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Strategic Petroleum Reserve Cavern Leaching Monitoring CY21

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ABSTRACT

The U.S. Strategic Petroleum Reserve (SPR) is a crude oil storage system administered by the U.S. Department of Energy. The reserve consists of 60 active storage caverns located in underground salt domes spread across four sites in Louisiana and Texas, near the Gulf of Mexico. Beginning in 2016, the SPR started executing Congressionally mandated oil sales. The configuration of the reserve, with a total capacity of greater than 700 million barrels (MMB), requires that unsaturated water (referred to herein as "raw" water) is injected into the storage caverns to displace oil for sales, exchanges, and drawdowns. As such, oil sales will produce cavern growth to the extent that raw water contacts the salt cavern walls and dissolves (leaches) the surrounding salt before reaching brine saturation.

SPR injected a total of over 45 MMB of raw water into twenty-six caverns as part of oil sales in CY21. Leaching effects were monitored in these caverns to understand how the sales operations may impact the long-term integrity of the caverns. While frequent sonars are the most direct means to monitor changes in cavern shape, they can be resource intensive for the number of caverns involved in sales and exchanges. An intermediate option is to model the leaching effects and see if any concerning features develop.

The leaching effects were modeled here using the Sandia Solution Mining Code, SANSMIC. The modeling results indicate that leaching-induced features do not raise concern for the majority of the caverns, 15 of 26. Eleven caverns, BH-107, BH-110, BH-112, BH-113, BM-109, WH-11, WH-112, WH-114, BC-17, BC-18, and BC-19 have features that may grow with additional leaching and should be monitored as leaching continues in those caverns. Additionally, BH-114, BM-4, and BM-106 were identified in previous leaching reports for recommendation of monitoring.

Nine caverns had pre- and post-leach sonars that were compared with SANSMIC results. Overall, SANSMIC was able to capture the leaching well. A deviation in the SANSMIC and sonar cavern shapes was observed near the cavern floor in caverns with significant floor rise, a process not captured by SANSMIC. These results validate that SANSMIC continues to serve as a useful tool for monitoring changes in cavern shape due to leaching effects related to sales and exchanges.

ACKNOWLEDGEMENTS

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ACRONYMS AND TERMS

Acronym/Term	Definition
bbl	barrel (of oil); 1 bbl = 42 gal (US) ≅ 0.158987 m^3
BH	Big Hill site
BM	Bryan Mound site
CAVEMAN	cavern management software; tracks fluid movements and cavern pressures
CY	calendar year
EOT	depth of end of brine string tubing
EP	period of equilibration during which leaching occurs
MB	thousand barrels
MMB	million barrels
Max Mod OBI_i	Maximum Modified Initial Oil Brine Interface; the deepest initial OBI in all leaching phases auto selected by the SANSMIC code
Min OBI_f	Minimum Final Oil Brine Interface; the shallowest final OBI in all leaching phases
Mod EOT	Modified End of Tubing; End of Tubing auto selected by the SANSMIC code
OBI	oil-brine interface
SANSMIC	Sandia solution mining code
SPR	Strategic Petroleum Reserve
WH	West Hackberry site

1. INTRODUCTION TO CAVERN LEACHING MONITORING

The U.S. Strategic Petroleum Reserve (SPR) is a crude oil storage system run by the U.S. Department of Energy (DOE). The reserve consists of 60 active storage caverns spread across four sites near the Gulf of Mexico. The Big Hill (BH) and Bryan Mound (BM) sites are located in Texas, and the Bayou Choctaw (BC) and West Hackberry (WH) sites are located in Louisiana. The fall 2021 storage capacity of the SPR is 714 million barrels (MMB).

The purpose of the SPR, as it was designed, is to mitigate emergency supply disruption of crude oil within the U.S. and to also fulfill International Energy Agency treaty obligations. Because of the large size of the reserve, brine drive has never been a part of the SPR; instead, oil is withdrawn – or drawn down – using raw water. Raw water is local surface water that is fresh to saline in its salt content and is highly undersaturated when compared to (fully saturated) brine and readily available at rates necessary to support drawdown.

With respect to the SPR, when a cavern is fully emptied of oil all at once it is referred to as a full drawdown. When only part of the oil within a cavern is removed followed by an extended waiting period, then it is called a partial drawdown. While a full drawdown may have short breaks between oil removal activities, or delivery batches, multiple partial drawdowns can be identified by the presence of waiting periods that are long enough that the brine sump equilibrates back to a fully saturated state.

1.1. Partial Drawdowns Used to Deliver Oil for Sales and Exchange for Storage

The SPR is currently involved in crude oil sales mandated by Congress. To sell oil from the reserve, oil is withdrawn using water displacement where water is injected into the cavern pushing oil out of it (Figure 1-1). Additionally, in 2020, oil was received as temporary fill and later drawn down as part of the Exchange for Storage program; oil was withdrawn in the same manner as for congressionally mandated sales. "Raw" drive water for SPR is obtained from naturally occurring surface water near the sites and is not saturated with brine. As such, raw water injection reduces the salinity of the brine in the cavern below the oil. The now-undersaturated brine in contact with the cavern walls dissolves the salt at the cavern walls, and this process constitutes cavern leaching.

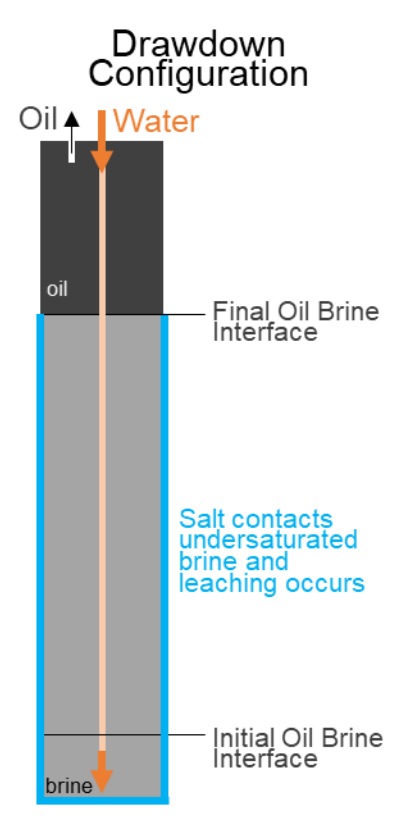

Figure 1-1. Schematic of drawdown configuration which results in cavern wall leaching.

The impact of leaching on cavern shape depends on the type of leaching that occurs. Sales generally involve partial drawdowns of the oil inventory in several caverns. The leaching pattern for a single-phase partial drawdown generally involves a "flare" pattern with the greatest growth at the depth of the end of the brine string tubing (EOT) that tapers up to the final oil-brine interface (OBI) depth (Figure 1-2) [1][8]. This pattern reflects the concentration of salt in the injected water over time, as the well-mixed brine in the region between the EOT and OBI is lower in concentration compared to the rest of the cavern brine—with greater exposure times to undersaturated brine near the EOT, there is a resultant greater radial growth. If the EOT is relatively high above the cavern floor, the flared part of the cavern is not at the cavern floor and a feature, referred to here as a shelf, may form.

Many SPR caverns have multiple phases of leaching and the final leaching pattern depends on the cumulative effects for all phases. This report shows that caverns with multiple leaching phases have a range of leaching outcomes which deviate from the single-phase flare pattern and are difficult to predict *a priori* from any single metric. Thus, SANSMIC modeling was particularly helpful in understanding the potential leaching outcomes for these caverns.

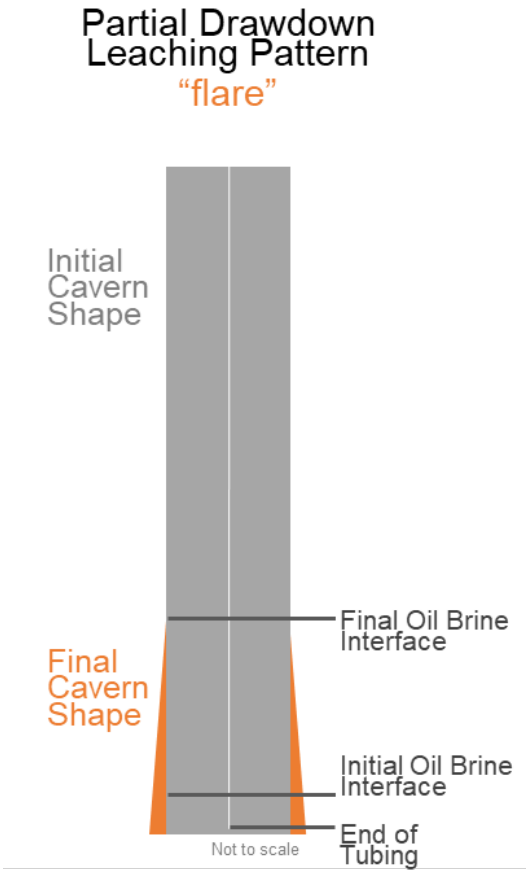

Figure 1-2. Schematic of leaching pattern from a partial drawdown.

Longer time exposure to brine with undersaturated salt concentrations will produce the greatest leaching of the salt walls and corresponding radial growth of the cavern. Thus, the greatest radial growth for a partial drawdown is at the depth of the end of tubing, as shown schematically by the difference in position between the pre- (grey) and post- (orange) cavern shapes.

A full drawdown, while still having more leaching at the bottom of the cavern than the top, is sufficiently fast that the entire cavern sees relatively more evenly distributed leaching in terms of changing cavern radius. The contrast between the resulting cavern geometry for a cavern undergoing a full drawdown and one that exhibits "flaring" due to partial drawdowns can be quite dramatic, particularly when a cycle of small partial drawdowns followed by refilling the cavern results in the "flare" being applied multiple times at the same depth.

1.2. Review Leaching History in Sonars

The actual leaching history for each cavern participating in 2021 sales was examined here by comparing past sonars. This comparison was used to understand if historically leaching has occurred in the caverns and if it was radial or asymmetric. If it was generally radial in the past, it may also be radial in the future. An example leaching history is shown in Figure 1-3 for BH-101. Sonars taken in well A from 2000 and 2012 are shown on the left, with the surface color coded by depth with blue being the deepest. A comparison of vertical cross sections through each sonar are shown in the middle, with the 2000 sonar represented by the blue line and the 2012 sonar represented by the orange line. The change in vertical profile from 2000 (blue) to 2012 (orange) in this cavern indicates

that the cavern floor has risen 50 ft between sonars and the base of the cavern has spread radially. The radial spread at particular depths of 4050' and 3800' are shown in the later cross sections which again compare the 2000 (blue) and 2012 (orange) cavern extents. The depths of the lateral cross sections were chosen to illustrate the change in radius of different parts of the cavern. At both depths in this cavern, the leaching pattern looks to be approximately radial: a relatively simple radial extension of the 2000 profile (blue) reaches out to the 2012 (orange) profile. And based on this information, it would be expected that any water injected after the 2012 sonar would continue to leach the cavern relatively symmetrically.

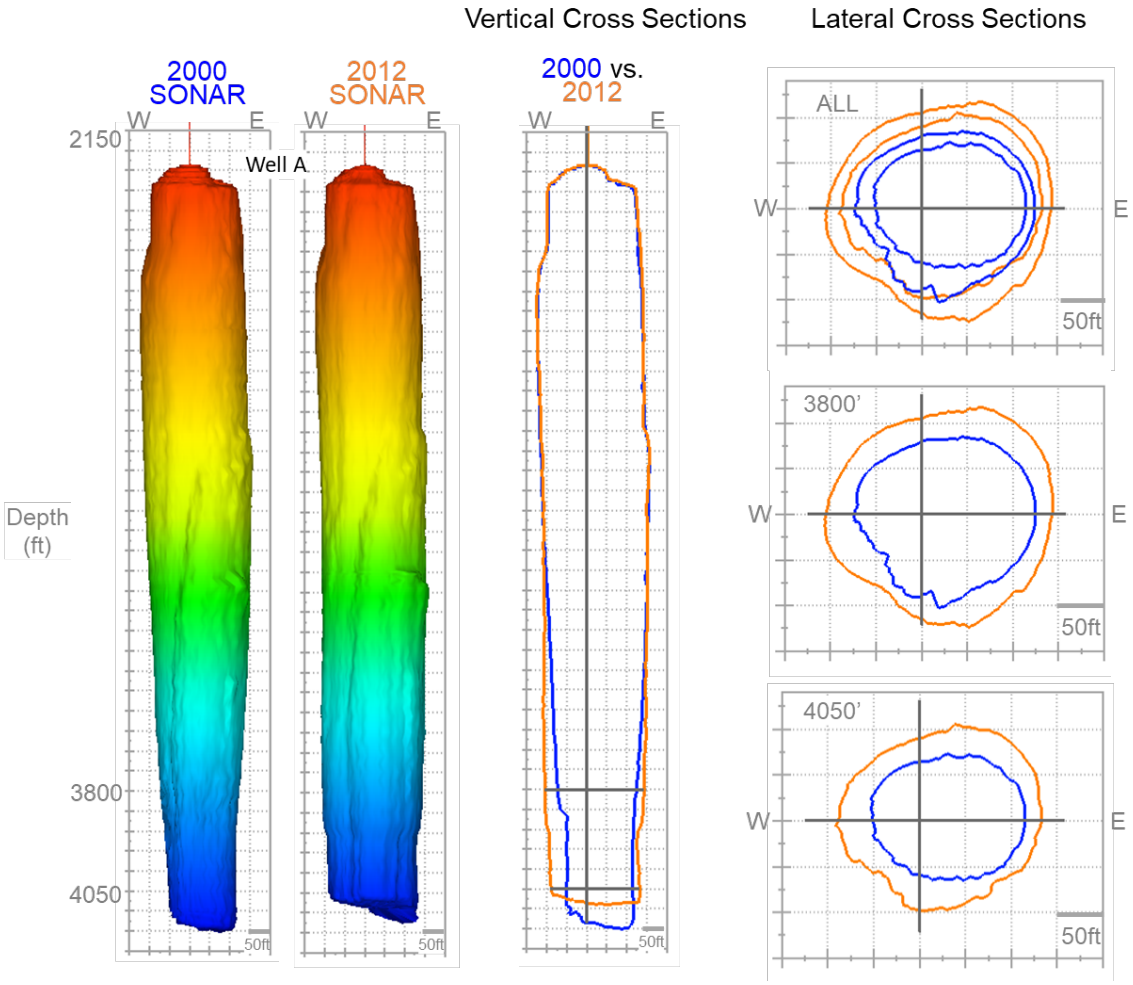

Figure 1-3. Example leaching history for BH-101.

1.3. Monitor Partial Drawdown Leach Effects Using SANSMIC

Changes in cavern shape may impact the integrity of the cavern over time if features are introduced into the cavern geometry that concentrate stress. The most direct means to monitor for adverse leaching effects on the caverns is to take regular sonar measurements of the cavern geometry; however, this is resource intensive and may not be necessary for all caverns. Instead, leaching effects are being modeled in all sales caverns to predict changes in caverns which may be less geomechanically favorable. These simulations can then inform decisions regarding the choice of caverns to sonar to direct limited resources where they are needed most to ensure long term cavern integrity while executing mandatory sales.

Leaching effects are modeled with the **San**dia **S**olution **Mi**ning **C**ode (SANSMIC) [9]. SANSMIC was developed in the early 1980's to model the effects of leaching on the cavern shape and volume. The code uses standard salt dissolution models that account for the salinity of the injected water, temperature, and flow velocity [9]. Simulations use sonar derived cavern shapes at the start of the simulation, the actual casing depths, and the field-reported injected water volumes. The model computes the effects of leaching on cavern shape and volume, treating the cavern as a stack of cylindrical disks and limiting leaching to cavern depths below the OBI. The OBI moves as fluids are moved into the cavern.

SANSMIC was validated for conventional leach (both direct and reverse) capabilities by comparison with cavern creation data [10]. Subsequent comparisons between SANSMIC modeled cavern geometries and sonar measurements following the 2011 oil sale and subsequent remedial leach activities indicated the simulated cavern radius is within 5% of the measured cavern radius and the leached volumes are within 10% [1]. A re-validation of SANSMIC in withdrawal, direct and reverse leach modes for caverns leached by SPR indicated that simulated radial profiles match sonar observations within 1.5% - 12 % and the observed leach volume was simulated within 1% -13% [4].

It is important to note that, after discussion with sonar vendors, Sandia uses an assumed volumetric accuracy for a sonar survey of ±1% of the volume. With older sonar surveys, irregularly shaped caverns, and with very wide caverns, the error bounds increase. SANSMIC predictions also depend on the vertical resolution of the input cavern geometry; EOT depths, OBI depths, and final depths are rounded to the nearest cell boundary, which can impact results depending on the cell size chosen. For SANSMIC calculations performed for prior leaching reports [6][8][12], the vertical resolution of 10-ft was used. In this report, for SANSMIC calculations performed based on sonars that were not used for baseline cavern geometries in previous reports, vertical resolution of 1-ft was used.

SANSMIC simulations start from a known cavern geometry, EOT and OBI depths, and injected water volumes. The cavern geometry is usually taken as the last sonar prior to injection. A 2-D, axisymmetric representation of the cavern geometry with an equivalent cavern volume is then calculated and used as the initial geometry. A comparison is shown in Figure 1-4 of the 3D sonar (blue lines) and the 2D axisymmetric representation (orange lines) for BH-101. For this cavern, the lateral cross sections show that the circular cross section assumption was likely a reasonable approximation as the cavern only has small variations from circular.

The EOT and OBI depths are taken from the weekly site reports, however they are included in SANSMIC as a distance above the cavern floor, herein called a rise, rather than a depth. SANSMIC automatically modifies the value (in part, based on rounding the input rise values in order that they land on a cell edge) for the EOT and OBI and those values are referred to as mod EOT rise and mod OBI rise (SANSMIC also includes the injection rate in the calculation of mod EOT).

The daily raw water injection amounts are taken from CAVEMAN and daily site reports and phases of water injection are identified. For each phase (period of time), an average injection rate is calculated from the daily rates over the stage duration. This approach is illustrated in Figure 1-5 for BH-101. For phase 1, there were 5 days of injection in 2014 for a total of 53,697 bbl. That was modeled as a 5-day long injection with 10,739 bbl injected each day. SANSMIC results appear sensitive to monthly variations, hence the phases, but insensitive to daily variations, hence an average rate used for each day. For 2021 oil sales in caverns participating in spring and fall oil sales, a separate phase was included for spring and fall sales, whereas in previous reports, the spring and fall sales were sometimes combined.

Leaching occurs during and after injection, called the equilibration period (EP). The EP is generally chosen as 60 days to ensure the simulations have enough time to reach equilibrium as indicated by the specific gravity of the fluid in the outlet reaching a value of 1.2, the expected value for fully saturated brine (temperature dependent) [11]. The injection history is therefore composed of injection periods followed by equilibration periods as shown in Figure 1-6. The simulation results are evaluated using the efficiency of the leach, the ratio of the change in cavern volume to the volume of injected water, which is expected to be around 15% (the exact value is dependent on the initial specific gravity and the cavern temperature).

The final cavern geometry after leaching was modeled and compared with the pre-leaching geometry to understand the leaching effects from CY21 water injection. An example is shown in Figure 1-7 for BH-101. The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar, which is the SANSMIC input, is shown in orange, and the SANSMIC output is shown in magenta and titled '2020 SANSMIC prediction'. The volume of injected water that led to the leaching pattern is shown with a grey arrow, in this case 1.0 MMB.

Vertical cross sections from each of the cavern geometries reveal the general changes from leaching, which are the slight radial spread of the cavern floor in this case. The character of that radial spread at a given depth is also seen in the lateral cross sections.

Caverns were selected for CY21 SANSMIC modeling based on the criteria that at least 10,000 bbls of raw water had been injected in CY21 and there has been no sonar subsequent to the final raw water injection. The modeling results for the 24 caverns that met those criteria are described in Section 2. Additionally, there are 9 caverns for which sonars were taken in 2021[1], allowing for comparison with the latest SANSMIC modeling prior to the sonar. Those comparisons are described in Section 3. For BH-111 and BM-110, each cavern had at least 10,000 bbls of raw water injection in 2021 and a 2021 sonar, so they are included in both Sections 2 and 3.

[1] For BM-104, a sonar was taken in 2021, but results were not yet available at the time this report was drafted.

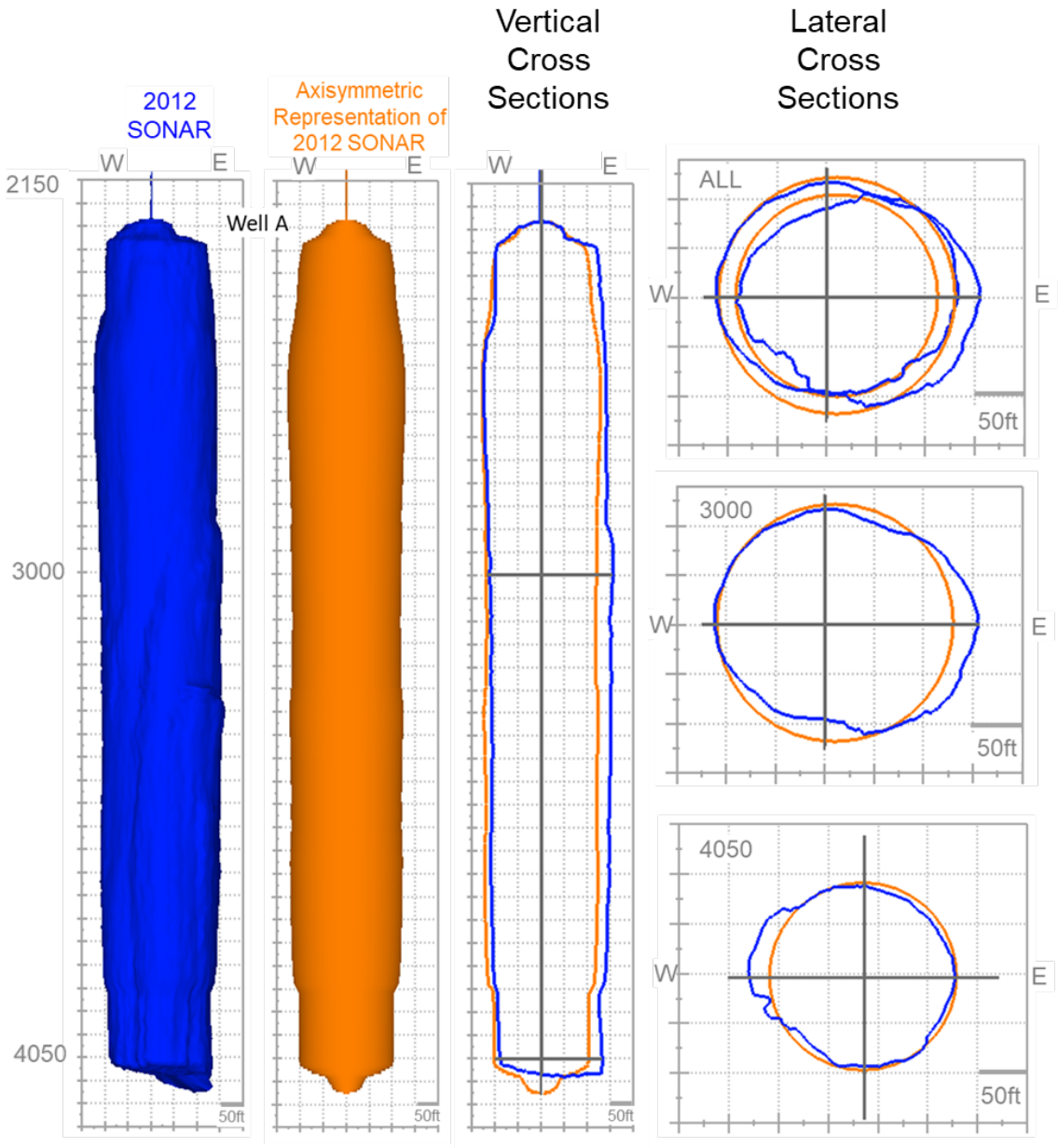

Figure 1-4. Example of 2D axisymmetric representation (orange) of 3D cavern geometry (blue) for BH-101.

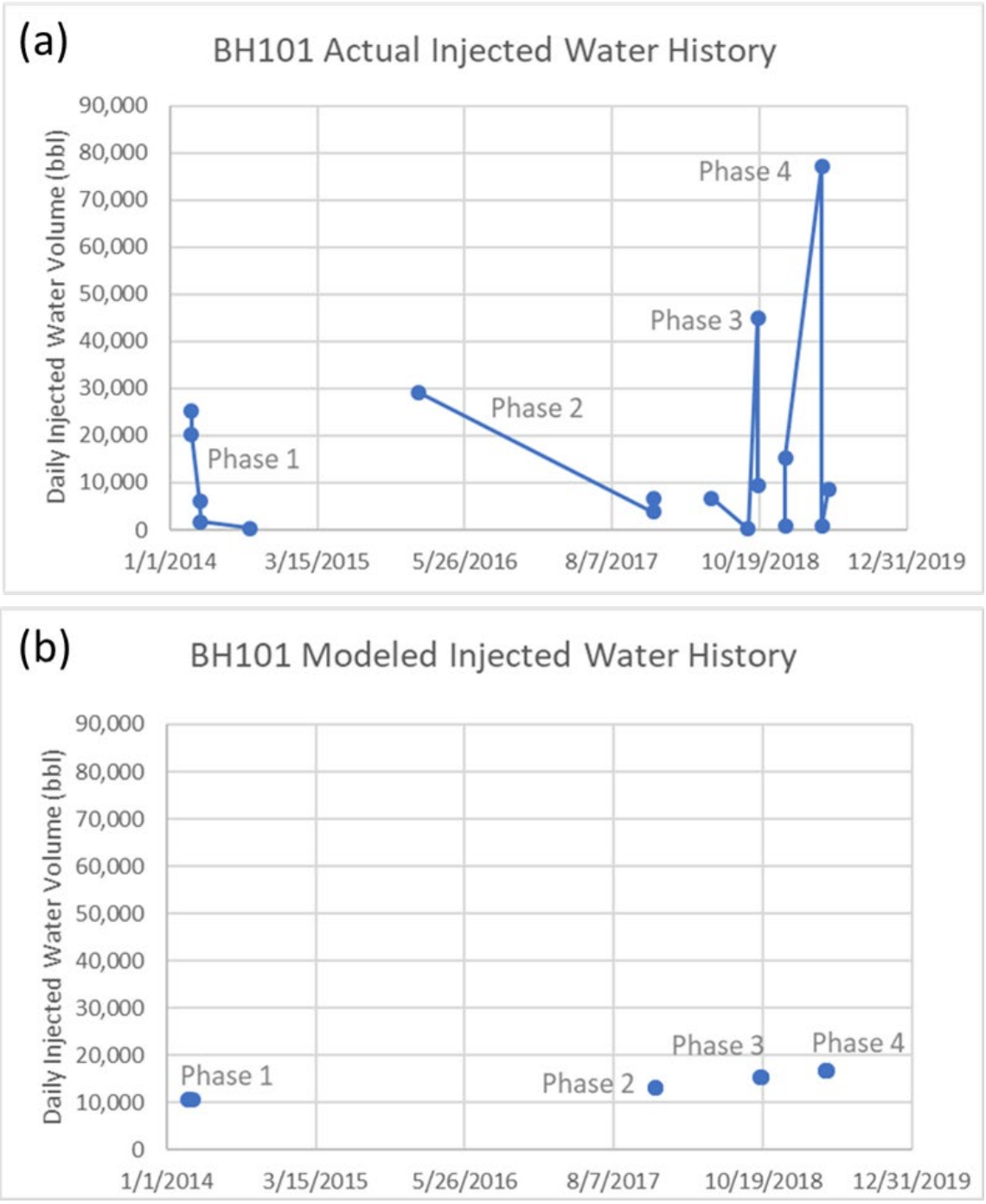

Figure 1-5. Example of (a) actual and (b) modeled injected water history for BH-101.

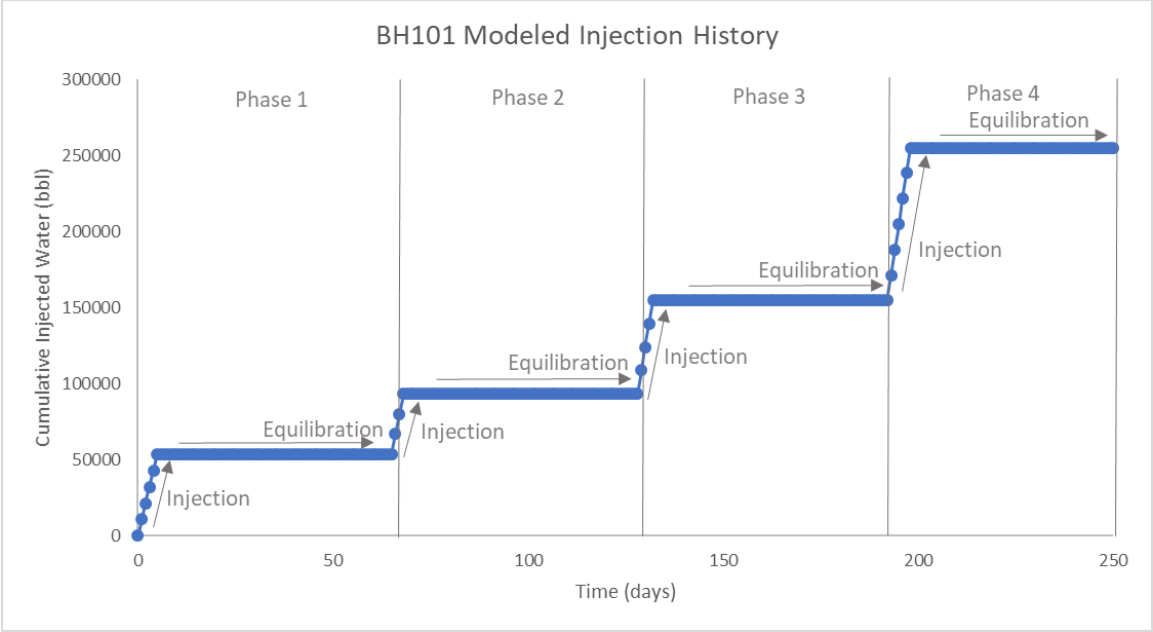

Figure 1-6. Example of modeled injection history for BH-101 showing injection and equilibration periods.

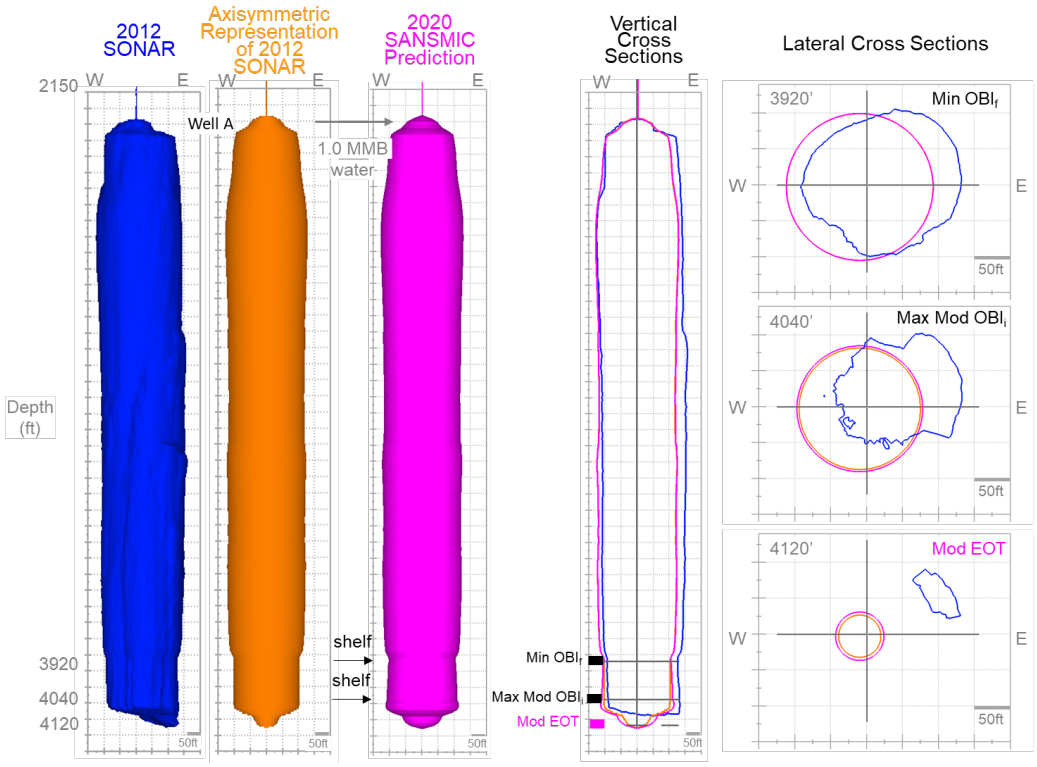

Figure 1-7. Example model results for BH-101.

2. SIMULATED CAVERN LEACHING RESULTS FOR CY21

Water was injected into caverns at all four sites in CY21. Leaching was simulated for caverns at all sites and the results are described in Sections 2.1 (Big Hill), 2.2 (Bryan Mound), 2.3 (West Hackberry), and 2.4 (Bayou Choctaw).

2.1. Big Hill

Simulation results for Big Hill are summarized in Table 2-1, including the volume of raw water injection simulated with SANSMIC modeling and any potential concerns observed. Eight caverns had at least 10 MB of raw water injected in CY21. Two of those caverns have had at least 3 MMB of raw water injected since the last sonar. While most caverns do not have a leaching induced feature of concern at this time, four caverns, BH-107, BH-100, BH-112, and BH-113, have features which should be monitored as leaching continues in those caverns.[2] A brief leaching history and the results of SANSMIC modeling of leaching since the last sonar are discussed below for each cavern.

Table 2-1. Caverns at Big Hill with water injected in CY21.

Cavern	Last Sonar	Injected Water Volume (MMB)*	Concerns
BH-106	2015	4.0	No
BH-107	2019	2.6	Monitor flare near cavern floor
BH-108	2019	1.9	No
BH-109	2020	0.50	No
BH-110	2020	4.2	Monitor flare near cavern floor
BH-111	2021	1.7	No
BH-112	2015	0.099	Monitor flare near cavern floor
BH-113	2015	0.33	Monitor flare near cavern floor

* Since last sonar

[2] Although it did not participate in CY21 oil sales, the cavern BH-114 was identified in the CY20 leaching report [12] as recommendation for monitoring.

2.1.1. BH-106

2.1.1.1. Leaching History

Sonars taken in the A well of BH-106 in 2005 and 2015 are shown in Figure 2-1. There was 0.14 MMB of water injected into this cavern between sonars which resulted in little change to the cavern shape.

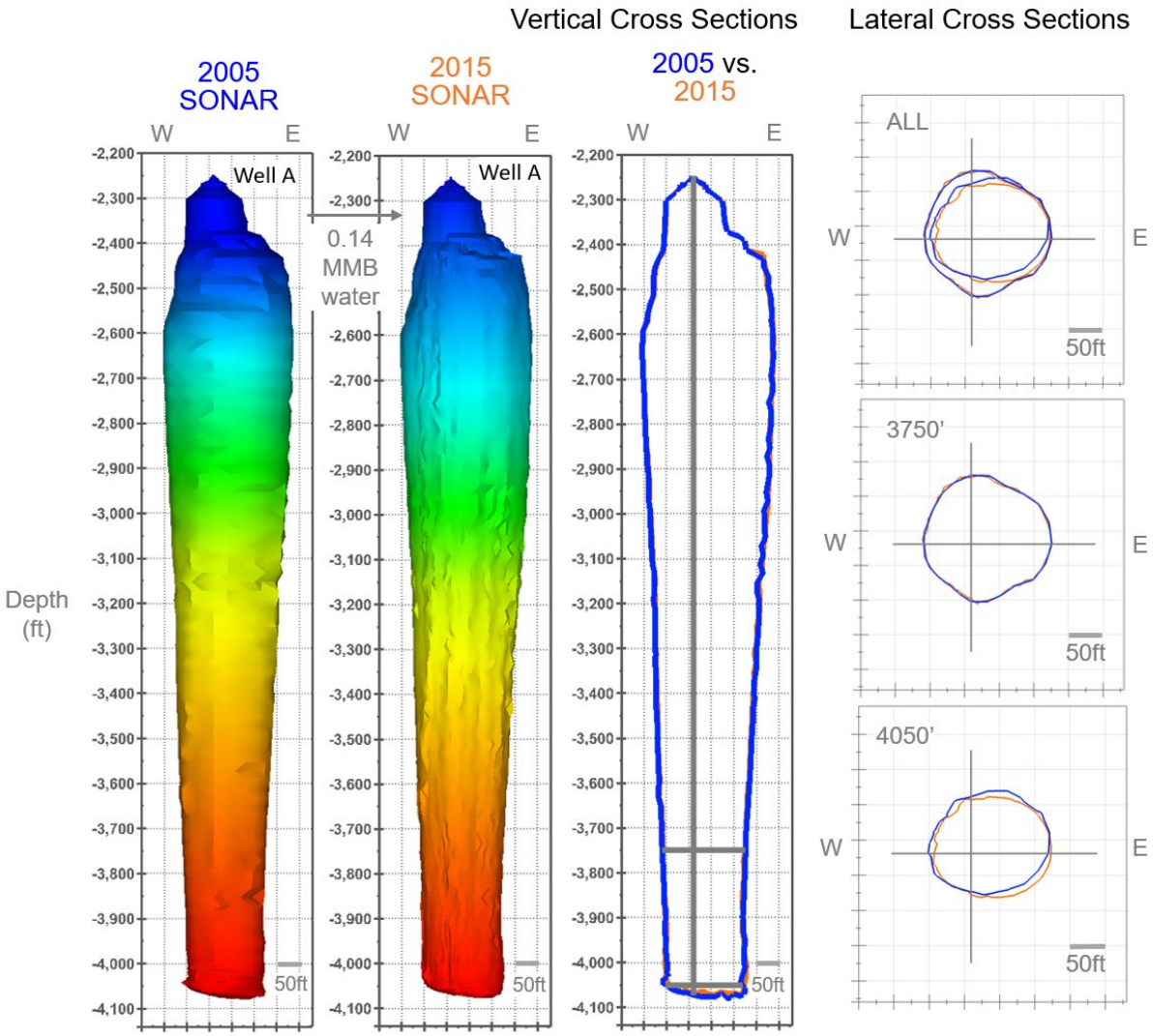

Figure 2-1. Leaching history in BH-106 from 2005 (blue) to 2015 (orange) via sonars in well A.

2.1.1.2. Simulated Leaching Between 2015 Sonar and End of CY21

The last sonar taken in BH-106 was in 2015. Since that sonar, 4.0 MMB of water have been injected into the cavern from 2017-2021 (see Table 2-2). The injection history was modeled as five phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the three phases modeled for the CY18-19 report [8]. This cavern has had two Mod EOT rises.

Table 2-2. Summary of Simulation Input for BH-106

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	11/09/17-12/07/17	4,105	24	20	45	50	17,197	29	498,713
2	05/30/18-12/17/18	4,105	31	30	178	180	12,191	96	1,170,336
3	05/12/19-05/13/19	4,105	24	20	435	440	16,798	5	83,990
4	05/24/21-05/25/21	4,105	40	30	447	450	33,709	2	67,418
5	10/03/21-12/14/21	4,105	40	30	Auto	460	29,818	73	2,176,744
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	205	3,997,201

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-3, the leaching efficiency for this cavern was 16.1%.

Table 2-3. Summary of Simulation Output for BH-106

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	180	1.1993	83,000	16.6
2	440	1.2001	194,000	16.6
3	450	1.2014	13,000	15.5
4	460	1.2015	10,000	14.8
5	820	1.1993	345,000	15.8
ALL	820	1.1993	645,000	16.1

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2015 sonar and the end of CY21 (see Figure 2-2). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 4.0 MMB.

Vertical cross sections from each of the cavern geometries reveal the general changes from leaching, which include a radial spread near the cavern floor. The spread can be seen by the variation between the input (orange) and output (magenta) cavern profiles in the lateral cross sections. Figure 2-3 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output.

Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-3) reveals a modeled leaching zone (see Figure 2-4) that is about 800 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be up to 20 ft near the EOT. Even with the notable increase in predicted cavern radius near the EOT, the simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

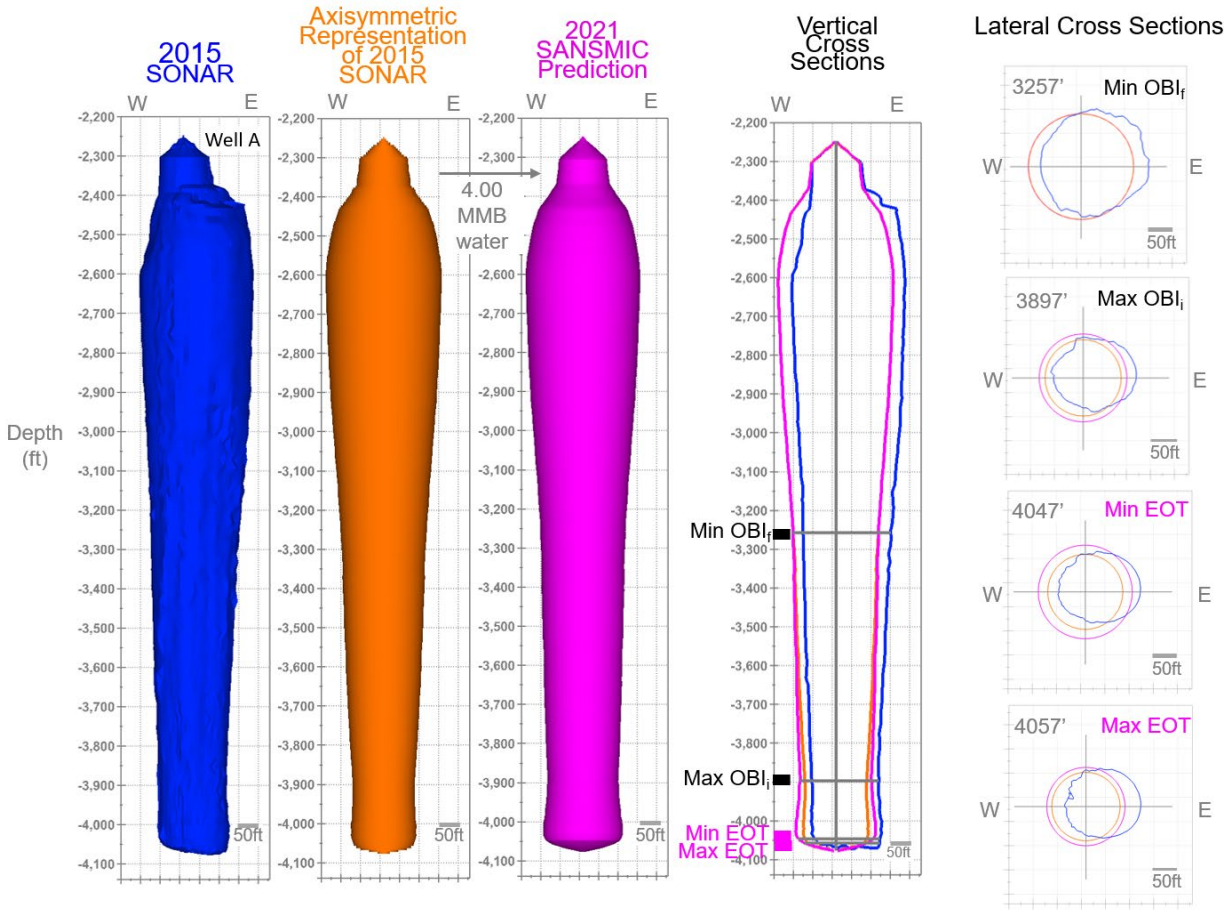

Figure 2-2. BH-106 modeling results for leaching between 2015 sonar and end of CY21.

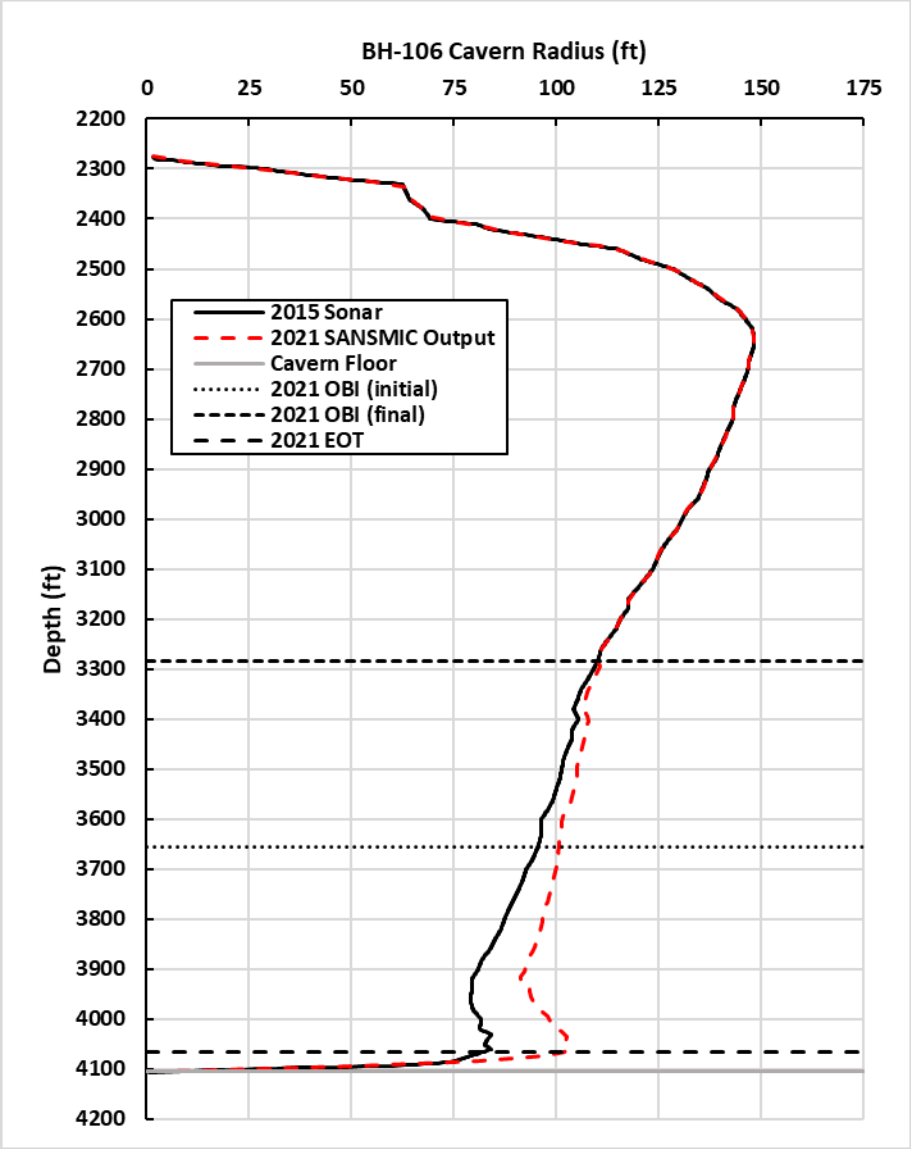

Figure 2-3. BH-106 axisymmetric representation of 2015 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

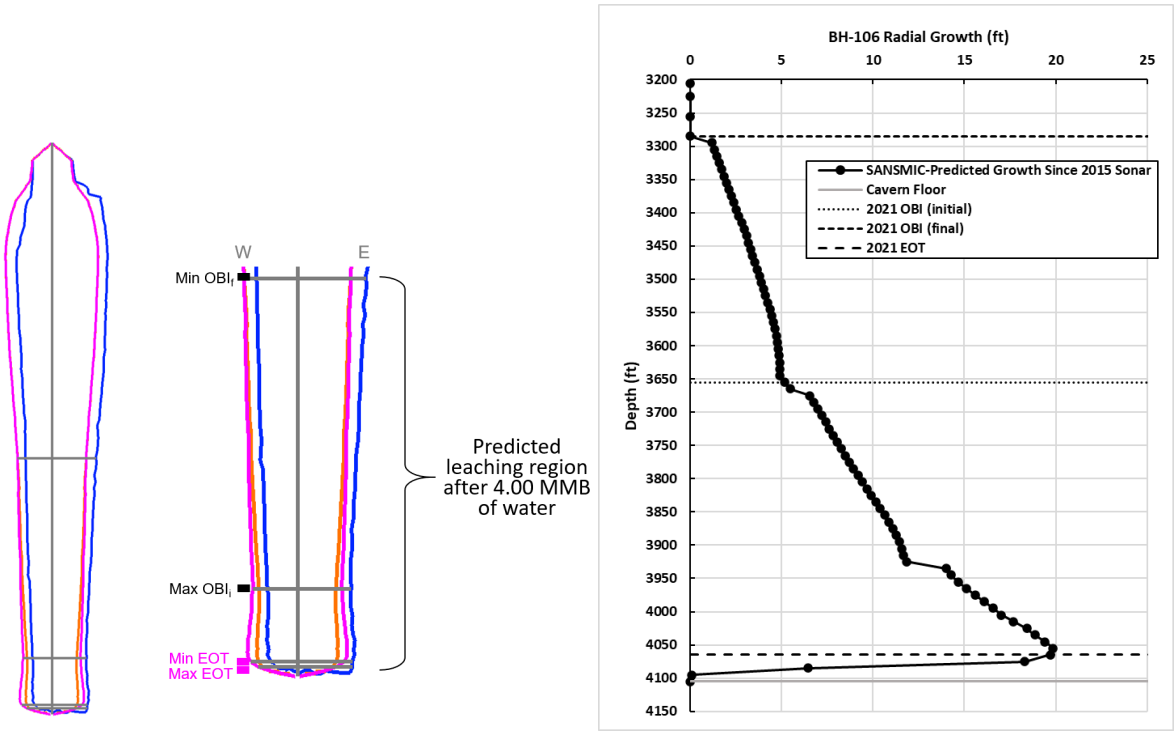

Figure 2-4. BH-106 SANSMIC-predicted radial growth since 2015 sonar.

2.1.2. BH-107

2.1.2.1. Leaching History

Sonars taken in the A well of BH-107 in 2010 and 2019 are shown in Figure 2-5. Floor rise and spread occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical cross sections. There was 2.9 MMB of water injected into this cavern between sonars which contributed to this change in cavern shape. Leaching was primarily radial from 2010 to 2019, but it concentrated in a small zone near 4020 ft depth. Continued growth of that feature could be geomechanically unfavorable.

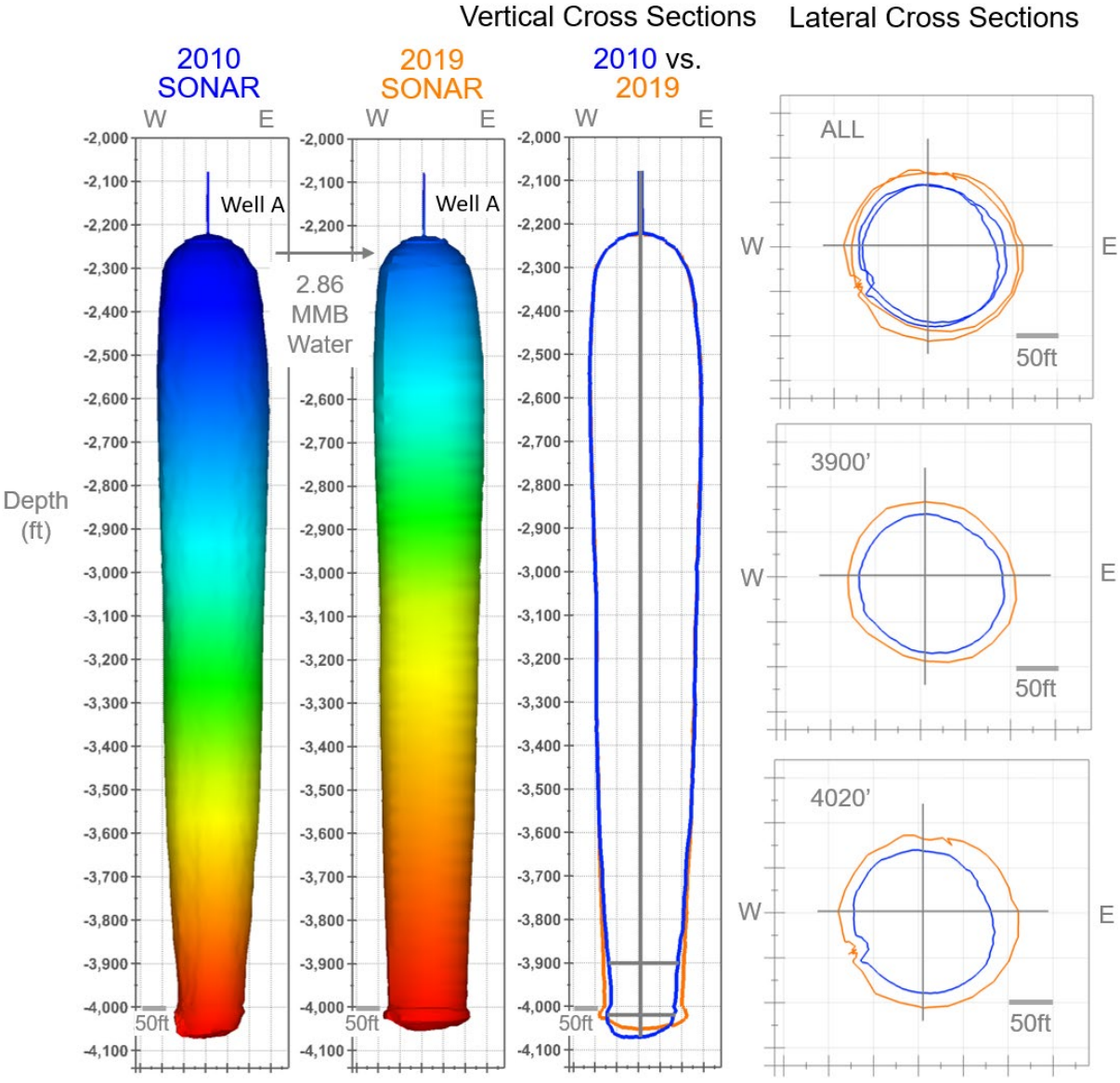

Figure 2-5. Leaching history in BH-107 from 2010 (blue) to 2019 (orange) via sonars in well A.

2.1.2.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BH-107 was in 2019. Since that sonar, 2.64 MMB of water have been injected into the from 2020-2021 (see Table 2-4). The injection history was modeled using three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the single phases modeled for the CY20 report [12].

Table 2-4. Summary of Simulation Input for BH-107

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/04/20-10/05/20	4,090	20	10	598	600	31,981	14	447,734
2	04/07/21-06/27/21	4,090	7	10	674	670	7,231	82	592,943
3	10/03/21-12/13/21	4,090	7	10	Auto	760	22,280	72	1,604,134
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	168	2,644,811

The final outlet SG was 1.200, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-5, the leaching efficiency for this cavern was 15.7%.

Table 2-5. Summary of Simulation Output for BH-107

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	670	1.200	67,000	15.0
2	760	1.201	93,000	15.7
3	990	1.200	254,000	15.8
ALL	990	1.200	414,000	15.7

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-6). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 2.64 MMB.

Vertical cross sections from each of the cavern geometries reveal the general changes from leaching, which include the slight radial spread of the cavern floor. The spread can be seen by the variation between the input (orange) and output (magenta) cavern profiles in the lateral cross sections. Figure 2-7 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-7) reveals

a modeled leaching zone (see Figure 2-8) that is about 1,000 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be a maximum of only about 5 ft. Monitoring of the flare feature observed near the floor in the 2019 sonar has been previously recommended [8][12]. The observed feature has grown in size with the modeled CY21 leaching. Continued monitoring of the flare is recommended.

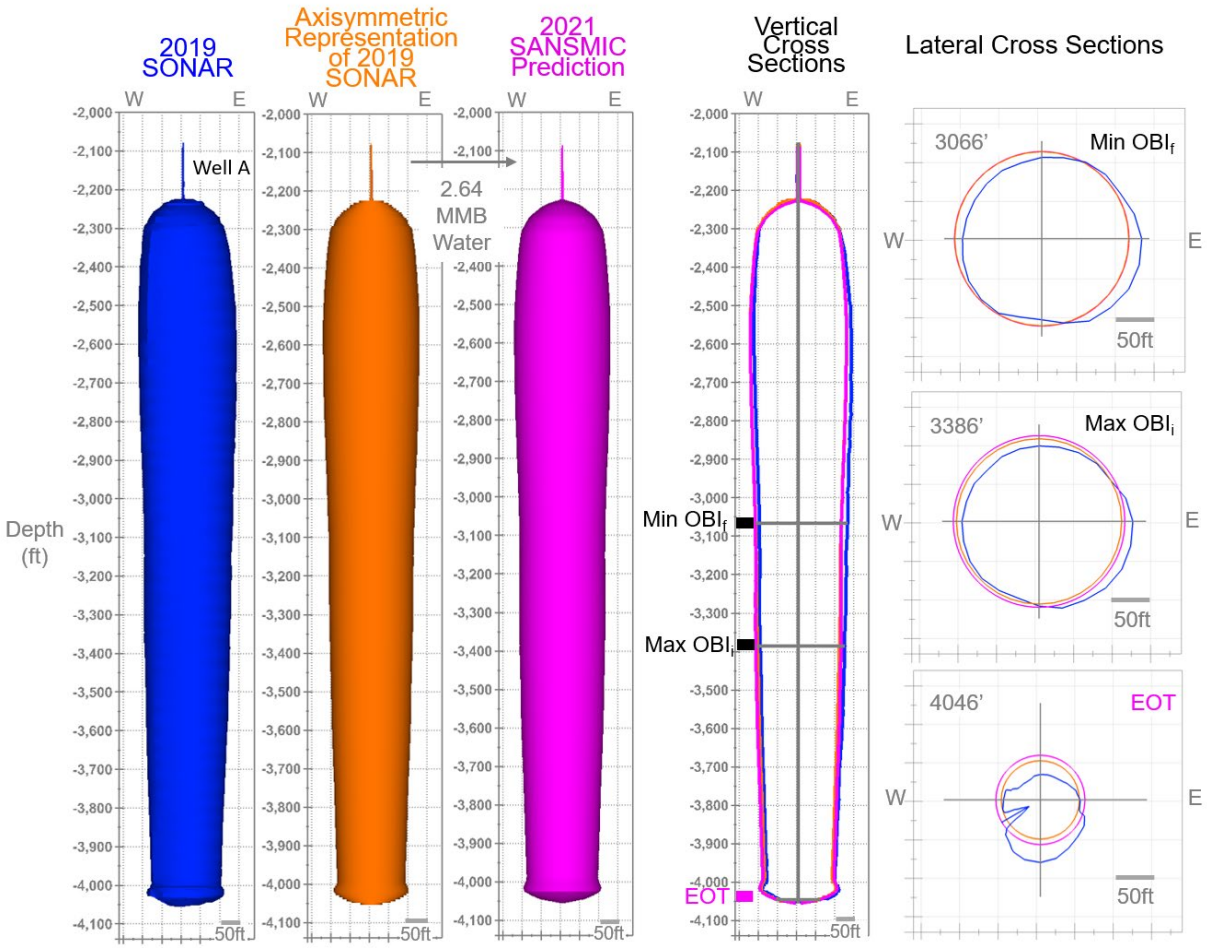

Figure 2-6. BH-107 modeling results for leaching between 2019 sonar and end of CY21.

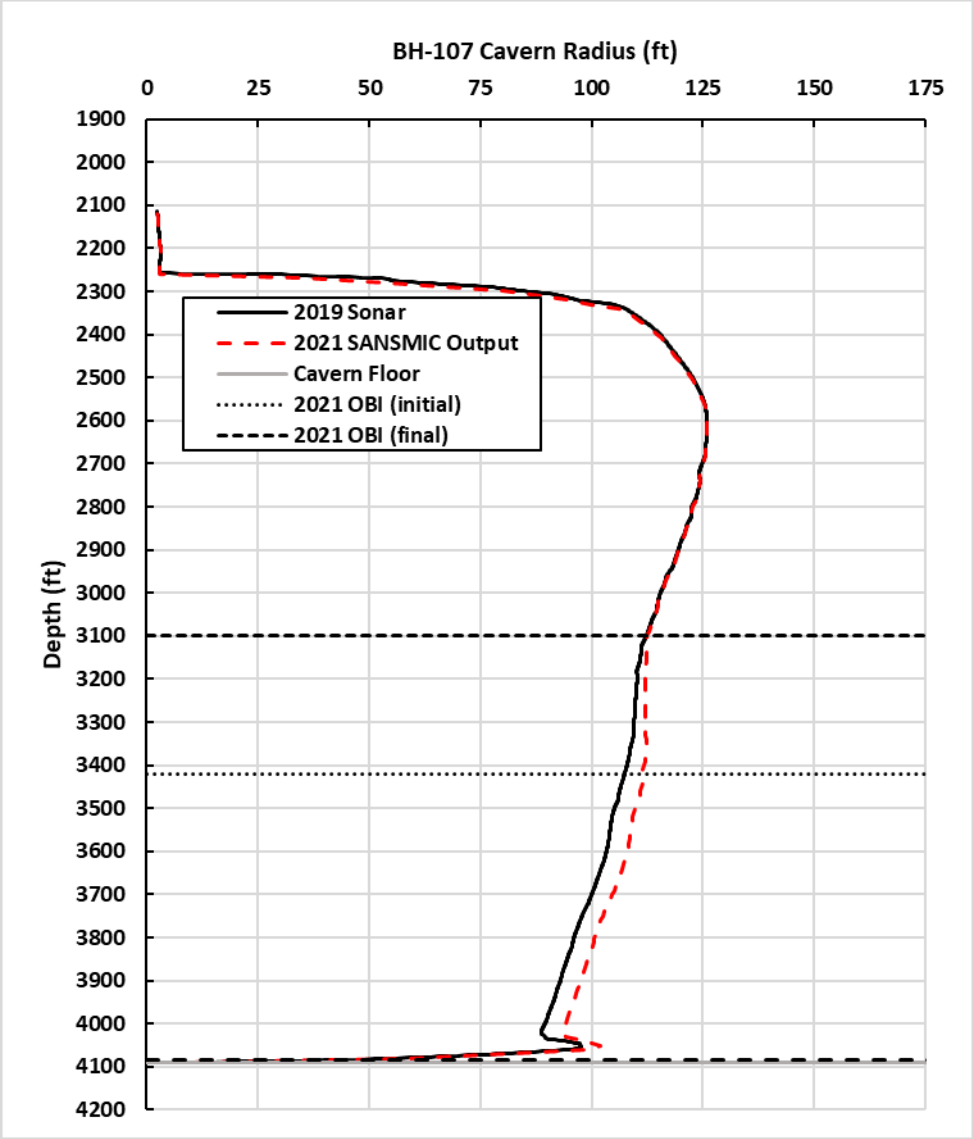

Figure 2-7. BH-107 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

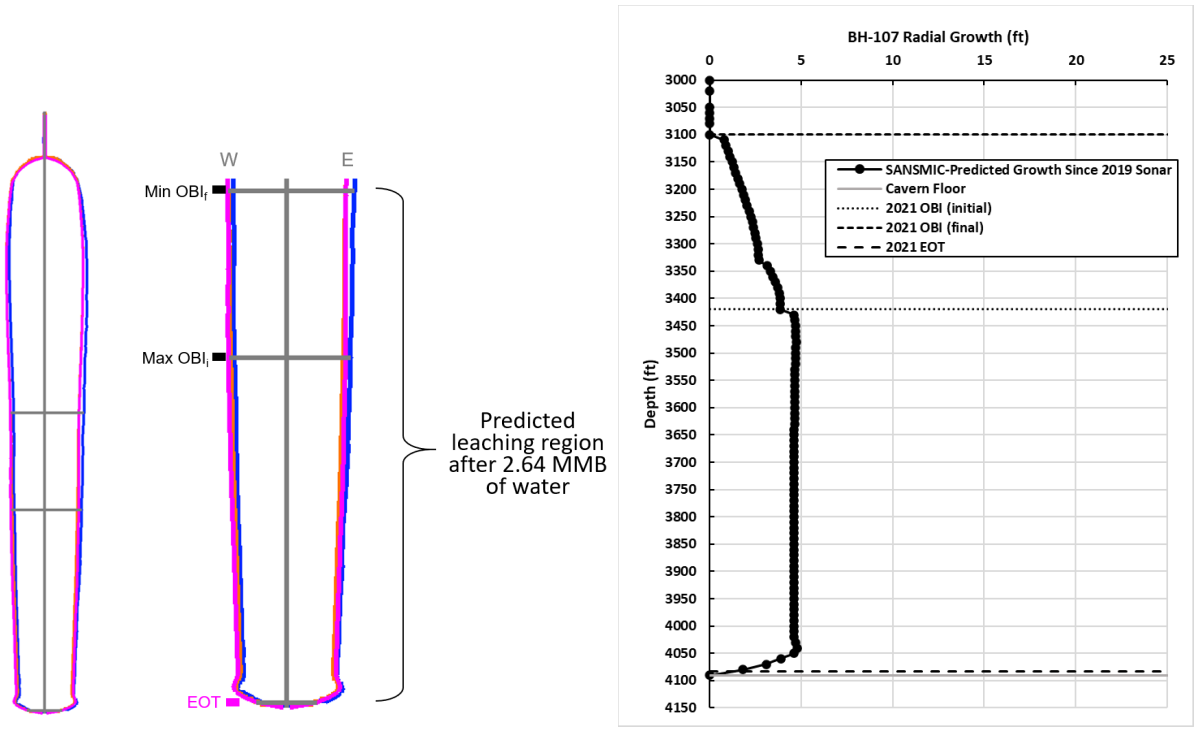

Figure 2-8. BH-107 SANSMIC-predicted radial growth since 2019.

2.1.3. BH-108

2.1.3.1. Leaching History

Sonars taken in the A well of BH-108 in 2015 and 2019 are shown in Figure 2-9. Floor rise occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 4.1 MMB of water injected into this cavern between sonars which contributed to some change in cavern shape. One notable feature in the lateral cross section at 4000 ft depth is the presence of two notches in the cavern wall in the northeast and southwest. These notches were not in the lateral cavern profile at 4000 ft depth in 2015 and may represent a geologic control on cavern leaching. That same feature is evident in both the 2015 and 2019 lateral cross sections at 3050 ft, suggesting that geologic control extends vertically along the cavern. Despite that feature, leaching was primarily radial from 2015 to 2019 suggesting radial leaching should be expected for the 1.9 MMB of water that was injected since the 2019 sonar.

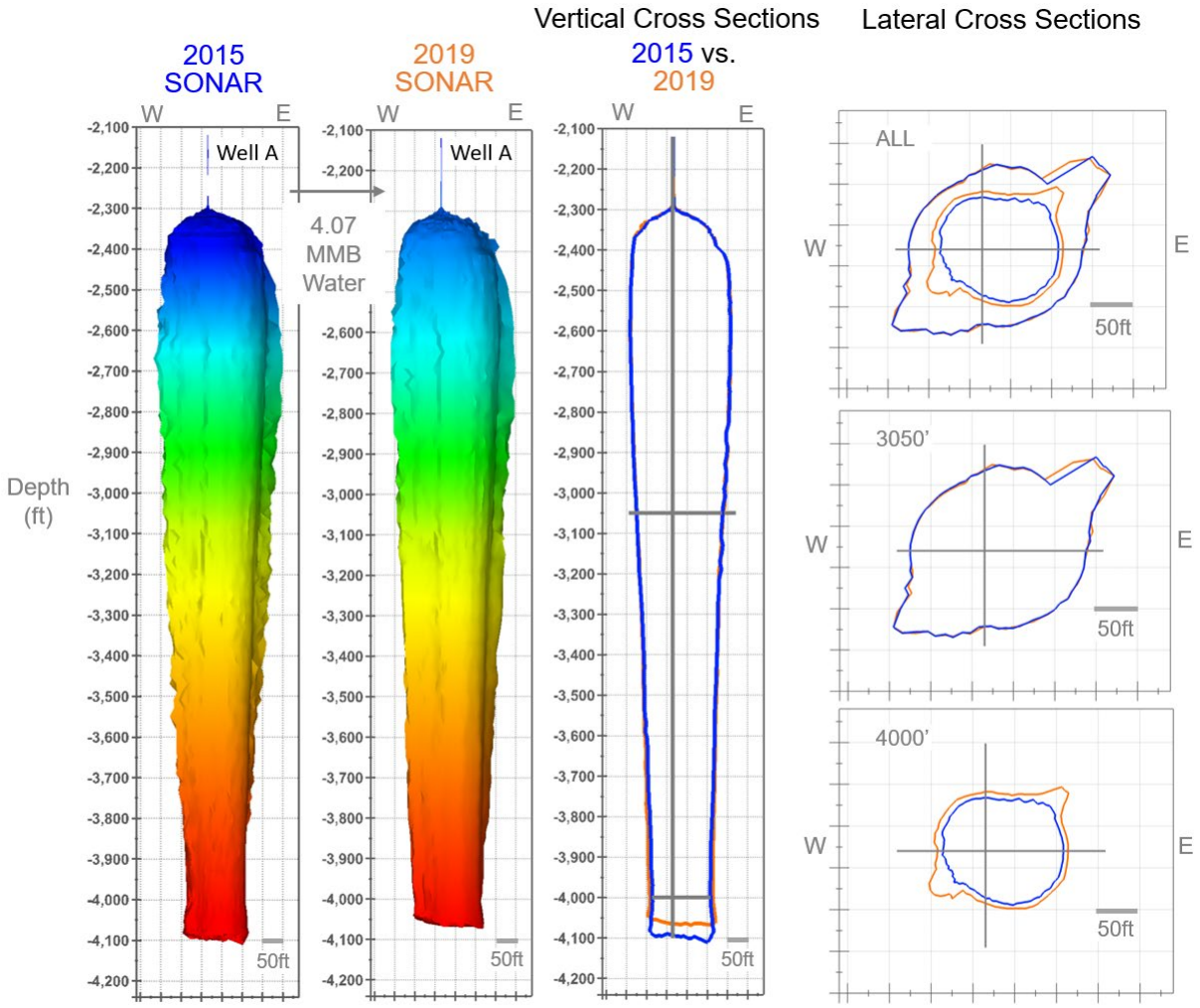

Figure 2-9. Leaching history in BH-108 from 2015 (blue) to 2019 (orange) via sonars in well A.

2.1.3.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BH-108 was in 2019. Since that sonar, around 1.9 MMB of water have been injected into the cavern from 2020-2021 (see Table 2-6). The injection history was modeled using three leaching phases with an EP of 60 days following each injection phase. To represent CY21 water injection, one phase was added to the two phases modeled for the CY20 report [12].

Table 2-6. Summary of Simulation Input for BH-108

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	01/23/20-01/30/20	4105	116	110	913	910	63,287	6	379,722
2	09/04/20-10/07/20	4105	116	110	959	960	30,415	15	456,225
3	04/07/21-07/14/21	4,105	29	20	1,033	1,030	10,696	99	1,058,929
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	1,894,876

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of the final EP. As summarized in Table 2-7, the leaching efficiency for this cavern was 15.5%.

Table 2-7. Summary of Simulation Output for BH-108

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	970	1.2003	57,000	15.0
2	1020	1.2003	69,000	15.1
3	1,170	1.2008	168,000	15.9
ALL	1,170	1.2008	294,000	15.5

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-10). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.9 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-11 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-3) reveals a modeled leaching zone (see Figure 2-12) that is about 1,000 ft tall and reflects the large

distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-3 ft. The results do not indicate any leaching-induced features which may be of concern for this cavern at this time.

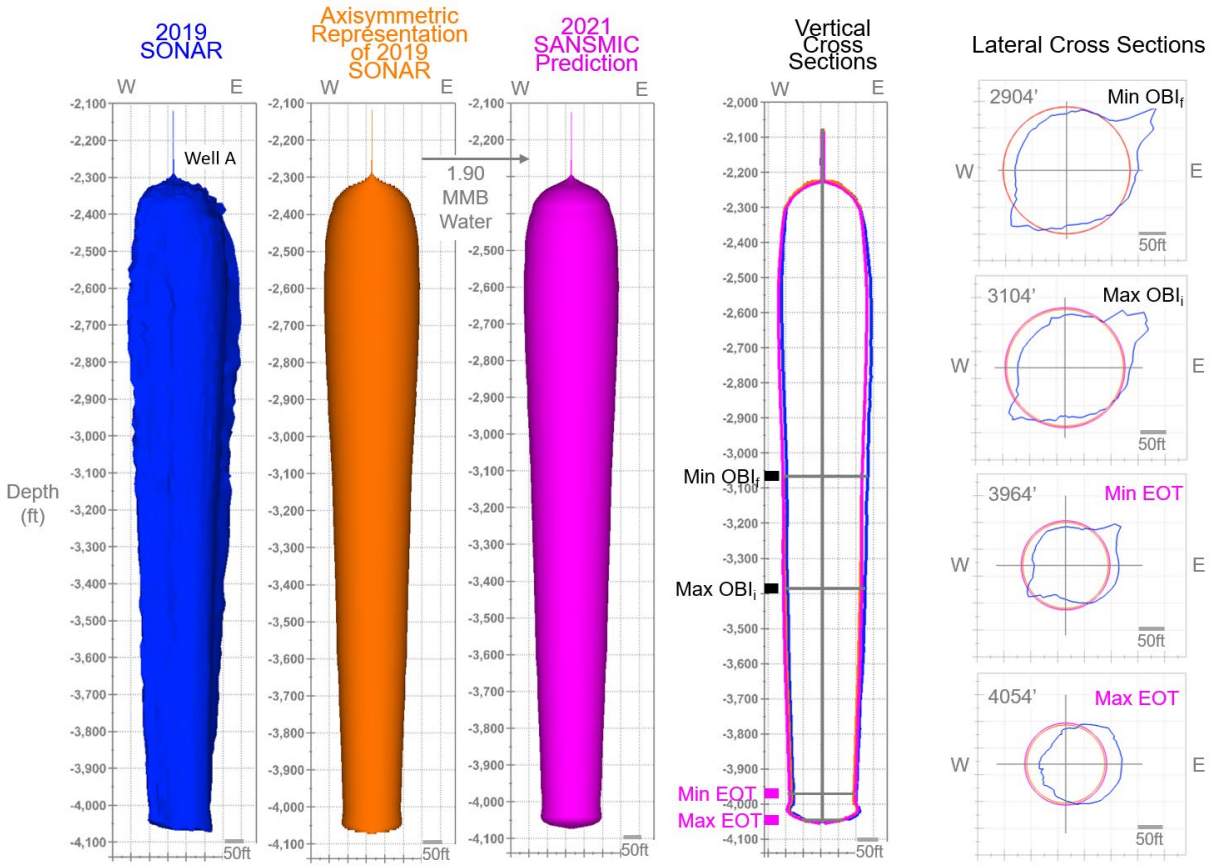

Figure 2-10. BH-108 modeling results for leaching between 2019 sonar and end of CY21.

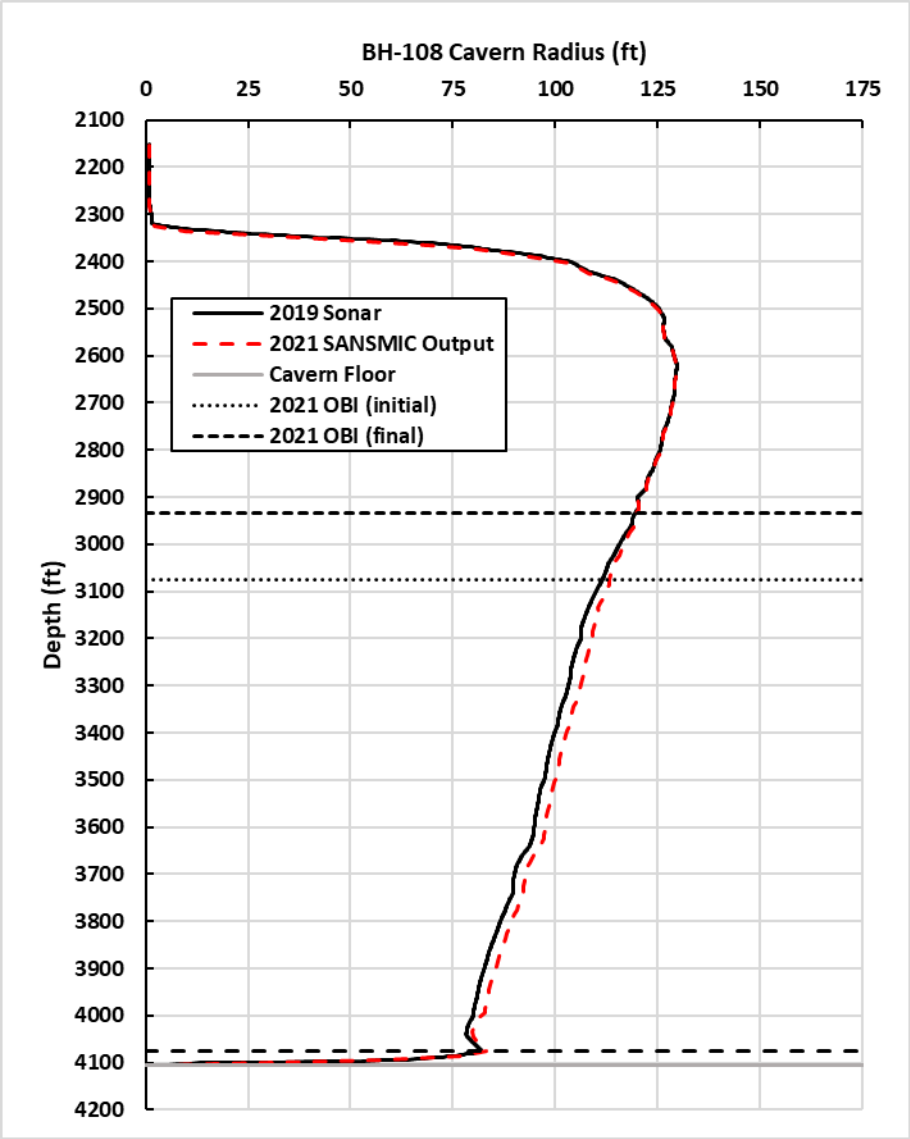

Figure 2-11. BH-108 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

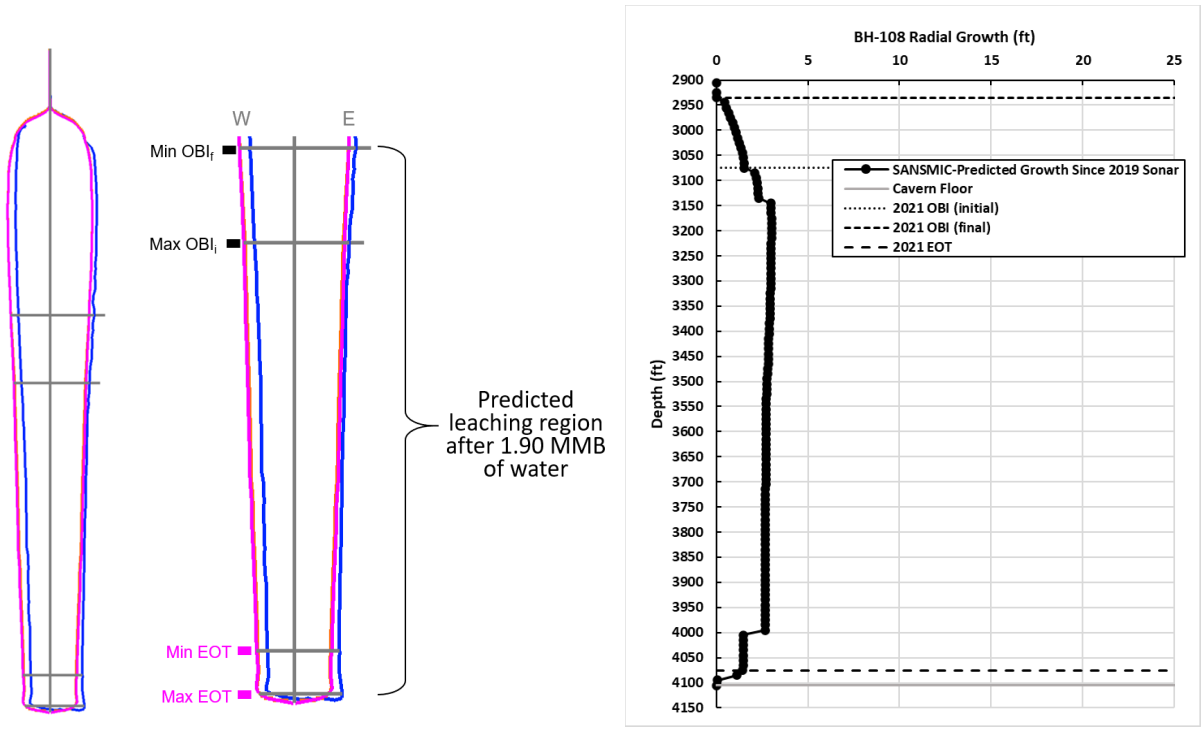

Figure 2-12. BH-108 SANSMIC-predicted radial growth since 2019 sonar.

2.1.4. BH-109

2.1.4.1. Leaching History

Sonars taken in the A well of BH-109 in 2015 and 2020 are shown in Figure 2-13. Floor rise occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 3.2 MMB of water injected into this cavern between sonars which contributed to the observed change in cavern shape. Leaching was primarily radial from 2015 to 2020, suggesting that radial leaching should be expected for the 0.50 MMB of water that has been injected since the 2020 sonar.

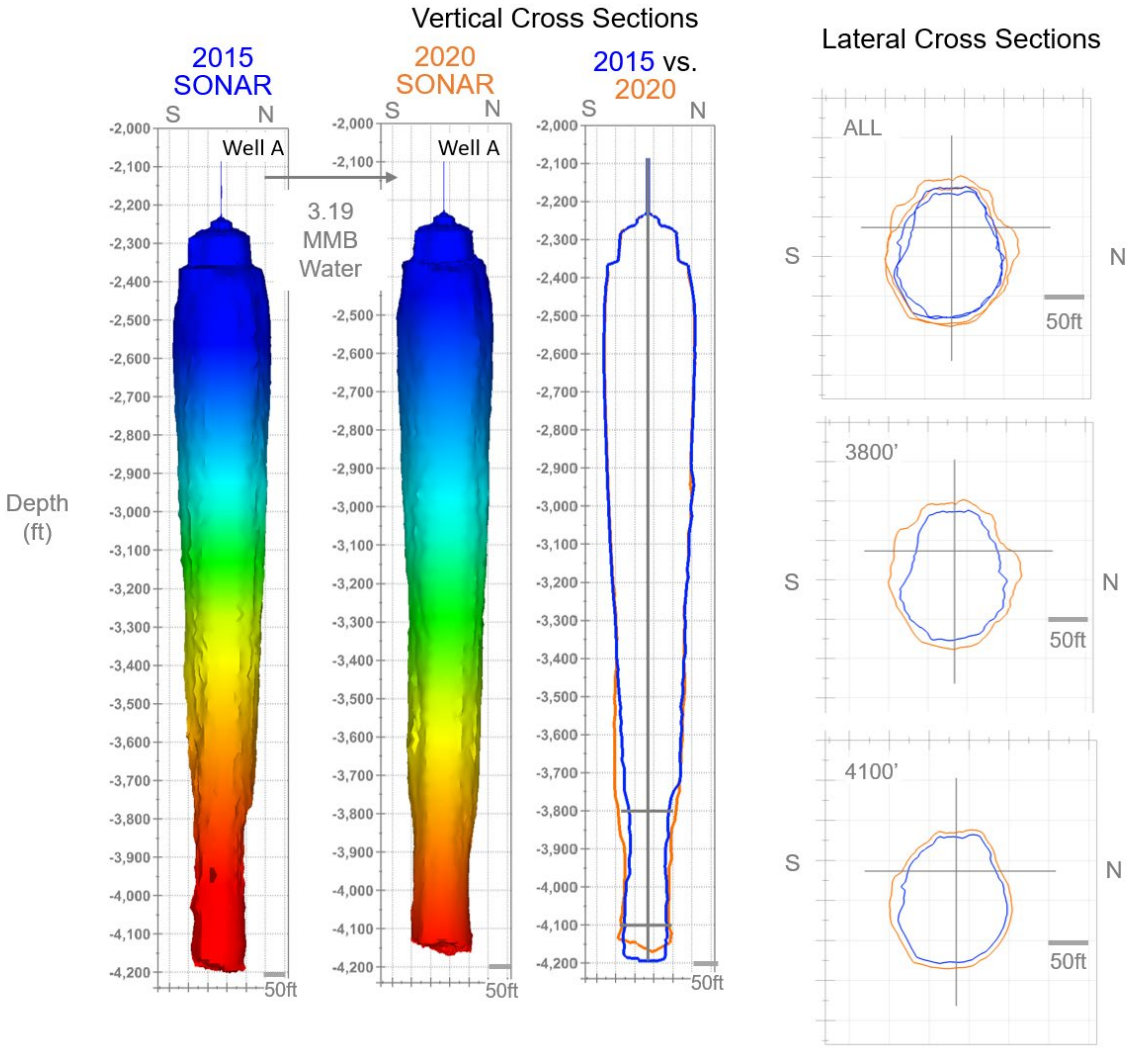

Figure 2-13. Leaching history in BH-109 from 2015 (blue) to 2020 (orange) via sonars in well A.

2.1.4.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in BH-109 was in 2020. Since that sonar, around 0.50 MMB of water has been injected into the cavern from 2020-2021 (see Table 2-8). The injection history was modeled using three phases of leaching each with an EP of 60 days. To represent CY21 water injection, one phase was added to the one phase modeled for the CY20 report [12]. This cavern has had two Mod EOT rises.

Table 2-8. Summary of Simulation Input for BH-109

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/04/20-09/05/20	4,205	426	420	767	770	42,190	2	84,380
2	04/07/21-05/11/21	4,205	48	40	812	810	11,754	35	411,393
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	495,773

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-9, the leaching efficiency for this cavern was 15.5%.

Table 2-9. Summary of Simulation Output for BH-109

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	780	1.2012	13,000	15.4
2	880	1.2009	64,000	15.6
ALL	880	1.2009	77,000	15.5

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-14). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. In this case, there is an observable difference between the North-South (N-S) extent of the cavern in the region ~3,900-4,100 ft as shown in the sonar and (blue) the axisymmetric representation of the sonar (orange). The difference is due to the ovality of the cavern—in this region, it has a greater East-West (E-W) extent compared to the N-S extent. When an axisymmetric representation is calculated, the N-S extent increases and the E-W extent decreases. The total volume of injected water modeled is shown with a grey arrow, in this case 0.5 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-15 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure

2-15) reveals a modeled leaching zone (see Figure 2-16) that is about 1,000 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

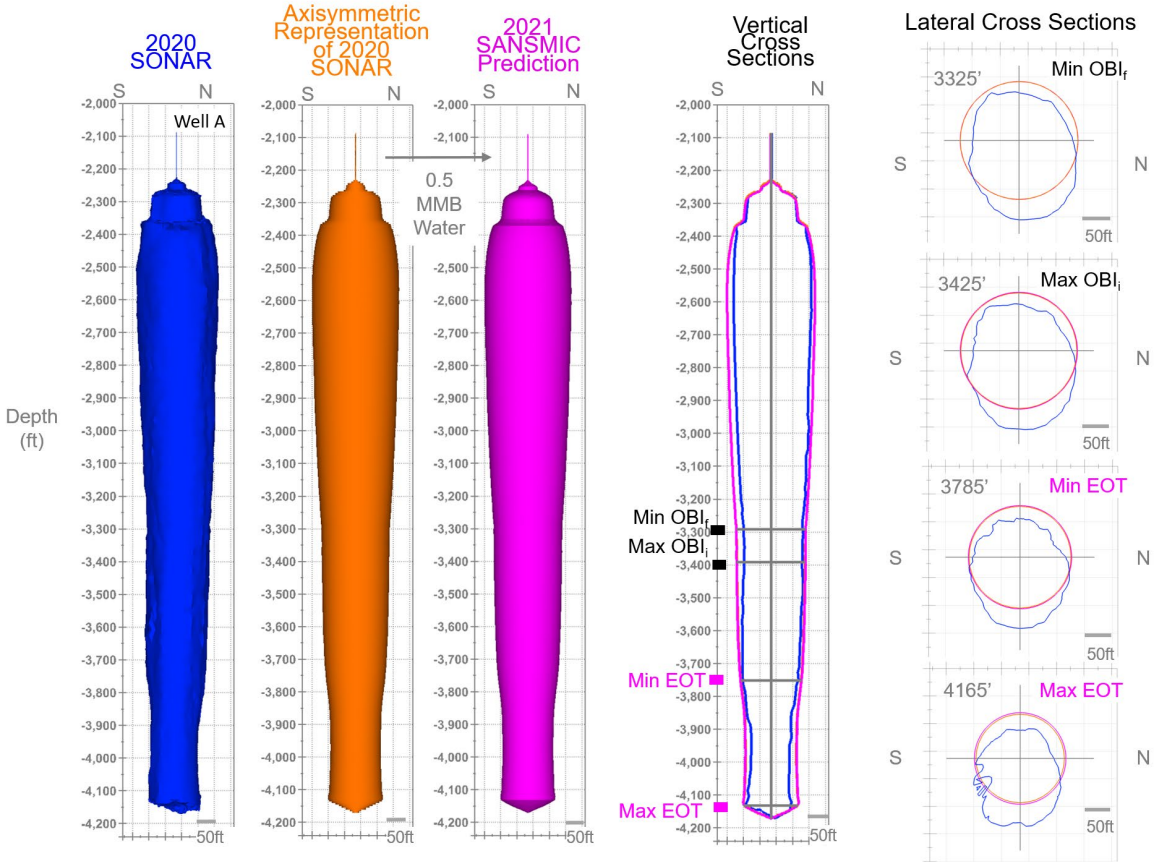

Figure 2-14. BH-109 modeling results for leaching between 2020 sonar and end of CY21.

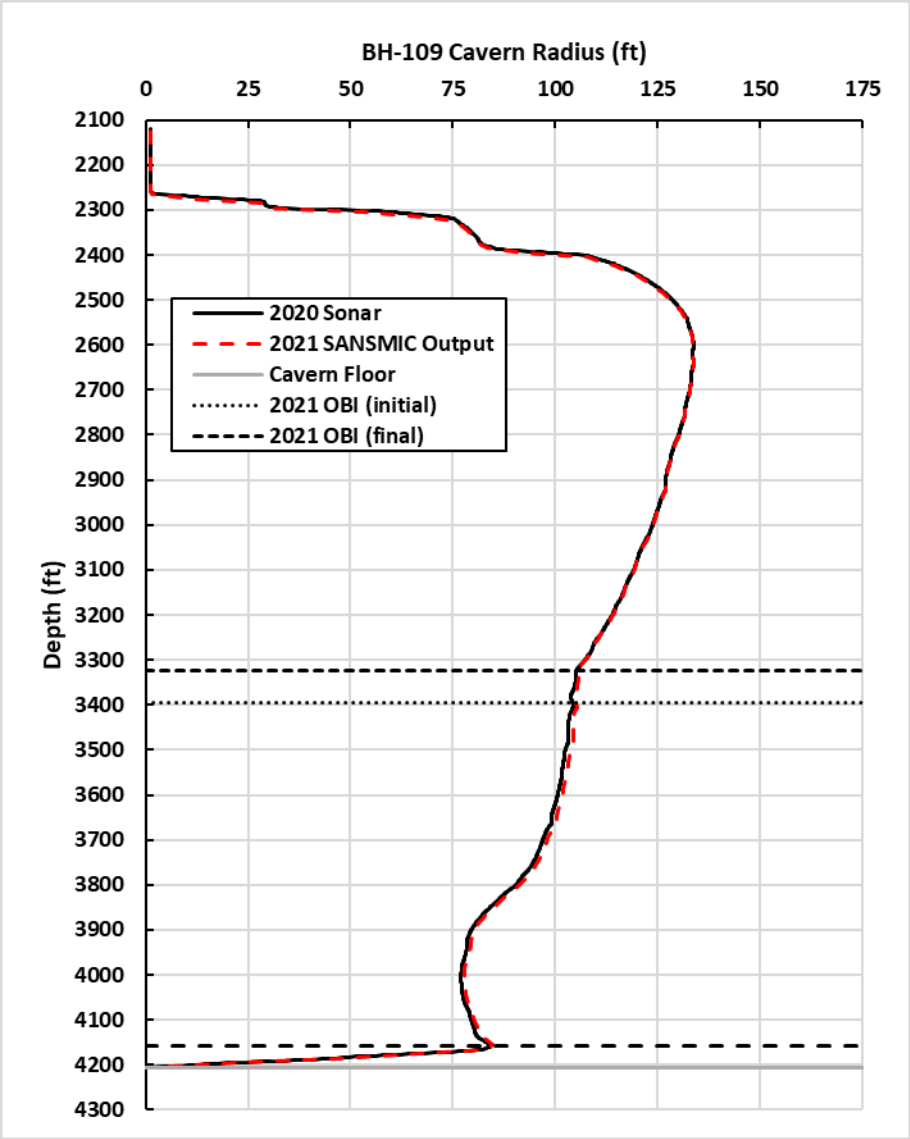

Figure 2-15. BH-109 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

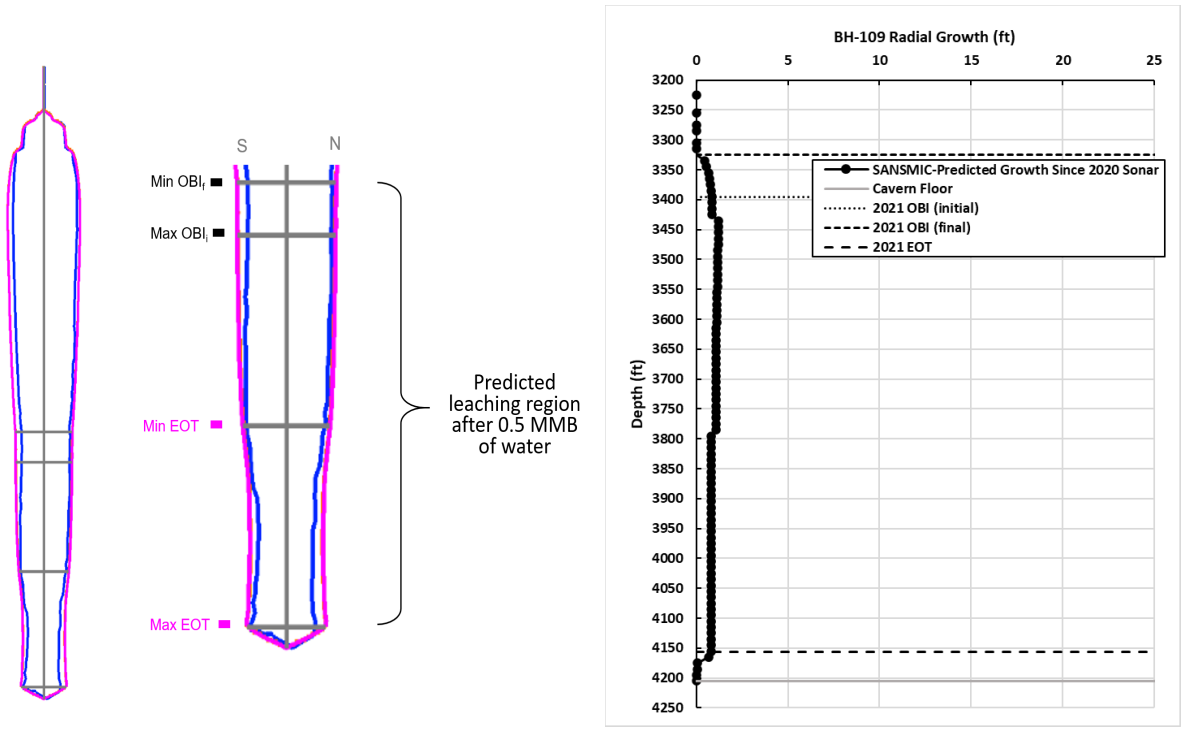

Figure 2-16. BH-109 SANSMIC-predicted radial growth since 2020 sonar.

2.1.5. BH-110

2.1.5.1. Leaching History

Sonars taken in the A well of BH-110 in 2015 and 2020 are shown in Figure 2-17. Some floor rise and floor spread occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 1.1 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. Leaching was primarily radial from 2015 to 2020, suggesting that radial leaching should be expected for the 4.2 MMB of water that has been injected since the 2020 sonar.

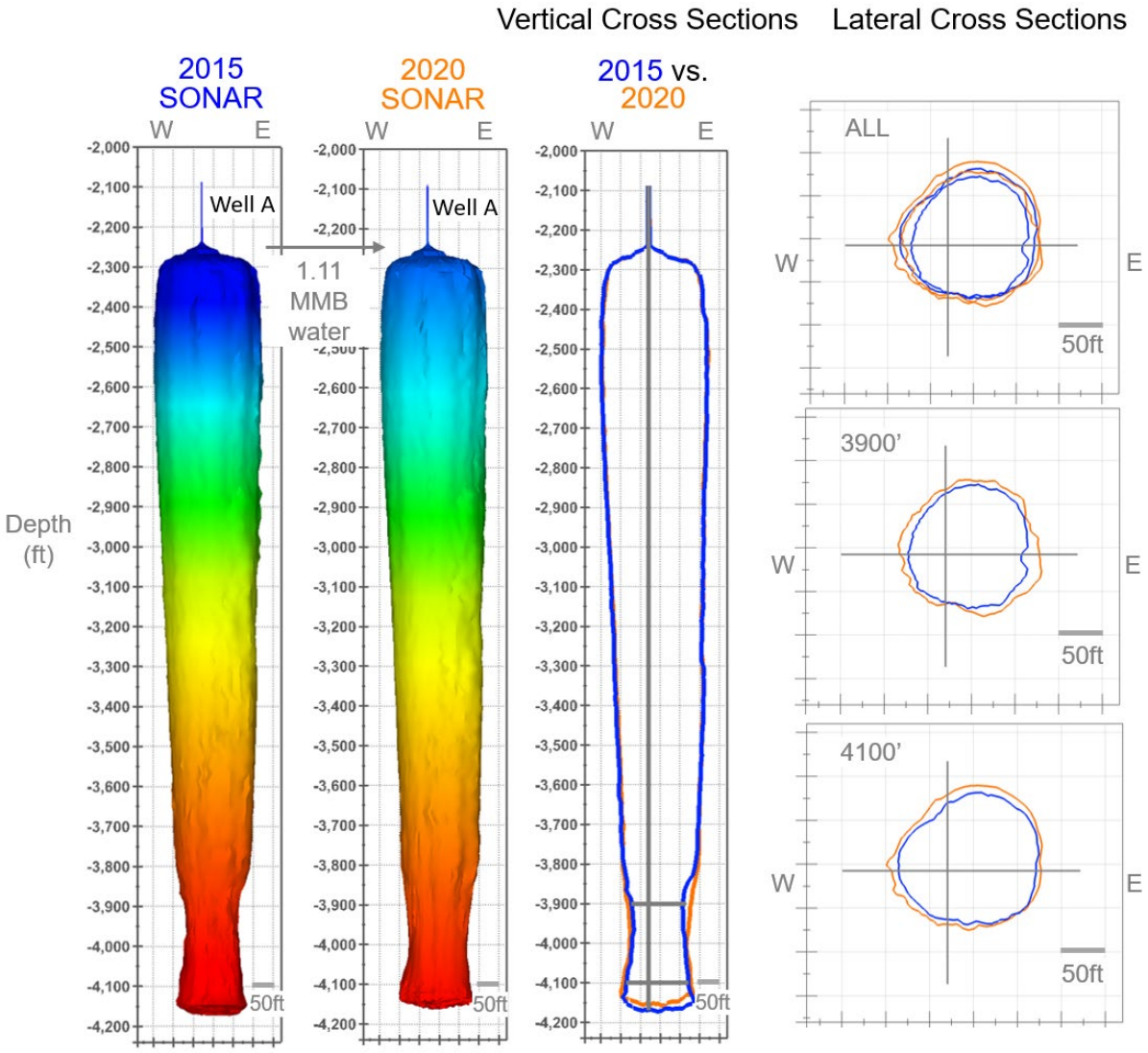

Figure 2-17. Leaching history in BH-110 from 2015 (blue) to 2020 (orange) via sonars in well A.

2.1.5.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in BH-110 was in 2020. Since that sonar, about 4.2 MMB of water have been injected into the cavern from 2020-2021 (see Table 2-10). To represent CY21 water injection, two phases were added to the one phase modeled for the CY20 report [12]. This cavern has had two Mod EOT rises.

Table 2-10. Summary of Simulation Input for BH-110

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	05/14/20-10/09/20	4,197	23	20	481	480	25,651	21	538,671
2	04/07/21-06/26/21	4,197	40	30	603	600	13,790	81	1,116,951
3	10/03/21-12/13/21	4,197	40	30	Auto	780	35,335	72	2,544,089
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	174	4,199,711

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-11, the leaching efficiency for this cavern was 15.9%.

Table 2-11. Summary of Simulation Output for BH-110

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	580	1.2001	84,000	15.6
2	780	1.2002	177,000	15.8
3	1,120	1.1993	406,000	16.0
ALL	1,120	1.1993	667,000	15.9

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-18). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 4.2 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-19 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-19) reveals a modeled leaching zone (see Figure 2-20) that is about 1,000 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only

about 5-8 ft. A small growth of the flare near the cavern floor was observed in previous leaching work [8][12]. The observed feature has grown in size with the modeled CY21 leaching. Monitoring of the flare is recommended.

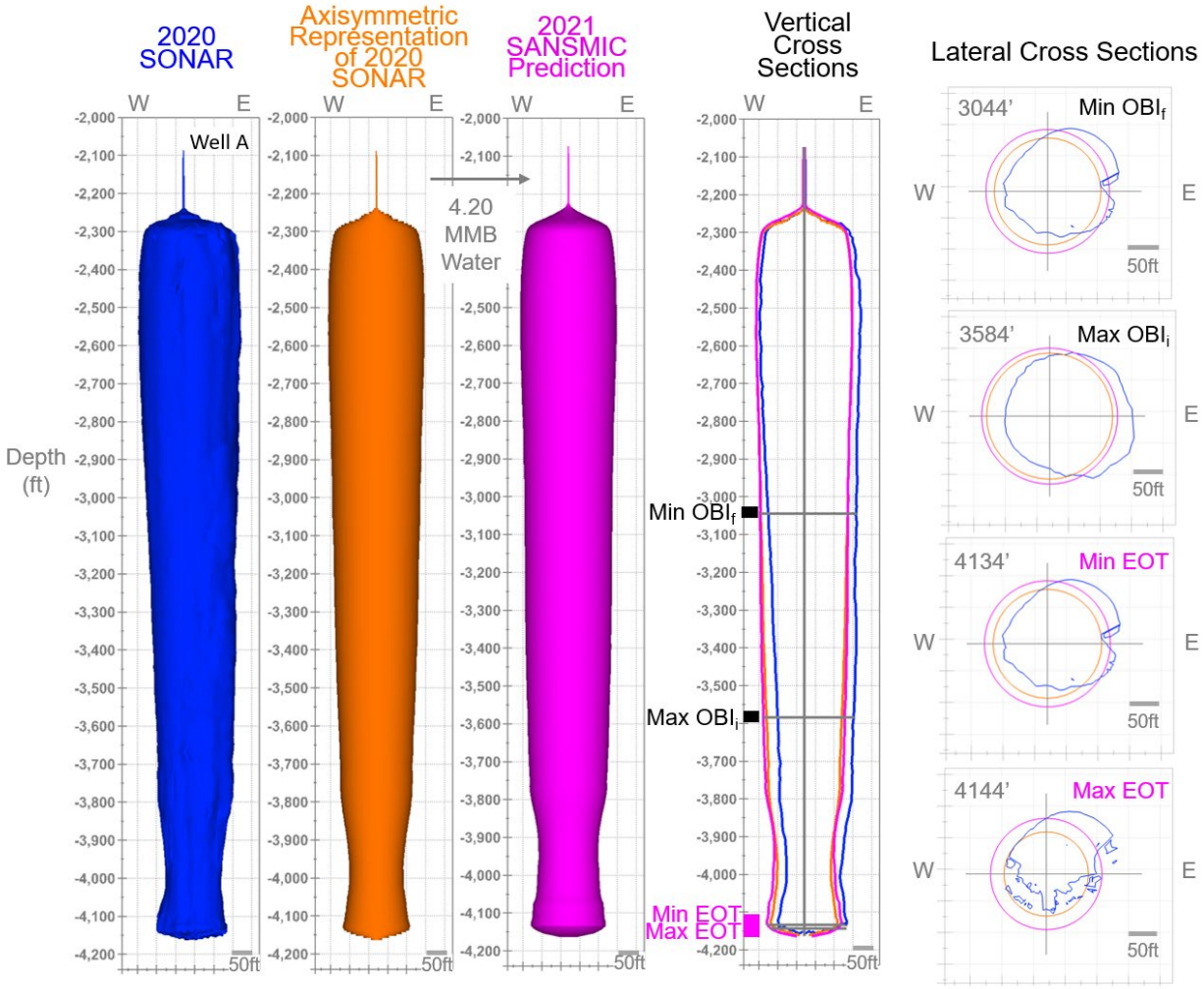

Figure 2-18. BH-110 modeling results for leaching between 2020 sonar and end of CY21.

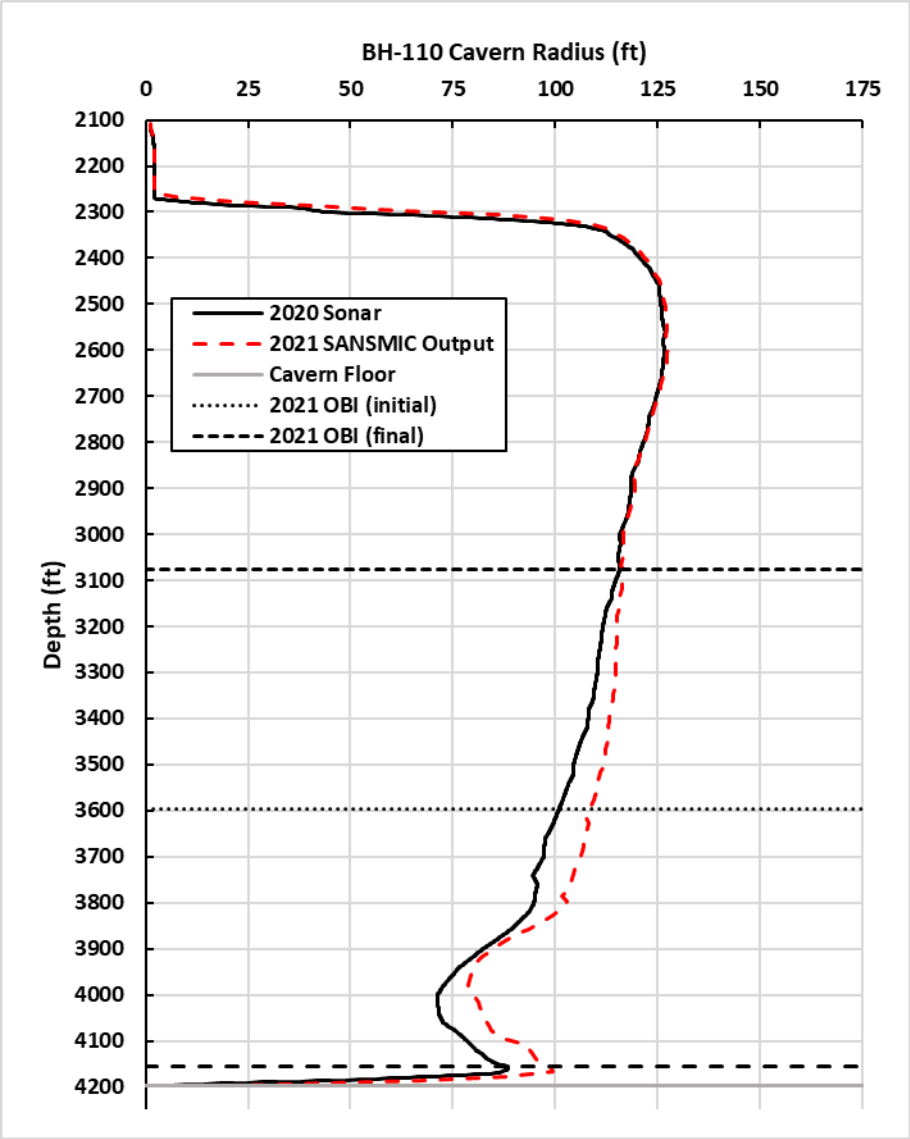

Figure 2-19. BH-110 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

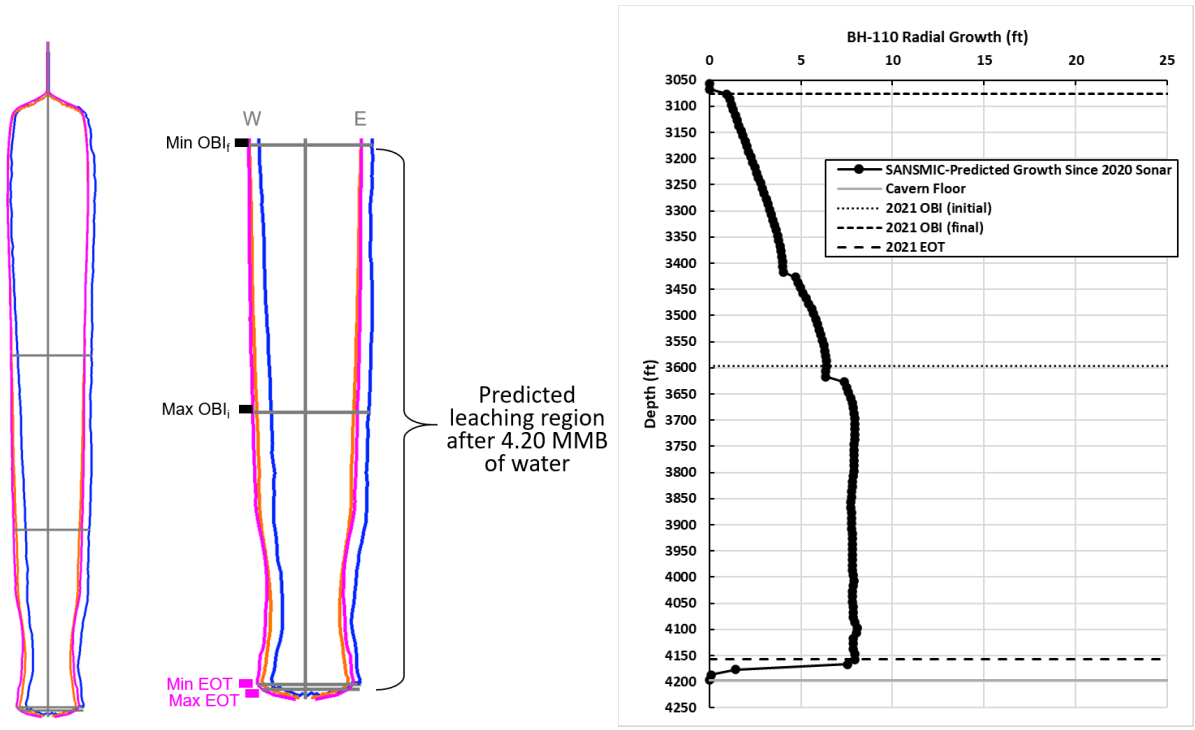

Figure 2-20. BH-110 SANSMIC-predicted radial growth since 2020 sonar.

2.1.6. BH-111

2.1.6.1. Leaching History

Sonars taken in the A well of BH-111 in 2015 and 2021 are shown in Figure 2-21. Little change is observed in the cavern floor (slight rise) and wall positions near the floor in the vertical and lateral cross sections. Preferential cavern growth in the northern direction is observed at depths of 3,400-3,800 ft. There was 2.0 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. With the observed preferential leaching from 2015 to 2021, radial leaching may not be expected for the 1.7 MMB of water that has been injected since the 2021 sonar.

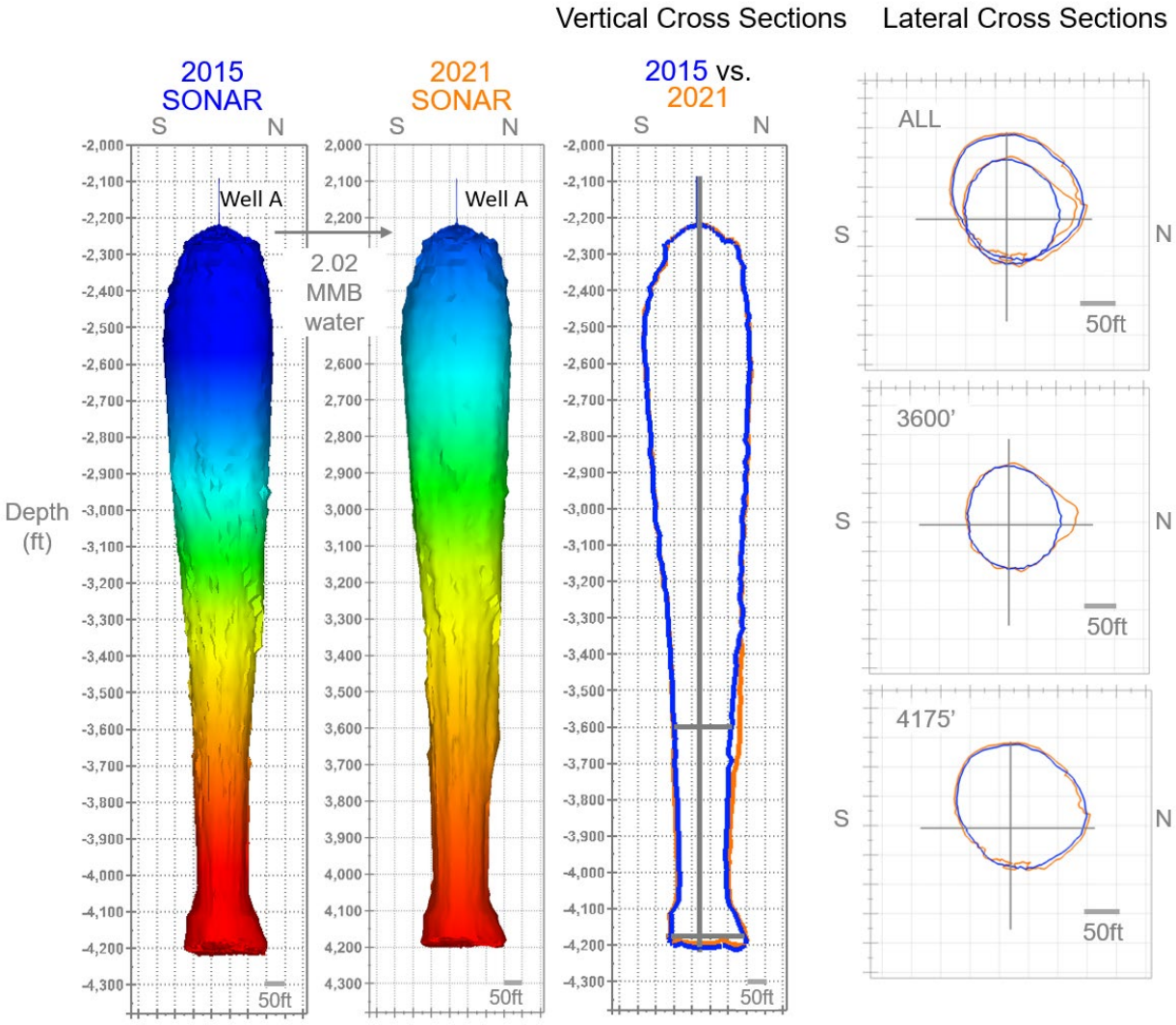

Figure 2-21. Leaching history in BH-111 from 2015 (blue) to 2021 (orange) via sonars in well A.

2.1.6.2. Simulated Leaching Between 2021 Sonar and End of CY21

The last sonar taken in BH-111 was in 2021. Since that sonar, about 1.7 MMB of water have been injected into the cavern in 2021 (see Table 2-12). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-12. Summary of Simulation Input for BH-111

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/03/21-12/14/21	4,233	11	9	841	841	23,034	73	1,681,508

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-13, the leaching efficiency for this cavern was 15.9%.

Table 2-13. Summary of Simulation Output for BH-111

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	1,113	1.1999	268,000	15.9

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2021 sonar and the end of CY21 (see Figure 2-22). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.7 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-23 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-23) reveals a modeled leaching zone (see Figure 2-24) that is about 1,000 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-3 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time. A comparison of the 2021 sonar with SANSMIC results for leaching between the 2015 and 2021 sonars can be found in Section 3.1.

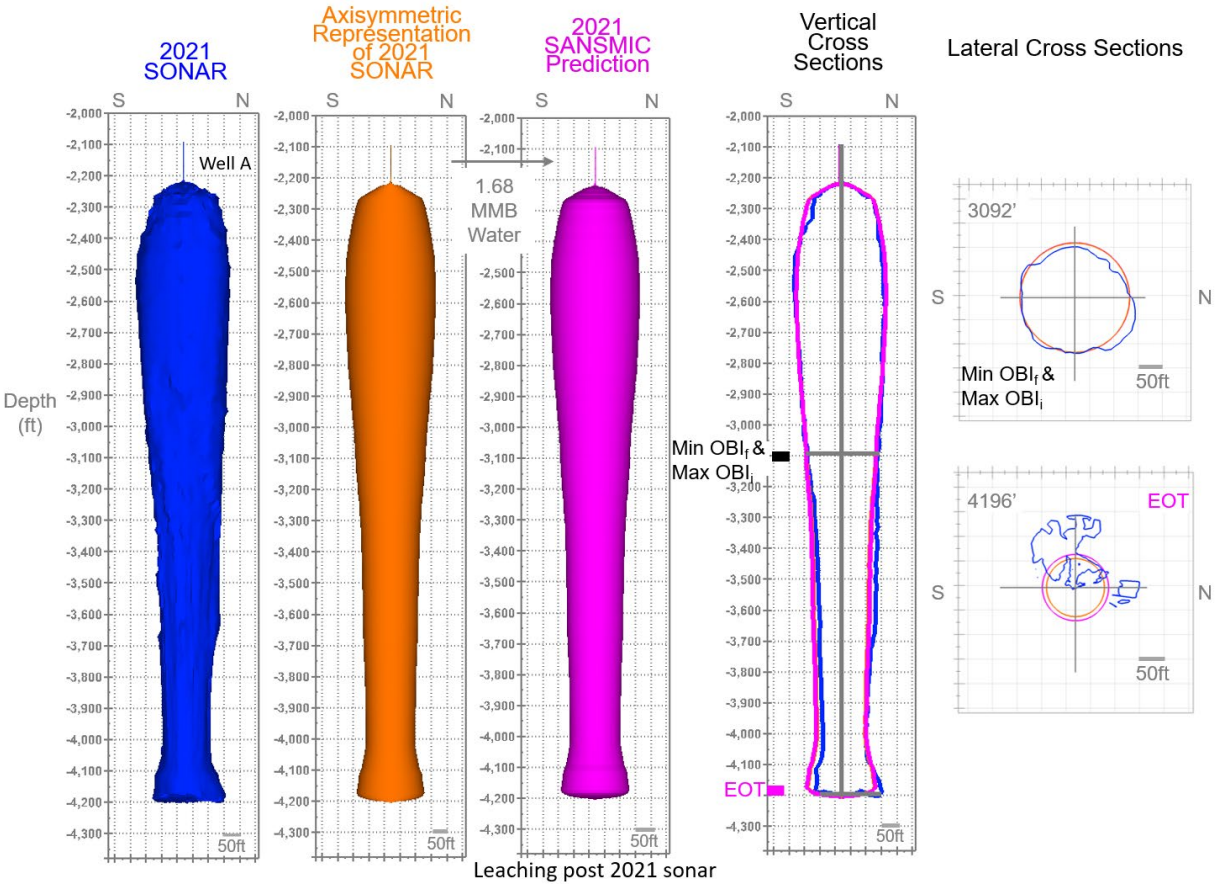

Figure 2-22. BH-111 modeling results for leaching between 2021 sonar and end of CY21.

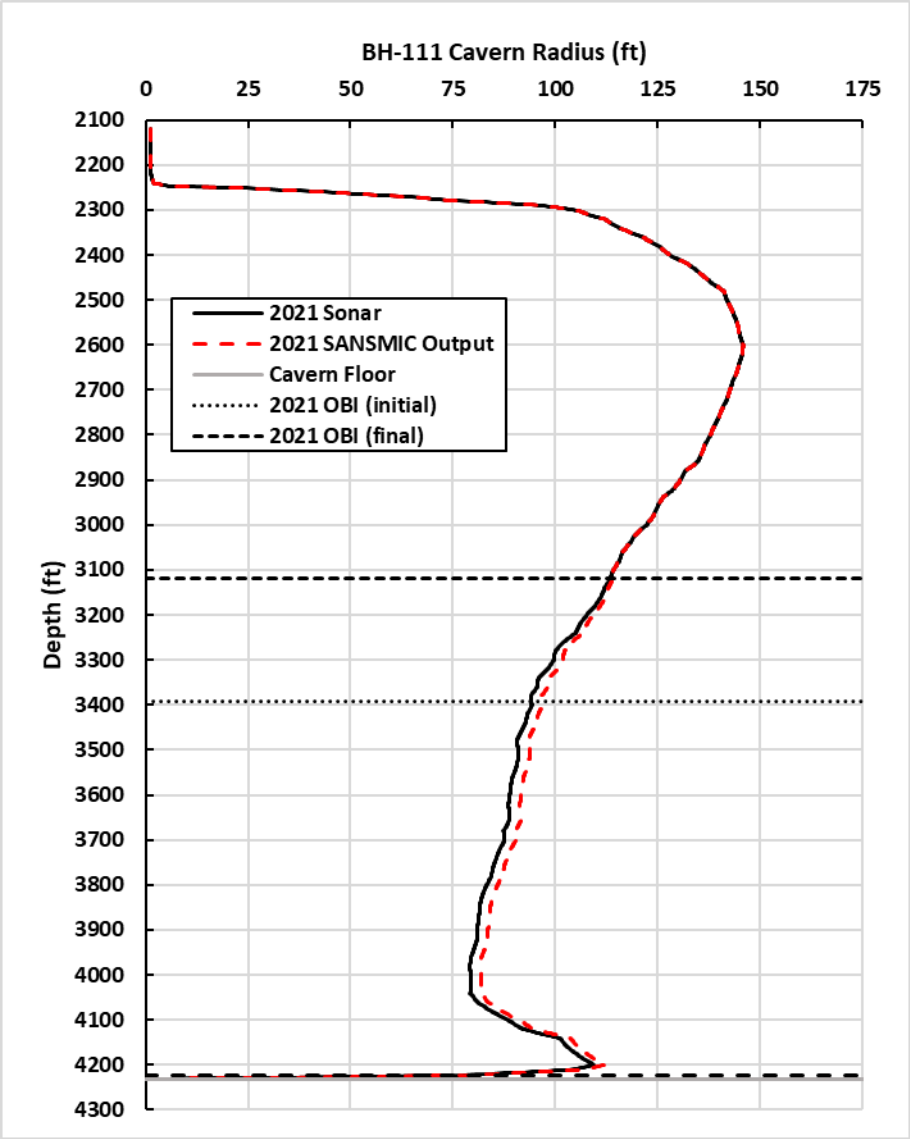

Figure 2-23. BH-111 axisymmetric representation of 2021 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

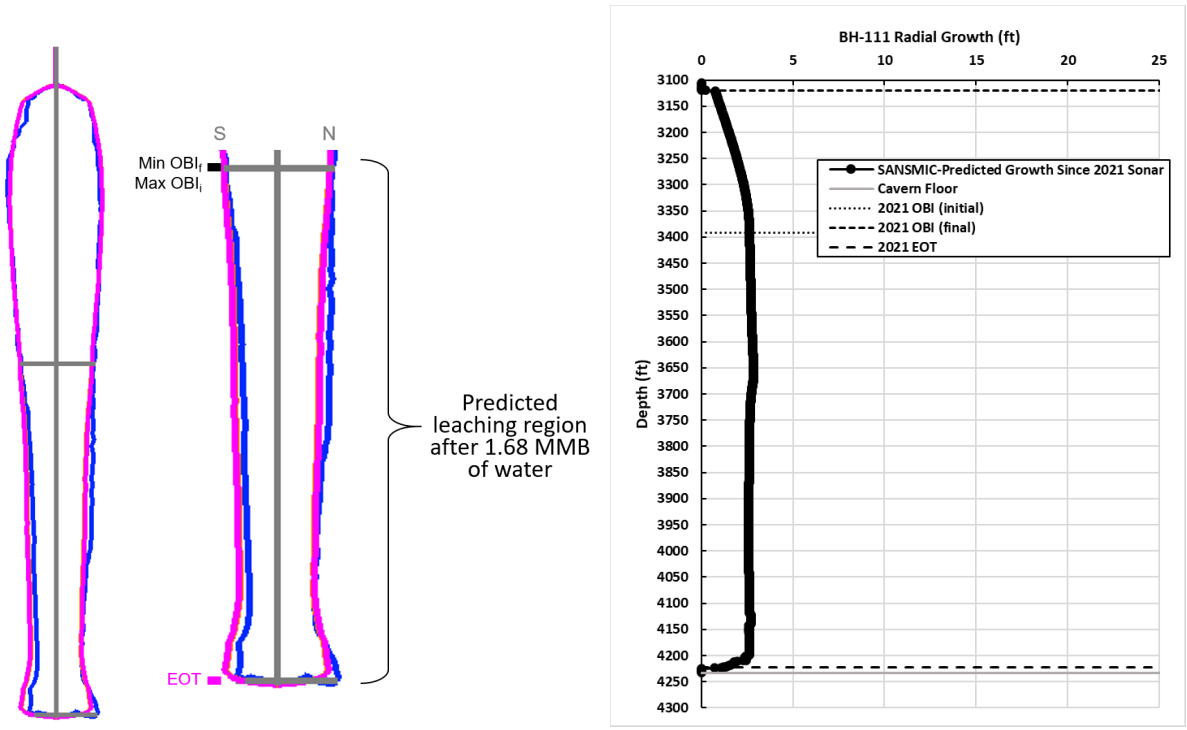

Figure 2-24. BH-111 SANSMIC-predicted radial growth since 2021 sonar.

2.1.7. BH-112

2.1.7.1. Leaching History

Sonars taken in the A well of BH-112 in 2003 and 2015 are shown in Figure 2-25. Some floor rise occurred in this cavern, but very little radial change due to the small volume of water injected. There was 0.05 MMB of water injected into this cavern between sonars.

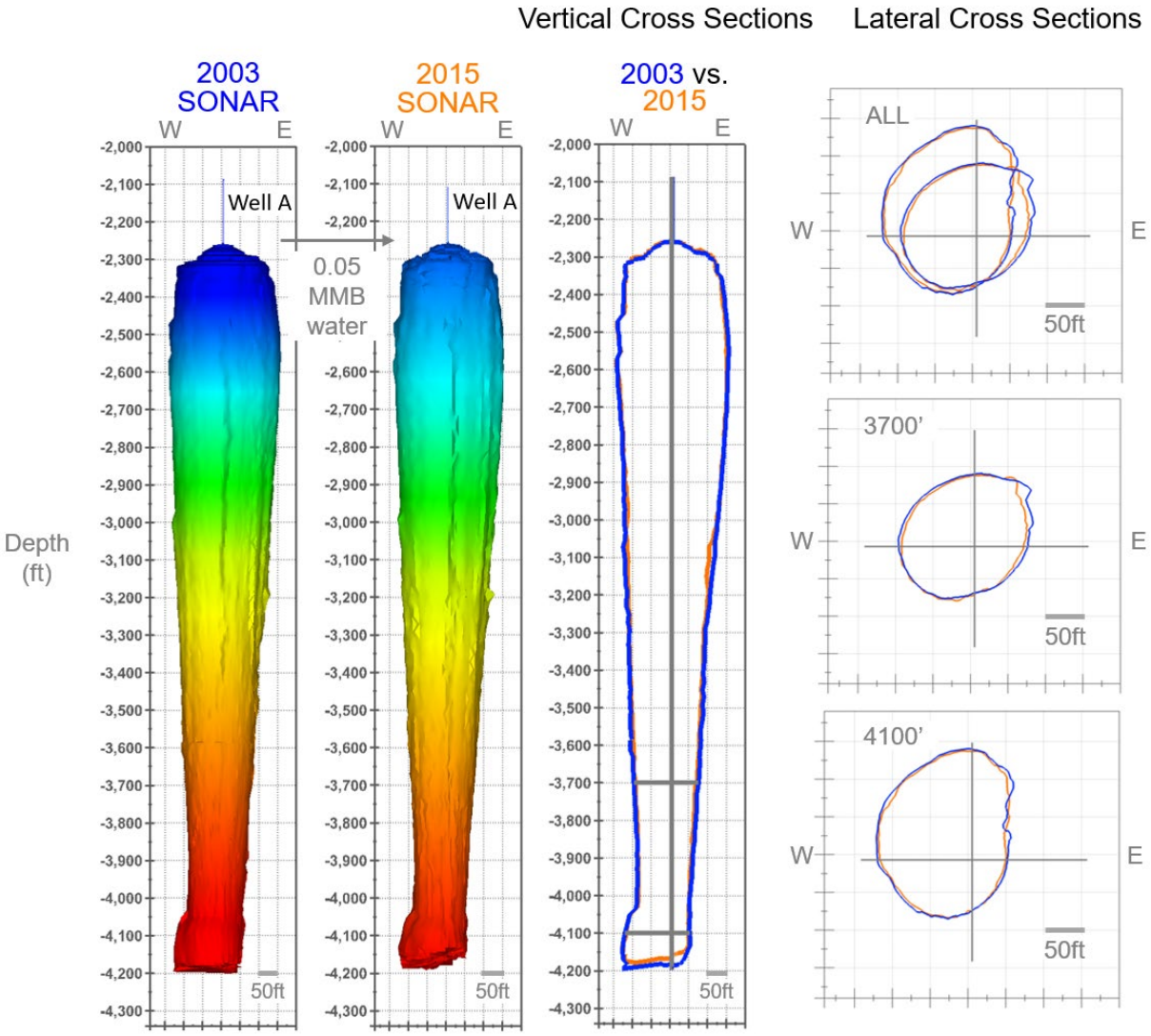

Figure 2-25. Leaching history in BH-112 from 2003 (blue) to 2015 (orange) via sonars in well A.

2.1.7.2. Simulated Leaching Between 201520 Sonar and End of CY21

The last sonar taken in BH-112 was in 2015. Since that sonar, about 0.1 MMB of water have been injected into the cavern in 2021 (see Table 2-14). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-14. Summary of Simulation Input for BH-112

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	12/13/21-12/19/21	4,220	55	54	77	77	14,185	7	99,292

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-15, the leaching efficiency for this cavern was 16.1%.

Table 2-15. Summary of Simulation Output for BH-112

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	95	1.1981	16,000	16.1

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2015 sonar and the end of CY21 (see Figure 2-26). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 0.1 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching due to the small volume of water injected. Figure 2-27 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-27) reveals a modeled leaching zone (see Figure 2-28) that is about 50 ft tall. The radial growth over this depth is predicted to be only about 1-3 ft. There is an existing flare near the depth of the EOT at about 4,170. Monitoring of the flare is recommended.

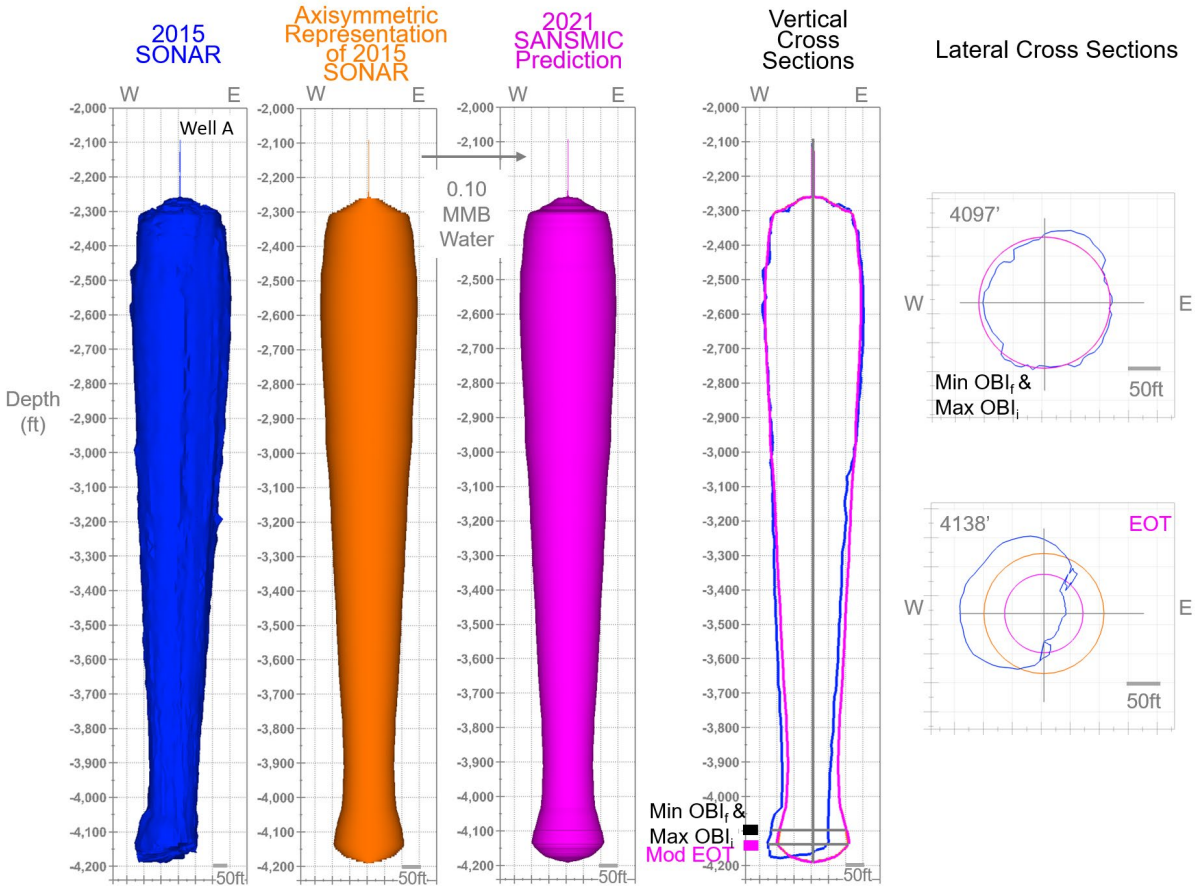

Figure 2-26. BH-112 modeling results for leaching between 2015 sonar and end of CY21.

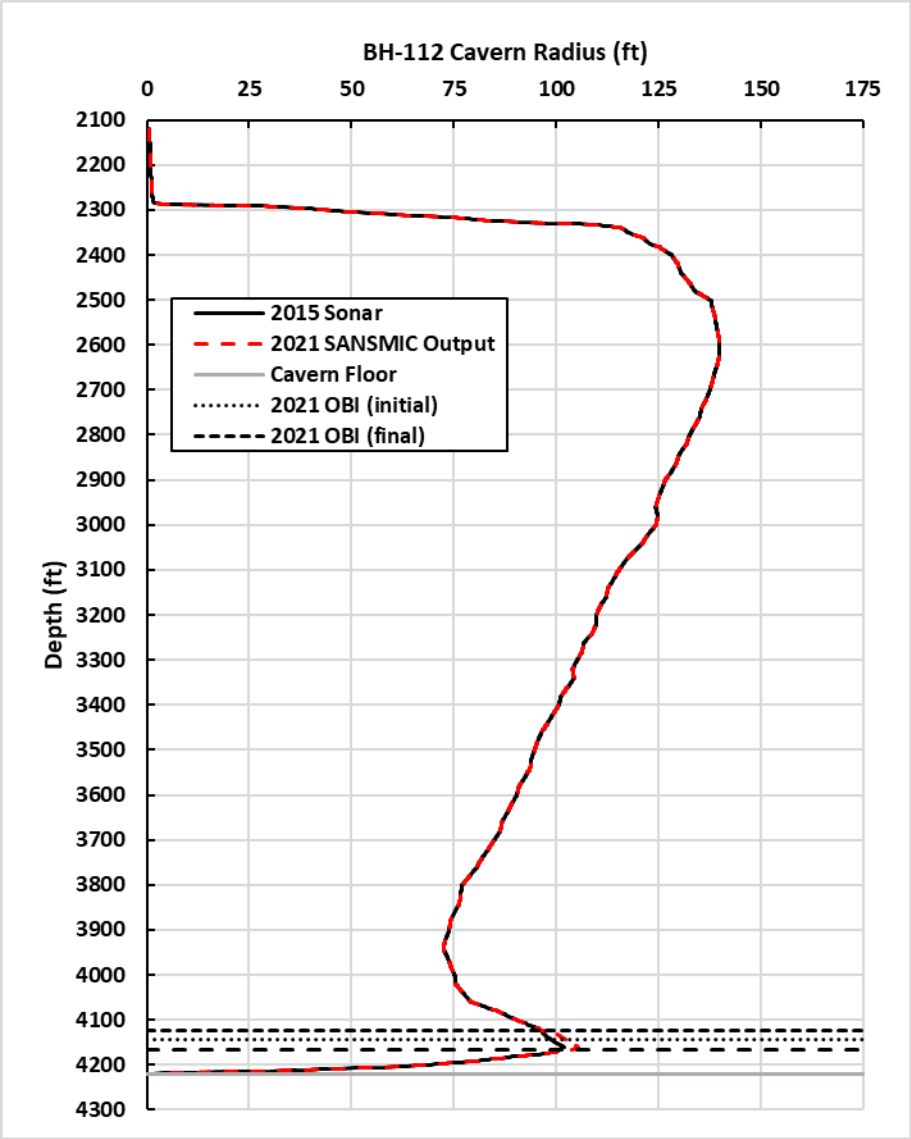

Figure 2-27. BH-112 axisymmetric representation of 2015 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

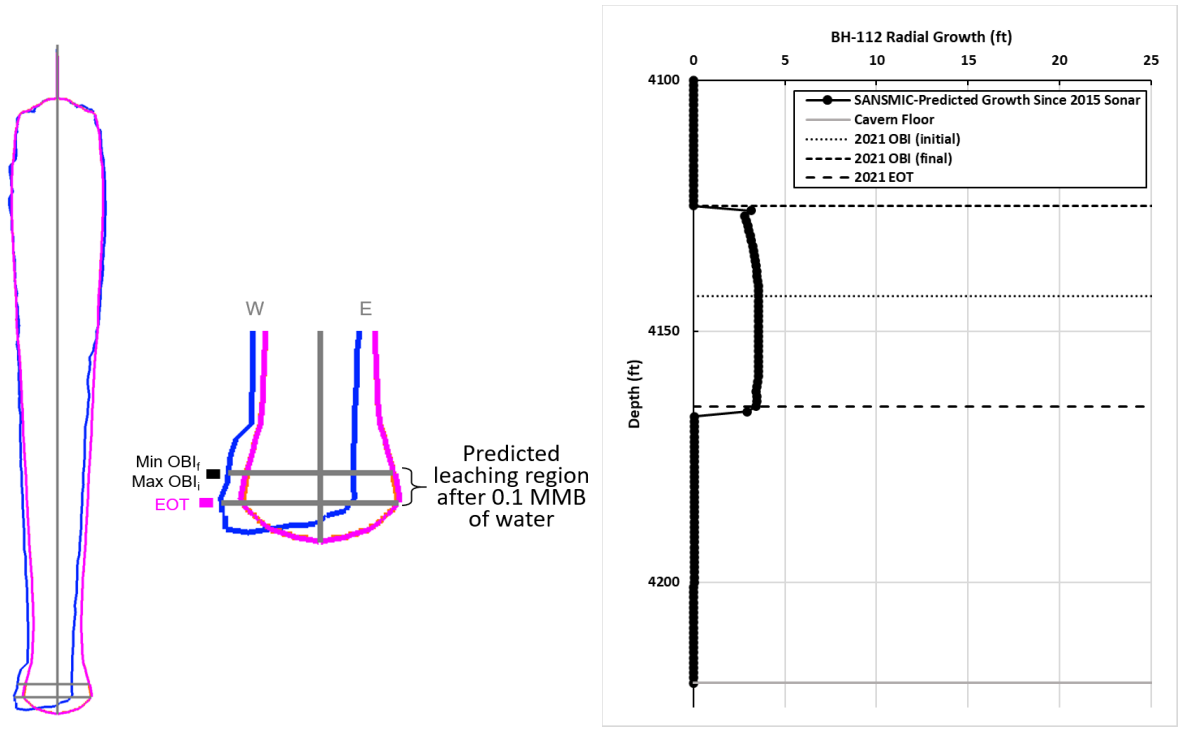

Figure 2-28. BH-112 SANSMIC-predicted radial growth since 2015.

2.1.8. BH-113

2.1.8.1. Leaching History

Sonars taken in the A well of BH-113 in 2005 and 2015 are shown in Figure 2-29. Some floor rise was observed in this cavern between sonars as evidenced in the change in cavern wall positions near the floor in the vertical and lateral cross sections. Only 0.14 MMB of water was injected into this cavern between sonars and so very little change in cavern shape is observed, but the change is relatively radial, suggesting that radial leaching should be expected for the 0.3 MMB of water that has been injected since the 2015 sonar.

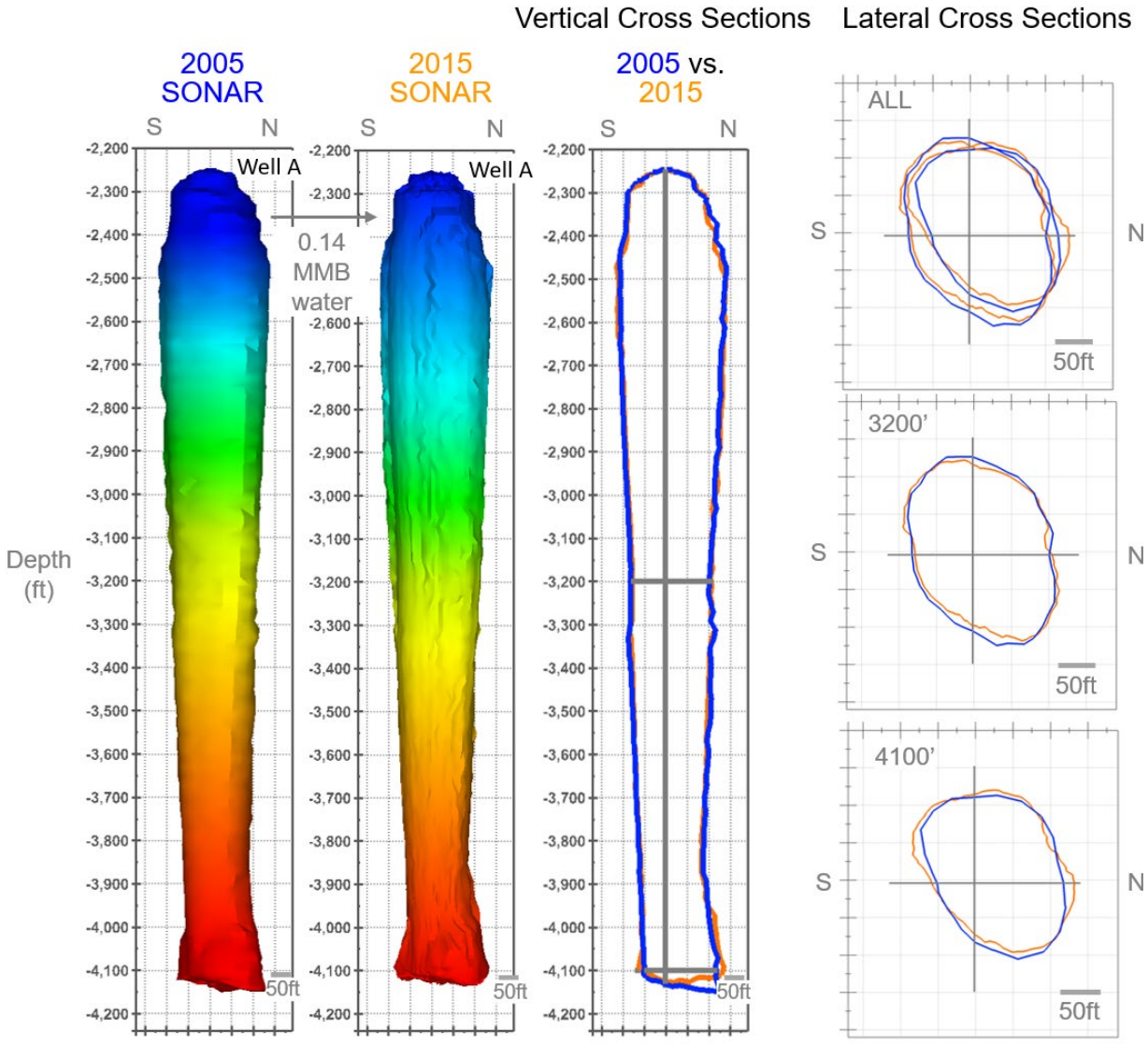

Figure 2-29. Leaching history in BH-113 from 2005 (blue) to 2015 (orange) via sonars in well A.

2.1.8.2. Simulated Leaching Between 2015 Sonar and End of CY21

The last sonar taken in BH-113 was in 2015. Since that sonar, around 0.33 MMB of water have been injected into the cavern in 2020-2021 (see Table 2-16) (additionally, less than 3 MB were injected on one day in 2017, but that small amount is not included in the modeling here). The injection history was modeled as two phases of leaching each with an EP of 60 days. To represent CY21 water injection, one phase was added to the one phase modeled for the CY20 report [12]. This cavern has had two Mod EOT rises.

Table 2-16. Summary of Simulation Input for BH-113

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/08/20-10/09/20	4,167	17	10	49	50	31,173	10	311,730
2	10/10/21-10/10/21	4,157	28	20	146	150	15,564	1	15,564
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	327,294

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-17, the leaching efficiency for this cavern was 15.0%.

Table 2-17. Summary of Simulation Output for BH-113

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	100	1.1968	47,000	15.1
2	150	1.2017	2,000	12.9
ALL	150	1.2017	49,000	15.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2015 sonar and the end of CY21 (see Figure 2-30). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 0.33 MMB.

Vertical cross sections from each of the cavern geometries reveal the general changes from leaching, which include the slight radial spread of the cavern floor. The spread can be seen by the variation between the input (orange) and output (magenta) cavern profiles in the lateral cross sections. Figure 2-31 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-31) reveals a modeled leaching zone (see Figure 2-32) that is about 100 ft tall. The maximum radial growth over this depth is predicted to be about 5 ft. The 2015 sonar shows a flare near the floor that

could potentially grow with additional small leaches. Continued monitoring of the flare is recommended.

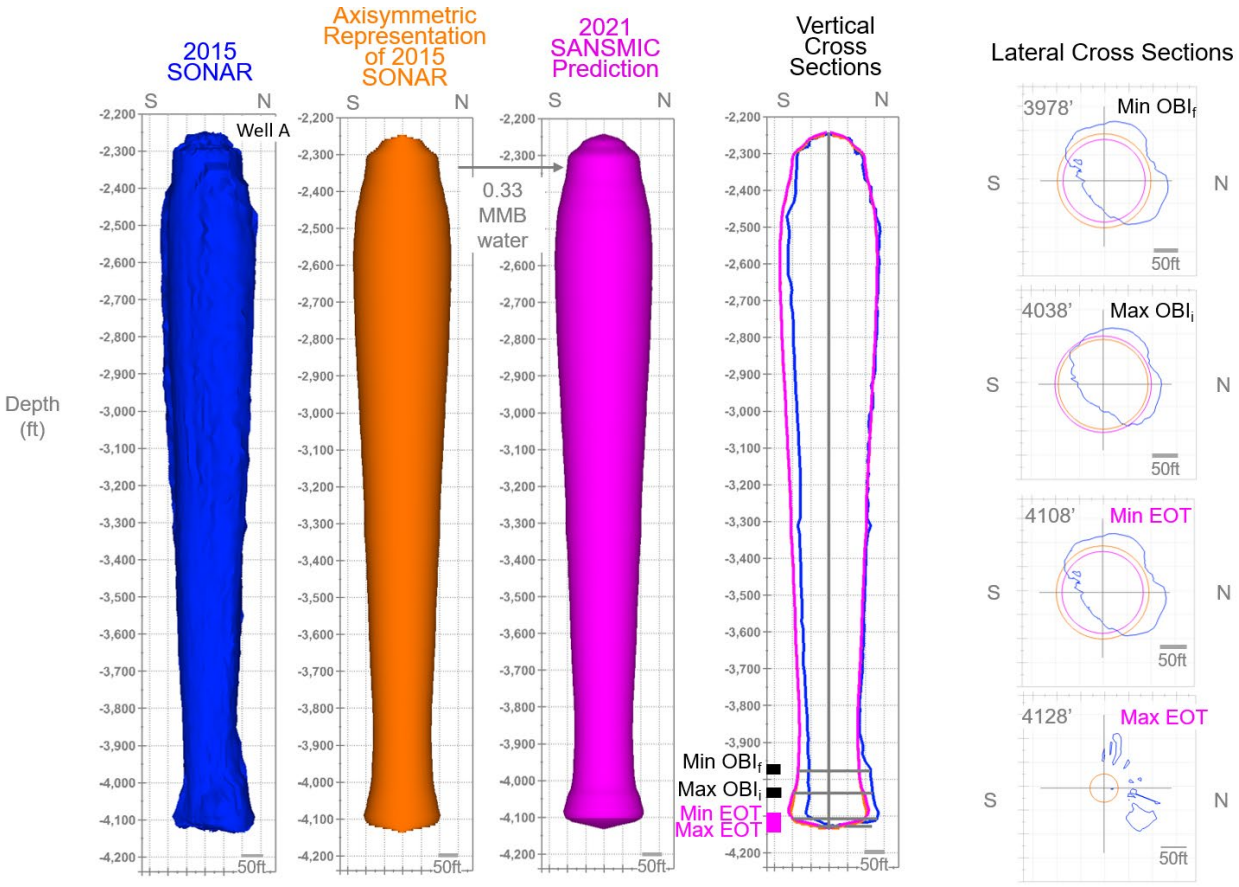

Figure 2-30. BH-113 modeling results for leaching between 2015 sonar and end of CY21.

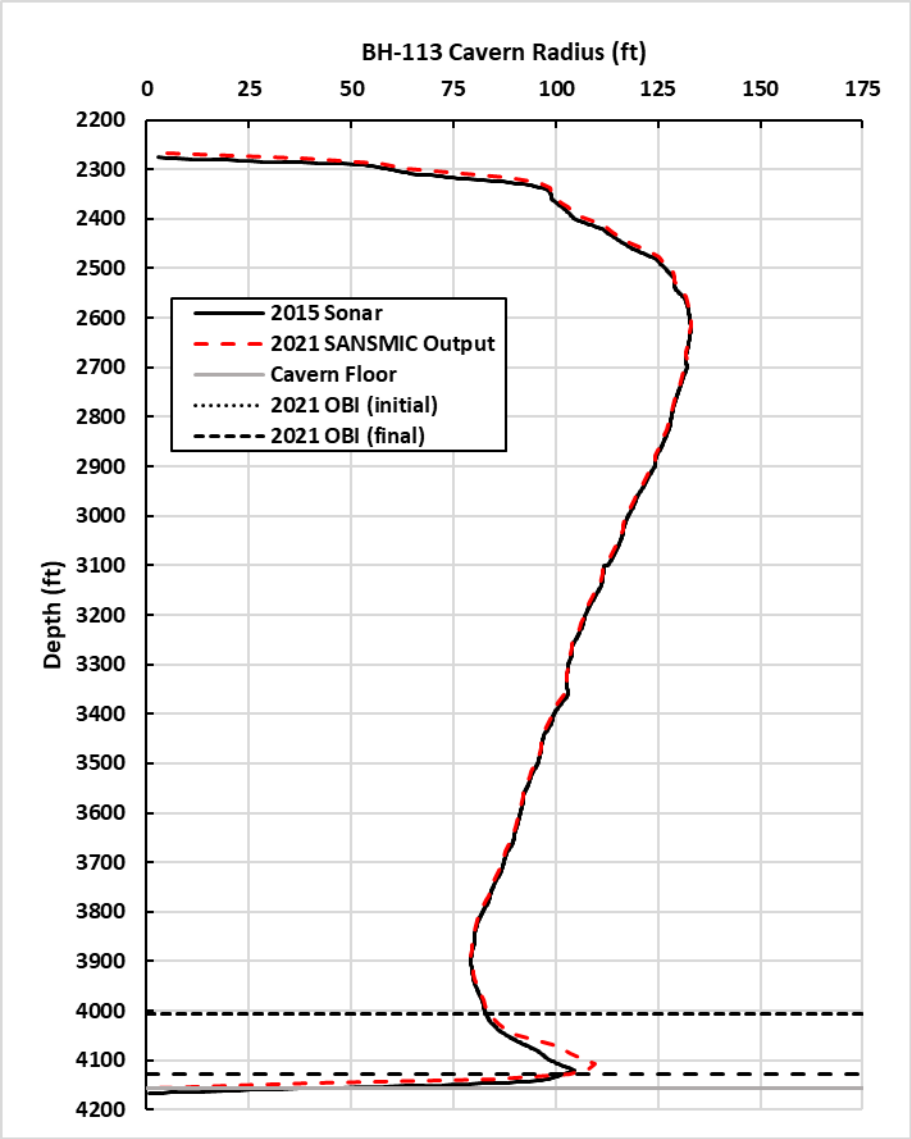

Figure 2-31. BH-113 axisymmetric representation of 2015 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

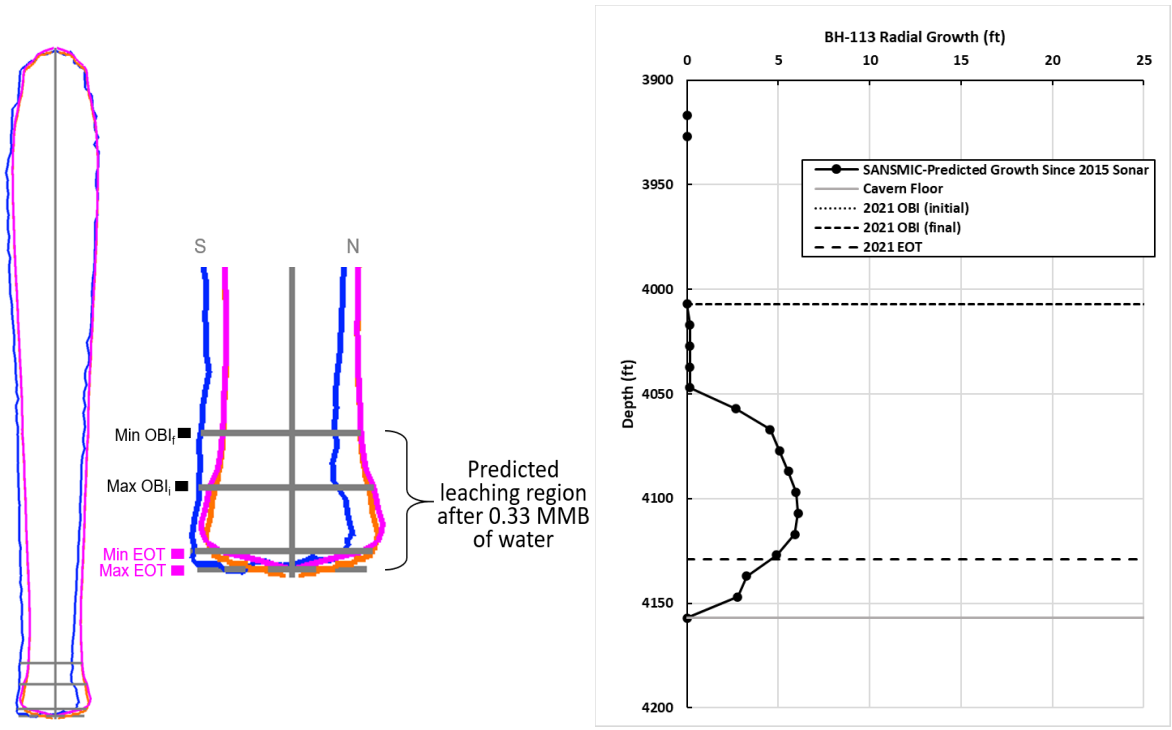

Figure 2-32. BH-113 SANSMIC-predicted radial growth since 2015 sonar.

2.2. Bryan Mound

Simulation results for Bryan Mound are summarized in Table 2-18, including the volume of raw water injection simulated with SANSMIC modeling and any potential concerns observed. Six caverns had at least 10 MB water injected in CY21. One of those caverns (BM-111) has had at least 3 MMB of water injected since the last sonar. While most caverns do not have a leaching induced feature of concern at this time, one cavern, BM-109, has a feature which should be monitored as leaching continues in those caverns.[3] A brief leaching history and the results of SANSMIC modeling of leaching since the last sonar are discussed below for each cavern.

Table 2-18. Caverns at Bryan Mound with water injected in CY21.

Cavern	Last Sonar	Injected Water Volume* (MMB)	Concerns
BM-102	2020	1.2	No
BM-103	2019	2.0	No
BM-104	2011	1.3	No
BM-109	2016	2.0	Monitor flare near cavern floor
BM-110	2021	1.3	No
BM-111	2020	3.1	No

* Since last sonar

[3] Although they did not participate in CY21 oil sales, the caverns BM-4 and BM-106 were identified in the CY20 leaching report [12] as recommendation for monitoring.

2.2.1. BM-102

2.2.1.1. Leaching History

Sonars taken in the C well of BM-102 in 2013 and 2020 are shown in Figure 2-33. No floor rise is observed. There was 1.1 MMB of water injected into this cavern between sonars. Leaching was primarily radial from 2015 to 2020, suggesting that radial leaching should be expected for the 1.2 MMB of water that has been injected since the 2020 sonar.

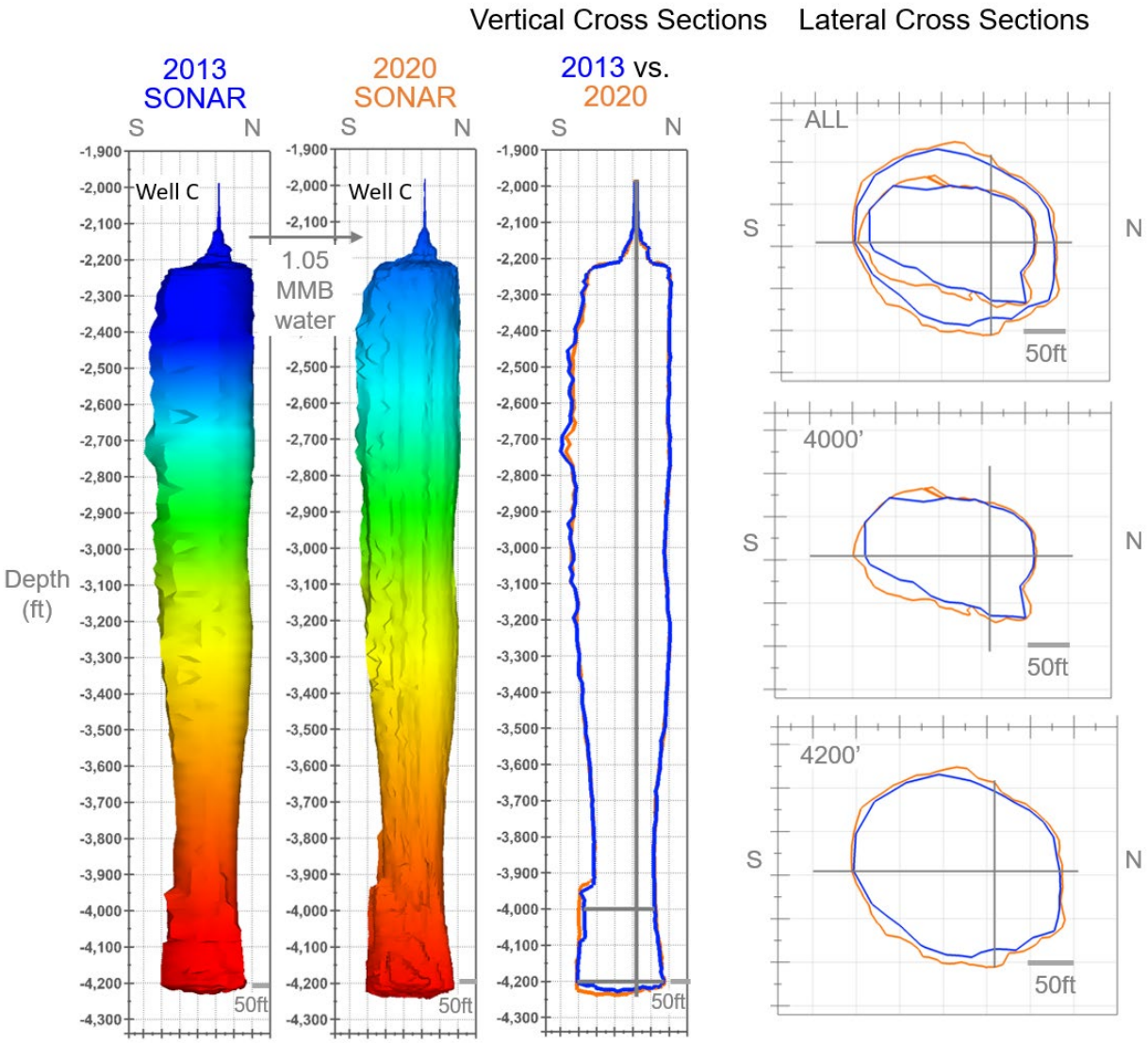

Figure 2-33. Leaching history in BM-102 from 2013 (blue) to 2020 (orange) via sonars in well C.

2.2.1.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in BM-102 was in 2020. Since that sonar, about 1.2 MMB of water have been injected into the cavern in 2021 (see Table 2-19). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-19. Summary of Simulation Input for BM-102

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	04/02/21-06/26/21	4,252	207	228	384	384	14,338	86	1,233,094

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-20, the leaching efficiency for this cavern was 16.1%.

Table 2-20. Summary of Simulation Output for BM-102

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	739	1.2004	198,000	16.1

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-34). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.2 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-35 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-35) reveals a modeled leaching zone (see Figure 2-36) that is about 500 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-5 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

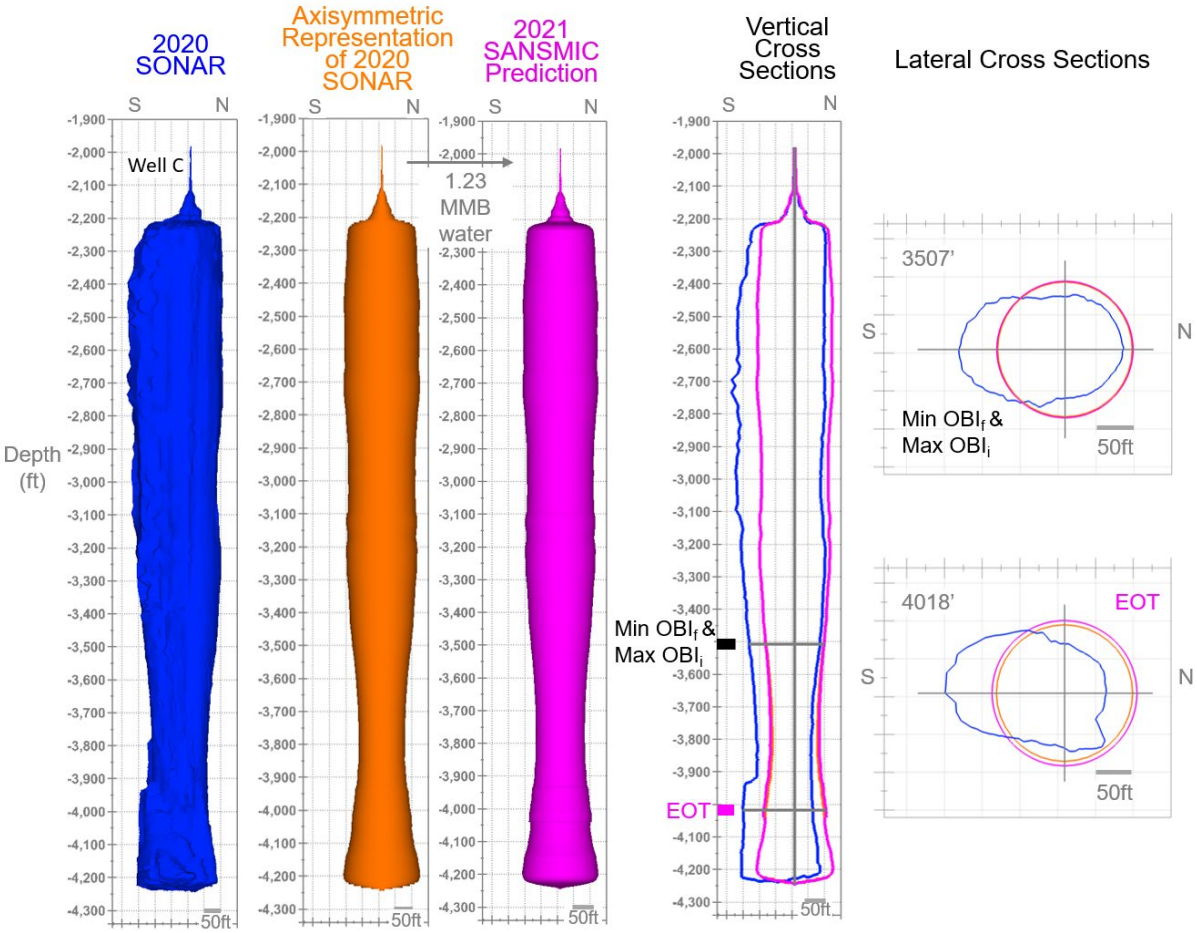

Figure 2-34. BM-102 modeling results for leaching between 2020 sonar and end of CY21.

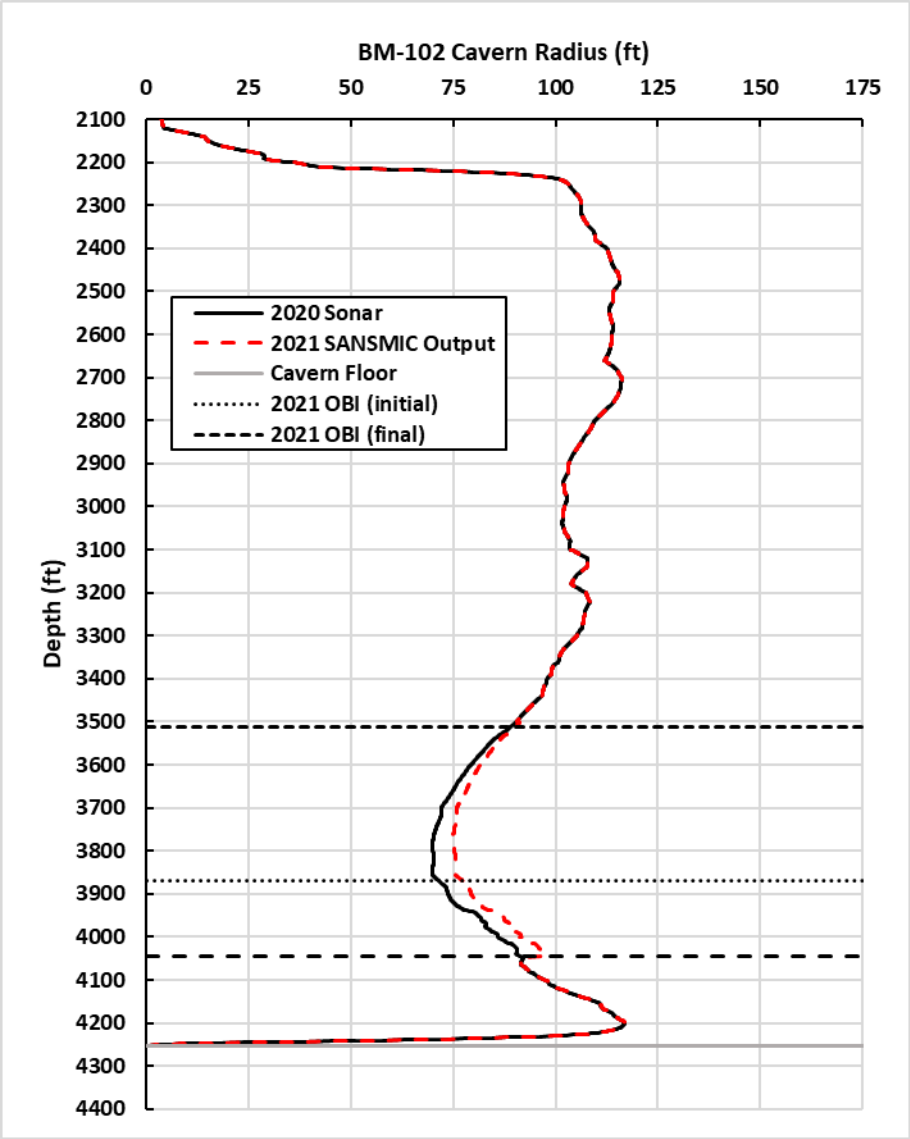

Figure 2-35. BM-102 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

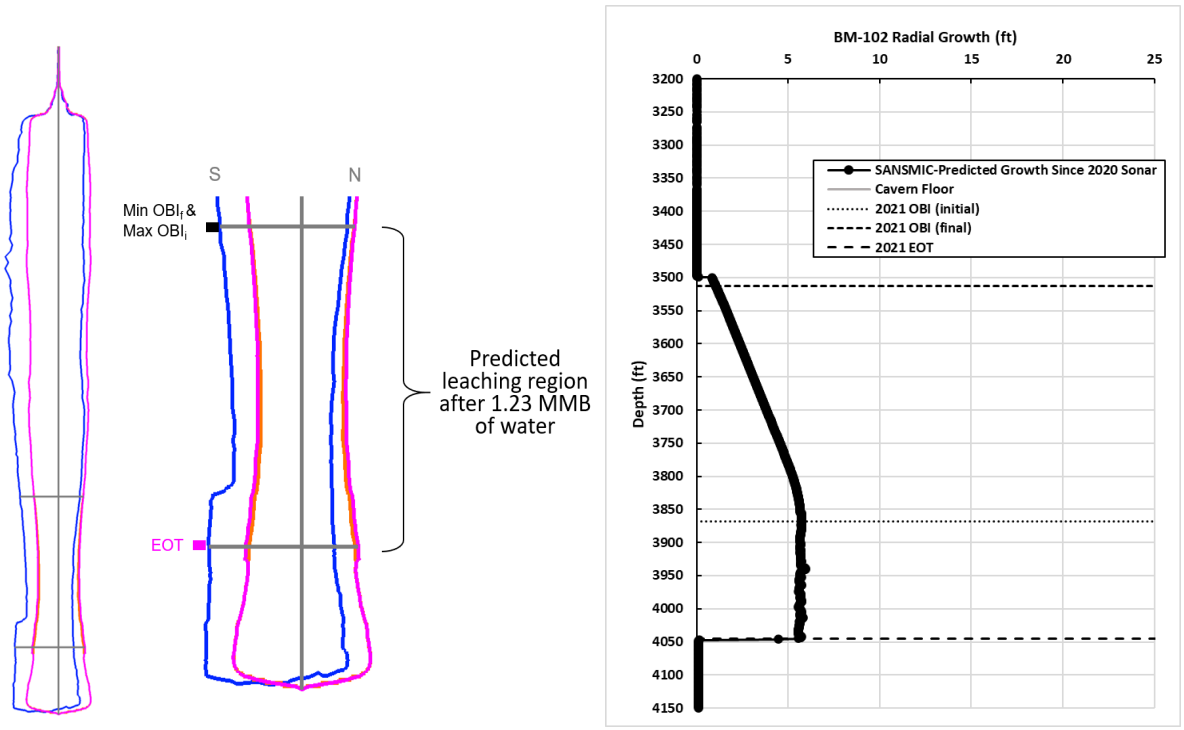

Figure 2-36. BM-102 SANSMIC-predicted radial growth since 2020.

2.2.2. BM-103

2.2.2.1. Leaching History

Sonars taken in the B well of BM-103 in 2016 and 2019 are shown in Figure 2-37. Some floor rise and floor spread occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 0.76 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. Leaching was primarily radial from 2015 to 2020 (apart from a feature at a depth of about 3,350 ft that might be attributed to a sonar that included tilted measurements in 2019), suggesting that radial leaching should be expected for the 2.0 MMB of water that has been injected since the 2020 sonar.

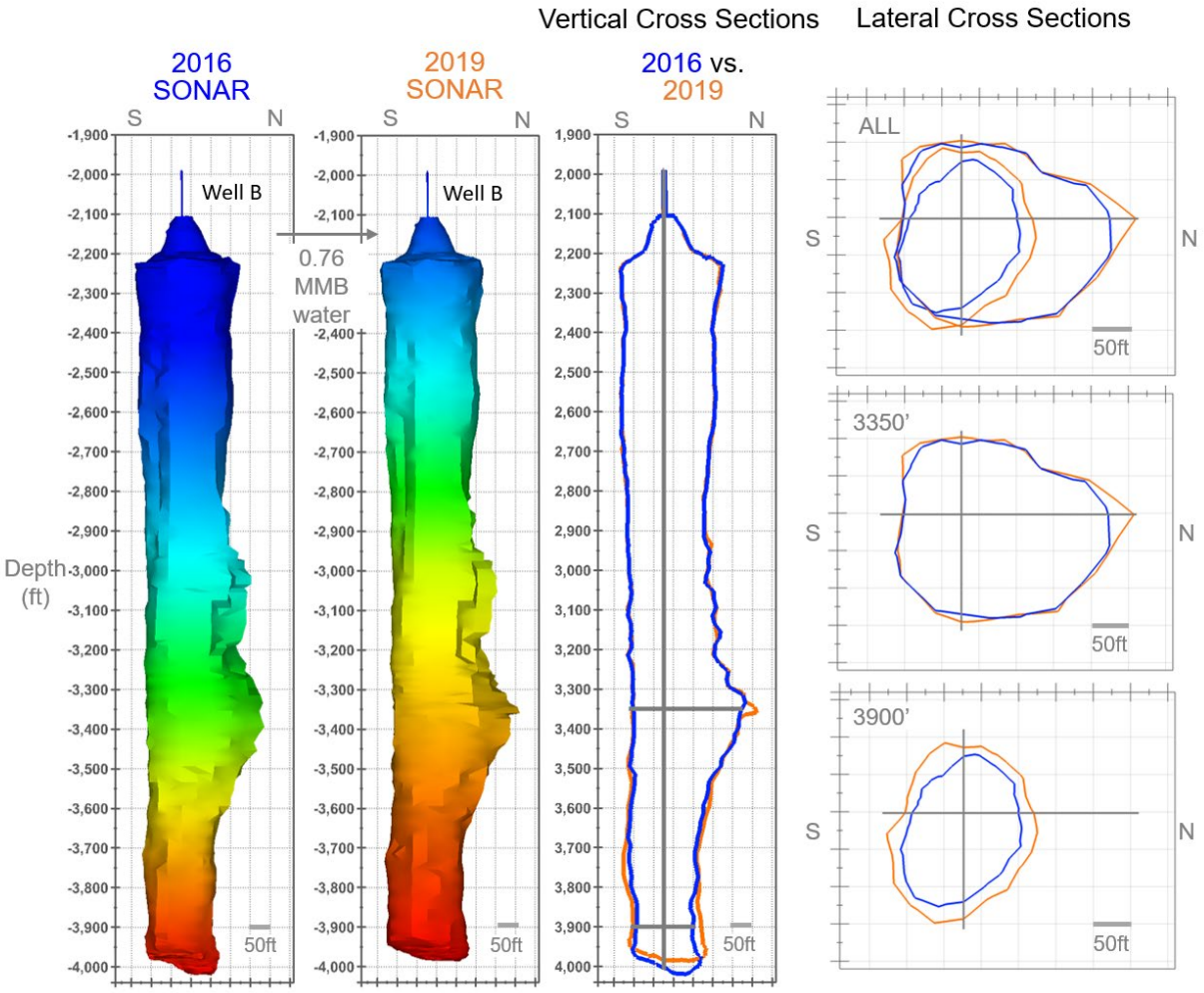

Figure 2-37. Leaching history in BM-103 from 2016 (blue) to 2019 (orange) via sonars in well B.

2.2.2.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BM-103 was in 2019. Since that sonar, about 2.0 MMB of water have been injected into the cavern in 2021 (see Table 2-21). The injection history was modeled using two leaching phases each with an EP of 60 days.

Table 2-21. Summary of Simulation Input for BM-103

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	04/02/21-06/26/21	3,993	29	28	643	643	6,574	86	565,324
2	10/04/21-12/15/21	3,993	29	27	Auto	703	20,099	73	1,467,204
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	159	2,032,528

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-22, the leaching efficiency for this cavern was 15.6%.

Table 2-22. Summary of Simulation Output for BM-103

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	703	1.2008	87,000	15.4
2	888	1.1996	231,000	15.7
ALL	888	1.1996	318,000	15.6

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-38). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 2.0 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-39 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-3) reveals a modeled leaching zone (see Figure 2-40) that is about 800 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-3 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

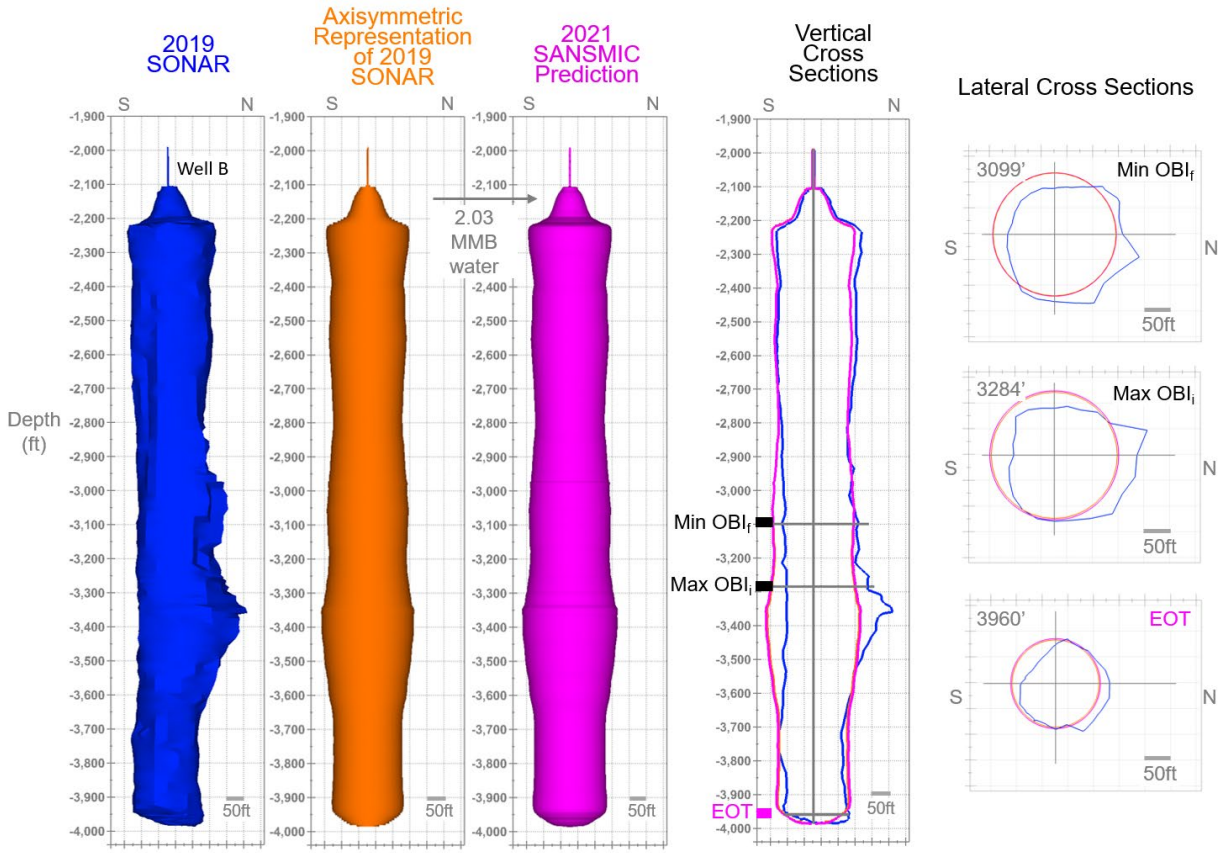

Figure 2-38. BM-103 modeling results for leaching between 2019 sonar and end of CY21.

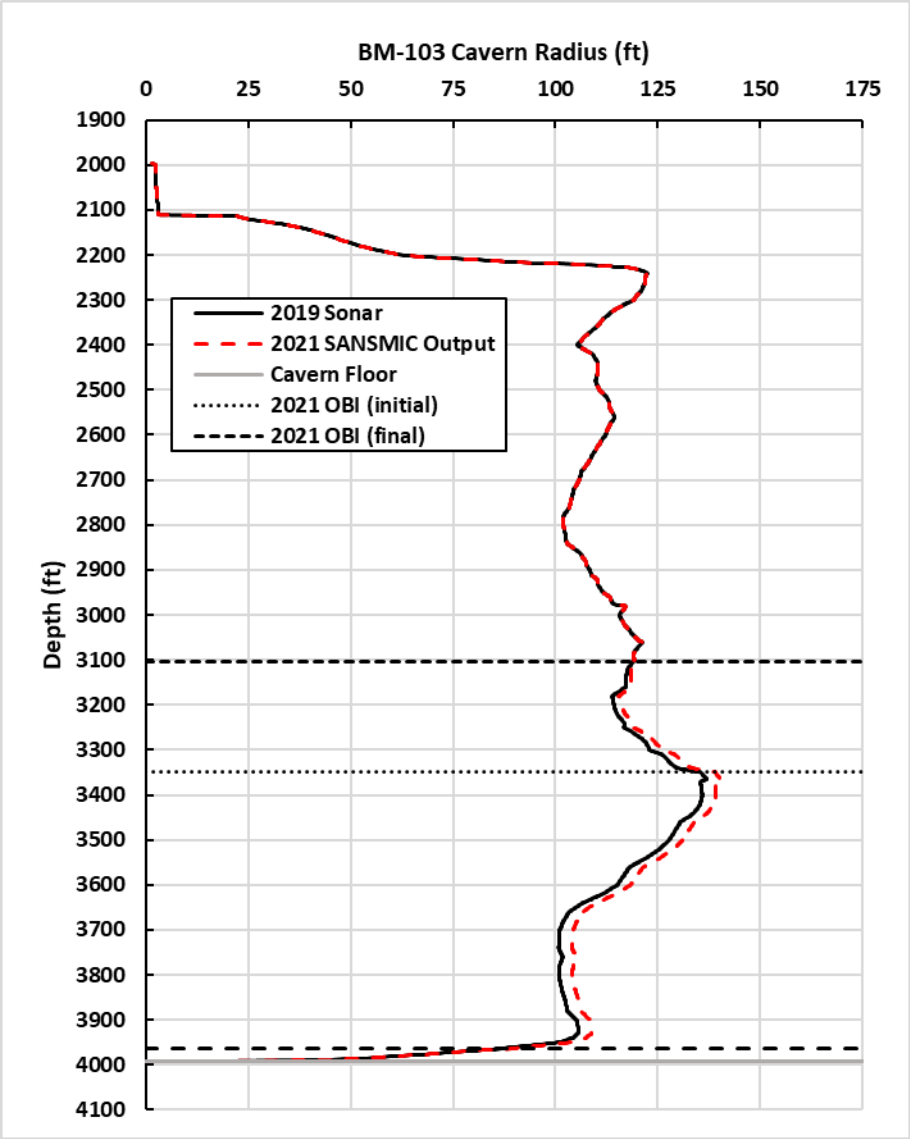

Figure 2-39. BM-103 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

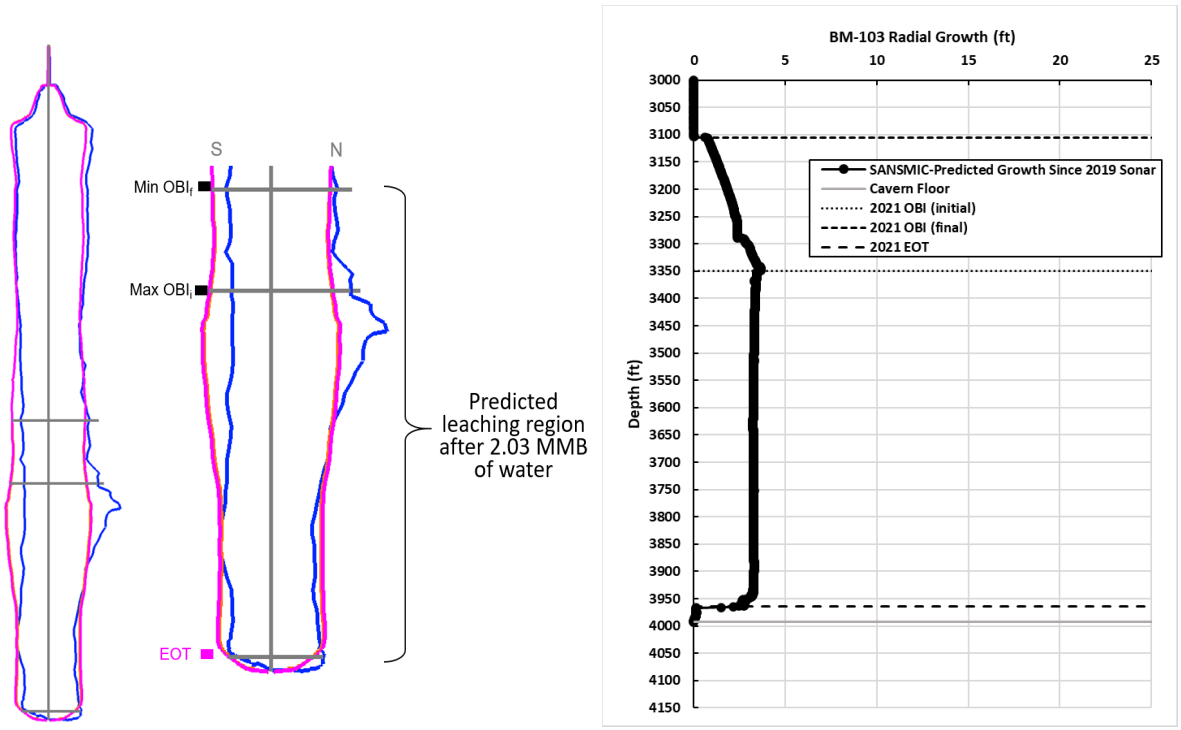

Figure 2-40. BM-103 SANSMIC-predicted radial growth since 2019 sonar.

2.2.3. BM-104

2.2.3.1. Leaching History

Sonars taken in the A well of BM-104 in 2006 and 2011 are shown in Figure 2-41. Some floor spread is observed in this cavern between sonar. There was 2.2 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape.

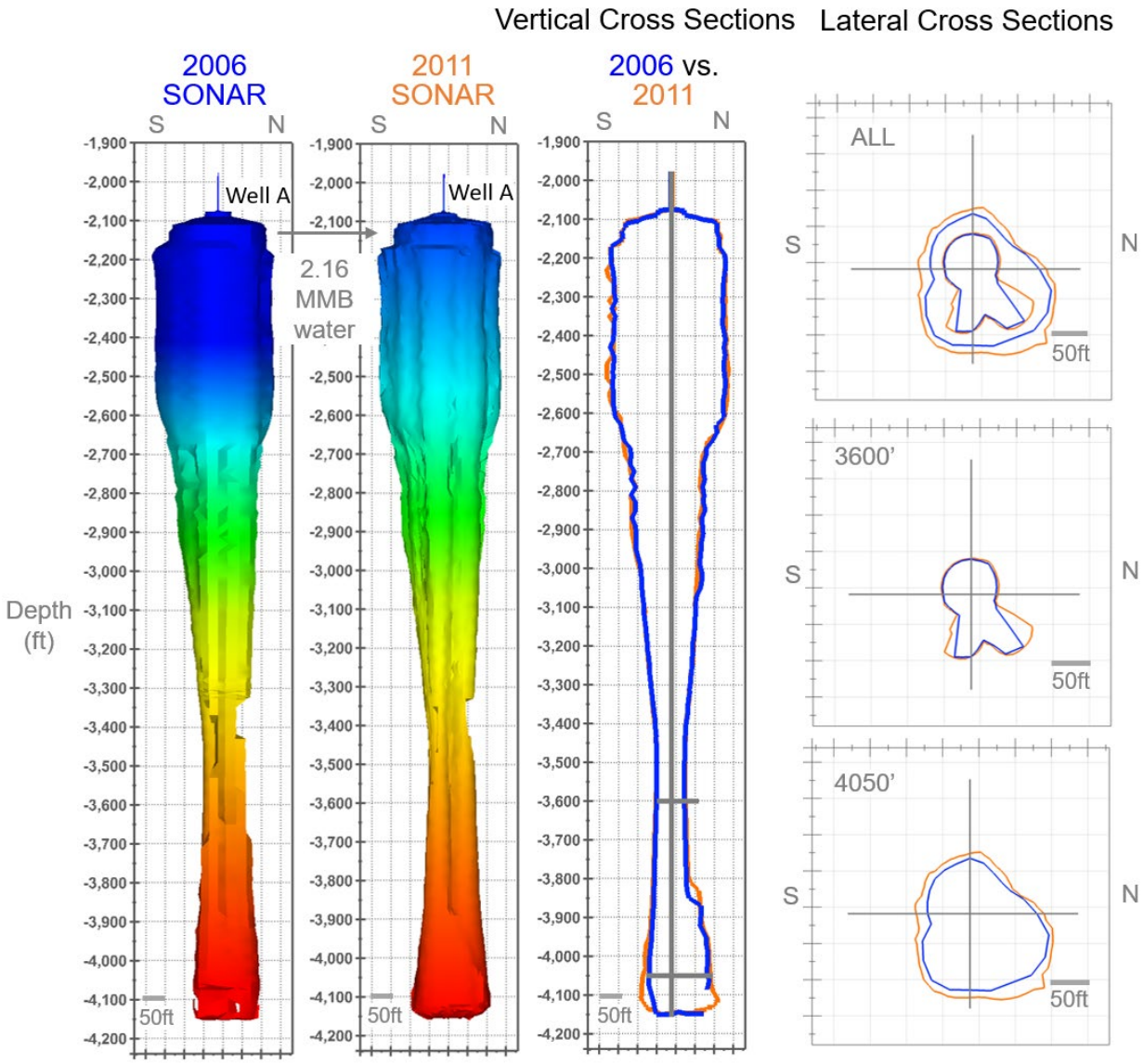

Figure 2-41. Leaching history in BM-104 from 2006 (blue) to 2011 (orange) via sonars in well A.

2.2.3.2. Simulated Leaching Between 2011 Sonar and End of CY21

The last sonar taken in BM-104 was in 2011 (a newer sonar was taken in 2021, but results were not yet available). Since that sonar, about 1.3 MMB of water have been injected into the cavern in 2021 (see Table 2-23). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-23. Summary of Simulation Input for BM-104

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	04/02/21-06/16/21	4,171	25	23	61	61	17,063	76	1,296,760

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-24, the leaching efficiency for this cavern was 16.0%.

Table 2-24. Summary of Simulation Output for BM-104

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	363	1.1993	207,000	16.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-42). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.3 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-43 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-43) reveals a modeled leaching zone (see Figure 2-44) that is about 300 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 10-12 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

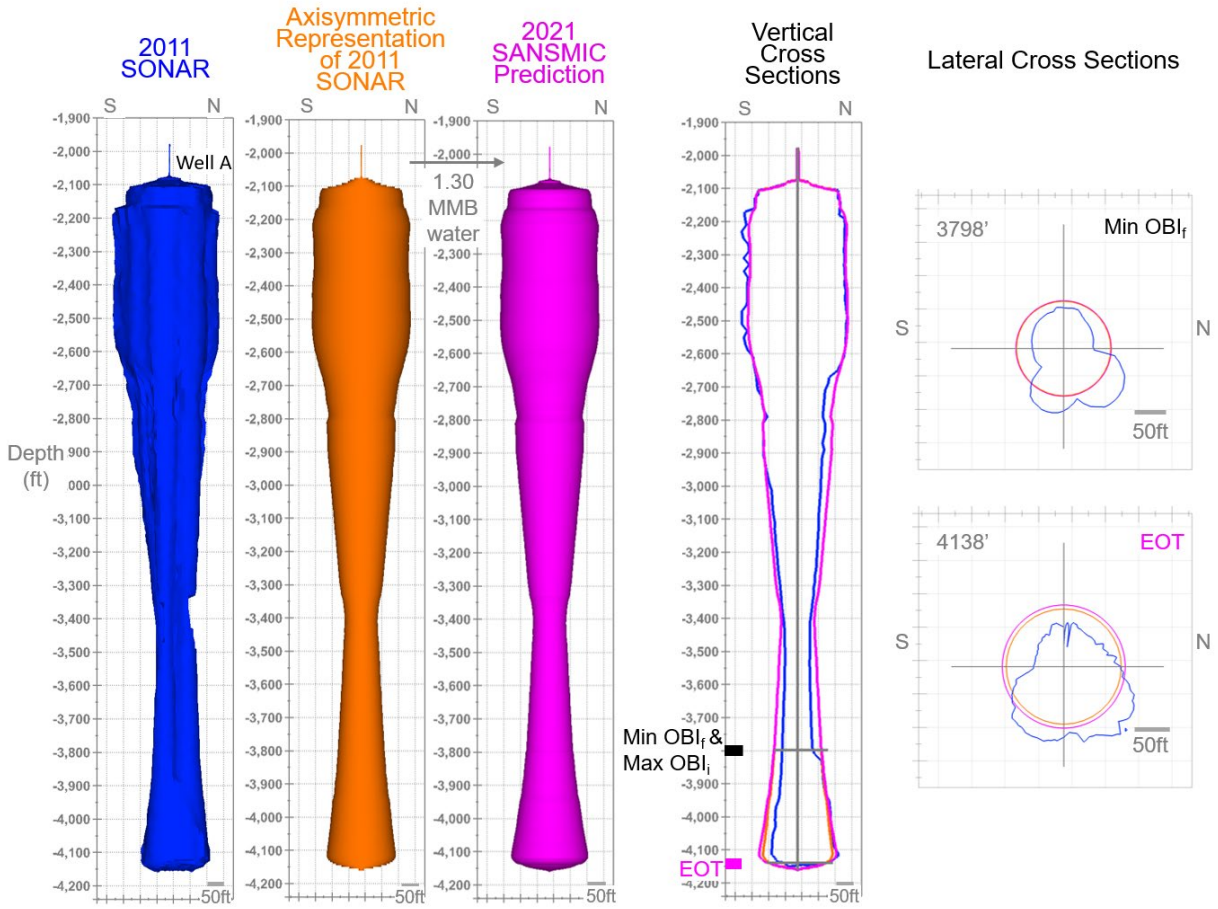

Figure 2-42. BM-104 modeling results for leaching between 2011 sonar and end of CY21.

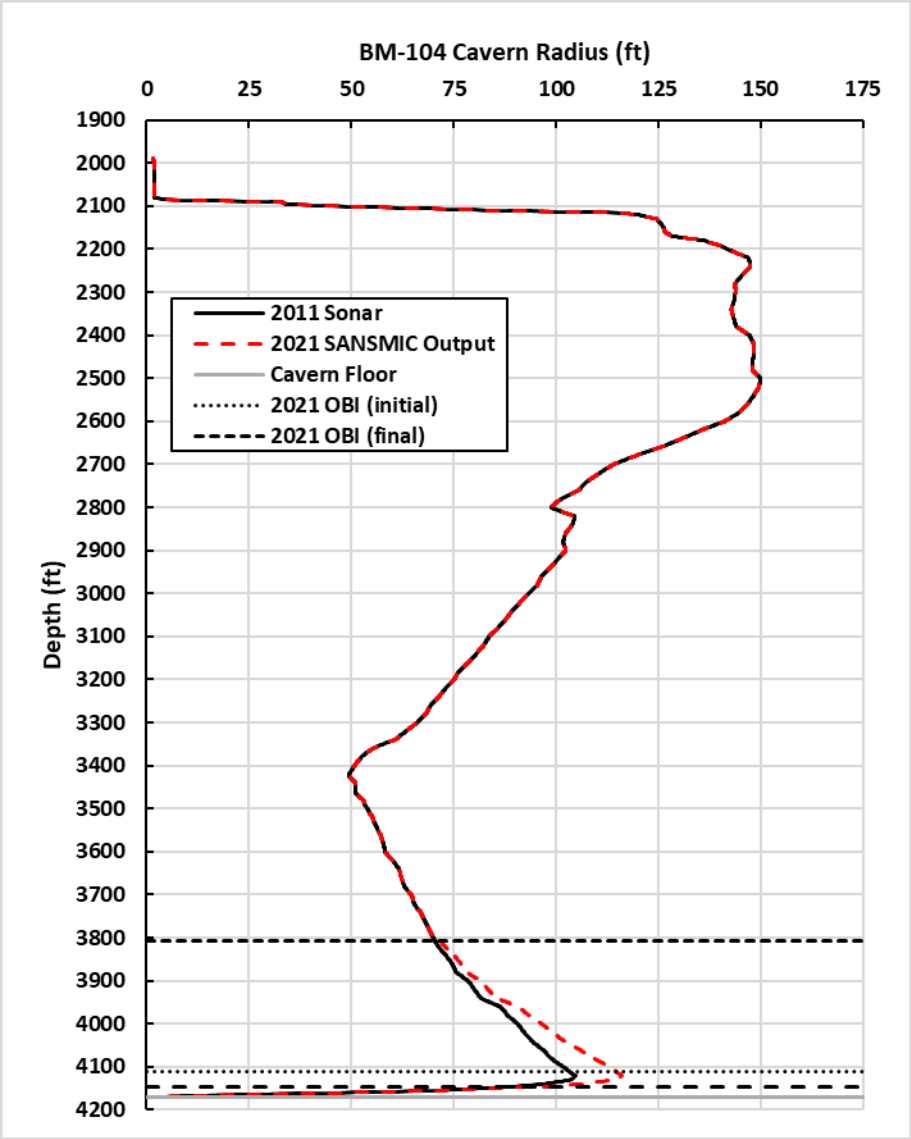

Figure 2-43. BM-104 axisymmetric representation of 2011 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

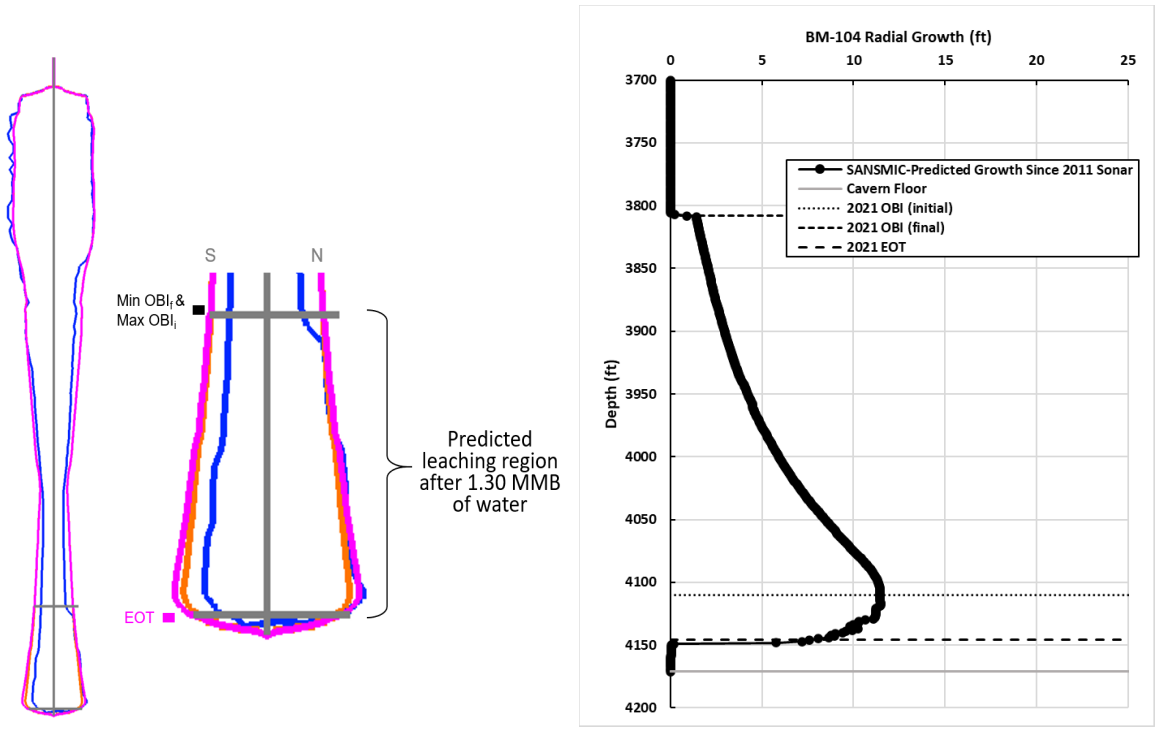

Figure 2-44. BM-104 SANSMIC-predicted radial growth since 2011 sonar.

2.2.4. BM-109

2.2.4.1. Leaching History

Sonars taken in the B and C wells of BM-109 in 1997, 2006, and 2016 are shown in Figure 2-45. Some floor rise occurred in this cavern between sonars. There was 0.58 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. Leaching was primarily radial from 2015 to 2020, suggesting that radial leaching should be expected for the 2.0 MMB of water that has been injected since the 2016 sonar.

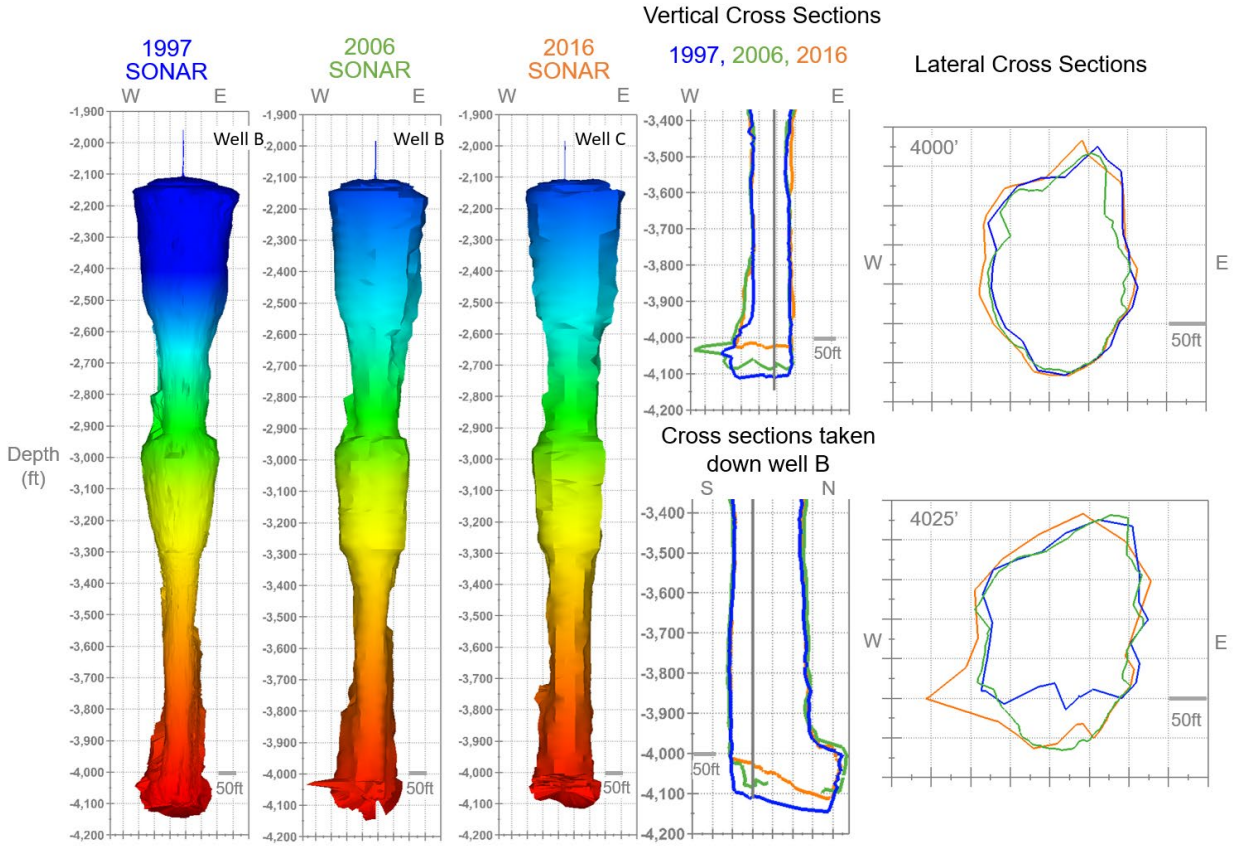

Figure 2-45. Leaching history in BM-109 from 1997 (blue) to 2006 (green) and 2016 (orange) via sonars in wells B and C.

2.2.4.2. Simulated Leaching Between 2016 Sonar and End of CY21

The last sonar taken in BM-109 was in 2016. Since that sonar, about 2.0 MMB of water have been injected into the cavern in 2018-2021 (see Table 2-25). The injection history was modeled as three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the one phase modeled for the CY18-19 report [8]. This cavern has had two Mod EOT rises.

Table 2-25. Summary of Simulation Input for BM-109

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/03/18-12/15/18	4,130	20	10	40	40	11,881	46	546,526
2	10/08/19-10/09/19	4,130	20	10	Auto	130	36,430	2	72,860
3	10/04/21-12/15/21	4,132	82	80	170	170	18,335	73	1,338,477
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	121	1,957,863

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-26, the leaching efficiency for this cavern was 16.0%.

Table 2-26. Summary of Simulation Output for BM-109

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	130	1.1975	89,000	16.3
2	140	1.1993	13,000	17.8
3	460	1.1992	212,000	15.8
ALL	460	1.1992	314,000	16.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2016 sonar and the end of CY21 (see Figure 2-46). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 2.0 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-47 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-47) reveals a modeled leaching zone (see Figure 2-48) that is about 400 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be up to about 15 ft. The odd shape of growth in the cavern can be attributed to multiple EOTs (10 and 80 ft above the cavern floor). A small growth of the flare near the cavern floor is observed. Monitoring of the flare is recommended.

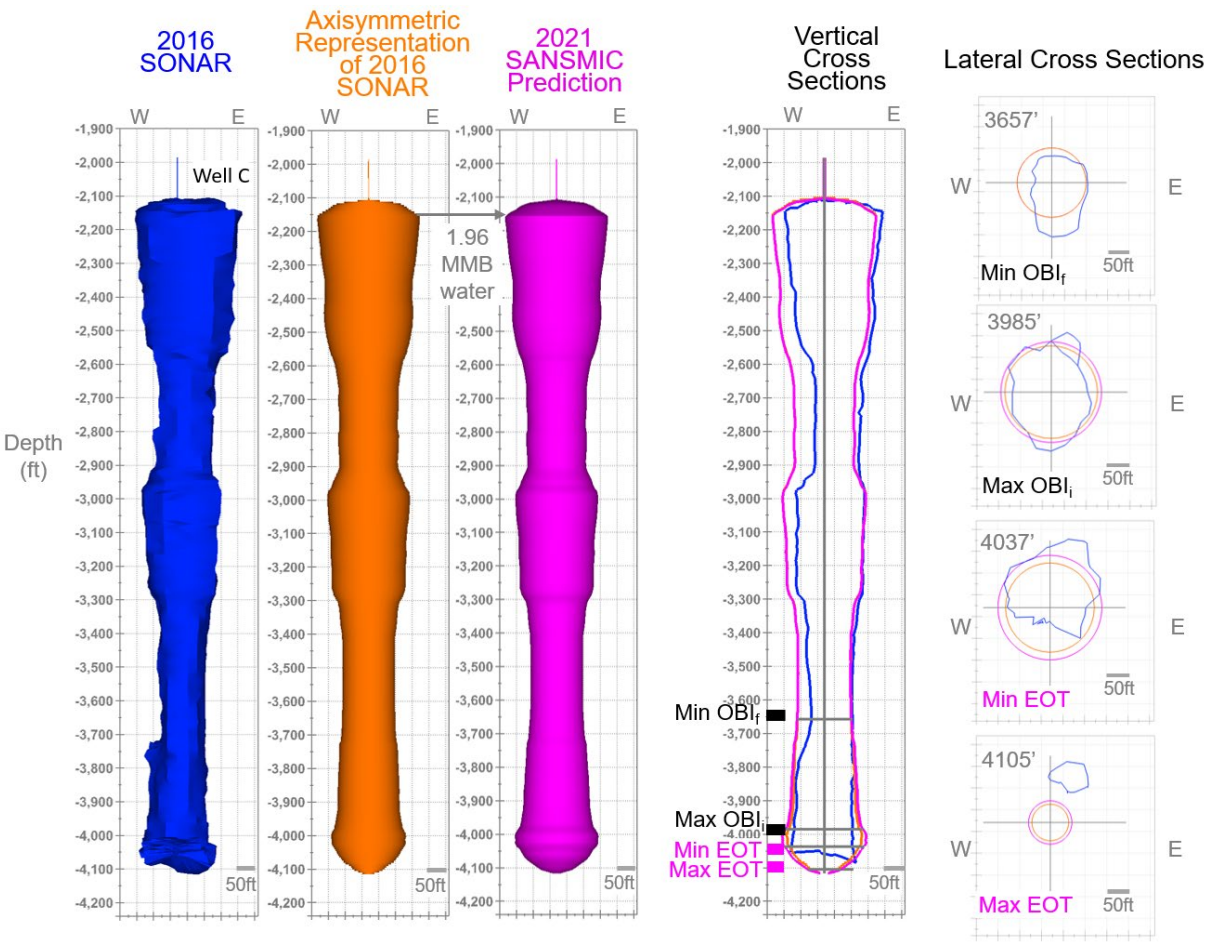

Figure 2-46. BM-109 modeling results for leaching between 2016 sonar and end of CY21.

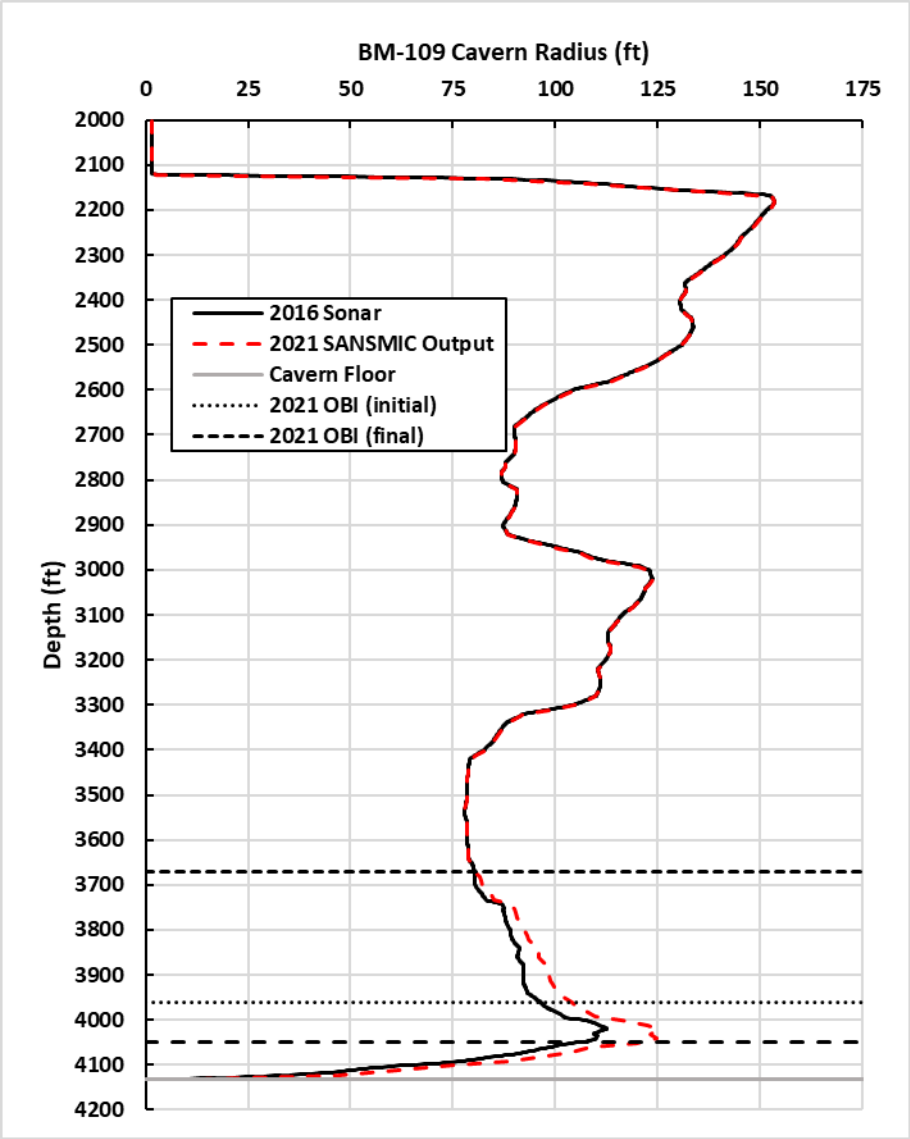

Figure 2-47. BM-109 axisymmetric representation of 2016 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

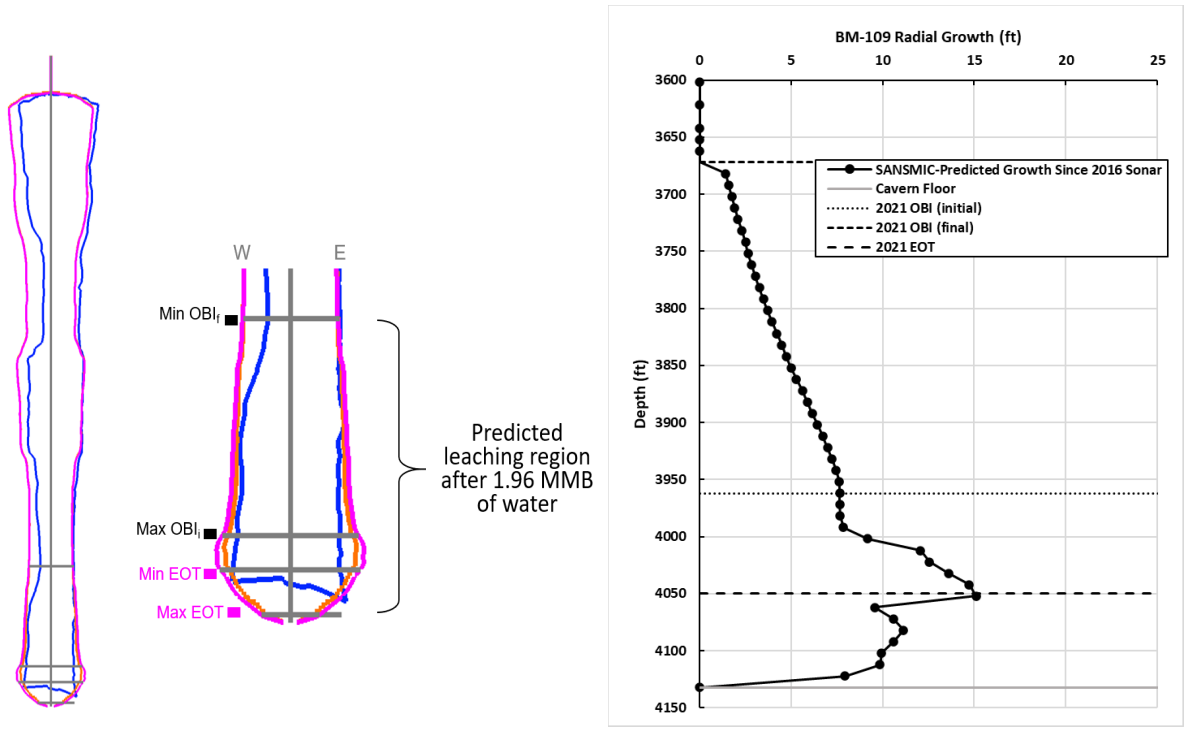

Figure 2-48. BM-109 SANSMIC-predicted radial growth since 2016 sonar.

2.2.5. BM-110

2.2.5.1. Leaching History

Sonars taken in the B and C wells of BM-110 in 2001, 2006, and 2016 are shown in Figure 2-49. Minimal changes to the floor depth are observed over the sonars even though sonar resolution changed over the time the sonars were performed. There was 1.9 MMB of water injected into this cavern between sonars.

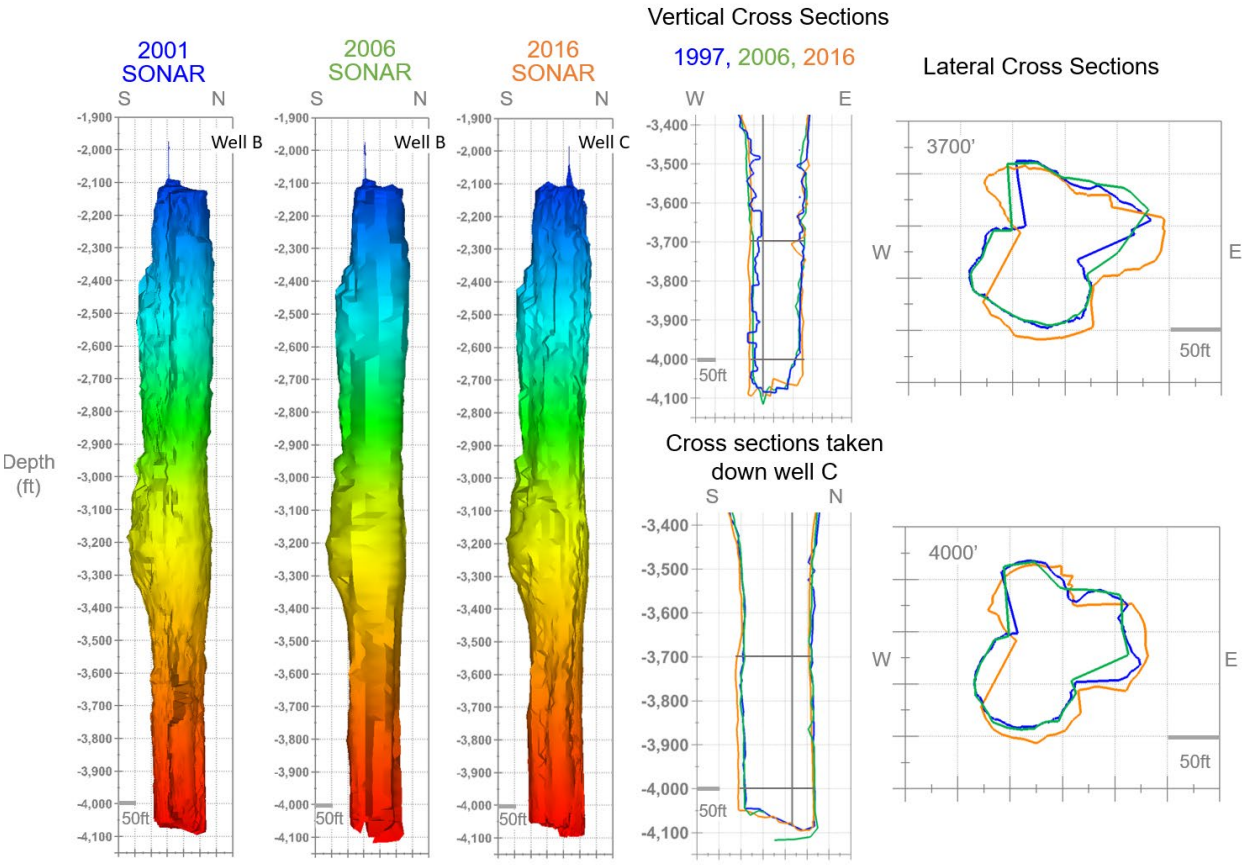

Figure 2-49. Leaching history in BM-110 from 2001 (blue) to 2006 (green) and 2016 (orange) via sonars in wells B and C.

2.2.5.2. Simulated Leaching Between 2016 Sonar and End of CY21

The last sonar taken in BM-110 was in 2021. Since that sonar, about 1.3 MMB of water have been injected into the cavern in 2021 (see Table 2-27). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-27. Summary of Simulation Input for BM-110

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/04/21-12/15/21	4,081	24	22	600	600	17,518	73	1,278,836

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-28, the leaching efficiency for this cavern was 16.0%.

Table 2-28. Summary of Simulation Output for BM-110

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	815	1.1994	204,000	16.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2021 sonar and the end of CY21 (see Figure 2-50). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.3 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-51 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-51) reveals a modeled leaching zone (see Figure 2-52) that is about 800 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-3 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time. A comparison of the 2021 sonar with 2019 SANSMIC results from [8] can be found in Section 3.3.

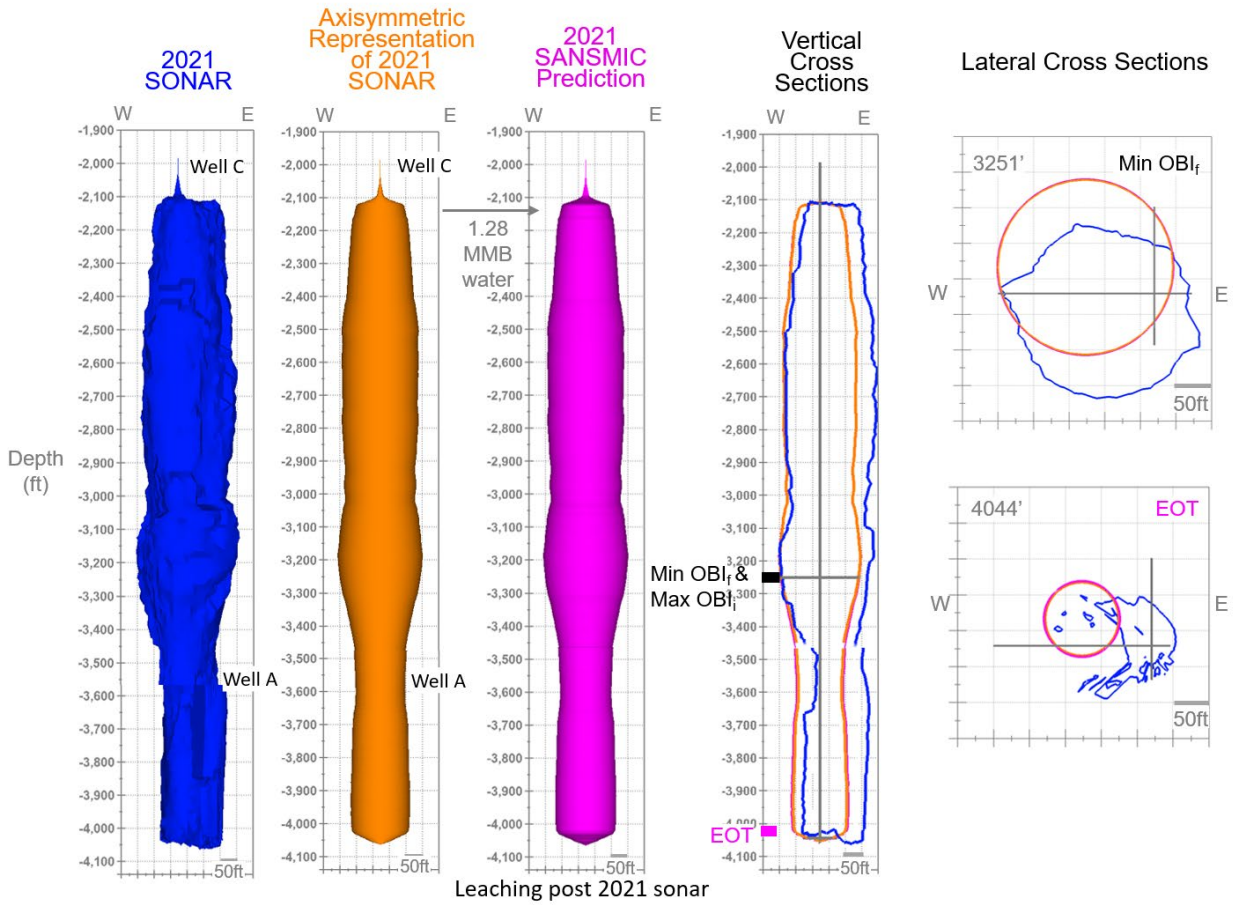

Figure 2-50. BM-110 modeling results for leaching between 2021 sonar and end of CY21.

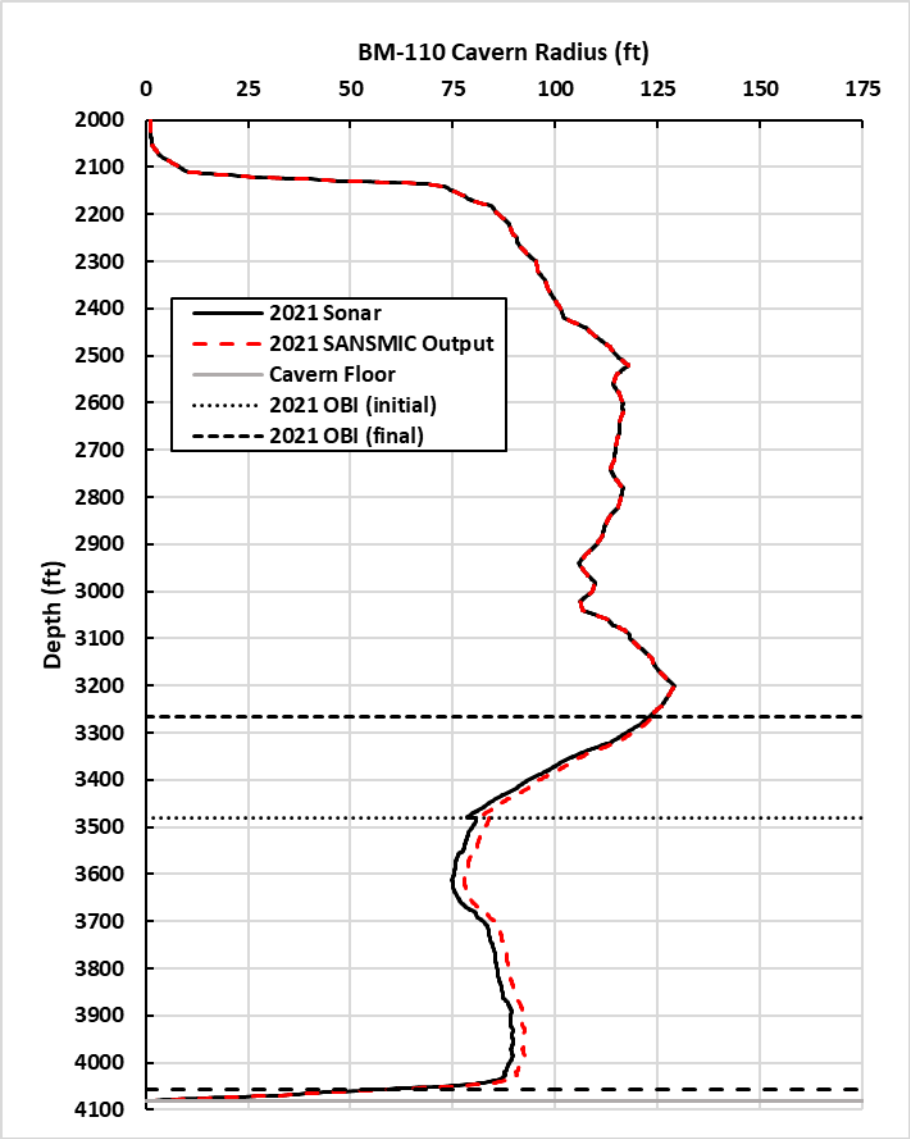

Figure 2-51. BM-110 axisymmetric representation of 2021 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

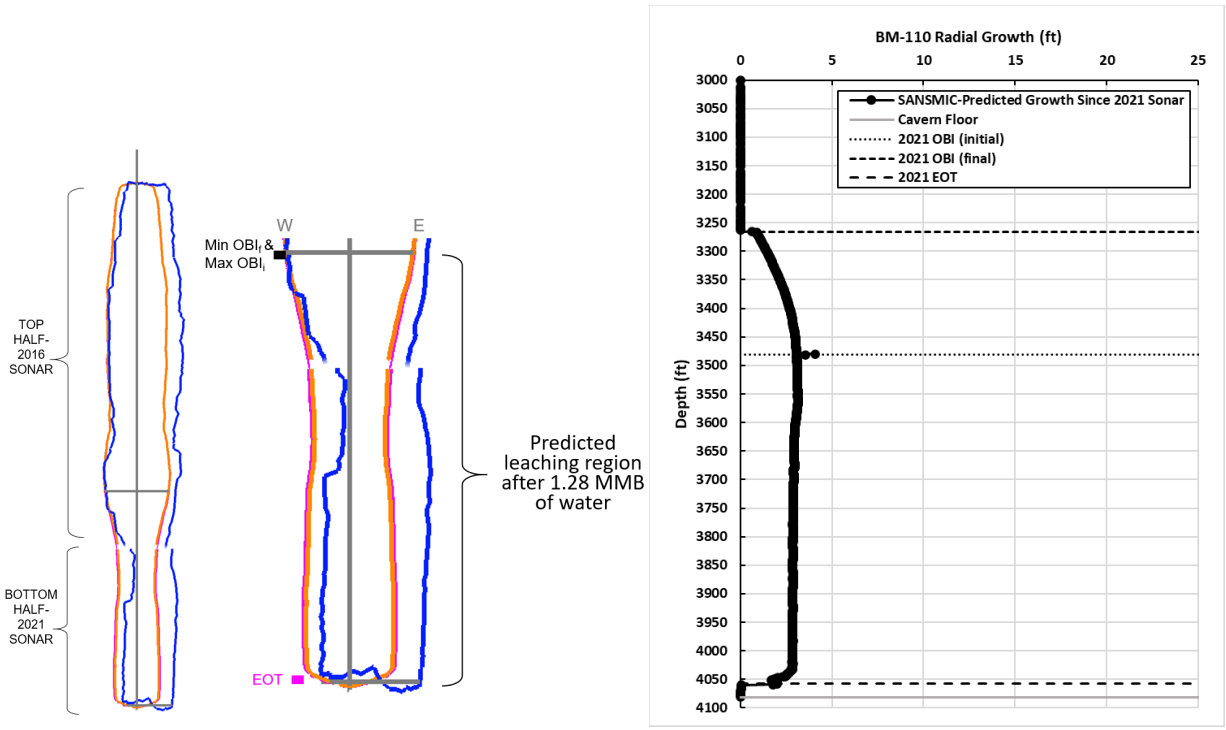

Figure 2-52. BM-110 SANSMIC-predicted radial growth since 2021 sonar.

2.2.6. BM-111

2.2.6.1. Leaching History

Sonars taken in the A well of BM-111 in 2016 and 2020 are shown in Figure 2-53. Some floor rise and floor spread occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 4.3 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. Leaching was primarily radial from 2016 to 2020, suggesting that radial leaching should be expected for the 3.1 MMB of water that has been injected since the 2020 sonar.

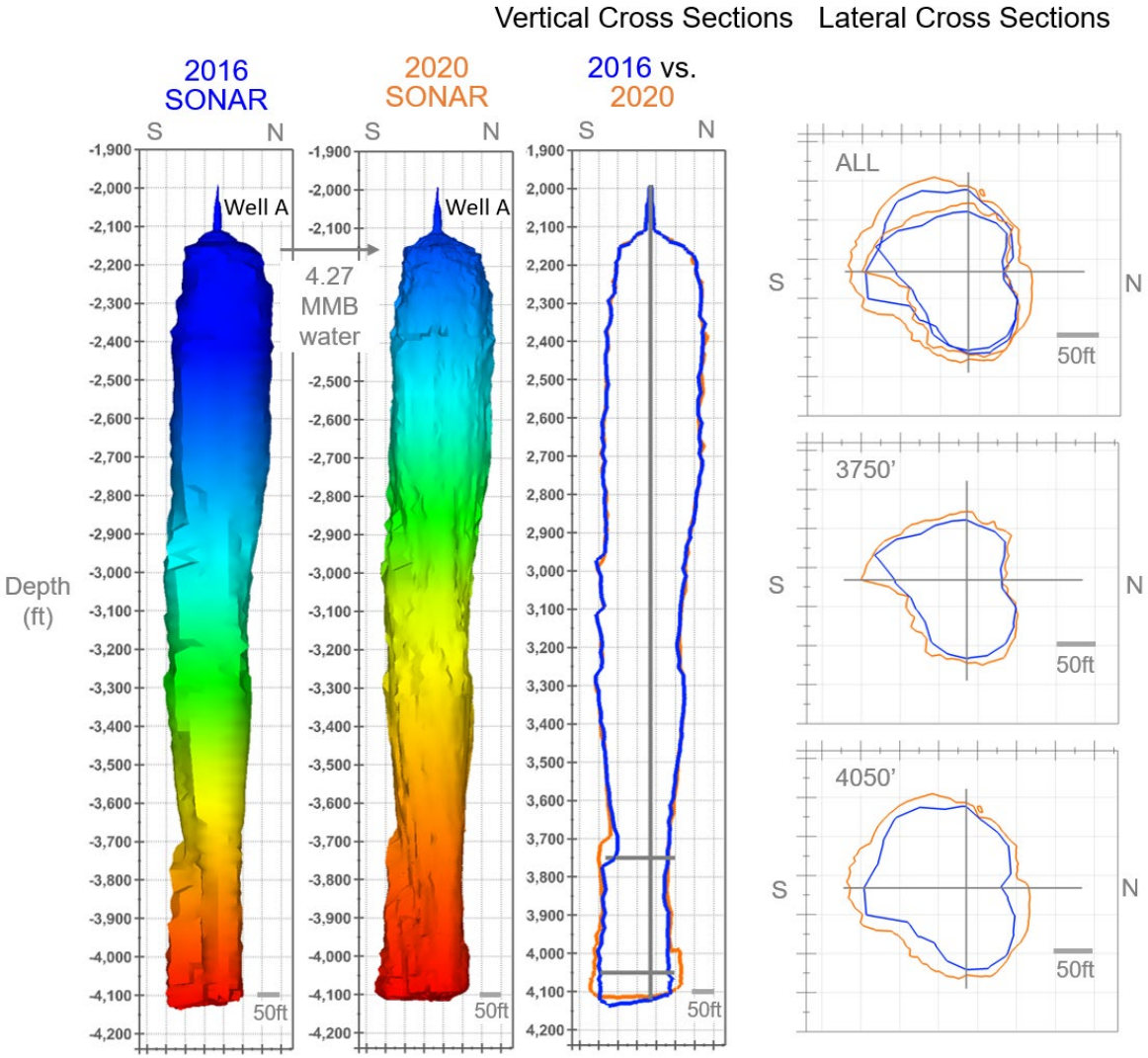

Figure 2-53. Leaching history in BM-111 from 2016 (blue) to 2020 (orange) via sonars in well A.

2.2.6.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in BM-111 was in 2020. Since that sonar, about 3.1 MMB of water have been injected into the cavern in 2021 (see Table 2-29). The injection history was modeled as two phases of leaching each with an EP of 60 days.

Table 2-29. Summary of Simulation Input for BM-111

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	04/02/21-06/26/21	4,126	29	27	809	809	19,442	86	1,671,989
2	10/04/21-12/15/21	4,126	45	43	Auto	1,037	19,544	73	1,426,719
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	159	3,098,708

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-30, the leaching efficiency for this cavern was 16.0%.

Table 2-30. Summary of Simulation Output for BM-111

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	1,037	1.2002	263,000	15.7
2	1,236	1.2004	232,000	16.3
ALL	1,236	1.2004	495,000	16.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-54). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.1 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-55 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-55) reveals a modeled leaching zone (see Figure 2-56) that is about 1,200 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1-5 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

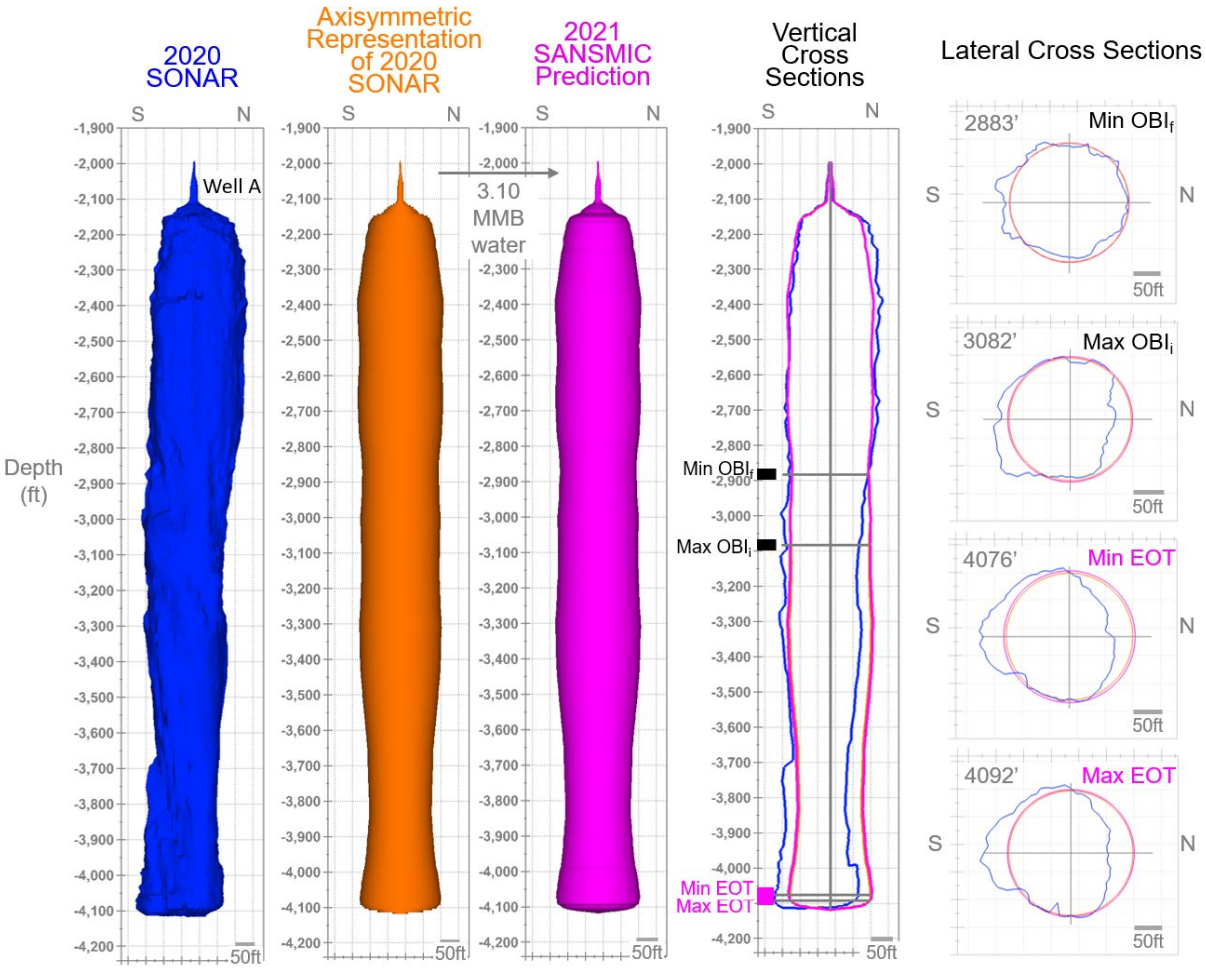

Figure 2-54. BM-111 modeling results for leaching between 2020 sonar and end of CY21.

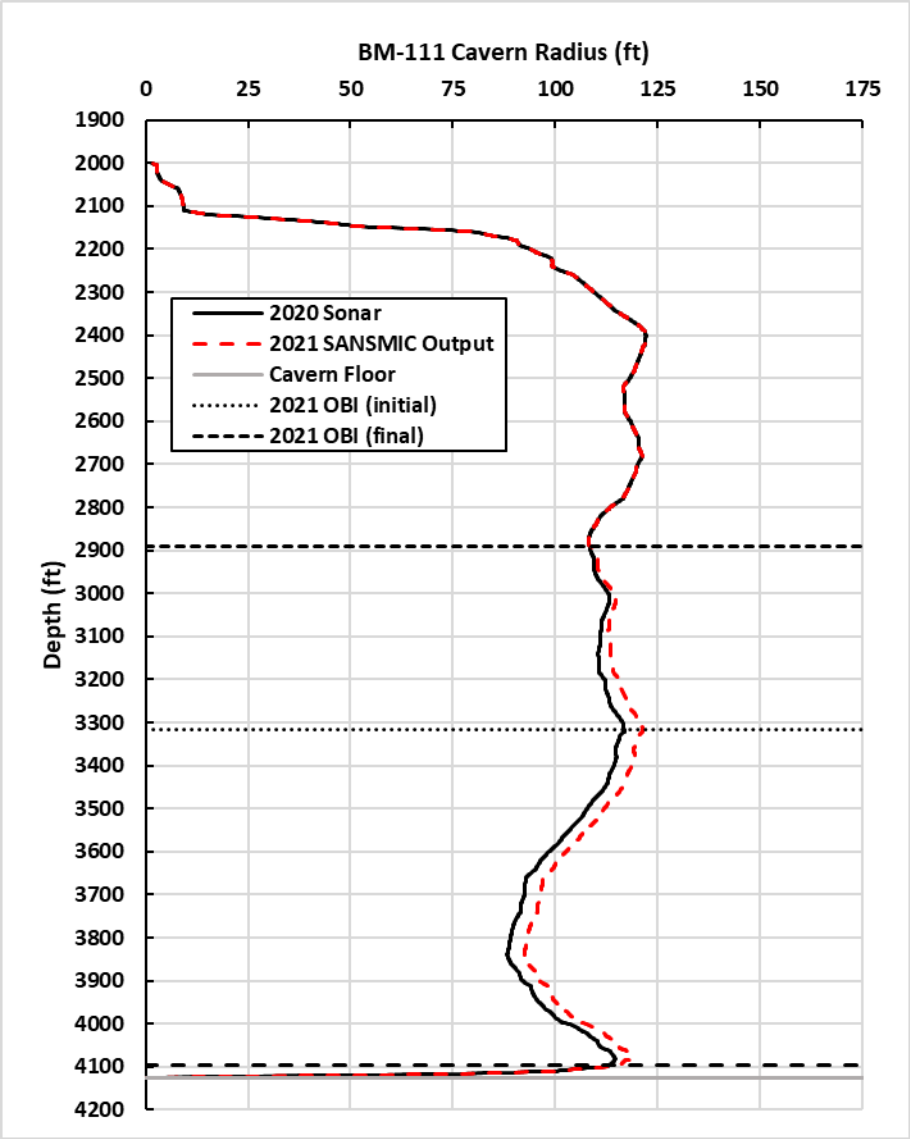

Figure 2-55. BM-111 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

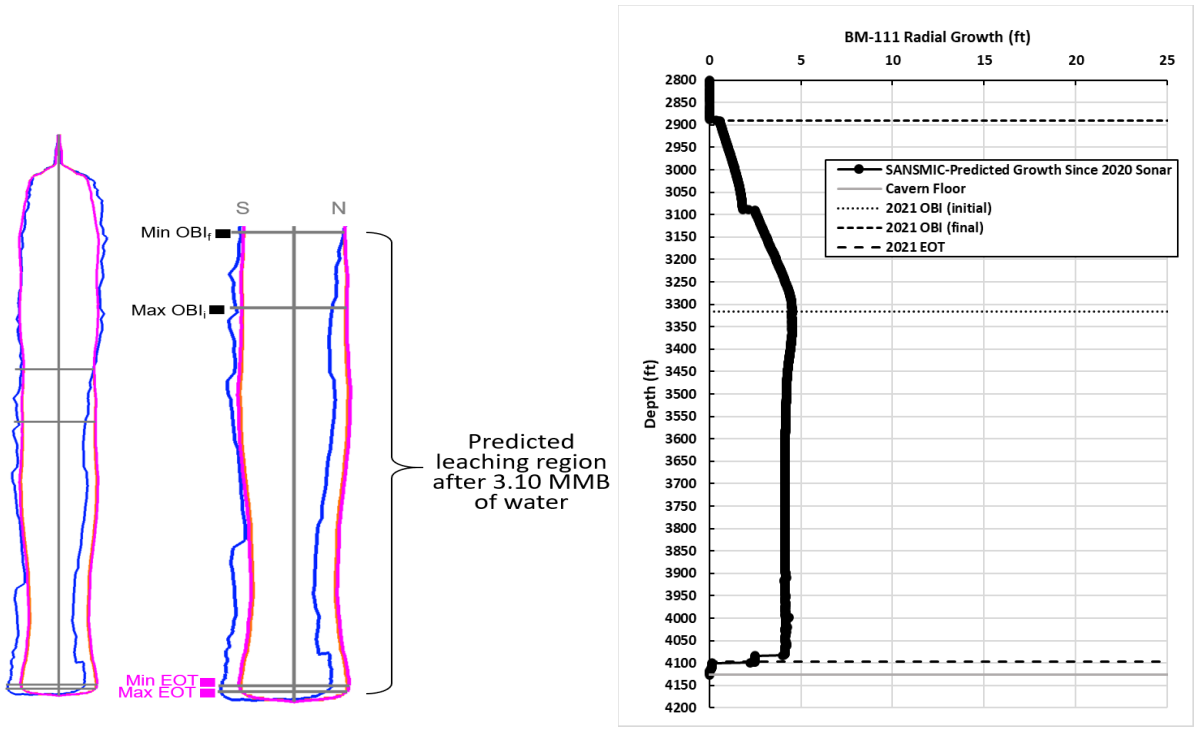

Figure 2-56. BM-111 SANSMIC-predicted radial growth since 2020 sonar.

2.3. West Hackberry

Simulation results for West Hackberry are summarized in Table 2-31, including the volume of raw water injection simulated with SANSMIC modeling and any potential concerns observed. Seven caverns had at least 10 MB of raw water injected in CY21, but two (WH-111 and WH-117) had a sonar taken subsequent to raw water injection—leaching for those two caverns is discussed in Section 3. Four of those caverns (WH-109, WH-111, WH-114, WH-115) have had at least 3 MMB of water injected since the last sonar. While most of the caverns do not have leaching induced features of concern at this time, WH-11, WH-112, and WH114 have features which should be monitored with continued leaching in that cavern. A brief leaching history and the results of SANSMIC modeling of leaching since the last sonar are discussed below for each cavern.

Table 2-31. Caverns at West Hackberry with water injected in CY21.

Cavern	Last Sonar	Injected Water Volume* (MMB)	Concerns
WH-11	2020	2.4	Monitor shelf/ledge near 3,650’
WH-109	2019	3.5	No
WH-111**	2015, 2021	4.0	No
WH-112	2018	1.7	Monitor flare near EOT
WH-114	2020	3.6	Monitor feature near 4215’
WH-115	2020	3.4	No
WH-117**	2019, 2021	1.6	No

* Since last sonar
** No raw water injected subsequent to 2021 sonar. See Section 3.

2.3.1. WH-11

2.3.1.1. Leaching History

Sonars taken in the S and B wells of WH-11 in 2018 and 2020 are shown in Figure 2-57. The 1.3 MMB of water injected between sonars resulted in small radial growth above the existing flaring of the cavern floor (i.e., the "flipper" feature described in [8]), but no growth of the existing flare. Additionally, some small floor rise is observed. Based on leaching from 2018 to 2020, the leaching pattern may be symmetric that was associated with the 2.4 MMB of water that has been injected since the 2020 sonar.

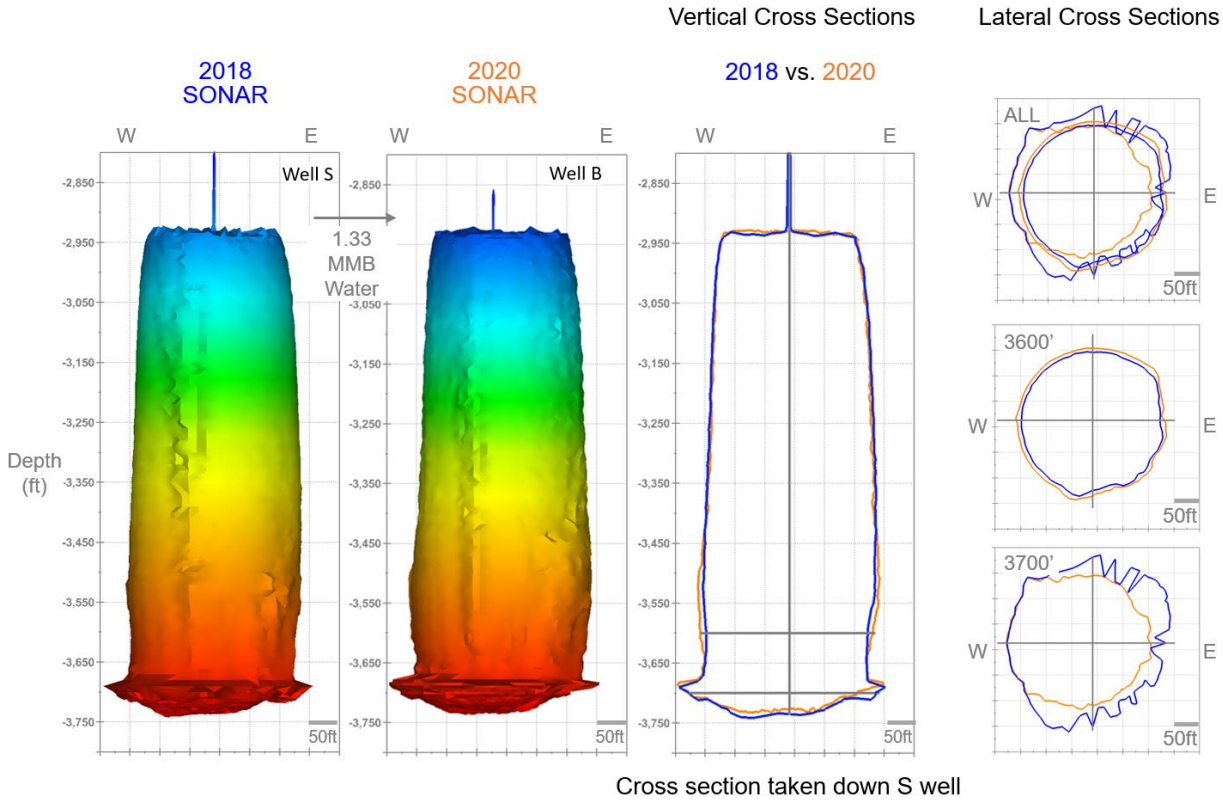

Figure 2-57. Leaching history in WH-11 from 2018 (blue) to 2020 (orange) via sonars in wells S and B.

2.3.1.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in WH-11 was in 2020. Since that sonar, around 2.4 MMB of water have been injected into the cavern in 2020-2021 (see Table 2-32). The injection history was modeled using three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the one phase modeled for the CY20 report [12]. This cavern has had two Mod EOT rises.

Table 2-32. Summary of Simulation Input for WH-11

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	08/02/20-08/22/20	3750	111	100	156	160	83,396	6	500,376
2	06/02/21-06/29/21	3,750	118	110	211	210	26,383	28	738,725
3	10/04/21-12/11/21	3,750	118	110	Auto	270	16,846	69	1,162,346
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	103	2,401,447

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-33, the overall leaching efficiency for this cavern was 15.2%.

Table 2-33. Summary of Simulation Output for WH-11

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	200	1.194	72,500	14.5
2	270	1.1953	107,400	14.5
3	360	1.1967	184,200	15.8
ALL	360	1.1967	364,100	15.2

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-58). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 2.4 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-59 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-59) reveals a modeled leaching zone (see Figure 2-60) that is about 250 ft tall and reflects the

distance between OBI and EOT. The maximum radial growth over this depth is predicted to be up to about 10-15 ft. The SANSMIC-predicted growth of a sharp flare feature near the cavern floor was noted in [8]. Later, the EOT was moved higher in the cavern to avoid further growth of the flare. With the current EOT depth, a shelf/ledge feature has developed in addition to the flare feature at a depth of about 3,650 ft. Monitoring of the shelf/ledge is recommended with the EOT at the current depth.

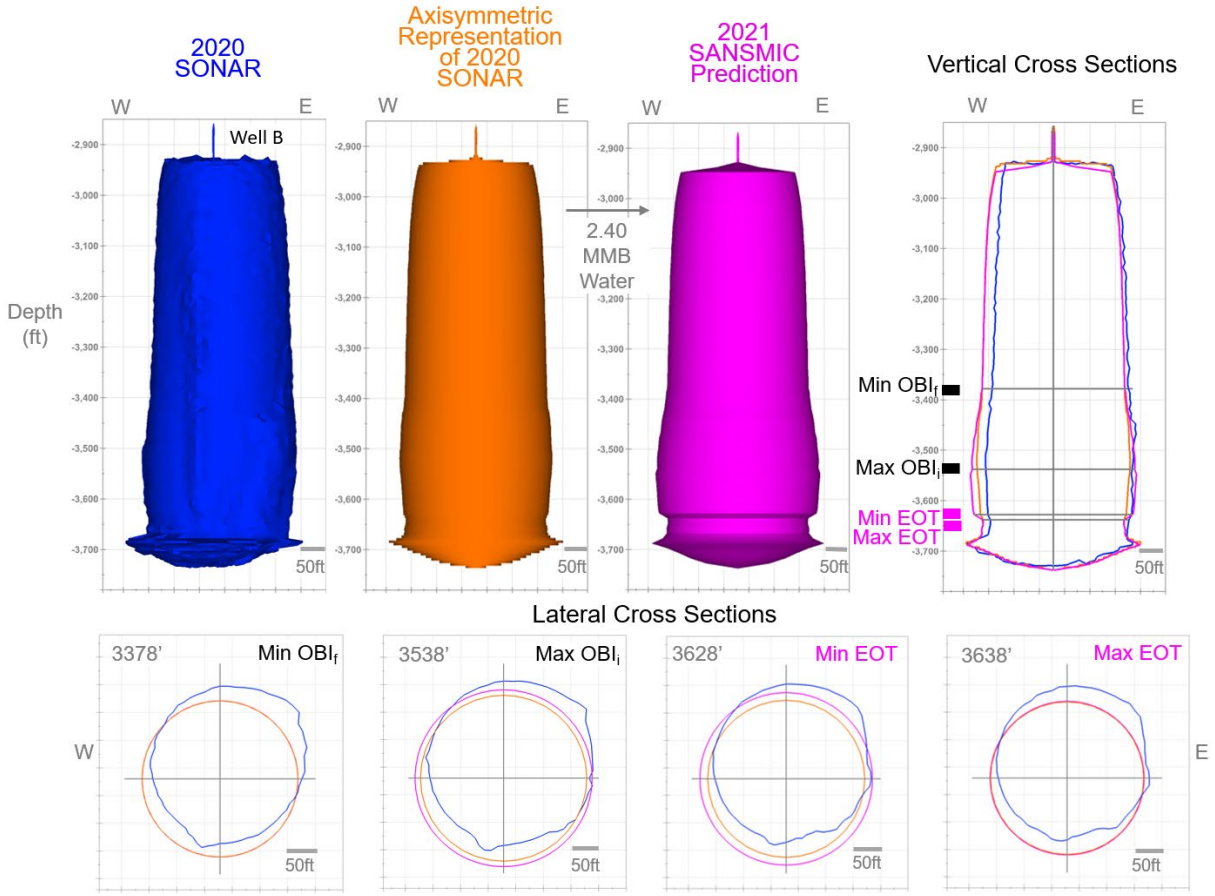

Figure 2-58. WH-11 modeling results for leaching between 2020 sonar and end of CY21.

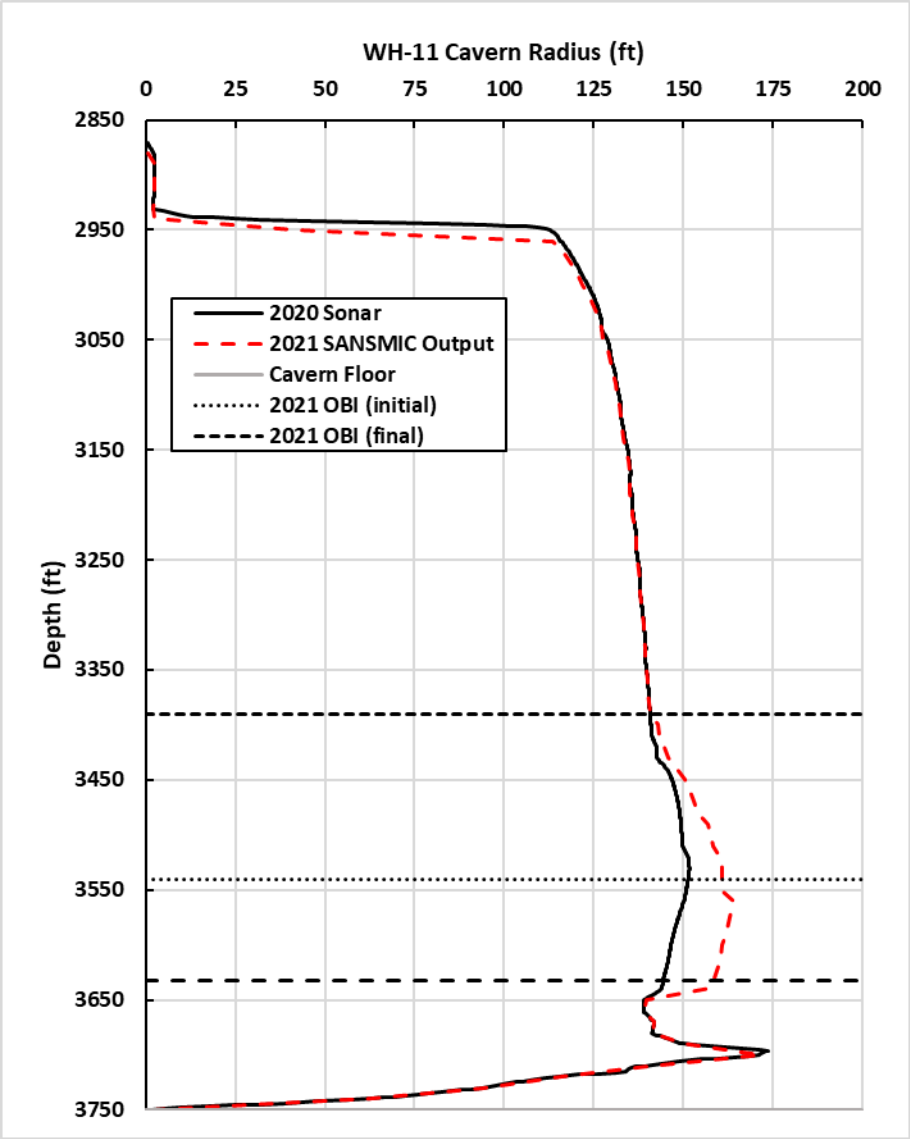

Figure 2-59. WH-11 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

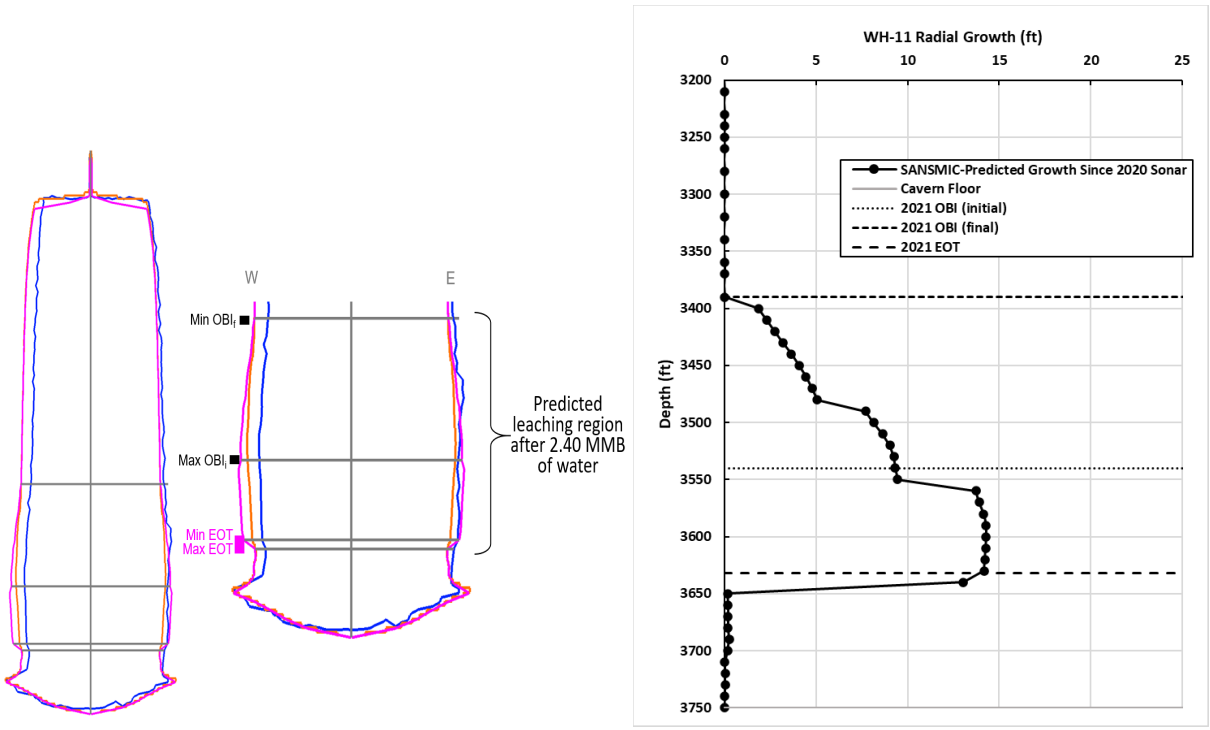

Figure 2-60. WH-11 SANSMIC-predicted radial growth since 2020 sonar.

2.3.2. WH-109

2.3.2.1. Leaching History (new cavern)

Sonars taken in WH-109 in 2012 and 2019 are shown in Figure 2-61. Floor rise is observed. There was 2.9 MMB of water injected into this cavern between sonars. Based on leaching from 2004 to 2019, the leaching pattern may be relatively symmetric (although leaching is observed to be somewhat biased toward east-west rather than north-south) that was associated with the 3.5 MMB of water that has been injected since the 2019 sonar.

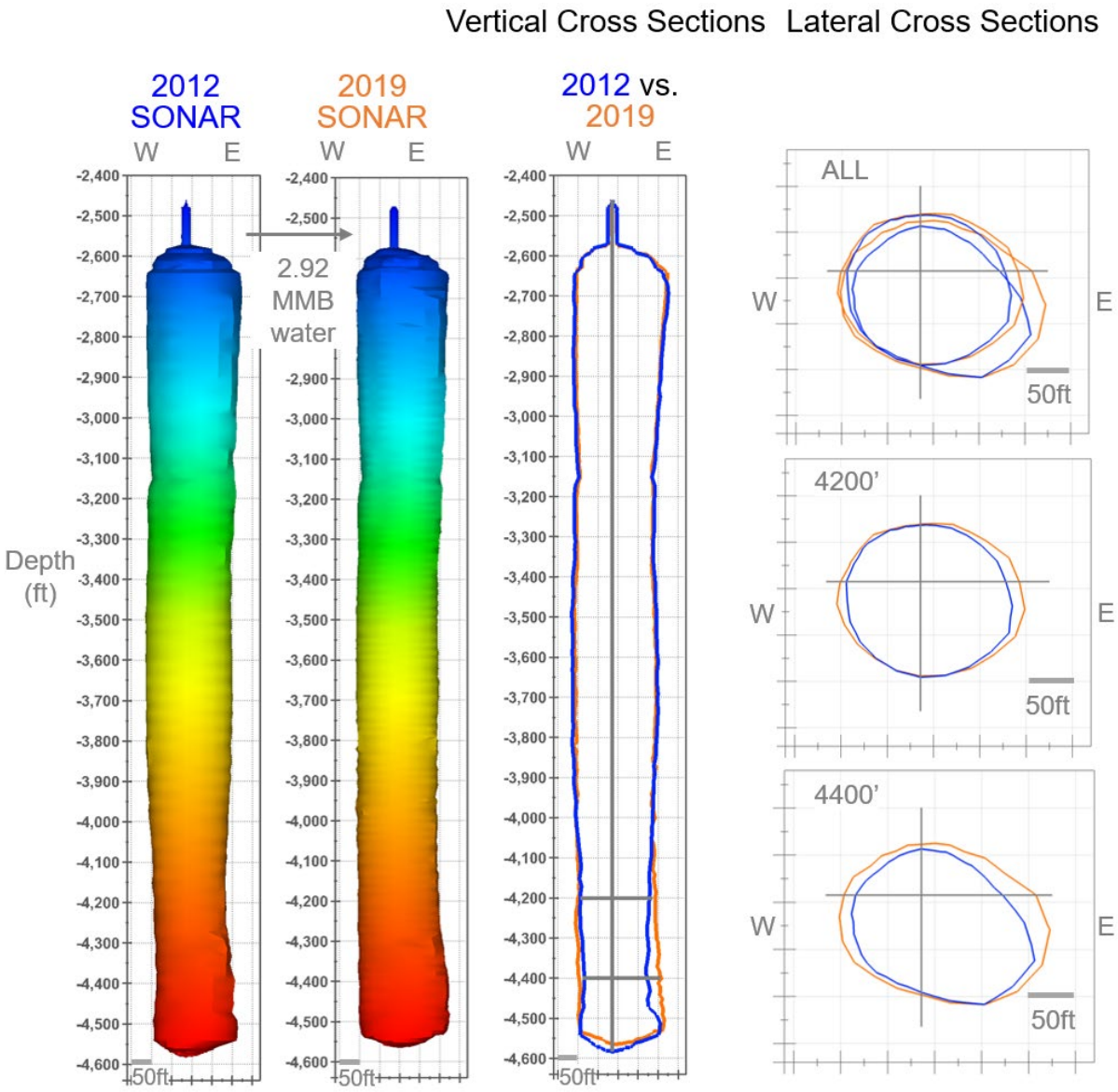

Figure 2-61. Leaching history in WH-109 from 2012 (blue) to 2019 (orange) via sonars.

2.3.2.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in WH-109 was in 2019. Since that sonar, around 3.5 MMB of water was injected into the cavern in 2020-2021 (see Table 2-34). The injection history was modeled as three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the one phase modeled for the CY20 report [12].

Table 2-34. Summary of Simulation Input for WH-109

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/27/20-11/22/20	4574	22	20	598	600	25,100	9	225,900
2	02/03/21-06/29/21	4,574	28	20	644	640	10,392	147	1,527,572
3	10/04/21-12/14/21	4,574	28	20	Auto	900	24,780	72	1,784,179
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	228	3,537,651

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-35, the overall leaching efficiency for this cavern was 15.9%.

Table 2-35. Summary of Simulation Output for WH-109

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	640	1.2008	33,000	14.6
2	900	1.2009	244,000	16.0
3	1,190	1.2002	286,000	16.0
ALL	1,190	1.2002	563,000	15.9

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-62). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.5 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-63 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-63) reveals a modeled leaching zone (see Figure 2-64) that is about 1,100 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only

about 1-5 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

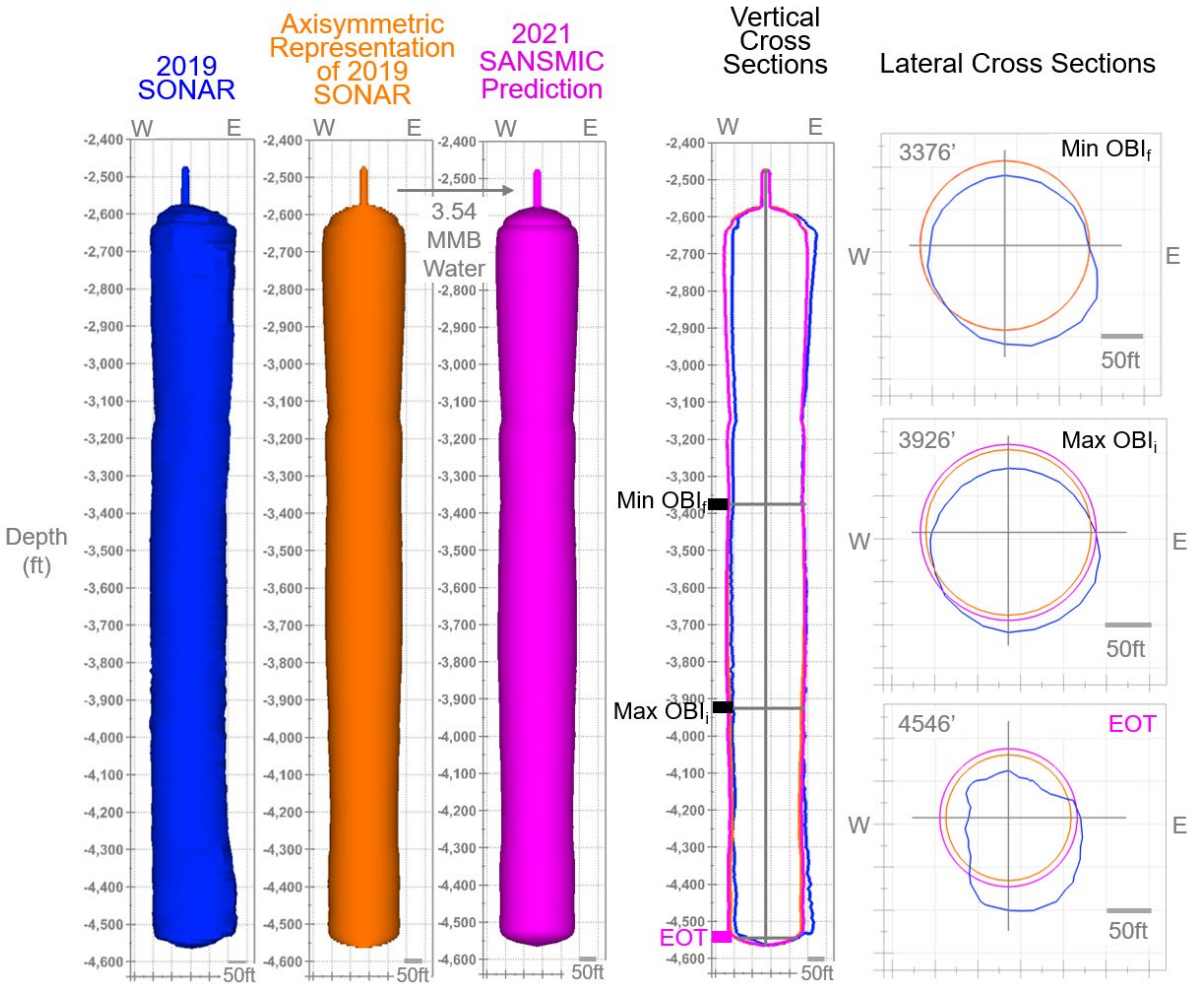

Figure 2-62. WH-109 modeling results for leaching between 2019 sonar and end of CY21.

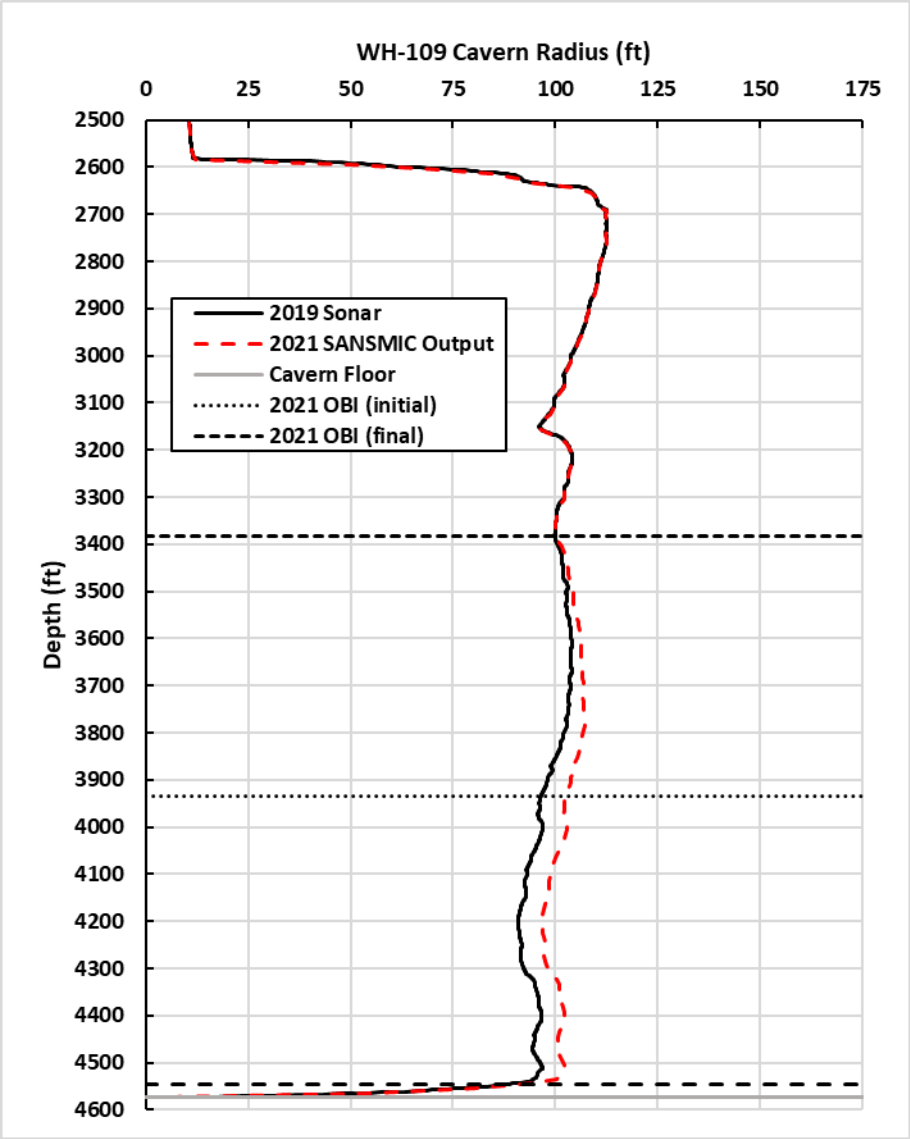

Figure 2-63. WH-109 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

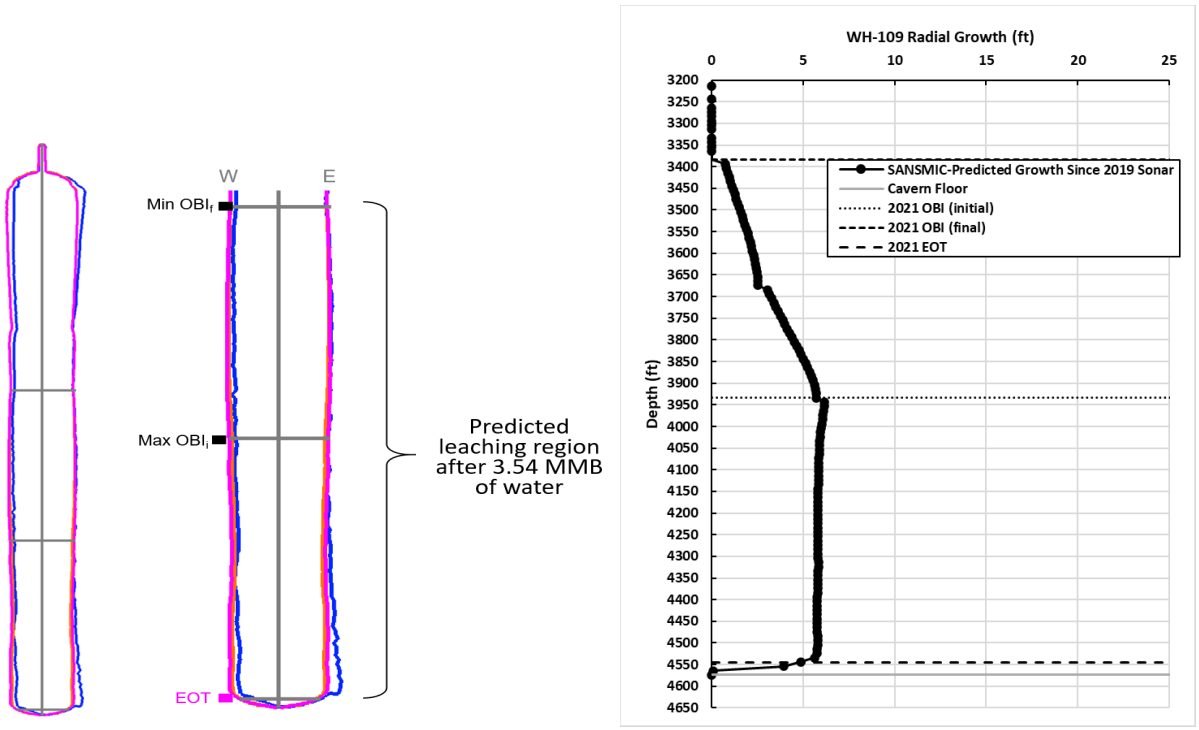

Figure 2-64. WH-109 SANSMIC-predicted radial growth since 2019 sonar.

2.3.3. WH-112

2.3.3.1. Leaching History

Sonars taken in WH-112 in 2004 and 2018 are shown in Figure 2-65. It appears that contraction/creep has occurred in this cavern between sonars as evidenced by the small changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 0.01 MMB of water injected into this cavern between sonars. Based on the relatively small amount of leaching from 2004 to 2018, it is difficult to estimate the leaching pattern associated with the 1.7 MMB of water that has been injected since the 2018 sonar.

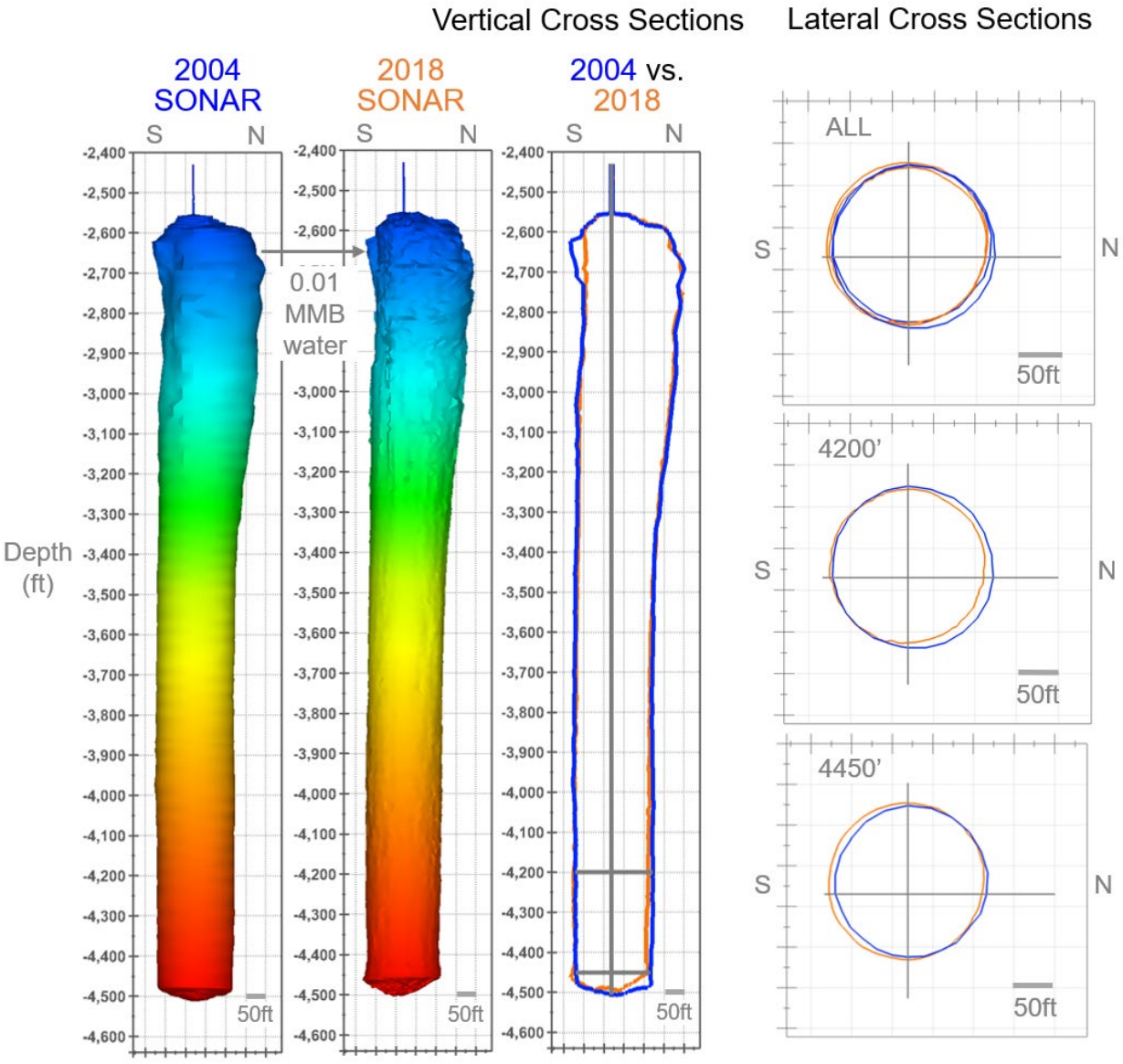

Figure 2-65. Leaching history in WH-112 from 2004 (blue) to 2018 (orange) via sonars.

2.3.3.2. Simulated Leaching Between 2018 Sonar and End of CY21

The last sonar taken in WH-112 was in 2018. Since that sonar, around 1.7 MMB of water have been injected into the cavern in 2018-2020 (see Table 2-36). The injection history was modeled using four phases of leaching each with an EP of 60 days. To represent CY21 water injection, a single phase was added to the three phases modeled for the CY20 [12]. This cavern has had three Mod EOT rises.

Table 2-36. Summary of Simulation Input for WH-112

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/04/18-11/30/18	4513	21	20	55	60	13,657	58	792,106
2	04/30/19-05/15/19	4513	21	10	248	250	31,699	5	158,495
3	08/22/20-08/22/20	4513	21	10	273	270	39,959	1	39,959
4	06/02/21-06/29/21	4,513	34	30	295	300	26,830	28	751,237
All	N/A	N/A	N/A	N/A	N/A	N/A	N/A	92	1,741,797

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of each EP. As summarized in Table 2-37, the overall leaching efficiency for this cavern was 15.8%.

Table 2-37. Summary of Simulation Output for WH-112

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	220	1.1988	129,000	16.3
2	280	1.1999	24,000	15.1
3	280	1.2014	6,000	15.0
4	450	1.1991	116,000	15.4
All	450	1.1991	275,000	15.8

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2018 sonar and the end of CY21 (see Figure 2-66). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.0 MMB.

Vertical cross sections from each of the cavern geometries reveal overall slight changes from leaching, though they are more pronounced at the EOT. Figure 2-67 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output.

Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-67) reveals a modeled leaching zone (see Figure 2-68) that is about 400 ft tall and reflects the large distance between OBI and EOT, as well as large variation in OBI. The maximum radial growth over this depth is predicted to be about 15 ft. The flaring at the bottom of the cavern is predicted to be more pronounced than in previous leaching reports [8][12]. he simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time. Monitoring of the flare is recommended.

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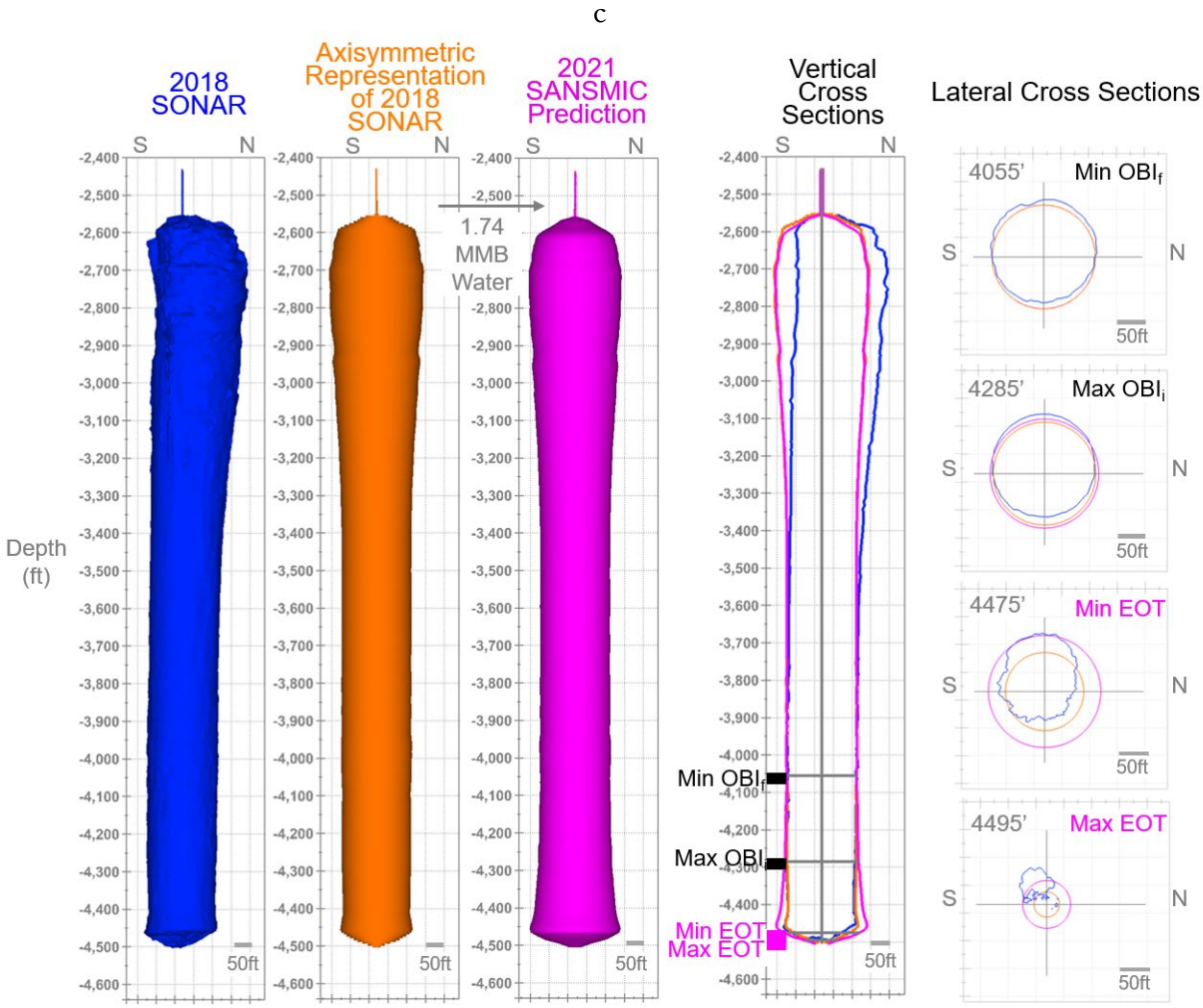

Figure 2-66. WH-112 modeling results for leaching between 2018 sonar and end of CY21.

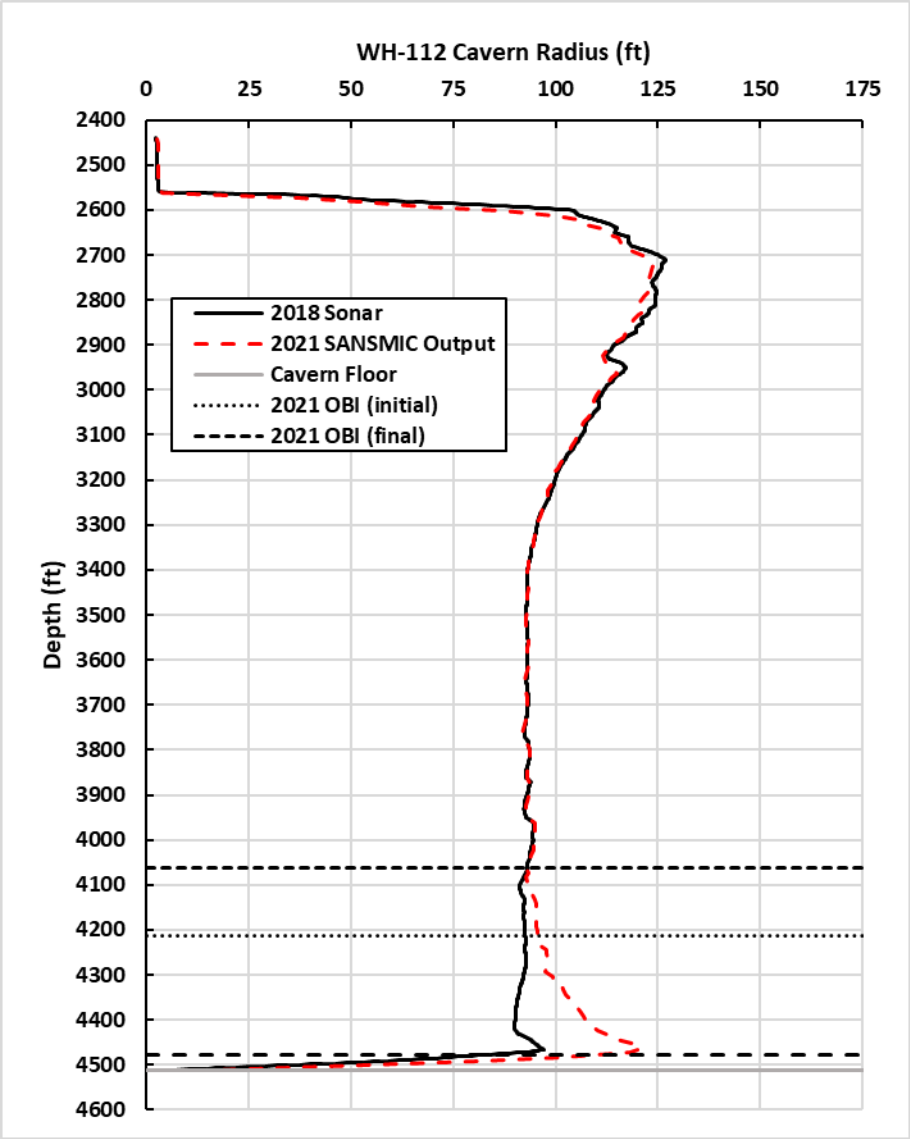

Figure 2-67. WH-112 axisymmetric representation of 2018 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

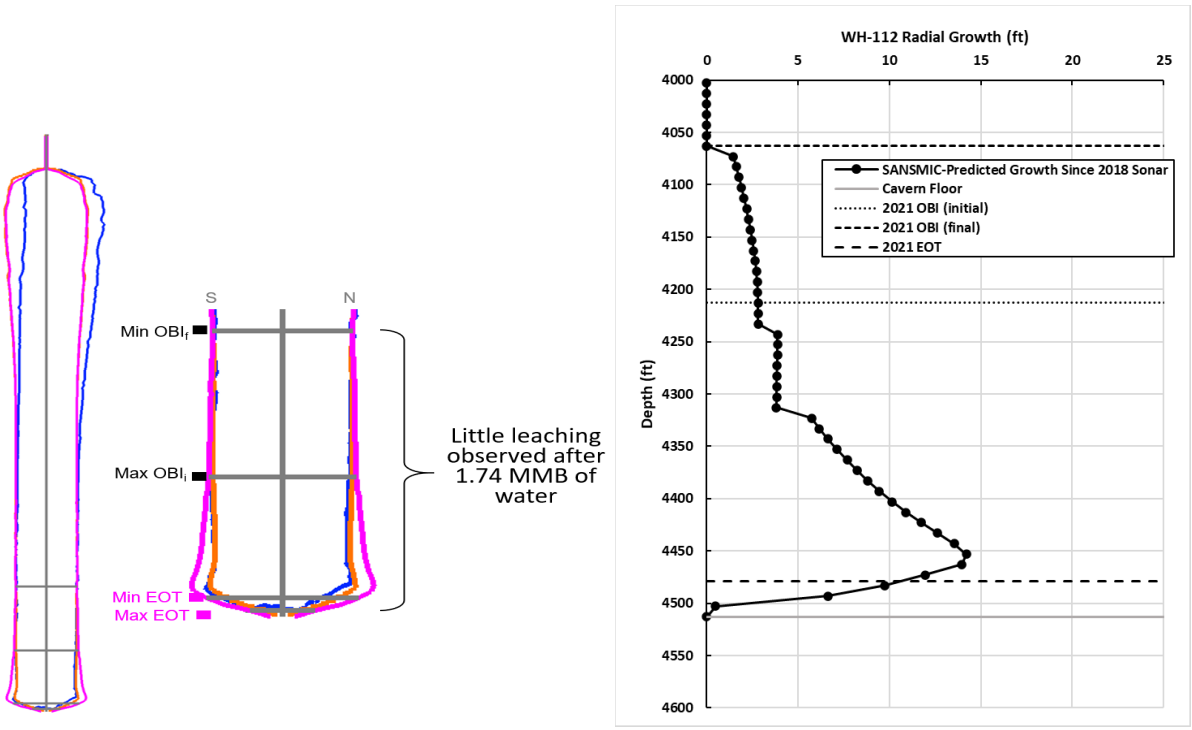

Figure 2-68. WH-112 SANSMIC-predicted radial growth since 2018 sonar.

2.3.4. WH-114

2.3.4.1. Leaching History

Sonars taken in WH-114 in 2015 and 2020 are shown in Figure 2-69. Floor rise has occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 4.0 MMB of water injected into this cavern between sonars, but at least part of the time, the EOT was approximately 300 ft above the floor, whereas by the time of 2020 leaching, it was only about 10-20 ft from the floor. As a result, an increased cavern radius at about 4,200 ft is observed. Based on leaching from 2015 to 2020 and the movement of the EOT, it is not clear what leaching pattern may result from the 3.6 MMB of water that has been injected since the 2020 sonar, but it is likely to be radially symmetric.

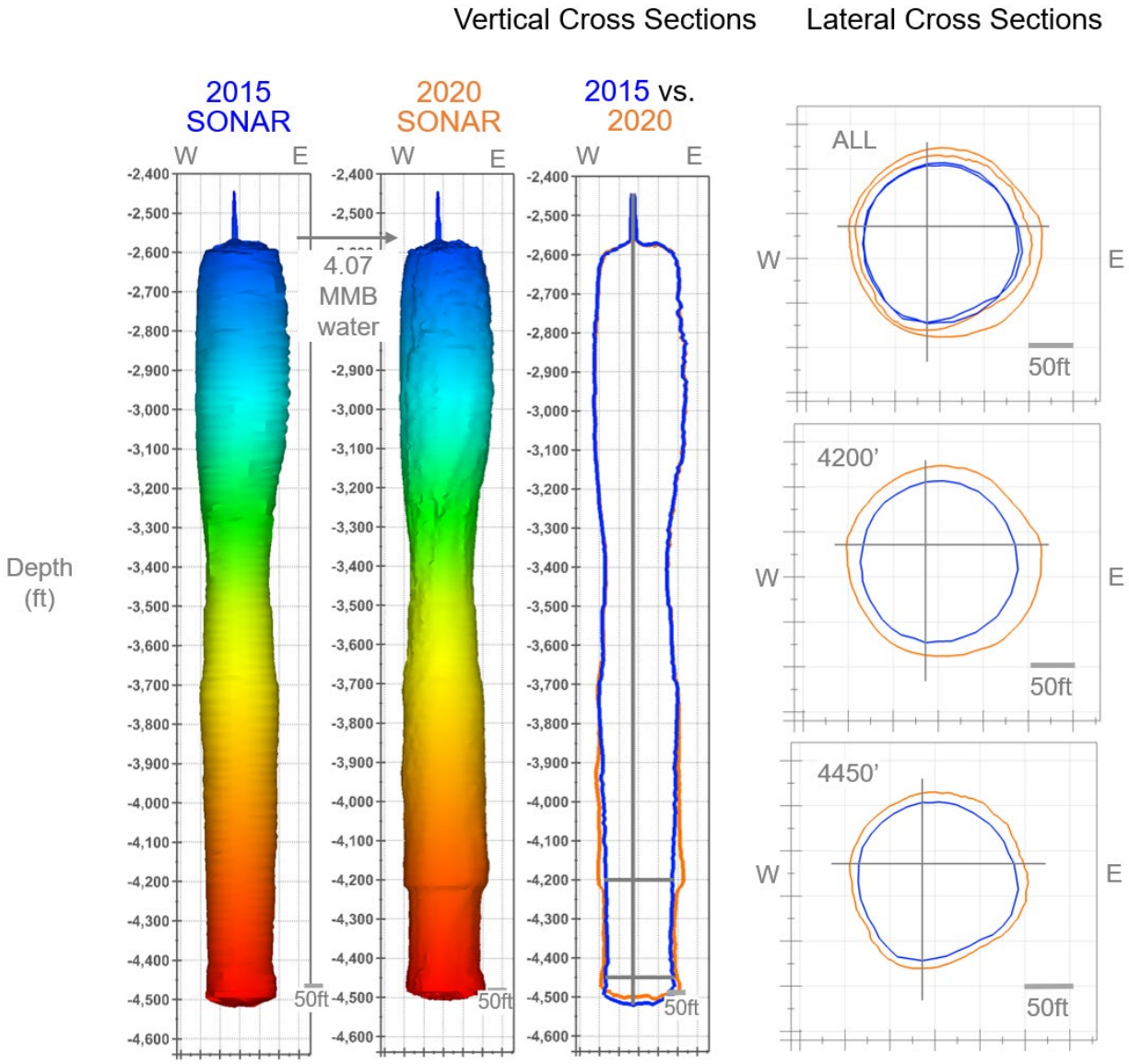

Figure 2-69. Leaching history in WH-114 from 2015 (blue) to 2020 (orange) via sonars.

2.3.4.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in WH-114 was in 2020. Since that sonar, around 3.6 MMB of water was injected into the cavern in 2020 (see Table 2-38). The injection history was modeled as three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the one phase modeled for the CY20 report [12]. This cavern has had two Mod EOT rises.

Table 2-38. Summary of Simulation Input for WH-114

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	08/02/20-11/22/20	4515	21	10	815	820	38,703	13	503,139
2	02/03/21-05/30/21	4,515	26	20	938	940	11,136	117	1,302,945
3	10/04/21-12/14/21	4,515	26	20	Auto	1,240	25,206	72	1,814,843
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	202	3,620,927

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-39, the overall leaching efficiency for this cavern was 15.8%.

Table 2-39. Summary of Simulation Output for WH-114

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	910	1.2003	74,000	14.7
2	1,240	1.2011	207,000	15.9
3	1,510	1.2002	290,000	16.0
ALL	1,510	1.2002	571,000	15.8

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-70). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.6 MMB.

Vertical cross sections from each of the cavern geometries reveal the minimal changes from leaching. The changes can be seen by the variation between the input (orange) and output (magenta) cavern profiles in the lateral cross sections. Figure 2-71 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-71) reveals a modeled leaching zone (see Figure 2-72)

that is about 1,500 ft tall and reflects the large distance between OBI and EOT. The maximum radial growth over this depth is predicted to be only about 5 ft. Shelf formation at about 300 ft above the cavern floor was previously predicted [8] and that shelf appeared in the 2020 Sonar. With only minimal growth since the 2020 sonar, the simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time, but it should be monitored if leaching continues in this cavern.

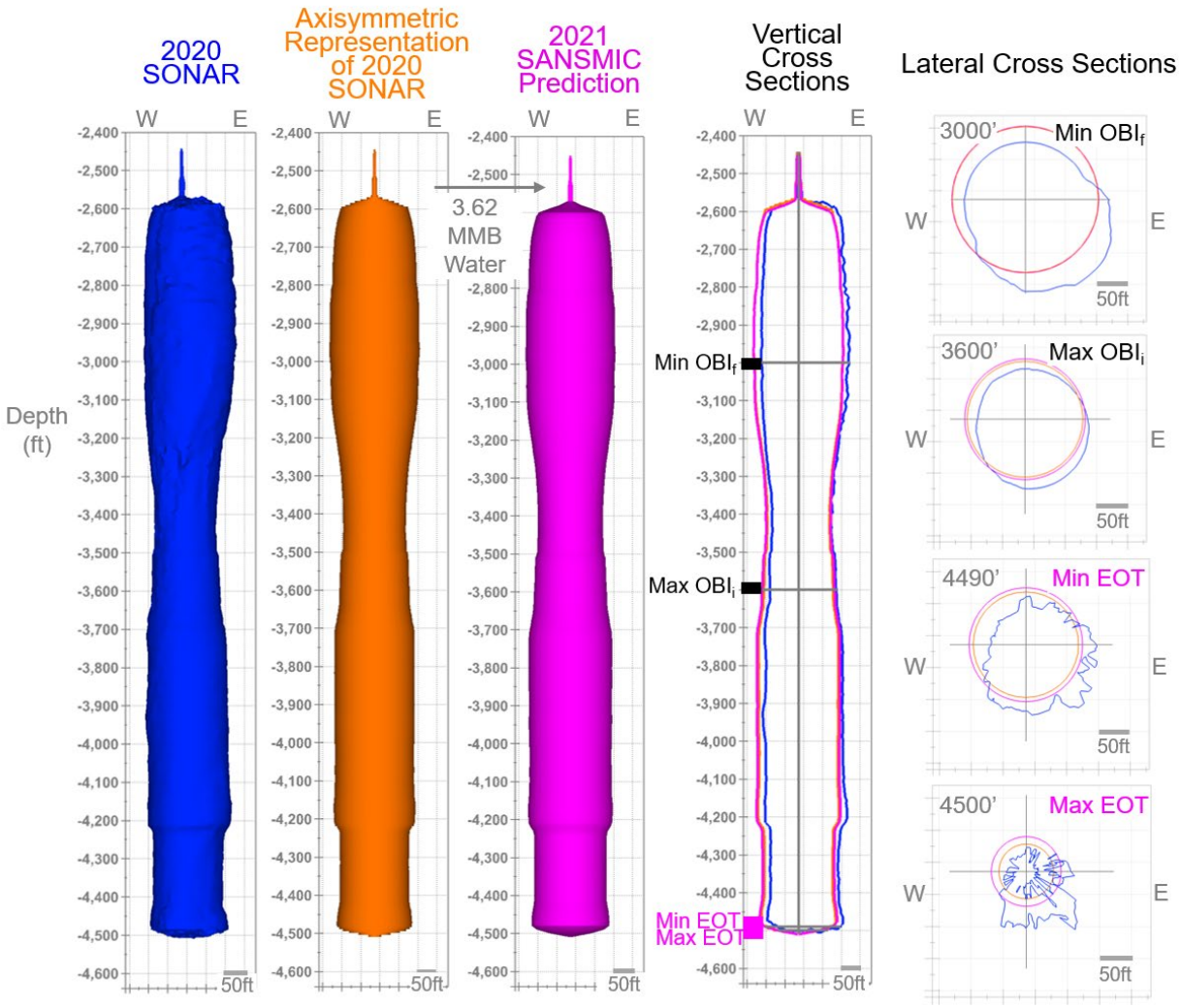

Figure 2-70. WH-114 modeling results for leaching between 2020 sonar and end of CY21.

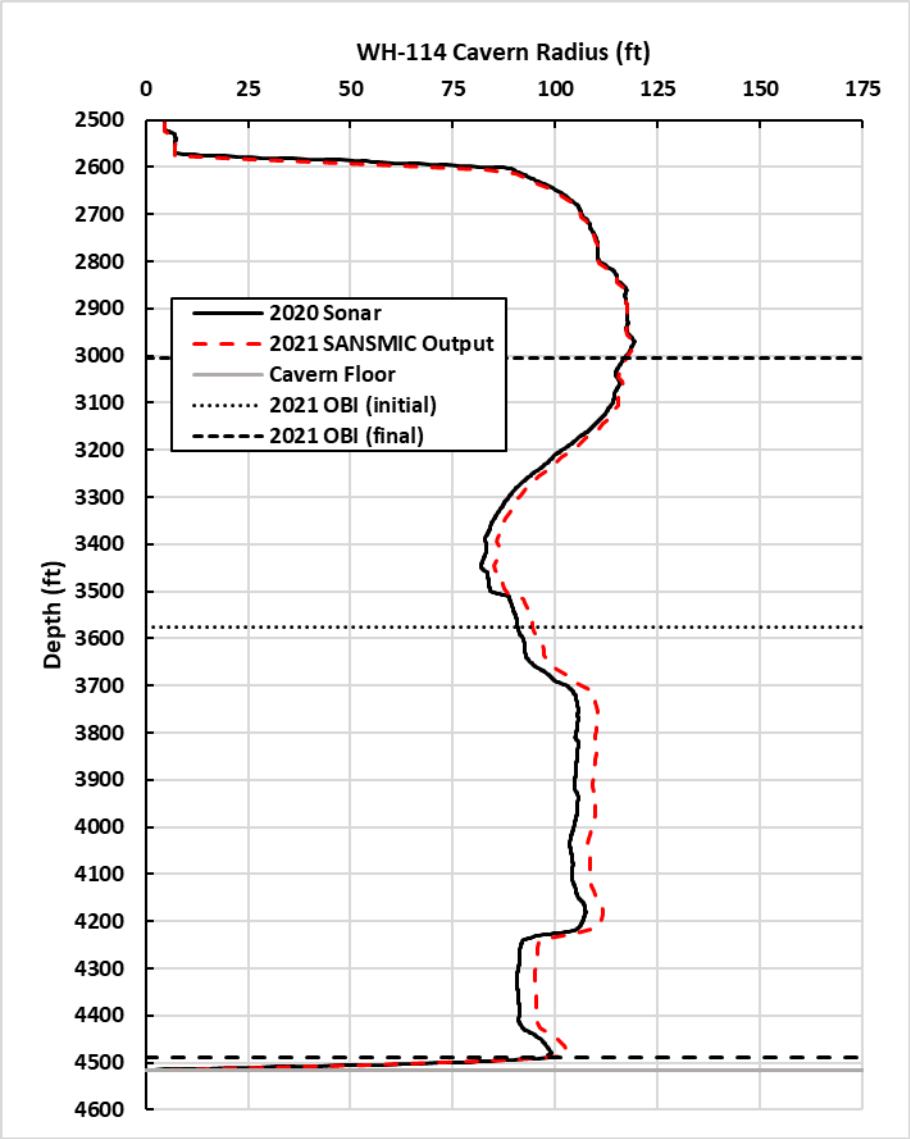

Figure 2-71. WH-114 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

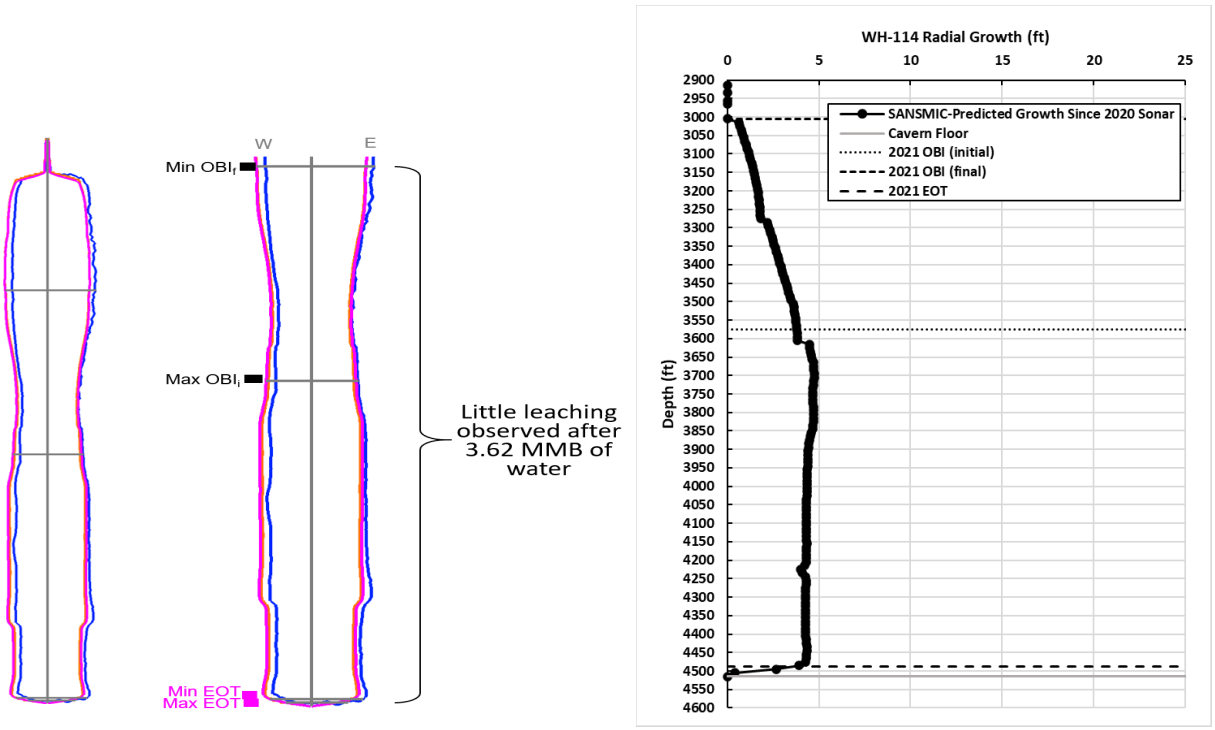

Figure 2-72. WH-114 SANSMIC-predicted radial growth since 2020 sonar.

2.3.5. WH-115

2.3.5.1. Leaching History

Sonars taken in WH-115 in 2012 and 2020 are shown in Figure 2-73. The 2020 sonar only covered the bottom portion of the cavern (approximately from the floor to the OBI), so the remainder of the cavern sonar plot for 2020 is identical to 2017. Overall, not much change has occurred in this cavern between sonars as evidenced by the lack of changes in the cavern wall positions near the floor in the vertical and lateral cross sections, but some small floor rise is observed. There was 2.5 MMB of water injected into this cavern between sonars and an additional 3.4 MMB of water that has been injected since the 2020 sonar.

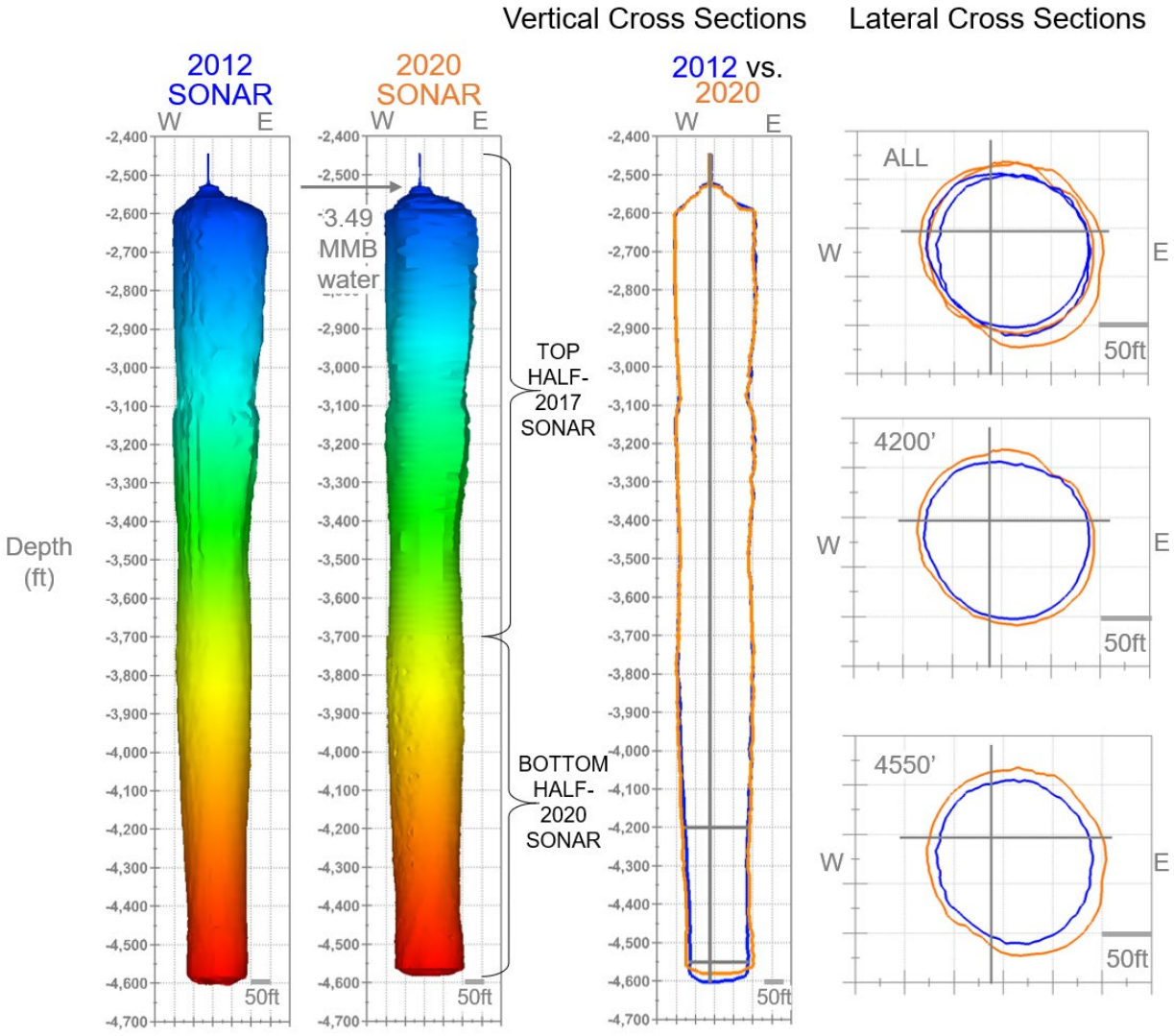

Figure 2-73. Leaching history in WH-115 from 2012 (blue) to 2020 (orange) via sonars.

2.3.5.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in WH-115 was in 2020. Since that sonar, around 3.4 MMB of water was injected into the cavern in 2020-2021 (see Table 2-40). Because the 2020 sonar only covered the bottom portion of the cavern (approximately from the floor to the OBI), the remainder of the cavern sonar plot for 2020 was used in SANSMIC modeling for the top of the cavern. The injection history was modeled as three phases of leaching each with an EP of 60 days. To represent CY21 water injection, two phases were added to the one phase modeled for the CY20 report [12]. This cavern has had three Mod EOT rises.

Table 2-40. Summary of Simulation Input for WH-115

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	08/02/20-11/22/20	4,591	21	10	790	790	37,817	14	529,438
2	02/03/21-06/29/21	4,591	22	20	914	910	8,782	147	1,290,953
3	10/04/21-12/14/21	4,591	755	750	Auto	1,160	22,113	72	1,592,137
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	233	3,412,528

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-41, the overall leaching efficiency for this cavern was 16.0%.

Table 2-41. Summary of Simulation Output for WH-115

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	880	1.2003	80,000	15.1
2	1,160	1.2013	207,000	16.0
3	1,420	1.1995	258,000	16.2
ALL	1,420	1.1995	545,000	16.0

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-74). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.4 MMB.

Vertical cross sections from each of the cavern geometries reveal the minimal changes from leaching. The changes can be seen by the variation between the input (orange) and output (magenta)

cavern profiles in the lateral cross sections. Figure 2-75 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-75) reveals a modeled leaching zone (see Figure 2-76) that is about 1,300 ft tall and reflects the large distance between OBI and EOT. The maximum radial growth over this depth is predicted to be only about 1-7 ft. The odd shape of growth in the cavern can be attributed to multiple EOTs (20 and 750 ft above the cavern floor).

Increased growth of the flare near the cavern floor was previously predicted [8] and that flare growth in apparent from the 2020 sonar. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

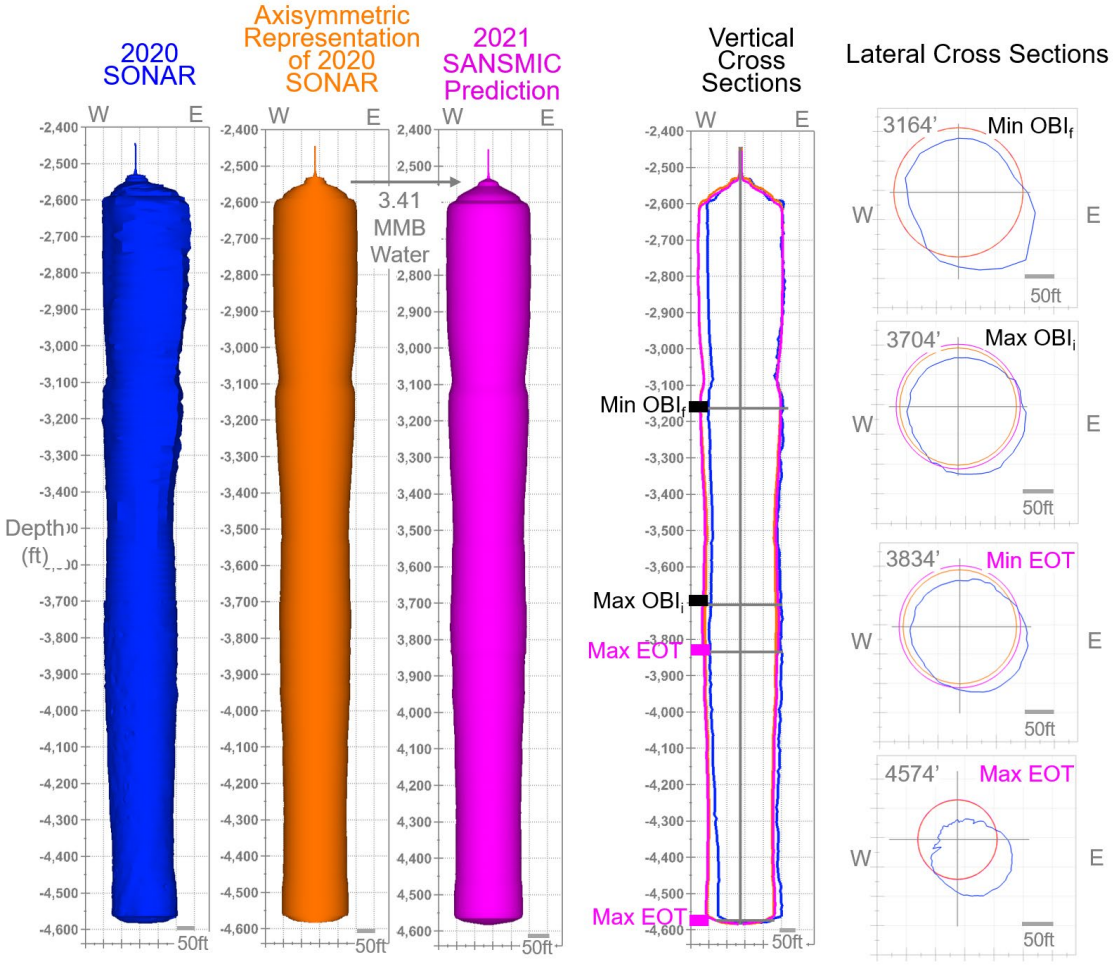

Figure 2-74. WH-115 modeling results for leaching between 2020 sonar and end of CY21.

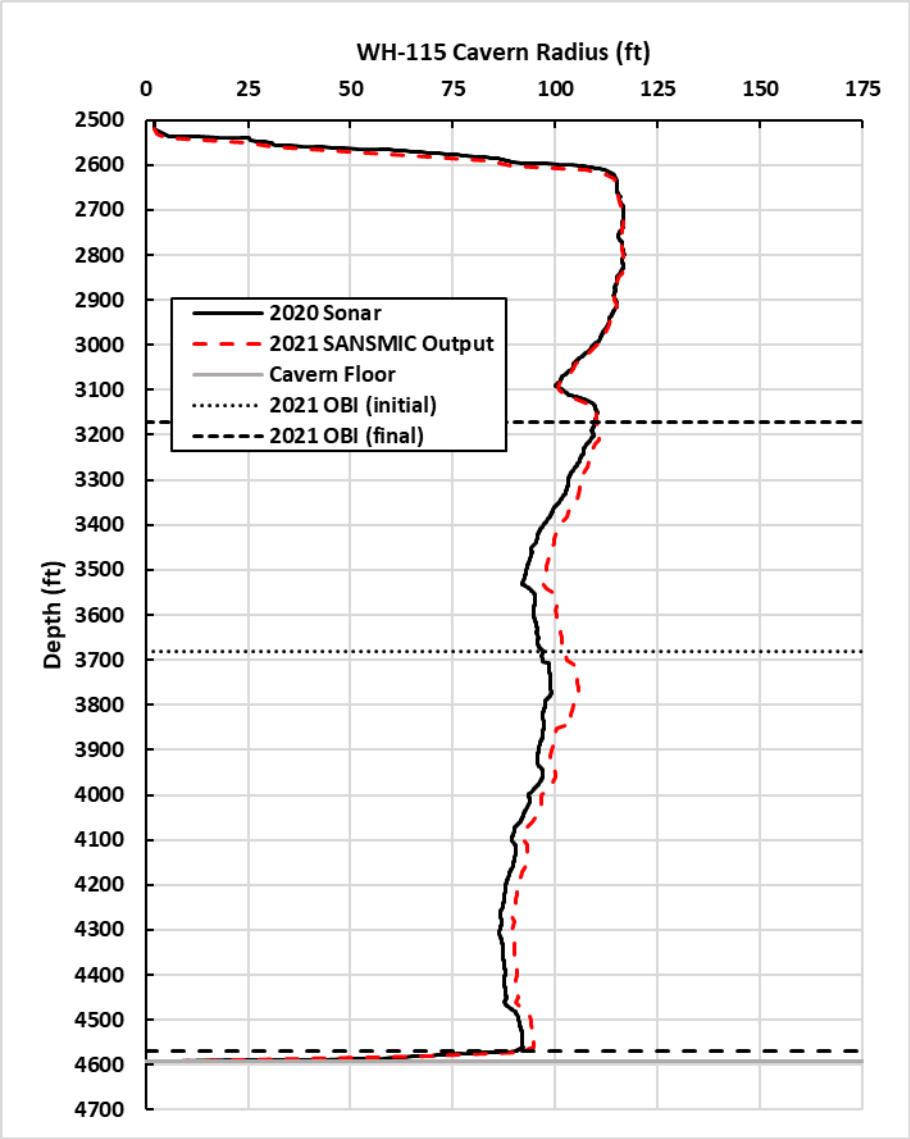

Figure 2-75. WH-115 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

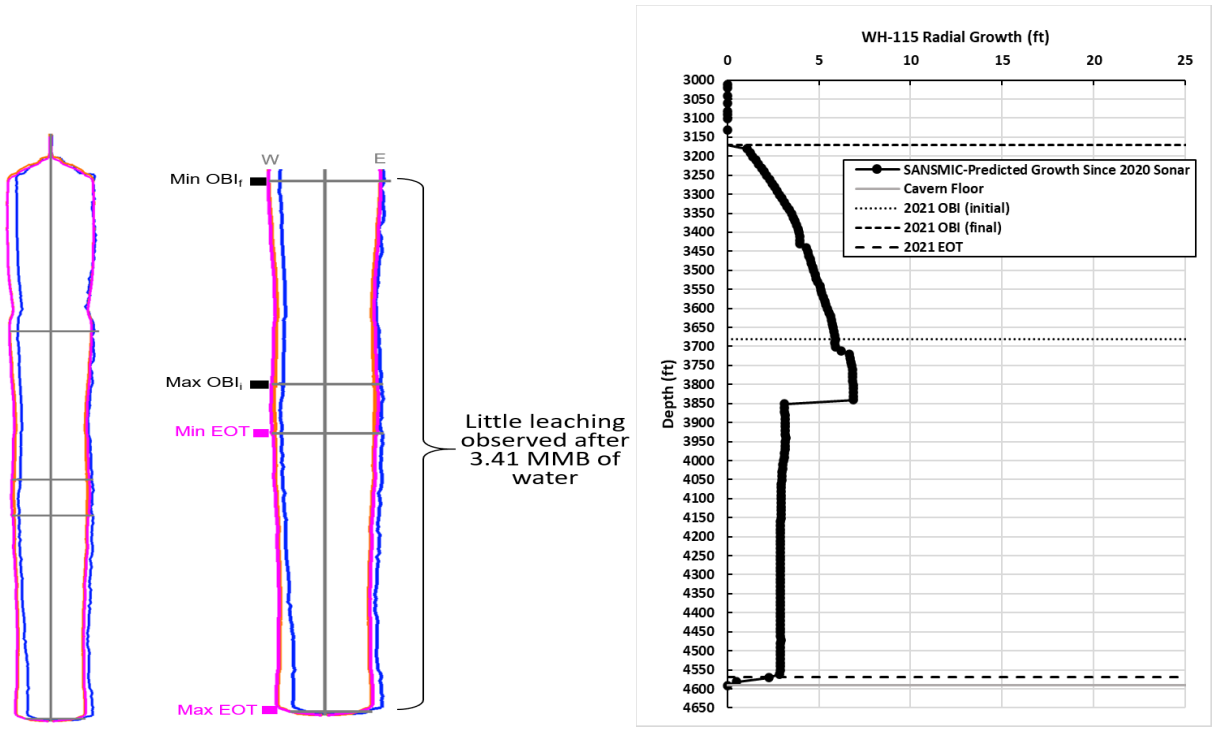

Figure 2-76. WH-115 SANSMIC-predicted radial growth since 2020 sonar.

2.4. Bayou Choctaw

Simulation results for Bayou Choctaw are summarized in Table 2-42. Five caverns had water injected in CY21. Two of those caverns (BC-17 and BC-101) have had at least 3 MMB of water injected since the last sonar. While most caverns do not have a leaching induced feature of concern at this time, three caverns, BC-17, BC-18, and BC-19, have features which should be monitored as leaching continues in those caverns. A brief leaching history and the results of SANSMIC modeling of leaching since the last sonar are discussed below for each cavern.

Table 2-42. Caverns at Bayou Choctaw with Water Injected in CY21

Cavern	Last Sonar	Injected Water Volume* (MMB)	Concerns
BC-17	2019	3.7	Monitor flare near cavern floor
BC-18	2020	0.16	Monitor flare near cavern floor
BC-19	2019	1.3	Monitor flare near cavern floor and shelf near 4,000’
BC-101	2019	3.0	No
BC-102	2017	2.0	No

* Since last sonar

2.4.1. BC-17

2.4.1.1. Leaching History

Sonars taken in BC-17 in 2009 and 2019 are shown in Figure 2-77. There was 2 MB of water injected into this cavern between sonars which would not be expected to contribute to a change in cavern shape. An additional 3.7 MMB of water has been injected since the 2020 sonar.

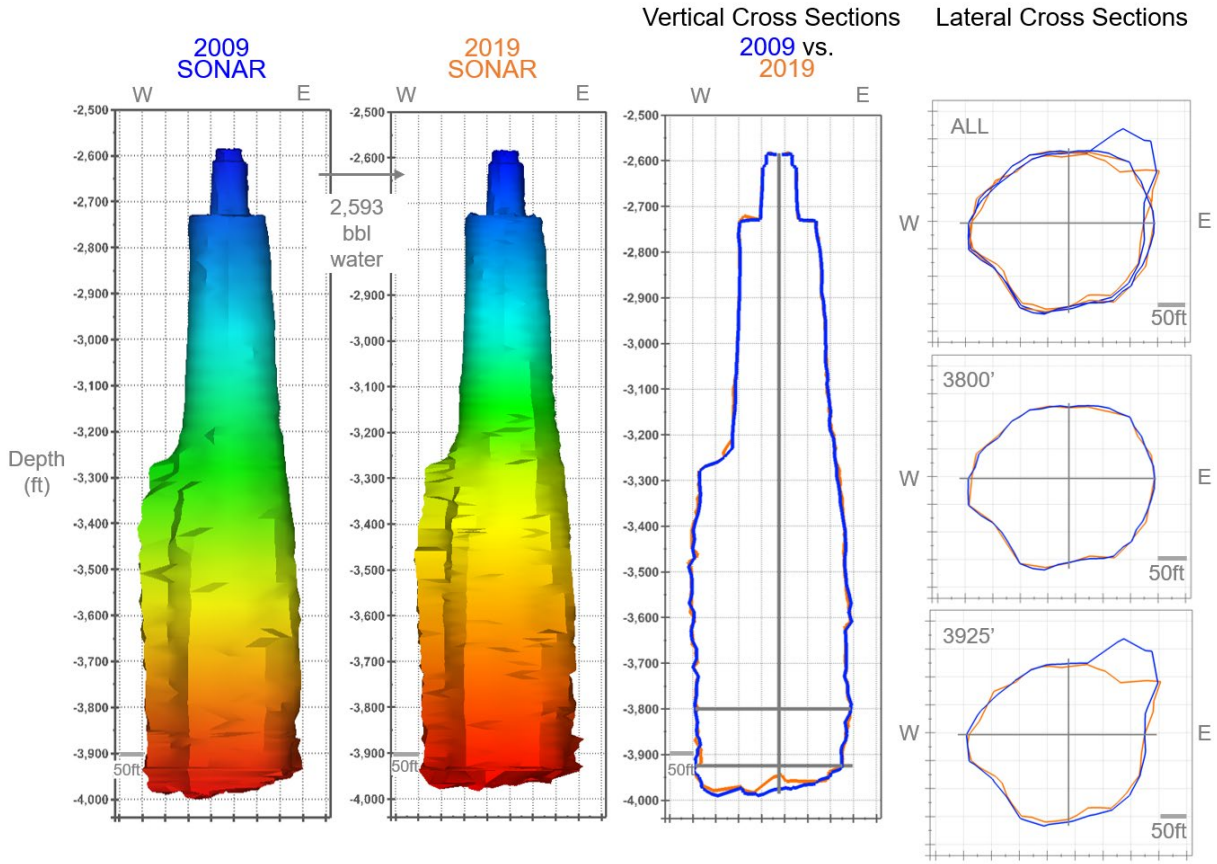

Figure 2-77. Leaching history in BC-17 from 2009 (blue) to 2019 (orange) via sonars.

2.4.1.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BC-17 was in 2019. Since that sonar, about 3.7 MMB of water have been injected into the cavern in 2021 (see Table 2-43). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-43. Summary of Simulation Input for BC-17

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/09/21-12/31/21	3,995	50	47	63	63	32,618	114	3,718,460

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-44, the leaching efficiency for this cavern was 15.5%.

Table 2-44. Summary of Simulation Output for BC-17

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	340	1.1949	576,000	15.5

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-78). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.7 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-79 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-79) reveals a modeled leaching zone (see Figure 2-80) that is about 300 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be up to about 20-25 ft. Development of the flare near the cavern floor should be monitored. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time, but it should be monitored if leaching continues in this cavern.

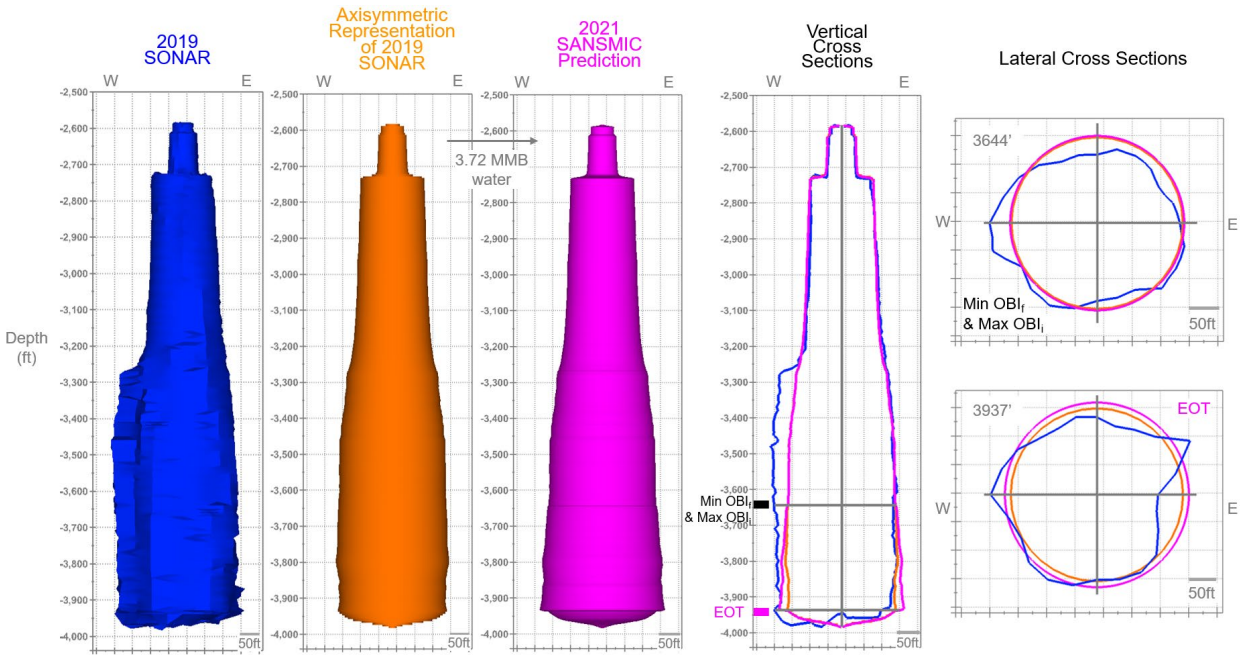

Figure 2-78. BC-17 modeling results for leaching between 2019 sonar and end of CY21.

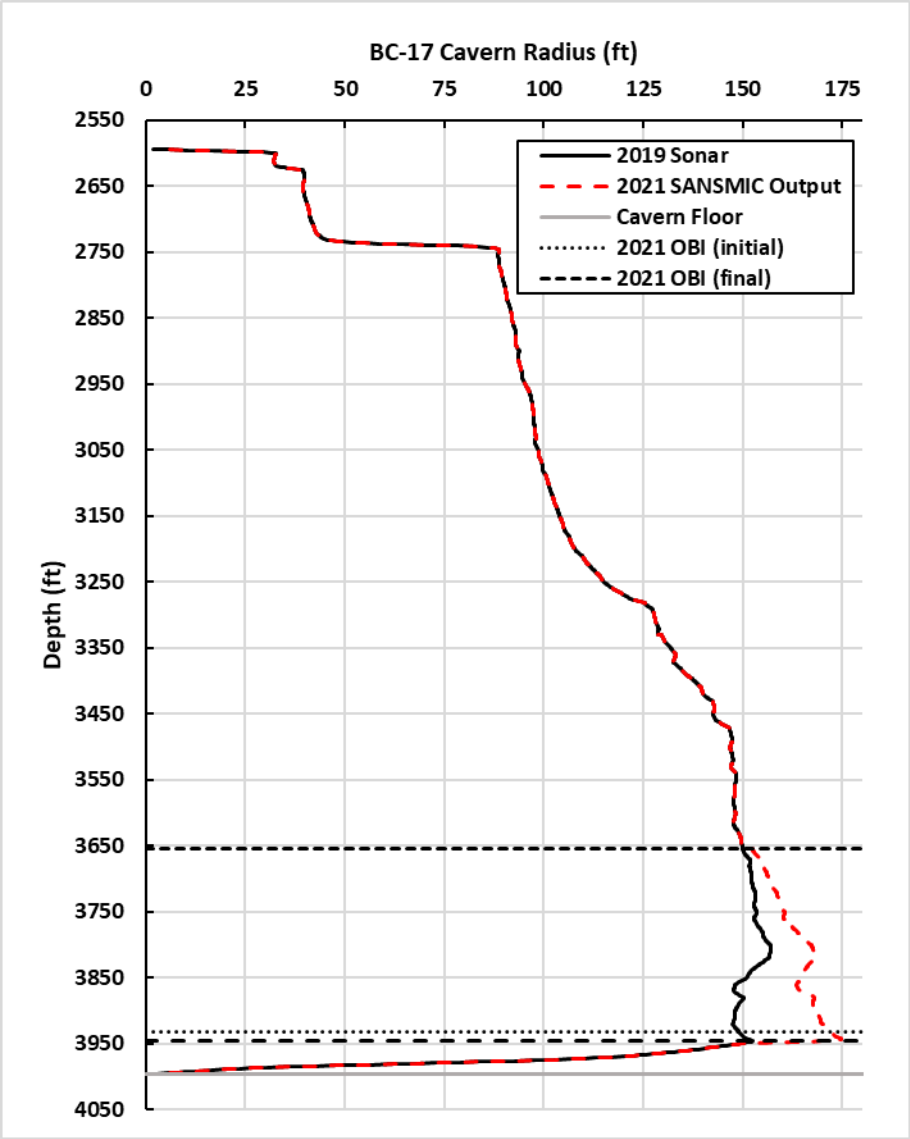

Figure 2-79. BC-17 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

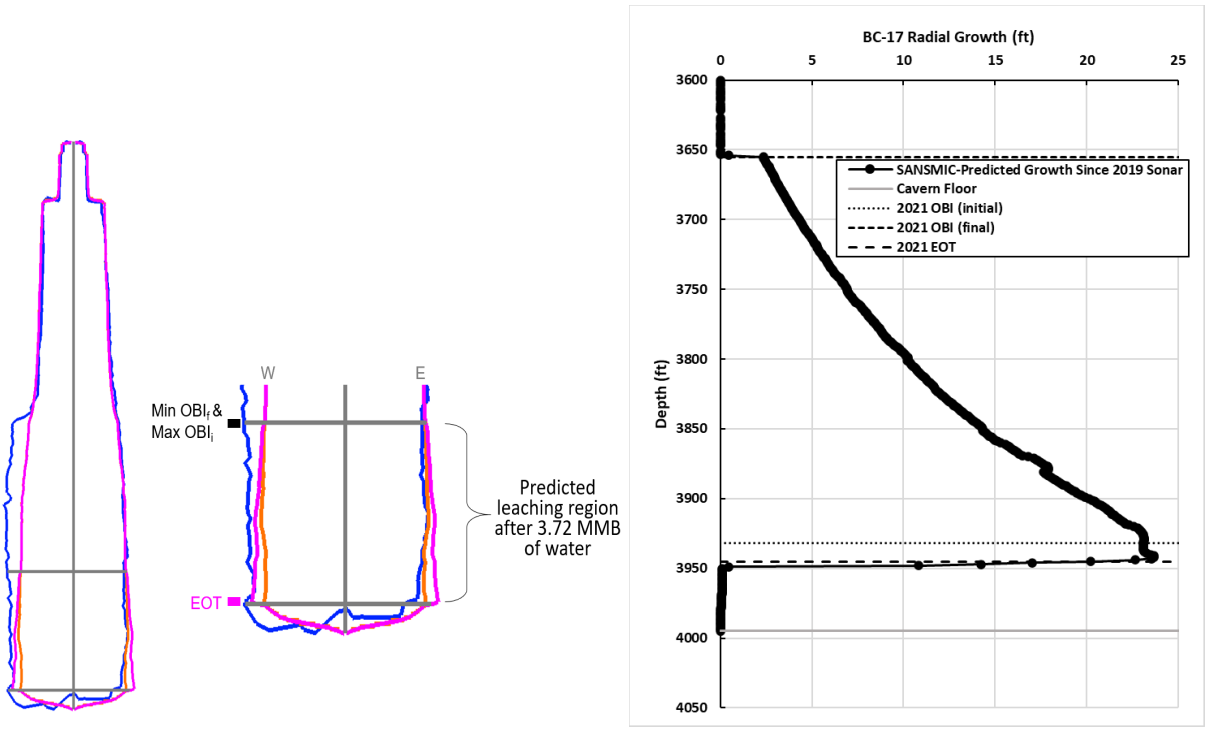

Figure 2-80. BC-17 SANSMIC-predicted radial growth since 2019 sonar.

2.4.2. BC-18

2.4.2.1. Leaching History

Sonars taken in BC-18 in 2014 and 2020 are shown in Figure 2-81. Some floor rise and floor spread occurred in this cavern between sonars as evidenced by the changes in the cavern wall positions near the floor in the vertical and lateral cross sections. There was 5.1 MMB of water injected into this cavern between sonars which may have contributed to the change in cavern shape. Leaching was primarily radial from 2014 to 2020, suggesting that radial leaching should be expected for the 0.16 MMB of water that has been injected since the 2020 sonar.

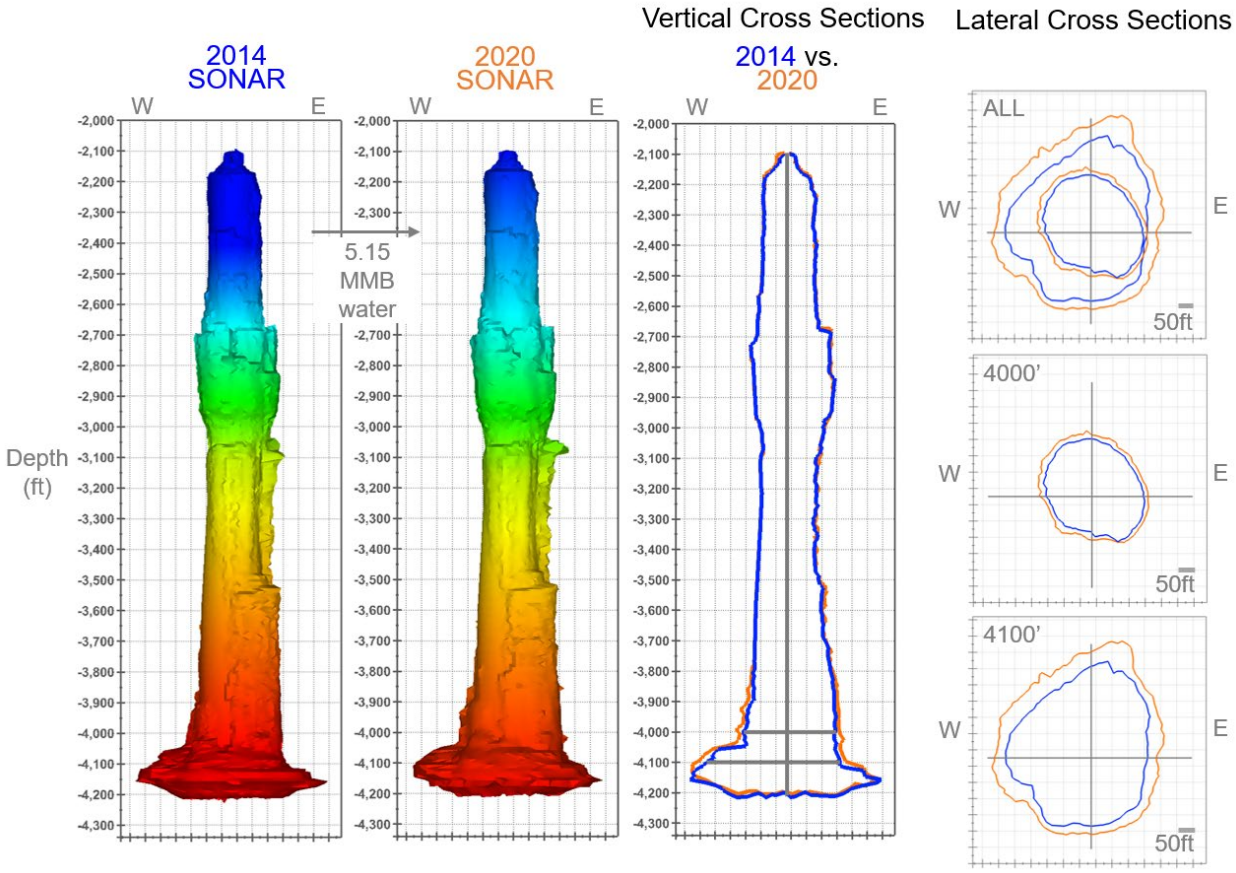

Figure 2-81. Leaching history in BC-18 from 2014 (blue) to 2020 (orange) via sonars.

2.4.2.2. Simulated Leaching Between 2020 Sonar and End of CY21

The last sonar taken in BC-18 was in 2020. Since that sonar, about 0.16 MMB of water have been injected into the cavern in 2021 (see Table 2-45). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-45. Summary of Simulation Input for BC-18

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/10/21-09/15/21	4,227	142	140	427	427	26,450	6	158,698

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-46, the leaching efficiency for this cavern was 13.2%, lower than the expected range of 15-16%, likely due to the small injected volume.

Table 2-46. Summary of Simulation Output for BC-18

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	442	1.2005	21,000	13.2

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2020 sonar and the end of CY21 (see Figure 2-18). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 0.16 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-83 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-83) reveals a modeled leaching zone (see Figure 2-84) that is about 300 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be only about 1 ft. The existing flare below the EOT should be monitored for future leaching.

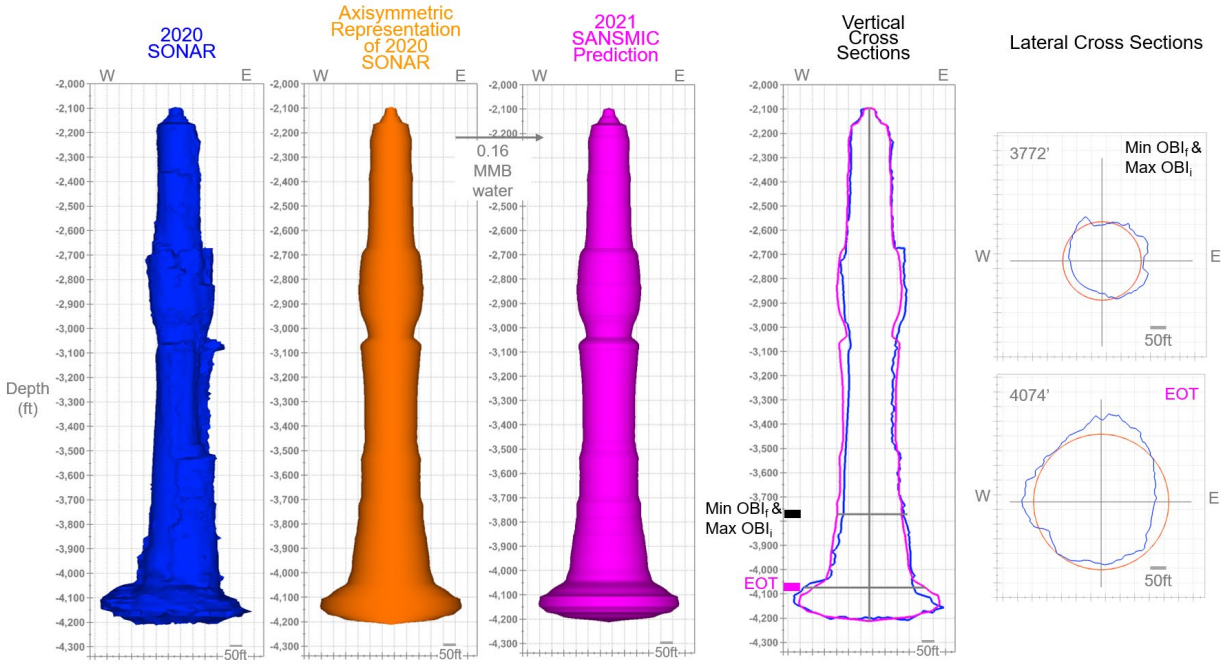

Figure 2-82. BC-18 modeling results for leaching between 2020 sonar and end of CY21.

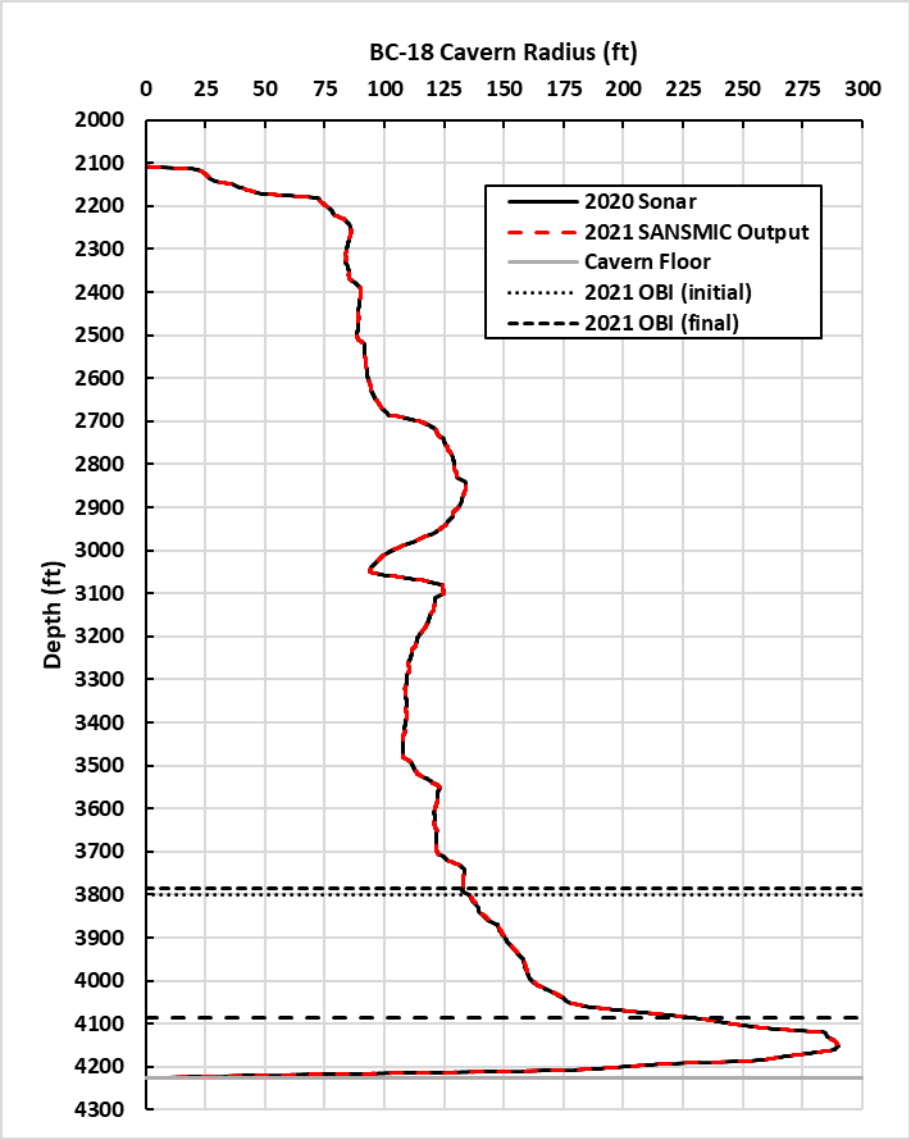

Figure 2-83. BC-18 axisymmetric representation of 2020 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

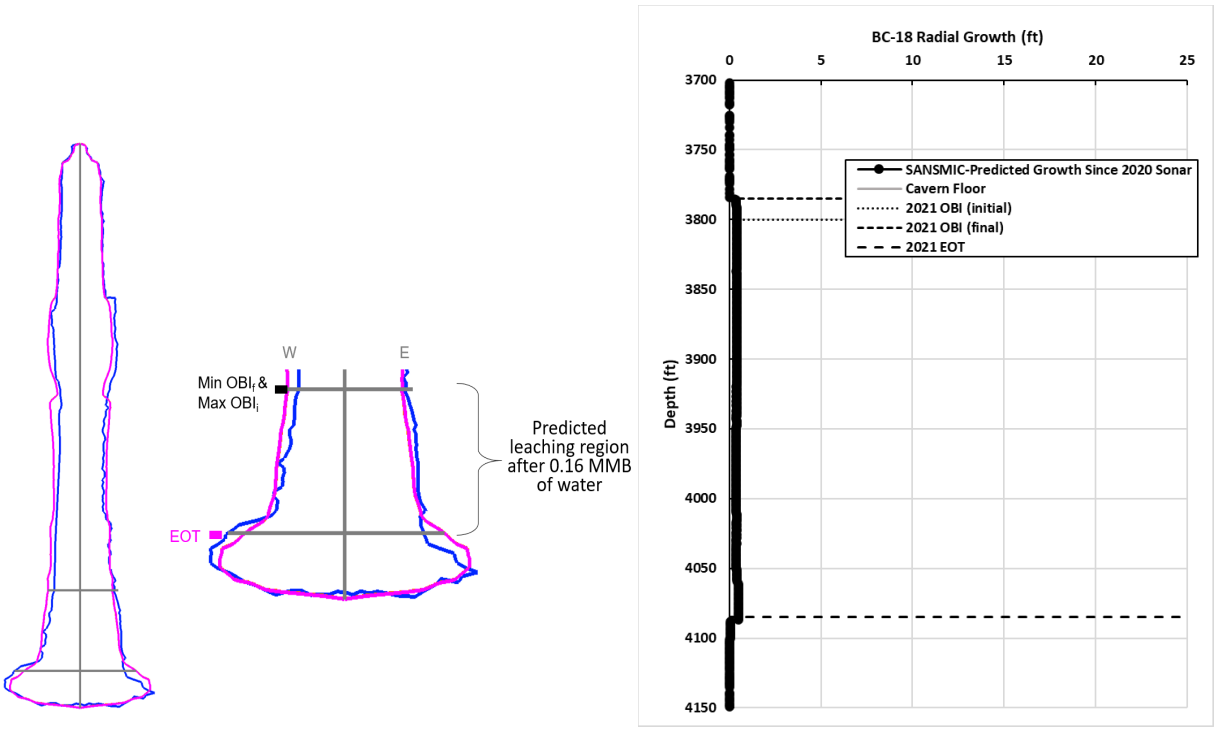

Figure 2-84. BC-18 SANSMIC-predicted radial growth since 2020 sonar.

2.4.3. BC-19

2.4.3.1. Leaching History

Sonars taken in the A well of BC-19 in 2009 and 2019 are shown in Figure 2-85. Due to the low volume of water (0.016 MMB) injected into this cavern, there is no expected change in cavern shape; differences in sonars could be attributed to different resolution in sonars. An additional 1.3 MMB of water that has been injected since the 2019 sonar.

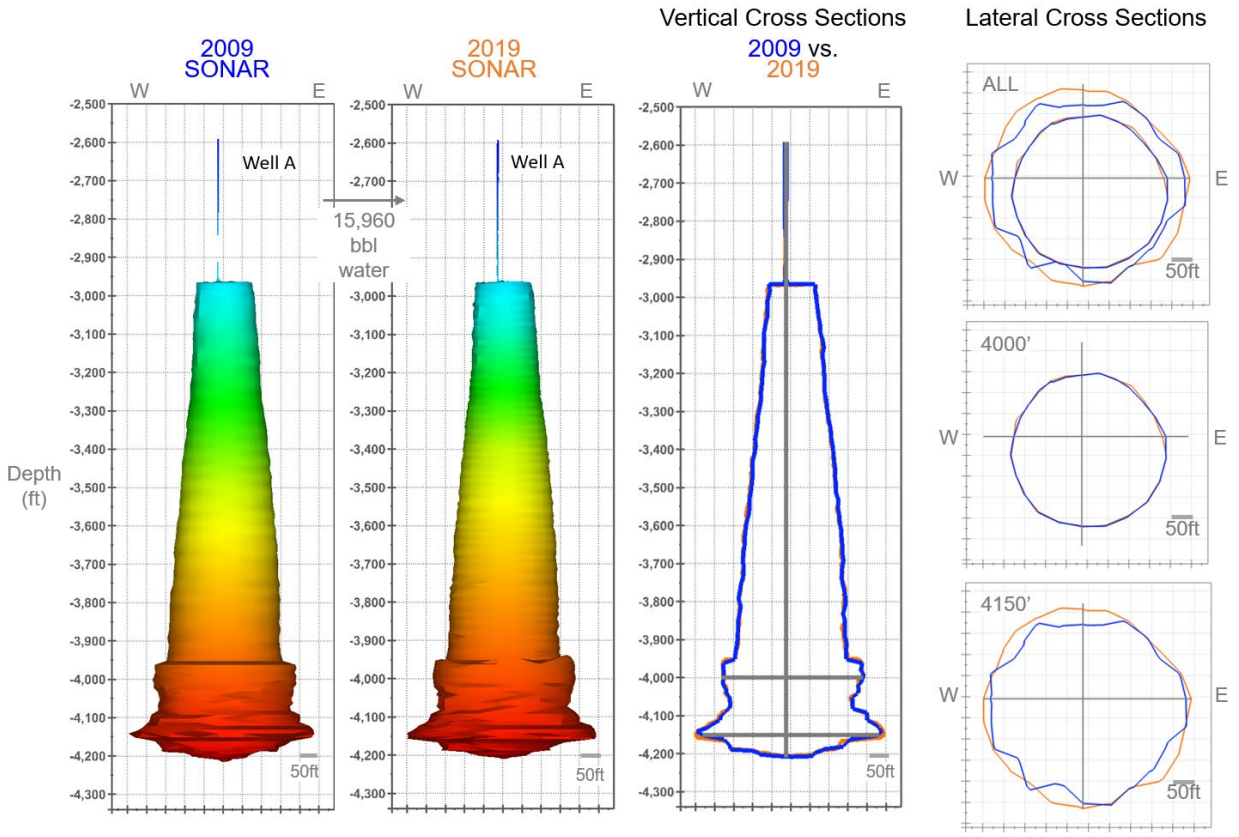

Figure 2-85. Leaching history in BC-19 from 2009 (blue) to 2019 (orange) via sonars in well A.

2.4.3.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BC-19 was in 2019. Since that sonar, about 1.3 MMB of water have been injected into the cavern in 2021 (see Table 2-47). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-47. Summary of Simulation Input for BC-19

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/18/21-12/31/21	4,219	27	26	64	64	12,508	105	1,313,289

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-48, the leaching efficiency for this cavern was 14.8%.

Table 2-48. Summary of Simulation Output for BC-19

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	111	1.1922	195,000	14.8

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-86). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 1.3 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-87 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-87) reveals a modeled leaching zone (see Figure 2-88) that is about 100 ft tall. The radial growth over this depth is predicted to range over about 5-15 ft. The odd shape of predicted growth in the cavern (i.e., instead of a smooth growth curve, what is observed is growth up to ~15 ft, then down to 5 ft, then back up to ~15 ft) can be attributed to the relative flatness of the cavern profile in that region and the limitation of SANSMIC modeling regarding "horizontal leaching". The flare just above the EOT and the flare above that (~4,000 ft) should be monitored for future leaching.

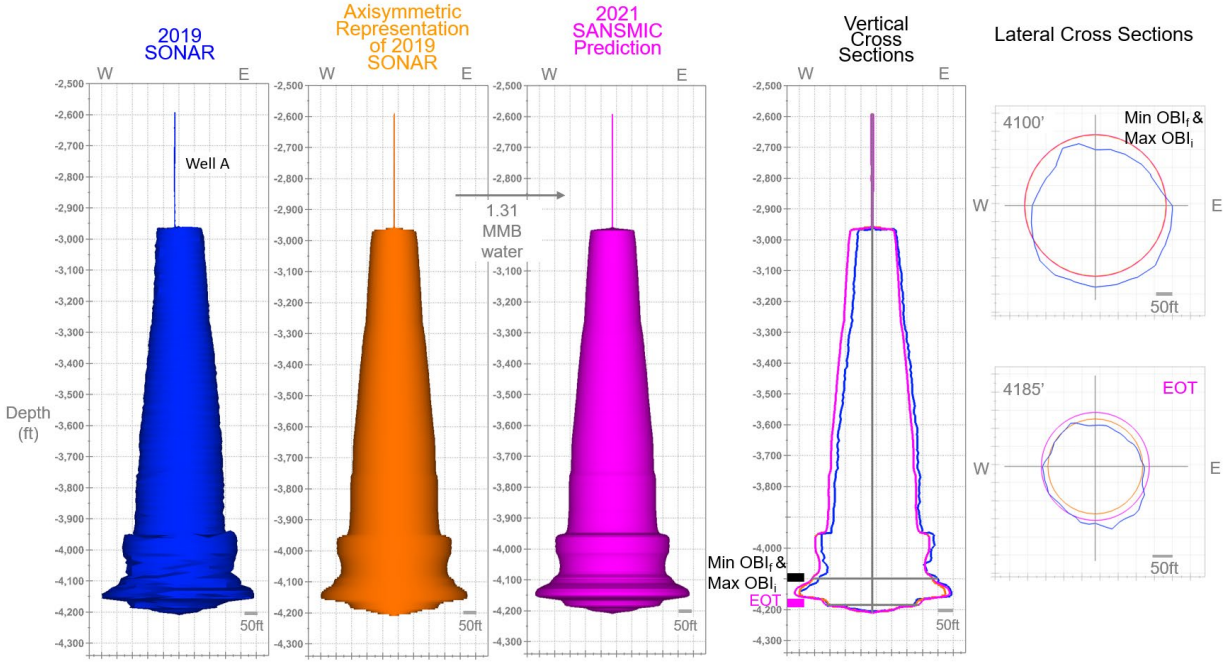

Figure 2-86. BC-19 modeling results for leaching between 2019 sonar and end of CY21.

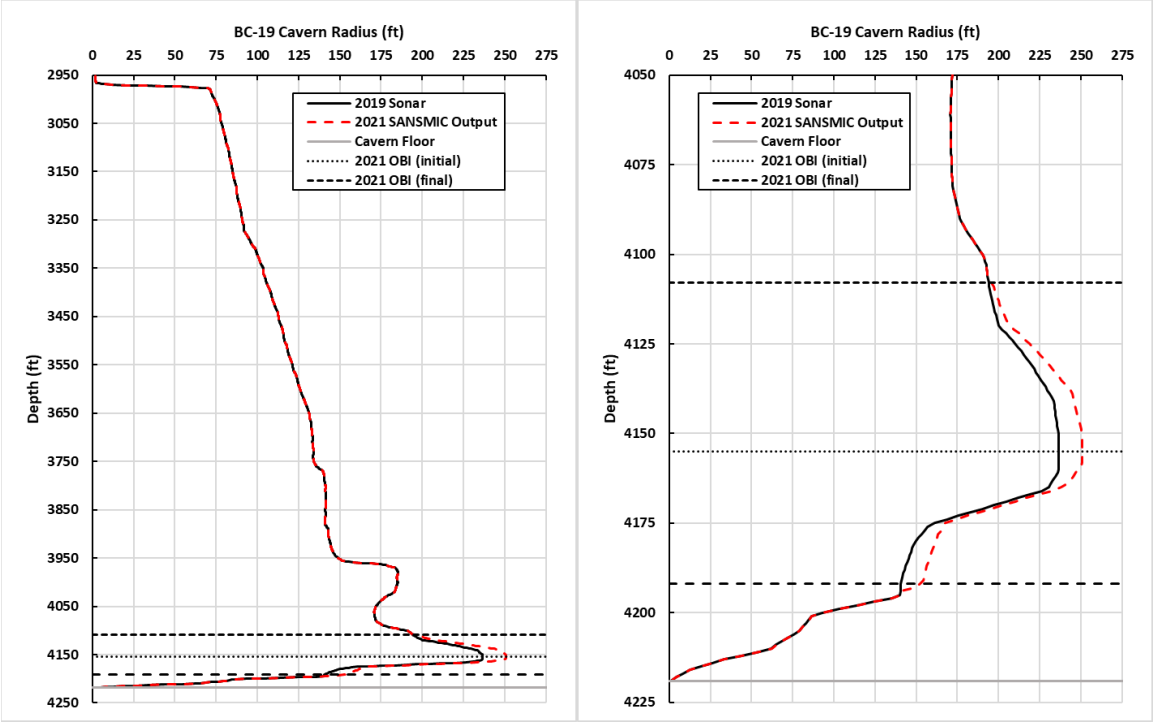

Figure 2-87. BC-19 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

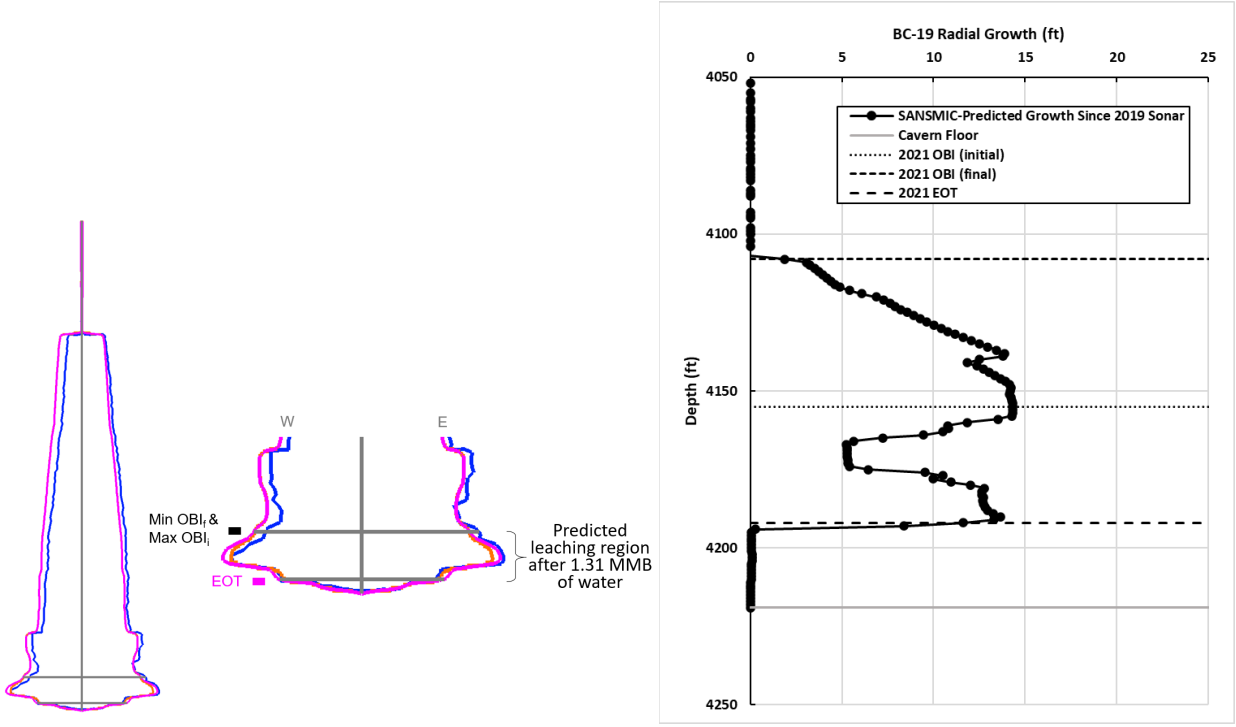

Figure 2-88. BC-19 SANSMIC-predicted radial growth since 2019 sonar.

2.4.4. BC-101

2.4.4.1. Leaching History

Sonars taken in the B well of BC-101 in 2014 and 2019 are shown in Figure 2-89. Due to the low volume of water (0.026 MMB) injected into this cavern, there is no expected change in cavern shape; differences in sonars could be attributed to different resolution in sonars. An additional 3.0 MMB of water that has been injected since the 2019 sonar.

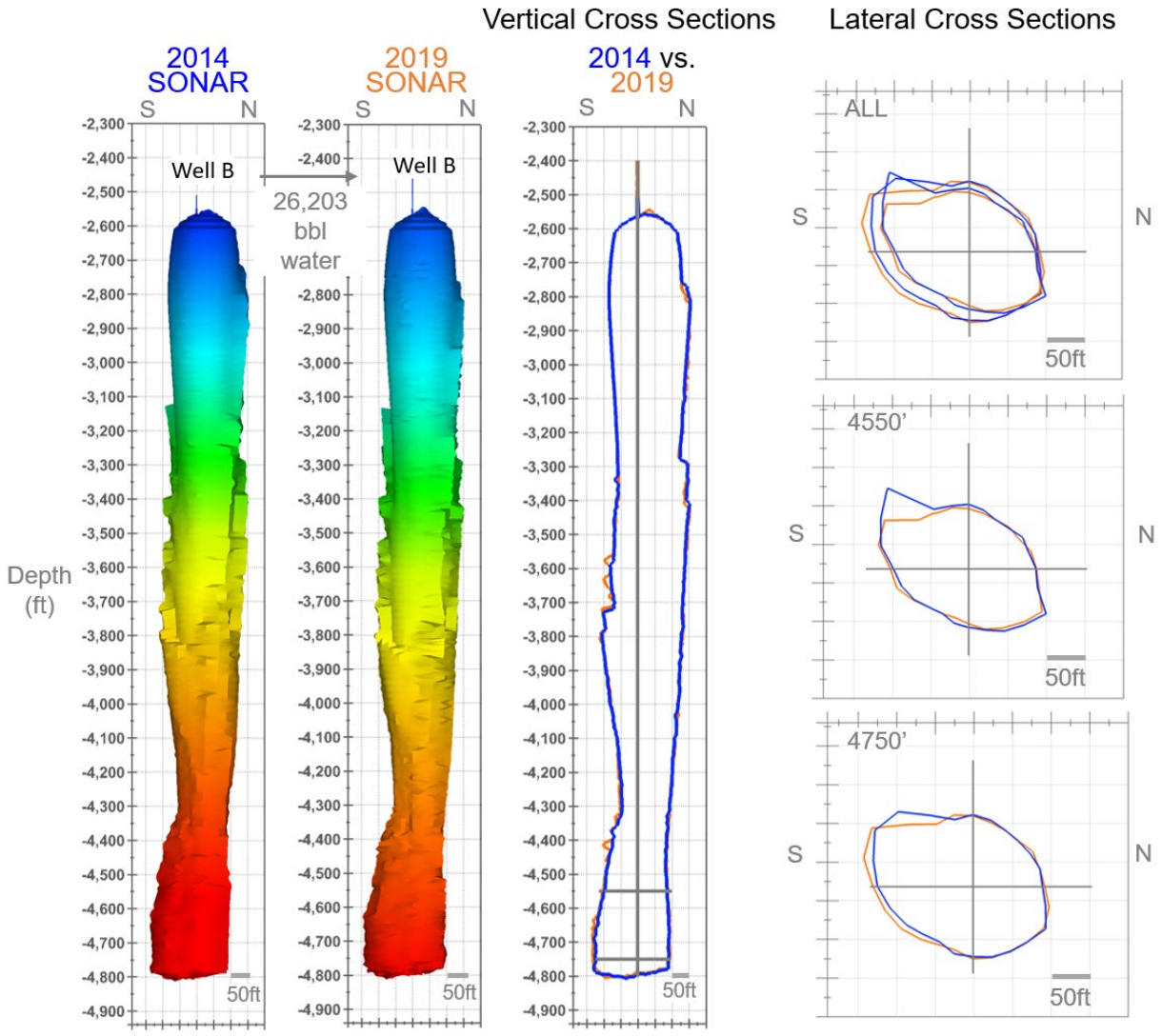

Figure 2-89. Leaching history in BC-101 from 2014 (blue) to 2019 (orange) via sonars in well B.

2.4.4.2. Simulated Leaching Between 2019 Sonar and End of CY21

The last sonar taken in BC-101 was in 2020. Since that sonar, about 3.0 MMB of water have been injected into the cavern in 2021 (see Table 2-49). The injection history was modeled using a single leaching phase with an EP of 60 days.

Table 2-49. Summary of Simulation Input for BC-101

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/09/21-12/31/21	4,824	52	50	177	148	26,005	114	2,964,563

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 2-50, the leaching efficiency for this cavern was 16.1%.

Table 2-50. Summary of Simulation Output for BC-101

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	884	1.1999	477,000	16.1

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2019 sonar and the end of CY21 (see Figure 2-90). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 3.0 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-91 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-91) reveals a modeled leaching zone (see Figure 2-92) that is about 800 ft tall and reflects the large distance between OBI and EOT. The radial growth over this depth is predicted to be up to about 10 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

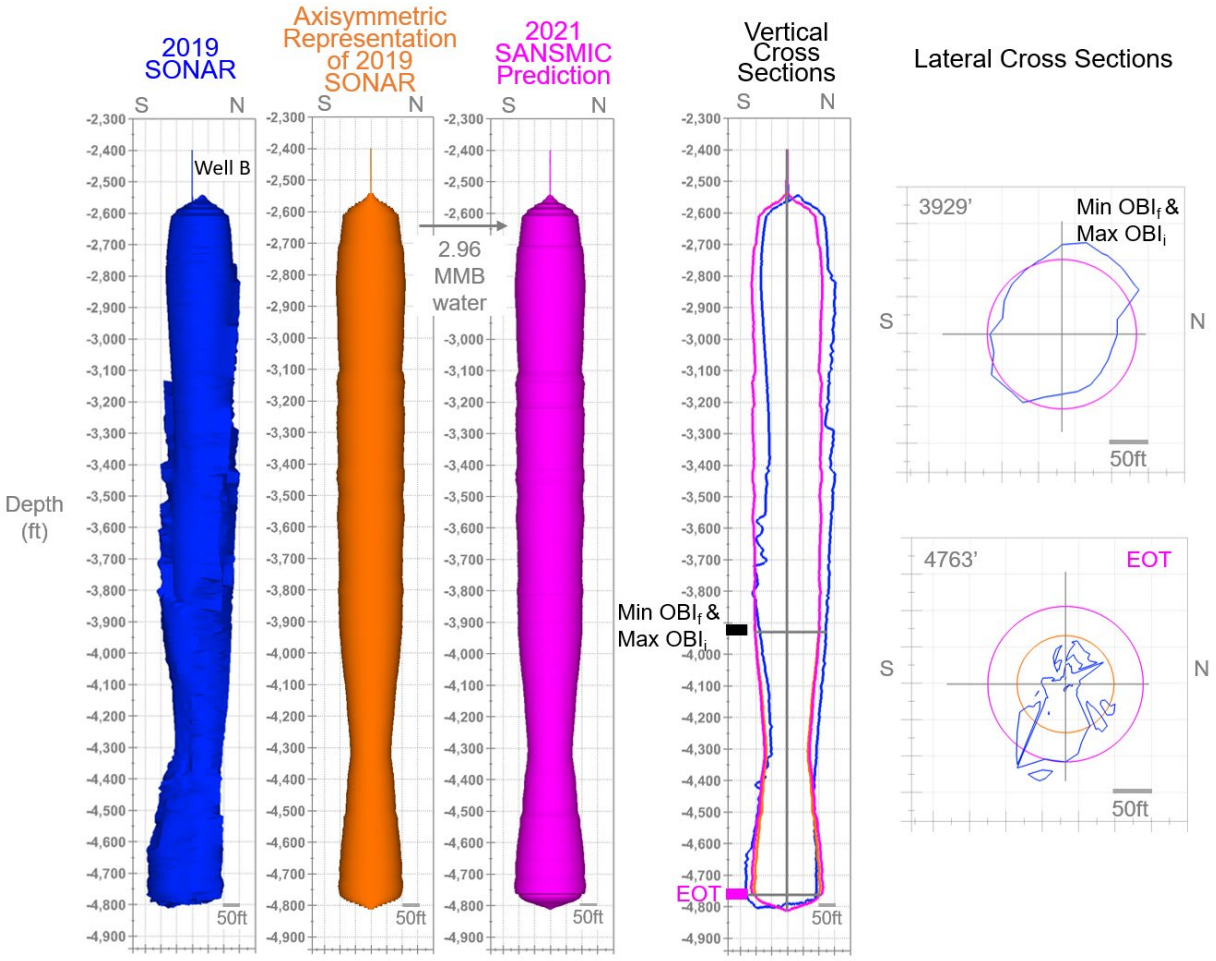

Figure 2-90. BC-101 modeling results for leaching between 2019 sonar and end of CY21.

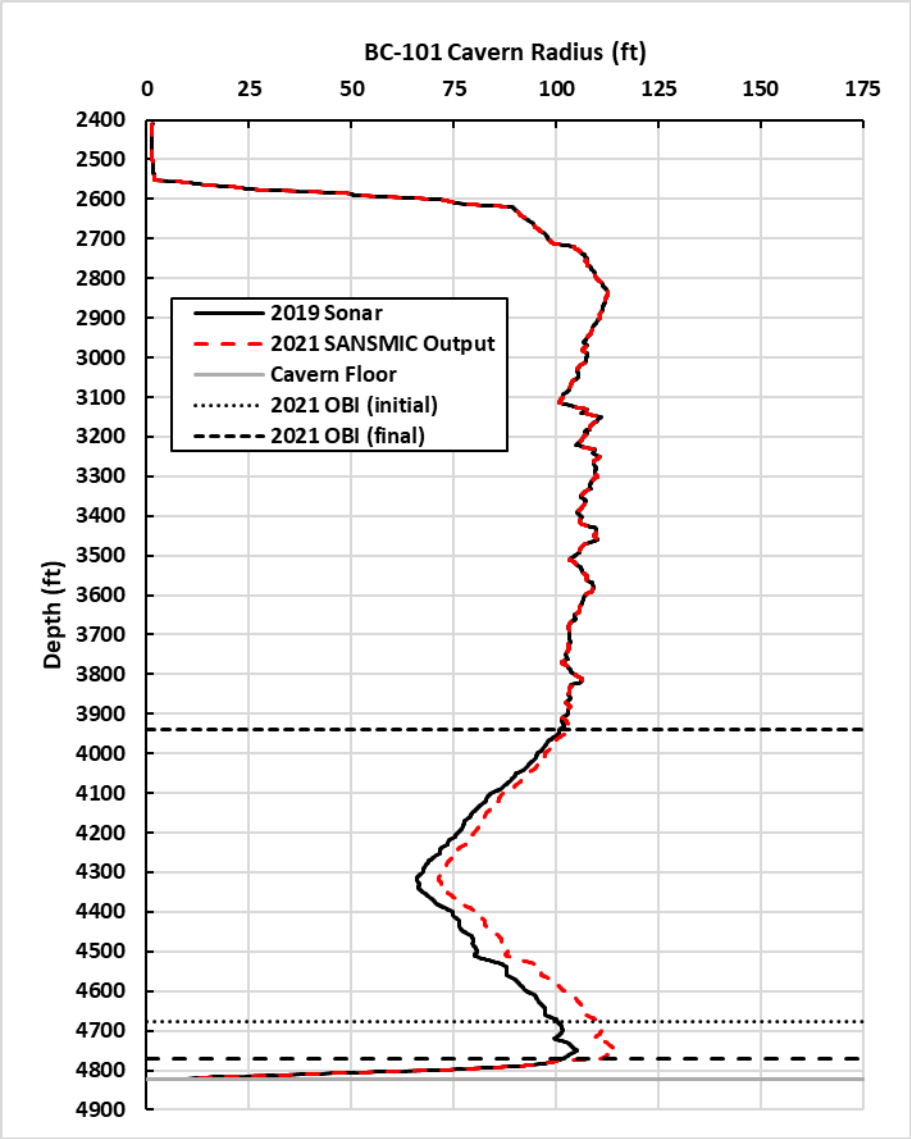

Figure 2-91. BC-101 axisymmetric representation of 2019 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

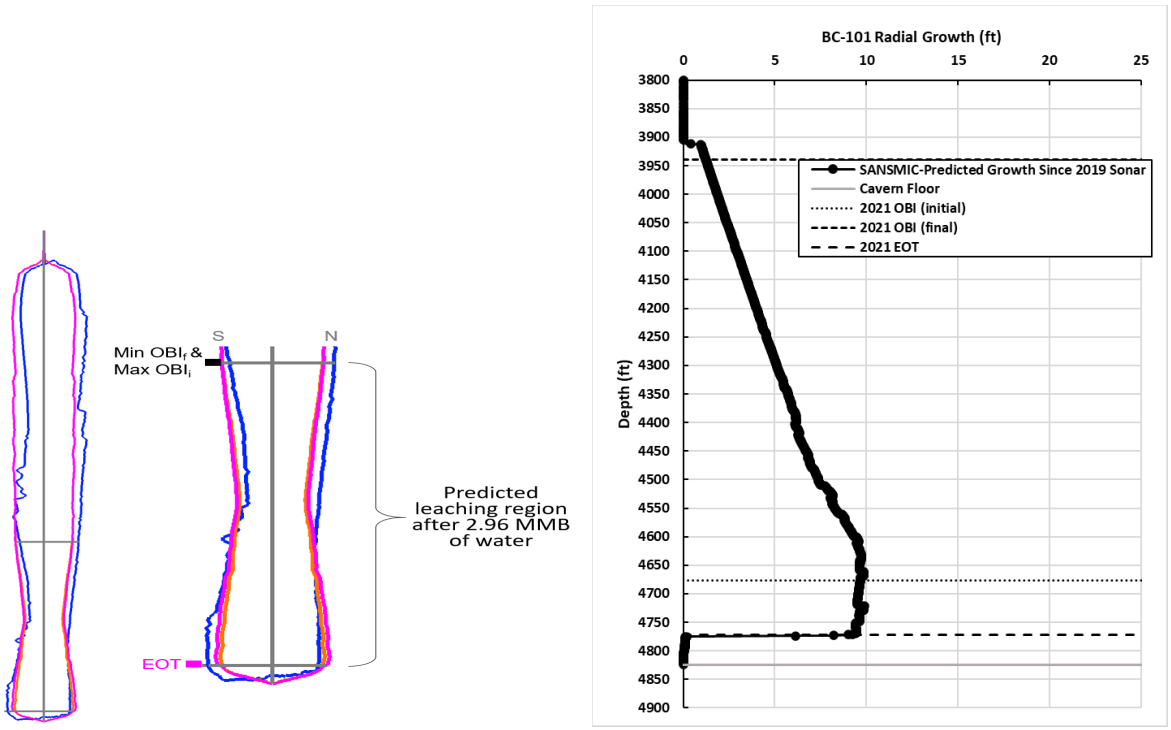

Figure 2-92. BC-101 SANSMIC-predicted radial growth since 2019 sonar.

2.4.5. BC-102

2.4.5.1. Leaching History

Sonars taken in the A and B wells of BC-102 in 2012 and 2017 are shown in Figure 2-93. Due to the low volume of water (0.023 MMB) injected into this cavern, there is no expected change in cavern shape; differences in sonars could be attributed to different resolution in sonars. An additional 2.0 MMB of water that has been injected since the 2017 sonar.

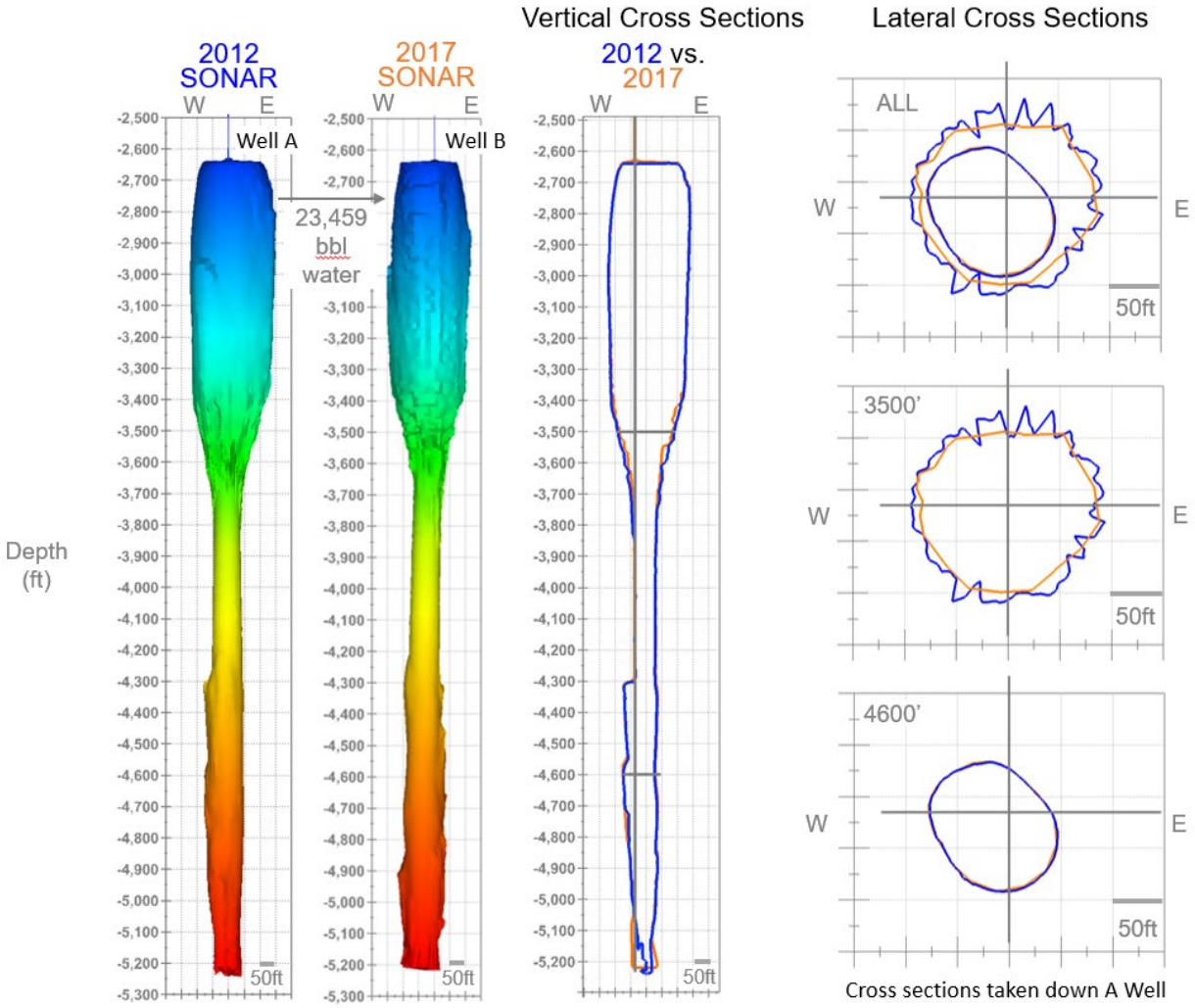

Figure 2-93. Leaching history in BC-102 from 2012 (blue) to 2017 (orange) via sonars in wells A and B.

2.4.5.2. Simulated Leaching Between 2017 Sonar and End of CY21

The last sonar taken in BC-102 was in 2017. Since that sonar, around 2.0 MMB of water have been injected into the cavern in 2017 and 2020-2021 (see Table 2-51). The injection history was modeled using three leaching phases with an EP of 60 days following each injection phase. To represent CY21 water injection, a single phase was added to the two phases modeled for the CY20 report [12]. This cavern has had a single Mod EOT rise.

Table 2-51. Summary of Simulation Input for BC-102

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	09/03/17-09/29/17	5243	50	40	1738	1740	38,212	24	917,088
2	10/05/20-10/31/20	5243	50	40	1298	1300	48,600	20	972,000
3	09/10/21-09/15/21	5,243	43	40	1,200	1,200	26,154	6	156,925
All	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50	2,046,013

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of each EP. As summarized in Table 2-52, the overall leaching efficiency for this cavern was 16.2%.

Table 2-52. Summary of Simulation Output for BC-102

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	1890	1.2002	148,800	16.2
2	1790	1.2003	156,400	16.1
3	1,320	1.2019	25,700	16.4
All	1,320	1.2019	330,900	16.2

The resultant cavern geometry after leaching was then computed and compared with the pre-leaching geometry to understand the leaching effects from water injection between the 2017 sonar and the end of CY21 (see Figure 2-94). The most recent sonar is shown in blue, the 2D axisymmetric representation of that sonar – the SANSMIC input – is shown in orange, and the SANSMIC output is shown in magenta and titled '2021 SANSMIC prediction'. The total volume of injected water modeled is shown with a grey arrow, in this case 2.0 MMB.

Vertical cross sections from each of the cavern geometries reveal only slight changes from leaching. Figure 2-95 shows a comparison of the axisymmetric representations for the sonar and SANSMIC output. Plotting SANSMIC-predicted radial growth (the difference between the curves in Figure 2-95) reveals a modeled leaching zone (see Figure 2-96) that is about 1800 ft tall and reflects the large distance between OBI and EOT. The maximum radial growth over this depth is predicted to be only about 5 ft. The simulated shape of this cavern does not suggest any leaching-induced features which may be of concern for this cavern at this time.

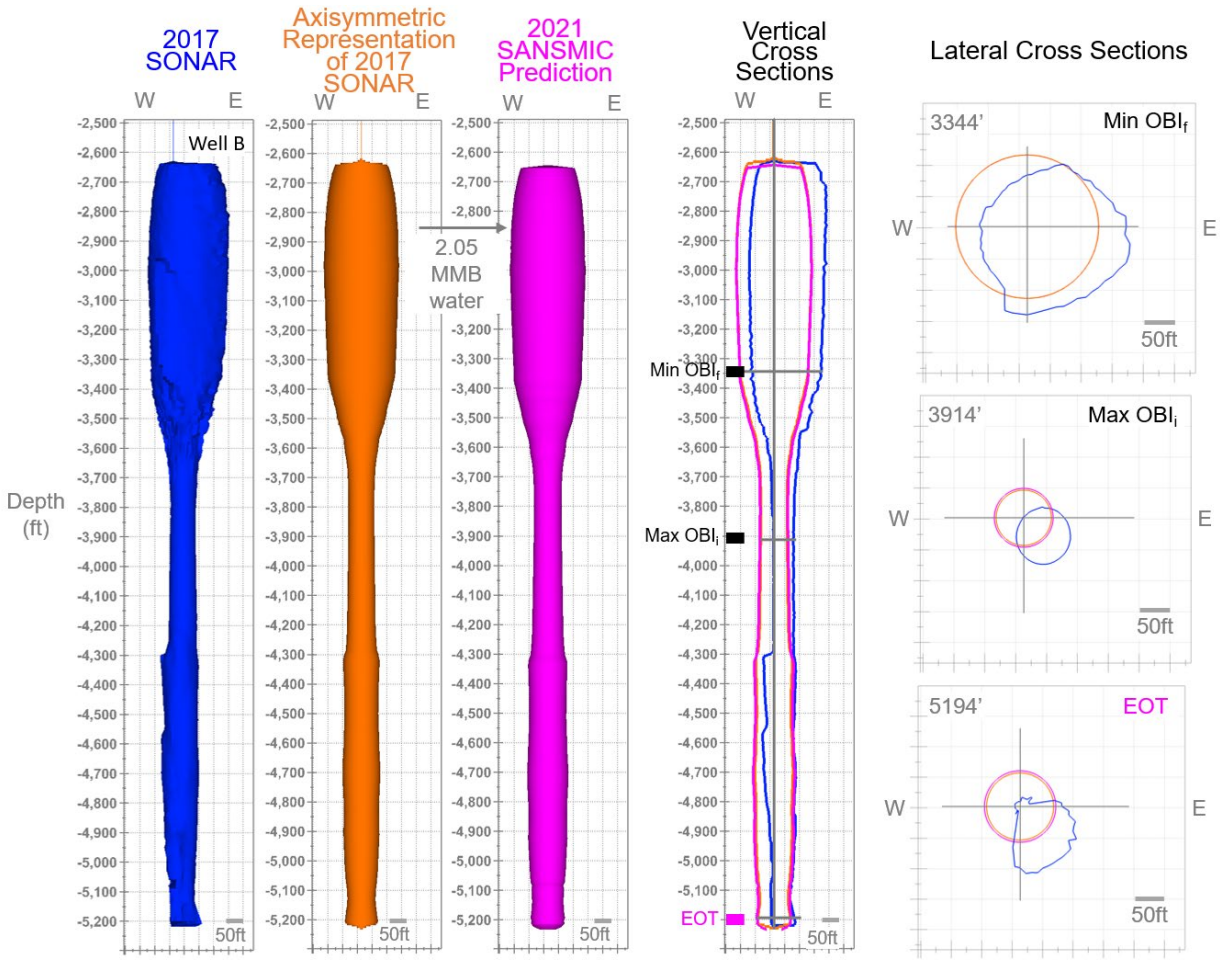

Figure 2-94. BC-102 modeling results for leaching between 2017 sonar and end of CY21.

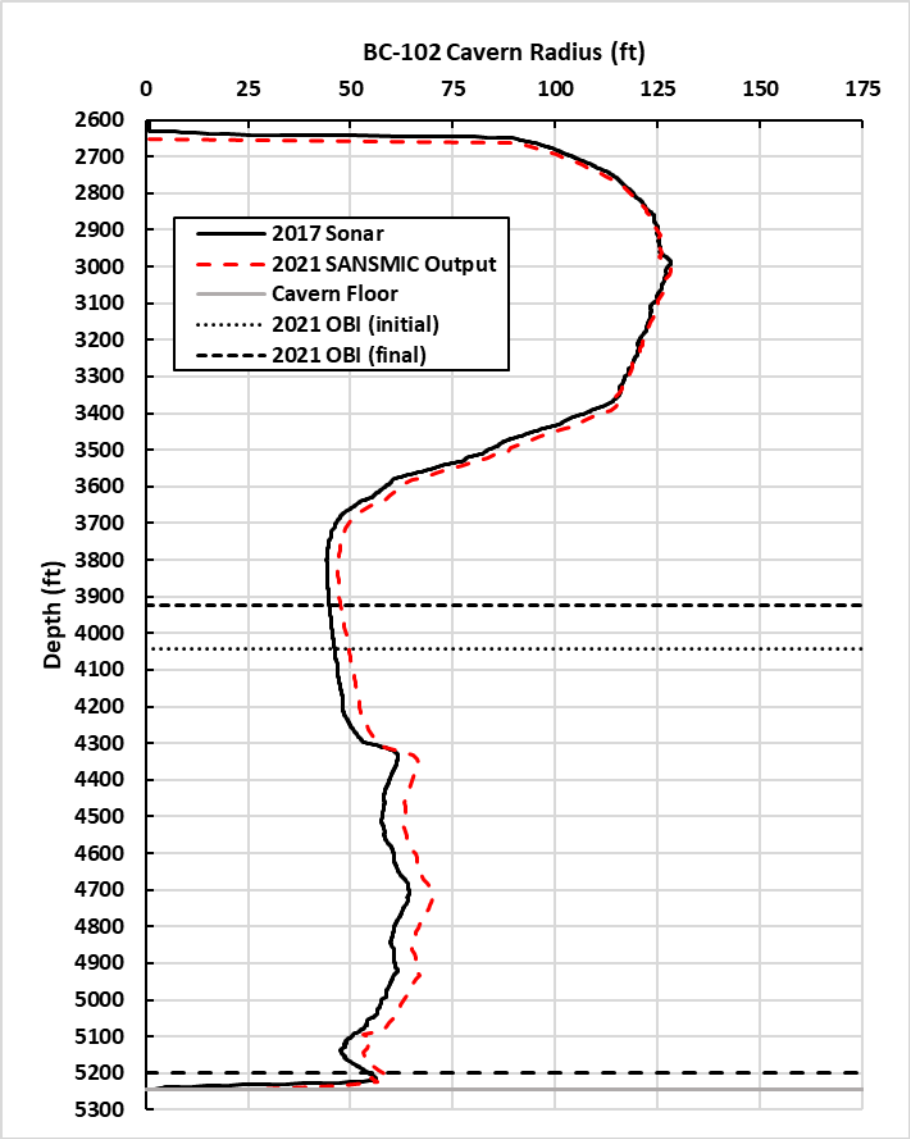

Figure 2-95. BC-102 axisymmetric representation of 2017 sonar and 2021 SANSMIC output (exaggerated horizontal scale).

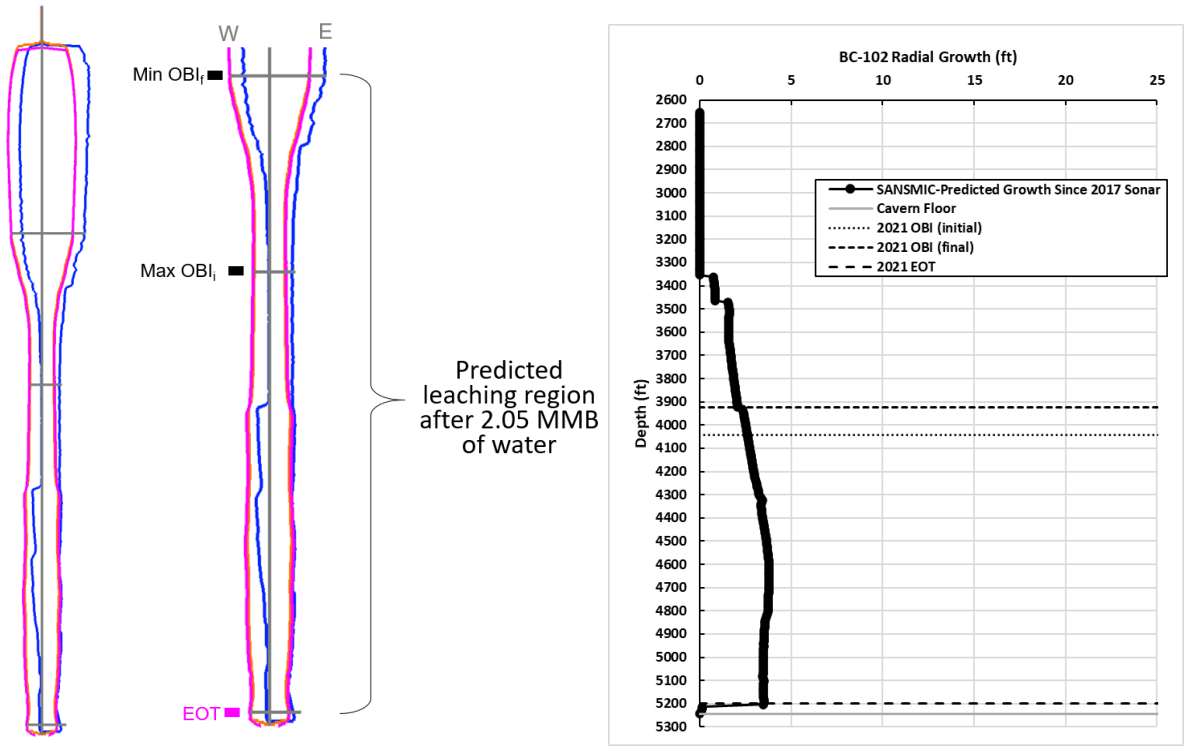

Figure 2-96. BC-102 SANSMIC-predicted radial growth since 2017 sonar.

3. COMPARISON OF SIMULATED RESULTS WITH SONARS

Results from SANSMIC simulations are compared to the CY21 sonars in this section. In these figures, the latest post-sale sonar is shown in blue, the axisymmetric representation of that sonar is shown in orange, and the SANSMIC predicted-geometry is shown in magenta. The SANSMIC-predicted geometry in some cases is from previous leaching reports. Vertical and lateral cross sections of each representation are then overlayed and presented to enable comparisons among the data. Comparisons for nine caverns are included in this section.

Raw water injection volumes between the two latest sonars were used as input for SANSMIC calculations. For five of the nine caverns, the SANSMIC results were drawn from previously published cavern leaching reports [8][12]. In these five cases, each cavern did not have more than 10,000 bbls of raw water injected in 2021, so no new SANSMIC simulations were performed. In the cases of BH-111, BM-110, WH-111, WH-117, new SANSMIC calculations were done to include the impact of raw water injection in 2021; the 2021 sonar was performed subsequent to 2021 raw water injection. In general, SANSMIC is reasonably predicting the observed leaching behavior, particularly the formation of flares and shelves.[12]

The error metrics for the sonar comparisons include:

- SANSMIC uses axisymmetric caverns representations as input, which does not allow for preferential leaching (i.e., non-radial) to be modeled
- OBIs and cavern shapes are influenced by cavern creep between sonars, and creep is not a part of the SANSMIC model
- OBIs and cavern shapes are influenced by floor rise between sonars, and floor rise is not a part of the SANSMIC model
- OBIs and EOTs are automatically modified by SANSMIC due to limitations on the number of cells in a SANSMIC simulation, meaning that the Δh_{OBI} is only accurate to $\pm 2.0 \Delta z_{CELL}$.
- Sonar volumes are only accurate to $\pm$1-3% V, meaning that ΔV is only accurate to $\pm(0.02 \text{ to } 0.06)(V_{final})$
- Errors/omissions in reported raw water injection volumes from CAVEMAN
- Errors/omissions in reported OBI/EOT depths (including undetected hanging string breaks) in weekly reports

Accounting for some of these errors, OBI over/under prediction is less relevant than the qualitative prediction of changes at the EOT or initial OBI (flares/shelves). Thus, SANSMIC is a useful tool for understanding leaching outcomes in the caverns due to the partial drawdowns associated with sales and exchanges, particularly for caverns with multiple phases of leaching.

3.1. BH-111

A sonar was taken in BH-111 in 2021 subsequent to raw water injections. No additional water was injected subsequent to the sonar. Previous to the 2021 sonar, the last sonar taken in BH-111 was in 2015. Between the two sonars, around 1.9 MMB of water were injected into the cavern (see Table 3-1). To represent the complete water injection history between the two sonars, one phase was added to the three phases modeled for the CY18-19 report [8] and additional SANSMIC calculations were performed.

When the 2021 SANSMIC results are compared with the 2021 sonar in BH-111, some difference in the position of the cavern floor is observed (see Figure 3-1 and Figure 3-2). This difference is the result of floor rise that occurred prior to the 2021 sonar in BH-111. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC did capture the leaching behavior well in terms of growth of the flare the bottom of the cavern. SANSMIC has overpredicted the extent of flare growth, in some part due to the extreme floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. As a result, SANSMIC has also underpredicted leaching further up in the cavern. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

Table 3-1. Summary of Simulation Input for BH-111

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	03/25/17-04/01/17	4,250	13	10	498	500	6,882	8	55,056
2	11/29/17-12/2/17	4,250	20	10	328	330	2,146	2	4,292
3	10/04/19-12/10/19	4,250	20	10	Auto	330	29,397	28	823,116
4	04/07/21-06/27/21	4,251	29	20	606	610	13,006	82	1,066,519
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	120	1,948,983

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 3-2, the leaching efficiency for this cavern was 16.2%.

Table 3-2. Summary of Simulation Output for BH-111

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	510	1.2017	9,000	16.3
2	330	1.2019	1,000	23.3
3	570	1.1998	135,000	16.4
4	840	1.2008	170,000	15.9
ALL	840	1.2008	315,000	16.2

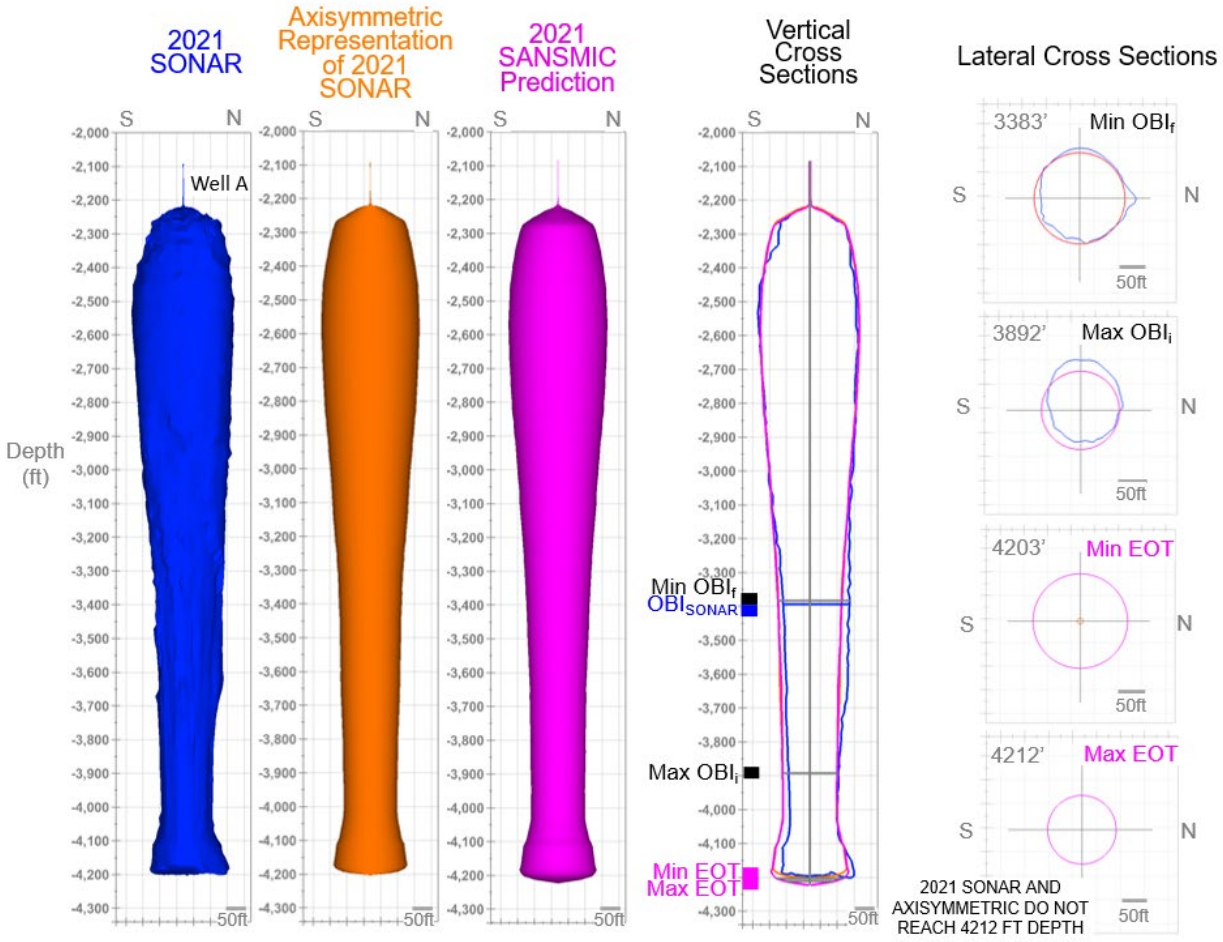

Figure 3-1. Predicted (magenta) and observed (blue, orange) cavern geometries for BH-111.

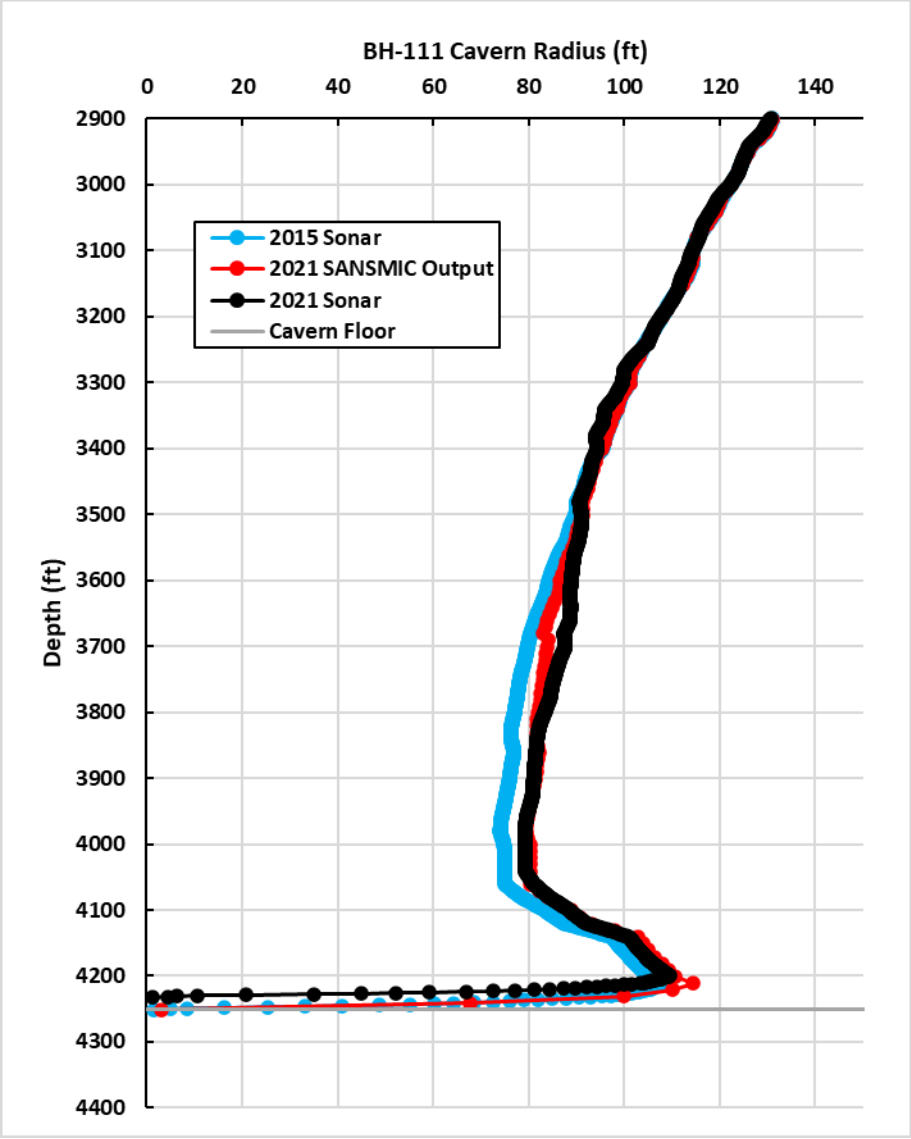

Figure 3-2. Axisymmetric BH-111 cavern profiles for 2015 sonar (blue), 2021 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.2. BH-114

The CY20 SANSMIC modeling report [12] presented results based on leaching since the 2013 sonar in BH-114. When the 2020 SANSMIC results are compared with the 2021 sonar in BH-114, a notable difference in the position of the cavern floor is observed (see Figure 3-3 and Figure 3-4). This difference is the result of significant floor rise that occurred prior to the 2021 sonar in BH-114. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC predicted growth of the flare near a depth of ~4,100 ft, but the axisymmetric representation of the sonar shows a relatively vertical wall near the floor. SANSMIC has overpredicted the extent of flare growth, in some part due to the extreme floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. As a result, SANSMIC has also underpredicted leaching further up in the cavern. Interestingly, the 2021 sonar diverges substantially from the 2013 sonar in the region 3,200-3,600 ft, where no leaching is predicted—the features in the 2013 do not exist in the 2021 sonar and the 2021 sonar shows smaller cavern size in that region.

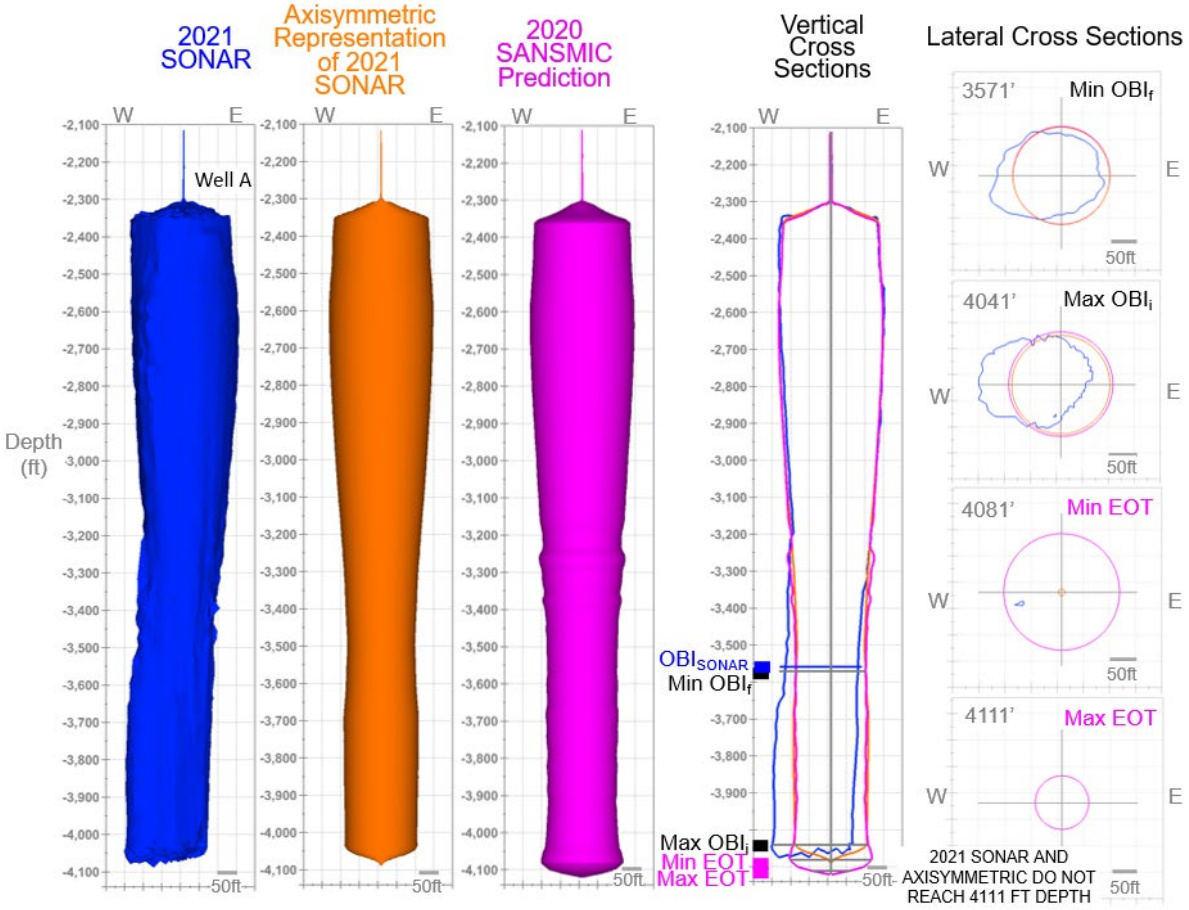

Figure 3-3. Predicted (magenta) and observed (blue, orange) cavern geometries for BH-114.

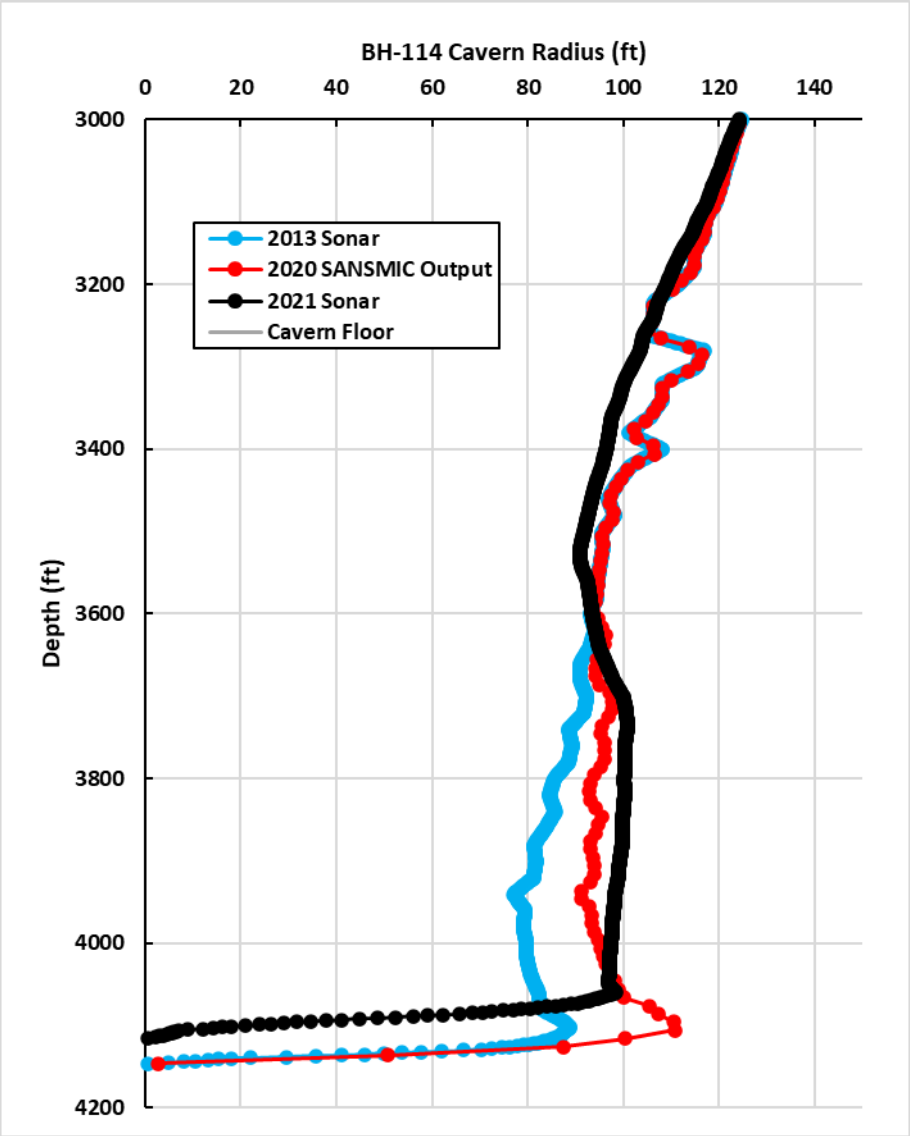

Figure 3-4. Axisymmetric BH-114 cavern profiles for 2013 sonar (blue), 2020 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.3. BM-110

A sonar was taken in BM-110 in 2021 subsequent to raw water injections. No additional water was injected subsequent to the sonar. Previous to the 2021 sonar, the last sonar taken in BM-110 was in 2016. Between the two sonars, around 1.8 MMB of water were injected into the cavern (see Table 3-3). To represent the complete water injection history between the two sonars, one phase was added to the one phase modeled for the CY18-19 report [8] and additional SANSMIC calculations were performed.

When the 2019 SANSMIC results are compared with the 2021 sonar in BM-110, a notable difference in the position of the cavern floor is observed (see Figure 3-5 and Figure 3-6). This difference is the result of significant floor rise that occurred prior to the 2021 sonar in BM-110. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC did capture the leaching behavior well in terms of

growth near the bottom of the cavern. SANSMIC has overpredicted the extent of the growth, in some part due to the extreme floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. As a result, SANSMIC has also underpredicted leaching further up in the cavern. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern.

Table 3-3. Summary of Simulation Input for BM-110

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/08/19-11/10/19	4,110	17	10	131	130	49,093	6	294,558
2	04/02/21-06/26/21	4,114	38	30	230	230	17,655	86	1,518,323
ALL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	92	1,812,881

The final outlet SG was close to the value of 1.2, suggesting that leaching was near completion at the end of the EP. As summarized in Table 3-4, the leaching efficiency for this cavern was 16.2%.

Table 3-4. Summary of Simulation Output for BM-110

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	220	1.1995	49,000	16.6
2	630	1.2003	244,000	16.1
ALL	630	1.2003	293,000	16.2

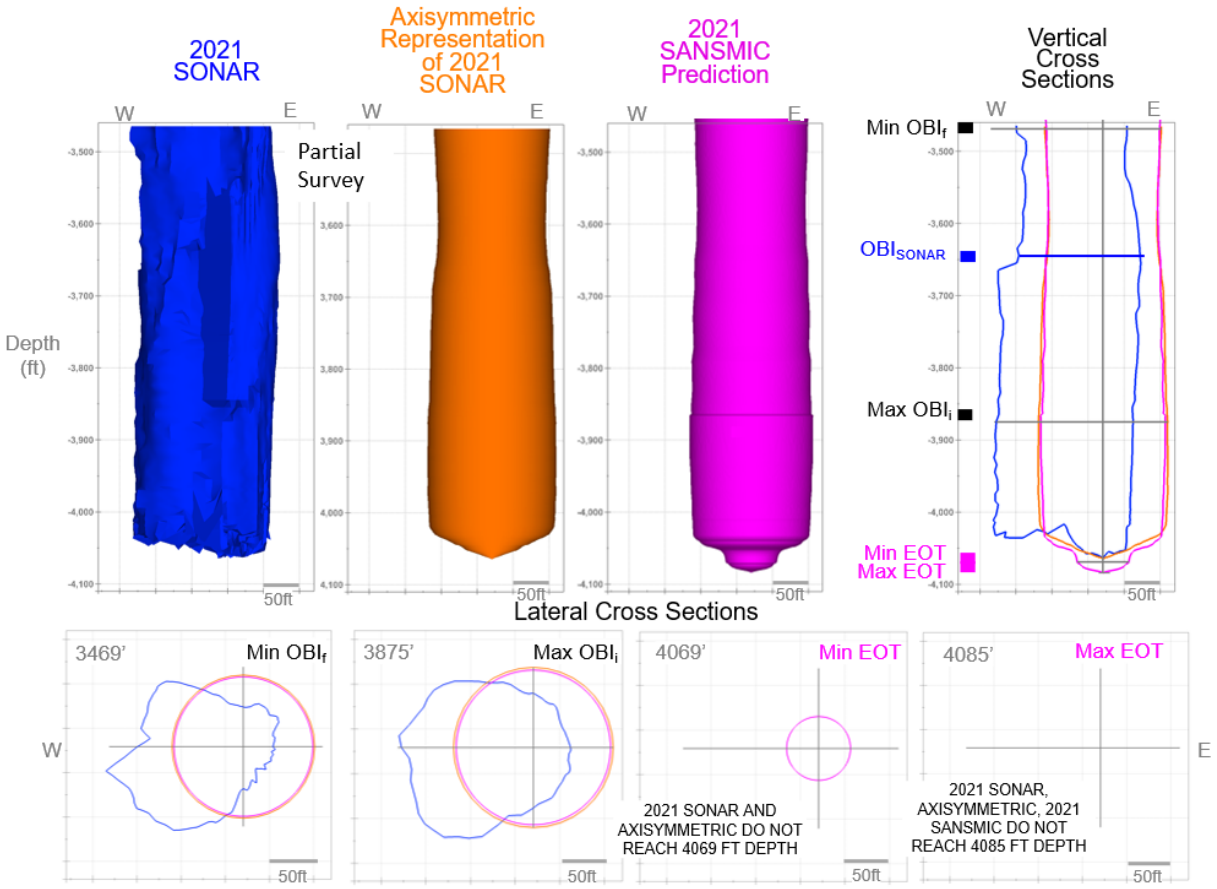

Figure 3-5. Predicted (magenta) and observed (blue, orange) cavern geometries for BM-110.

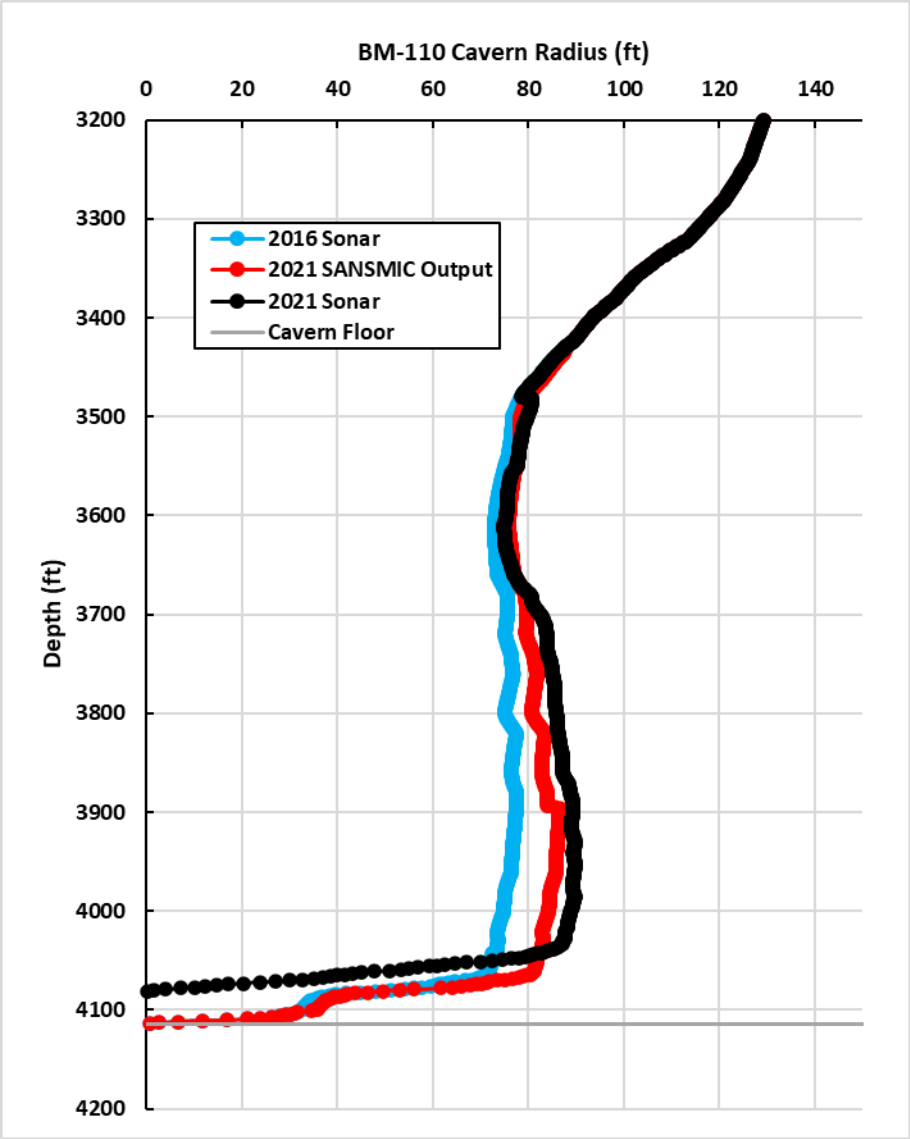

Figure 3-6. Axisymmetric BM-110 cavern profiles for 2016 sonar (blue), 2021 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.4. BM-114

The CY20 SANSMIC modeling report [12] presented results based on leaching since the 2012 sonar in BM-114. When the 2020 SANSMIC results are compared with the 2021 sonar in BM-114, a slight difference in the position of the cavern floor is observed (see Figure 3-7 and Figure 3-8). This difference is the result of some floor rise that occurred prior to the 2021 sonar in BM-114. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC did capture the leaching behavior well in terms of growth of the flare the bottom of the cavern. SANSMIC has overpredicted the horizontal growth near the floor, in some part due to the floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. As a result, SANSMIC has also slightly underpredicted leaching further up in the cavern. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

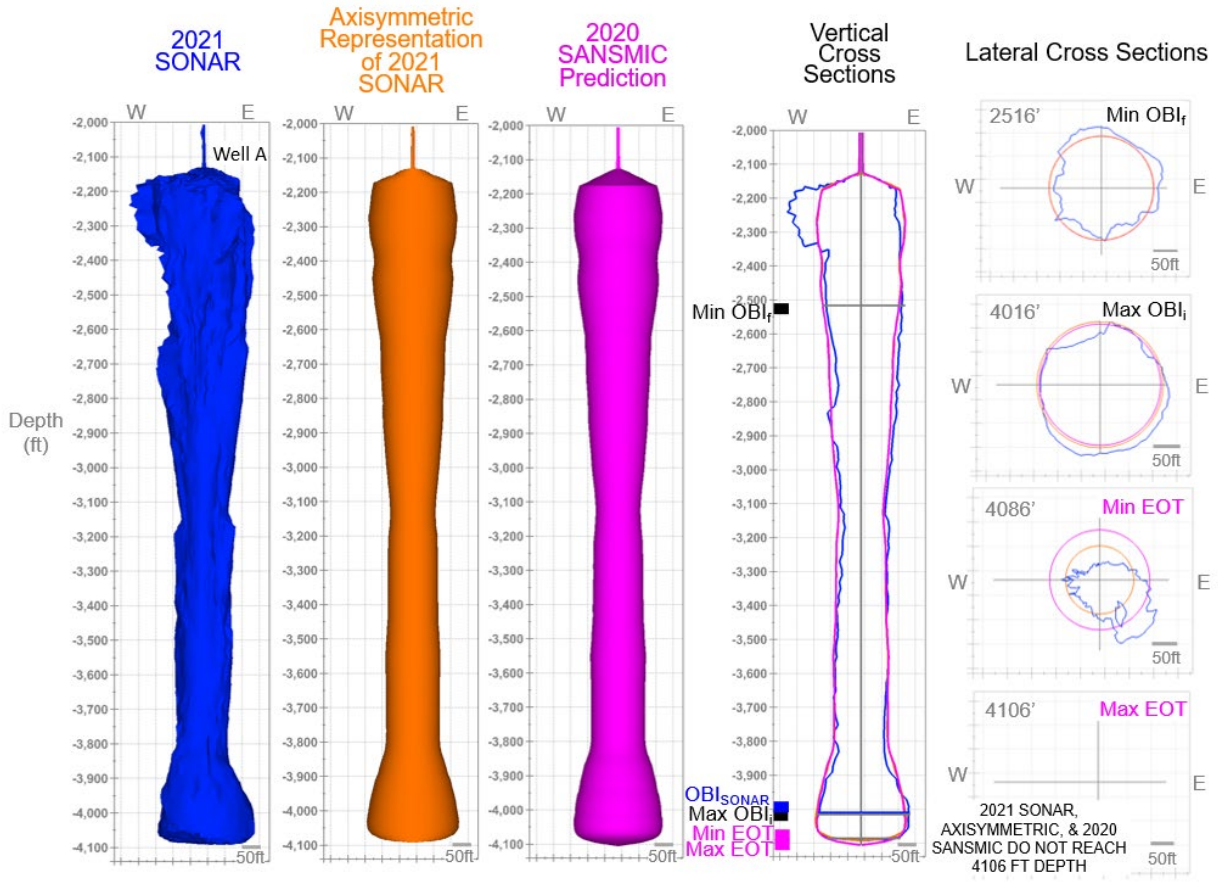

Figure 3-7. Predicted (magenta) and observed (blue, orange) cavern geometries for BM-114.

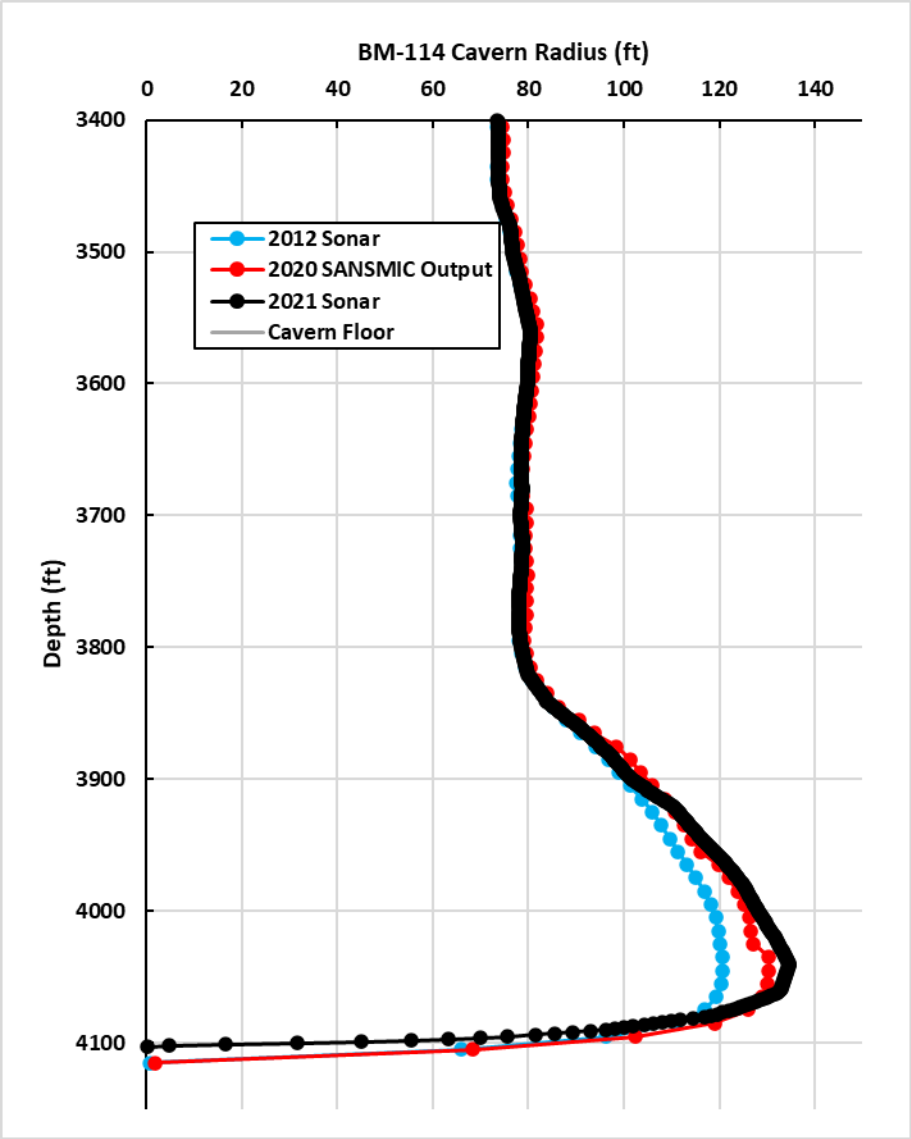

Figure 3-8. Axisymmetric BM-114 cavern profiles for 2012 sonar (blue), 2020 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.5. BM-115

The CY18-CY19 SANSMIC modeling report [8] presented results based on leaching since the 2011 sonar in BM-115. When the 2019 SANSMIC results are compared with the 2021 sonar in BM-115, a notable difference in the position of the cavern floor is observed (see Figure 3-9 and Figure 3-10). This difference is the result of floor rise that occurred prior to the 2021 sonar in BM-115. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC did capture the leaching behavior well in terms of growth of the flare the bottom of the cavern. SANSMIC has overpredicted the extent of flare growth, in some part due to the floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

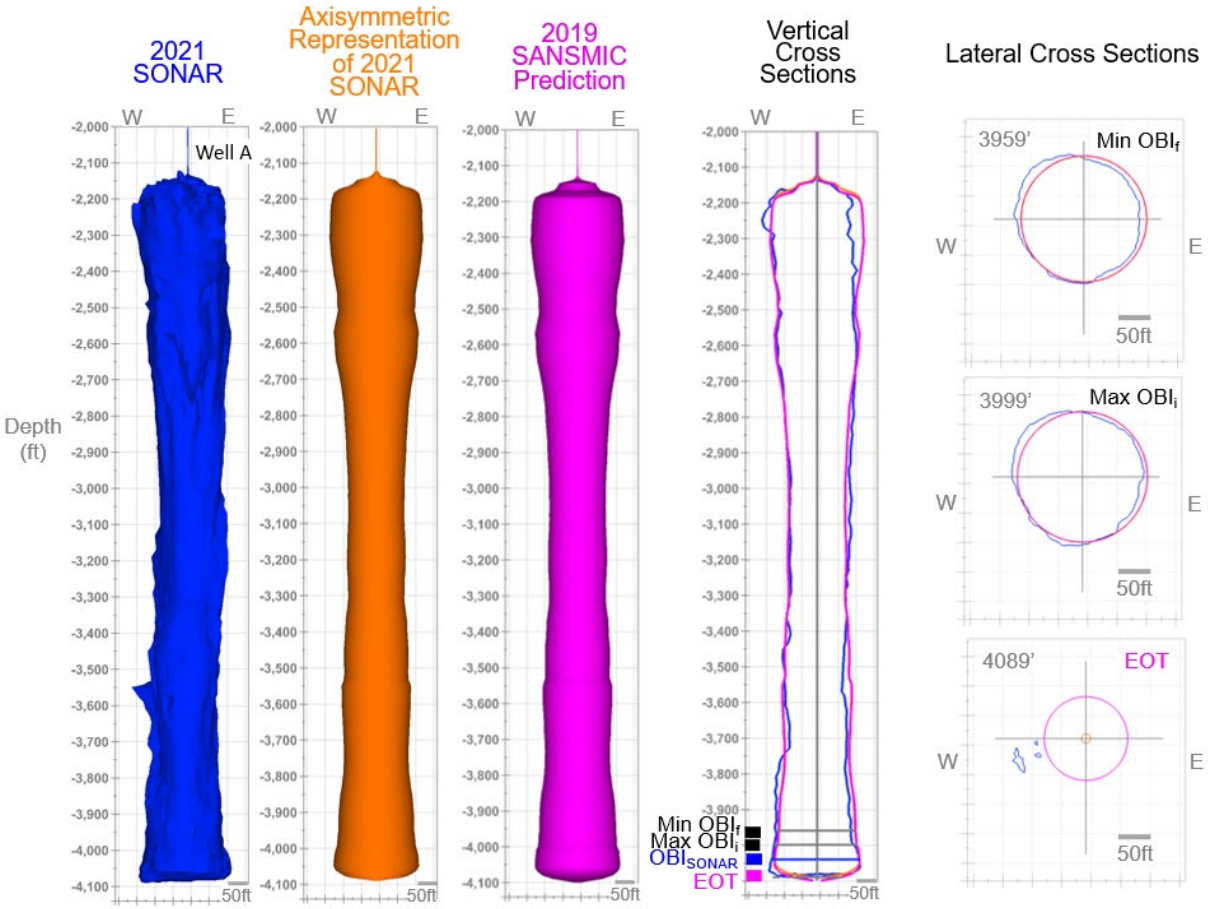

Figure 3-9. Predicted (magenta) and observed (blue, orange) cavern geometries for BM-115.

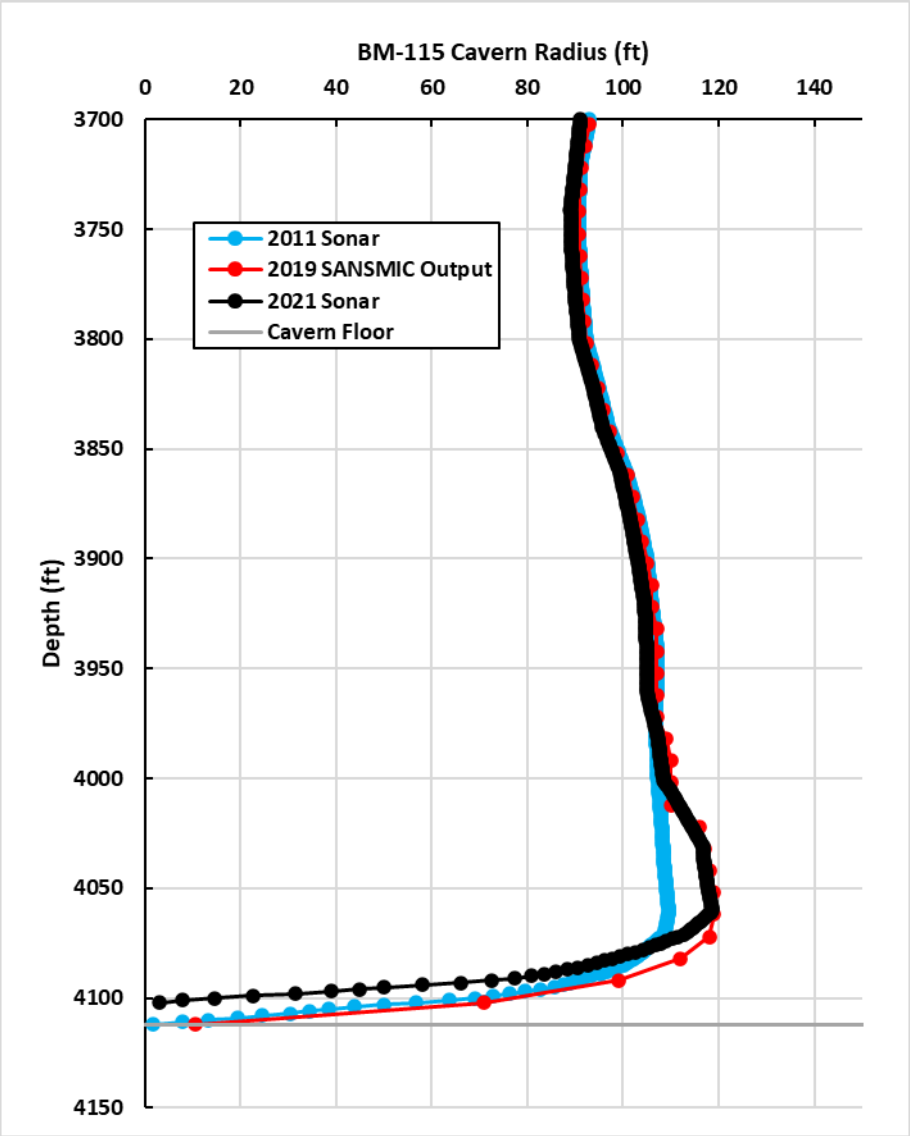

Figure 3-10. Axisymmetric BM-115 cavern profiles for 2011 sonar (blue), 2019 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.6. BM-116

The CY20 SANSMIC modeling report [12] presented results based on leaching since the 2011 sonar in BM-116. When the 2020 SANSMIC results are compared with the 2021 sonar in BM-116, a notable difference in the position of the cavern floor is observed (see Figure 3-11 and Figure 3-12). This difference is the result of significant floor rise that occurred prior to the 2021 sonar in BM-116. Floor rise is not a process that is currently included in SANSMIC and thus the change in floor rise cannot be accurately estimated with it. SANSMIC did capture the leaching behavior well in terms of growth occurring near the bottom of the cavern. SANSMIC has overpredicted the extent of radial growth near the floor, in some part due to the floor rise; the lack of floor rise in the SANSMIC model leads to additional leaching closer to the cavern floor. As a result, SANSMIC has also underpredicted leaching further up in the cavern. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

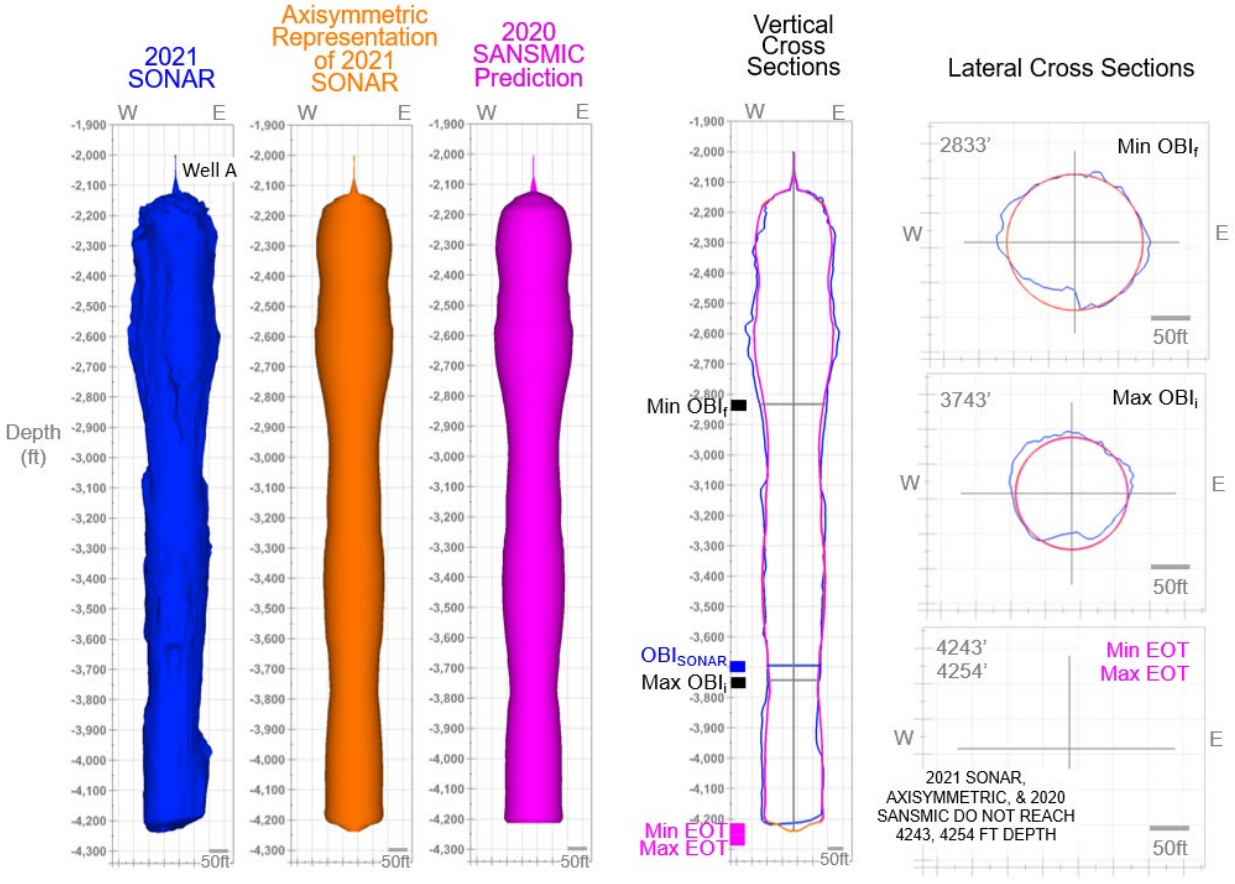

Figure 3-11. Predicted (magenta) and observed (blue, orange) cavern geometries for BM-116.

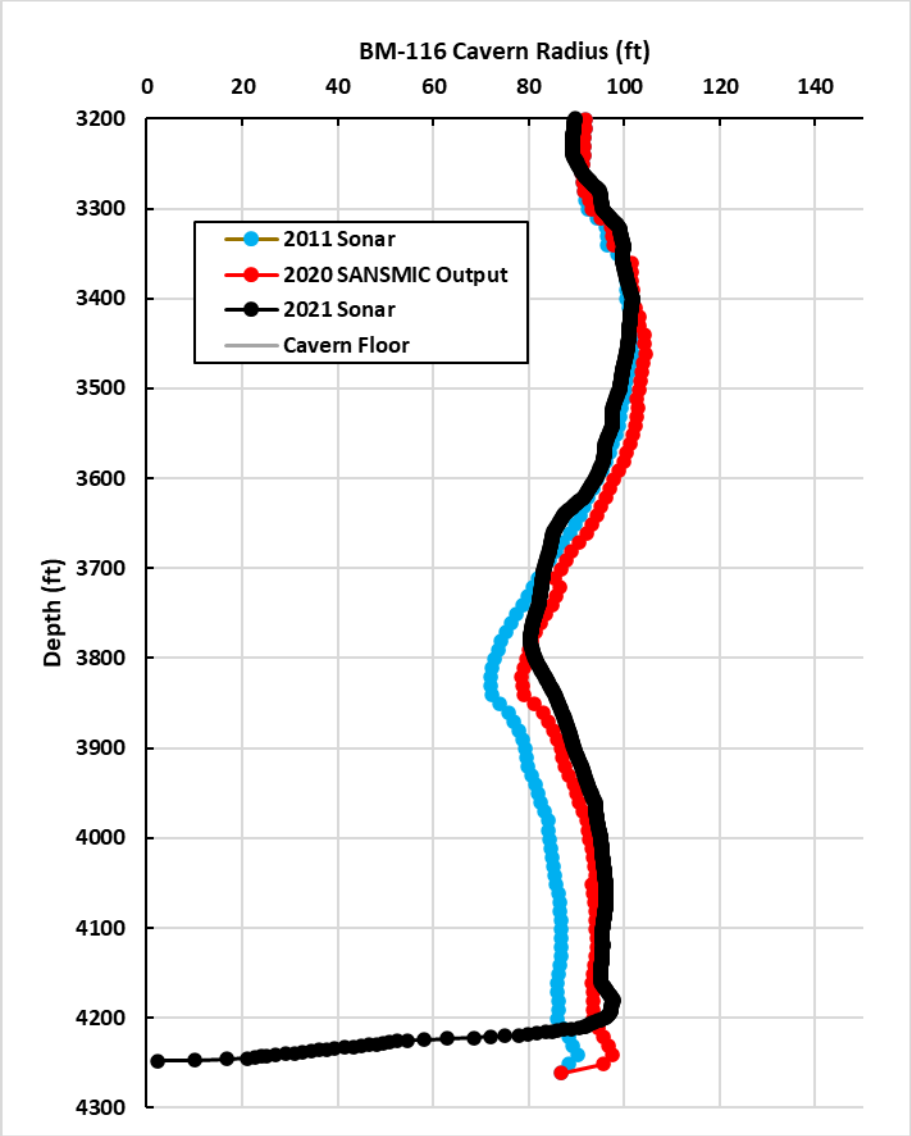

Figure 3-12. Axisymmetric BM-116 cavern profiles for 2011 sonar (blue), 2020 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.7. WH-108

The CY18-CY19 SANSMIC modeling report [8] presented results based on leaching since the 2018 sonar in WH-108. When the 2019 SANSMIC results are compared with the 2021 sonar in WH-108, an overall good agreement is observed (see Figure 3-13 and Figure 3-14). Almost no floor rise is noted. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

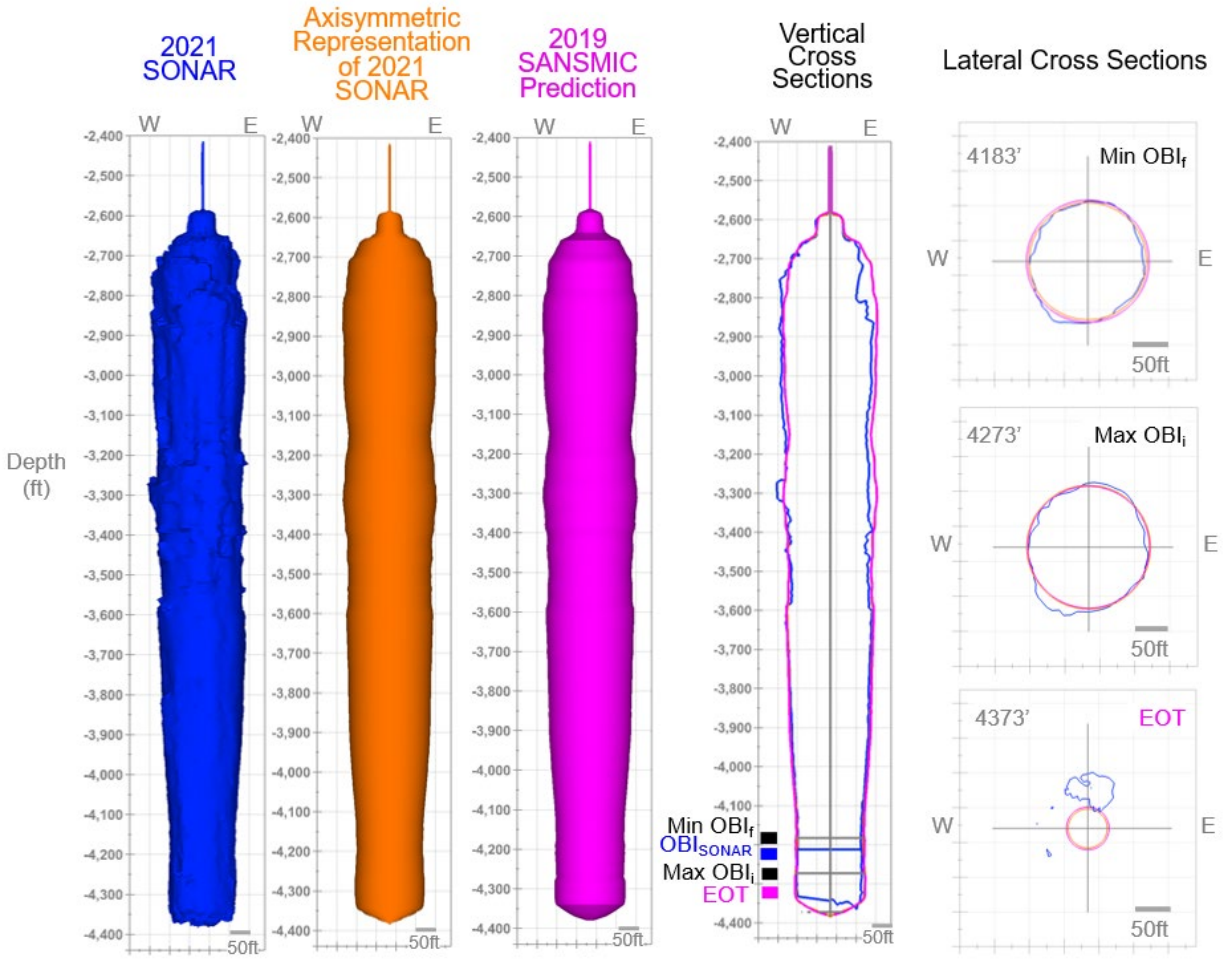

Figure 3-13. Predicted (magenta) and observed (blue, orange) cavern geometries for WH-108.

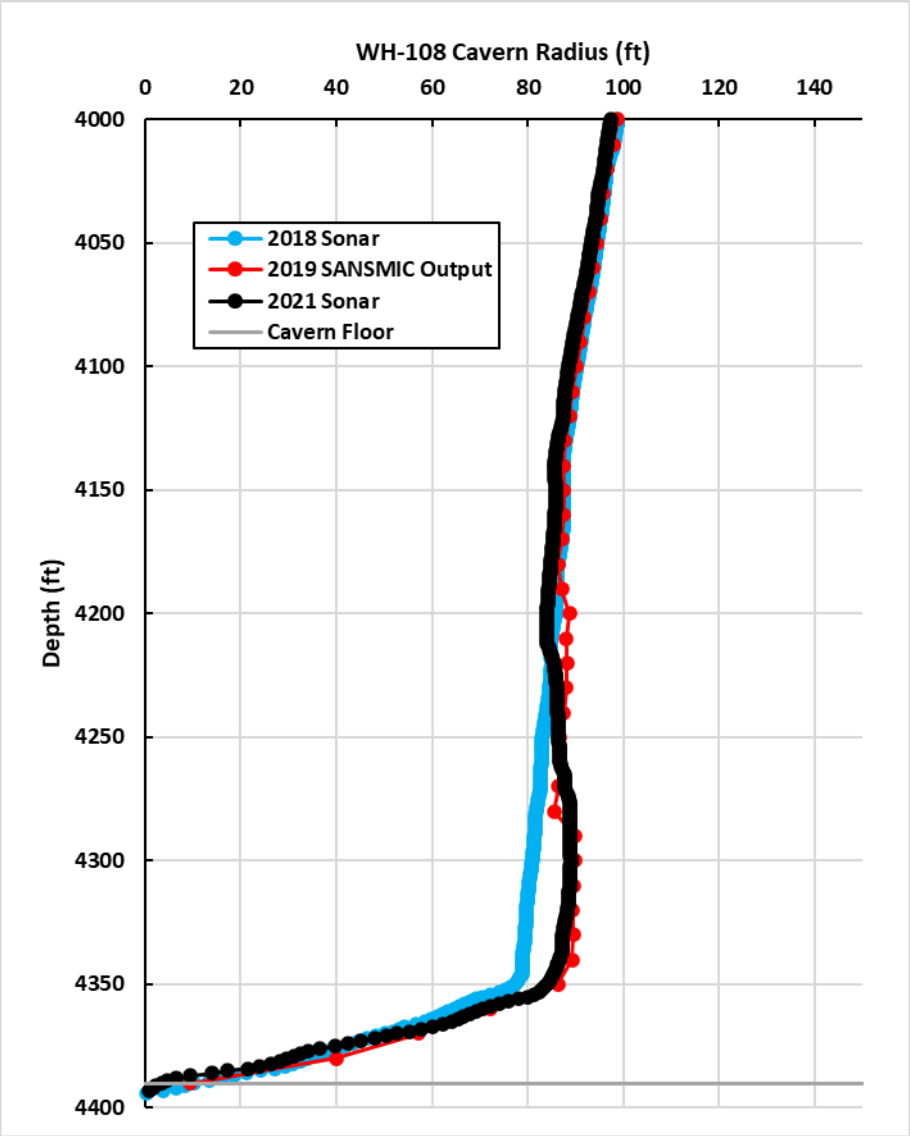

Figure 3-14. Axisymmetric WH-108 cavern profiles for 2018 sonar (blue), 2019 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.8. WH-111

A sonar was taken in WH-111 in 2021 subsequent to raw water injections. No additional water was injected subsequent to the sonar. Previous to the 2021 sonar, the last sonar taken in WH-111 was in 2015. Between the two sonars, around 4.0 MMB of water were injected into the cavern (see Table 3-5). To represent the complete water injection history between the two sonars, one phase was added to the four phases modeled for the CY20 report [12] and additional SANSMIC calculations were performed.[4]

When the 2020 SANSMIC results are compared with the 2021 sonar in WH-111, an overall good agreement is observed (see Figure 3-15 and Figure 3-16). Almost no floor rise is noted. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

Table 3-5. Summary of Simulation Input for WH-111

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	2017	4527	25	20	1142	1140	75,750	5	378,750
2	2017	4527	25	20	Auto	1220	39,597	44	1,742,268
3	2017	4527	14	10	1402	1400	12,585	140	1,761,900
4	10/26/20-11/22/20	4527	14	20	1575	1580	4,055	4	16,220
5	04/22/21-05/18/21	4,522	82	80	1,434	1,430	4,996	27	134,887
All	N/A	N/A	N/A	N/A	N/A	N/A	N/A	220	4,034,025

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of each EP. As summarized in Table 3-6, the overall leaching efficiency for this cavern was 15.7%. The leaching efficiency of phase 5 was anomalously calculated as 43.2%, likely due to the relatively small volumes and the precision of the SANSMIC output.

Table 3-6. Summary of Simulation Output for WH-111

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	1220	1.2009	57,000	15.4
2	1,477	1.1979	265,000	15.4
3	1,625	1.1957	282,000	12.8
4	1,577	1.2019	6,000	43.2
5	1,451	1.2019	22,000	16.3

[4] Note that there was an error in SANSMIC runs performed in 2020 and 2017 regarding initial cavern geometries –they should have been based on 2015 sonar. The 2020 SANSMIC calculations were redone here using the 2015 sonar as a baseline and the results are referred to as '2020 SASNSMIC Output' in Figure 3-16.

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
ALL	1,451	1.2019	632,000	15.7

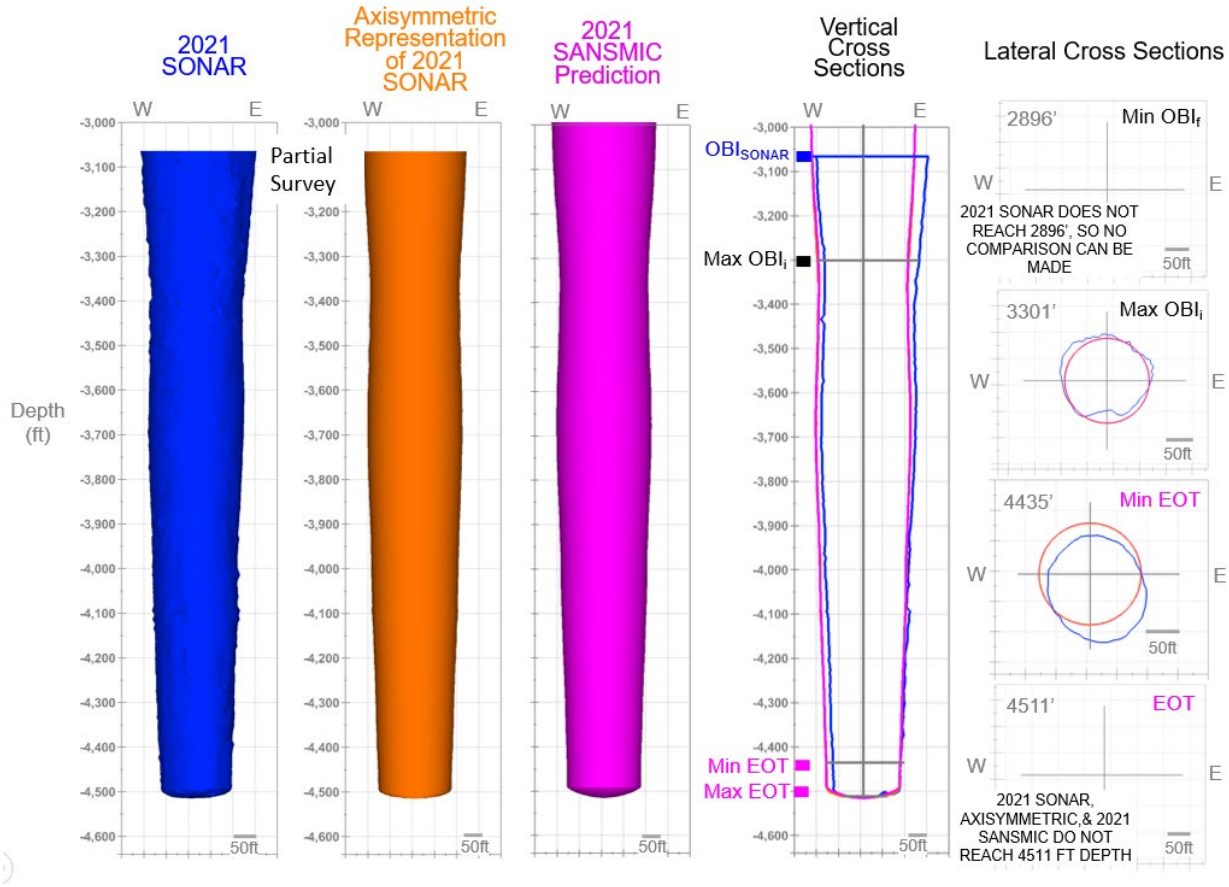

Figure 3-15. Predicted (magenta) and observed (blue, orange) cavern geometries for WH-111.

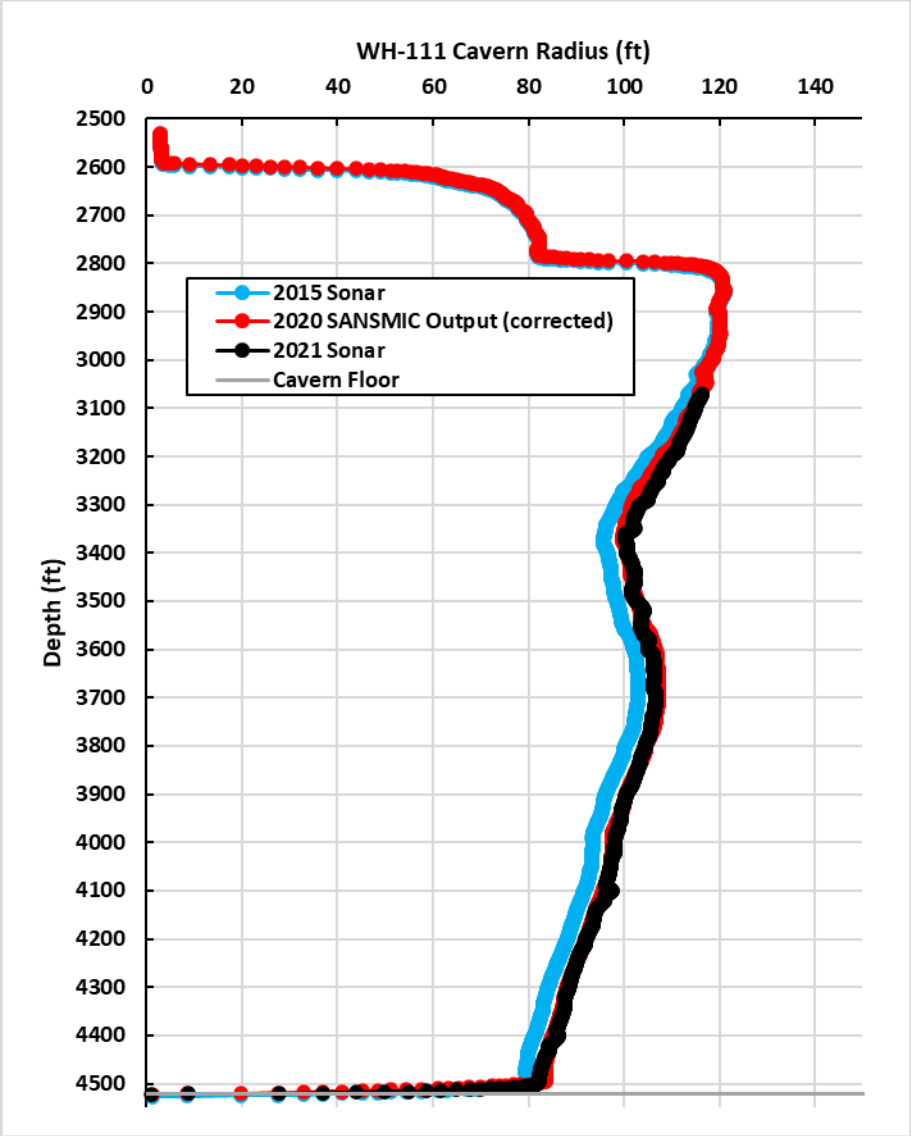

Figure 3-16. Axisymmetric WH-111 cavern profiles for 2015 sonar (blue), 2020 SANSMIC output (corrected) (red), and 2021 sonar (black) (exaggerated horizontal scale).

3.9. WH-117

A sonar was taken in WH-117 in 2021 subsequent to raw water injections. No additional water was injected subsequent to the sonar. Previous to the 2021 sonar, the last sonar taken in WH-117 was in 2019. Between the two sonars, around 1.6 MMB of water were injected into the cavern (see Table 3-7). To represent the complete water injection history between the two sonars, one phase was added to the two phases modeled for the CY18-19 report [8] and additional SANSMIC calculations were performed.

When the 2021 SANSMIC results are compared with the 2021 sonar in WH-117, an overall good agreement is observed (see Figure 3-17 and Figure 3-18). Almost no floor rise is noted. Overall, SANSMIC did a reasonable job estimating the leaching in this cavern and the resultant flare.

Table 3-7. Summary of Simulation Input for WH-117

Phase	Dates	Cavern Floor Depth (ft)	EOT Rise (ft)	Mod EOT Rise (ft)	OBI Rise (ft)	Mod OBI Rise (ft)	Injection Rate (bbl/day)	Injection Duration (days)	Total Injected Water Volume (bbl)
1	10/07/19-12/04/19	4575	11	0	366	370	37,675	33	1,243,275
2	08/02/20-08/22/20	4576	13	20	187	190	55,620	6	333,720
3	05/20/21-06/29/21	4,567	22	20	300	300	19,578	41	802,682
All	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39	2,379,677

The final outlet SG for each phase was close to the value of 1.2, suggesting that leaching was near completion at the end of each EP. As summarized in Table 3-8, the overall leaching efficiency for this cavern was 16.1%.

Table 3-8. Summary of Simulation Output for WH-117

Phase	Final OBI Rise (ft)	Outlet SG	Change in Volume (bbl)	Leaching Efficiency (%)
1	670	1.1995	204,000	16.4
2	260	1.1987	52,000	15.6
3	470	1.1995	126,000	15.7
ALL	470	1.1995	382,000	16.1

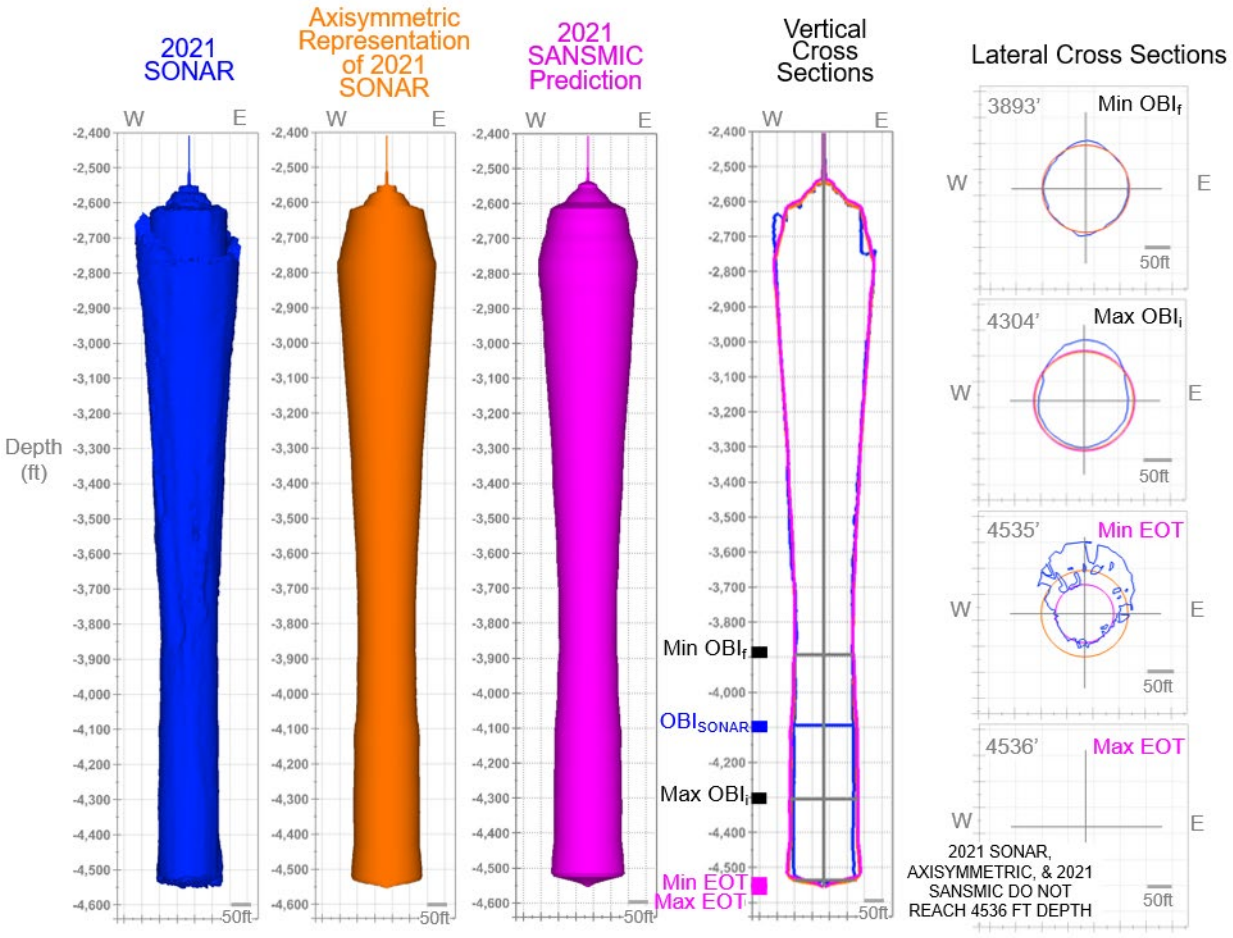

Figure 3-17. Predicted (magenta) and observed (blue, orange) cavern geometries for WH-117.

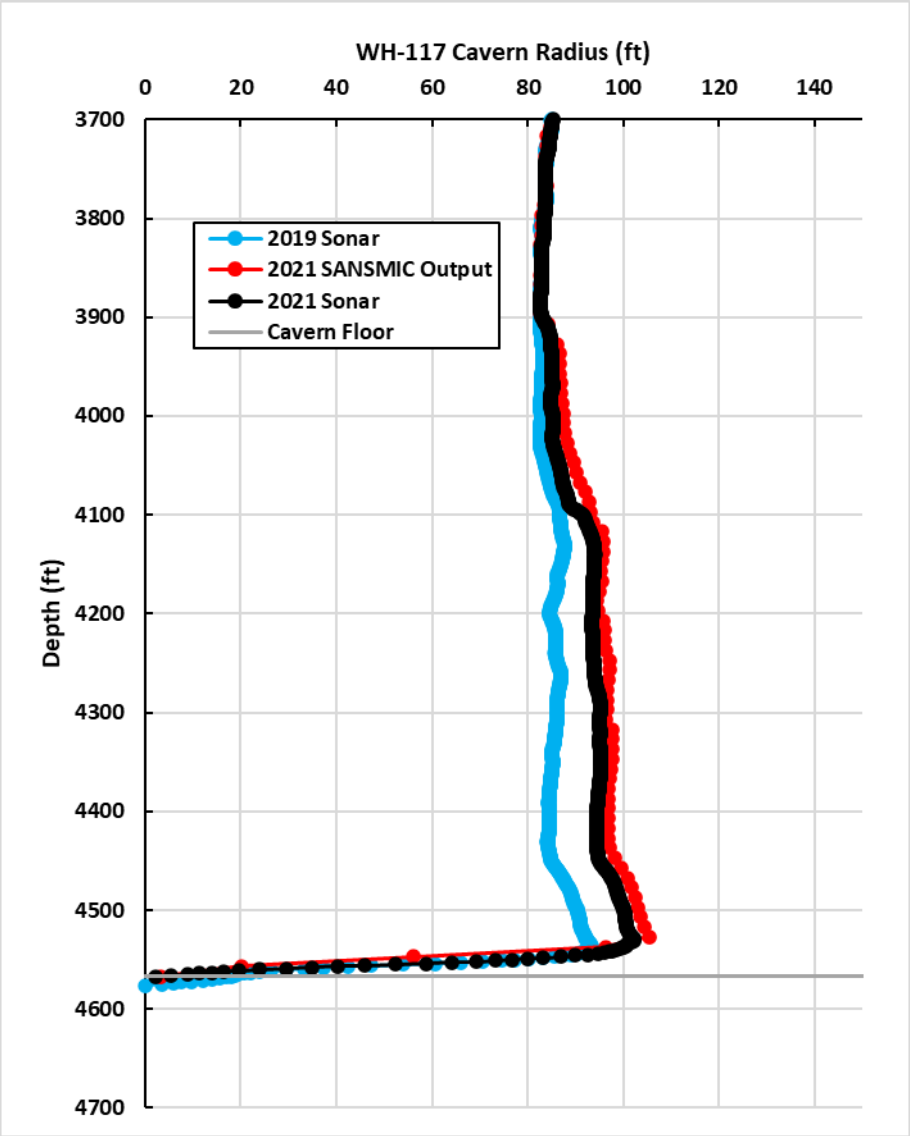

Figure 3-18. Axisymmetric WH-117 cavern profiles for 2019 sonar (blue), 2021 SANSMIC output (red), and 2021 sonar (black) (exaggerated horizontal scale).

4. SUMMARY AND CONCLUSIONS

Twenty-six caverns had over 45 MMB of water injected in CY21 as part of oil sales. Leaching effects were monitored in these caverns to understand how the sales operations may impact the long-term integrity of the caverns. While frequent sonars are the most direct means to monitor changes in cavern shape, they can be resource intensive for the number of caverns involved in sales and exchanges. An intermediate option is to model the leaching effects and see if any concerning features develop.

The leaching effects were modeled here using the Sandia Solution Mining Code. The results indicate that leaching induced features are not of concern in the majority of the caverns, 15 of 26. Eleven caverns, BH-107, BH-110, BH-112, BH-113, BM-109, WH-11, WH-112, WH-114, BC-17, BC-18, and BC-19 have features that may grow with additional leaching and should be monitored as leaching continues in those caverns. Additionally, BH-114, BM-4, and BM-106 were previously identified for recommendation of monitoring.

Nine caverns had sonars that were compared with SANSMIC results. Overall, SANSMIC was able to capture the leaching well. A deviation in the SANSMIC and sonar cavern shapes was observed near the cavern floor in caverns with significant floor rise, a process not captured by SANSMIC. These results suggest SANSMIC is a useful tool for monitoring changes in cavern shape due to leaching effects related to sales and exchanges.

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APPENDIX A. MAIN APPENDIX TITLE

This appendix provides reference to the CY21 raw water injection volumes used in SANSMIC modeling. Table A-1 summarizes 2021 raw water injection volumes for each cavern for spring and fall sales. Table A-2 contains the raw fluid movement data from CAVEMAN with those values used for raw water injection volumes highlighted. Note that for BC caverns, no raw water volumes were recorded in 2021; to derive raw water volumes for BC caverns, oil withdrawal volumes were assumed to be identical to raw water injection volumes.

Table A-1. Summary of 2021 Raw Water Injection Volumes by Cavern

Cavern	Spring Sales					Fall Sales					Total Volume (BBL)
	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	
BC17	-	-	-	-	-	3718460	9/9/2021	12/31/2021	114	32618	3718460
BC18	-	-	-	-	-	158698	9/10/2021	9/15/2021	6	26450	158698
BC19	-	-	-	-	-	1313289	9/18/2021	12/31/2021	105	12508	1313289
BC101	-	-	-	-	-	2964563	9/9/2021	12/31/2021	114	26005	2964563
BC102	-	-	-	-	-	156925	9/10/2021	9/15/2021	6	26154	156925
BH106	67418	5/24/2021	5/25/2021	2	33709	2176744	10/3/2021	12/14/2021	73	29818	2244162
BH107	592943	4/7/2021	6/27/2021	82	7231	1604134	10/3/2021	12/13/2021	72	22280	2197077
BH108	1058929	4/7/2021	7/14/2021	99	10696	-	-	-	-	-	1058929
BH109	411393	4/7/2021	5/11/2021	35	11754	-	-	-	-	-	411393
BH110	1116951	4/7/2021	6/26/2021	81	13790	2544089	10/3/2021	12/13/2021	72	35335	3661040
BH111	1066519	4/7/2021	6/27/2021	82	13006	1681508	10/3/2021	12/14/2021	73	23034	2748027

Cavern	Spring Sales					Fall Sales					Total Volume (BBL)
	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	
BH112	-	-	-	-	-	99292	12/13/2021	12/19/2021	7	14185	99292
BH113	-	-	-	-	-	15564	10/10/2021	10/10/2021	1	15564	15564
BM102	1233094	4/2/2021	6/26/2021	86	14338	-	-	-	-	-	1233094
BM103	565324	4/2/2021	6/26/2021	86	6574	1467204	10/4/2021	12/15/2021	73	20099	2032528
BM104	1296760	4/2/2021	6/16/2021	76	17063	-	-	-	-	-	1296760
BM109	-	-	-	-	-	1338477	10/4/2021	12/15/2021	73	18335	1338477
BM110	1518323	4/2/2021	6/26/2021	86	17655	1278836	10/4/2021	12/15/2021	73	17518	2797159
BM111	1671989	4/2/2021	6/26/2021	86	19442	1426719	10/4/2021	12/15/2021	73	19544	3098708
WH11	738725	6/2/2021	6/29/2021	28	26383	1162346	10/4/2021	12/11/2021	69	16846	1901071
WH109	1527572	2/3/2021	6/29/2021	147	10392	1784179	10/4/2021	12/14/2021	72	24780	3311751
WH111	134887	4/22/2021	5/18/2021	27	4996	-	-	-	-	-	134887
WH112	751237	6/2/2021	6/29/2021	28	26830	-	-	-	-	-	751237
WH114	1302945	2/3/2021	5/30/2021	117	11136	1814843	10/4/2021	12/14/2021	72	25206	3117788

Cavern	Spring Sales					Fall Sales					Total Volume (BBL)
	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	Volume (bbls)	Start Date	End Date	Days	Raw Water Injection Rate (BBL/day)	
WH115	1290953	2/3/2021	6/29/2021	147	8782	1592137	10/4/2021	12/14/2021	72	22113	2883090
WH117	802682	5/20/2021	6/29/2021	41	19578	-	-	-	-	-	802682
										Total	**45446651**

Table A-2. CAVEMAN 2021 Fluid Movement Data (Highlighted Volumes Used as Raw Water Injection Volumes)

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC17	2/24/2021	8139	oil	0		
BC17	2/25/2021	11457	oil	0		
BC17	2/26/2021	3118	oil	0		
BC17	2/27/2021	23614	oil	0		
BC17	2/28/2021	11261	oil	0		
BC17	3/6/2021	942	oil	0		
BC17	3/7/2021	4640	oil	0		
BC17	3/8/2021	272	oil	0		
BC17	3/9/2021	494	oil	0		
BC17	3/10/2021	566	oil	0		
BC17	3/11/2021	904	oil	0		
BC17	3/12/2021	1222	oil	0		
BC17	3/13/2021	392	oil	0		
BC17	3/14/2021	505	oil	0		
BC17	3/15/2021	725	oil	0		
BC17	3/16/2021	818	oil	0		
BC17	3/17/2021	1329	oil	0		
BC17	3/18/2021	787	oil	0		
BC17	3/22/2021	1893	oil	0		
BC17	4/1/2021	1156	oil	0		
BC17	4/5/2021	883	oil	0		
BC17	4/6/2021	99	oil	0		
BC17	4/20/2021	0		5490	brine	88
BC17	4/21/2021	0		10917	brine	88
BC17	4/24/2021	0		7162	brine	75
BC17	7/17/2021	22442	oil	14557	brine	
BC17	7/18/2021	46190	oil	41677	brine	
BC17	7/19/2021	29210	oil	26649	brine	
BC17	7/24/2021	5781	oil	7258	brine	88
BC17	8/5/2021	1925	oil	0		
BC17	8/12/2021	0		16172	oil	100
BC17	8/13/2021	0		3380	oil	100
BC17	9/9/2021	130809	oil	0		
BC17	9/10/2021	15678	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC17	9/11/2021	45981	oil	0		
BC17	9/12/2021	101876	oil	0		
BC17	9/13/2021	118171	oil	0		
BC17	9/14/2021	27203	oil	0		
BC17	9/15/2021	21333	oil	0		
BC17	9/16/2021	117018	oil	0		
BC17	9/17/2021	59215	oil	0		
BC17	9/18/2021	89033	oil	0		
BC17	9/19/2021	19682	oil	0		
BC17	9/20/2021	86862	oil	0		
BC17	9/21/2021	108618	oil	0		
BC17	9/22/2021	76521	oil	0		
BC17	9/24/2021	23753	oil	0		
BC17	9/25/2021	65531	oil	0		
BC17	9/26/2021	74414	oil	0		
BC17	9/27/2021	60855	oil	0		
BC17	9/29/2021	66913	oil	0		
BC17	10/9/2021	0		1338	brine	70
BC17	10/14/2021	5587	oil	0		
BC17	10/15/2021	21866	oil	0		
BC17	10/16/2021	81808	oil	0		
BC17	10/17/2021	90028	oil	0		
BC17	10/18/2021	89344	oil	0		
BC17	10/19/2021	22564	oil	0		
BC17	10/20/2021	5497	oil	0		
BC17	11/3/2021	68619	oil	0		
BC17	11/4/2021	58515	oil	0		
BC17	11/10/2021	83551	oil	0		
BC17	11/11/2021	42685	oil	0		
BC17	12/3/2021	77844	oil	77844	1	
BC17	12/4/2021	46066	oil	46066	1	
BC17	12/11/2021	34049	oil	37018	1	
BC17	12/12/2021	47294	oil	45200	1	
BC17	12/13/2021	92772	oil	93105	1	
BC17	12/14/2021	102862	oil	105660	1	
BC17	12/15/2021	105305	oil	109050	1	
BC17	12/16/2021	98154	oil	97500	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC17	12/17/2021	113865	oil	114150	1	
BC17	12/18/2021	12061	oil	15300	1	
BC17	12/19/2021	38818	oil	34500	1	
BC17	12/20/2021	118187	oil	123600	1	
BC17	12/21/2021	110381	oil	112888	1	
BC17	12/22/2021	90659	oil	101400	1	
BC17	12/23/2021	113531	oil	126064	1	
BC17	12/24/2021	116914	oil	120375	1	
BC17	12/25/2021	100384	oil	90510	1	
BC17	12/26/2021	95380	oil	94500	1	
BC17	12/27/2021	94658	oil	90650	1	
BC17	12/28/2021	91340	oil	99750	1	
BC17	12/29/2021	70488	oil	73500	1	
BC17	12/31/2021	30788	oil	30300	1	
BC18	1/15/2021	6954	brine	0		
BC18	1/16/2021	43746	oil	0		
BC18	1/17/2021	16170	oil	0		
BC18	1/21/2021	5958	oil	0		
BC18	1/22/2021	6228	oil	0		
BC18	1/23/2021	5605	oil	0		
BC18	1/24/2021	3396	oil	0		
BC18	1/25/2021	2064	oil	0		
BC18	1/26/2021	1470	oil	0		
BC18	1/27/2021	705	oil	0		
BC18	1/28/2021	970	oil	0		
BC18	1/29/2021	1692	oil	0		
BC18	1/30/2021	1032	oil	0		
BC18	1/31/2021	924	oil	0		
BC18	2/1/2021	1276	oil	0		
BC18	2/2/2021	1262	oil	0		
BC18	2/3/2021	233	oil	0		
BC18	2/4/2021	2048	oil	0		
BC18	2/5/2021	268	oil	0		
BC18	2/6/2021	563	oil	0		
BC18	2/7/2021	809	oil	0		
BC18	2/8/2021	1900	oil	0		
BC18	2/9/2021	3994	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC18	2/10/2021	2335	oil	0		
BC18	2/13/2021	909	oil	0		
BC18	2/21/2021	2112	oil	0		
BC18	2/22/2021	1328	oil	0		
BC18	3/2/2021	0		964	brine	
BC18	3/3/2021	0		17712	brine	60
BC18	3/4/2021	0		40597	brine	
BC18	4/22/2021	9259	oil	0		
BC18	4/23/2021	4169	brine	5014	1	75
BC18	4/24/2021	0		8478	1	75
BC18	4/28/2021	0		2101	brine	75
BC18	5/8/2021	0		54	oil	100
BC18	6/3/2021	1116	brine	0		
BC18	6/5/2021	0		1774	brine	100
BC18	6/7/2021	0		1361	brine	75
BC18	8/5/2021	3620	brine	0		
BC18	9/10/2021	81429	oil	0		
BC18	9/13/2021	0		186	oil	
BC18	9/14/2021	68388	oil	0		
BC18	9/15/2021	8881	oil	0		
BC18	10/9/2021	0		22323	brine	70
BC19	2/26/2021	8796	brine	0		
BC19	2/27/2021	28546	brine	28512	oil	100
BC19	2/28/2021	17867	brine	12919	oil	100
BC19	4/22/2021	1800	brine	3170	oil	100
BC19	4/23/2021	0		3078	1	70
BC19	4/29/2021	0		5502	brine	
BC19	4/30/2021	0		5024	brine	
BC19	7/16/2021	3211	brine	0		
BC19	8/11/2021	305	brine	0		
BC19	8/12/2021	41542	oil	41092	brine	
BC19	8/13/2021	10432	oil	8183	brine	
BC19	9/18/2021	74131	oil	0		
BC19	9/19/2021	19445	oil	0		
BC19	9/20/2021	91803	oil	0		
BC19	9/21/2021	115519	oil	0		
BC19	9/22/2021	78470	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC19	9/24/2021	25742	oil	0		
BC19	9/25/2021	66907	oil	0		
BC19	9/26/2021	71078	oil	0		
BC19	9/27/2021	60301	oil	0		
BC19	9/29/2021	67753	oil	0		
BC19	10/10/2021	0		7102	brine	70
BC19	10/11/2021	0		24504	brine	70
BC19	12/9/2021	39734	brine	0		
BC19	12/11/2021	7831	oil	4800	1	
BC19	12/12/2021	19867	oil	9600	1	
BC19	12/13/2021	30723	oil	36500	1	
BC19	12/14/2021	36077	oil	40000	1	
BC19	12/15/2021	38522	oil	42000	1	
BC19	12/16/2021	36632	oil	39000	1	
BC19	12/17/2021	41217	oil	44000	1	
BC19	12/18/2021	4580	oil	6000	1	
BC19	12/19/2021	16632	oil	12000	1	
BC19	12/20/2021	52825	oil	48000	1	
BC19	12/21/2021	49736	oil	43840	1	
BC19	12/22/2021	38917	oil	40000	1	
BC19	12/23/2021	28600	oil	48920	1	
BC19	12/24/2021	36448	oil	45000	1	
BC19	12/25/2021	30264	oil	34480	1	
BC19	12/26/2021	26760	oil	36000	1	
BC19	12/27/2021	27478	oil	34000	1	
BC19	12/28/2021	40094	oil	38000	1	
BC19	12/29/2021	28466	oil	28000	1	
BC19	12/31/2021	13299	oil	12000	1	
BC101	9/9/2021	128913	brine	0		
BC101	9/10/2021	15677	oil	0		
BC101	9/11/2021	44763	oil	0		
BC101	9/12/2021	100221	oil	0		
BC101	9/13/2021	119006	oil	0		
BC101	9/14/2021	27275	oil	0		
BC101	9/15/2021	21666	oil	0		
BC101	9/16/2021	125891	oil	0		
BC101	9/17/2021	22565	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC101	9/24/2021	9542	oil	0		
BC101	9/25/2021	65807	oil	0		
BC101	9/26/2021	73619	oil	0		
BC101	9/27/2021	60083	oil	0		
BC101	9/29/2021	68054	oil	0		
BC101	10/14/2021	0		10502	oil	
BC101	10/15/2021	0		21866	oil	
BC101	10/16/2021	0		81808	oil	
BC101	10/17/2021	0		90028	oil	
BC101	10/18/2021	0		89344	oil	
BC101	10/19/2021	0		22564	oil	
BC101	10/20/2021	0		59086	oil	
BC101	10/21/2021	0		18645	oil	
BC101	11/3/2021	64298	oil	0		
BC101	11/4/2021	58612	oil	0		
BC101	11/10/2021	81393	oil	0		
BC101	11/11/2021	42429	oil	0		
BC101	12/3/2021	79461	oil	79461	1	
BC101	12/4/2021	46667	oil	46667	1	
BC101	12/11/2021	36036	oil	33619	1	
BC101	12/12/2021	50421	oil	45200	1	
BC101	12/13/2021	93360	oil	90105	1	
BC101	12/14/2021	105157	oil	105660	1	
BC101	12/15/2021	105305	oil	109050	1	
BC101	12/16/2021	97812	oil	97500	1	
BC101	12/17/2021	116248	oil	114150	1	
BC101	12/18/2021	12061	oil	15300	1	
BC101	12/19/2021	39930	oil	34500	1	
BC101	12/20/2021	121272	oil	123600	1	
BC101	12/21/2021	113210	oil	112888	1	
BC101	12/22/2021	99541	oil	101400	1	
BC101	12/23/2021	117550	oil	126064	1	
BC101	12/24/2021	114360	oil	120375	1	
BC101	12/25/2021	101870	oil	90510	1	
BC101	12/26/2021	91191	oil	94500	1	
BC101	12/27/2021	87585	oil	90650	1	
BC101	12/28/2021	95512	oil	99750	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC101	12/29/2021	76094	oil	73500	1	
BC101	12/31/2021	30944	oil	30300	1	
BC102	1/15/2021	9362	brine	0		
BC102	1/16/2021	41643	brine	43746	oil	100
BC102	1/17/2021	15705	brine	16170	oil	100
BC102	1/21/2021	22156	brine	5958	oil	100
BC102	1/22/2021	9472	brine	6228	oil	100
BC102	1/23/2021	8804	brine	5605	oil	100
BC102	1/24/2021	5931	brine	3396	oil	100
BC102	1/25/2021	5931	brine	2064	oil	100
BC102	1/26/2021	2732	brine	1470	oil	100
BC102	1/27/2021	1240	brine	705	oil	100
BC102	1/28/2021	0		970	oil	100
BC102	1/29/2021	0		1692	oil	100
BC102	1/30/2021	0		1032	oil	100
BC102	1/31/2021	0		924	oil	100
BC102	2/1/2021	0		1276	oil	100
BC102	2/2/2021	0		1262	oil	100
BC102	2/3/2021	0		233	oil	100
BC102	2/4/2021	0		2048	oil	100
BC102	2/5/2021	0		268	oil	100
BC102	2/6/2021	0		563	oil	100
BC102	2/7/2021	0		809	oil	100
BC102	2/8/2021	0		1900	oil	100
BC102	2/9/2021	0		3994	oil	100
BC102	2/10/2021	0		2335	oil	100
BC102	2/13/2021	0		909	oil	100
BC102	2/21/2021	3740	brine	2112	oil	100
BC102	2/22/2021	1791	brine	1328	oil	100
BC102	4/22/2021	2018	oil	0		
BC102	4/23/2021	4109	brine	0		
BC102	4/27/2021	0		3394	1	75
BC102	4/30/2021	0		3521	brine	
BC102	6/3/2021	5170	brine	0		
BC102	6/5/2021	0		6393	brine	100
BC102	7/16/2021	5349	brine	3211	brine	
BC102	9/10/2021	83435	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BC102	9/14/2021	64884	oil	0		
BC102	9/15/2021	8606	oil	0		
BC102	10/9/2021	0		16893	brine	70
BH102	1/14/2021	3187	brine	0		
BH102	6/18/2021	2631	oil	308	brine	90
BH102	6/21/2021	3978	brine	0		
BH102	8/18/2021	8609	oil	4065	brine	97
BH102	8/19/2021	11141	oil	10530	brine	97
BH102	11/16/2021	24222	brine	0		
BH102	11/18/2021	2752	oil	0		
BH102	11/19/2021	7003	oil	0		
BH102	11/20/2021	7013	oil	0		
BH102	11/21/2021	6867	oil	0		
BH102	11/22/2021	6992	oil	0		
BH102	11/23/2021	6732	oil	0		
BH102	11/24/2021	6735	oil	0		
BH102	11/25/2021	6901	oil	0		
BH102	11/26/2021	4165	oil	0		
BH102	11/27/2021	6610	oil	0		
BH102	11/28/2021	7395	oil	0		
BH102	11/30/2021	7065	oil	0		
BH102	12/1/2021	6343	oil	0		
BH102	12/2/2021	4874	oil	0		
BH102	12/3/2021	2396	oil	0		
BH102	12/4/2021	2451	oil	0		
BH102	12/5/2021	2077	oil	0		
BH102	12/6/2021	266	oil	0		
BH102	12/8/2021	1746	oil	0		
BH102	12/9/2021	2065	oil	0		
BH102	12/10/2021	1820	oil	0		
BH102	12/11/2021	1122	oil	0		
BH102	12/12/2021	1710	oil	0		
BH102	12/13/2021	1384	oil	0		
BH102	12/14/2021	1592	oil	0		
BH102	12/15/2021	2288	oil	0		
BH102	12/16/2021	1034	oil	0		
BH102	12/17/2021	1226	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH102	12/18/2021	1092	oil	0		
BH102	12/19/2021	888	oil	0		
BH102	12/20/2021	1312	oil	0		
BH102	12/21/2021	322	oil	567	brine	105
BH106	5/11/2021	12685	brine	0		
BH106	5/24/2021	44295	oil	29904	1	78
BH106	5/25/2021	25052	oil	37514	1	86
BH106	6/27/2021	0		5576	1	84
BH106	6/29/2021	0		2059	1	88
BH106	9/27/2021	11371	brine	0		
BH106	10/3/2021	51740	oil	49605	1	84
BH106	10/4/2021	0		2040	1	84
BH106	10/10/2021	53369	oil	54781	1	95
BH106	10/11/2021	86252	oil	62641	1	84
BH106	10/12/2021	17699	oil	61435	1	84
BH106	10/13/2021	89225	oil	85652	1	84
BH106	10/14/2021	0		167	1	85
BH106	10/15/2021	66372	oil	60202	1	84
BH106	10/16/2021	0		11056	1	84
BH106	10/18/2021	53688	oil	57278	1	84
BH106	10/19/2021	82753	oil	78539	1	78
BH106	10/20/2021	42589	oil	52270	1	76
BH106	10/21/2021	113510	oil	110091	1	76
BH106	10/22/2021	0		18877	1	76
BH106	10/24/2021	107695	oil	95567	1	93
BH106	10/25/2021	22857	oil	44503	1	82
BH106	10/26/2021	71055	oil	60627	1	86
BH106	10/27/2021	33715	oil	46715	1	77
BH106	11/4/2021	78032	oil	71614	1	87
BH106	11/5/2021	24941	oil	26561	1	68
BH106	11/10/2021	75693	oil	79386	1	74
BH106	11/11/2021	24179	oil	28735	1	74
BH106	11/12/2021	75875	oil	78780	1	70
BH106	11/13/2021	22708	oil	24172	1	70
BH106	11/18/2021	72082	oil	78576	1	74
BH106	11/19/2021	24605	oil	27005	1	74
BH106	11/20/2021	75054	oil	80030	1	64

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH106	11/21/2021	70431	oil	76351	1	64
BH106	11/25/2021	50606	oil	53051	1	
BH106	11/27/2021	72329	oil	78321	1	
BH106	11/28/2021	70001	oil	74839	1	
BH106	12/1/2021	48648	oil	53472	1	
BH106	12/2/2021	58389	oil	62374	1	
BH106	12/3/2021	38481	oil	40954	1	
BH106	12/4/2021	47947	oil	52347	1	
BH106	12/6/2021	73952	oil	78923	1	
BH106	12/10/2021	49590	oil	52567	1.1	60
BH106	12/13/2021	72357	oil	78935	1.1	60
BH106	12/14/2021	0		27705	1	68
BH106	12/17/2021	0		6432	1	68
BH106	12/20/2021	2187	oil	0		
BH106	12/23/2021	0		4355	1	64
BH107	3/18/2021	726	brine	0		
BH107	4/4/2021	4290	brine	0		
BH107	4/5/2021	8514	brine	0		
BH107	4/6/2021	1174	oil	0		
BH107	4/7/2021	8579	oil	7144	1	78
BH107	4/8/2021	0		800	1	84
BH107	5/13/2021	74837	oil	48824	1	84
BH107	5/14/2021	18838	oil	36875	1	84
BH107	5/24/2021	45131	oil	28648	1	78
BH107	5/25/2021	25013	oil	42329	1	86
BH107	6/6/2021	71706	oil	61415	1	78
BH107	6/7/2021	0		13253	1	78
BH107	6/8/2021	70662	oil	57679	1	80
BH107	6/9/2021	0		14370	1	84
BH107	6/11/2021	49634	oil	35856	1	82
BH107	6/12/2021	13308	oil	13490	1	82
BH107	6/14/2021	0		6495	1	84
BH107	6/15/2021	71594	oil	66920	1	86
BH107	6/16/2021	0		17684	1	88
BH107	6/21/2021	0		1576	1	86
BH107	6/22/2021	71499	oil	54606	1	86
BH107	6/23/2021	14745	oil	35175	1	88

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH107	6/26/2021	44903	oil	45541	1	86
BH107	6/27/2021	0		4263	1	84
BH107	6/29/2021	0		5119	1	88
BH107	6/30/2021	0		716	1	86
BH107	7/14/2021	0		1040	1	88
BH107	9/27/2021	8452	brine	0		
BH107	10/3/2021	18400	oil	7978	1	84
BH107	10/4/2021	0		9263	1	84
BH107	10/10/2021	32139	oil	30929	1	95
BH107	10/11/2021	80080	oil	57956	1	84
BH107	10/12/2021	17459	oil	36453	1	84
BH107	10/13/2021	67046	oil	68493	1	84
BH107	10/14/2021	0		959	1	85
BH107	10/15/2021	57878	oil	49363	1	84
BH107	10/16/2021	0		8439	1	84
BH107	10/18/2021	43712	oil	45435	1	84
BH107	10/19/2021	70636	oil	49605	1	78
BH107	10/20/2021	34088	oil	43183	1	76
BH107	10/21/2021	89847	oil	86681	1	76
BH107	10/22/2021	0		14714	1	76
BH107	10/24/2021	87687	oil	73439	1	93
BH107	10/25/2021	18835	oil	36491	1	82
BH107	10/26/2021	58487	oil	46661	1	86
BH107	10/27/2021	27566	oil	37228	1	77
BH107	11/4/2021	59648	oil	59648	1	87
BH107	11/5/2021	20162	oil	20710	1	68
BH107	11/10/2021	62468	oil	62887	1	74
BH107	11/11/2021	19716	oil	22689	1	74
BH107	11/12/2021	61509	oil	61154	1	70
BH107	11/13/2021	18303	oil	18745	1	70
BH107	11/18/2021	59663	oil	61546	1	74
BH107	11/19/2021	20124	oil	21205	1	74
BH107	11/20/2021	61290	oil	62554	1	64
BH107	11/21/2021	57974	oil	59891	1	64
BH107	11/25/2021	40483	oil	40916	1	
BH107	11/27/2021	60538	oil	61900	1	
BH107	11/28/2021	57520	oil	18778	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH107	12/1/2021	40291	oil	41854	1	
BH107	12/2/2021	49501	oil	50547	1	
BH107	12/3/2021	30924	oil	32047	1	
BH107	12/4/2021	39522	oil	40874	1	
BH107	12/6/2021	59908	oil	60718	1	
BH107	12/10/2021	41718	oil	41711	1.1	60
BH107	12/13/2021	58220	oil	60490	1.1	60
BH107	12/14/2021	42631	brine	66756	oil	105
BH107	12/15/2021	33483	brine	33243	oil	105
BH107	12/17/2021	0		3234	1	68
BH107	12/18/2021	0		1386	1	68
BH107	12/23/2021	0		1320	1	64
BH108	1/1/2021	943	oil	0		
BH108	1/2/2021	763	oil	0		
BH108	1/3/2021	836	oil	0		
BH108	1/4/2021	704	oil	0		
BH108	1/5/2021	1484	oil	264	brine	95
BH108	1/6/2021	866	oil	0		
BH108	1/7/2021	796	oil	0		
BH108	1/8/2021	586	oil	0		
BH108	1/9/2021	958	oil	0		
BH108	1/10/2021	578	oil	0		
BH108	1/11/2021	1156	oil	132	brine	95
BH108	1/12/2021	1214	oil	132	brine	95
BH108	1/13/2021	1119	oil	198	brine	95
BH108	1/14/2021	630	oil	0		
BH108	1/26/2021	0		19341	1	84
BH108	1/27/2021	0		7878	1	76
BH108	3/18/2021	126	brine	0		
BH108	4/5/2021	5859	brine	0		
BH108	4/6/2021	3528	brine	0		
BH108	4/7/2021	58349	oil	55847	1	78
BH108	4/8/2021	0		93	1	84
BH108	4/9/2021	69047	oil	69434	1	78
BH108	4/13/2021	751	brine	0		
BH108	4/20/2021	66698	oil	61643	1	73
BH108	4/21/2021	32473	oil	40192	1	73

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH108	5/7/2021	48551	oil	49887	1	80
BH108	5/9/2021	75774	oil	71368	1	82
BH108	5/10/2021	88641	oil	98069	1	84
BH108	5/13/2021	75222	oil	71202	1	84
BH108	5/14/2021	18899	oil	26745	1	84
BH108	6/6/2021	76641	oil	77100	1	78
BH108	6/7/2021	0		4996	1	78
BH108	6/8/2021	79127	oil	64266	1	80
BH108	6/9/2021	0		14278	1	84
BH108	6/11/2021	64622	oil	55919	1	82
BH108	6/12/2021	20451	oil	20168	1	82
BH108	6/14/2021	0		3198	1	84
BH108	6/15/2021	78330	oil	80813	1	86
BH108	6/16/2021	0		10912	1	88
BH108	6/21/2021	0		2008	1	86
BH108	6/22/2021	89615	oil	78904	1	86
BH108	6/23/2021	21207	oil	35548	1	88
BH108	6/26/2021	55367	oil	56755	1	86
BH108	6/27/2021	0		1291	1	84
BH108	6/30/2021	0		4126	1	86
BH108	7/1/2021	0		3160	1	88
BH108	7/14/2021	0		1007	1	88
BH108	12/2/2021	756	brine	0		
BH108	12/6/2021	0		263	1	
BH108	12/21/2021	567	brine	0		
BH109	1/1/2021	0		5557	oil	95
BH109	1/2/2021	0		2646	oil	95
BH109	1/6/2021	0		1483	oil	95
BH109	1/7/2021	0		2954	oil	95
BH109	1/8/2021	0		1513	oil	95
BH109	1/14/2021	0		3497	oil	95
BH109	1/15/2021	0		15737	oil	95
BH109	1/16/2021	0		758	oil	95
BH109	1/28/2021	0		2677	1	66
BH109	4/5/2021	14190	brine	0		
BH109	4/7/2021	49863	oil	34549	1	78
BH109	4/8/2021	0		16228	1	84

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH109	4/9/2021	68289	oil	64224	1	78
BH109	4/10/2021	0		7403	1	78
BH109	4/20/2021	66675	oil	45354	1	73
BH109	4/21/2021	25473	oil	49969	1	73
BH109	5/7/2021	48321	oil	49160	1	80
BH109	5/8/2021	0		1876	1	80
BH109	5/9/2021	72373	oil	50977	1	82
BH109	5/10/2021	63347	oil	79235	1	84
BH109	5/11/2021	0		12418	1	84
BH109	5/12/2021	0		9637	brine	93
BH109	5/17/2021	0		2244	1	68
BH109	6/21/2021	403	brine	0		
BH109	9/29/2021	14636	brine	0		
BH109	9/30/2021	8466	brine	0		
BH109	10/1/2021	501	oil	0		
BH109	10/2/2021	0		14241	1	95
BH110	4/5/2021	13266	brine	0		
BH110	4/6/2021	1452	brine	1174	oil	95
BH110	4/7/2021	59633	oil	58679	1	78
BH110	4/9/2021	75268	oil	76621	1	78
BH110	4/20/2021	68579	oil	61810	1	73
BH110	4/21/2021	32871	oil	40825	1	73
BH110	5/7/2021	47303	oil	49709	1	80
BH110	5/9/2021	76258	oil	67530	1	82
BH110	5/10/2021	88666	oil	98670	1	84
BH110	5/11/2021	0		520	1	84
BH110	5/13/2021	74742	oil	66945	1	84
BH110	5/14/2021	18192	oil	27679	1	84
BH110	5/24/2021	45106	oil	39351	1	78
BH110	5/25/2021	25010	oil	33254	1	86
BH110	6/6/2021	72815	oil	72815	1	78
BH110	6/7/2021	0		7037	1	78
BH110	6/8/2021	79237	oil	61752	1	80
BH110	6/9/2021	0		13775	1	84
BH110	6/11/2021	64105	oil	51535	1	82
BH110	6/12/2021	20435	oil	19201	1	82
BH110	6/14/2021	0		5479	1	84

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH110	6/15/2021	77061	oil	68742	1	86
BH110	6/16/2021	0		16992	1	88
BH110	6/21/2021	0		2306	1	86
BH110	6/22/2021	90436	oil	76214	1	95
BH110	6/23/2021	21532	oil	38196	1	88
BH110	6/26/2021	58354	oil	61314	1	86
BH110	6/27/2021	0		498	1	84
BH110	6/30/2021	0		6866	1	86
BH110	7/14/2021	0		1095	1	88
BH110	7/15/2021	0		93	1	88
BH110	9/28/2021	8944	brine	0		
BH110	10/3/2021	49750	oil	48192	1	84
BH110	10/10/2021	57532	oil	56690	1	95
BH110	10/11/2021	93752	oil	69801	1	84
BH110	10/12/2021	22534	oil	37429	1	84
BH110	10/13/2021	80785	oil	82048	1	84
BH110	10/15/2021	65465	oil	63859	1	84
BH110	10/16/2021	0		1982	1	84
BH110	10/18/2021	57754	oil	59807	1	84
BH110	10/19/2021	88927	oil	69805	1	78
BH110	10/20/2021	44382	oil	47147	1	76
BH110	10/21/2021	137204	oil	133159	1	76
BH110	10/22/2021	0		14053	1	76
BH110	10/24/2021	123303	oil	106125	1	93
BH110	10/25/2021	27218	oil	43878	1	82
BH110	10/26/2021	82783	oil	71523	1	86
BH110	10/27/2021	44335	oil	52269	1	77
BH110	11/4/2021	101871	oil	93492	1	87
BH110	11/5/2021	34884	oil	34444	1	68
BH110	11/10/2021	94351	oil	96083	1	74
BH110	11/11/2021	33782	oil	35928	1	74
BH110	11/12/2021	104934	oil	103867	1	70
BH110	11/13/2021	31301	oil	31505	1	70
BH110	11/18/2021	103541	oil	105015	1	74
BH110	11/19/2021	35545	oil	36103	1	74
BH110	11/20/2021	107345	oil	108302	1	64
BH110	11/21/2021	101150	oil	103002	1	88

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH110	11/25/2021	67172	oil	69092	1	
BH110	11/27/2021	107311	oil	107627	1	
BH110	11/28/2021	99875	oil	100875	1	
BH110	12/1/2021	76174	brine	72797	1	
BH110	12/2/2021	80251	oil	80308	1	
BH110	12/3/2021	55481	oil	55982	1	
BH110	12/4/2021	69127	oil	69613	1	
BH110	12/6/2021	105976	oil	107541	1	
BH110	12/10/2021	66123	oil	68236	1.1	60
BH110	12/13/2021	103816	oil	106510	1.1	60
BH110	12/14/2021	0		18592	1	68
BH110	12/18/2021	0		10692	1	68
BH110	12/23/2021	0		2376	1	64
BH110	12/30/2021	0		1305	1	74
BH111	4/5/2021	13455	brine	0		
BH111	4/7/2021	72051	oil	48013	1	78
BH111	4/8/2021	0		13011	1	84
BH111	4/9/2021	85215	oil	64631	1	78
BH111	4/10/2021	0		11952	1	78
BH111	4/20/2021	80700	oil	46479	1	73
BH111	4/21/2021	23958	oil	50316	1	73
BH111	4/29/2021	488	oil	0		
BH111	5/7/2021	60020	oil	51539	1	80
BH111	5/8/2021	0		7394	1	80
BH111	5/9/2021	89498	oil	59924	1	82
BH111	5/10/2021	90229	oil	99676	1	84
BH111	5/11/2021	0		12202	1	84
BH111	5/13/2021	98010	oil	59154	1	84
BH111	5/14/2021	18783	oil	48683	1	84
BH111	5/24/2021	59868	oil	31018	1	78
BH111	5/25/2021	29405	oil	54890	1	86
BH111	6/6/2021	73541	oil	57918	1	78
BH111	6/7/2021	0		14485	1	78
BH111	6/8/2021	74796	oil	54986	1	80
BH111	6/9/2021	0		16403	1	84
BH111	6/11/2021	50046	oil	31853	1	82
BH111	6/12/2021	14157	oil	12363	1	82

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH111	6/14/2021	0		7321	1	84
BH111	6/15/2021	71297	oil	61585	1	86
BH111	6/16/2021	0		19180	1	88
BH111	6/21/2021	0		1722	1	86
BH111	6/22/2021	72048	oil	48996	1	95
BH111	6/23/2021	14628	oil	34673	1	88
BH111	6/26/2021	44684	oil	40868	1	86
BH111	6/27/2021	0		5284	1	84
BH111	7/1/2021	0		6705	1	88
BH111	7/15/2021	0		594	1	88
BH111	9/28/2021	8629	brine	0		
BH111	10/3/2021	48586	oil	31380	1	84
BH111	10/4/2021	0		12263	1	84
BH111	10/10/2021	47119	oil	41940	1	95
BH111	10/11/2021	79407	oil	54497	1	84
BH111	10/12/2021	17430	oil	35937	1	84
BH111	10/13/2021	67160	oil	62968	1	84
BH111	10/14/2021	0		971	1	85
BH111	10/15/2021	57740	oil	46017	1	84
BH111	10/16/2021	0		8040	1	84
BH111	10/18/2021	43909	oil	42690	1	84
BH111	10/19/2021	69132	oil	54624	1	78
BH111	10/20/2021	32803	oil	39071	1	76
BH111	10/21/2021	84740	oil	76286	1	76
BH111	10/22/2021	0		12968	1	76
BH111	10/24/2021	88106	oil	67482	1	93
BH111	10/25/2021	18996	oil	35450	1	82
BH111	10/26/2021	51156	oil	37749	1	86
BH111	10/27/2021	25807	oil	31165	1	77
BH111	11/4/2021	54128	oil	49676	1	87
BH111	11/5/2021	22171	oil	19640	1	68
BH111	11/10/2021	66800	oil	62238	1	74
BH111	11/11/2021	19757	oil	22223	1	74
BH111	11/12/2021	62946	oil	58851	1	70
BH111	11/13/2021	18437	oil	17767	1	70
BH111	11/18/2021	60873	oil	58589	1	74
BH111	11/19/2021	20788	oil	20039	1	74

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH111	11/20/2021	62443	oil	59732	1	64
BH111	11/21/2021	58958	oil	56885	1	88
BH111	11/25/2021	40586	oil	38859	1	
BH111	11/27/2021	66538	oil	61801	1	
BH111	11/28/2021	61607	oil	118551	1	
BH111	12/1/2021	41116	oil	41169	1	
BH111	12/2/2021	49407	oil	46709	1	
BH111	12/3/2021	34258	oil	32368	1	
BH111	12/4/2021	41705	oil	41705	1	
BH111	12/6/2021	64528	oil	61044	1	
BH111	12/10/2021	40900	oil	40186	1.1	60
BH111	12/13/2021	62362	oil	60561	1.1	60
BH111	12/14/2021	0		21417	1	68
BH111	12/18/2021	0		7590	1	68
BH111	12/19/2021	0		1242	1	68
BH111	12/26/2021	0		1291	1	70
BH112	1/15/2021	22753	brine	0		
BH112	1/16/2021	758	oil	787	brine	80
BH112	5/26/2021	5599	brine	0		
BH112	9/29/2021	20570	brine	0		
BH112	9/30/2021	52023	oil	0		
BH112	10/7/2021	6925	oil	0		
BH112	10/8/2021	5563	oil	0		
BH112	10/14/2021	6016	oil	0		
BH112	10/27/2021	3087	oil	0		
BH112	10/28/2021	5093	oil	0		
BH112	10/31/2021	2659	oil	0		
BH112	11/5/2021	2860	oil	0		
BH112	11/6/2021	2732	oil	0		
BH112	11/7/2021	4544	oil	0		
BH112	11/8/2021	5271	oil	0		
BH112	11/9/2021	2503	oil	0		
BH112	11/10/2021	1928	oil	0		
BH112	11/11/2021	1493	oil	0		
BH112	11/12/2021	1308	oil	0		
BH112	11/13/2021	1257	oil	0		
BH112	11/14/2021	1131	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH112	11/15/2021	1100	oil	0		
BH112	11/16/2021	1018	oil	0		
BH112	11/17/2021	939	oil	0		
BH112	11/18/2021	898	oil	0		
BH112	11/19/2021	678	oil	0		
BH112	11/20/2021	1283	oil	0		
BH112	11/21/2021	606	oil	0		
BH112	11/22/2021	1480	oil	552	brine	105
BH112	11/23/2021	638	oil	0		
BH112	11/24/2021	699	oil	0		
BH112	11/25/2021	1183	oil	0		
BH112	11/26/2021	607	oil	0		
BH112	11/27/2021	820	oil	0		
BH112	11/28/2021	805	oil	0		
BH112	11/30/2021	1126	oil	0		
BH112	12/1/2021	664	oil	0		
BH112	12/2/2021	1005	oil	0		
BH112	12/9/2021	0		6981	brine	90
BH112	12/10/2021	0		16368	brine	60
BH112	12/13/2021	0		27738	1.1	60
BH112	12/14/2021	66756	oil	39052	1	68
BH112	12/15/2021	33243	oil	27948	1	68
BH112	12/19/2021	0		4554	1	68
BH113	2/22/2021	1448	oil	0		
BH113	2/24/2021	178	oil	0		
BH113	3/3/2021	157	oil	0		
BH113	5/24/2021	12379	brine	0		
BH113	6/27/2021	0		5304	1	84
BH113	6/30/2021	0		499	1	86
BH113	9/28/2021	12914	brine	0		
BH113	10/3/2021	32069	oil	25413	1	84
BH113	10/7/2021	12876	brine	0		
BH113	10/8/2021	8499	brine	7106	oil	95
BH113	10/9/2021	6141	brine	3615	oil	95
BH113	10/10/2021	9171	oil	15564	1	95
BH113	10/13/2021	155	oil	0		
BH113	10/14/2021	8641	brine	7460	oil	95

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BH113	10/27/2021	12325	brine	0		
BH113	10/28/2021	8536	brine	8483	oil	100
BH113	11/6/2021	7475	brine	4966	oil	100
BH113	11/7/2021	9336	brine	8800	oil	100
BH113	11/9/2021	9061	brine	7966	oil	100
BH113	11/17/2021	14767	brine	9799	oil	95
BH113	11/26/2021	0		8869	oil	
BH113	12/8/2021	11855	brine	5895	oil	70
BH113	12/14/2021	0		14639	1	68
BM102	4/2/2021	5603	oil	177	1	60
BM102	4/5/2021	50218	oil	48667	1	63
BM102	4/6/2021	13766	oil	14510	1	63
BM102	4/11/2021	26071	oil	26410	1	66
BM102	4/19/2021	41607	oil	45210	1	69
BM102	4/20/2021	20297	oil	21644	1	69
BM102	4/24/2021	55893	oil	60327	1	69
BM102	4/25/2021	2449	oil	1990	1	69
BM102	4/27/2021	20202	oil	21252	1	76
BM102	4/28/2021	98213	oil	102247	1.1	70
BM102	4/29/2021	21178	oil	21836	1.1	70
BM102	5/1/2021	12722	oil	13776	1.1	70
BM102	5/2/2021	51048	oil	53728	1.1	70
BM102	5/3/2021	36751	oil	38332	1.1	70
BM102	5/4/2021	92882	oil	96081	1.1	70
BM102	5/5/2021	49	oil	67	1.1	75
BM102	5/6/2021	45745	oil	48492	1.1	75
BM102	5/9/2021	48165	oil	50800	1.1	75
BM102	5/10/2021	75939	oil	78294	1	79
BM102	5/14/2021	65249	oil	69755	1	78
BM102	5/15/2021	2604	oil	2524	1	78
BM102	5/19/2021	14515	oil	17658	1	73
BM102	5/20/2021	42761	oil	43924	1	72
BM102	6/1/2021	50144	oil	50846	1	78
BM102	6/16/2021	48510	oil	54354	1	80
BM102	6/23/2021	42079	oil	42214	1	80
BM102	6/24/2021	77511	oil	79914	1	82
BM102	6/25/2021	43752	oil	44573	1	82

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM102	6/26/2021	81033	oil	83492	1	83
BM102	7/27/2021	653	brine	0		
BM102	9/10/2021	33278	oil	0		
BM102	9/11/2021	11970	oil	0		
BM102	9/12/2021	1010	oil	0		
BM102	9/13/2021	360	oil	0		
BM102	9/14/2021	794	oil	0		
BM102	9/15/2021	504	oil	0		
BM102	9/17/2021	1226	oil	0		
BM102	9/18/2021	577	oil	0		
BM102	9/19/2021	577	oil	0		
BM102	9/20/2021	361	oil	0		
BM102	9/21/2021	360	oil	0		
BM102	9/22/2021	144	oil	0		
BM102	9/23/2021	360	oil	0		
BM102	9/24/2021	73	oil	0		
BM102	9/25/2021	144	oil	0		
BM102	9/26/2021	216	oil	0		
BM102	9/27/2021	289	oil	0		
BM102	9/28/2021	216	oil	0		
BM102	9/29/2021	649	oil	0		
BM102	9/30/2021	216	oil	679	brine	
BM102	10/1/2021	866	oil	0		
BM102	10/2/2021	72	oil	0		
BM102	10/6/2021	288	oil	0		
BM102	10/7/2021	865	oil	0		
BM102	10/8/2021	217	oil	0		
BM102	10/9/2021	504	oil	0		
BM102	10/11/2021	794	oil	0		
BM102	10/12/2021	288	oil	630	brine	
BM102	10/13/2021	0		17834	oil	
BM102	10/14/2021	0		18677	oil	
BM102	10/28/2021	0		605	1	89
BM102	11/3/2021	0		1579	brine	
BM102	12/27/2021	5329	brine	0		
BM103	3/10/2021	22	brine	0		
BM103	3/21/2021	29	brine	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM103	4/2/2021	35272	oil	27958	1	60
BM103	4/3/2021	83184	oil	86128	1	62
BM103	4/11/2021	37261	oil	40809	1	66
BM103	4/12/2021	31342	oil	32946	1	66
BM103	6/3/2021	54236	oil	55835	1	78
BM103	6/4/2021	9247	oil	9487	1	78
BM103	6/6/2021	50349	oil	53147	1	77
BM103	6/23/2021	42921	oil	44957	1	80
BM103	6/24/2021	83747	oil	86775	1	82
BM103	6/25/2021	42918	oil	44302	1	82
BM103	6/26/2021	80139	oil	82980	1	83
BM103	7/15/2021	27043	brine	26535	oil	
BM103	7/16/2021	9871	brine	9785	oil	
BM103	8/5/2021	14400	brine	13412	oil	
BM103	8/6/2021	35976	brine	36776	oil	
BM103	9/9/2021	14556	brine	14566	oil	
BM103	9/10/2021	7919	brine	8508	oil	
BM103	9/30/2021	679	brine	0		
BM103	10/3/2021	1634	brine	0		
BM103	10/4/2021	41749	oil	45442	1	71
BM103	10/5/2021	32235	oil	33146	1	
BM103	10/8/2021	44769	oil	45411	1	63
BM103	10/9/2021	29452	oil	30602	1	63
BM103	10/10/2021	67319	oil	69895	1	64
BM103	10/12/2021	34240	oil	35363	1	94
BM103	10/13/2021	30437	oil	31883	1	94
BM103	10/14/2021	24765	brine	24444	oil	
BM103	10/15/2021	25368	brine	26530	oil	
BM103	10/17/2021	68536	oil	72135	1	90
BM103	10/23/2021	39908	oil	41317	1	90
BM103	10/24/2021	23798	oil	25305	1	90
BM103	10/27/2021	37334	oil	39019	1	90
BM103	10/28/2021	79435	oil	82145	1	89
BM103	10/29/2021	23860	oil	25520	1	82
BM103	10/30/2021	95388	oil	98155	1	82
BM103	10/31/2021	61607	oil	64018	1	86
BM103	11/1/2021	115	oil	179	1	82

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM103	11/2/2021	41258	oil	43933	1	89
BM103	11/3/2021	23681	oil	24568	1	88
BM103	11/5/2021	61751	oil	64582	1	85
BM103	11/6/2021	886	oil	996	1	85
BM103	11/8/2021	29749	oil	32162	1	84
BM103	11/9/2021	36458	oil	137951	1	85
BM103	11/12/2021	56153	oil	59108	1	83
BM103	11/13/2021	13960	oil	13698	1	83
BM103	11/16/2021	62614	oil	66316	1	85
BM103	11/17/2021	4985	oil	5041	1	85
BM103	11/20/2021	36328	oil	39548	1	82
BM103	11/21/2021	28368	oil	28000	1	85
BM103	12/6/2021	49801	oil	53605	1	84
BM103	12/7/2021	29039	oil	29366	1	85
BM103	12/10/2021	66432	oil	68493	1	85
BM103	12/14/2021	40414	oil	42252	1	85
BM103	12/15/2021	17347	oil	18050	1	85
BM103	12/22/2021	26473	brine	25700	oil	
BM103	12/28/2021	9064	brine	8734	oil	
BM104	4/2/2021	50976	oil	54824	1	60
BM104	4/3/2021	94823	oil	102328	1	62
BM104	4/5/2021	41177	oil	47090	1	63
BM104	4/6/2021	18731	oil	20241	1	63
BM104	4/11/2021	35296	oil	38713	1	66
BM104	4/12/2021	22545	oil	24969	1	66
BM104	4/19/2021	41219	oil	44825	1	69
BM104	4/20/2021	18963	oil	20746	1	69
BM104	4/24/2021	60949	oil	67172	1	69
BM104	4/25/2021	2966	oil	2223	1	69
BM104	4/27/2021	14177	oil	15990	1	76
BM104	4/28/2021	81456	oil	87482	1.1	70
BM104	4/29/2021	21668	oil	22530	1.1	70
BM104	5/1/2021	12637	oil	14021	1.1	70
BM104	5/2/2021	46041	oil	49463	1.1	70
BM104	5/3/2021	36383	oil	38918	1.1	70
BM104	5/4/2021	94936	oil	100441	1.1	70
BM104	5/6/2021	44207	oil	48084	1.1	75

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM104	5/9/2021	50608	oil	55161	1.1	75
BM104	5/10/2021	76710	oil	83167	1	79
BM104	5/14/2021	55721	oil	62169	1	78
BM104	5/15/2021	2432	oil	2438	1	78
BM104	5/19/2021	13230	oil	17615	1	73
BM104	5/20/2021	51673	oil	55149	1	72
BM104	6/1/2021	51301	oil	53730	1	78
BM104	6/3/2021	43595	oil	48467	1	78
BM104	6/4/2021	8490	oil	9156	1	78
BM104	6/6/2021	48767	oil	53684	1	77
BM104	6/16/2021	49043	oil	55964	1	80
BM104	7/13/2021	720	brine	0		
BM104	7/27/2021	613	brine	0		
BM104	12/21/2021	4325	oil	0		
BM109	2/22/2021	6488	oil	0		
BM109	6/17/2021	24560	oil	0		
BM109	6/18/2021	39733	oil	0		
BM109	6/19/2021	6706	oil	0		
BM109	6/20/2021	3462	oil	0		
BM109	6/22/2021	3677	oil	0		
BM109	6/23/2021	1947	oil	0		
BM109	6/24/2021	1571	oil	0		
BM109	6/25/2021	1298	oil	0		
BM109	6/27/2021	2452	oil	0		
BM109	6/28/2021	1659	oil	0		
BM109	6/29/2021	1298	oil	387	brine	
BM109	6/30/2021	1081	oil	126	brine	
BM109	7/1/2021	1082	oil	510	brine	
BM109	7/2/2021	1009	oil	0		
BM109	7/3/2021	794	oil	0		
BM109	7/4/2021	793	oil	0		
BM109	7/5/2021	793	oil	0		
BM109	7/6/2021	289	oil	0		
BM109	7/7/2021	1081	oil	971	brine	
BM109	7/8/2021	1731	oil	480	brine	
BM109	7/9/2021	72	oil	0		
BM109	7/10/2021	577	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM109	7/11/2021	721	oil	0		
BM109	7/12/2021	1298	oil	960	brine	
BM109	7/13/2021	793	oil	720	brine	
BM109	7/14/2021	694	oil	26699	brine	
BM109	7/15/2021	0		26096	oil	
BM109	8/3/2021	0		5027	brine	
BM109	10/3/2021	2155	brine	0		
BM109	10/4/2021	39614	oil	44432	1	71
BM109	10/5/2021	30859	oil	33801	1	69
BM109	10/8/2021	43968	oil	45423	1	63
BM109	10/9/2021	29202	oil	31698	1	63
BM109	10/10/2021	59707	oil	65397	1	64
BM109	10/12/2021	29308	oil	32052	1	94
BM109	10/13/2021	27626	oil	30589	1	94
BM109	10/17/2021	58057	oil	63028	1	90
BM109	10/23/2021	38153	oil	41753	1	90
BM109	10/24/2021	23220	oil	24965	1	90
BM109	10/27/2021	42880	oil	47945	1	90
BM109	10/28/2021	90590	oil	96334	1	89
BM109	10/29/2021	23077	oil	25815	1	82
BM109	10/30/2021	107814	oil	116502	1	82
BM109	10/31/2021	59194	oil	64881	1	86
BM109	11/1/2021	890	oil	882	1	82
BM109	11/2/2021	38249	oil	41915	1	89
BM109	11/3/2021	21920	oil	23780	1	88
BM109	11/5/2021	63203	oil	69086	1	85
BM109	11/6/2021	1060	oil	1356	1	85
BM109	11/8/2021	26815	oil	29949	1	84
BM109	11/9/2021	33384	oil	35935	1	85
BM109	11/12/2021	42775	oil	46823	1	83
BM109	11/13/2021	11171	oil	11240	1	83
BM109	11/16/2021	49981	oil	55103	1	
BM109	11/17/2021	3959	oil	4357	1	85
BM109	11/20/2021	34067	oil	38977	1	82
BM109	11/21/2021	24933	oil	24958	1	85
BM109	12/6/2021	47637	oil	52627	1	84
BM109	12/7/2021	23161	oil	23815	1	85

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM109	12/10/2021	56245	oil	60838	1	85
BM109	12/14/2021	32925	oil	36284	1	85
BM109	12/15/2021	14311	oil	15937	1	85
BM109	12/21/2021	2452	oil	0		
BM110	2/5/2021	100	brine	0		
BM110	2/8/2021	273	brine	0		
BM110	2/9/2021	677	brine	0		
BM110	2/10/2021	192	brine	0		
BM110	4/2/2021	47960	oil	41421	1	60
BM110	4/3/2021	90513	oil	92708	1	62
BM110	4/5/2021	44080	oil	49234	1	63
BM110	4/6/2021	15294	oil	15482	1	63
BM110	4/11/2021	10155	oil	11882	1	66
BM110	4/12/2021	23620	oil	25389	1	66
BM110	4/19/2021	43440	oil	44028	1	69
BM110	4/20/2021	21011	oil	21897	1	69
BM110	4/24/2021	60220	oil	64116	1	69
BM110	4/25/2021	3058	oil	2131	1	69
BM110	4/27/2021	20500	oil	21646	1	76
BM110	4/28/2021	101719	oil	104365	1.1	70
BM110	4/29/2021	22903	oil	22850	1.1	70
BM110	5/1/2021	11822	oil	13184	1.1	70
BM110	5/2/2021	47213	oil	48319	1.1	70
BM110	5/3/2021	40425	oil	41997	1.1	70
BM110	5/4/2021	102391	oil	105129	1.1	70
BM110	5/5/2021	41	oil	71	1.1	75
BM110	5/6/2021	53157	oil	55227	1.1	75
BM110	5/9/2021	48102	oil	49536	1.1	75
BM110	5/10/2021	73620	oil	79724	1	79
BM110	5/14/2021	58342	oil	62181	1	78
BM110	5/15/2021	2374	oil	2179	1	78
BM110	5/19/2021	13675	oil	16929	1	73
BM110	5/20/2021	50663	oil	51452	1	72
BM110	6/1/2021	48497	oil	48432	1	78
BM110	6/3/2021	53546	oil	55879	1	78
BM110	6/4/2021	9316	oil	10060	1	78
BM110	6/6/2021	51742	oil	54227	1	77

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM110	6/16/2021	49474	oil	53339	1	80
BM110	6/23/2021	42448	oil	43210	1	80
BM110	6/24/2021	81078	oil	83424	1	82
BM110	6/25/2021	42820	oil	44194	1	82
BM110	6/26/2021	79572	oil	82481	1	83
BM110	7/27/2021	619	brine	0		
BM110	8/10/2021	19805	oil	0		
BM110	8/11/2021	25009	oil	0		
BM110	8/12/2021	3101	oil	0		
BM110	8/13/2021	1226	oil	0		
BM110	8/15/2021	1298	oil	0		
BM110	8/16/2021	360	oil	0		
BM110	8/17/2021	433	oil	0		
BM110	8/18/2021	361	oil	0		
BM110	8/19/2021	216	oil	0		
BM110	8/20/2021	577	oil	0		
BM110	8/21/2021	288	oil	0		
BM110	8/22/2021	361	oil	0		
BM110	8/23/2021	649	oil	0		
BM110	8/24/2021	432	oil	0		
BM110	8/25/2021	577	oil	577	brine	
BM110	8/26/2021	433	oil	213	brine	
BM110	8/27/2021	360	oil	0		
BM110	8/28/2021	289	oil	0		
BM110	8/29/2021	288	oil	0		
BM110	8/30/2021	73	oil	0		
BM110	8/31/2021	360	oil	0		
BM110	9/1/2021	433	oil	0		
BM110	9/2/2021	72	oil	0		
BM110	9/3/2021	72	oil	0		
BM110	9/4/2021	72	oil	0		
BM110	9/5/2021	216	oil	0		
BM110	9/6/2021	145	oil	0		
BM110	9/7/2021	937	oil	0		
BM110	9/8/2021	144	oil	86	brine	
BM110	9/9/2021	649	oil	473	brine	
BM110	9/10/2021	0		20090	oil	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM110	9/22/2021	0		22498	oil	
BM110	10/3/2021	1539	brine	0		
BM110	10/4/2021	42626	oil	45381	1	71
BM110	10/5/2021	33492	oil	34362	1	69
BM110	10/8/2021	45241	oil	45146	1	63
BM110	10/9/2021	30122	oil	30023	1	63
BM110	10/10/2021	62708	oil	64793	1	64
BM110	10/12/2021	31537	oil	33053	1	94
BM110	10/13/2021	28756	oil	29843	1	94
BM110	10/17/2021	55827	oil	58827	1	90
BM110	10/23/2021	39012	oil	40916	1	90
BM110	10/24/2021	23988	oil	24694	1	90
BM110	10/27/2021	43033	oil	46965	oil	
BM110	10/28/2021	90233	oil	97711	1	89
BM110	10/29/2021	23229	oil	25463	1	82
BM110	10/30/2021	90137	oil	92291	1	82
BM110	10/31/2021	59508	oil	60619	1	86
BM110	11/1/2021	385	oil	787	1	82
BM110	11/2/2021	38887	oil	40718	1	89
BM110	11/3/2021	22787	oil	24084	1	88
BM110	11/5/2021	59533	oil	62020	1	85
BM110	11/6/2021	954	oil	1241	1	85
BM110	11/8/2021	27912	oil	29699	1	84
BM110	11/9/2021	31430	oil	32200	1	85
BM110	11/12/2021	42960	oil	44898	1	83
BM110	11/13/2021	11328	oil	11173	1	83
BM110	11/16/2021	51891	oil	54535	1	85
BM110	11/17/2021	4392	oil	4626	1	85
BM110	11/20/2021	32989	oil	35396	1	82
BM110	11/21/2021	28980	oil	28581	1	85
BM110	12/6/2021	47076	oil	50248	1	84
BM110	12/7/2021	22724	oil	21859	1	85
BM110	12/10/2021	58114	oil	60398	1	85
BM110	12/14/2021	30562	oil	32165	1	85
BM110	12/15/2021	13369	oil	14121	1	85
BM110	12/21/2021	1992	oil	0		
BM111	1/4/2021	42	brine	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM111	1/5/2021	41	brine	0		
BM111	1/13/2021	82	brine	0		
BM111	1/17/2021	18744	oil	22141	1	
BM111	2/3/2021	0		437	oil	
BM111	2/4/2021	0		246	oil	
BM111	3/25/2021	9610	brine	0		
BM111	3/26/2021	5695	brine	9805	oil	
BM111	3/27/2021	28397	brine	30711	oil	
BM111	4/1/2021	29	brine	0		
BM111	4/2/2021	52891	oil	55080	1	60
BM111	4/3/2021	90756	oil	99185	1	62
BM111	4/5/2021	43566	oil	51807	1	63
BM111	4/6/2021	19371	oil	21657	1	63
BM111	4/11/2021	38902	oil	44606	1	66
BM111	4/12/2021	22772	oil	26065	1	66
BM111	4/19/2021	39483	oil	45286	1	69
BM111	4/20/2021	20441	oil	24208	1	69
BM111	4/24/2021	58161	oil	65408	1	69
BM111	4/25/2021	2915	oil	2117	1	69
BM111	4/27/2021	20670	oil	24776	1	76
BM111	4/28/2021	95935	oil	106428	1.1	70
BM111	4/29/2021	22367	oil	24397	1.1	70
BM111	5/1/2021	13193	oil	15322	1.1	70
BM111	5/2/2021	51437	oil	57413	1.1	70
BM111	5/3/2021	38051	oil	42500	1.1	70
BM111	5/4/2021	99644	oil	109401	1.1	70
BM111	5/5/2021	40	oil	88	1.1	75
BM111	5/6/2021	54578	oil	61973	1.1	75
BM111	5/9/2021	46616	oil	52014	1.1	75
BM111	5/10/2021	74057	oil	74770	1	79
BM111	5/12/2021	20596	brine	22715	oil	84
BM111	5/13/2021	15624	brine	16729	oil	
BM111	5/14/2021	57539	oil	64832	1	78
BM111	5/15/2021	2116	oil	2495	1	78
BM111	5/19/2021	14815	oil	19440	1	73
BM111	5/20/2021	44848	oil	50841	1	72
BM111	6/1/2021	46937	oil	50196	1	78

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM111	6/3/2021	60856	oil	68573	1	78
BM111	6/4/2021	10092	oil	11311	1	78
BM111	6/6/2021	48408	oil	55469	1	77
BM111	6/16/2021	49628	oil	57971	1	80
BM111	6/18/2021	9118	brine	5409	oil	
BM111	6/19/2021	43917	brine	47232	oil	
BM111	6/23/2021	44680	oil	51556	1	80
BM111	6/24/2021	82819	oil	91707	1	82
BM111	6/25/2021	44653	oil	49464	1	82
BM111	6/26/2021	84055	oil	93633	1	83
BM111	7/14/2021	18971	oil	0		
BM111	7/15/2021	858	oil	0		
BM111	7/16/2021	41243	oil	0		
BM111	7/18/2021	3317	oil	0		
BM111	7/20/2021	4615	oil	0		
BM111	7/21/2021	1947	oil	0		
BM111	7/22/2021	2524	oil	480	brine	
BM111	7/23/2021	1226	oil	0		
BM111	7/24/2021	1154	oil	0		
BM111	7/25/2021	1370	oil	0		
BM111	7/26/2021	2524	oil	0		
BM111	7/27/2021	1443	oil	95	brine	
BM111	7/28/2021	1081	oil	190	brine	
BM111	7/29/2021	938	oil	0		
BM111	7/30/2021	865	oil	0		
BM111	7/31/2021	865	oil	0		
BM111	8/1/2021	433	oil	0		
BM111	8/2/2021	1226	oil	90	brine	
BM111	8/3/2021	1009	oil	426	brine	
BM111	8/4/2021	1082	oil	426	brine	
BM111	8/5/2021	865	oil	1065	brine	
BM111	8/10/2021	0		19805	oil	
BM111	8/11/2021	0		27317	oil	
BM111	8/16/2021	0		7956	brine	
BM111	8/24/2021	0		4269	brine	
BM111	8/25/2021	0		1175	brine	
BM111	10/4/2021	41956	oil	46698	1	71

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
BM111	10/5/2021	35406	oil	37789	1	69
BM111	10/8/2021	45930	oil	48550	1	63
BM111	10/9/2021	30973	oil	33060	1	63
BM111	10/10/2021	59535	oil	63803	1	64
BM111	10/12/2021	34990	oil	37978	1	94
BM111	10/13/2021	32579	oil	35547	1	94
BM111	10/17/2021	66845	oil	72652	1	90
BM111	10/23/2021	38434	oil	41600	1	90
BM111	10/24/2021	22931	oil	25302	1	90
BM111	10/27/2021	36549	oil	39438	1	90
BM111	10/28/2021	76763	oil	82517	1	89
BM111	10/29/2021	24751	oil	27319	1	82
BM111	10/30/2021	110417	oil	118387	1	82
BM111	10/31/2021	66590	oil	71815	1	86
BM111	11/1/2021	670	oil	478	1	82
BM111	11/2/2021	40562	oil	44461	1	89
BM111	11/3/2021	22108	oil	23889	1	88
BM111	11/5/2021	60835	oil	66502	1	85
BM111	11/6/2021	1041	oil	888	1	85
BM111	11/8/2021	28894	oil	32865	1	84
BM111	11/9/2021	34442	oil	36950	1	85
BM111	11/12/2021	57064	oil	62361	1	83
BM111	11/13/2021	13486	oil	13641	1	83
BM111	11/16/2021	66223	oil	72346	1	85
BM111	11/17/2021	5105	oil	5716	1	85
BM111	11/20/2021	32719	oil	36891	1	82
BM111	11/21/2021	30640	oil	31592	1	85
BM111	12/6/2021	51469	oil	56969	1	84
BM111	12/7/2021	28205	oil	29905	1	85
BM111	12/10/2021	68048	oil	73369	1	85
BM111	12/14/2021	35318	oil	38546	1	85
BM111	12/15/2021	15458	oil	16895	1	85
WH11	1/27/2021	0		3195	oil	
WH11	1/28/2021	0		2075	oil	
WH11	2/25/2021	524	brine	0		
WH11	4/20/2021	1295	brine	0		
WH11	5/17/2021	9007	brine	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH11	5/24/2021	0		380	oil	
WH11	6/2/2021	22241	oil	21627	1	
WH11	6/3/2021	63573	oil	64835	1	
WH11	6/4/2021	18271	oil	18692	1	
WH11	6/8/2021	0		1867	1	
WH11	6/9/2021	33474	oil	33808	1	
WH11	6/11/2021	62852	oil	63121	1	
WH11	6/12/2021	20225	oil	20000	1	
WH11	6/13/2021	49757	oil	52648	1	
WH11	6/16/2021	67388	oil	69794	1	
WH11	6/17/2021	2969	oil	2375	1	
WH11	6/18/2021	81512	oil	84117	1	
WH11	6/21/2021	73133	oil	72627	1	
WH11	6/22/2021	29880	oil	32839	1	
WH11	6/24/2021	37026	oil	37408	1	
WH11	6/25/2021	38111	oil	41150	1	
WH11	6/26/2021	33381	oil	34517	1	
WH11	6/28/2021	56769	oil	57994	1	
WH11	6/29/2021	18999	oil	29306	1	
WH11	7/30/2021	0		2477	1	
WH11	7/31/2021	0		1668	1	
WH11	8/5/2021	11588	brine	12940	oil	
WH11	8/6/2021	33576	brine	33286	oil	
WH11	8/7/2021	625	brine	202	oil	
WH11	9/13/2021	7846	brine	0		
WH11	9/15/2021	17775	brine	15490	oil	
WH11	10/4/2021	63903	oil	63112	1	
WH11	10/5/2021	13232	oil	17512	1	
WH11	10/27/2021	73081	oil	73194	1.1	100
WH11	10/28/2021	54135	oil	58938	1	
WH11	10/29/2021	79462	oil	80413	1	
WH11	10/30/2021	71812	oil	75528	1	
WH11	10/31/2021	74566	oil	79797	1	
WH11	11/3/2021	105260	oil	109127	1	
WH11	11/4/2021	26434	oil	27145	1.1	55
WH11	11/5/2021	52391	oil	56210	1.1	55
WH11	11/6/2021	27295	oil	28414	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH11	11/7/2021	99271	oil	103924	1	
WH11	11/13/2021	25902	oil	25473	1	
WH11	11/14/2021	51653	oil	56395	1	
WH11	11/17/2021	31080	oil	33828	1	
WH11	11/18/2021	52063	oil	50513	1	
WH11	11/22/2021	36079	oil	41785	1	
WH11	11/23/2021	48696	oil	51196	1.1	55
WH11	12/3/2021	25103	oil	27840	1	
WH11	12/8/2021	25850	oil	25662	1	
WH11	12/11/2021	74282	oil	76340	1	
WH11	12/16/2021	0		583	oil	
WH11	12/17/2021	0		23	oil	70
WH11	12/21/2021	0		7043	1	
WH11	12/28/2021	0		4780	1	
WH109	1/28/2021	12260	brine	0		
WH109	2/3/2021	10624	oil	10514	1	
WH109	2/4/2021	45056	oil	44816	1	
WH109	2/7/2021	50302	oil	54210	1	
WH109	2/8/2021	27	oil	8103	1	
WH109	2/18/2021	523	brine	0		
WH109	3/25/2021	10239	brine	0		
WH109	4/10/2021	74168	oil	75009	1	
WH109	4/11/2021	12758	oil	12237	1	
WH109	4/16/2021	36664	oil	36617	1	
WH109	4/17/2021	42994	oil	43151	1	
WH109	4/21/2021	86156	oil	89657	1.1	
WH109	4/22/2021	68243	oil	69177	1	
WH109	4/23/2021	6516	oil	6977	1	
WH109	4/27/2021	25290	oil	28611	1	
WH109	4/28/2021	59515	oil	60808	1	
WH109	5/1/2021	14340	oil	15945	1	
WH109	5/2/2021	37549	oil	38597	1	
WH109	5/4/2021	84901	oil	88553	1	
WH109	5/8/2021	52762	oil	53935	1	
WH109	5/14/2021	41434	oil	42531	1	
WH109	5/15/2021	75267	oil	76867	1	
WH109	5/16/2021	17707	oil	18402	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH109	5/17/2021	58717	oil	60038	1	
WH109	5/18/2021	72293	oil	75056	1	
WH109	5/20/2021	61897	oil	60368	1.1	75
WH109	5/21/2021	11809	oil	13071	1.1	75
WH109	5/22/2021	72208	oil	74507	1.1	75
WH109	5/23/2021	43429	oil	47812	1	
WH109	5/29/2021	31361	oil	31598	1.1	75
WH109	5/30/2021	53477	oil	56342	1.1	75
WH109	6/2/2021	19015	oil	18508	1	
WH109	6/13/2021	49584	oil	52706	1	
WH109	6/24/2021	37862	oil	37779	1	
WH109	6/25/2021	37409	oil	37249	1	
WH109	6/28/2021	55346	oil	56601	1	
WH109	6/29/2021	18477	oil	31220	1	
WH109	9/30/2021	11493	brine	0		
WH109	10/4/2021	62584	oil	57994	1	
WH109	10/5/2021	14643	oil	13811	1	
WH109	10/9/2021	0		240	1	
WH109	10/25/2021	2605	brine	0		
WH109	10/27/2021	71302	oil	70338	1.1	100
WH109	10/28/2021	51809	oil	53273	1	
WH109	10/29/2021	77085	oil	76835	1	
WH109	10/30/2021	71124	oil	72396	1	
WH109	10/31/2021	74420	oil	77402	1	
WH109	11/2/2021	88674	oil	91744	1	
WH109	11/3/2021	101841	oil	102811	1	
WH109	11/4/2021	25115	oil	25595	1.1	55
WH109	11/5/2021	49703	oil	51683	1.1	55
WH109	11/6/2021	27774	oil	28400	1	
WH109	11/7/2021	100631	oil	102459	1	
WH109	11/9/2021	65186	oil	71448	1	
WH109	11/10/2021	18600	oil	19686	1	
WH109	11/12/2021	26028	oil	24930	1	
WH109	11/13/2021	87106	oil	89416	1	
WH109	11/14/2021	50874	oil	51025	1	
WH109	11/15/2021	66078	oil	70995	1	
WH109	11/17/2021	30329	oil	32419	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH109	11/18/2021	50739	oil	46089	1	
WH109	11/22/2021	34390	oil	41088	1	
WH109	11/23/2021	48464	oil	48226	1.1	55
WH109	11/26/2021	87322	oil	87960	1.1	55
WH109	11/27/2021	24449	oil	23709	1.1	55
WH109	11/30/2021	66180	oil	68440	1.1	55
WH109	12/3/2021	25431	oil	26672	1	
WH109	12/6/2021	51531	oil	53345	1	
WH109	12/7/2021	14149	oil	14641	1	
WH109	12/8/2021	25103	oil	24918	1	
WH109	12/11/2021	75707	oil	76371	1	
WH109	12/13/2021	78358	oil	80288	1	
WH109	12/14/2021	6682	oil	7532	1	
WH109	12/21/2021	0		2928	1	
WH111	1/6/2021	322	brine	0		
WH111	1/7/2021	1071	brine	1189	oil	
WH111	1/8/2021	2101	brine	0		
WH111	1/11/2021	536	oil	0		
WH111	1/16/2021	3910	brine	4071	oil	
WH111	1/20/2021	708	brine	0		
WH111	1/30/2021	20172	brine	14503	oil	
WH111	1/31/2021	41745	brine	39097	oil	
WH111	2/1/2021	66748	brine	67700	oil	
WH111	2/2/2021	62930	brine	64088	oil	
WH111	2/3/2021	24685	brine	24515	oil	
WH111	2/4/2021	31077	brine	31898	oil	
WH111	2/5/2021	62202	brine	63520	oil	
WH111	2/6/2021	27792	brine	29291	oil	
WH111	2/7/2021	492	oil	0		
WH111	2/8/2021	49878	brine	49446	oil	
WH111	2/9/2021	64127	brine	66085	oil	
WH111	2/10/2021	68880	brine	70080	oil	
WH111	2/11/2021	67530	brine	68846	oil	
WH111	2/12/2021	72546	brine	74064	oil	
WH111	2/13/2021	71008	brine	72557	oil	
WH111	2/14/2021	34858	brine	36665	oil	
WH111	2/18/2021	507	brine	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH111	3/30/2021	2573	brine	0		
WH111	3/31/2021	49114	brine	49601	oil	
WH111	4/2/2021	693	brine	1044	oil	
WH111	4/6/2021	23132	brine	22677	oil	
WH111	4/7/2021	46768	brine	46776	oil	
WH111	4/8/2021	72808	brine	74093	oil	
WH111	4/9/2021	28850	brine	29397	oil	
WH111	4/14/2021	0		1781	oil	
WH111	4/22/2021	68041	oil	66671	1	
WH111	4/23/2021	7016	oil	2556	oil	
WH111	4/30/2021	0		417	oil	
WH111	5/17/2021	47132	oil	42652	1	
WH111	5/18/2021	18507	oil	25564	1	
WH111	5/25/2021	0		150	brine	
WH111	5/26/2021	0		2795	brine	
WH111	5/30/2021	0		6580	1.1	75
WH111	6/29/2021	0		568	1	
WH112	2/18/2021	519	brine	0		
WH112	4/1/2021	1035	brine	0		
WH112	4/23/2021	2556	oil	0		
WH112	5/25/2021	13963	brine	0		
WH112	6/2/2021	21265	oil	22280	1	
WH112	6/3/2021	64964	oil	65710	1	
WH112	6/4/2021	18111	oil	19023	1	
WH112	6/9/2021	33403	oil	33990	1	
WH112	6/11/2021	65102	oil	66229	1	
WH112	6/12/2021	21161	oil	20699	1	
WH112	6/13/2021	49748	oil	54958	1	
WH112	6/16/2021	67553	oil	71305	1	
WH112	6/17/2021	3016	oil	2572	1	
WH112	6/18/2021	79555	oil	83544	1	
WH112	6/21/2021	69636	oil	70116	1	
WH112	6/22/2021	28339	oil	31927	1	
WH112	6/24/2021	37218	oil	38248	1	
WH112	6/25/2021	37361	oil	41200	1	
WH112	6/26/2021	33576	oil	35542	1	
WH112	6/28/2021	56678	oil	58549	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH112	6/29/2021	18877	oil	35345	1	
WH112	8/24/2021	0		3976	oil	
WH112	10/11/2021	6741	oil	0		
WH114	1/28/2021	9884	brine	0		
WH114	2/3/2021	10792	oil	10240	1	
WH114	2/4/2021	43120	oil	45569	1	
WH114	2/7/2021	46963	oil	52978	1	
WH114	2/8/2021	0		7589	1	
WH114	2/18/2021	496	brine	0		
WH114	3/25/2021	8681	brine	0		
WH114	4/10/2021	72427	oil	75599	1	
WH114	4/11/2021	12654	oil	13337	1	
WH114	4/16/2021	39055	oil	40222	1	
WH114	4/17/2021	44571	oil	48961	1	
WH114	4/21/2021	76854	oil	77988	1.1	
WH114	4/22/2021	66379	oil	68572	1	
WH114	4/23/2021	6710	oil	9108	1	
WH114	4/27/2021	23469	oil	28109	1	
WH114	4/28/2021	55737	oil	59588	1	
WH114	5/1/2021	13791	oil	14818	1	
WH114	5/2/2021	34032	oil	38163	1	
WH114	5/4/2021	80542	oil	87184	1	
WH114	5/8/2021	44793	oil	48002	1	
WH114	5/14/2021	39406	oil	44215	1	
WH114	5/15/2021	74837	oil	81592	1	
WH114	5/16/2021	17874	oil	19401	1	
WH114	5/17/2021	57030	oil	60899	1	
WH114	5/18/2021	68859	oil	74579	1	
WH114	5/20/2021	61178	oil	64270	1.1	75
WH114	5/21/2021	12109	oil	14037	1.1	75
WH114	5/22/2021	68165	oil	73554	1.1	75
WH114	5/23/2021	41241	oil	45815	1	
WH114	5/29/2021	28099	oil	27806	1.1	75
WH114	5/30/2021	51571	oil	70750	1.1	75
WH114	6/29/2021	0		3557	1	
WH114	8/14/2021	50	oil	0		
WH114	8/24/2021	3976	oil	0		

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH114	8/25/2021	0		2829	oil	
WH114	9/8/2021	0		956	1.1	65
WH114	9/15/2021	9327	oil	0		
WH114	9/30/2021	1832	brine	0		
WH114	10/4/2021	58253	oil	60062	1	
WH114	10/5/2021	13031	oil	16302	1	
WH114	10/11/2021	7130	brine	6741	oil	
WH114	10/27/2021	70683	oil	71060	1.1	100
WH114	10/28/2021	51801	oil	58020	1	
WH114	10/29/2021	77528	oil	81133	1	
WH114	10/30/2021	70852	oil	76662	1	
WH114	10/31/2021	71481	oil	77885	1	
WH114	11/2/2021	75874	oil	81749	1	
WH114	11/3/2021	99244	oil	106542	1	
WH114	11/4/2021	26630	oil	26646	1.1	55
WH114	11/5/2021	47125	oil	51855	1.1	55
WH114	11/6/2021	27125	oil	28773	1	
WH114	11/7/2021	97535	oil	105672	1	
WH114	11/9/2021	62533	oil	70570	1	
WH114	11/10/2021	17074	oil	18891	1	
WH114	11/12/2021	23401	oil	23276	1	
WH114	11/13/2021	74880	oil	80461	1	
WH114	11/14/2021	45645	oil	49160	1	
WH114	11/15/2021	68385	oil	74383	1	
WH114	11/17/2021	34500	oil	38975	1	
WH114	11/18/2021	51400	oil	51842	1	
WH114	11/22/2021	34301	oil	41803	1	
WH114	11/23/2021	48296	oil	50697	1.1	55
WH114	11/26/2021	78940	oil	83213	1.1	55
WH114	11/27/2021	20441	oil	20799	1.1	55
WH114	11/28/2021	0		635	1.1	55
WH114	11/30/2021	68371	oil	73891	1.1	55
WH114	12/2/2021	0		1356	1	
WH114	12/3/2021	25634	oil	27455	1	
WH114	12/6/2021	51735	oil	55700	1	
WH114	12/7/2021	13857	oil	15571	1	
WH114	12/8/2021	24370	oil	24192	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH114	12/11/2021	75987	oil	81635	1	
WH114	12/13/2021	74962	oil	79637	1	
WH114	12/14/2021	6216	oil	8340	1	
WH114	12/21/2021	0		5848	1	
WH114	12/28/2021	0		5244	1	
WH115	1/1/2021	0		1924	1	60
WH115	1/2/2021	3838	brine	2285	1	60
WH115	1/13/2021	0		1761	1	
WH115	1/14/2021	2624	brine	0		
WH115	1/27/2021	3073	oil	0		
WH115	1/28/2021	2075	oil	0		
WH115	2/3/2021	10700	oil	9797	1	
WH115	2/4/2021	44007	oil	43423	1	
WH115	2/7/2021	50728	oil	51031	1	
WH115	2/8/2021	88	oil	0		
WH115	2/18/2021	505	brine	0		
WH115	3/18/2021	0		2866	1	
WH115	3/25/2021	5223	brine	0		
WH115	3/29/2021	2960	oil	369	oil	
WH115	3/30/2021	0		315	oil	
WH115	4/7/2021	0		49	oil	
WH115	4/10/2021	67016	oil	65091	1	
WH115	4/11/2021	10857	oil	27323	1	
WH115	4/13/2021	0		150	1	
WH115	4/14/2021	0		1034	1	
WH115	4/16/2021	39158	oil	38162	1	
WH115	4/17/2021	47342	oil	48092	1	
WH115	4/21/2021	86994	oil	85285	1.1	
WH115	4/22/2021	68865	oil	69269	1	
WH115	4/23/2021	7028	oil	7356	1	
WH115	4/27/2021	25297	oil	28565	1	
WH115	4/28/2021	59360	oil	59475	1	
WH115	5/1/2021	13920	oil	15747	1	
WH115	5/2/2021	36661	oil	36945	1	
WH115	5/4/2021	84482	oil	86362	1	
WH115	5/5/2021	0		340	oil	
WH115	5/6/2021	0		266	oil	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH115	5/8/2021	53093	oil	52878	1	
WH115	5/13/2021	0		416	1	
WH115	5/14/2021	39927	oil	39992	1	
WH115	5/15/2021	75611	oil	76531	1	
WH115	5/16/2021	18032	oil	18501	1	
WH115	5/17/2021	57132	oil	57178	1	
WH115	5/18/2021	69877	oil	71800	1	
WH115	5/20/2021	64563	oil	63757	1.1	75
WH115	5/21/2021	13026	oil	13163	1.1	75
WH115	5/22/2021	77460	oil	77734	1.1	75
WH115	5/23/2021	47820	oil	47820	1	
WH115	5/29/2021	31282	oil	30643	1.1	75
WH115	5/30/2021	54221	oil	55847	1.1	75
WH115	6/29/2021	0		11586	1	
WH115	7/1/2021	157	oil	0		
WH115	7/6/2021	0		201	oil	
WH115	7/7/2021	0		334	oil	
WH115	9/15/2021	6163	oil	0		
WH115	9/30/2021	6181	brine	0		
WH115	10/4/2021	59575	oil	57515	1	
WH115	10/5/2021	12624	oil	14912	1	
WH115	10/9/2021	0		5720	1	
WH115	10/13/2021	0		1065	1.1	70
WH115	10/16/2021	523	oil	0		
WH115	10/21/2021	67	oil	0		
WH115	10/23/2021	0		83	oil	
WH115	10/24/2021	0		336	oil	
WH115	10/25/2021	6508	brine	206	oil	
WH115	10/27/2021	71330	oil	70014	1.1	100
WH115	10/28/2021	52043	oil	52266	1	
WH115	10/29/2021	80328	oil	80380	1	
WH115	10/30/2021	72775	oil	72909	1	
WH115	10/31/2021	73910	oil	75235	1	
WH115	11/2/2021	80171	oil	81884	1	
WH115	11/3/2021	105982	oil	107102	1	
WH115	11/4/2021	26470	oil	26859	1.1	55
WH115	11/5/2021	51260	oil	53205	1.1	55

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH115	11/6/2021	27633	oil	28239	1	
WH115	11/7/2021	100904	oil	101637	1	
WH115	11/9/2021	68330	oil	71264	1	
WH115	11/10/2021	18247	oil	17991	1	
WH115	11/12/2021	25679	oil	24900	1	
WH115	11/13/2021	87790	oil	89488	1	
WH115	11/14/2021	50842	oil	50788	1	
WH115	11/15/2021	65412	oil	68389	1	
WH115	11/26/2021	68574	oil	70563	1.1	55
WH115	11/27/2021	20528	oil	20306	1.1	55
WH115	11/30/2021	65403	oil	66737	1.1	55
WH115	12/3/2021	25098	oil	26064	1	
WH115	12/6/2021	54173	oil	56796	1	
WH115	12/7/2021	14597	oil	15135	1	
WH115	12/8/2021	26014	oil	25822	1	
WH115	12/11/2021	73182	oil	72488	1	
WH115	12/13/2021	77573	oil	78732	1	
WH115	12/14/2021	6968	oil	7732	1	
WH115	12/21/2021	0		2924	1	
WH115	12/27/2021	493	oil	0		
WH115	12/29/2021	0		411	oil	
WH117	2/18/2021	497	brine	0		
WH117	4/5/2021	7031	brine	0		
WH117	4/21/2021	2283	oil	0		
WH117	4/30/2021	417	oil	0		
WH117	5/16/2021	16798	brine	0		
WH117	5/20/2021	62868	oil	58619	1.1	75
WH117	5/21/2021	11702	oil	13509	1.1	75
WH117	6/2/2021	19579	oil	20293	1	
WH117	6/3/2021	66417	oil	66683	1	
WH117	6/4/2021	19103	oil	19787	1	
WH117	6/8/2021	390	brine	0		
WH117	6/9/2021	33258	oil	33651	1	
WH117	6/11/2021	61735	oil	62003	1	
WH117	6/12/2021	19141	oil	17349	1	
WH117	6/13/2021	50415	oil	53798	1	
WH117	6/16/2021	65418	oil	67814	1	

Cavern	Date	Volume Out (bbls)	Fluid Out	Volume In (bbls)	Fluid In	Temperature Fluid In (degF)
WH117	6/17/2021	2685	oil	2009	1	
WH117	6/18/2021	80589	oil	82703	1	
WH117	6/21/2021	71132	oil	69030	1	
WH117	6/22/2021	28348	oil	32450	1	
WH117	6/24/2021	37436	oil	37584	1	
WH117	6/25/2021	37157	oil	40275	1	
WH117	6/26/2021	33251	oil	34239	1	
WH117	6/28/2021	56082	oil	57162	1	
WH117	6/29/2021	18869	oil	33724	1	
WH117	8/7/2021	0		623	oil	
WH117	12/21/2021	6450	brine	0		

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