within the 2023 EA partial shutdown window for EA EGC cowling installation.

Long-term mitigation for controlling scale deposition on the platform is the application of scale inhibitor as proposed in MOC88207. Scale inhibition at the wellheads is expected to be commissioned in Q3' 2023.

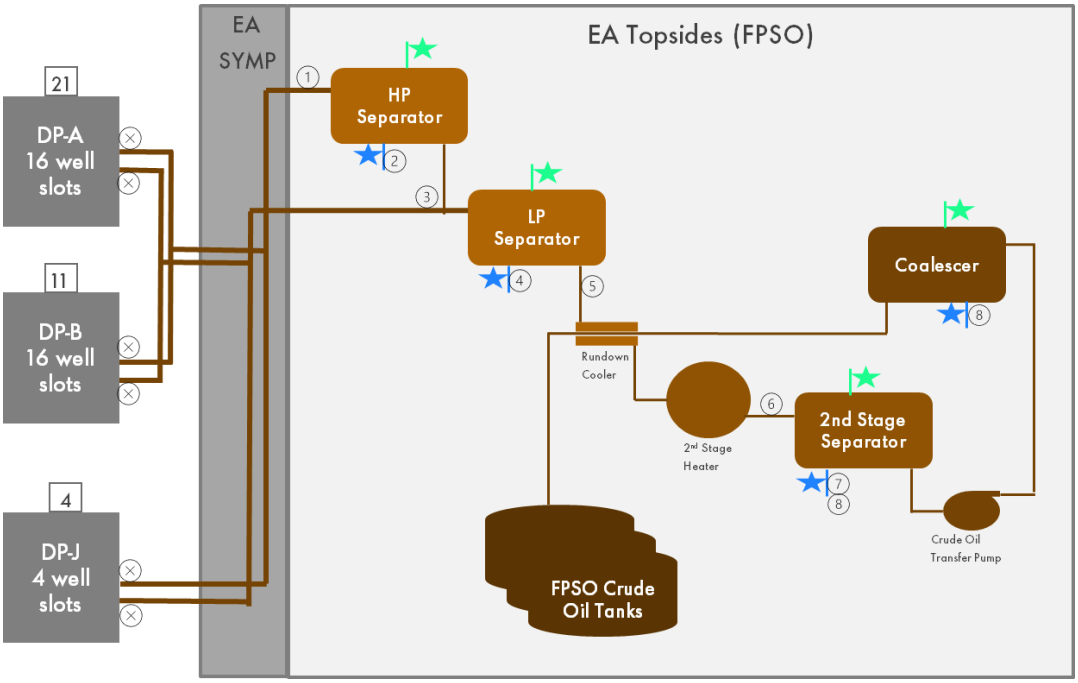
1.2 Process Description

EA/ EJA field wells are located on three steel jacket platforms; DP-A, DP-B and DP-J. Production from all wells in each platform are bulked into low pressure (LP) and high pressure (HP) lines that travel subsea, from the platforms to the FPSO. Figure 2 shows the fluid separation steps on the FPSO; from HP and LP separators, through the 2nd stage separator and coalescer to crude oil storage tanks from where custody is transferred to cargo vessels.

Current injection points for the six production chemicals used in EA/EJA field are annotated with numbers in figure 2, showing scale inhibitor injection points at the HP separator water outlet and the LP separator oil outlet. This configuration implies there is no mitigation for potential scale deposition on the HP & LP separator, subsea line and flowlines on the platforms.

Figure 3 shows a schematic of surface lines on DPA, showing how flowlines gather oil from wells to test header as well as HP & LP headers that evacuate oil from the platform through pig-able subsea lines to the FPSO. Scaled up line sections are also indicated.

Figure 4 shows a schematic of typical wells at Sea Eagle DP-A, with an indication of the areas observed to be experiencing carbonate scale and necessitating the need to chemically de-scale the flow lines. The wells on each platform are configured to produce either through the east or west manifolds of the LP & HP headers.



Key

- Line to gas process
- Line to produced water process
- ①③⑥ Demulsifier injection points
- ②⑤ Scale inhibitor injection points
- ① Naphthenate inhibitor injection point
- ④⑦ Water Clarifier injection point
- ③⑧ Biocide injection point
- ⊗ Corrosion inhibitor injection point
- ⑥ Antifoam injection point (not in use)
- [2] # of strings per platform

Figure 2: Sea Eagle process flow overview - Oil

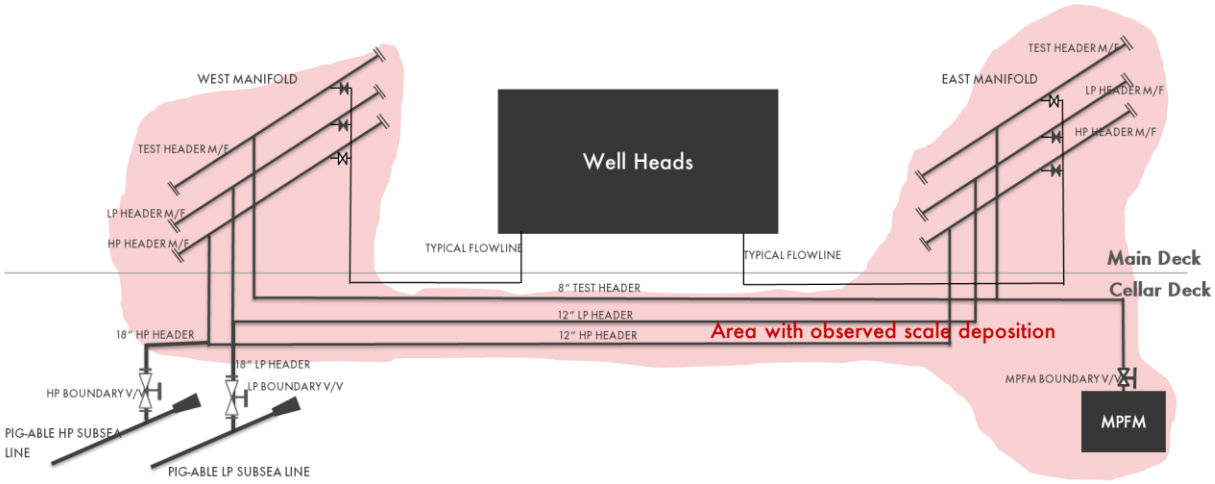


Figure 3: Schematic of DPA Surface Lines – flowlines and headers

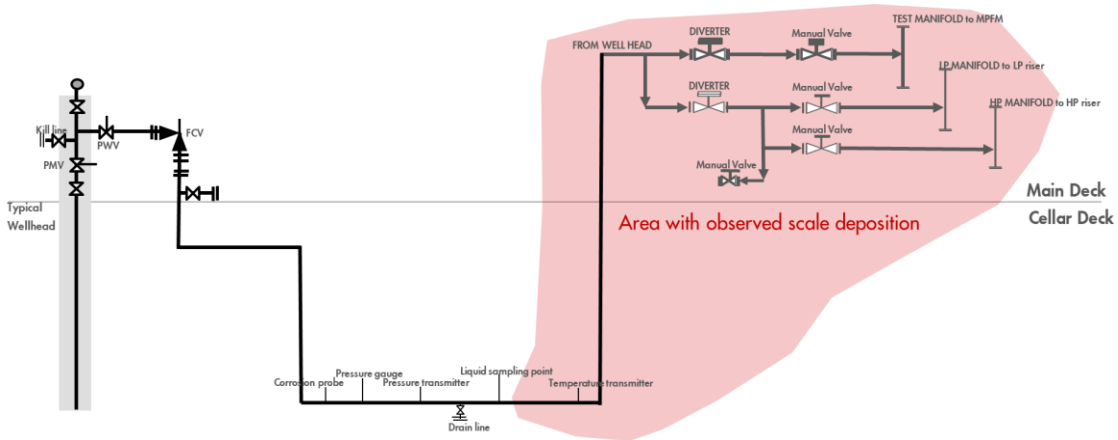


Figure 4: Schematic of a typical well configuration on DPA

1.3 Business Case

Inorganic scale deposition on EA DPA flowlines and headers have led to;

- Lost production of ca 3,000 bopd
- Asset integrity risk due to under deposit corrosion resulting in pin hole leaks on a few flow lines
- Stuck open flow line valves, impacting seamless operations on DPA platform

This document presents the details of EA DPA surface flow lines chemical de-scaling, executed between April & May 2023, covering 23 flowlines (21 of which are in active production), test, HP and LP headers, up to the boundary valve to the pig-able subsea header shown in figure 3. This intervention unlocked well potential of >3kbopd (annualized gain of >$66million at $75/bbl and 80% availability) at a one-off execution cost of F$501k.

2 DE-SCALING EXECUTION AND RESULT

2.1 Treatment Overview

To execute the planned scope, circulation loops as shown in figure 5 were set up allowing circulation of chemicals for treatment. De-scaled lines were split into three (East FLs, West FLs and headers) for easy management, based on the lines' physical position on the platform. Chemical injection and recovery points were on the main deck, as indicated in figure 6 whilst the circulation pump and tank were mounted on the top deck.

Treatment progressed in the following steps, as detailed in the de-scaling program [10].

Step 1: Site preparation – Positively isolate, depressurize and drain lines to be descaled. Prepare and lay out work area. Protect equipment that may be affected by chemicals

Step 2: Set up treatment circulation loop – as illustrated in figure 5

Step 3: Leak test circulation loop and function test chemical circulation pump

Step 4: De-grease lines and scale deposits with Amsolv6100 (pre-flush) and rinse with water

Step 5: Treat scale with inhibited acid – Amsolv 6920 (main flush)

Step 6: Neutralise acid and passivate with Amsolv 6100 (post-flush)

Step 7: Flush lines with water to wash off any neutralisation salts

Step 8: Return site to "as was met status" and demobilise

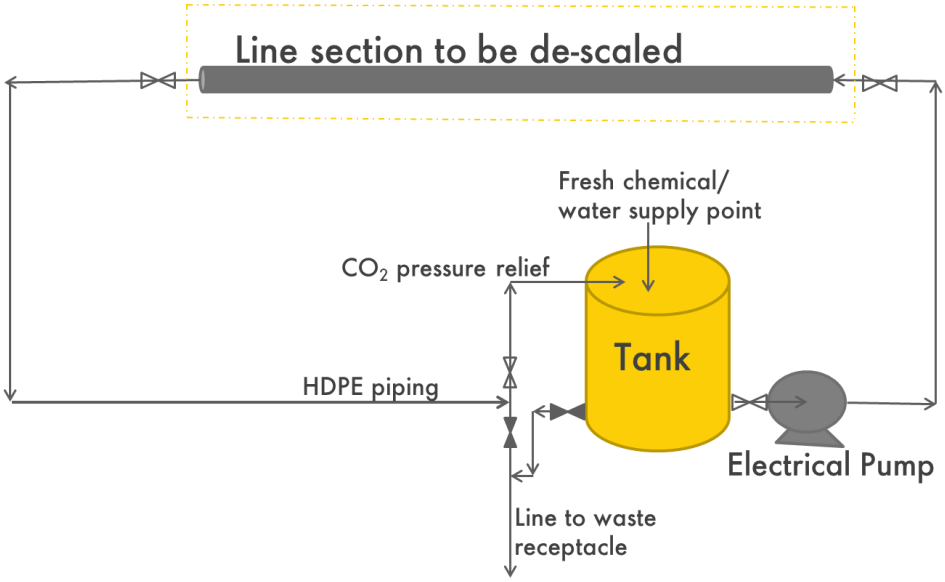


Figure 5: Schematic of circulation loop for flowlines chemical de-scaling

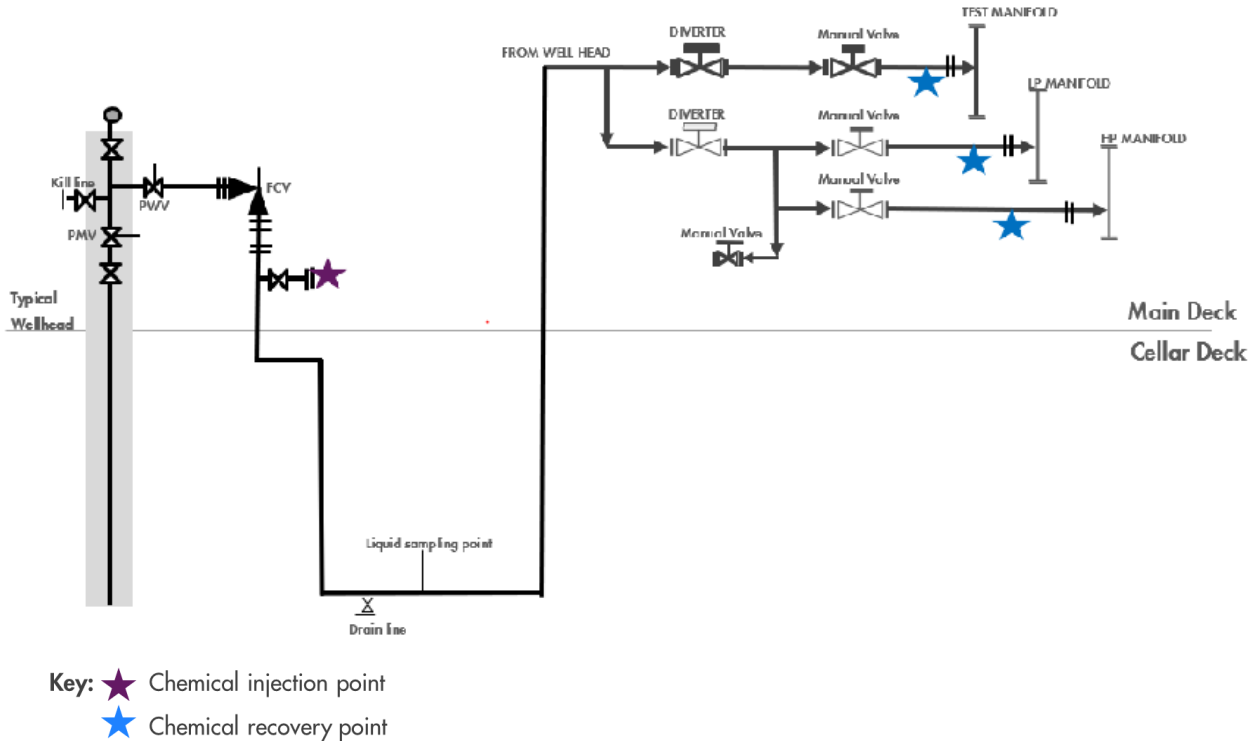


Figure 6: Schematic of typical DPA flowline, showing decaling chemicals injection and recovery points.

2.2 HSSE

Execution was done in line with Sea Eagle Permit to Work System, using e-PtW #0159124. A detailed job hazard analysis for the scope was completed [11] and adhered to during execution. The main risks and mitigations identified are highlighted in Table 1.

S/N	Risk	Mitigation
1	Chemical impact on Personnel	a. Personnel involved in chemical handling wore appropriate PPEs including rubber gloves, rubber safety shoes, rubber aprons, organic nose masks (for any generated H_2S), face shield, PFD, hard hats & coveralls when working with chemicals. Personnel not directly involved in chemical handling used minimum required PPEs including safety shoes, coveralls, eye goggles, gloves, hard hats and PFD. b. Circulation loop was confirmed to be leak free prior to introducing chemicals c. Only essential personnel were in actual work area when chemical was introduced

		d. Spent inhibited acid was neutralised onsite, before sending onshore for incineration
2	Chemical impact on Asset	a. Inhibited acid was used to mitigate metal corrosion. Acid neutralisation and water flushing was done before demobilisation b. External surface of pipe and equipment in work area were covered with water-proof material to prevent contact with chemical c. Leak test was carried out prior to chemical introduction to prevent any chemical leaks from the circulation loop. d. Spent chemicals recovered and not produced into the FPSO, to avoid any downstream asset integrity impact. All chemicals and water used were backloaded onshore for incineration
3	H_2S exposure	H_2S presence was considered possible, albeit unlikely to be present at high concentration. Possible because acid is used and any sulphide scales present can be converted to H_2S on contact with acid. Lab tests however show scale is largely carbonate and previous acid descaling on the platform have not detected H_2S. However, a. personnel wore organic nose masks and used gas monitors when chemical descaling was in progress. b. personnel were briefed on response (evacuate the area) in the event gas monitors detect H_2S presence c. circulation loop vent was located at a very well-ventilated area (DPA top deck) for rapid diffusion of any H_2S generated.
4	Temporary equipment	a. Pumps were pre-mobbed for offshore use prior to site mobilisation b. Asset electrical team to assess pumps before hookup to DPA power system and use for chemical descaling
5	Marine Transport safety	a. Compliance to marine journey management plan b. Use of personal flotation device as required c. Proper personnel induction on boat landing crossing

Table 1: Main HSE risks and Mitigations

2.3 De-scaling Outcome

Chemical de-scaling activity was successfully completed on the flow lines and HP header manifolds. Figures 7 to 10 show some before and after de-scaling pictures, illustrating effectiveness of the treatment. Table 2 shows EA DPA production volumes before and after descaling, showing a difference of >3kbopd as a result of eliminating the constriction in the flowlines and headers.

Before	After	Before	After
			
EA23T FL to HP header, d/s diverter valve		EA23T FL to LP header, d/s diverter valve	
			
EA57L FL to HP header, d/s diverter valve		EA51T FL to HP header, d/s diverter valve	
			
EA19L FL to HP header, d/s diverter valve		EA19S FL to LP header, d/s diverter valve	

Figure 7: Before and After chemical descaling pictures of select EA DPA East Flow Lines

Before	After	Before	After
			
EA36T FL to HP header, d/s diverter valve		EA54T FL to test header, d/s diverter valve	
			
EA26T FL to HP header, d/s diverter valve		HP/LP/Test manifold spool piece	

Figure 8: Before and After chemical descaling pictures of select EA DPA East Flow Lines

Before		After
 EA26 HP Header valve	 EA36 HP Header valve	
 EA21 LP Header valve	 EA54 Test Head' valve	

Figure 9: Before and After chemical descaling pictures of select EA DPA flow line valve

Before	After	Before	Ater
			
EA DPA HP header - EA36T tie-in point		EA DPA LP header - EA36T tie-in point	
			
EA DPA HP header – EA26T tie-in point		EA DPA Test header – EA54T tie-in point	
			
EA DPA LP header – EA54T tie-in point		EA DPA HP header – EA54T tie-in point	

Figure 10: Before and After chemical descaling pictures of select EA DPA Headers

#	Description	Reference Date	DPA Production allocation (BOPD)	Remark
1	Before Descaling	02.04.23 Reported 03.04.23	10,781	• 21 Wells online: EA19L/S, EA20, EA21, EA23, EA24, EA25, EA26, EA36, EA45, EA46, EA47, EA50, EA51, EA54, EA55, EA56, EA57L/S & EA58L/S. **EA net oil = 20,838 bbls**
		04.04.23 Reported 05.04.23	10,606	• 21 Wells online: EA19L/S, EA20, EA21, EA23, EA24, EA25, EA26, EA36, EA45, EA46, EA47, EA50, EA51, EA54, EA55, EA56, EA57L/S & EA58L/S. **EA net oil = 20,907 bbls**
2	After Descaling	17.05.23 Reported 18.05.23	13,915	• 21 Wells online: EA19L/S, EA20, EA21, EA23, EA24, EA25, EA26, EA36, EA45, EA46, EA47, EA50, EA51, EA54, EA55, EA56, EA57L/S & EA58L/S. • EA56 MER stage-3 test @ 90% choke ongoing. • EA56 MER stage-2 test @80% choke completed. • EA24 GL closed for high THT monitoring. • EA50 closed for PW handling on 15.05.23 • **EA net oil = 25,201 bbls**
		20.05.23 Reported 21.05.23	14,240	• 21 Wells online: EA19L/S, EA20, EA21, EA23, EA24, EA25, EA26, EA36, EA45, EA46, EA47, EA50, EA51, EA54, EA55, EA56, EA57L/S & EA58L/S. • EA25 choke adjusted 50% to 100% @0904hrs. • EA54 MER stage-3 test @100% choke completed • EA50 closed for PW handling on 15.05.23 **EA net oil = 25,439 bbls**
	Production Gain range		**3,134 bbl to 3,634 bbl**	Total EA field net oil gain range 4,294 to 4,601 bbl

Table 2: EA DPA before & after descaling production

As indicated in table 2, a total production gain of >3kbopd was realized from the chemical descaling activity, taking into consideration the total allocated production from the platform on the reference days across the execution window of 7th April to 5th May 2023. The reference days were selected on the basis of;

1. Closeness to the descaling execution window. Some days allowance was however given for production stabilization post descaling, to eliminate the potential impact of flash production due to extended (1month) period of wells shut-in during the descaling exercise.

2. Similarity in operating parameters, including same number of DPA wells in production, largely same choke setting for all wells and similarity in gas lift utilization.
3. No other intervention activity in the field, to account for difference in production volumes

Overall, the chemical de-scaling activity was successfully delivered;

- **safely** - no health, safety, security or environment incident
- **on schedule** – within the FPSO EGC cowling installation PSD window, eliminating the need to execute scope with deferment
- **within budget** – no cost escalation or PO variations
- **flawlessly** – complete scale dissolution/removal – ref figures 7 to 10

2.4 Economics

Given >3kbopd gain following EA DPA de-scaling, table 3 shows a first-pass economic evaluation. Annual gross revenue shown on the table is total increase in revenue if the additional well potential is produced 80% of the time over a year while "Chemical de-scaling cost" is the total cost for de-scaling the lines as in Purchase Orders 4510484019, 4710155580 & 4710155580 totaling F$500.5k, using the prevailing exchange rate of NG~~₦~~459.98/US$.

Description	Oil Price Scenarios		
	$65 /bbl	$75* /bbl	$85 /bbl
Net oil gain	3000+ bopd	3000+ bopd	3000+ bopd
Annualised net oil gain @80% availability	876,000+ bbl	876,000+ bbl	876,000+ bbl
Annual gross revenue gains from chemical descaling	>$56.9million	>$65.7million	>$74.5million
Chemical descaling cost (material, services & markup)	F$0.5million	F$0.5million	F$0.5million
Return on Investment	>$56.4million	>**$65.2million**	>$74.0million

Table 3: EA DPA Descaling economics evaluation

It is noteworthy that current (12 July 2023) oil price for Bonny Light oil is US$80.68, hence the base case scenario of $75/bbl oil price promises an ROI of >US$65.2million at 80% availability.

3 CONCLUSION

Based on observations made during the chemical de-scaling, as well as production values recorded before and after the chemical descaling activity, the following conclusions have been reached;

- Chemical solution proffered to remove carbonate scale on Sea Eagle DPA surface lines was effective and completely dissolved inorganic deposits constricting production
- Total production gain of >3kbopd was achieved, based on production figures before and after chemical descaling
- An annualized ROI of >US$65million for the F$500k invested in chemical descaling. ROI was premised on Bonny Light price of $75/bbl and 80% well availability
- Chemical de-scaling project was delivered safely on schedule, within budget and flawlessly

4 RECOMMENDATIONS

The following recommendations are proposed;

- Implementation of a permanent solution for EA DPA scale deposition, as de-scaling the lines is a temporary solution. Deployment of a scale inhibition system with injection points downstream of the culprit wells flow control valves is required. This will also mitigate scale deposition on the HP & LP separators.
- Re-assessment for repeat de-scaling of flow lines, post scale inhibition system deployment, if deployment tarries beyond 12months post this descaling (i.e. May 2024)
- Secure NUPRC approval for increasing Technical Allowable Rates (TAR) of de-scaled wells, to enable maximization of production gains from de-scaling activity

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