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BP Exploration (Alaska) Inc.
P.O. Box 196612
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Anchorage, AK 99519-6612

September 26, 2016

Cathy P Foerster, Chair
Alaska Oil and Gas Conservation Commission
333 West 7th Ave, Suite 100
Anchorage, AK 99501

Re: Final Report and Application to Convert Pilot to Permanent Status
Conservation Order 207A.002 and Area Injection Order 4E.038 (now 4F)
Lisburne Gas Cap Water Injection (*GCWI*) Pilot Project – Well L5-29
Lisburne Oil Pool, Prudhoe Bay Unit

Dear Chair Foerster:

BP Exploration (Alaska), Inc., as operator of the Prudhoe Bay Unit and on behalf of the working interest owners, submits the attached Final Report of the referenced pilot project, and requests that the Commission amend its prior orders to authorize continued GCWI into the Lisburne Oil Pool.

We submit the attached *Final Report for Lisburne Gas Cap Water Injection Pilot Project at L5-29 Well (07/01/14 – 07/01/16)* pursuant to Conditions 4 and 5 of Conservation Order 207A.001 and Area Injection Order 4E.029, dated June 4, 2008.

The Final Report discusses and documents the GCWI pilot period, and demonstrates that this GCWI method is a viable enhanced oil recovery process that leads to greater overall recovery from the Lisburne Oil Pool.

The GCWI project going forward is not expected to be expanded to other areas of the Lisburne Oil Pool. The project will target water injection rates up to 20,000 bwpd in L5-29 for an estimated incremental oil recovery benefit of 100-350 bopd, or 0.5-3 MMSTBO. We request that the maximum injection limits be removed from the referenced commission order to allow for greater operational flexibility as our understanding of the reservoir progresses.

We respectfully request that the Commission approve this request and make the referenced GCWI pilot project permanent, rename it the Lisburne GCWI Project, and allow GCWI into the Lisburne Oil Pool gas cap through Well L5-29 for enhanced Lisburne oil recovery. We propose to include an update of the Lisburne GCWI Project as part of the Lisburne Oil Pool Annual Surveillance Report, due June 15th of each year.

Should you have any questions regarding this request please contact Bill Bredar at 907-564-5348 and William.bredar@bp.com.

Sincerely,

Diane Richmond

Diane Richmond
Performance and Data Management Team Lead

Enclosure: *Final Report for Lisburne Gas Cap Water Injection Pilot Project at L5-29 Well*

cc:
Mr. Eric Reinbold, ConocoPhillips Alaska, Inc
Mr. Phil Tsunemori, ConocoPhillips Alaska, Inc
Mr. Hank Jamieson, ExxonMobil Alaska, Production Inc
Ms. Katherine Motteram, ExxonMobil Alaska, Production Inc
Mr. Gerry Smith, ExxonMobil Alaska, Production Inc
Mr. Phil Ayer, Chevron USA
Mr. Dave White, Chevron USA

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FINAL REPORT FOR LISBURNE GAS CAP WATER INJECTION PILOT PROJECT AT L5-29 WELL (07/01/14 – 07/01/16)

RESPONSE TO CONDITION NO. 5 UNDER ALASKA OIL AND GAS CONSERVATION COMMISSION ADMINISTRATIVE APPROVALS CO 207a.001 & AIO 4E.029

Submitted by BP as Operator on Behalf of the Prudhoe Bay Unit Working Interest Owners

Dated: 9/01/2016

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Executive Summary

The Lisburne L5 Gas Cap Water Injection (GCWI) pilot project began in July 2008 and terminated July 1st, 2016. Progress reports were submitted in 2011 and 2014 to the Alaska Oil and Gas Conservation Commission (AOGCC). This report will primarily cover the period following the last progress report, comprising the period of July 1st 2014 to July 1st, 2016, as well as give a final overview of the pilot.

Through the course of the pilot, 22.1 MMBW were injected into L5-29, a volume nearly two and a half times the volume of water injected during the L2 waterflood pilot of 1987-1989. The GCWI pilot met the original five objectives of the pilot, however individual well performance was not consistent in behavior: Oil production has increased or decline has been suppressed in some of the offset wells. Pressure has increased approximately 300 psi since the start of the pilot. Gas/Oil Ratio (GOR) has been suppressed in some offset wells.

L5-29 has been capable of injecting the desired rates during the pilot. Although hydrate problems related to GCWI occurred in some offset wells, it currently is providing a net positive oil benefit on the order of 100-350 bopd. This benefit has mostly been through sustained or increased fluid rates associated with higher reservoir pressure and suppressed gas rates. Although this is less than the aspired benefit of about 2,000 bopd, it has proven a greater technical success than the original L2 waterflood pilot.

As the GCWI process has been successful in increasing oil production in the L5 area, the operator recommends continuing to inject into L5-29. At this time the Prudhoe Bay Unit working interest owners do not plan to expand the program of GCWI to other locations in the field due to the current low benefit and high cost of implementation at other drillsites, and scarcity of viable locations.

Introduction

Objectives

The Lisburne L5 Gas Cap Water Injection (GCWI) initial pilot project had the following objectives:

1. Increase Lisburne oil production rates (primarily from L5 pad wells)
2. Provide pressure support to the Lisburne Reservoir, primarily in the L5 pad area
3. Reduce produced gas / oil ratios of L5 pad wells
4. Determine water injectivity for Lisburne wells
5. Evaluate gas cap water injection as a process that has potential to be expanded to other areas of the Lisburne gas cap to recover additional Lisburne oil

Geologic Setting

The Lisburne Field is the only producing carbonate field in Alaska (Figures 1 & 2). It is located approximately 250 miles north of the Arctic Circle at latitude of 71° N. The Lisburne Oil Pool encompasses some 39,200 acres (61 square miles). A significant portion of the Lisburne Oil Pool underlies the Prudhoe Bay Permo-Triassic reservoirs, separated by shale sequences. The Lisburne field was discovered in early 1968 with the drilling of the Prudhoe Bay State #1 well by ARCO and Exxon.

The Lisburne Oil Pool is defined by Rule 2 of Conservation Order No. 207. It is the accumulation of oil and gas found within stratigraphic sections that correlate with the stratigraphic section occurring in the Atlantic Richfield-Humble Prudhoe Bay State No. 1 well between the depths of 8,790 feet measured depth and 10,440 feet measured depth.

The Lisburne Reservoir is a combination structural and stratigraphic trap of carbonate lithology. It is an anticlinal structure that is bounded on the north by the Prudhoe Bay-Niakuk fault complex, by the Lower Cretaceous Unconformity (LCU) truncation to the east, and by the Pre-Echooka Unconformity (PEU) truncation to the west. The unitized intervals are of Mississippian / Pennsylvanian age and include the Alapah and Wahoo formations of the Lisburne Group. Over the past eight years, the L5-29 GCWI Pilot Project injected seawater only into the Wahoo formation.

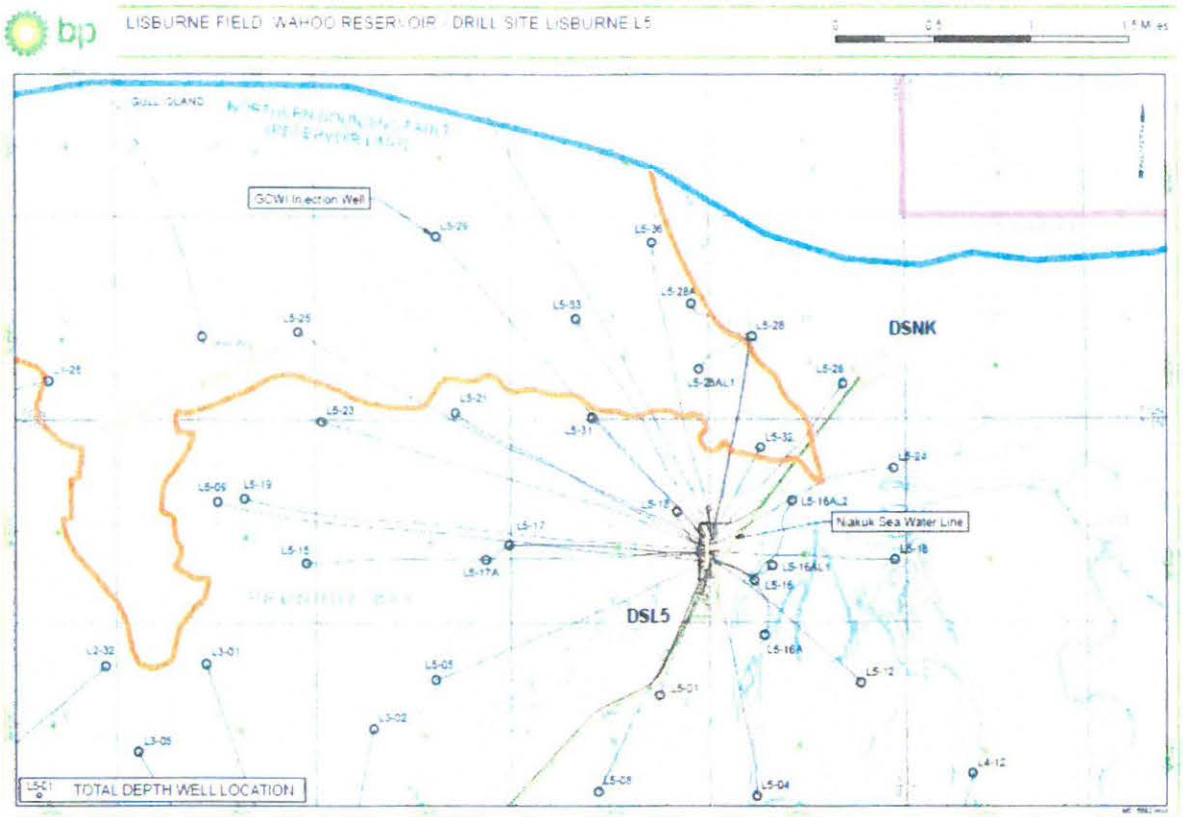

Figure 1: L5-29 Gas Cap Water Injector Location Plat

Local Geologic Highlights for the L5-29 Area

The area around L5-29 is geologically unique for the Lisburne field. Logs indicate 40%+ porosity enhancement locally (Figure 3) at the top of Wahoo Zone 6 from LCU exposure in the northernmost fault block. Wells L5-29 and L5-36 experienced large lost circulation events while drilling through this interval, and the drillers described it as a "cave". This super-porosity/permeability enhancement around L5-29 and L5-36 is not representative of matrix properties anywhere else in the field. The porosity enhancement is constrained by the Prudhoe Bay fault to the north and other major east-west faults to the south that appear to form a permeability barrier / baffle (Figures 4A, 4B and 4C).

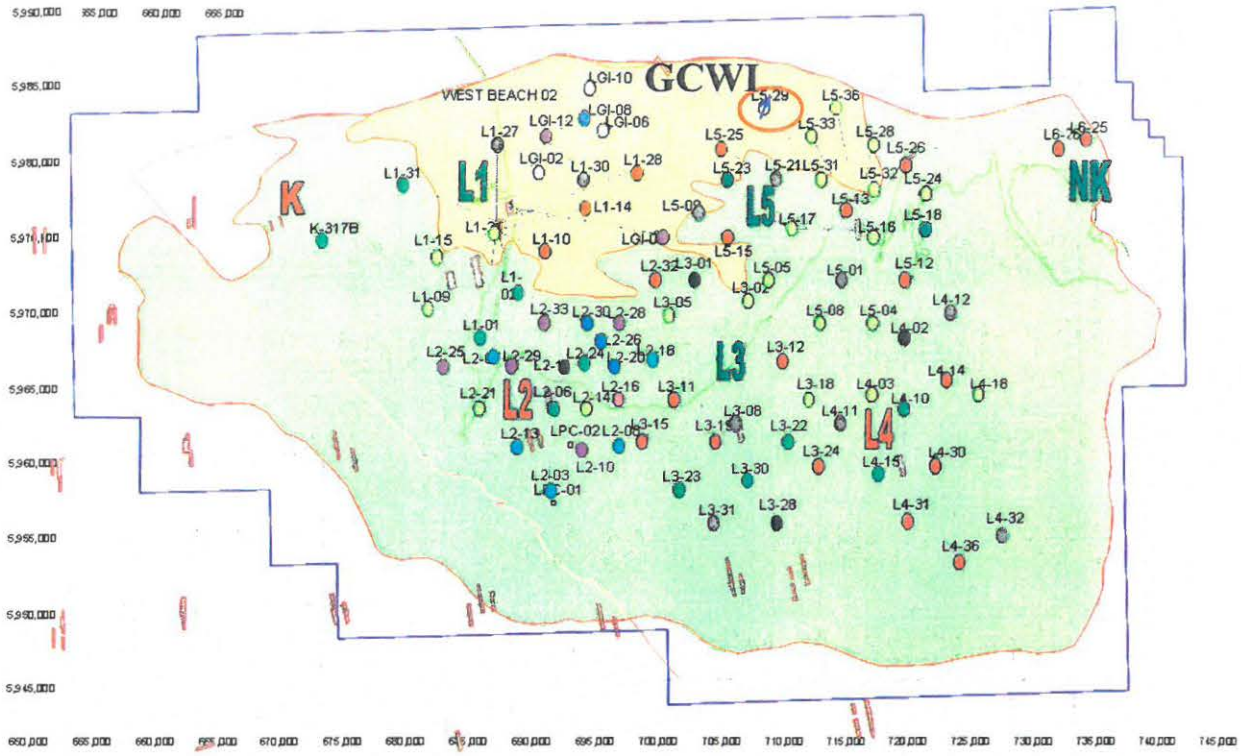

Figure 2: Lisburne Field Fluid Contact Base Map with GCWI Pilot

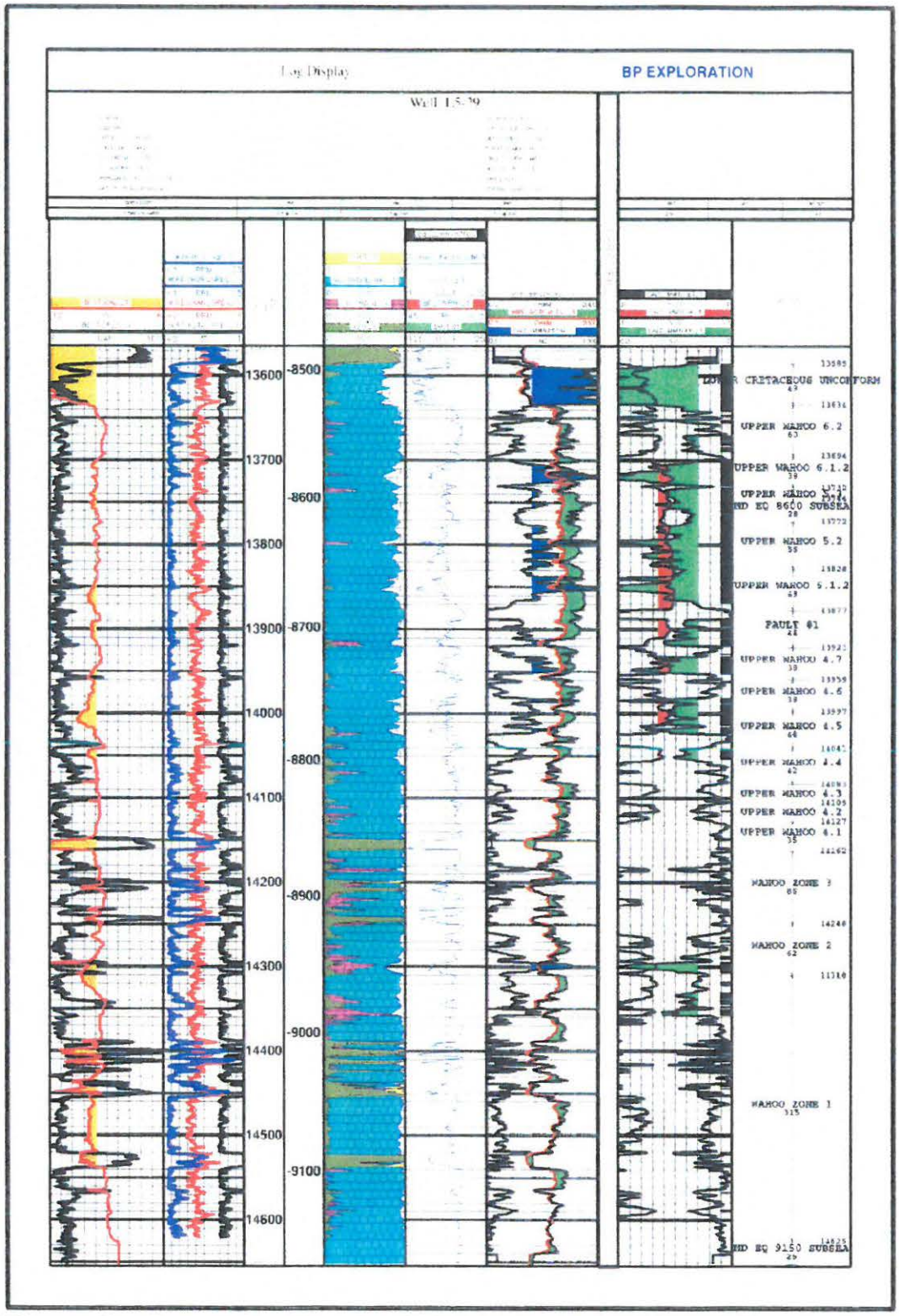

Figure 3: Log Suite Showing High Porosity at Top of Zone 6 Below LCU

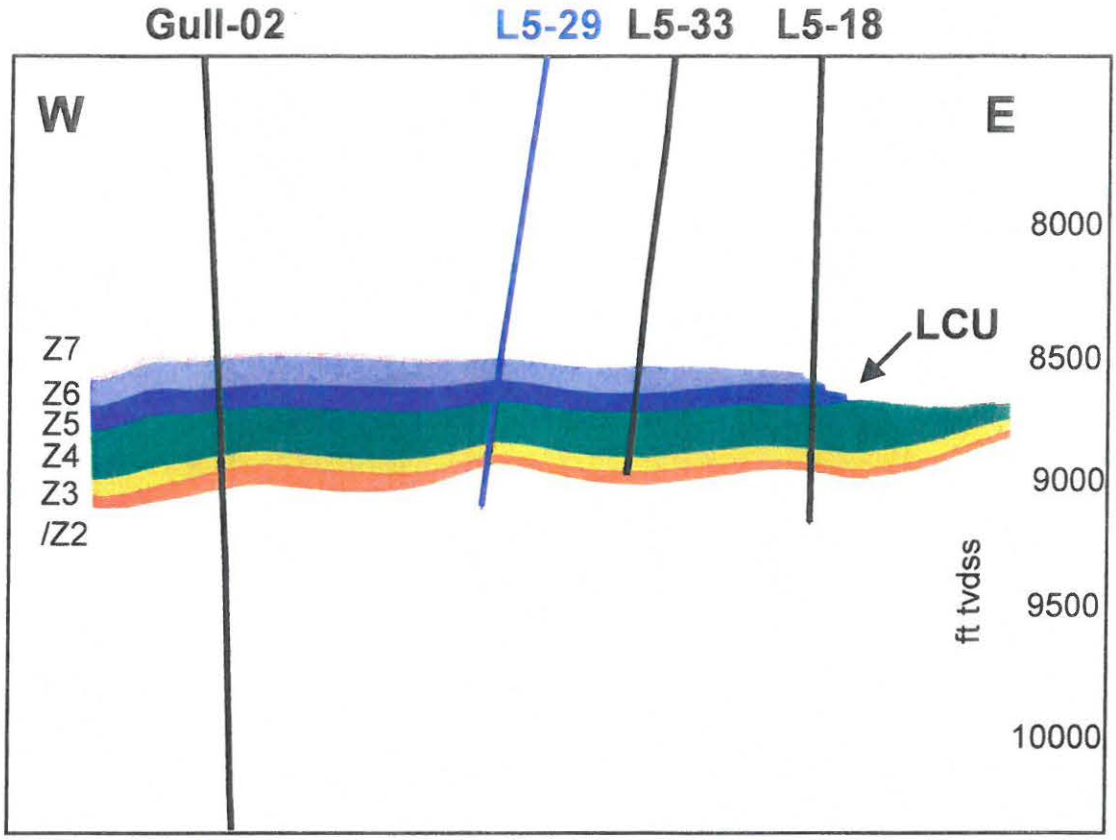

Figure 4A: L5 West to East Structural Cross-Section

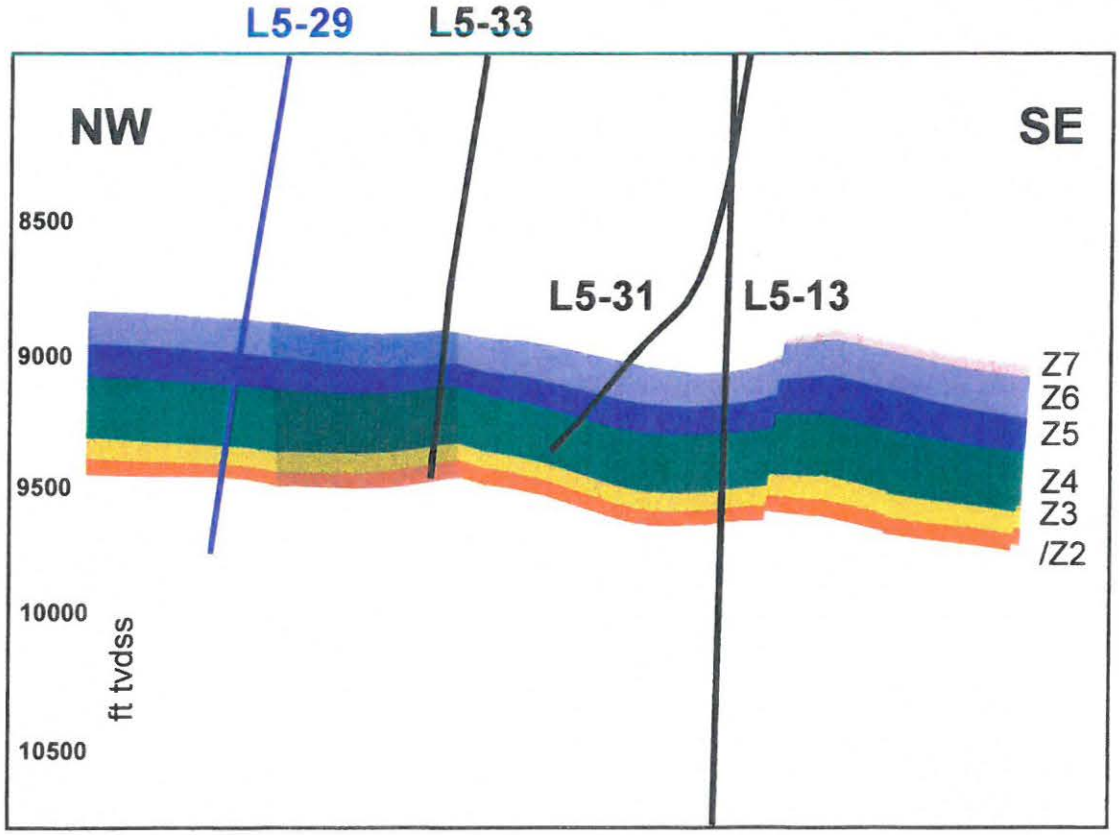

Figure 4B: L5 Northwest to Southeast Structural Cross-Section

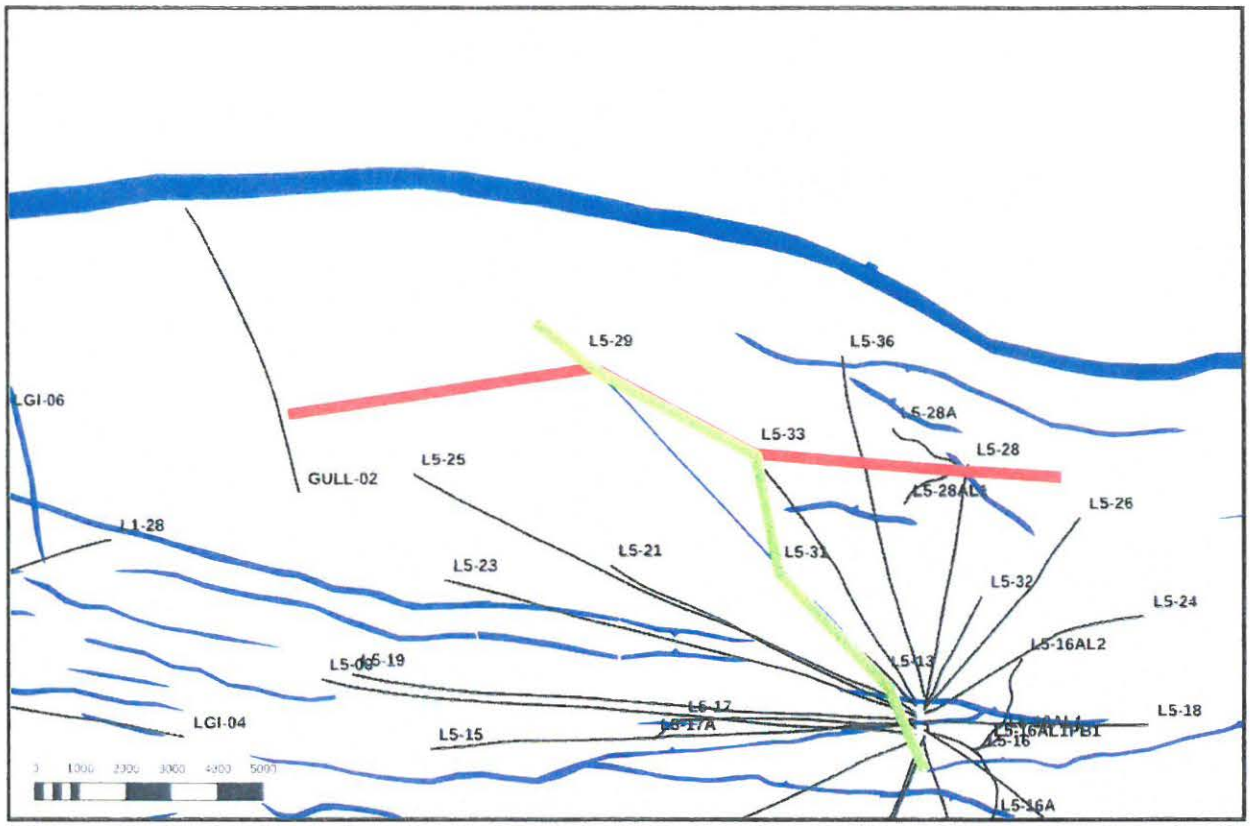

Figure 4C: L5 Pad Location Map for Structural Cross-Sections in Figures 4A and 4B

Surveillance and Performance

Summary of Surveillance Activities

As a part of GCWI surveillance, Static Bottom-hole Pressures (SBHP) were measured in offset producers. L5-29 wellhead pressures and well performance of online producers were also monitored.

Injection History

Figure 5 illustrates the injection rate history along with periods when the injector was shut in during the reporting period of July 2014 through July 2016. As of July 1, 2016 the cumulative water injection reached 22.1 MMbbls. The current plan is to attempt to repair the well and continue injection.

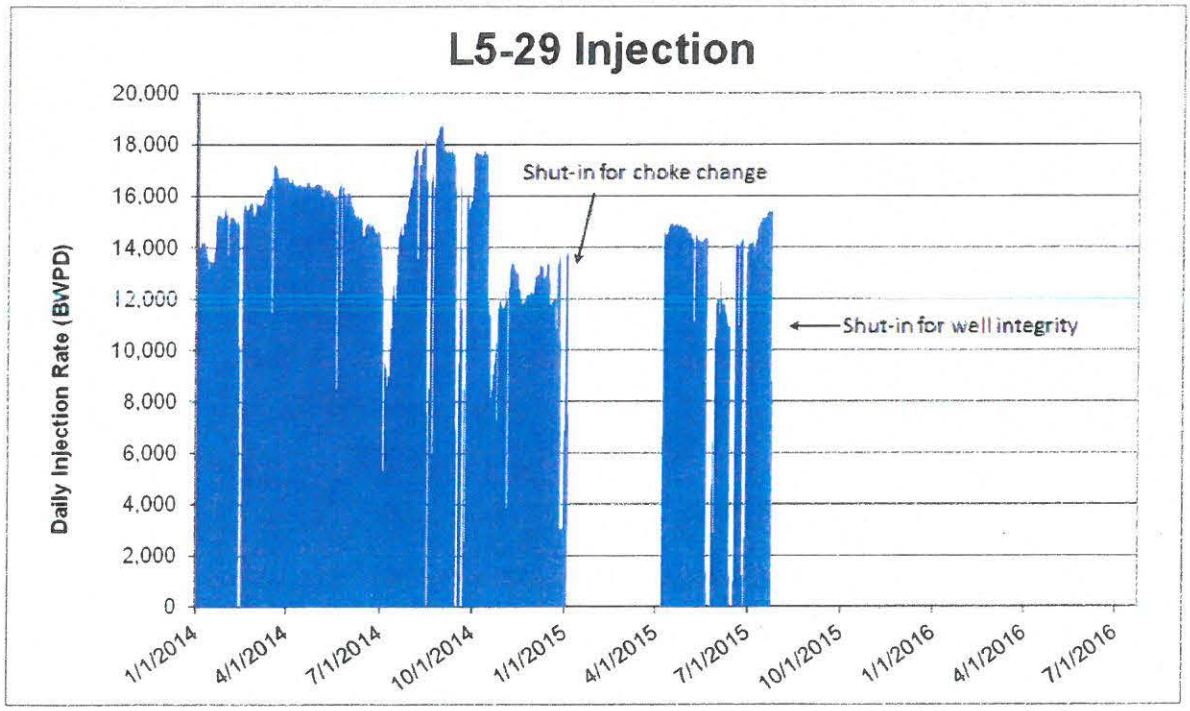

Figure 5: L5-29 Seawater Injection Rates for current reporting period

Daily injection rates are plotted against wellhead pressure to investigate changes in L5-29 injectivity as shown in Figure 6. The rates and corresponding wellhead pressures are color coded by date. Figure 6 depicts a significant decrease in injectivity from year 2014 to 2015. This change does not represent the reservoir behavior as it is caused by installation of a different choke.

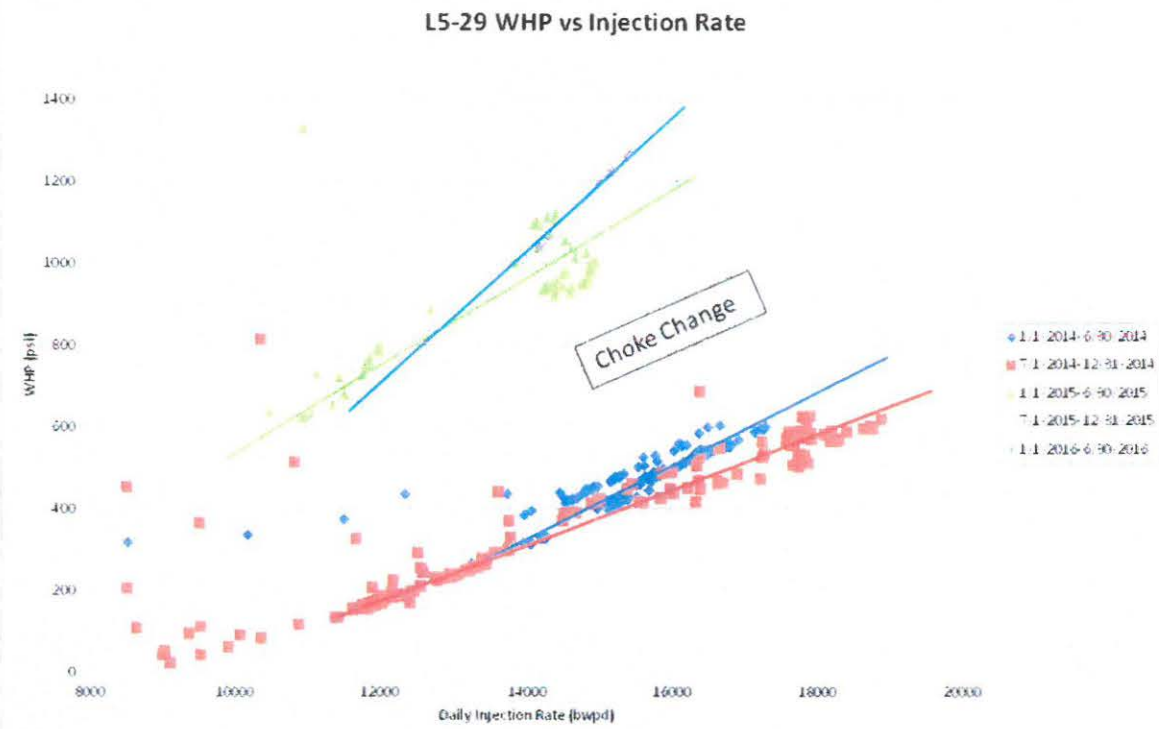

Figure 6: L5-29 WHP vs. Injection Rate

Static Bottom-hole Pressure

Frequent static bottom-hole pressures were measured for surveillance in the offset producers and showed pressures increased by ~100-150 psi in the first row of offset producers (Figure 7) during this reporting period, ~350-400 psi in total increase in pressure from 2008. The pressure increase shown on Figure 8 is likely due to a combination of lower withdrawal rate and the pressure support from the GCWI pilot well. Recent production from these wells is lower than before the injection start-up, and the entire L5 drillsite was temporarily down due to corrosion in the pad production export line during the reporting period.

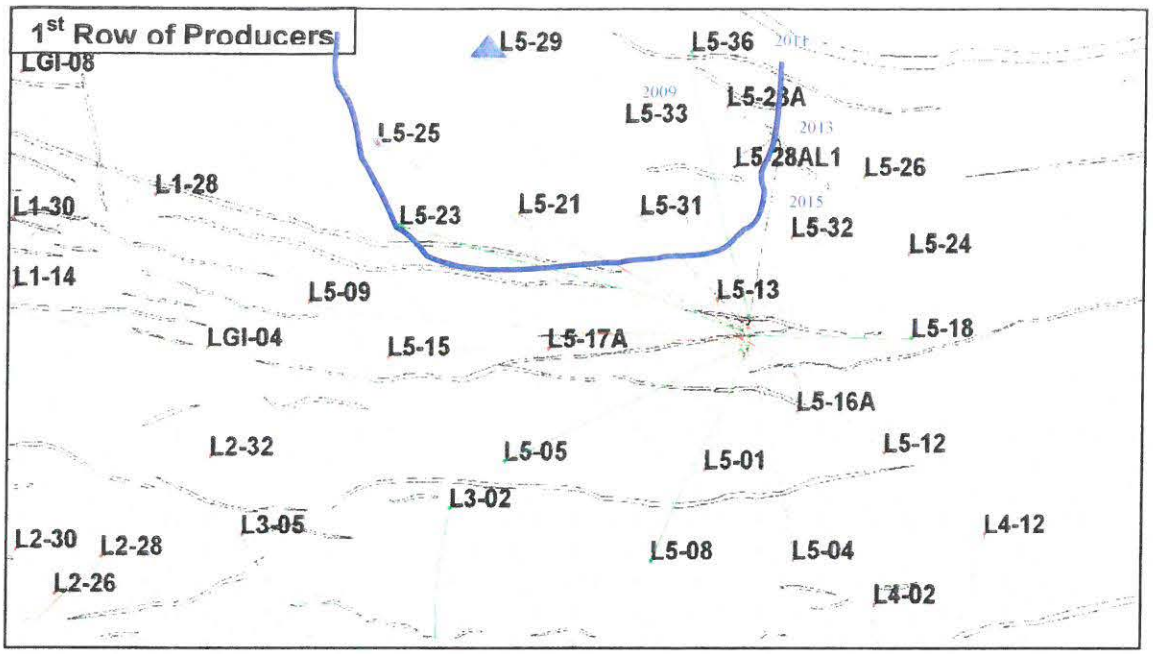

Figure 7: First Row of Producers Location Map with Year of Seawater Breakthrough

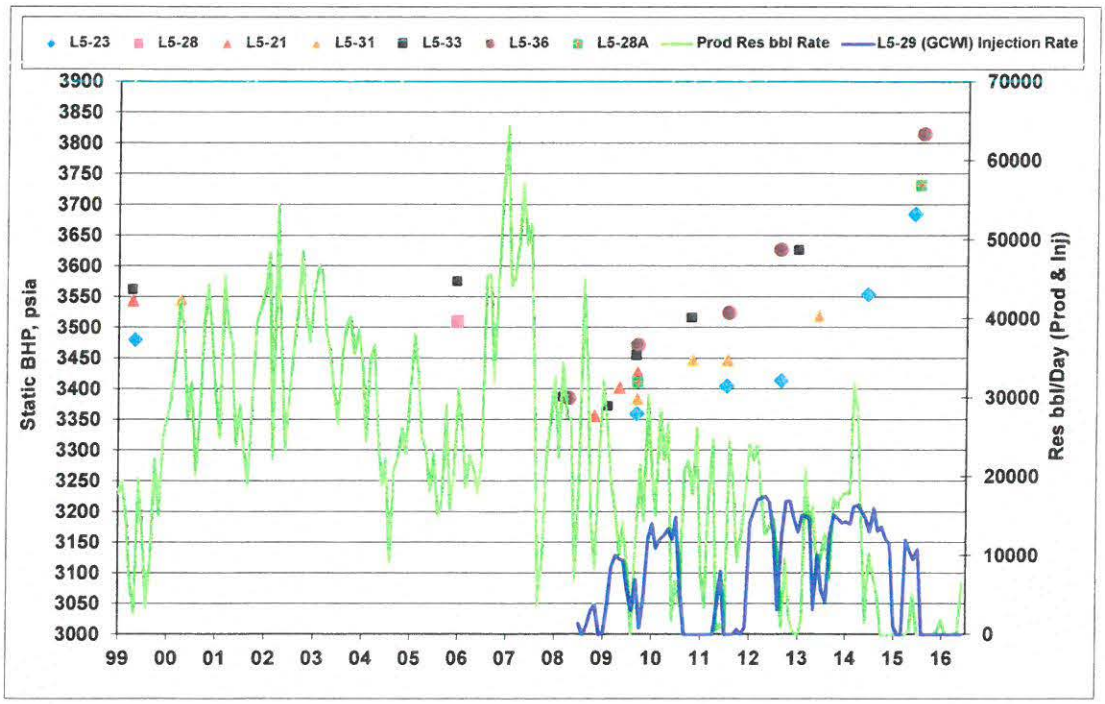

Figure 8: Static BHP/Production Plot for First Row of L5 Pad Producers

Well Performance

Figures 9-17 depict the production performance history of five offset producers. The top plot in each figure is well test information (oil/water/gas rates and GOR/WC), and the bottom plot shows monthly average GOR vs. cumulative oil production on the X-axis. Presently, the signs of incremental oil benefit during the GCWI pilot are based on the individual well production history, and are on the order of 100-350 bopd. This benefit has largely been from suppressed GOR, and increased fluid rates. Not every well surrounding L5-29 has shown a positive benefit, as associated water production has caused hydrate problems in some of the offset wells. Well performance trends have also been masked or affected by other factors outside of GCWI such as pad and facility downtime.

Figure 18 is a semi-log plot of GOR vs. cumulative oil production for L5-23, L5-28A, L5-31, L5-33, and L5-36 combined. The pre-GCWI trend is drawn to show GOR increase with respect to the cumulative oil production. The flattening of GOR trend (circled in the figure) since the injection began may be an indication of improved recovery. GOR trends may also be artificially affected by the facility limitations and the maturity of many wells across multiple fields.

Seawater breakthrough took has been observed in producers L5-28A, L5-32, L5-33 and L5-36 (Figures 13, 15, 16, 17). Observed estimated benefits and comments may be found in Table 1.

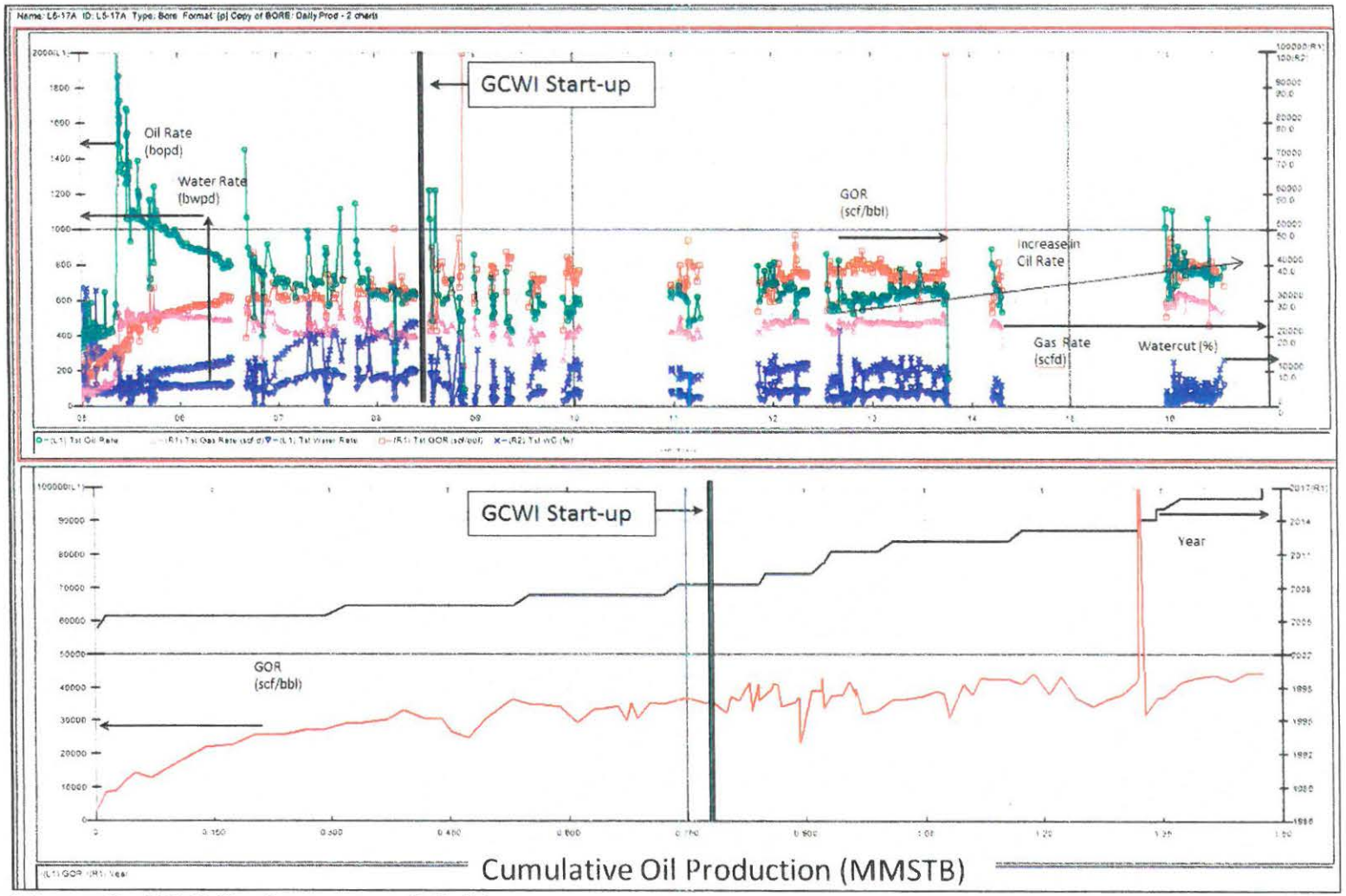

Figure 9: Well Performance: L5-17

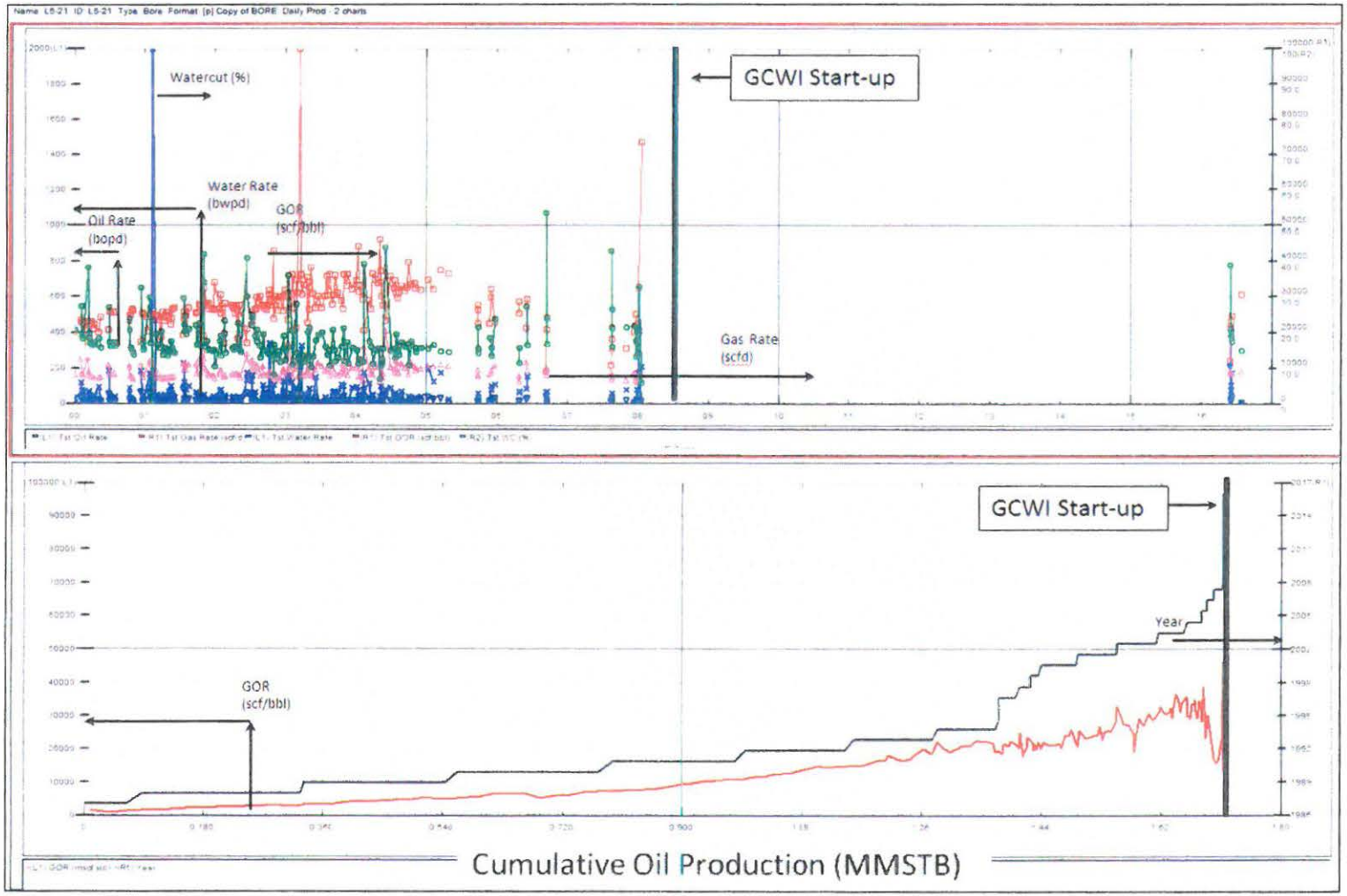

Figure 10: Well Performance: L5-21

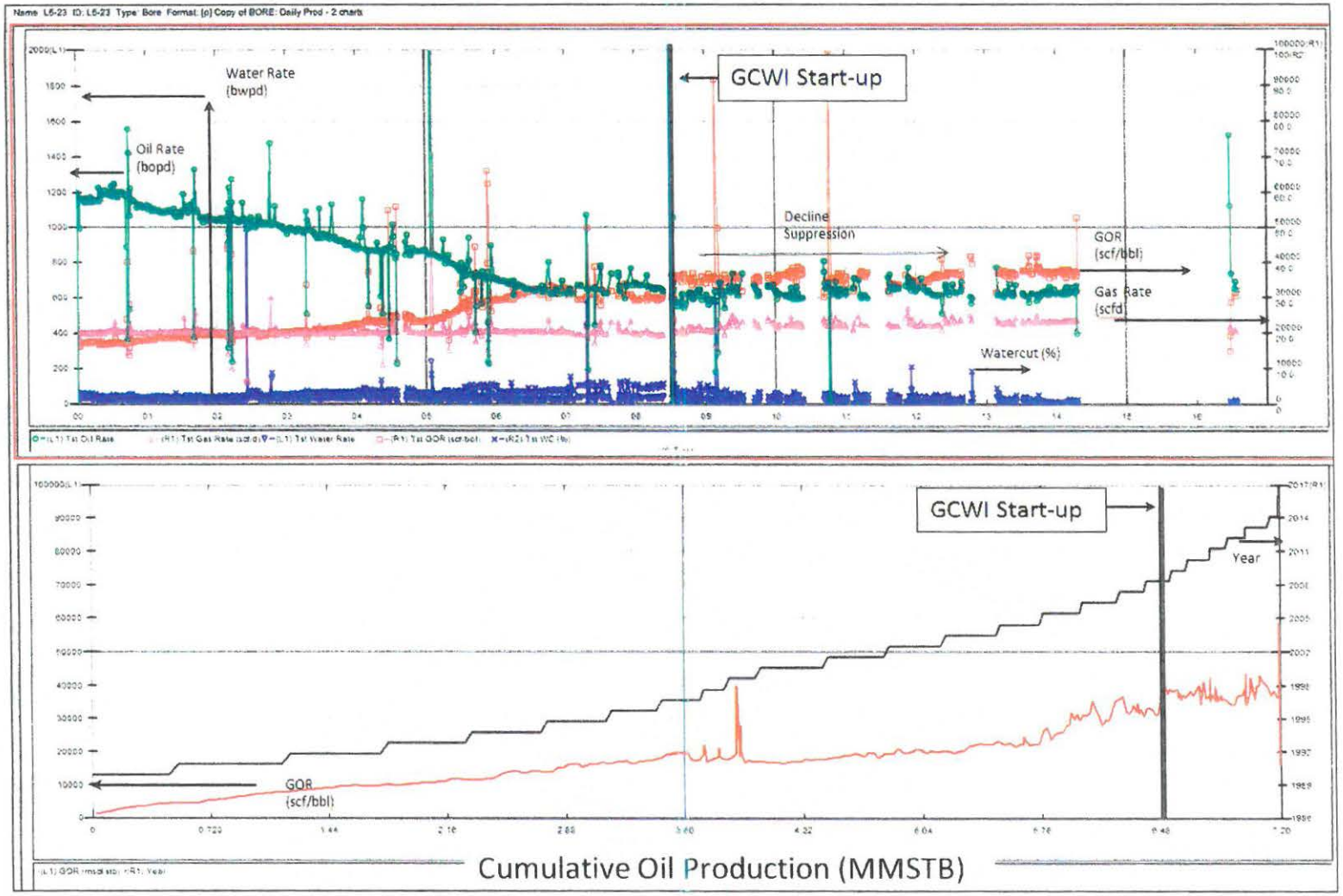

Figure 11: Well Performance: L5-23

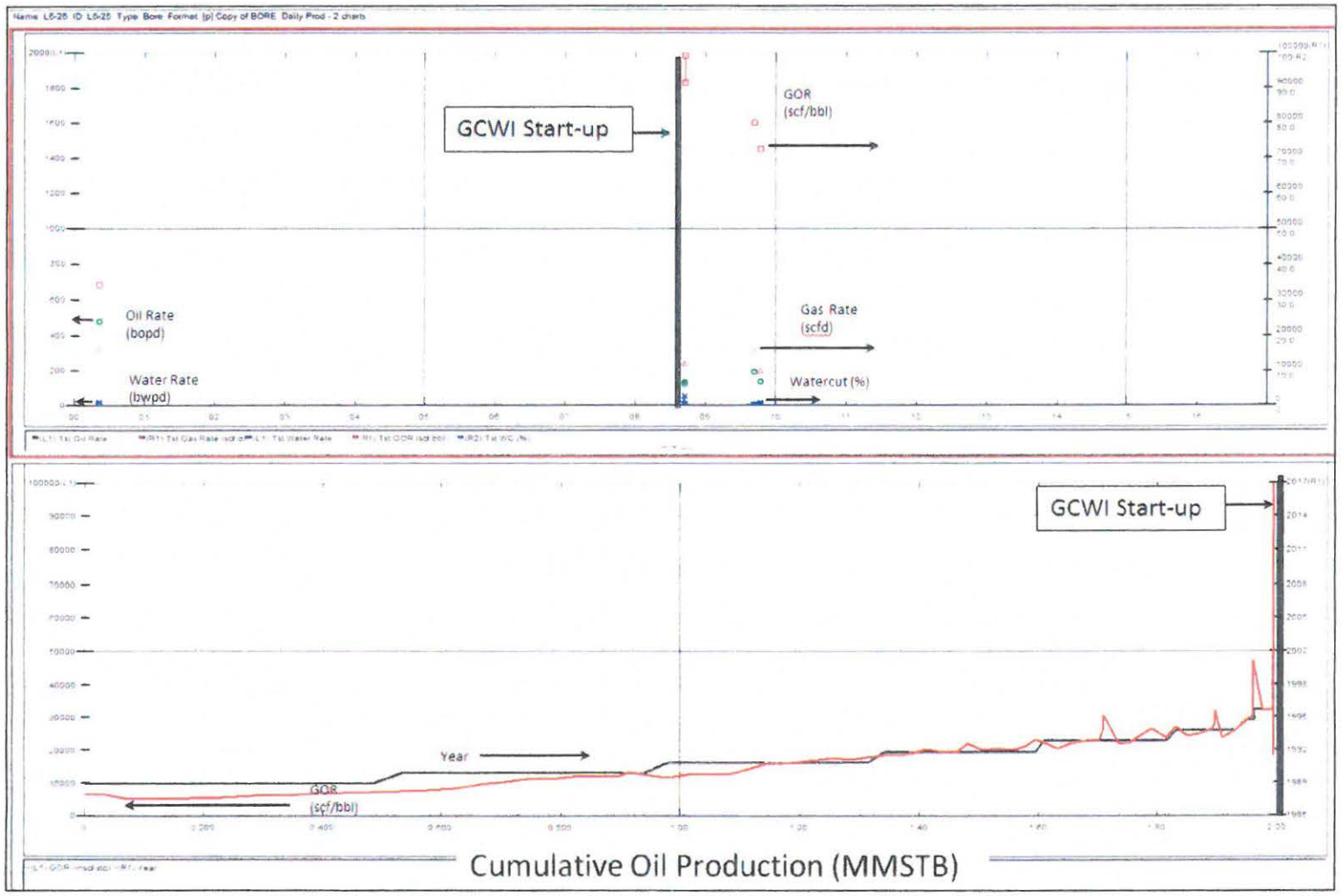

Figure 12: Well Performance: L5-25

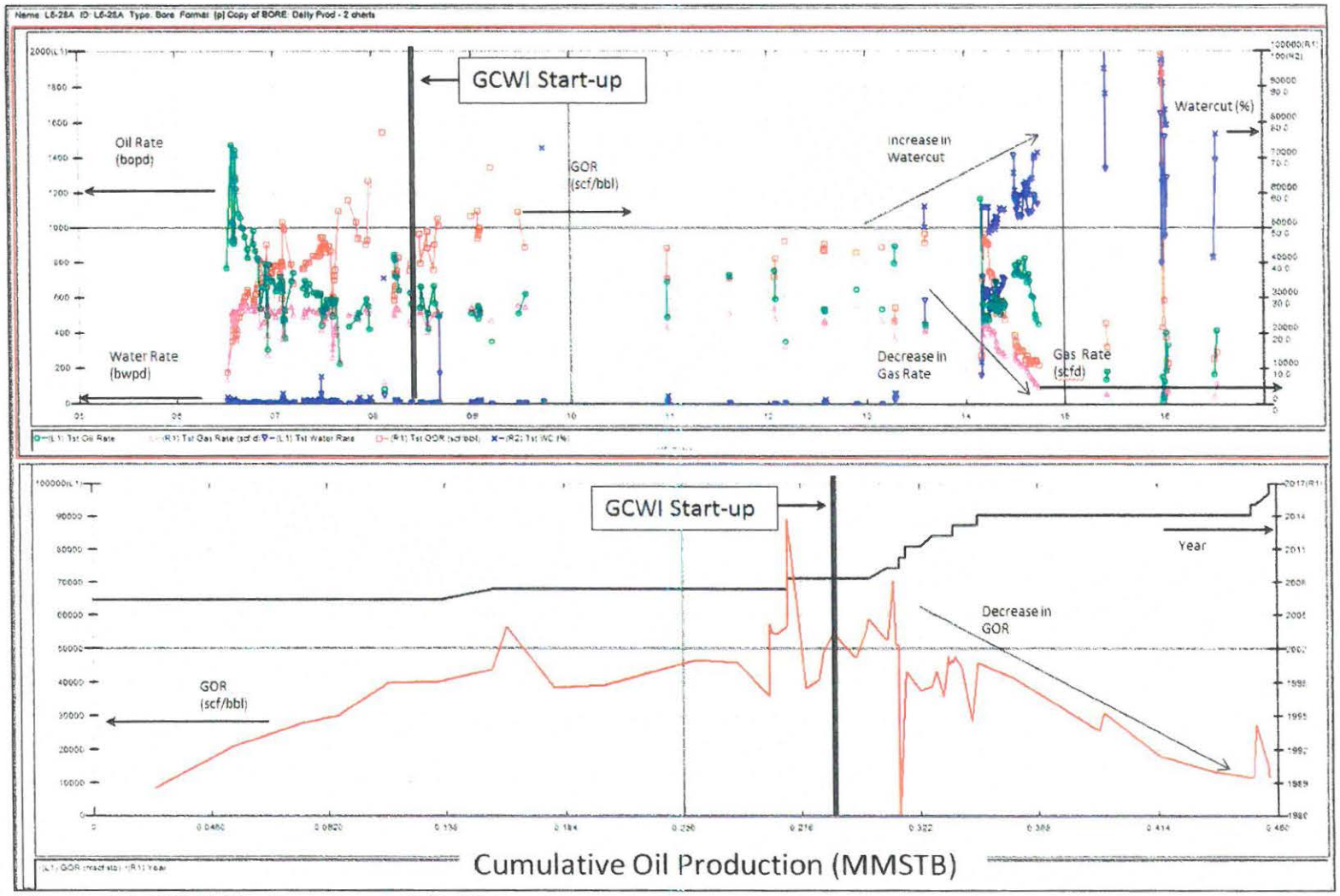

Figure 13: Well Performance: L5-28A

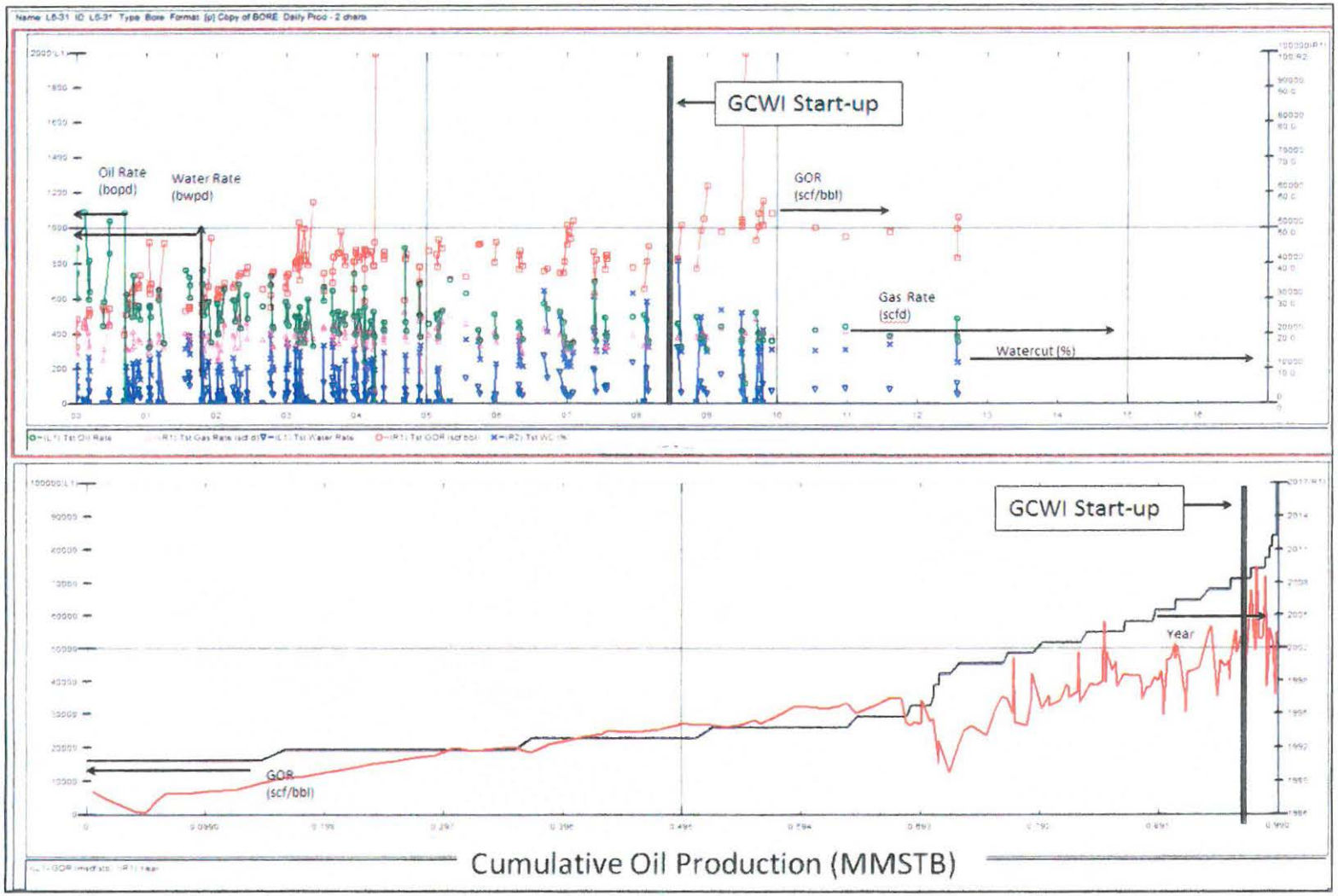

Figure 14: Well Performance: L5-31

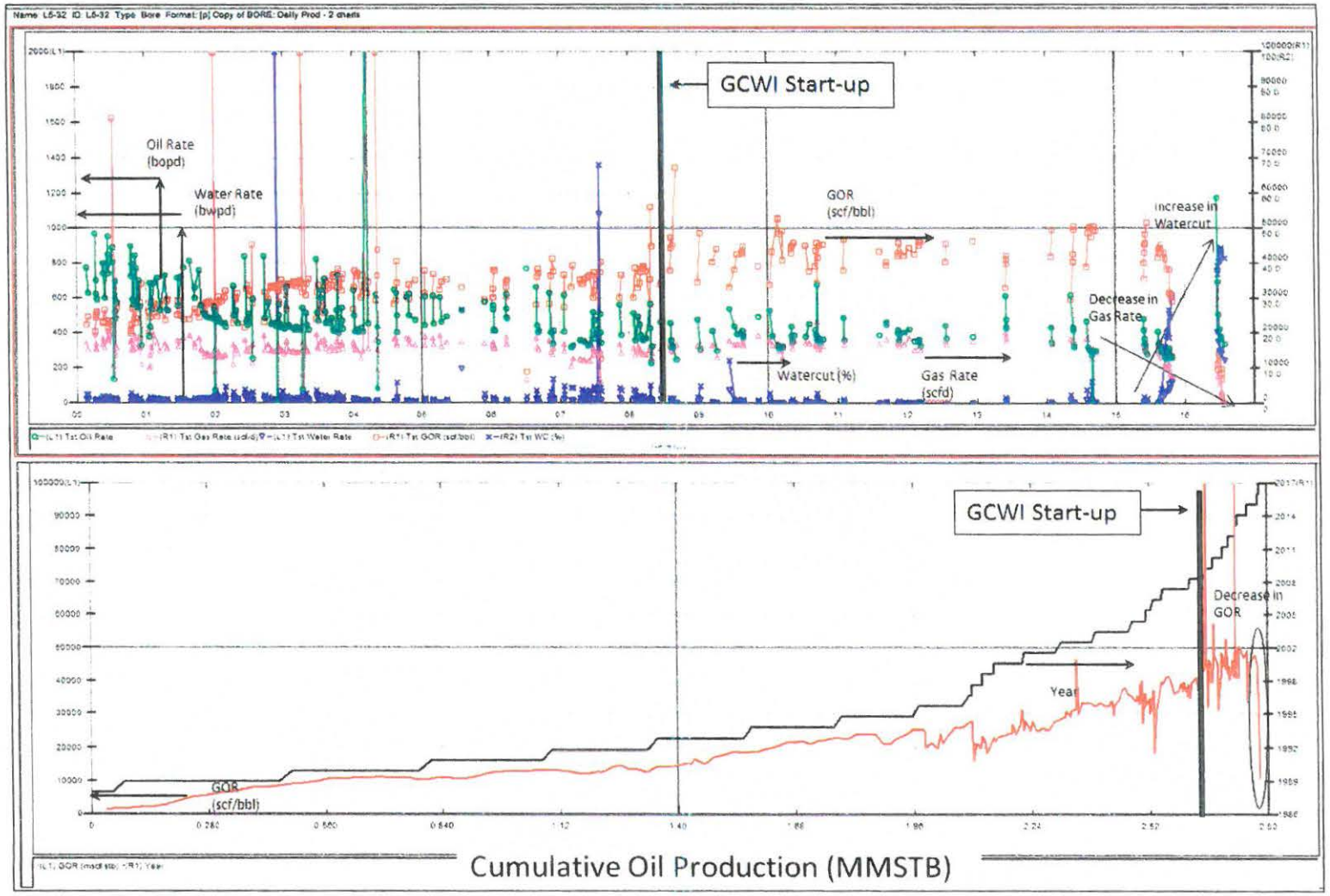

Figure 15: Well Performance: L5-32

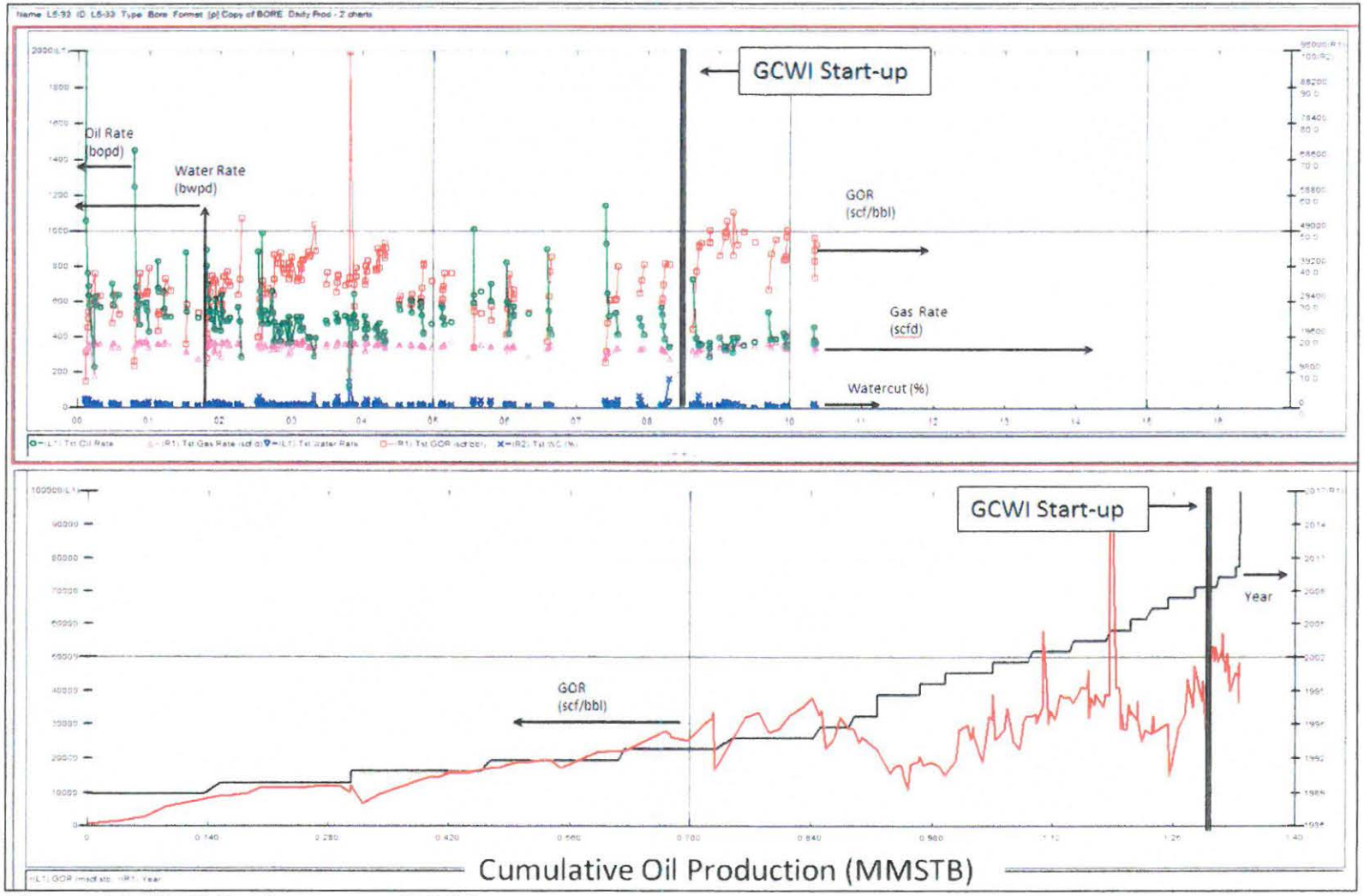

Figure 16: Well Performance: L5-33

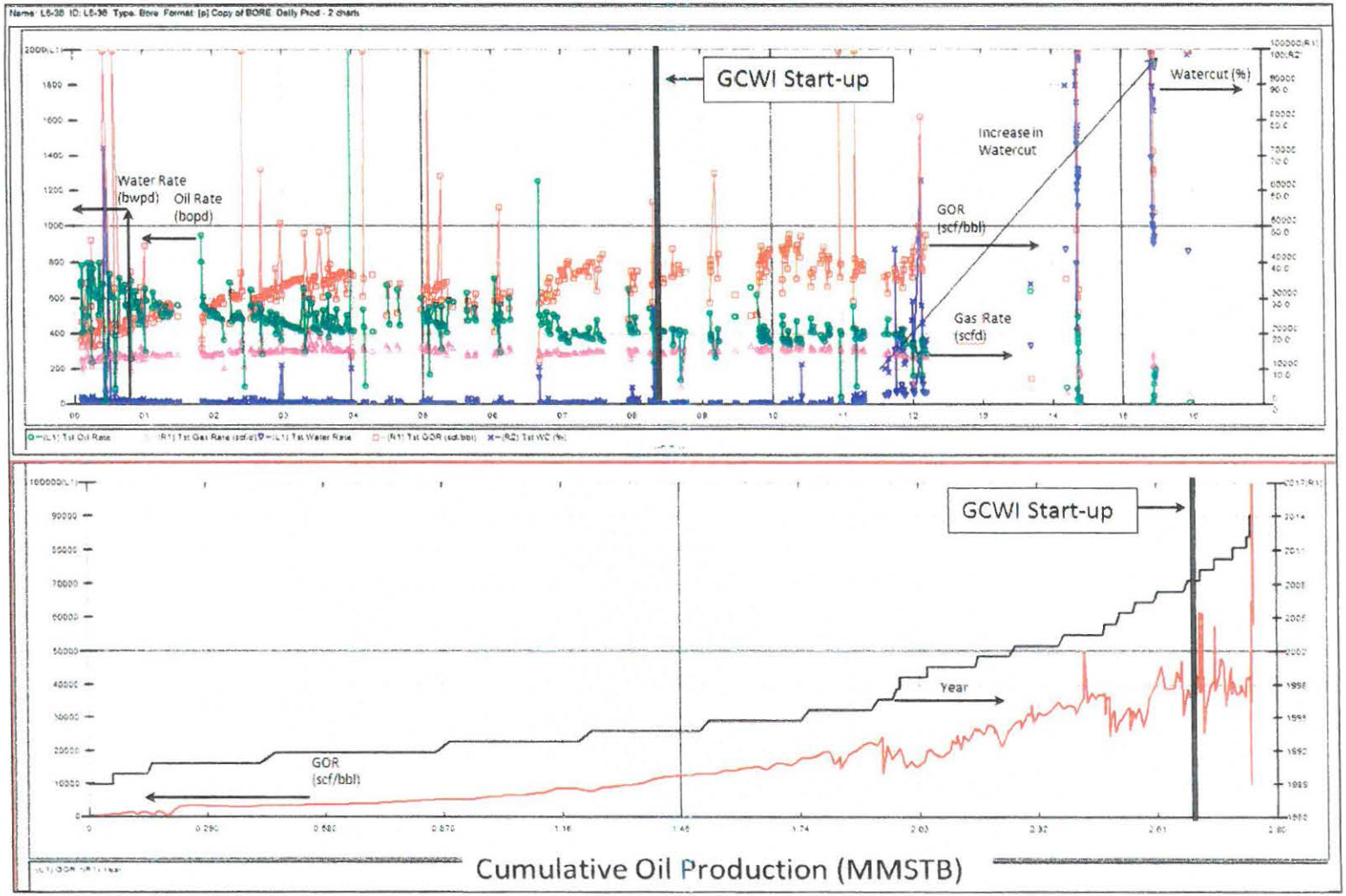

Figure 17: Well Performance: L5-36

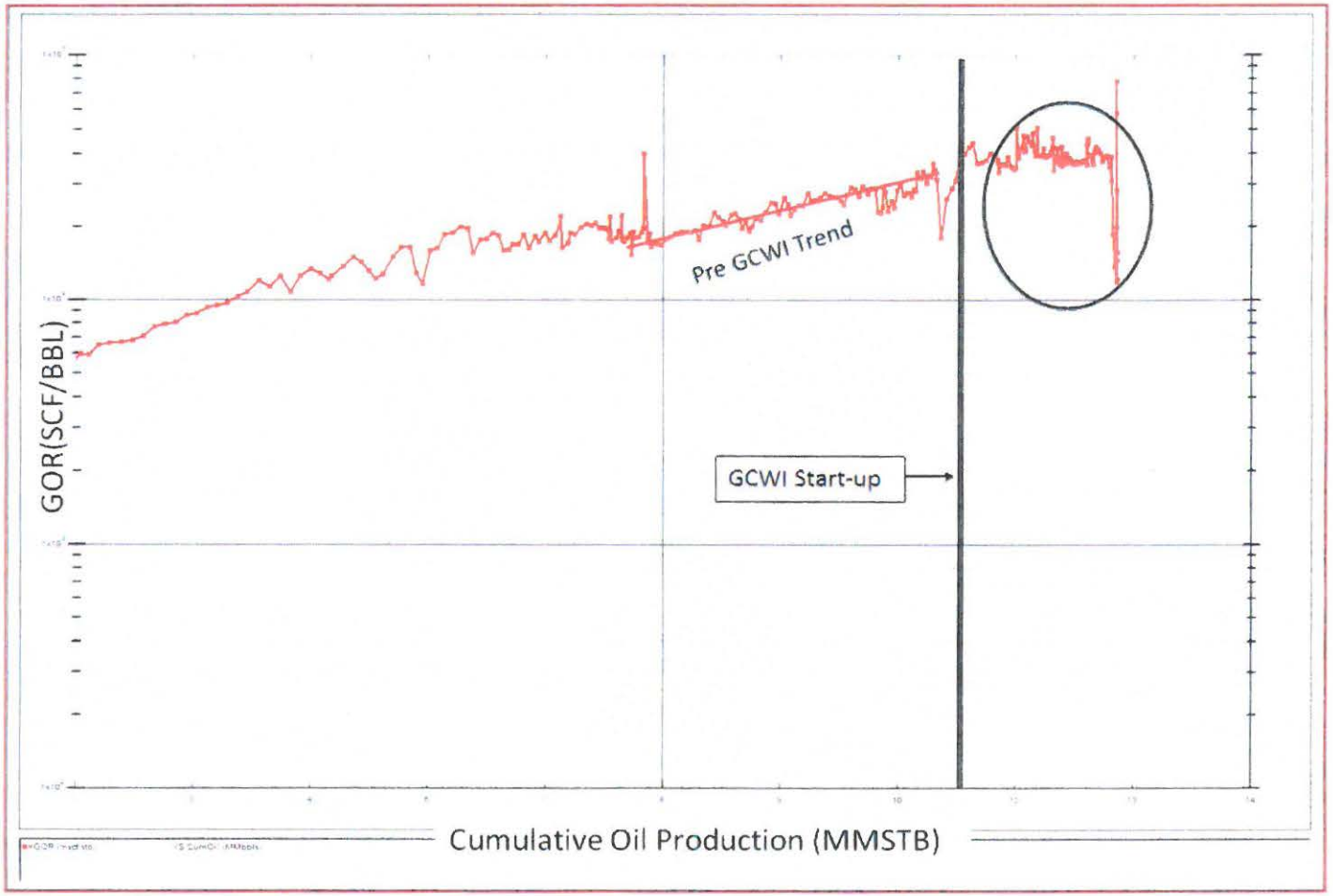

Figure 18: Combined GOR vs. Cumulative Oil Production for L5-23, L5-28A, L5-31, L5-33 and L5-36

Table 1: Estimated Benefit of L5-29 on Nearby Wells

L5-29 Gas Cap Water Injection Estimated Benefit				
Well	Estimated 2016 IOR (bopd)	Breakthrough Year	Approximate Distance (ft)	Comments
L5-17A	100	N/A	7400	Well has increased in oil production, although also has had long periods of being shut in for gas production.
L5-21	0	N/A	4650	Well has a history of hydrate problems, and was offline from January 2008 to May 2016 due to integrity problem which has since been resolved.
L5-23	25	N/A	5300	Fluid rate decline became near zero in 2009.
L5-25	0	N/A	4250	Non-operable well, has been shut in for almost entirety of pilot and a reservoir P&A has recently been executed.
L5-28A	200*	2013	6150	Well was previously high gas rate well with low ontime. Well now has much lower gas rate, but also a higher watercut and now requires a gas lift line (pending installation). Benefit derived from increased ontime and lower GOR. Estimated benefits assume successful well after adding gas lift. **Due to poor ontime while waiting for gas lift, actual 2016 benefit is near 0 bopd.**
L5-31	0	N/A	5900	High GOR well with low ontime and hydrate problems. Shut-in since 2012.
L5-32	50	2015	9235	**Benefit may be from injection in L5-13 (2,800 ft away)**. Well recently cycled on (June 2016) at higher fluid rates and reduced gas production. Well will now likely require installation of gas lift line with the higher WC and lower GOR. Evidence of seawater production not obtained until July 2016, but early shift in trends began in Fall 2015.
L5-33	-25	2009	3550	Well has had hydrate problems since 2009, and has not been able to sustain production since 2010 despite multiple hydrate remediation attempts.
L5-36	-30	2011	5000	Well developed hydrate problems with the water production and has had trouble sustaining production despite hydrate remediation attempts. Higher watercut has also offset increased fluid rates, resulting in an overall lower oil rate.

Conclusions

Estimated Resource Recovery

1. Reservoir pressure has increased around L5-29, resulting in greater fluid production rates.

2. GOR suppression has been observed in several of the offset wells, creating an incremental benefit, even if the oil rate did not increase.

3. Increased watercut in some of the wells has created hydrate problems resulting in deferred production and increased remediation costs.

4. Increased watercut in some of the wells coupled with the favorable reduction in gas rate has created the need for gas lift.

5. Changes in well performance, both favorable and negative around L5-29, have often been sudden and rapid, making long term predictions difficult.

    a. Current observed net incremental rate from L5-29 is estimated to be in the range of 100-350 bopd, compared to original expected benefits of 2,310 bopd.
    b. Incremental net recovery benefits currently are estimated in the range of 0.5 to 3 MMSTB, compared to original predictions of 1-12 MMSTB
    c. Unforeseen facility and well problems resulting in injector and producer downtime obfuscates some of the well trends and producer-injector interactions.
    d. L5-29 may have larger field-wide impacts that are more difficult to quantify due to a combination of cycle, full-time, and offline wells spread over multiple drillsites.

Plan Forward for GCWI

1. Attempt repair of injector L5-29.

2. Request AOGCC permission for permanent injection into L5-29.

3. Continue monitoring wells in the area to maximize performance and recovery.

4. The Prudhoe Bay Unit working interest owners at this time do not plan to expand GCWI outside of L5-29, however, the owners periodically review future opportunities as new information is acquired through time and understanding of performance changes.