LONQUIST & CO. LLC
PETROLEUM ENGINEERS | ENERGY ADVISORS

May 23, 2022

Phillip Goetze
Hearing Examiner
Oil Conservation Division of New Mexico
1220 S. St. Francis Drive
Santa Fe, New Mexico 87505

RE: Step Rate Test Analysis
Milestone Environmental Services LLC
Beaza SWD No. 1 (30-025-49600)
Order No. R-21441

Dear Mr. Goetze:

Lonquist & Co. LLC ("Lonquist") is submitting an analysis of two step rate tests performed on the above referenced Beaza SWD No. 1 Disposal Well ("Beaza") in Lea County. This testing required by the Oil Conservation Division of New Mexico ("OCD") is pursuant to Order No. R-21441. This order requires that a step rate test ("SRT") be performed prior to commencing the second year of injection.

The maximum sustained injection rate for the first test was 37,872 bbl/day. This was estimated to be the maximum safe fluid velocity for injection through the 4-1/2" diameter tubing. The second test reached a maximum sustained injection rate of 23,380 bbl/day, and was performed to verify reservoir behavior at lower injection rates. The pressure vs. rate chart (Figure 3) showed a gradual decrease in slope for the first several stages of each test. As discussed below, this behavior is known as rate-dependent skin. After a thorough analysis, the determination was made that it is highly unlikely that the formation parting pressure was reached during the tests and the results were inconclusive in the identification of the formation parting pressure gradient for this well. Additionally, it is believed that a repeat SRT would yield equally inconclusive results within the maximum safe fluid velocity for this well. Available SRT data from offset wells has been provided in this report and demonstrates for the currently permitted injection range that formation parting pressure was not reached in Beaza SWD No. 1.

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This letter documents the analysis and conclusions of the tests. The next sections of the report detail the test procedures, data analysis and results, followed by the evaluation of offset SRTs and conclusions. The attached set of figures provides graphic depictions of the analysis and findings.

Test Procedure

The initial test was performed prior to initial injection, on April 4, 2022. This was done to ensure that the bottom hole pressure would be at or near the native reservoir pressure. Surface pressure was monitored in the tubing throughout the test and bottom-hole pressure readings were captured by a pressure gauge set at 6,400 feet. Surface pressure, bottom-hole pressure, and flow rate readings were captured and recorded at one-second intervals. Fourteen stages of continuous-rate injection were performed at incrementally increasing volumes. Injection at each stage was performed at equal time intervals of 30 minutes throughout the test. Injection began at very low rates in order to ensure that formation behavior would be adequately observed prior to the formation parting pressure were it to occur earlier than anticipated. At the completion of the final injection stage, pumping was ceased and the well was shut-in, allowing pressure to bleed-off into the injection zone. Figure 1 in the attached analysis provides an overview of the pressures and flow rate data captured during the first test.

Anomalous pressure behavior in the low-rate steps led to speculation that fluid movement was being constrained to a limited portion of the perforated intervals early in the test. A revised test procedure to counter this behavior was proposed and a second test was performed.

The second test was performed on May 4, 2022. The well remained shut-in between the first and second test. Similar to the initial test, surface pressure was monitored in the tubing and bottom-hole pressure readings were captured by a pressure gauge set at 6,400 feet. Surface pressure, bottom-hole pressure, and flow rate readings were captured and recorded at one-second intervals. Seventeen injection stages were performed, ten at increasing rates, followed by seven at decreasing rates. The decreasing rate stages were included in the second test to confirm reservoir behavior and ensure that all perforations were accepting fluid during low injection rate stages. Additionally, the duration of each stage was increased from 30 minutes in the initial test to 60 minutes to ensure pressure stabilization. Figure 2 in the attached analysis provides an overview of the pressures and flow rate data captured during the second test.

Data Analysis and Results

Bottom-hole pressure and flow rate measurements at the end of each injection stage were isolated to generate Table 1 and Table 2 below for each test.

First SRT (4/4/2022)			
Step	Flow Rate (bbl/min)	Flow Rate (bbl/day)	Bottom-hole Pressure (psi)
1	0.7	936	3,523
2	0.8	1,210	3,569
3	1.2	1,656	3,596
4	1.5	2,160	3,622
5	2.1	3,024	3,654
6	3.2	4,536	3,692
7	5.0	7,128	3,700
8	8.0	11,520	3,705
9	11.2	16,056	3,722
10	14.0	20,160	3,742
11	17.1	24,624	3,748
12	20.2	29,016	3,763
13	22.9	32,976	3,775
14	26.3	37,872	3,789

Table 1 – Summary of First SRT

Second SRT (5/4/2022)			
Step	Flow Rate (bbl/min)	Flow Rate (bbl/day)	Bottom-hole Pressure (psi)
1	0.6	814	3391
2	0.7	1068	3451
3	0.9	1284	3511
4	1.4	2077	3577
5	2.0	2905	3613
6	3.1	4458	3661
7	5.0	7243	3694
8	8.0	11457	3718
9	11.1	15997	3748
10	14.2	20380	3766
11	11.0	15807	3759
12	8.0	11533	3744
13	5.0	7223	3722
14	3.0	4357	3694
15	2.0	2880	3664
16	1.5	2160	3635
17	1.2	1728	3614

Table 2 – Summary of Second SRT

<u>Bottom-hole Pressure vs. Injection Rate</u>

Bottom-hole pressures from each table were plotted against the associated injection rates to illustrate their relationship. This is provided as Figure 3 in the attached analysis. The plot resulted in a continuous gradual decrease in slope throughout the low-rate stages of both tests followed by a linear trend at higher rates in the first test.

Typically, SRT data plotted in this way reveals one or more discrete changes in slope preceded and followed by linear trends. The distinct changes in slope are used to identify formation parting pressure, or their absence, in the case of a continuous straight line, indicates that the parting pressure was not reached.

During each change in injection rate, the data from these tests depicts a continuous and consistent transition in the effective permeability encountered in the formation for the first eight steps in both tests and for the entire step-down portion of the second test. This pressure response is indicative of a near-wellbore permeability (or skin) that varies with the injection rate. This behavior is known as rate-dependent skin. To verify this observation, the magnitude and shape of the pressure rises in each step were modeled in PanSystem™, a well testing analysis software. The skin value was adjusted for each step to achieve a match between pressure change and injection rate. The modeled skin value from each step was plotted against the associated injection rate. This plot has been provided as Figure 4. The plot depicts the strongly dependent relationship between skin and injection rate, particularly during the lower-rate steps. This is indicative of a rate-dependent skin as identified in studies of injection wells that exhibit this behavior. This phenomenon is explained by a gradual increase in the width of preexisting near-wellbore fractures as pressures rise due to injection. The increasing near-wellbore fracture width results in a decreasing skin value.

Given these findings, it is likely that near-wellbore fractures were created during the well completion and existed prior to commencement of these tests. The well was perforated with propellant enhanced perforating charges which are designed to create near-wellbore fractures for improved injectivity in disposal wells. Similar pressure behavior was observed in the SRT of another disposal well analyzed by Lonquist which utilized the same perforating technology for a completion in the Delaware Mountain Group ("DMG") in Loving County, TX. In the case of Beaza, a considerable quantity of these charges were deployed over a broad portion of the injection interval. In total, 1,600 of the specialty charges were detonated at a spacing of 4 shots per foot in the lower 400 feet of the 786 feet perforated interval. 2,316 standard 0.52" EHD charges were detonated at spacing of 6 shots per foot on the upper 386 feet of the perforated interval. A product brochure outlining the specific properties of this specialty perforating technology has been provided as an attachment to this report.

Parting Pressure of Confining Layers

Given the magnitude of the pressure gradients reached during these injection tests and the associated injection depths, it is unlikely that damage would have been caused to the upper or lower confining formations. The highest formation pressure gradient recorded during these tests was 0.592 psi/ft at an injection rate of 37,872 bbl/day. This gradient is significantly lower than the parting pressure gradients estimated from published literature for the upper confining layer, the Castile anhydrite, and the lower confining layer, the Bone Spring. These confining layers have been noted to exhibit parting pressure gradients of roughly of 0.66 psi/ft and 0.75 psi/ft, respectively.

Analog Well Discussion and Conclusions

Step Rate Test data from analog injection wells suggests that the formation parting pressure gradient was not reached during testing at Beaza. Data from the nearest four DMG disposal wells with publicly available SRT reports was considered. Following step rate testing on each of these four wells, MASIP values were issued to reflect the findings of these tests. These wells and their respective MASIPs are listed in the Table 3 below for reference.

Well	MASIP	
	(psi)	(psi/ft)
Beaza SWD No. 1	1,099	0.200
Antelope Ridge Unit No. 4	1,350	0.261
Antelope Ridge No. 5	1,228	0.238
Curry Federal No. 2	1,360	0.260
North Bell Lake Unit 4 No .15	1,870	0.370

Table 3 – MASIP Summary

Figure 5 shows the MASIPs assigned for each of these four offset wells overlaid with surface pressure vs injection rate for the Beaza SRTs. All anomalous pressure behavior in the Beaza tests can be seen to lie beneath a surface injection pressure of 300 psi and below a rate of 5,000 bbl/day. Aside from a slight upward curve due to friction in the tubing, a linear relationship in the Beaza data can be seen for pressures and rates above 300 psi and 5,000 bbl/day. The currently assigned MASIP for Beaza is not reached until an injection rate of about 25,000 bbl/day, significantly surpassing the permitted maximum of 10,000 bbl/day. The MASIPs from the four closest DMG offset injection wells with SRT data are not reached until higher rates, and the linear pressure vs. rate trend remains consistent until the highest step is reached at a rate of 37,872 bbl/day and an injection pressure of 2,077 psi.

The nearest of the offset wells reviewed was the Antelope Ridge Unit No. 4 which is located 5.5 miles northwest of Beaza. While the other three offset SRTs begin at higher bottomhole pressure gradients, the Antelope Ridge Unit No. 4 covers the range of pressure gradients over which the anomalous pressure behavior occurs in the Beaza SRT. The changing slope on the BHP vs rate chart for Beaza occurs continuously from approximately 0.55 to 0.58 psi/ft. The SRT at the Antelope Ridge Unit No. 4 shows a linear BHP vs rate trend over this gradient range from 0.561 psi/ft to the parting pressure gradient seen at 0.588 psi/ft.

Beaza was able to inject at a rate of 29,000 bbl/day before reaching the parting pressure gradient witnessed in the Antelope Ridge No. 4 of 0.588 psi/ft. Furthermore, no indication of slope change was observed in the Beaza data from 0.588 psi/ft to the final measured gradient of 0.592 psi/ft at an injection rate of 37,872 bbl/day. This indicates that Beaza is able to inject at rates in excess of the permitted rate of 10,000 bbl/day without approaching the parting pressure gradient of the injection zone. This is further supported by the parting pressure gradients seen at the other three offset wells which are significantly higher than the maximum gradient seen during testing at Beaza. The table below lists the initial and final bottom-hole pressure gradients ("BHG") seen during each step rate test as well as the parting pressure gradient, if identified during testing.

Step Rate Test Bottom-Hole Gradient Summary			
Well	**SRT Initial BHG (psi/ft)**	**SRT Parting Pressure BHG (psi/ft)**	**SRT Final BHG (psi/ft)**
Beaza SWD No. 1 (First SRT)	0.551	Not Identified	0.592
Beaza SWD No. 1 (Second SRT)	0.530	Not Identified	0.589
Antelope Ridge Unit No. 4	0.561	**0.588**	0.598
Antelope Ridge No. 5	0.620	**0.660**	0.674
North Bell Lake Unit No. 15	0.593	**> 0.647**	0.647
Curry Federal No. 2	BHG unknown (BH gauge depth not specified)		

Table 4 – Step Rate Test Bottom-Hole Gradient Summary

As requested in Order No. R-21441, this test and analysis has been performed in an effort to determine the parting pressure gradient of the injection formation in accordance with current OCD guidelines. We respectfully request a MASIP for the Beaza SWD No. 1 of 2,000 psi. Please call if you require additional information or clarification. Contact information is below:

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Phone: 713-559-9990; ben@lonquist.com

Respectfully submitted:

Certified By:
Lonquist & Co., LLC

5/23/2022 P.E.

Ben H. Bergman, P.E.
Sr. Engineer
New Mexico License No. 23122

Date Signed: May 23rd
2022 Houston, Texas

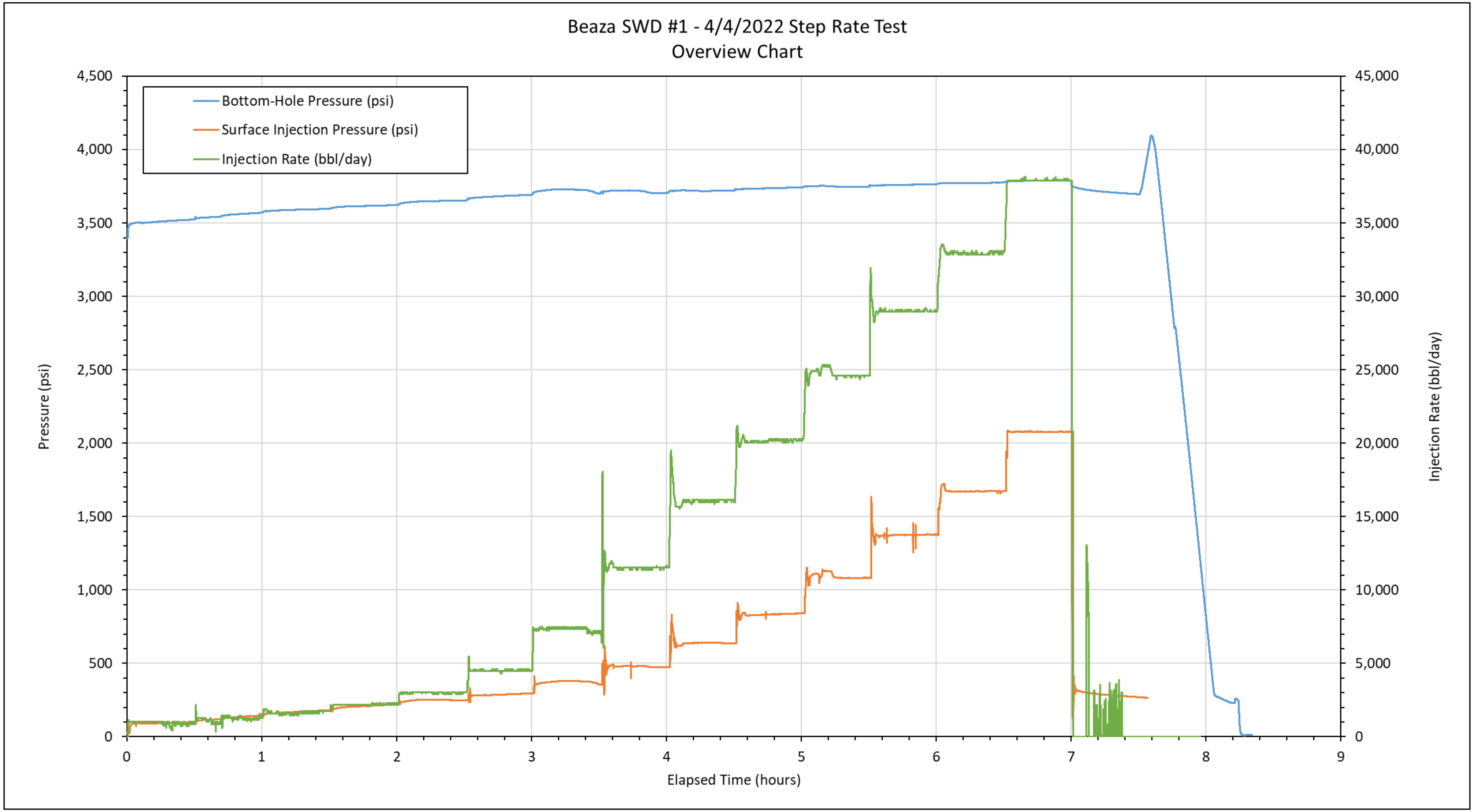


Figure 1 – First Step Rate Test Overview Chart

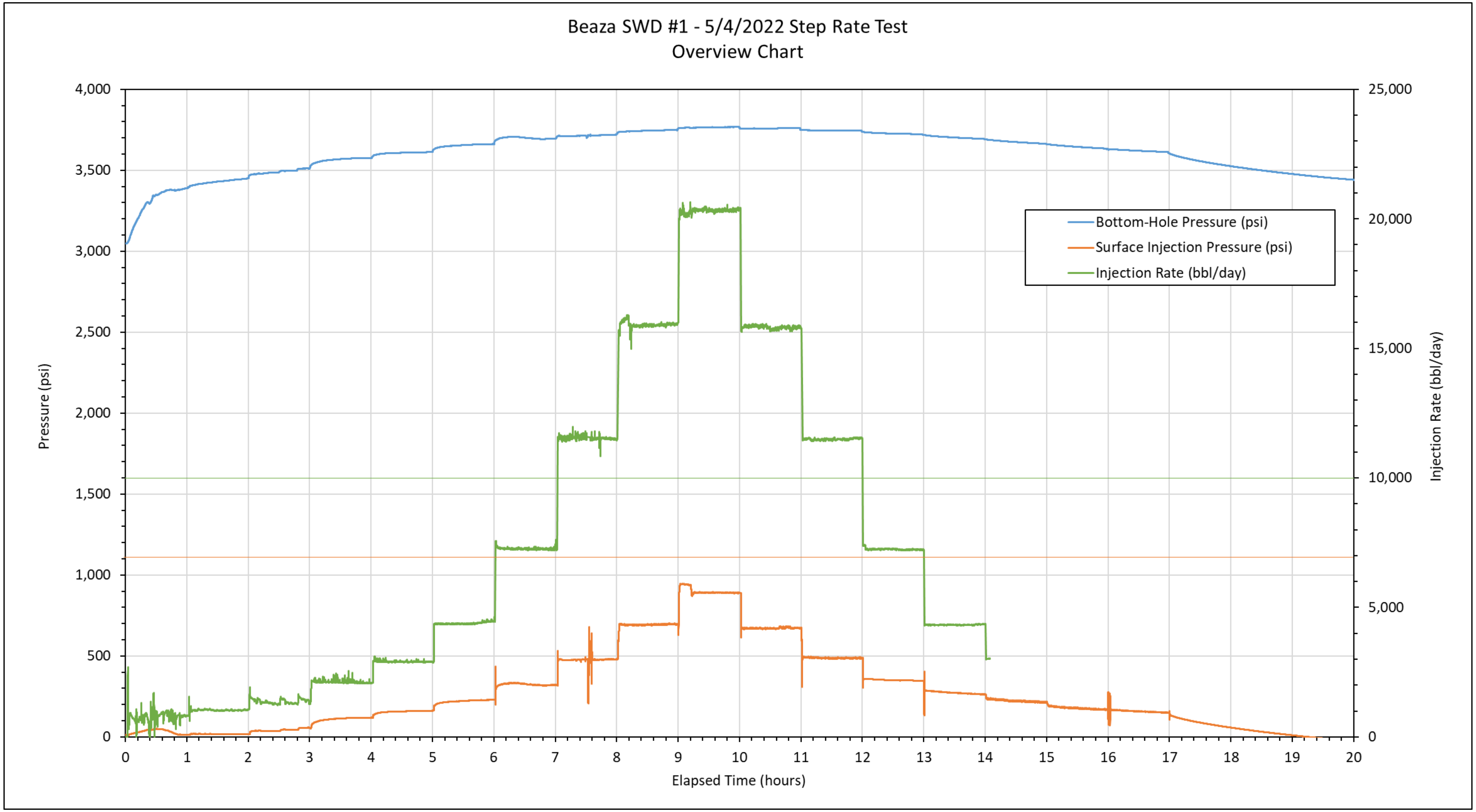


Figure 2 – Second Step Rate Test Overview Chart

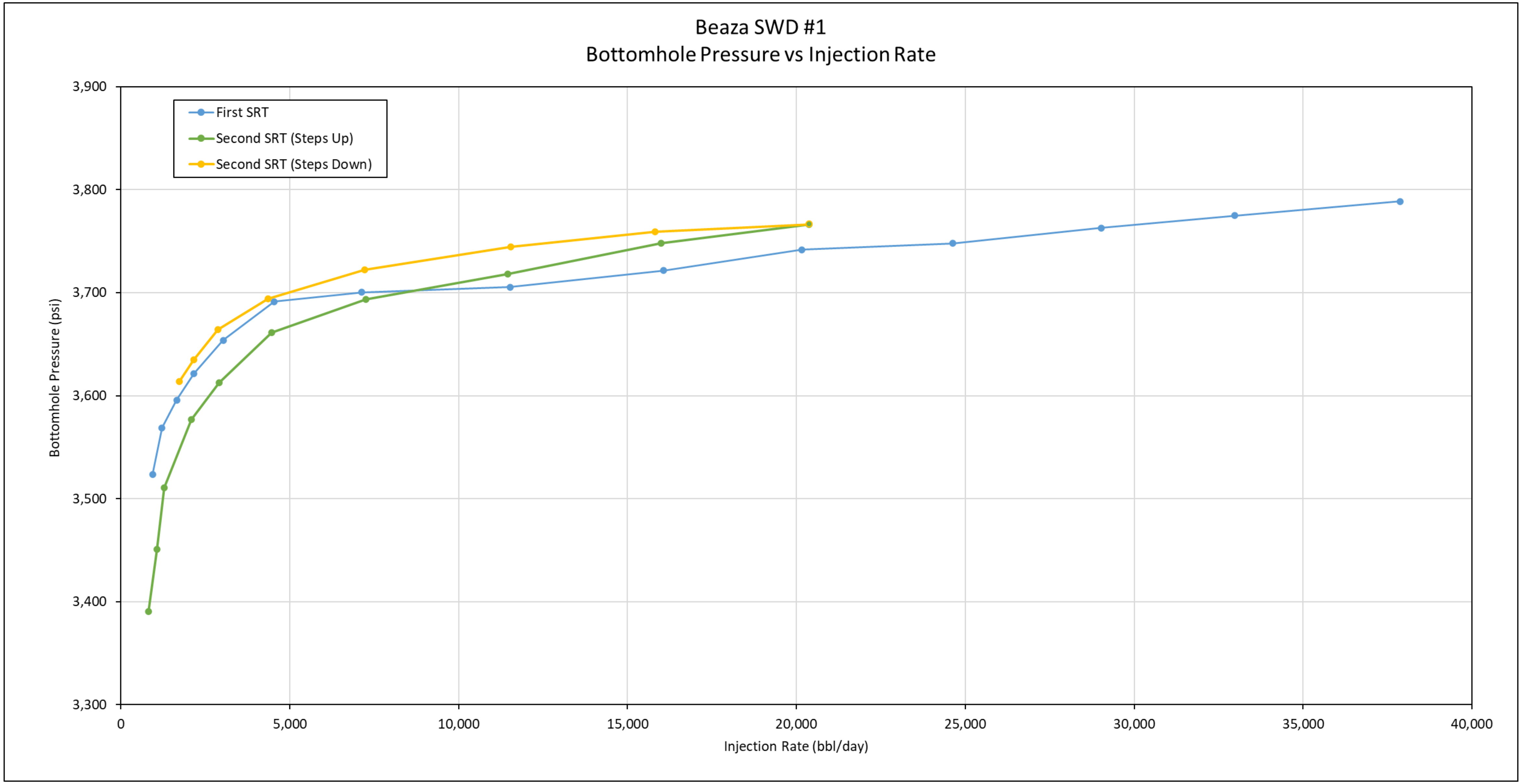


Figure 3 – Bottom-Hole Pressure vs Injection Rate Chart

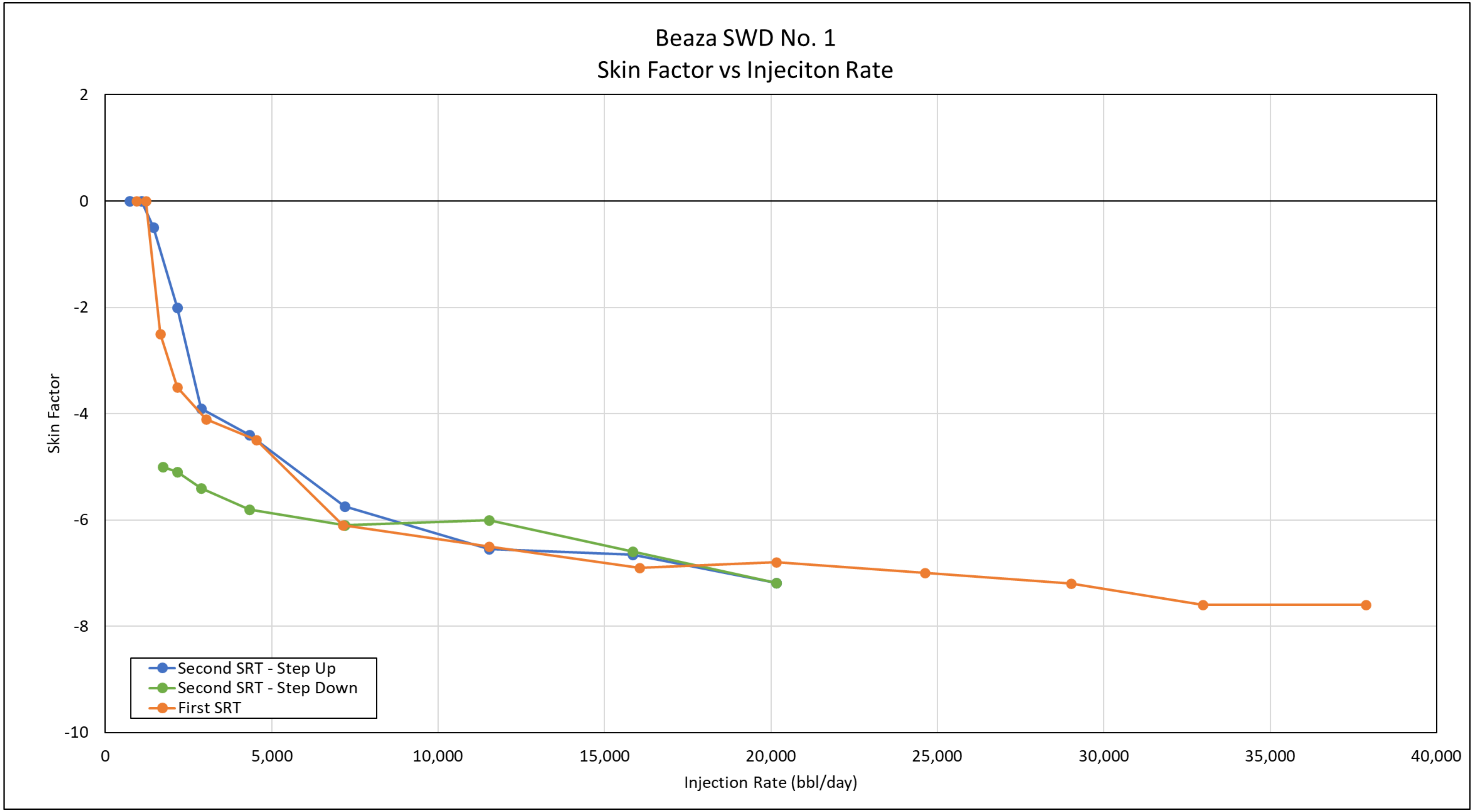


Figure 4 – Modeled Skin vs Injection Rate Chart

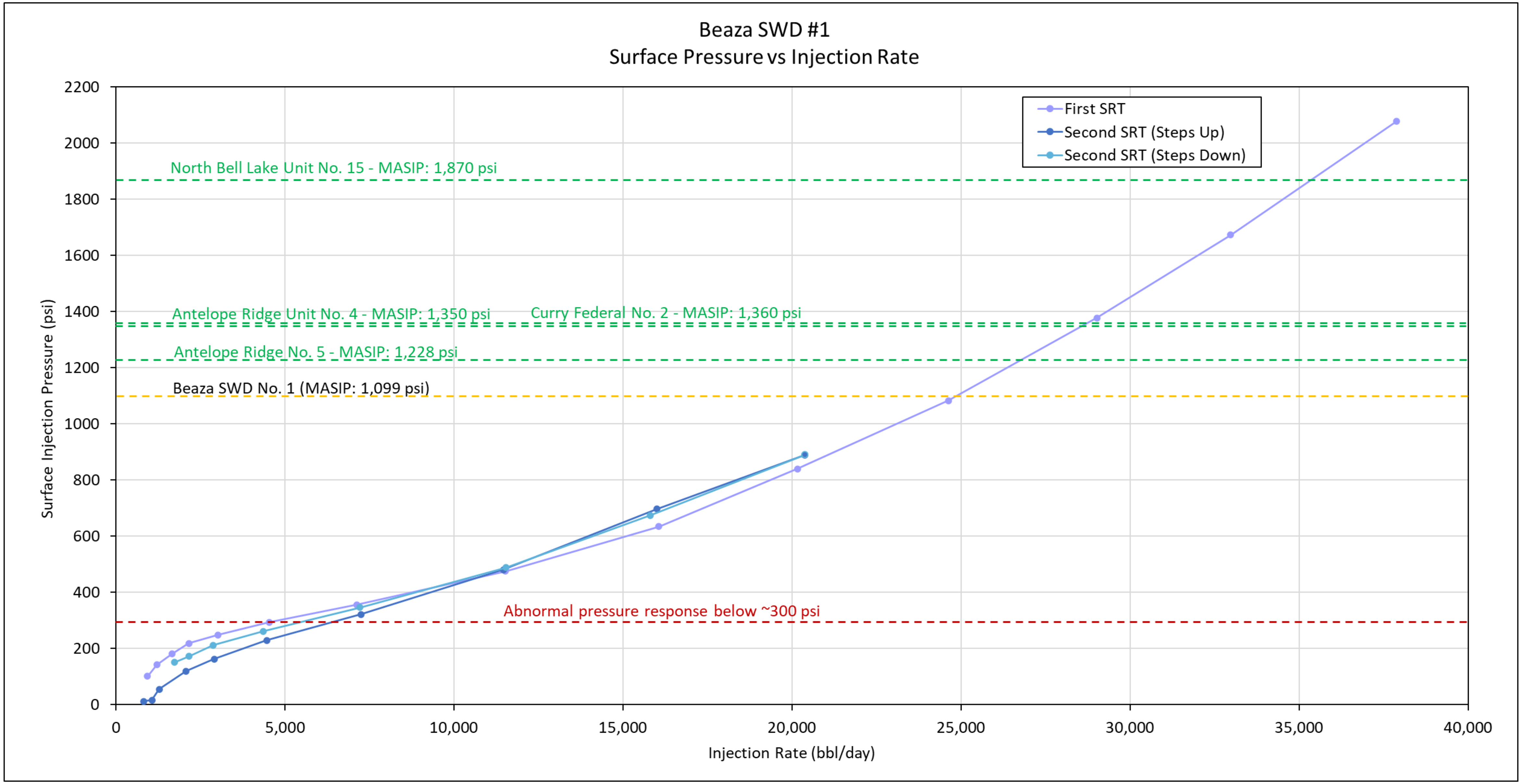


Figure 5 – Modeled Skin vs Injection Rate Chart

Maximize SWD Injection

ENHANCED ENERGETICS

Fracture past perf tunnel damage

- Create ideal flow paths for injection
- Extend useful life of SWD wells

Replace or enhance acid jobs

- Less time, cost and NPT than an acid job
- Allows acid to penetrate deeper into formation

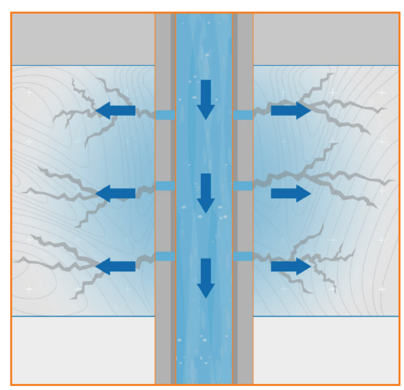
Lower pumping pressures

- Increase injection rates and volumes
- Reduce power consumption

Break down all perforations for injection

- Improve injectivity index and profile

Saltwater disposal and waterflood injection well efficiency is significantly improved with Kraken® propellant boosters. The efficiency gained by penetrating deeply beyond perforation tunnel damage lowers surface pressure, increases injection rates and achieves measurably lower injection cost per barrel. Kraken has allowed some operators to eliminate acid jobs or to decrease workover acid job frequency.



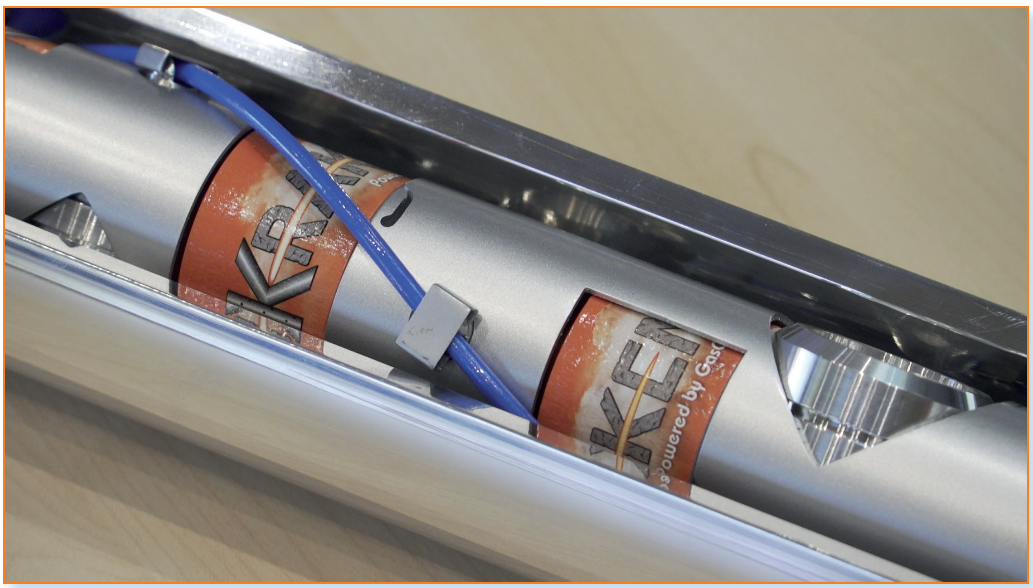
Hundreds of thousands of dollars can be saved by applying Kraken technology to new injection well completions and recompletions.

Kraken Enhanced Perforating Technology

Kraken technology is a progressively burning, solid propellant designed to increase penetration, eliminate clogged perforations and overcome near-wellbore damage from compaction caused by traditional perforators. Progressively burning Kraken propellant boosters generate high-pressure gas in the perforation tunnels, which creates fractures that improve well connectivity. Engineers who analyze Kraken results by breakdown pressure, initial production or injection increase (IP/II), operating time and safety will observe that the return on incremental investment in enhanced perforating performance routinely exceeds their expectations.

Enhanced Energetics offers a proven propellant-enhanced perforating technology (U.S. Patent 10,024,145 B1) designed to lower total cost of operations and improve profitability of vertical and horizontal producing and injection wells. Kraken® enhanced perforating is significantly more effective than standard perforating at improving completion and recompletion performance in conventional, unconventional and saltwater disposal wells. Standard gun systems and shaped charges can easily be enhanced with Kraken technology to

- Perforate and stimulate in one trip
- Create fractures in every perforation tunnel prior to hydraulic fracturing
- Bypass skin to enhance productivity or injectivity index
- Break down the formation to lower treating pressures and improve rates.



Gun size	2.75, 3.125, 4.0 in. [70, 79, 102 mm]
Typical gun swell	0.22 in. [5.6 mm]
Maximum shot density	6 spf [19 spm]
Maximum pressure	20,000 psi [138 MPa]
1-hr temperature rating*	280°F [138°C]
10-hr temperature rating*	260°F [127°C]

*Exceeding maximum temperature ratings can result in unintentional detonation.

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