Title:	**MON-1 & MON-2 Wellhead Maintenance and Flow Test Report**
Client:	**Government of Montserrat**
Date:	**1 June 2023**
Revision:	**1.0**

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IV. ACRONYM TABLE

Acronym	Definition
ANSI	American National Standard Institute
ASME	American Society of Mechanical Engineers
Barg	Gauge pressure
DegC	Degrees 5elsius
Ft^3/min	Cubic Feet per Minute
H2S	Hydrogen Sulphide
Hrs	Hours
HT	High Temperature
HUD	Hold Up Depth
Ltrs/Sec	Litres per second
Lb	Pounds (weight)
Min	Minute
MWe	Megawatt electrical
NCG	Non-condensable gas
NPT	National Pipe Taper (referring to hardware)
NPT	Non-Productive Time (referring to time and performance)
Psi	Pounds per square inch
RFP	Request for Proposal
SOV	Side outlet valve
TV	Throttle Valve
WECO	Well Engineering Company Design
WHP	Well Head Pressure
WHT	Well Head Temperature

Table 1: Full list of acronyms used throughout report.

V. DOCUMENT CONTROL

Document Title	Submission Date	Author / Reviser
MON-1 & MON-2 Wellhead Maintenance and Flow Test Report Rev 1.0	May-2023	N.Young / J. Gilliland

Table 2: Document Control Summary

Change Summary

Section	Sub-Section	Page(s)	Content Change

Table 3: Change Summary

1 EXECUTIVE SUMMARY

The Government of Montserrat (GoM) contracted JRG Energy Consultants in December 2022 to carry out works to maintain the integrity of the wellhead equipment on 3 geothermal wells namely MON-1, MON-2 and MON-3. This work was carried out in two phases and is summarised below.

Phase 1 was executed from the 12th to the 17th of December 2022 and completed the servicing of all three wellheads and attempted to flow test MON-1 well. Flow testing attempts were carried out for MON-1 well only due to time constrains and were unsuccessful. It was also observed during this scope that the condition of several flow test equipment components required minor maintenance to ensure integrity for future well flow operations. Notably all observations from phase 1 indicated that all well head assets themselves, were in good repair both visibly and functionally and provided no cause for concern nor required any planned maintenance with the exception of a new tree cap for MON-3.

Phase 2 was executed between the 27th of March to the 10th of April 2023 and focused on the remedial works planned from Phase 1, with an emphasis of initiating well discharge via air lifting to flow test both MON-1 and MON-2 wells. This report contains a detailed description of this work scope including, maintenance recommended from phase 1, the results obtained from flow testing on both MON-1 and MON-2 wells, general observations, discussion on the results and recommendations/suggested as next steps.

During phase 2 work scope both wells completed an extended flow period as planned. At 13:50 on the 1st of April, MON-1 well commenced flowing and continued to increase production rate until it reached steady state at 15:00 on the 2nd of April with a WHT of approximately 178 DegC and a WHP of 130psi. The well flow rate was estimated at 12.43 ft^3/min (352 litres/min or 5.87 litres/sec) over the initial 250 min of well flow. The MON-2 well came online at 18:30 on May 7th and after the initial beam-up period the WHP and WHT were very sensitive to TV movement. As such it was difficult to reach steady state at the optimum well flow conditions in the time allowed for MON-2. The maximum WHT recorded was 147 DegC with a WHP of 50psi at an estimated flow rate of 10.75 litres/sec.

The primary objective of Phase 2 scope was to establish the viability of both MON-1 and MON-2 wells as geothermal producers and make a general comparison of the results compared to those obtained during the previous test ~10 years prior. This was successfully met by recording the well measurements of WHP, WHT with an estimate of flow rate, which were recorded and presented alongside similar available data from the 2013 well test. Whilst the data shows that both wells do flow at potentially power producing rates, the analysis was not conclusive enough due to lack of vital measurements, namely the James Tube pressures on both MON1 and MON-2 wells. Therefore, the best analysis for consideration is that of equating the acquired WHP/WHT/Flow rate during the flow test results from 2023 to the same data obtained during the well test completed in 2013. By doing so, it would seem reasonable to assume that similar estimates for electrical power generation would be possible.

With respect to operational performance, both MON-1 and MON-2 well interventions were successfully achieved within a relatively short time frame and with a number of operational constraints. Although this intervention activity offered up a number of lessons learned it also showcased the capability of island personnel to learn on the job with impressive speed and to work collaboratively and safely to execute operations whilst dealing with a number of adverse factors.

2 INTRODUCTION

2.1 Background:

Between 2013 and 2017, three geothermal wells were drilled in the Weekes area, between Salem and Plymouth as shown in Figure 1. MON-1 and MON-2 exploration wells were successfully drilled, installed, and tested in 2013 – 2014. MON-3 was drilled in 2016 to confirm the three-dimensional model of the reservoir. However, well testing of MON-3 was never undertaken due to inadequate well stability after completion.

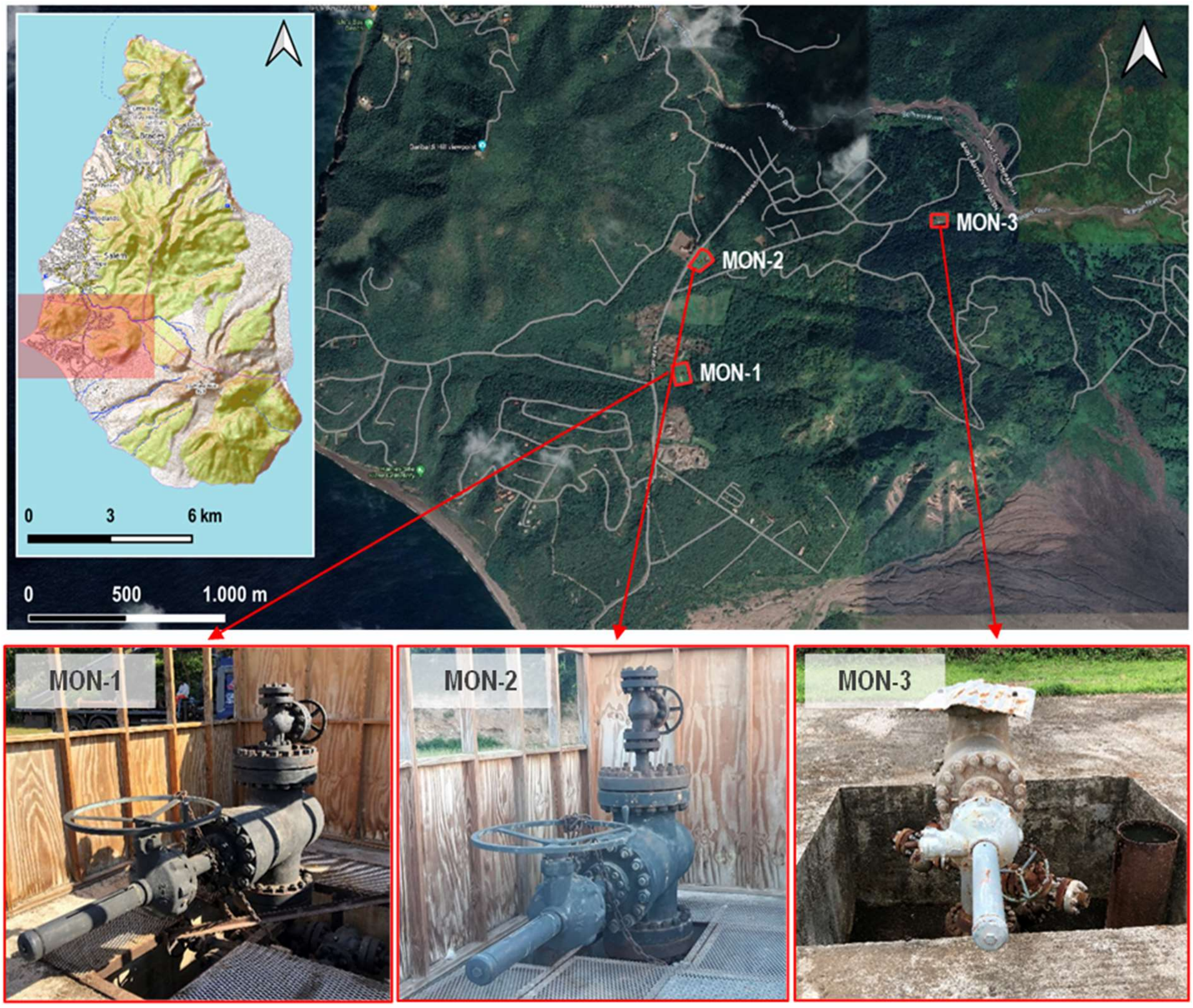

Figure 1: Location and photo of Montserrat geothermal wells: MON-1, MON-2, and MON-3.

The MON-1 and MON-2 wells were flow tested between late August to late December in 2013. Initial well test results indicated that both MON-1 and MON-2 wells could produce 2MWe of power and could sustain long-term production. Following completion of the initial drilling and the well testing scope, both wells were shut and never put into production [1].

The Government of Montserrat (GoM) contracted JRG Energy Consultants in December 2022 to carry out works to maintain the integrity of the wellhead equipment on 3 geothermal wells: MON-1, MON-2 and MON-3. The original scope of work included:

- Servicing of the 3 geothermal wellheads.

- Assessing the quality of the wellheads for operational use and any other geothermal assets owned by the GoM.
- Attempting to discharge MON-1 and MON-2 safely.
- Creating a maintenance manual and routine maintenance strategy for the GoM
- Increasing the capacity and training of local staff to conduct future maintenance operations internally.

Phase 1 included the servicing of the three wellheads and MON-1 flow test attempts, which were carried out from the 12th to the 17th of December 2022. Flow testing attempts were carried out for MON-1 only due to the time constrain.

During this first phase, the team from JRG carried out an initial reconnaissance of the area, established the condition of the equipment, performed all possible maintenance on the geothermal assets, and listed all required remedial work to be carried out during Phase 2 of the operational scope. The work carried out during Phase 1 was detailed in the field report *"Geothermal Wellhead Maintenance Report_Rev01"[2].*

Phase 2 commenced in March 2023 and was focused primarily on the remedial works from Phase 1, with an emphasis of initiating well discharge and flow testing on MON-1 and MON-2.

2.2 Report Structure

This report covers all work performed during Phase 2 and is listed below:

- Carry out high priority repair and replacement works identified during Phase 1.
- Perform slickline well survey on MON-1.
    - This step was later made a contingency operation if well did not flow.
- Perform well flow testing on MON-1
- Perform slickline well survey on MON-2
    - This step was later made a contingency operation if well did not flow.
- Perform well flow testing on MON-2 well (OPTIONAL)
    - This scope was later made critical path.
- Deliver report summarizing works undertaken.

This report contains a detailed description of the above steps, the results obtained from well flow testing, general observations, discussion on the results and recommendations/suggested next steps.

See below links for access to the documented record of operations carried out as part of these phase 2 maintenance and well flow operations:

- Archive of photographic documentation:

https://drive.google.com/drive/folders/11o3etKj25H-z4TxzTrvQueL8GdxkIKgA?usp=share_link

- Archive of Daily reports:

https://drive.google.com/drive/folders/1uW0XiMlC7zkBNT6nGjaaJ99qxzhc5Xzt?usp=sharing

3 INITIAL OBSERVATIONS

3.1 MON-1

Below is a description of the well site at MON-1 prior to commencement of operations on Monday 27th March supported with photographic evidence. Note that this well site had been left set up from Phase 1 of operations in December and left unaltered.

Figure 2 below shows the initial state of the complete set up as well as showing details of the wellhead with the Flow-T and flanged crown valve on top. From here you can also see the general layout from which the following items can be identified:

- Section 1 – Flow-T with top and bottom ASME B16.5 12” Flanged faces that requires 2 x R57 ring gaskets. This section of pipe also carried 3 x 1.1/2” female NPT ports.
- Section 2 – Delta Pacific Valve (DPV) supplied 10” Throttle valve (TV) that requires 2 x R53 ring gaskets.
- Section 3 – 10” Crossover spool piece from R53 ring gasket at Throttle Valve flange interface to ANSI 300lb spiral wound stainless steel gasket on the downstream side.
- Section 4 – 10” 90-degree elbow which requires 2 x ANSI 300lb spiral wound stainless steel gaskets.
- Section 5 – 10” pup-joint for carrying James’ Tube insert complete with 2 x 1.1/2” NPT female NPT ports for reading pressure and/or taking samples.
- Separator – This, along with the outflow pipe make up the remainder of the set up.

Note that missing from this set up was a V-notched weir box. On arrival, one was requested to be manufactured however, due to limited fabrication resources on the island, this arrived in time for MON-2 operations only and was not available for MON-1 testing.

From the initial assessment of MON-1 the following valve positions were observed:

- 12” Class 900 ANSI/AMSE Master Valve (MV) was found in the in the closed position (240 turns to fully open/close on gear box)
- Tree Cap (TC) with a 3” Class 900 ANSI/AMSE Crown Valve (CV) found in the closed position (40 Turns to fully open/close).
- 3” Class 900 ANSI/AMSE Side Outlet Valve (SOV) x 2 were both found in the closed position (40 turns to fully open/close).
- On SOV (RHS facing well head), there was a companion flange attached with a 2” WECO connection for hooking up fluid supply.
- On SOV (LHS facing the well head), there was a blind flange.

The water supply point was positioned at the opposite side of the test pit and supplied water via a 4” x 2” plastic pipe. This water is supplied at 250psi and was later attached to the 2” WECO connection with a fitting rated to 16bar (232psi). The operating pressure was therefore larger than the safe working pressure of the line. In this instance the operation of injecting fluid into the well was controlled such that the well was lined up prior to opening at the main supply point to the field and after closing at the same point to avoid trapping excessive pressure in the water supply hose. Recommendation for future operations is to either source higher rated connections to match water pressure or install throttling equipment with sufficient instrumentation to monitor line pressure. The same scenario was observed at MON-2 also.

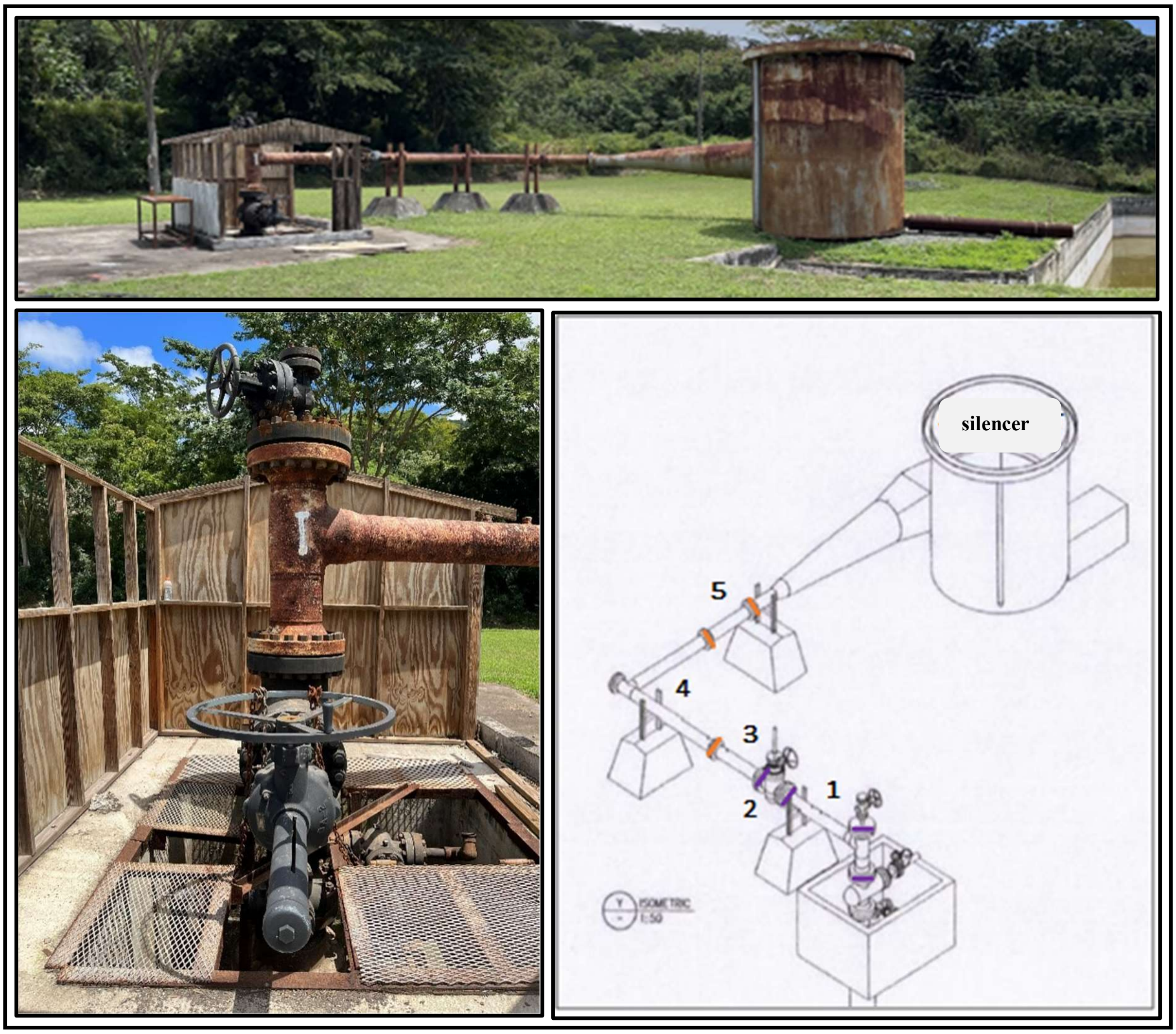

Figure 2: Top picture shows MON-1 well site in the initial configuration 27-03-2023 / Bottom left Shows the configuration of the tree close-up on MON-1 well head / Bottom right shows the general arrangement for both MON-1 and MON-2 set up.

3.2 MON-2

Below is a description of the MON-2 well site in the initial condition. Located at the MON-2 wellsite were the storage containers housing the required intervention and testing equipment, namely:

- 1.9” tubulars for running to lift the well.
- 1.9” tubular complete with hang-off flange and pump-in elbow.
- An assortment of James Tubes.
- Giberson Head.
- Pipe elevators.
- Slips.
- Spare 0.092” wireline reel.
- 3” Intervention lubricator.
- Spare drill bits.

While the containers were locked and mostly secured from the elements, there were notable holes in the ceiling of the container which in turn created an atmosphere that supported rusting and decay of equipment. The James tubes were determined to be in an unusable state. There were several James Tubes with broken pitot tubes along with unusable threaded connections for connecting the external pressure gauges.

From the initial assessment of MON-2 the following observations are observed:

- 12” Class 900 ANSI/AMSE Master Valve (MV) was found in the in the closed position (240 turns to fully open/close on gear box)
- Tree Cap (TC) with a homemade 2” extension piece to a 3” flange which was in turn connected to a 3” Class 900 ANSI/AMSE Crown Valve (CV) and was found in the closed position (40 Turns to fully open/close).
- 3” Class 900 ANSI/AMSE Side Outlet Valve (SOV) x 2 were both found in the closed position (40 turns to fully open/close).
- On SOV RHS (facing well head), there was a companion flange attached with a 2” WECO connection for hooking up fluid supply.
- Also affixed to this SOV was a pressure gauge reading 0psi for well head pressure.
- On SOV LHS (facing the well head), there was a blind flange.

From the photos in Figures 3 you can also see the wooden protection structure that was removed to allow access scaffolding along with casing that had to be removed to grant access for the well flow test equipment.

Figure 3: Pictures above show the initial condition of the MON-2 well site (top) along with the initial condition of the Giberson head (bottom left), the James Tubes (bottom centre), the slips, elevators and spare 0.092" Wire (bottom right).

As observed from Figures 3 above, the general condition of the equipment was rusty and unmaintained. Below are observations of some of the key flow-test equipment:

- Some of the bolts on the Giberson head were unserviceable at site and therefore the Giberson head could not be prepared to function fully as designed. General condition of all nuts and bolts on the Giberson head were either damaged or severely rusted.
- The general repair of the split bowl and slips were good and functioned without problem.
- The pipe was visibly rusty on the external, however, later inspection on the male and female threads showed generally good condition.
- The James Tubes were observed to be unusable with none of the spares able to take a thread to allow for an external pressure measurement at the James Tube.
- The weir box was heavily corroded with many unrepairable holes rendering it unusable.

4 MAINTENANCE WORKS

From the previous Phase 1 well report the following maintenance issues were identified with remedial actions to correct during Phase 2. These Phase 1 observations are listed below with follow up actions carried out during Phase 2 and detailed on the following pages:

Issue	Comments
Leak at upper joint on Flow-T	- A leak from the joint between Part 1 and the cap was detected during well flow activities. Although the joints and ring were cleaned, greased, and dried, the degree of corrosion of the joint's surface had damaged the grip. - The issue was temporarily fixed by wrapping the ring in Teflon tape. - Prior to continuing with the well flow activities, the joint needs to be sealed. The following actions are recommended: - Temporary repair: using high temperature gasket material or high-performance silicone (temperature / pressure) such as JB Weld. - Permanent solution (recommended): replacing or resurfacing the flanges (e.g., sand blasting, cutting as needed to remove the corroded layer)
Leak at 10" throttle valve (TV)	- A leak from the 10" valve (Part 2) was detected during well flow attempts. The issue appears to be due to an internal sealing defect, resulting in the gas / air leaking through the stem and melting the grease / lubricant. - A new packing needs to be installed at the stem, which requires the proper packing and tools for removal, dismantle of the valve body and installation of packing.
James-tubes highly corroded	- The James-tubes are highly corroded, which has resulted in damaging / breaking the outer tube and obstructing the orifice – as per the photo. - Enough James-tubes remain usable. - No action needed, except storage in a container.
All parts: severe rusting	- The flowing line parts are generally severely rusty, and the joints corroded. - It is recommended to resurface the flanges, to sand blast, scrub, cut – if needed – the parts to remove the rusty / corroded layer and prevent further alterations / damage of the joints and outlets. - All parts should be stored away (e.g., in a container or warehouse) to minimize exposure to weather and prevent rusting.
Nuts and bolts removed	- Nuts and bolts are still in short supply with inventory of back-up urgently required.
Air line	- The air line with the connections needs to be replaced - this is about a 20 to 25' hose with a 3k+ rating with 1502 figure hammer union connections of at least 4 complete unions. These unions are 5k rated but standard to these units.
Air compressor	- The air compressor used for the well flow activities experienced overheating issues due to bad or slipping fan belts. - The air compressor needs to be serviced. - Prior to use, the fuel filters, all fluid levels, pressure testing to 500 psi should be checked by a mechanic.

Table 4: Description of required maintenance scope identified during phase 1 scope for follow-up during phase 2 scope.

4.1 Leak at upper joint on Flow-T – High Priority.

This was correctly identified as a corrosion issue on the ring gasket profile and can be seen in Figure 4 with the remedial action to insert HT silicon to enable a leak-tight seal.

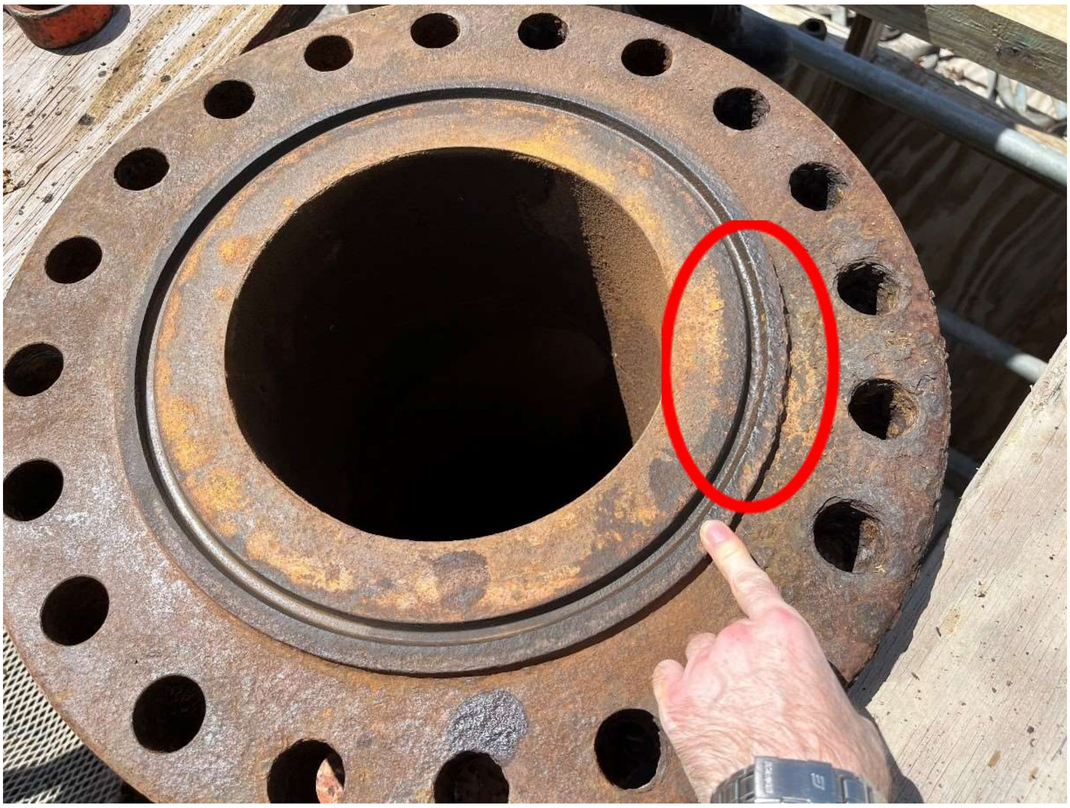

Figure 4: Indicating the start of the pitting corrosion area.

The HT silicon was applied to the top connection of the Flow-T in the area shown in the picture above which carries a ring groove for a R57 gasket on the 12" AMSE/ANSI B15.5 flanged connection. Whilst the application of the HT silicon did pass the 500psi gas pressure test i.e., no visible or audible leaks, it did start to weep during the flowing period of the operation on both MON-1 & MON-2. Due to the weep being sufficiently small with no recordable H2S, it was deemed manageable and did not necessitate a halt to operations. However, it is highly recommended to affect a more permanent repair to this piece of equipment preferably re-machining the flange face including the gasket profile. Conversely the tree cap originally attached to this face was in good condition and did not require anything more than cleaning.

4.2 Leak at 10” throttle valve (TV) – High Priority.

The ANSI 16.34 10” TV supplied by Delta Pacific Valves had a visible and audible leak on the steam seal packings. The plan was to affect a repair sufficient to prevent leak during the operational activities. This would have been affected by packing high-temp Teflon rope into the seal-stack cavity in behind the packing-gland and packing nut. However, on inspection the packing nut was seized to the main body of the valve, and whilst extensive attempts were made to remove the packing nut further attempts risked escalating the issue, as such it was decided to accept the leak and instead mitigate the risk of injury to personnel operating the valve.

Figure 5: 10" TV in the initial Condition (Left). View on top of packing gland where leak was emanating (Right).

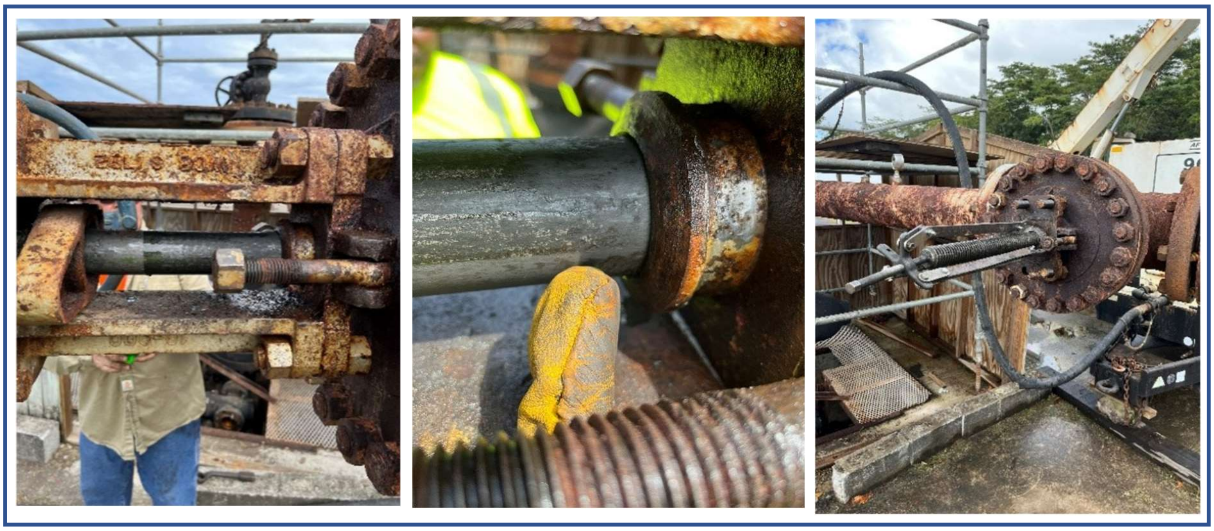

Figure 6: Side view of the stem with the packing gland retracted (Left), area where leak was emanating between packing nut and stem (centre), Attempt to retract with ceased packing nut with modified gasket removal tool (Right).

From Figure 6 above, the extent of the attempted repairs can be seen with a modified three-pronged gasket removal tool anchored on the end of the stem after removal of the gear box and valve bonnet. The modification to the three-pronged removal tool was not precise enough to allow the removal tool to extract the packing nut. This was the last attempt to gain access to the back side of the seal stack before putting in place mitigation measure to protect persons operating the throttle valve.

4.3 James Tubes highly corroded

On arrival to MON-1 there was already a James Tube in place that was able to be made up to an external pressure gauge. During operations this gauge gave no useful data. The reason upon inspection after breaking out the flow line components was a broken pitot tube. On inspection of the remaining James tubes, it was impossible to clean the threads out on any of the James Tubes with the equipment at hand, see Figure 7 below as an example.

Figure 7: Indicative picture of all the threads on the spare James Tubes.

4.4 All parts: severe rusting

Throughout the operation there was a chronic short supply of nuts and bolts. This lack of usable parts necessitated the removing of bolts from the static well to ensure sufficient bolts were available for the critical path well.

Figure 8: Spare nuts and bolts inventory.

4.5 Airline Severely Worn

The two air hoses used to gas lift each well with 2” 1502 WECO connections were in poor condition see Figure 9 below. On pressure testing of the lines, one of the hoses showed signs of a leak through multiple layers of protection with visible bubbling on the outer rubber sleeve. This line was therefore condemned which reduced the length of hose available for use. This necessitated the need to locate the air compressor as close as possible to the well head.

Figure 9: Picture shows the visible signs of degradation of the 2x 2" 250 bar Semperit hoses.

4.6 Surface Flowline Equipment

All surface flowlines to the separator are in a weathered and rusty condition. Many sealing surfaces are in particularly poor condition and need to be cleaned or even re-machined to be effective again. The most concerning was the condition of the upper flanged surface on the master valve on MON-2, which can be seen in Figure 10 below, and has a severe issue with rust between flange surfaces. Conversely the TC was in very good condition with minimal to no rust.

Figure 10: Tap point to be re-worked (Left), hole in separator requiring repair (centre), excessive corrosion on MON-2 12" master valve upper flange face (right).

4.7 Air compressor

This equipment operated for the duration of the work scope largely without defect. A tyre was replaced, and a fuel re-fill was required between wells. However, this equipment is very aged and there was some ambiguity around whether it should be possible to function outlet valves with full operating pressure differential across the outflow valve.

4.8 General Equipment and Tooling

Throughout the operation there was a lack of tooling and equipment for the operation and although the overall objects were met, there was a number of occasions where operations were stopped or stalled waiting on tools.

5 FLOW-TEST METHODOLOGY

To lift both MON-1 and MON-2 wells, a total of 19 x 32ft strands of 1.9" diameter pipe (608 ft run depth) were run into each well to gas lift a water column recorded at 226ft on MON-1 well and 170ft on MON-2. This meant that approximately 382ft of well fluid was lifted on MON-1 and 438ft of well fluid was lifted on MON-2 to initiate flow. Considering a gradient of water of 0.433 psi/ft, means that the minimum required pressure from the air compressor to airlift each well was:

MON-1: 0.433psi/ft x (608ft - 226ft) = 165.4psi (EQ1)

MON-2: 0.433psi/ft x (608ft - 170ft) = 189.7psi (EQ2)

The max pressure output from the air compressor was 500psi so there was no concern regarding its ability to lift the well fluids even considering a full column of fluid to surface.

The technique used to lift each well was to first pressure up the well bore to push water back into the formation. This acted to heat the wellbore fluid before rapidly opening the 10" TV to effectively bounce the well whilst maintaining gas lift with the air compressor.

Using this technique, the Mon-1 well flowed on the first attempt and was left in lifting mode until visible signs of temperature and steam observed at surface indicated that well would sustain flow unassisted. Thereafter it was left on open flow for a further 30 hrs approx.

The same procedure was used for MON-2 well which came online on the fourth attempt at trying to bounce the well and continue to gas lifting. After about 2.5hrs the well appeared self-sustaining and the compressor was shut-off. The well continued to flow for the full 48hrs planned flow period. The following section details the summary of operations from MON-1 and MON-2 wells during the well flow period.

Figure 11: Above shows elevated working platform (left) and pipe rack full of recovered pipe after flowing MON-1 well (Right).

5.1 Measurements

On the commencement of flow from both MON-1 and MON-2 wells, well fluid flowed through the surface lines set up as described in Figure 1 to the test pit. The WHP was controlled by opening/closing a 10” inline TV which in turn altered the flow rate and resultant WHT. The resulting WHT was measured with an infrared laser thermometer at a point in the Flow-T directly above the master valve. TV position (% open/closed), temperature and pressure were all recorded and can be seen in the raw data for each well in each respective well performance summary.

Flow rate for geothermal wells is normally calculated from flow over a weir; however, due to the condition of the weir box from previous operations this was unusable and necessitated a temporary weir box to be constructed from wood. This new weir box was ready for MON-2 well only. The flow rate on MON-1 well was therefore calculated by assessing the rate of test pit fill over time. This was also checked against timing the fill of a 5-gallon container with results described in the respected performance summary sections below with raw data and calculations described in each respective well performance summary.

It is also standard practice to calculate the mass flow rate (steam and water), available enthalpies of the steam and water through the application of the Russel James equation which links mas flow rate of total well fluid flow with discharge pipe (James Tube area), discharge enthalpy and lip pipe pressure. However, as the lip pipe pressure was not able to be read with all remaining James Tubes being unserviceable and the absence of a weir on MON-1 well, these essential readings were not available to make the necessary calculations. As such any assessment of power potential needs to be inferred from WHP, WHT and estimated flow rates and compared to earlier obtained well test results.

6 OPERATIONAL SUMMARY

What follows is an operational summary of events as they occurred.

Date	Summary
27/03/23	Arrived on site, carried out initial observation surveys and mobilised tools and equipment to MON-1 well.
28/03/23	Continued rigging up on to MON-1 well site. Carried out temporary repair to Flow-T gasket profile using HT silicone.
29/03/23	Attempted to carryout repair to 10" throttle valve packing nut – Unsuccessful.
30/03/23	Continued to attempt repair to 10" throttle valve – Unsuccessful. Decision made to mitigate risk associated with leaking valve for fear of escalation of severity of leak. Meanwhile ascertained fluid depth.
31/03/23	Attempted to run pipe through Giberson head – Unsuccessful. Decision made to instead run the pipe open-hole and land string off with the bespoke pipe hanger flange.
01/04/23	Run in Hole (RIH) 19 lengths of pipe (608ft). Commenced air lifting well whilst recording pressure, temperature, and test pit fill.
02/04/23	Continued to lift well whilst recording pressure, temperature, and test pit fill.
03/04/23	Completed 48hr flow period and closed in well. Water facility not sufficient to overcome well pressure to rapid cool well to expedite pipe recovery operation. Decision taken to wait for well to cool overnight.
04/04/23	Water board increased available pressure and commenced pumping cold fluid to well to ensure no well flow whilst recovering pipe open hole. Recovered 1.9" air lifting string, rigged down flowline, reinstated and commenced transporting equipment to MON-2
05/04/23	Located to MON-2 and rigged down TC and commenced rigging up surface flow test equipment.
06/04/23	Continued with rigging up and testing of surface equipment on MON-2.
07/04/23	Completed rigging up on to MON-2 well and commenced air-lifting operations and observed well flow on forth attempt at bouncing the well.
08/04/23	Continued to flow well whilst recording temperature, pressure, and test pit fill.
09/04/23	Continued to flow well whilst recording temperature, pressure and monitored flow over the weir for approx. 6hrs. Closed in well and allowed to cool down.
10/04/23	Recovered 1.9" tubing from the well and reinstated tree cap on Flow-T. Left flow lines rigged up on well and commenced clearing worksite and backloading equipment. End of well operations on MON-2

Table 5: Tabulated high-level summary of operations.

7 MON-1 WELL PERFORMANCE SUMMARY

At 13:50 on the 1st of April, the MON-1 well commenced flowing and continued to increase production rate until it reached steady state at 15:00 on the 2nd of April at with a WHT of approximately 178 DegC and a WHP of 130psi. Initial returns were brownish and very soapy in appearance, thought to be due to the large volume of surfactant placed in the well during Phase 1 operations.

The well flow rate, estimated from recording test pit fill rate, was recorded at 12.43 ft^3/min (352 litres/min or 5.87 litres/sec), over a duration of 250 min. The data collected to estimate the flow rate is described in sections 7.1 to 7.3. Whilst taking these measurements, fluid samples were also collected by the team at the Montserrat Volcano Observatory (MVO) for further analysis.

This flow rates recorded using the pit fill volume compared very closely to filling a 5-gallon container with the following results. Note: due to the rather crude method of this test, the outlier results are excluded i.e. max and min and the remainder averaged to yield average results.

Attempt	Time (Sec)	Flow Rate (ltrs/sec)	Flow Rate (ltrs/min)
1	5	3.8	228
2	4	4.7	282
3	4	4.7	282
4	3	6.3	378
5	3	6.3	378
Average Result	3.67	5.23	314

Table 6: Flowrate assessment results using 5-gallon container.

Note, that both methods are best estimates with the equipment available and should be considered as a guide only. There are several inherent errors in the method used to record this data which are listed below:

- Error with starting and stopping the timer for filling the 5-gallon bucket.
- The actual fill of the bucket was not perfect due to spill and apparatus instability during reading.
- The estimate of pit fill was judged at distance by using a graduated pole in the test pit and not millimetre accurate.

Also, for clarity, between the evening of Saturday 1st and the morning Sunday 2nd the pit volume was filled. With no certainty of when the pit reached capacity and how much overnight rainwater contributed to this fill, therefore, readings after the evening of Saturday 1st 18:00 must be discarded leaving only 250 minutes of pit fill monitoring to base pit fill rate i.e. well flow rate.

All data recorded are presented below and are also represented graphically.

7.1 Raw Data set for MON-1 Flow Test

Date / Time	Cum Time Interval between Readings (mins)	Pwh (psi)	Temp (DegC)	Pit Freeboard (ft)	Notes
01/04/2023 13:50	0.00	10	33.0	7.000	
01/04/2023 14:00	10.00	15	38.3	7.000	
01/04/2023 14:10	20.00	10	45.6	7.000	
01/04/2023 14:20	30.00	10	56.3	7.000	Closed Throttle valve 1/8th (19 turns, 58 total, 37% open)
01/04/2023 14:30	40.00	10	59.2	6.900	
01/04/2023 14:40	50.00	15	80.0	6.800	
01/04/2023 14:50	60.00	20	96.7	6.800	
01/04/2023 15:00	70.00	30	112.6	6.700	
01/04/2023 15:10	80.00	40	124.9	6.600	Opened Throttle valve 1/8th (19 turns, 77 total, 50% open).
01/04/2023 15:20	90.00	50	117.8	6.600	Opened Throttle valve 1/8th (19 turns, 96 total, 62% open).
01/04/2023 15:30	100.00	60	137.5	6.500	
01/04/2023 15:40	110.00	70	146.7	6.400	Opened Throttle valve 1/8th (19 turns, 115 total, 75% open).
01/04/2023 15:45	115.00				Isolated air compressor. Well lifting unassisted.
01/04/2023 15:50	120.00	65	150.0	6.300	
01/04/2023 16:00	130.00	80	158.1	6.300	
01/04/2023 16:10	140.00	90	167.2	6.300	
01/04/2023 16:20	150.00	95	168.9	6.200	
01/04/2023 16:30	160.00	100	168.9	6.100	
01/04/2023 16:40	170.00	110	170.0	6.050	
01/04/2023 16:50	180.00	110	172.8	6.050	
01/04/2023 17:00	190.00	110	172.8	6.025	Opened Throttle valve 1/8th (19 turns, 134 tota, 87% open).
01/04/2023 17:10	200.00	110	173.0	6.000	
01/04/2023 17:20	210.00	110	171.0	5.950	
01/04/2023 17:30	220.00	110	175.0	5.900	Opened Throttle valve 1/8th (20 turns, 154 total, 100% open).
01/04/2023 17:40	230.00	110	173.0	5.900	
01/04/2023 17:50	240.00	110	173.0	5.800	

01/04/2023 18:00	250.00	115	174.0	5.800	
02/04/2023 08:00	1090.00	125	176.0	0.000	
02/04/2023 08:30	1120.00	125	176.0	0.000	
02/04/2023 09:00	1150.00	125	176.3	0.000	
02/04/2023 09:30	1180.00	125	178.1	0.000	
02/04/2023 12:00	1330.00	125	176.3	0.000	
02/04/2023 15:00	1510.00	130	177.9	0.000	
02/04/2023 18:00	1690.00	130	177.5	0.000	
03/04/2023 09:00	2590.00	130	177.8	0.000	
03/04/2023 09:30	2620.00	130	177.9	0.000	Closed in well, end of 48hr flow period

Table 7: Raw data captured during MON-1 well flow period.

7.2 Well Head Pressure, Temperature vs. Time MON-1

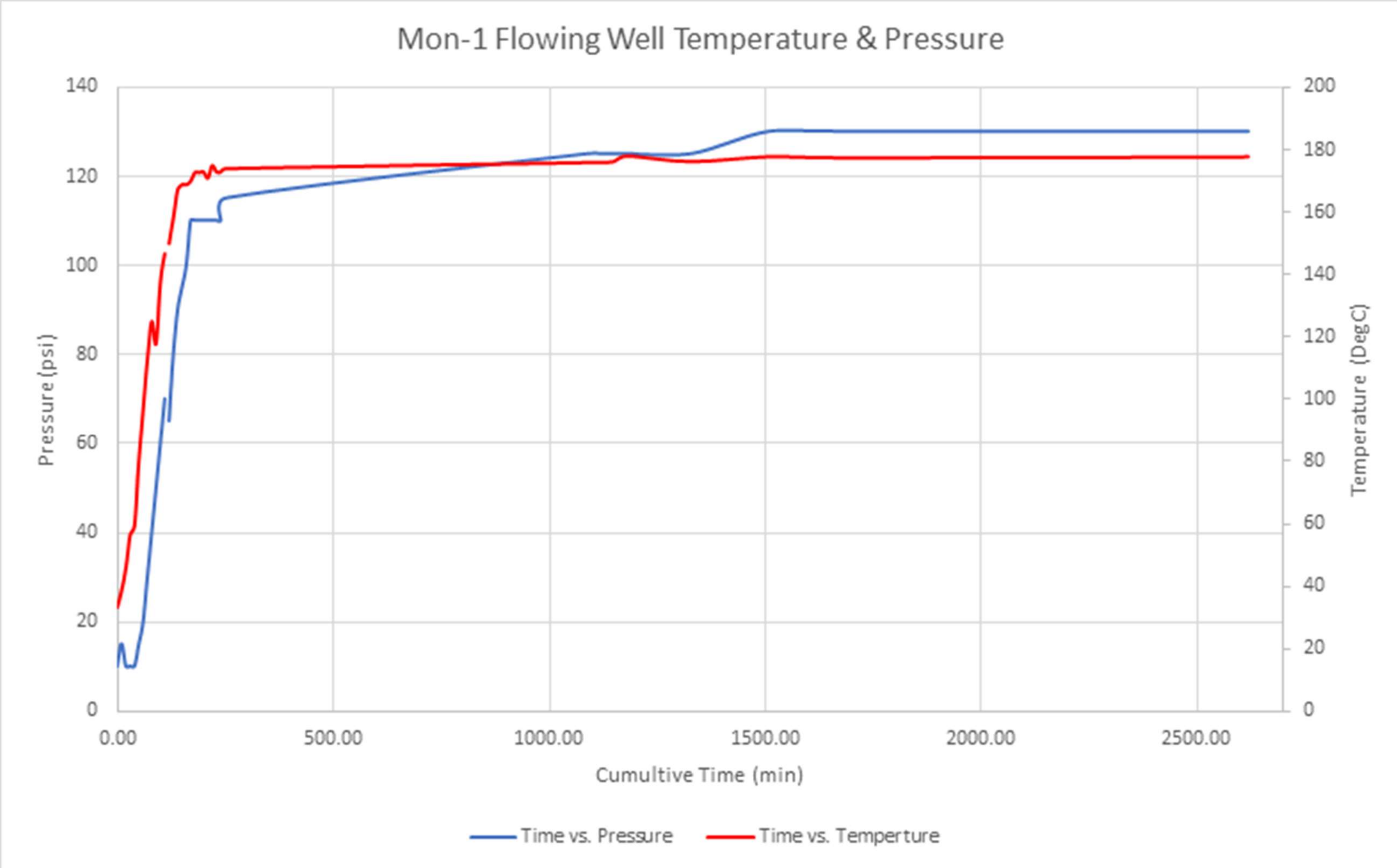

Figure 12: Pressure / Temperature vs. Time for MON-1 well flow period.

7.3 Estimated Volume Flow Rate MON-1

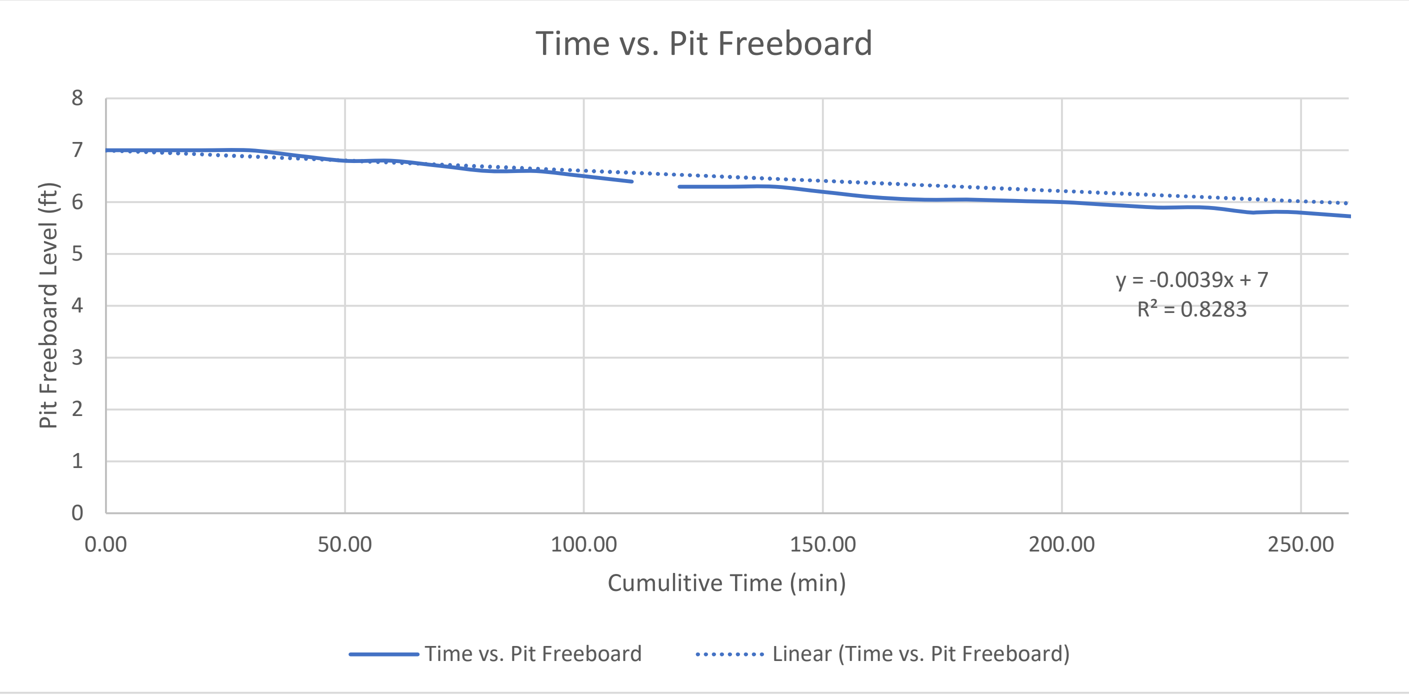

Figure 13: Pit freeboard reduction vs. time for volume fill/flow rate calculation.

From the Figure 13 above, showing the tracked reduction in freeboard on the side of the test pit, it is possible to estimate the volume fill rate over time. By plotting the freeboard hight vs. time, a best fit trend line can be fitted to the results from which the equation of a line is derived as can be seen above i.e. Y=-0.0067x+7. Equating this to the formula for the equation of a line Y=mX+C, yields, (C) as the initial starting constant (7ft), (Y) is the hight of freeboard at any time (X) and (m) is the slope or rate of reduction of freeboard (-0.0039). Therefore, by multiplying the rate of reduction of freeboard by the cross-sectional area (42.5ft x 75ft) you arrive at a fill rate which in this case is:

$$Q = -0.0067 \times (42.5 \times 75) = 12.43\, {}^{ft^3}/_{min} \; or\; 351\; {}^{Ltr^3}/_{min} \qquad \text{(EQ3)}$$

This equates to 0.207 ft^3/sec or 5.86 Ltr^3/sec

8 ANALYSIS OF MON-1 RESULTS

The 2013 MON-1 well flow-test results were compiled by a third-party contractor and recorded in the "Well Completion Report Montserrat – 1 and 2" [1]. The results suggested MON-1 had the following measurements and calculated values for geothermal development and are compared to the 2023 results for steady state on 100% open throttle valve in Table 8 below:

Description	ThermoChem Results 2013 [1]		2023 Results
Wellhead pressure (bar)	3.94	7.04	8.97
Flowing WHT (DegC)	145.2	166	177.9
Weir Mass Flow (kg/sec)	14.4	12.6	5.2[1]
James Tube Size	6"	4"	3"

Table 8: Comparison of similar results form well test back in 2013.

Due to available testing equipment, results of the 2023 flow-test adopt a higher inherent error. However, some critical values can still be used and with certain underlying assumptions, a comparative analysis can be drawn:

- The stabilized flowing wellhead pressure during the 2023 test was 130psi or ~8.97 barg.
- James Tube size was 3".
- Once at steady state the throttle valve was 100% open as per summary of beam up in Table 7 – Raw data captured during MON-1 well flow period.
- Flow rate was calculated by estimating test pit fill over time and confirmed by a secondary method at approx. 5.2 kg/sec.

[1] Weir box reading not available for MON-1 well. Data taken from test pit fill averaged over time details in Figure 13.

9 MON-2 WELL PERFORMANCE SUMMARY

After several failed attempts to kick-off MON-2, the well came online after the fourth attempt at 18:30 on May 7th and built up quickly, and louder in comparison to MON-1 well. This could somewhat be attributed to the fact there was no James tube in the flow line choking flow in the MON-2 well. Initial returns were observed to be dark brown in colour before turning to grey. As a result of this discharge colour, the well was left on clean up by bypassing the weir box for some time until the returns were clear. Samples from the produced brine along with the grey sludge produced were taken and shared with the team at the MVO for further analysis.

For the duration of the well flow period on MON-2, pressure and temperature fluctuations were very sensitive to valve movement, it was therefore difficult to achieve steady state at the optimum well flow conditions. The maximum well temperature was recorded at 147 DegC with a WHP of 50psi at an estimated flow rate of 10.75 litres/sec. This was achieved with a throttle valve position of ~93.5% Open, however, when the well was opened further to 100%, the WHP/WHT began to drop steadily. Various valve positions were attempted to maintain WHP/WHT though it was evident that the initial high reading could not be replicated.

The well flow rate was initially estimated from recording test pit fill rate and was subsequently recorded at 22.78 ft^3/min (645 litres/min or 10.75 litres/sec), over a period of 14.5 hours. The data collected and the calculations used to estimate the flow rate is shown below in sections 9.1 to 9.3. This compares to weir box data – that was recorded for only the last 6 hours of flow[2] – with the following results shown in Table 9 below.

Date and Time	Pressure (psi)	Temperature (DegC)	Throttle Valve Position (% Open)	Q (liters/sec)	Q (liters/min)
09/04/2023 17:00	15	121.7	0.25	8.67	520.47
09/04/2023 17:15	20	126	0.25	7.38	442.92
09/04/2023 17:45	30	133.6	0.125	5.16	309.71
09/04/2023 18:00	35	135.6	0.125	4.68	280.78
09/04/2023 18:15	20	127.4	0.125	2.68	160.73
09/04/2023 18:30	15	121.4	0.125	2.06	123.51
09/04/2023 18:45	0	103	1	4.23	253.54
09/04/2023 22:45	10	120.7	0.5	10.09	605.65

Table 9: Table of flow rate over the weir results.

Note, that both methods are best estimates with the equipment available and should be considered as a guide only. There are a number of inherent possible errors in the recording as follows:

- The estimate of pit fill was judged at distance by using a graduated pole in the test pit and not millimetre accurate.
- The measurements of the weir box fluid level were taken from a tape rule with errors in actual placement of the tape measure, +/- half the smallest measurement of the tape rule along with alignment from where the reading was recorded.
- The same +/- half the smallest measurement reading can also be included with pressure readings from the 1000psi bourdon pressure gauges.

[2] This was due to crane driver availability over holiday weekend.

9.1 Raw Data set for MON-2 Flow Test MON-2

Date / Time	Cum Time Interval between Readings (mins)	Pwh (psi)	Temp (DegC)	Pit Freeboard (ft)	Notes
07/04/2023 18:30	0.00	20	32	7	TV opened 57 turns (37.5% Open)
07/04/2023 18:40	10.00	20	32.7		
07/04/2023 18:50	20.00	10	37.6		
07/04/2023 19:05	35.00	40	33.7		Opened TV 3 turns and observed pressure drop.
07/04/2023 19:10	40.00	35	40.1		
07/04/2023 19:20	50.00	30	40.6		Opened TV 1/8th (19 turns, 77 total, 50% Open).
07/04/2023 19:30	60.00	10	44		
07/04/2023 19:40	70.00	10	51		
07/04/2023 19:45	75.00	10	54.7		Opened TV 5 turns (82 total, 52.5% Open).
07/04/2023 19:50	80.00	10	60		Opened TV 5 turns (87 total, 55.8% Open).
07/04/2023 20:00	90.00	10	68.1		
07/04/2023 20:05	95.00	10	72		Opened TV 10 turns (97 total, 62.3% Open).
07/04/2023 20:10	100.00	10	79.2		Observed compressor pressure steady at 150 psi.
07/04/2023 20:15	105.00	10	87		Opened TV 10 turns (107 total, 68.8% Open).
07/04/2023 20:20	110.00	10	89		
07/04/2023 20:30	120.00	20	105.6		Opened TV 1/8th (19 turns,126 total, 81% Open).
07/04/2023 20:40	130.00	50	147		Opened TV 1/8th (19 turns 145 total, 93.5% Open).
07/04/2023 20:45	135.00				Shut down air compressor
07/04/2023 20:50	140.00	40	144		Opened TV 1/16th (9 turns, 154 total, 100% Open).
07/04/2023 21:00	150.00	25	136		
07/04/2023 21:05	155.00	20	136		
07/04/2023 21:10	160.00	15	132		
07/04/2023 21:20	170.00	15	128		
07/04/2023 21:30	180.00	10	127		
07/04/2023 21:50	200.00	10	123		Closed TV 1/4 (38 turns, 116 total, 75% Open).
07/04/2023 22:00	210.00	15	125	5	

08/04/2023 08:30	840.00	5	120.5	1.5	Opened TV 1/4 (38 turns, 154 total, Open 100%).
08/04/2023 09:00	870.00	5	120.1	1.2	
08/04/2023 13:00	1110.00	5	118.1	0	Closed TV 1/4 (38 turns, 116 total, Open 75%).
08/04/2023 16:30	1137.00	8	117	0	Closed TV 1/4 (38 turns, 77 total, Open 50%).
08/04/2023 16:45	1152.00	8	118	0	
08/04/2023 17:00	1167.00	9	119	0	
08/04/2023 19:00	1287.00	15	126.2	0	
09/04/2023 08:30	2097.00	20	124.1	0	Opened TV 1/8 (19 turns, 96 total, open 62.5%).
09/04/2023 09:30	2157.00	15	123.42	0	
09/04/2023 10:00	2187.00	10	115	0	Closed TV 1/8 (19 turns, 77 total, open 50%).
09/04/2023 10:30	2367.00	10	118.5	0	
09/04/2023 13:30	2397.00	10	114.3		
09/04/2023 14:00	2427.00	10	114.3		Closed TV 1/4 (19 turns, 58 total, open 32.5%).
09/04/2023 14:30	2457.00	10	115.7	0	
09/04/2023 15:00	2487.00	15	120.5	0	
09/04/2023 15:30	2517.00	10	119.1	0	
09/04/2023 16:00	2547.00	10	118.9	0	
09/04/2023 16:15	2562.00	12	119.9	**Head of Fluid above V-notch of weir (inch)**	Removed bypass for clean-up and commenced flowing through weir box.
09/04/2023 16:45	2592.00	15	119.9		Level measured above weir = 7"
09/04/2023 17:00	2607.00	15	121.7	7	Closed TV 1/8 (19 turns, 38 total, open 25%).
09/04/2023 17:15	2622.00	20	126	7.25	
09/04/2023 17:45	2652.00	30	133.6	7.75	Closed TV 1/8 (19 turns, 20 total, open 12.5%).
09/04/2023 18:00	2667.00	35	135.6	7.875	
09/04/2023 18:15	2682.00	20	127.4	8.5	
09/04/2023 18:30	2697.00	15	121.4	8.75	Opened TV 7/8 (135 turns, 154 total, open 100%). Observed instantaneous drop of pressure.
09/04/2023 18:45	2712.00	0	103	8	Closed TV 1/2 (77 turns, 77 turns total, open 50%).
09/04/2023 22:45	2952.00	10	120.7	6.75	Closed in well, end of 48hr flow period

Table 10: Raw data captured during MON-2 well flow period.

9.2 Well Head Pressure, Temperature vs. Time MON-2

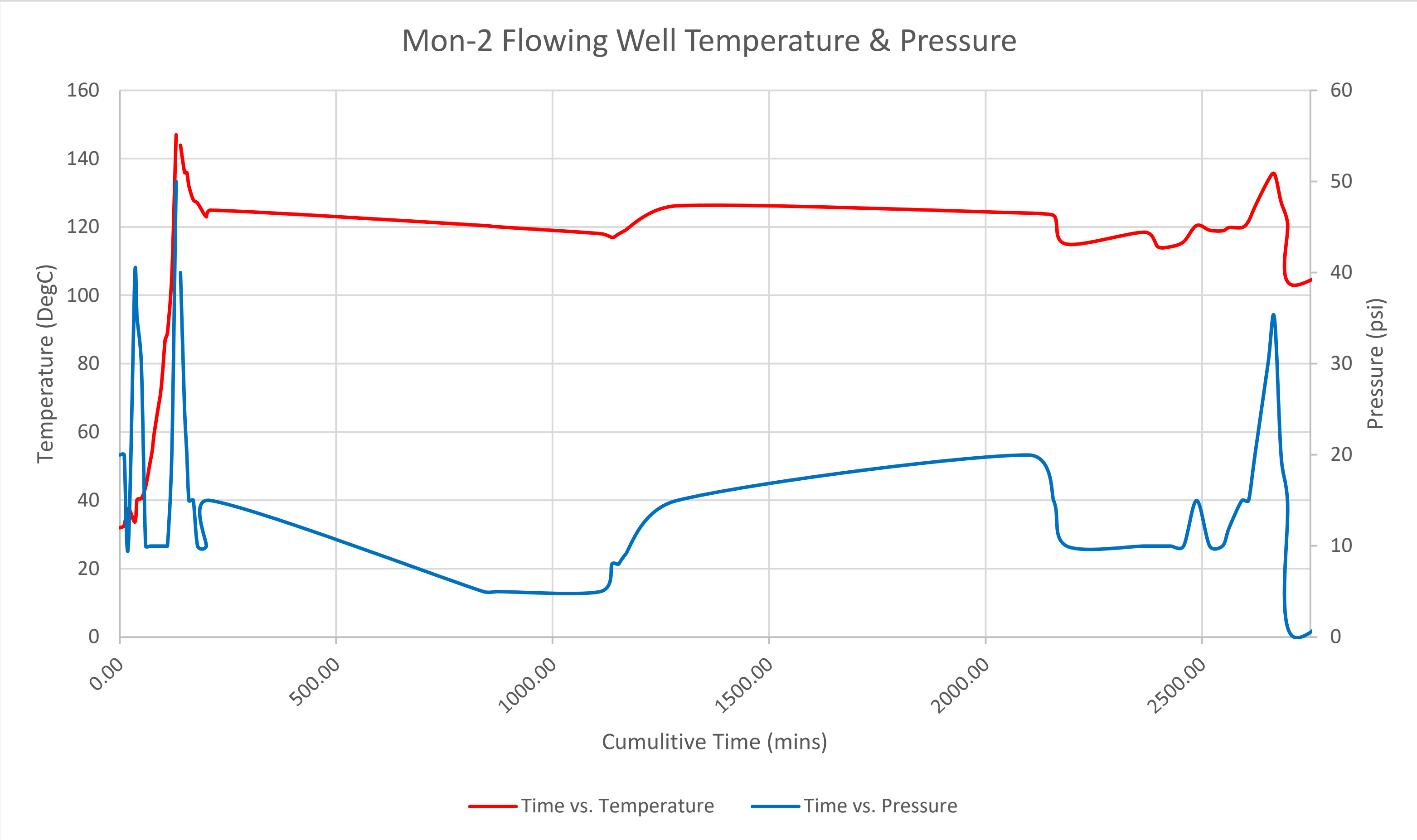

Figure 14: Pressure / Temperature vs. Time for MON-2 well flow period.

9.3 Estimated Volume Flow Rate MON-2

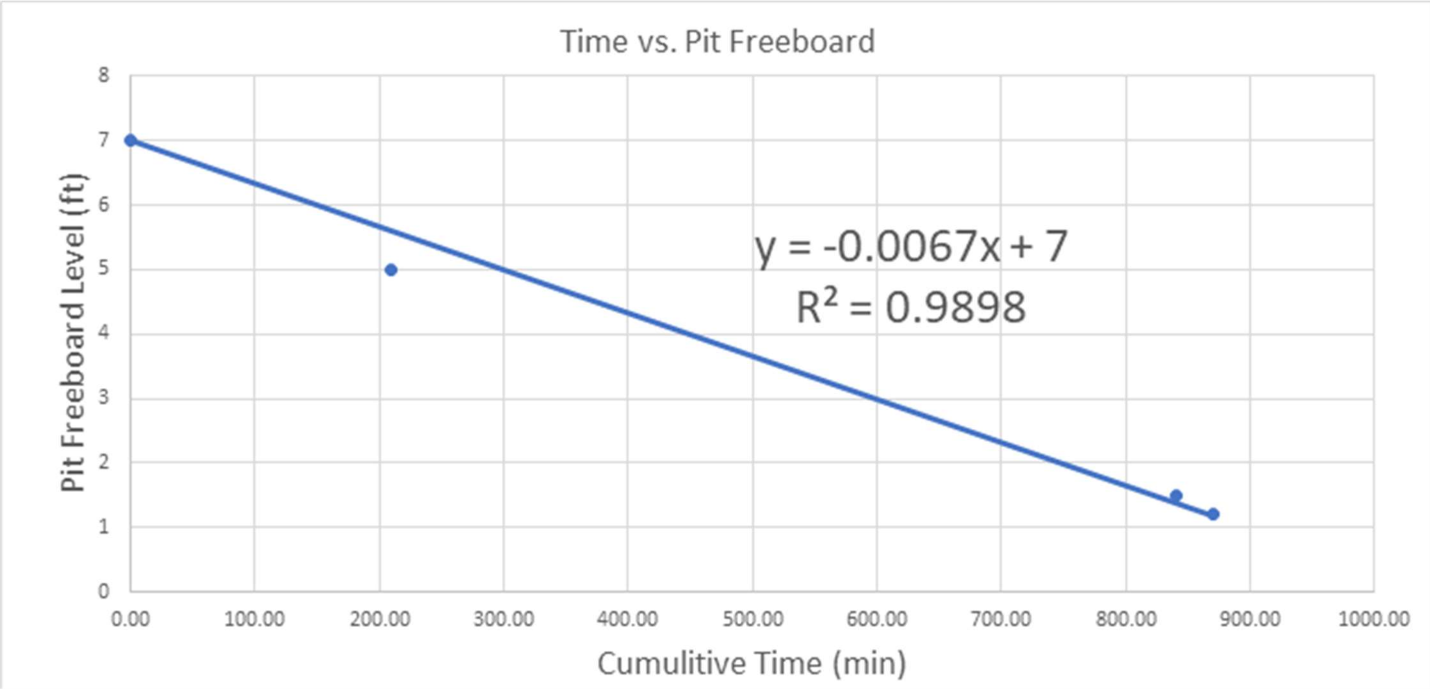

Figure 15: Pit freeboard reduction vs. time for volume fill/flow rate calculation.

From Figure 15 above, showing the tracked reduction in freeboard on the side of the test pit, it is possible to estimate the volume fill rate over time. By plotting the freeboard hight vs. time, a best fit trend line can be fitted to the results from which the equation of a line is derived as can be seen above i.e. Y=-0.0067x+7. Equating this to the formula for the equation of a line Y=mX+C, yields, (C) as the initial starting constant (7ft), (Y) is the hight of freeboard at any time (X) and (m) is the slope or rate of decay of freeboard (-0.0067). Therefore, by multiplying the rate of reduction of freeboard by the cross-sectional area (42.5ft x 80ft) you arrive at a fill rate which in this case is:

$$Q = -0.0067 \times (42.5 \times 80) = 22.78 {}^{ft^3}/_{min} \; or \; 645 \; {}^{Ltr^3}/_{min} \qquad \text{EQ4}$$

This equates to 0.380 ft^3/sec or 10.76 Ltr^3/sec.

Below is a summary of the data collected for calculateing flow rate over a weir with the methodology for calculating the results:

H (m)	Q (m3/sec)	Q (litres/sec)	Q (litres/min)
0.1016	0.0087	8.67	520.47
0.0953	0.0074	7.38	442.92
0.0826	0.0052	5.16	309.71
0.0794	0.0047	4.68	280.78
0.0635	0.0027	2.68	160.73
0.0572	0.0021	2.06	123.51
0.0762	0.0042	4.23	253.54
0.1080	0.0101	10.09	605.65

Table 11: Table of head of fluid over V-notch weir.

The following equation was used to calculate the results tabulated in table 11 above for flow rate over a weir:

$$Q = C_d \frac{8}{15} H^{5/2} \sqrt{2g} \tan\frac{\theta}{2} \qquad \text{EQ5}$$

Figure 16: Weir box set up in place on outlet of separator. The weir box measured 79" x 40" x 40" with a 120 degree V-notch weir extending to each side with the point of the V-notch 29" up from the bottom

10 ANALYSIS OF MON-2 RESULTS

The 2013 MON-2 flow-test results were compiled by a third-party geothermal contractor under the direction of GoM and detailed in attachment 1 from the *Well Completion Report Montserrat – 1 and 2*. The results suggested MON-2 had the following measurements and calculated values for geothermal development and are compared to the 2023 results for steady state on 50% open throttle valve:

Description	ThermoChem Results 2013		2023 Results
Wellhead pressure (bar)	7.1	4.9	0.7
Flowing WHT (DegC)	Not Available	Not Available	120.7
Weir Mass Flow (kg/sec)	6.91	7.36	10.09
James Tube Size	3”	4”	5” (TV 50% open)

Table 12: Comparison of similar results form well test back in 2013.

Due to lack of adequate testing equipment, results of the 2023 flow-test adopt a higher inherent error. However, some critical values can still be used and with certain underlying assumptions, a comparative analysis can be drawn.

MON-2 well, with less of a restriction at 50% open on the throttle valve exhibits a lower well head pressure and higher flowrate than expected compared to what was achieved in 2013 from a 4” and 3” James tube. This is under the assumption that the quantity of NCG and steam fraction remained similar between tests but cannot be verified at this time.

The data used for flow rate over the weir was for a throttle valve setting of 50% open to compare to similar sized flow restrictions provided by the James Tube in the 2013 results.

11 CONCLUSION

The primary objective of the Phase 2 scope was to establish the viability of both MON-1 and MON-2 wells as geothermal producers and make a general comparison of the present results compared to those obtained during the previous test ~10 years prior. This was successfully met by recording the well measurements of WHP, WHT and an estimate of flow rate, which were recorded and presented alongside similar available data from the 2013 well test. Whilst the data shows that both wells do flow at potentially power producing rates, the analysis was not conclusive enough due to lack of vital measurements, namely the James Tube pressures on both MON1 and MON-2 wells. Therefore, the best analysis for consideration is that of equating the acquired WHP/WHT/Flow rate during the flow test results from 2023 to the same data obtained during the well test complete in 2013. By doing so, it would seem reasonable to assume that similar estimates for electrical power generation would be possible.

Any apparent reduction in the expected flow rates, temperatures or well head pressures would require more investigation beyond that which was planned or indeed possible from this Phase 2 scope of work. As was noted in the MON-2 results section of this report, there were initially dirty returns on both wells, with MON-2 producing a large volume of grey sludge. This could be an indication of a number of things related to geochemistry, geology or well integrity and therefore, it would be very usefully to analyse this sample to confirm its origin and organic makeup. This could be an indication of a subsurface anomaly which may account for the temperamental nature of MON-2 in comparison to MON-1 and would necessitate a well intervention to confirm.

Any future investigation of either well bore by wireline intervention will require that the wireline unit on the island is fully serviced and new wire spooled on to the drum. The wire currently on the unit failed after 4 x wrap tests whilst slipping and cutting 25ft of wire between each test. This wire was in visibly bad condition and is the recommendation of the author that it should not be run in hole.

With respect to operational performance both MON-1 and MON-2 well interventions were successfully achieved within a relatively short time frame and with a number of operational constraints. Although this intervention activity offered up a number of lessons learned it also showcased the capability of island personnel to learn on the job with impressive speed and to work collaboratively and safely to execute operations whilst dealing with a number of adverse factors. Most notably the biggest issue facing operational excellence was logistics. Not only is it difficult to travel to the island of Montserrat it is difficult to locate vital equipment and essential parts. For this reason alone, it is vitally important that any follow-up work is duly planned well in advance of operations to allow for the sourcing and transportation of equipment and spares with possible offline work being carried out by island personnel prior to operations.

The general condition of equipment was a cause of concern throughout the operation with a number of safety critical components needing to be discarded and replaced. Rusting equipment was also widely observed and finding a suitable solution for recovering deeply corroded equipment and suitably storing it, should be a priority for GoM or other future asset owners with ambition to utilise this equipment again for services on MON-1 and MON-2 assets.

12 NEXT STEPS

The advised immediate next steps for the GoM would be to conclude all data and results from the phase 2 intervention scope by completing the analysis on all samples taken from MON-1 and MON-2 wells left with the MVO team. This would indicate the likely hood and type of scaling that may be expected from both wells as well as any possible wellbore damage from the grey sludge sample.

Following on from this the maintenance and refurbishment of all GoM owned assets should be considered high priority. The container used for storing equipment is neither weatherproof nor airconditioned, leaving all equipment inside to degrade over time. Additional to this, suggested equipment that could be mobilised to repair corroded flange material is listed in the summary of recommendations.

Also, it is highly recommended to replace and/or purchase essential spares to facilitate future well intervention scope. A list of which is also registered in the summary of recommendations in the proceeding section of this report.

Should it be desirable for GoM to further assess the condition of MON-1 and MON-2, it would be advisable to carry out the following operational investigations as lower cost / lower risk interventions:

- Slickline drift run to Hold-Up-Depth (HUD).
- It may be possible during this run to take a sample of the HUD which could help assess if well fill is occurring or to ascertain possible blockage material.
- A logging program to assess the well bore conditions by means of a series of gauge runs, PTS tool or multi-fingered calliper tool.
- A longer duration well test program with data loggers, a bespoke weir box and refurbished/new James Tubes for recording well parameters and calculating enthalpy.

Should further work aimed at performance enhancement of the wells be required, it would be advantages to first carry out the steps above as a data gathering exercise as well as revisiting the initial well design and original well objects that were established with the limitations of the equipment mobilised at the time of drilling. It would be worthwhile to consider if newer or larger drilling equipment could deliver a better producing well by side-tracking and taping into deeper hotter formations or drilling a lateral side-tracked well in the current formation to increase the production pay zone.

13 SUMMARY OF RECOMMENDATIONS

Item	Recommendation	Comments
1	Retrieve Sample analysis from MVO.	
2	Acquire suitable conditioned storage facilities for equipment.	
3	Service and maintain all pressure control and tubbing handling equipment.	
4	Replace or repair defective James Tubes. Repair as a minimum would require re-establishing the pitot tube on some and renewing the threaded ports on all James Tube flanges.	
5	Acquire equipment for cleaning rusted flanges and sealing surfaces. An example would be that supplied by Enerpac: https://www.enerpac.com/en-au/outside-mount-flange-facing-machines/outside-mount-flange-facing-machines/MM600E	
6	Order new stem seals for repair to the 10" throttle valve. This operation would be best achieved in workshop conditions. Valve manufacturer is Delta Pacific Valves (DPV): https://deltapacificvalve.com/	Advice from OEM: 1. If valve is still in line, half open valve, loosen packing nuts and put low pressure in the valve, this will push packing out. 2. If valve is out of line you will need to take the valve apart and use a packing extractor to remove the packing
7	Purchasing of spares nuts and bolts as follows: - 10" ANSI 900 Flange. - 12" ANSI 900 Flange. - 3" ANSI 900 Flange	
8	Purchase of spare RF and metal ring gaskets as follows: - 10" ANSI 300lbs RF spiral wound gaskets for flowline sections. - Spare R31 Ring gasket for 3" flanged connections. - Spare R53 Ring gaskets for 10" flanged connections. - Spare R57 Ring gaskets for 12" flanged connections. - Additionally - - Spare copper / nickel coating (tubes).	
9	Purchase replacements for the 2 x 2" 250bar Semperit hoses: https://hoses.semperitgroup.com/products/hydraulic-pressure-washer-hoses/braided-spiral-hoses/din-en-856-4-sh/ 2	
10	Carryout essential repairs and maintenance to the air compressor unit prior to future use. This piece of equipment would benefit from a full service.	

11	Purchase sufficient tools for rigging up/down GoM owned equipment. Sample list below: - Hydraulic torque wrenches for 12" 900 & 3" 900 bolts c/w sockets. - Handheld torque wrenches for 12" 900 & 3" 900 bolts c/w sockets.	Note - 250 Bar hoses are well over specified for the maximum anticipated well head pressures expected at MON-1 and MON-2. This will have a significant cost impact when replacing.
12	Purchase sufficient instrumentation for recording readings: - Spare analogue bourdon pressure gauge (10bar/150psi to 70bar/1000psi). - Digital pressure gauges (alternative optional). - Additional / Spare laser temp gun. - Possibly new James Tubes. - New weir box. - Accurate system for measure head above weir.	
13	Plan for all possible offline activities that can be carried out in advance of operation to be executed prior to arrival of external contractor such as: - Water utilities works. - Servicing of all operationally critical equipment i.e. Air compressor. - Erecting of all required scaffolding. - Cleaning and preparing of all required hand tools and spare nuts and bolts. - Any manufacture of critical components e.g. weir box. - Any excavation works i.e. placing weir box.	
14	Carryout full service on Giberson head and confirm correct rubber size for 1.9" tubing.	Note - 250 Bar hoses are well over specified for the maximum anticipated well head pressures expected at MON-1 and MON-2. This will have a significant cost impact when replacing.
15	Hold process safety pre-jobs with all persons selected to be on site at any point during operations.	
16	Confirm staffing requirements are clearly communicated prior to operations specifying working restriction i.e. national holidays, over time limitations etc.	
17	Service and replace wire on slickline unit.	
18	Allow for more time in plan and budget for mobilisation to and from location.	

Table 13: Summary of recommendations.

14 REFRENCES

[1] E. Inc, "Well Completion Report MON-1 & MON-2," 2014. [Online]. Available: https://drive.google.com/file/d/1sXPID_MbVl0CCzjXcolcXj0dAEH7zH2r/view?usp=share_link

[2] J. Energy, "JRG Energy Wellhead Maintenance Report Rev01," 2013. [Online]. Available: https://drive.google.com/file/d/1goYdXTJq7j1ldBGYUO33Rb7_FtCkoV8V/view?usp=share_link