Report on the

Volatile Organic Compound (VOC) Emissions from the

Snow Removal Incident at the

Alyeska Pipeline Service Company's

Valdez Marine Terminal East Tank Farm in Early 2022

by

Dr. Ranajit (Ron) Sahu, Consultant[1]

December 2024

The opinions expressed in this PWSRCAC-commissioned report are not necessarily those of PWSRCAC.

[1] Brief Biographical Summary provided in Appendix A.

Contents

Acronym List

APSC	Alyeska Pipeline Service Company
EPA	U.S. Environmental Protection Agency
ETF	East Tank Farm
FLIR	Forward Looking Infrared
HAPs	Hazardous Air Pollutants
IWC	Inches Water Column
LEL	Lower Explosive Limit
PWSRCAC	Prince William Sound Regional Citizens' Advisory Council
PVV	Pressure Vacuum Valves
RVP	Reid Vapor Pressure
TOEM	Terminal Operations and Environmental Monitoring Committee, PWSRCAC
VMT	Valdez Marine Terminal
VOC	Volatile Organic Compound
VRS	Vapor Recovery System

MEMORANDUM

DATE: May 1, 2025

SUBJECT: Prince William Sound Regional Citizens' Advisory Council Report: "Volatile Organic Compound Emissions from the Snow Removal Incident at the Alyeska Pipeline Service Company's Valdez Marine Terminal East Tank Farm in Early 2022"

FROM: Donna Schantz, Executive Director

This report is an analysis by Dr. Ranajit "Ron" Sahu, an air quality subject matter expert, commissioned by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC).

PWSRCAC is a federally mandated, independent nonprofit corporation whose mission is to promote the environmentally safe operation of the Valdez Marine Terminal and associated tankers. Our work is guided by the Oil Pollution Act of 1990, and our contract with Alyeska Pipeline Service Company (Alyeska). PWSRCAC's 19 member organizations are communities in the region affected by the 1989 Exxon Valdez oil spill, as well as commercial fishing, aquaculture, Alaska Native, recreation, tourism, and environmental groups.

PWSRCAC commissioned this report to address concerns raised by the public related to an incident in 2022, where hazardous air pollutants (HAPs) and volatile organic compound (VOC) emissions were released into the atmosphere from crude oil storage tanks at Alyeska's Valdez Marine Terminal. During this incident, inadequate removal of excessive snow and ice buildup led to vents being damaged or completely sheared off the crude oil storage tanks in the terminal's East Tank Farm. This damage resulted in the aforementioned emissions, though an estimated amount of those emissions is not known to the Council to have been provided by Alyeska or regulators to date.

These findings are intended to provide perspective on the impacts to air quality as a result of this incident for terminal employees and Valdez residents. In 2022, PWSRCAC requested information from Alyeska to better understand the 2022 tank vent incident. As of the date of this report, the information has not been provided by Alyeska. As such, this study is based primarily on information received from State of Alaska regulatory agencies with oversight responsibilities at the terminal. Alyeska's feedback and collaboration were solicited on both the draft report and throughout the finalization process. A short timeline of proceedings is listed below.

TIMELINE:

- **February 4, 2025:** A draft report of these findings was transmitted via email to Alyeska.

- **February 25, 2025:** A letter from Alyeska (GL60146) to PWSRCAC, dated February 25, 2025, confirmed receipt of this draft report and that the information contained herein was being reviewed by subject matter experts.
- **March 7, 2025:** A follow-up letter from Alyeska (GL60176, Appendix D) was transmitted on March 7, 2025, sharing that Alyeska reviewed Dr. Sahu's draft report, that Alyeska respectfully disagreed with many of the report's calculations and conclusions, and that they believe the total emission estimates are overestimated. Alyeska specifically cited that the report "…appears to rely upon several factual inaccuracies, including misstating PVV [pressure vacuum valve] set points and incorrectly calculating the time-period during which PVVs were damaged before being plugged or repaired. Of particular significance is that the report inaccurately describes the operation and dynamics of the VMT's tank and vapor system… We also note that the report does not include the modelling inputs or outputs, or other data relied upon by Dr. Sahu."
- **March 7, 2025:** During their regularly scheduled meeting, PWSRCAC's Terminal Operations and Environmental Monitoring (TOEM) Committee members verbally expressed to Alyeska staff present that the committee would like to collaborate with Alyeska to refine the report findings and address Alyeska's concerns.
- **March 13, 2025:** PWSRCAC transmitted the requested tank input/output data to Alyeska, per Alyeska's March 7 letter, noting the data was drawn from Alyeska source documents listed in the report body. Subsequently, Alyeska staff verbally confirmed receipt of the requested data, and stated that Alyeska would not be providing additional feedback or information on the report.
- **March 19, 2025:** Alyeska reconfirmed in writing that they would not be providing additional feedback on the report and expressed hope that PWSRCAC will work to make corrections and provide the context (such as the modeling) for how the report was generated. Some of the information requested had already been previously shared with Alyeska on March 13, 2025 (see above).

PWSRCAC worked with Dr. Sahu to make revisions based on the limited feedback provided by Alyeska. With that said, due to the lack of specific details on what Alyeska believes to be incorrect and/or lack of additional information needed from Alyeska to make corrections (which PWSRCAC has requested), PWSRCAC is restricted in our ability to make more substantial changes to address their concerns.

It is the goal of PWSRCAC to use the information contained in this report to advocate for the highest standards for operational and environmental safeguards in Prince William Sound - for the people who live near, work for, and are affected by the Valdez Marine Terminal and tanker operations. This analysis was also done in the interest of satisfying our mandate to monitor the environment impacts of the operation of the terminal facilities, per the Oil Pollution Act of 1990 and our contract with Alyeska.

With Alyeska's statements that they do not intend to provide any additional information, PWSRCAC has determined to move this report forward. Dr. Sahu developed this conservative VOC emission estimate based on a review of public records and documents produced by Alyeska, as well as his 30+ years of experience in air quality research, design, regulatory compliance, and projects involving communicating environmental data to the public. Dr. Sahu's preliminary conservative estimates range from roughly 79 to 193 tons of VOCs released over the February through May 2022 time period. Given the conservative assumptions used, Dr. Sahu believes that actual emissions are likely to have been *more* than 193 tons. This report is being released in the public interest of discussing and addressing emissions released as a result of the 2022 tank vent incident.

PWSRCAC remains open to further examining and/or reevaluating the findings and conclusions of this report should Alyeska provide further information. PWSRCAC will continue its efforts to help ensure that the operations of the terminal and associated tankers are the safest possible.

Summary

This report outlines the considerations involved in calculating Volatile Organic Compound (VOC) estimates from the 2022 Tank Vent Damage incident at the Alyeska Pipeline Service Company's (Alyeska or APSC) Valdez Marine Terminal (VMT). The preliminary conservative VOC emission estimates range from roughly 79 to roughly 193 tons over the February through May 2022 time period;[2] given the conservative assumptions used, actual emissions are likely to have been *more* than 193 tons. These levels of VOC emissions even on an annual basis would qualify the VMT as a "major source," defined by the U.S. Environmental Protection Agency (EPA) as a "stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants."[3]

As noted in the memorandum, Alyeska was provided with the opportunity to respond to these findings and subsequently stated that they believe these report findings disregard or discount certain critical factors and conditions that do not support the conclusions drawn (see Appendix D). Their letter noted that the report, "…appears to rely upon several factual inaccuracies, including misstating PVV [pressure vacuum valve] set points and incorrectly calculating the time-period during which PVVs were damaged before being plugged or repaired. Of particular significance is that the report inaccurately describes the operation and dynamics of the VMT's tank and vapor system… We also note that the report does not include the modelling inputs or outputs, or other data relied upon by Dr. Sahu."

The reasoning for the time period considered in calculating these emission estimates is outlined further in this report, and examples of the modelling input/outputs are attached as Appendix C (and previously shared with Alyeska). The data relied upon by Dr. Sahu is described in this report and drawn directly from Alyeska source documents and provided information.

Furthermore, the author notes that ultimately, the PVV set point in this incident is not a significant factor in calculating emission estimates, when the vents in question are significantly damaged/sheared off and cannot therefore contain the vapors generated in the tanks or effectively respond to pressure set points. The author emphasizes that leak prevention cannot be guaranteed with temporary blinds/plugs on the tanks without more permanent repairs, which is explained further within this report.

Subsequent to this input, Alyeska has provided no further information to the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC) or the contractor as to what these

[2] The author would like to note that this report does not address what the routine emissions of VOCs would be from the East Tank Farm, with or without damaged tank vents. The purpose of the report is to estimate the VOC emissions from the 2022 snow-related time period.

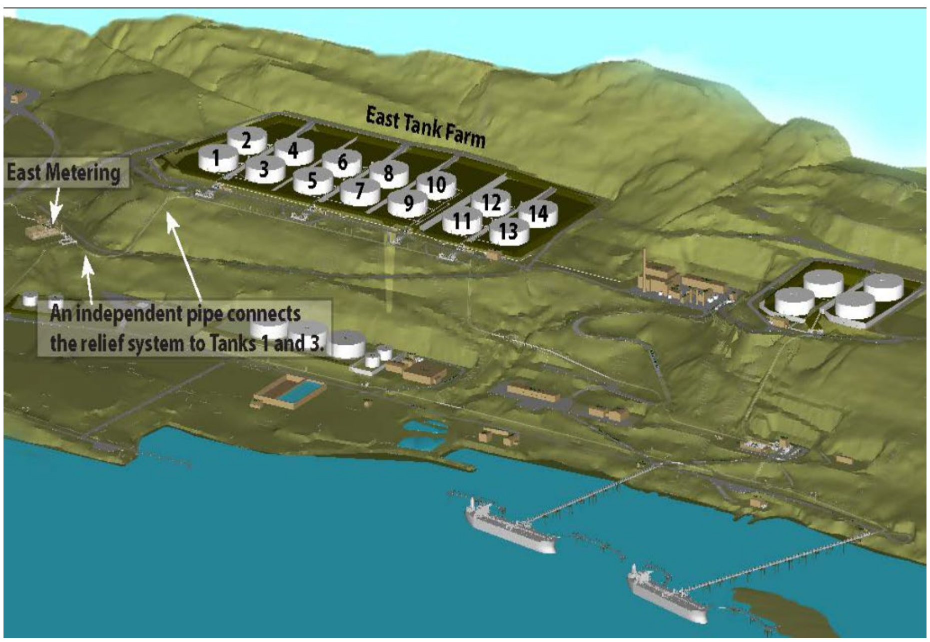
[3] U.S. EPA. "Summary of the Clean Air Act." https://www.epa.gov/laws-regulations/summary-clean-air-act, text under "Sources of Pollution" section. Page dated July 31, 2024.

critical factors and conditions are. PWSRCAC would welcome the opportunity to receive this information to refine the report findings as appropriate.

A. Overview of the Valdez Marine Terminal

Alyeska is the operator of the Trans Alaska Pipeline System (TAPS), including the VMT, which is the receiving end of the pipeline, and the East Tank Farm (ETF) at the VMT. The ETF has the storage capacity for nearly 7 million barrels of Alaska North Slope crude oil at any given time. There are 14 tanks in the ETF, of which 13 are currently in active use.[4] Each tank is of welded construction, has a conical roof with a tank diameter of 250 feet and a height of 63 feet. The nominal capacity of each tank is 510,000 barrels of crude oil. Figure 1 shows an overview of the VMT. The ETF is shown in the center with the tanks numbered 1 through 14.

Figure 1 – Map of the Valdez Marine Terminal[5]



[4] As of October 22, 2024, Alyeska permanently removed Tank 8 from service. Tank 8 is not in active use, but still subject to field checks and cathodic protection. Tank 8 was in operation at the time of the incident.

[5] Taken from Figure 8-5 of the VMT Tank Farm Manual, VOP/0500.

B. Brief Description of the Vapor Recovery System

Alyeska's Power Vapor facility "manages vapors from the tank farm and tanker loading activities… the plant can produce at least 50 percent of power requirements for the VMT from the vapor system; the rest is supplemented by ultra-low sulfur diesel."[6]

The Vapor Recovery System (VRS) is connected to each crude oil storage tank at the VMT East Tank Farm. The VRS ensures that the pressure inside these tanks is maintained close to atmospheric pressure by adding and removing gases to these tanks. Excess vapors are collected and burned for power across the VMT in Power Vapor, as described above.

The tanks regularly experience pressure changes that must be managed due to the nature of crude oil's volatile properties. This volatility produces pressure changes in two primary ways:

1) *Working losses* occur when the liquid level in the tanks change.

   Filling tanks with oil causes the liquid level to rise, displacing existing vapors, and increasing the amount of pressure in the tank. This requires removal of gases in the tanks to maintain atmospheric pressure.

   Withdrawing oil from tanks causes the liquid level to drop, creating more room for the existing vapors and decreasing the amount of pressure in the tank. This requires the addition of a blanket gas (nitrogen) to the tank to maintain atmospheric pressure.

2) *Breathing losses* occur when emissions are produced from the ambient heating of the tanks, often from sunlight or outside temperature increases. This also causes an excess buildup of pressure in the tanks. Breathing losses occur even when tank liquid levels do not change.

Figure 2 shows a close-up of a single tank and the individual components connected to the VRS, which allow for pressure management of these breathing and working losses.

The VRS is a critical system for VMT operative safety, as the design basis of these crude oil storage tanks does not account for significant vacuum/negative or positive pressures above atmospheric levels. Without the use of the VRS or tank venting, if these tanks were to internally experience extreme pressure differentials from atmospheric conditions without the use of vapor control, significant structural damage could result.

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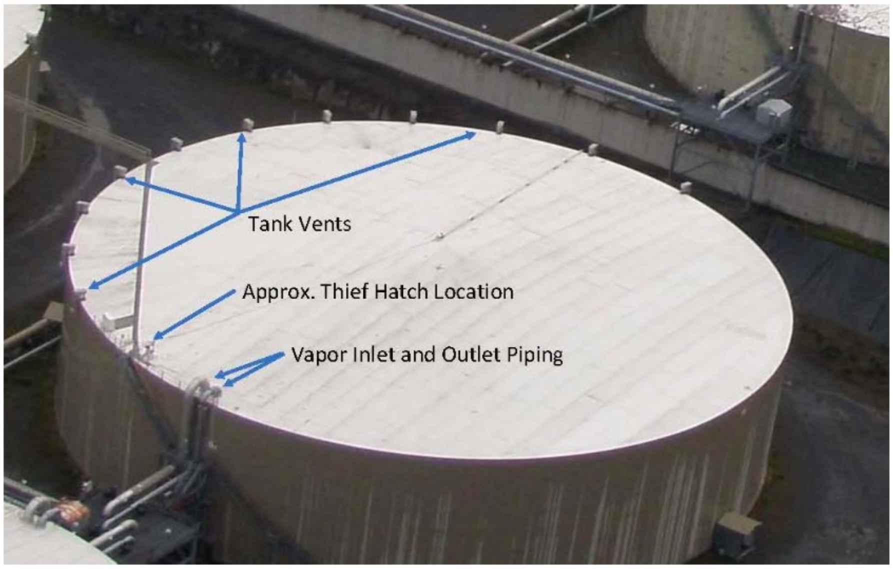
[6] https://alyeska-pipe.com/valdez-marine-terminal/, under "VMT Power Vapor" section, as of April 2025.

Figure 2 – Typical Tank, with Certain Details Shown



a. Vapor Inlet and Outlet Piping

As depicted in Figure 2, the vapor inlet is responsible for allowing vapors to enter the tank through a 16-inch diameter line used to discharge inert blanket gas inside the tank. Meanwhile, the vapor outlet is responsible for removing vapors from the tank via a 30-inch diameter vapor recovery line.

The relative close positioning of the vapor inlet and outlet piping is functionally a poor design given the large diameter of the tank. They should be farther away from one another to allow for more even gas mixing in the tank headspace without effectively "short-circuiting" the inlet/outlet gas flow without proper engagement with the rest of the large tank as a whole.

b. Thief Hatch

Also noted is the location of the thief hatch in close proximity to the vapor inlet and outlet piping. Thief hatches are used to test the tank liquid levels, tank pressure, and the headspace gaseous composition. Given that the thief hatch location is right next to where vapors are being removed and added to the tank headspace, the data collected here are not necessarily an accurate representation of the tank's gaseous composition as whole. A better design would include more space between the thief hatch and the inlet/outlet vapor piping locations.

c. Tank Vents

Tank vents are designed to modulate tank internal pressures around atmospheric pressure to both positive and negative pressure differentials. For example, when internal pressure increases, the tanks are able to reduce pressure via the release of emissions through tank vents (depicted around the tank circumference of Figure 2). Tank vents open and close when triggered by internal tank pressures at certain set points to maintain tank pressures around atmospheric pressure. When these vents open, vapors (emissions) vent to the atmosphere.

Figures 3 and 4 are schematics that show the flow of tank vapors in a typical vent during over-pressure and vacuum conditions, respectively. As Figure 3 shows via the red arrows, when the pressure inside the tank is greater than acceptable (i.e., there is an over-pressure condition), the vapors are vented to the atmosphere. Similarly, as shown in Figure 4, in an under-pressure or vacuum situation, ambient air (with potentially dangerous levels of oxygen) enters the tank.

Figure 3 – Vapor Flows in a Typical Vent (Over-Pressure Condition)

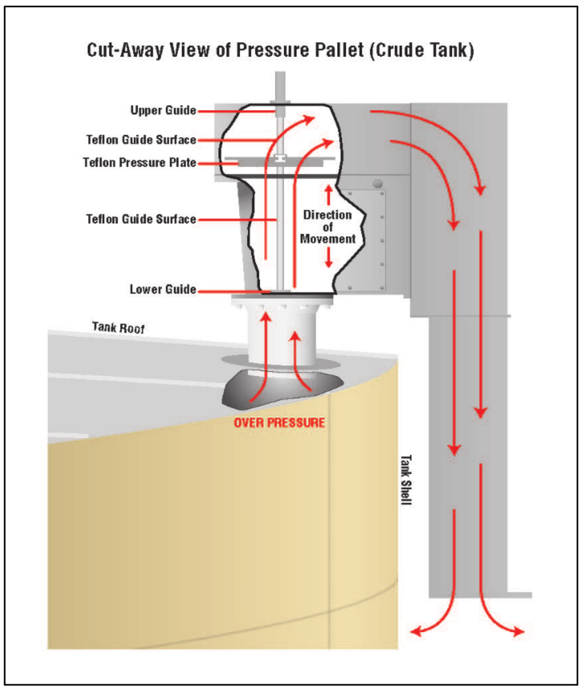
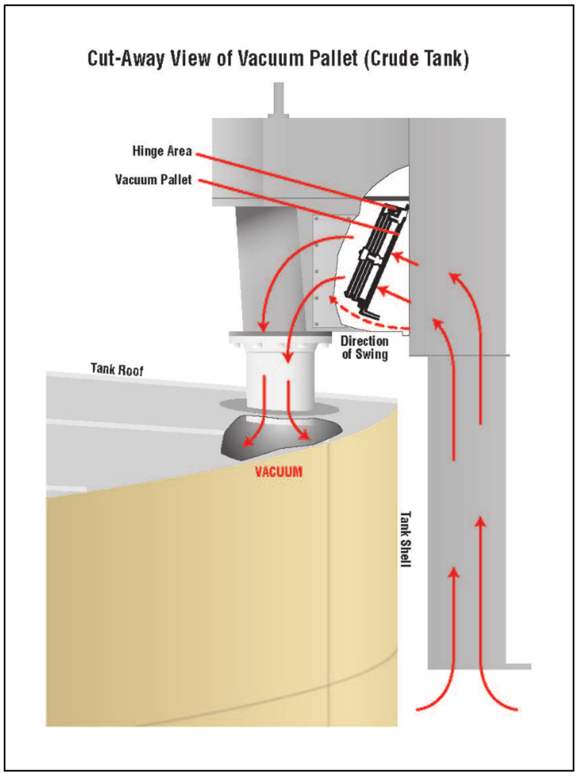


Figure 4 – Vapor Flows in a Typical Vent (Vacuum Condition)



C. The Snow Removal Event in 2022 and Resulting Damage

During the winter/spring of 2022, Alyeska's inadequate removal of excessive accumulation of snow and ice in winter 2021-2022 led to the migration/shedding of this accumulated snow and ice from the tank tops that exerted tremendous physical pressure on the tank vents. As a result, several tank vents were severely damaged or entirely sheared off. Taku Engineering's June 2023 report, commissioned by the Prince William Sound Regional Citizens' Advisory Council (PWSRCAC), titled "Crude Oil Storage Tank Vent Damage," supports the assertion above related to the cause of the tank vent damage, noting, "[snowfall that winter] …was not exceptionally high. Utilizing a 5-year benchmark, the accumulated snow depth that led to the tank vent damage was 25-30% lower in 2021 than in 2016. The snow accumulation was within the level that should have been anticipated."

This conservative preliminary assessment of timeline, damage, and emission estimates is based on a review of public records, and documents produced by the terminal operator and acquired by PWSRCAC through public records requests, which were then provided to the author.

a. Event Timeline

The full time period of this incident and resulting operator emission management could reasonably be framed as the period between February through July 2022. However, for the purposes of providing a conservative emissions estimate, the time period for which emissions were assessed in Winter/Spring 2022 is focused on late February through May 2022. This is discussed below. The source of the vent leak discovery and completion of repairs is taken from a document shown in Figure 5.

Figure 5 – Chart Showing Start/End of Vent Damage/Repair

Attachment E

The table below provides estimates for when Alyeska found either leaking or sheared vents, but these estimates are not an indicator that leaks or emissions were occurring during the time periods referenced below. Alyeska managed tank pressures to eliminate or reduce emissions, consistent with managing O_2 levels and tank safety, until the pressure vacuum vents were blinded, plugged, repaired, or found not to be leaking.

Note that times, where available, are approximate.

Tank	Valve	Discovery Date/Time	Type of Damage	Date/Time Repair	Type of Repair
1	B	3/28/2022 7:07	Broke Off	4/1/2022 15:30	Plugged
2	B	3/11/2022	Leak	3/17/2022	Repaired
2	C	3/13/2022 17:50	Broke Off	3/14/2022 15:24	Blind
2	D	3/22/2022	Leak	N/A	Found not to be leaking
2	E	3/18/2022	Leak	3/30/2022	Repaired
2	F	3/20/2022 7:50	Broke Off	3/26/2022	Plugged
2	H	3/10/2022 16:45	Broke Off	3/13/2022 14:30	Plugged
3	A	2/28/2022 14:30	Leak	N/A	Found not to be leaking
3	B	2/28/2022 14:30	Leak	N/A	Found not to be leaking
3	F	3/29/2022	Leak	3/31/2022	Blind
3	H	Leak Discovered 3/29/2022 Vent Broke off 3/30/2022 11:00	Leak Broke Off	3/30/2022	Plugged
4	B	Leak Discovered 3/10/2022 Vent Broke Off 3/19/2022 8:40	Leak Broke Off	3/19/2022	Plugged
4	D	2/28/2022 14:30	Leak	N/A	Found not to be leaking
4	F	Leak Discovered 3/25/2022 Vent Broke off 3/27/2022 1:15	Broke Off	3/27/2022	Plugged
4	I	3/10/2022 8:00	Broke Off	3/18/2022 16:16	Plugged
5	B	3/11/2022	Leak	3/24/2022 16:07	Repaired

5	C	2/28/2022 14:30	Leak	N/A	Found not to be leaking
5	E	3/15/2022	Leak	3/24/2022 16:07	Repaired
6	A	2/28/2022 14:30	Leak	N/A	Found not to be leaking
6	B	2/28/2022 14:30	Leak	N/A	Found not to be leaking
6	H	3/7/2022 0:38	Broke Off	3/10/2022 16:45	Plugged
9	D	3/28/2022	Leak	N/A	Found not to be leaking
9	G	3/11/2022	Leak	N/A	Found not to be leaking
9	H	3/21/2022	Leak	3/22/2022	Repaired
10	A	3/23/2022	Leak	3/23/2022 17:03	Repaired
10	C	2/28/2022 14:30	Leak	3/23/2022 17:03	Repaired
10	D	2/26/2022 10:23	Leak	3/23/2022 17:03	Repaired
10	E	2/26/2022 10:23	Leak	3/23/2022 17:03	Repaired
10	H	3/10/2022 17:00	Broke Off	3/20/2022	Plugged
11	K	3/10/2022	Leak	4/1/2022 17:23	Repaired
12	D	2/28/2022 14:30	Leak	3/13/2022	Repaired
13	N/A	1/20/2022 1:37	Venting	1/20/2022 1:37	N/A - Reported per permit requirements
13	A	3/26/2022 12:08	Leak	3/27/2022	Repaired
13	B	2/25/2022 04:30	Leak	2/28/22	Repaired
13	C	3/26/2022 12:08	Leak	3/27/2022	Plugged
13	F	3/28/2022	Leak	3/28/2022	Repaired
13	I	Leak Discovered 2/28/2022 14:30 Vent Broke off 3/21/2022 15:00	Leak Broke Off	3/22/2022	Plugged
13	K	3/28/2022	Leak	3/29/2022	Repaired
14	F	3/10/2022	Leak	3/14/2022	Plugged
14	H	3/3/2022 4:00	Broke Off	3/8/2022 17:51	Blind
14	I	2/28/2022 14:00	Leak	3/12/2022	Repaired

VMT records indicate that the damaged vents were first identified in February 2022.

However, there is evidence of leaking well before the February 2022 time period that is the beginning of this analysis. For example, see the entry in Figure 5 (above) for Tank 13, which was venting in January 2022. See also Daily Incident ID 33361 which confirmed a vent failure in Tank 13 discovered on January 19, 2022. Finally, as examples, see Work Orders 171021657-10 and 181014654-10, indicating damaged vents as far back as 2018. These confirm that certain vents were damaged well before the period of this analysis (i.e., February through May 2022).

During this incident, Alyeska also discovered a thief hatch leak on Tank 93. An Alyeska email dated March 15, 2022, links the observed damage on the thief hatch to snow/ice, causing the hatch to "leak a significant amount of HC [hydrocarbon] vapors]. We have instances in the past where they had to be 5200'd to get them to seal" [emphasis added]. The author notes that while this email thread makes clear that emissions from a thief hatch did occur during the 2022 snow vent damage incident, for the purpose of providing a highly conservative estimate, these emissions were not accounted for in the calculations.

After the vent damage detection in February 2022, Alyeska mobilized to begin shoveling off the accumulated snow and begin plugging/blinding the damaged vents. Operator data states that while most tanks were plugged/blinded by April 2022, Tank 2 is a marked exception, as pressure data indicates that despite tank vents C, F, and H being plugged/blinded in April, problems with the temporary repairs continued into May/June. **It is important to note here that simply plugging/blinding tanks does not assure there are no leaks.**

The operator continued to engage in tank pressure management in response to this tank vent damage incident into May, and level data shows, for example, that Tank 2 was not back in active use until the end of July 2022.

However, the record indicates leaks continued even after May 2022. For example, in an update (#9) on the tank vent damage provided by PWSRCAC to various recipients dated June 2, 2022, PWSRCAC staff, based on information provided by Alyeska, noted that after a comprehensive inspection of all 144 vents was completed, there were 13 vents that were out-of-service on eight tanks in the East Tank Farm. This indicates Alyeska was working on a permanent repair plan for these 13 vents. It is not clear when all of these vents and the rest of the 144 vents were permanently repaired such as by welding.

Given the above information, the author's estimate conservatively accounts for the time period of operator tank pressure management (i.e., when pressure management is known to have begun and ended, as noted by the terminal operator), which extends from late February to May 2022.

Crucially, the beginning of pressure management is not the same as when an actual vent on a specific tank first sustained damage and therefore began to leak (when the tank was at high pressure and likely being filled/emptied as would be the case typically). Thus, all VOC emissions – both from breathing/standing losses as well as from working losses – in the time period from when the first vent was damaged until pressure management was implemented on that tank – are unaccounted for in this estimate. This could be considerable. Examples of photographs showing the snow accumulation and resulting damage to the vent vents are shown in the Figures 6A through 6G below.

Figures 6A through 6G – Examples of Snow Loading and Damaged Tank Vents

The extent of the damage to the various vents is also summarized in the excerpted charts and diagrams created by Alyeska in March 2022, shown in Figure 7.

i. Specific Tanks Assessed

For the purposes of providing a conservative emission estimate, the author notes that VOCs were assessed from Tanks 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, and 14, which were reported by Alyeska as leaking. The reasoning for assessing emissions from these specific tanks is based on designations of broken and leaking vents, and are directly taken from summaries prepared by Alyeska.

The author did not include Tank 7 and 8 VOCs in these emission estimates based on Alyeska reports that Tanks 7 and 8 had no leaks. However, Tank 7 and 8 both sustained vent damage. For Tank 8, two vents were noted to be “severely tilted,” while Tank 7 experienced several vents with “slight tilts.” It is clear from a review of operational and tank pressure data that there were such VOC emissions from these two tanks as well. The author notes that the lack of leaking vents identified via a Lower Explosive Limit (LEL) meter does not mean that there were no leaks of VOCs – just that the leak levels were not high enough to cause explosion concerns.

Figure 7 shows all of the tanks in the East Tank Farm along with the vents and their alpha numbering. At each tank, the vents are numbered A, B, C, etc., following the directions shown in Figure 8. **Critically, the number of damaged vents is not identical across all tanks, requiring a tank-by-tank approach to calculating emissions estimates.**

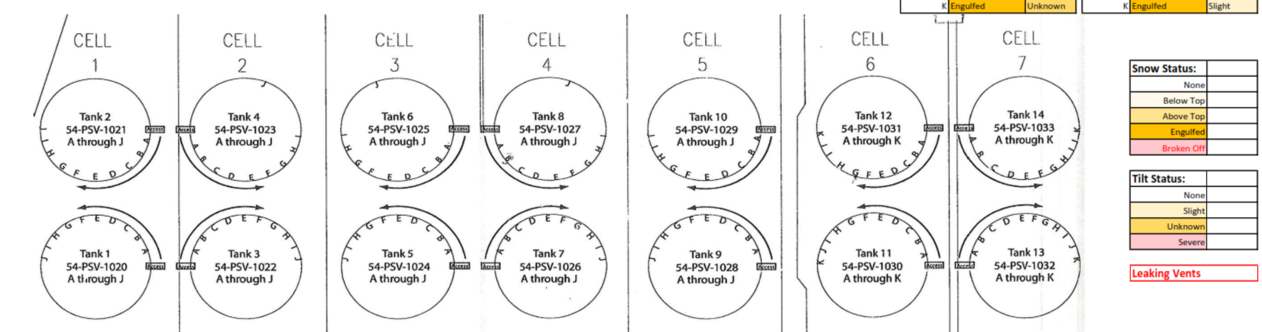
Also, importantly, **Figure 8 shows the degree to which vents in each tank were damaged.** Red triangles denote vents that had completely broken or sheared off. Green triangles show vents which were compromised and leaking. Those that were suspected to be leaking, but found to not to be after further investigation, are shown as black triangles.

Figure 7 – Tank Vent Damage Assessment in March 2022

EAST TANK FARM VACUUM VENT ASSESSMENT

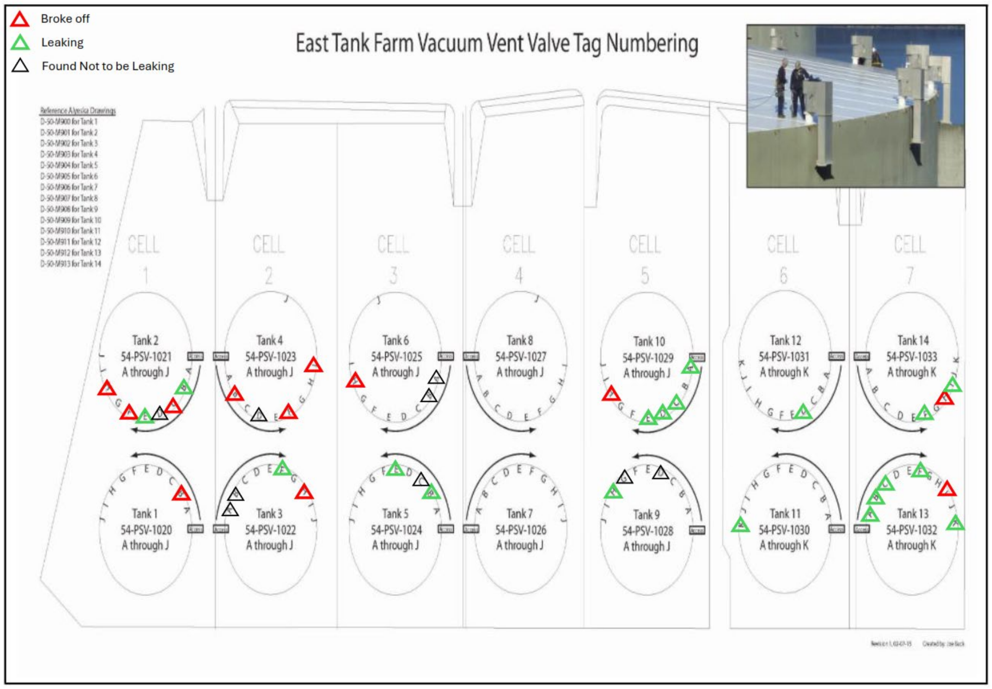
Conducted on 03/11/22 & 03/12/22 by Brian Huey & Eric Scheidt

Tank 2	Snow Cover	Tilt	Tank 4	Snow Cover	Tilt	Tank 6	Snow Cover	Tilt	Tank 8	Snow Cover	Tilt	Tank 10	Snow Cover	Tilt	Tank 12	Snow Cover	Tilt	Tank 14	Snow Cover	Tilt
A	None (no trunk)	None	A	Engulfed	Severe	A	Engulfed	Slight	A	Engulfed	Slight	A	Above Top	Slight	A	Above Top	Slight	A	Engulfed	Severe
B	None trunk broke	Slight	B	Engulfed	Severe	B	None	None	B	Engulfed	Slight	B	Engulfed	Slight	B	Above Top	None	B	Above Top	None
C	Engulfed	Unknown	C	Engulfed	Severe	C	Engulfed	Severe	C	Above Top	None	C	Engulfed	Severe	C	Engulfed	Slight	C	Engulfed	Slight
D	Engulfed	Severe	D	Engulfed	Severe	D	Engulfed	Slight	D	Above Top	None	D	Engulfed	Severe	D	Engulfed	None	D	Engulfed	Slight
E	Engulfed	Unknown	E	Engulfed	Slight	E	Engulfed	Unknown	E	Engulfed	None	E	Engulfed	Slight	E	Engulfed	Slight	E	Above Top	Slight
F	Engulfed	Severe	F	Engulfed	Severe	F	Engulfed	Slight	F	Engulfed	None	F	Engulfed	Slight	F	Engulfed	Slight	F	Engulfed	Severe
G	Above Top	Severe	G	Above Top	Slight	G	Engulfed	Severe	G	Engulfed	Slight	G	Engulfed	Severe	G	Engulfed	Severe	G	Above Top	Slight
H	Broke off		H	Engulfed	Slight	H	None - Plugged		H	Engulfed	Slight	H	Broken Off	Severe	H	Above Top	Slight	H	Blinded	
I	Engulfed	Severe	I	Broken Off	Severe	I	Engulfed	Severe	I	Engulfed	Severe	I	Engulfed	Severe	I	Engulfed	Severe	I	Engulfed	Severe
J	Engulfed	None	J	Below Top	None	J	None	None	J	Engulfed	Severe	J	Engulfed	Slight	J	Engulfed	None	J	Engulfed	Slight
															K	Engulfed	Unknown	K	Engulfed	Slight



Tank 1	Snow Cover	Tilt	Tank 3	Snow Cover	Tilt	Tank 5	Snow Cover	Tilt	Tank 7	Snow Cover	Tilt	Tank 9	Snow Cover	Tilt	Tank 11	Snow Cover	Tilt	Tank 13	Snow Cover	Tilt
A	Engulfed	Severe	A	Engulfed	None	A	Engulfed	Slight	A	Above Top	None	A	Engulfed	None	A	Above Top	Slight	A	Engulfed	Slight
B	Engulfed	Severe	B	Engulfed	None	B	Engulfed	Slight	B	Above Top	Slight	B	Above Top	None	B	Engulfed	Severe	B	None	None
C	Engulfed	Severe	C	Engulfed	None	C	Below Top	None	C	Above Top	Slight	C	Engulfed	Severe	C	Engulfed	Slight	C	Above Top	None
D	Engulfed	Unknown	D	Engulfed	Slight	D	Engulfed	Severe	D	Above Top	None	D	Engulfed	None	D	Engulfed	Slight	D	Engulfed	Slight
E	Engulfed	Unknown	E	Engulfed	Severe	E	Engulfed	Slight	E	Above Top	None	E	Engulfed	Slight	E	Engulfed	Slight	E	Above Top	Slight
F	Engulfed	Unknown	F	Engulfed	Severe	F	Engulfed	Unknown	F	Engulfed	Slight	F	Engulfed	Unknown	F	Engulfed	Severe	F	Engulfed	None
G	Engulfed	Unknown	G	Engulfed	Severe	G	Engulfed	Severe	G	Engulfed	Slight	G	Above Top	Slight	G	Above Top	None	G	Engulfed	None
H	Above Top	Severe	H	Engulfed	Severe	H	Below Top	None	H	Above TOp	Slight	H	Engulfed	Severe	H	Engulfed	Severe	H	Above Top	None
I	Engulfed	Slight	I	Engulfed	Slight	I	Above Top	Slight	I	Engulfed	Unknown	I	Engulfed	Severe	I	Above Top	Slight	I	Engulfed	Unknown
J	Engulfed	Slight	J	Engulfed	Severe	J	Below Top	None	J	Engulfed	Slight	J	Above Top	None	J	Engulfed	Severe	J	Engulfed	Slight
															K	Engulfed	Slight	K	Above Top	Slight

Figure 8 – Tank Vent Numbering and Condition During 2022 Snow Removal



D. Alyeska Response to Incident

VOC emissions are generated from both breathing and working losses, as described previously. That such emissions occurred, and vapors were released to the ambient air as a result of the 2022 tank vent damage, is not disputed. Alyeska's own documents, communications, correspondence, and data confirm this as described further in this section.

For example, high concentrations of vapors were measured in the vicinity and on the top of the tanks during snow removal. The author reviewed a variety of such documents and observational data from hand-held explosive monitors, and Forward Looking Infrared (FLIR) cameras, which demonstrated the release of emissions on video taken from ground level.

Given these emissions, Alyeska sought to minimize emissions from the damaged tanks/vents in two ways:

1) by limiting the filling of damaged tanks to reduce working losses; and

2) by attempting active pressure management using a slight negative vacuum on the tank headspace.

The following sections detail the evidence for both efforts and the ultimate limitations of each approach in reducing VOC emissions to ambient air.

However, given the critical role of tank vents in controlling tank VOC emissions as outlined in the previous section, this incident created areas of the tanks where emissions were actively released into the ambient air, instead of being collected by the VRS. While Alyeska instituted tank pressure management to minimize VOC emissions from the damaged tanks/vents, this did not entirely prevent VOC emissions from occurring. This is because even a single damaged tank vent presents a path of least resistance for vapors to escape to the atmosphere. Given the circumstances, the tank pressure management was not effective in preventing VOC emissions to the atmosphere.

a. Limiting the filling of damaged tanks to reduce working losses

The first effort at minimizing emissions from this incident is demonstrated by data received by the author depicting the tank level and tank pressure data for the period January 1 through July 31, 2022, for each of the tanks. This was provided in Excel format, and the author has provided an example of a small snippet of this dataset below in Figure 9 for illustrative purposes.

Figure 9 – Tank Pressure and Level Data Example

	54-tk-01		54-tk-02		54-tk-03	
	pressure:	level:	pressure:	level:	pressure:	level:
Date/time	IWC	feet	IWC	feet	IWC	feet
01-Jan-22 00:00:00	0.303254	6.9586182	0.296648	4.235473633	0.29842	6.82409668
01-Jan-22 00:01:00	0.294933	6.9586182	0.289596	4.235473633	0.293486	6.82409668
01-Jan-22 00:02:00	0.316006	6.9586182	0.300567	4.235473633	0.314317	6.82409668
01-Jan-22 00:03:00	0.290449	6.9586182	0.302823	4.235473633	0.298541	6.82409668
01-Jan-22 00:04:00	0.29541	6.9586182	0.301288	4.235473633	0.299993	6.82409668
01-Jan-22 00:05:00	0.300372	6.9586182	0.299753	4.235473633	0.29019	6.82409668
01-Jan-22 00:06:00	0.301492	6.9586182	0.298217	4.235473633	0.322304	6.82409668
01-Jan-22 00:07:00	0.29947	6.9586182	0.300795	4.235473633	0.297774	6.82409668
01-Jan-22 00:08:00	0.297448	6.9586182	0.304623	4.235473633	0.299001	6.82409668
01-Jan-22 00:09:00	0.304737	6.9586182	0.305559	4.235473633	0.300227	6.82409668
01-Jan-22 00:10:00	0.306015	6.9586182	0.291158	4.235473633	0.297696	6.82409668

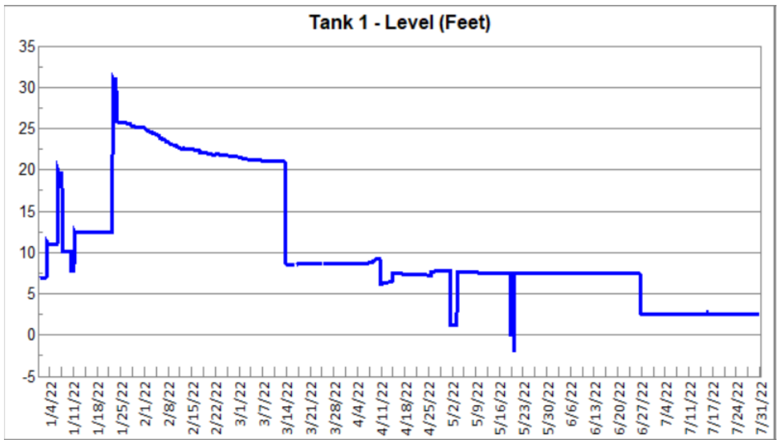
The red labels denote the tank designations. For example, Tank 1 is 54-tk-01, Tank 2 is 54-tk-02, and so on. While the table format for tank levels and pressures is helpful, a visual plot of the levels and pressure is more helpful.

As depicted in Figures 10 and 11, respectively, as an example, the author plotted the tank liquid level and the pressure for Tank 1 against the elapsed time, shown as in the X-axis.

Thus, Figure 10 shows that at a certain point in time, the liquid level in Tank 1 was dropped to roughly 8 feet or so, or a bit lower, and was not increased (i.e., the tank was not filled back up). **In general, damaged tanks were not filled during the time period between when the tank vents were discovered to be damaged and temporary repairs to the tank vents were made.** There are exceptions to this, however, likely due to operative needs necessitating the use of a damaged tank (given that the majority - 12 of the 14 - tanks were damaged for some periods of time).

While this was an attempt at reducing the emissions produced by working losses (filling the tanks with oil), this did not prevent emissions produced from breathing losses, as the tank was subject to ambient changes in the outside environment.

Figure 10 – Tank 1 Liquid Level During January-July 2022.



Note: X-axis shows time (date) and Y-axis shows the tank liquid height (in feet).

b. <u>Attempting active pressure management using a slight negative vacuum on the tank headspace</u>

When Alyeska determined that the vents on this tank were damaged, Alyeska's operator reduced the pressure in the tank to a much lower-than-normal value, with the goal of maintaining a slight negative pressure to reduce emissions venting to the atmosphere.

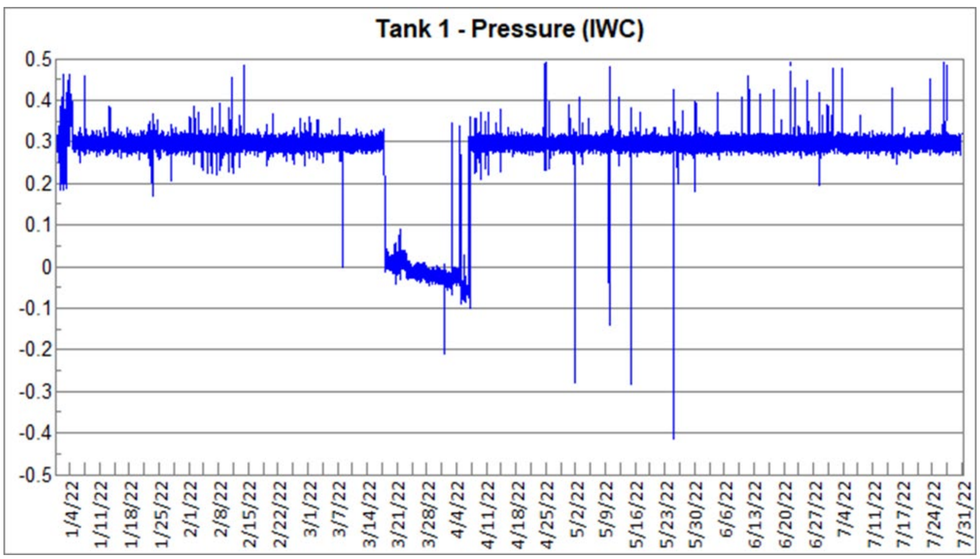
Yet eliminating emissions to the ambient air was rendered difficult for two main reasons: 1) creating a vacuum was at times unsuccessful given the configuration of the pressure management system, as evidenced by periods of positive pressure during pressure management; and 2) even when negative pressure was instituted, the damage left by the tank vents still left a pathway for emissions to escape into the ambient air due to the configuration of the pressure management system. The author describes the data for both reasons below.

i) While Alyeska attempted to institute pressure management using a slight negative vacuum, this effort was unsuccessful as shown in Figures 10 and 11, which depict how positive pressure did still occur despite the efforts to achieve negative pressure. **Positive pressure, no matter how slight, automatically**

indicates a vapor escape pathway as long as there is a damaged or broken vent on the tank.

Figure 11 provides an example to illustrate the attempted pressure management of a negative vacuum by depicting the corresponding pressure for Tank 1 in inches of water column (IWC) for the January – July 2022 time period. Normally, the tank operated with pressures around 0.3 IWC. However, the pressures were attempted to be reduced to a slight negative, as seen in the U-shaped dip in the pressure profile. Once the damaged vent(s) were repaired, tank pressures were brought back to the standard 0.3 IWC as shown in the Figure.

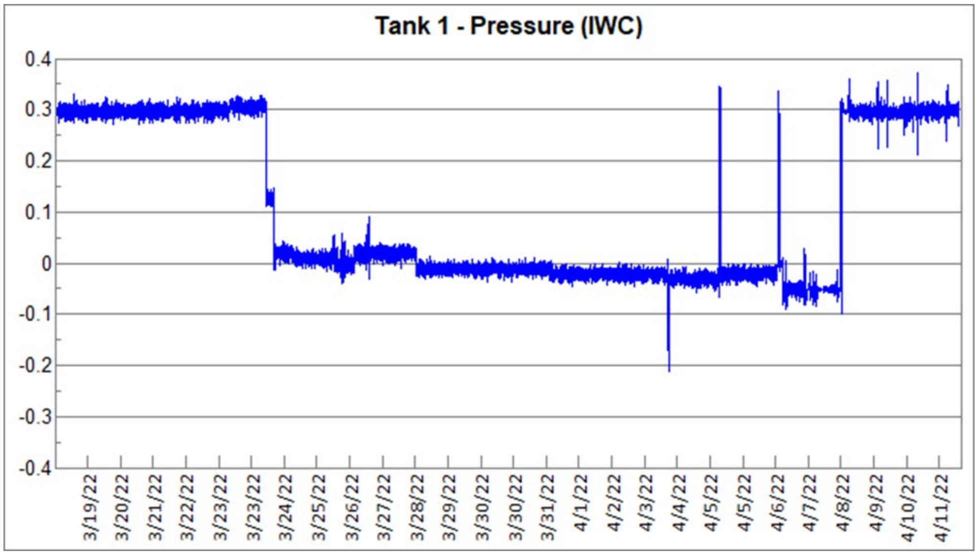
Figure 11 – Tank 1 Pressure During January – July 2022



Note: X-axis shows time (date) and Y-axis shows the tank pressure (measured in IWC).

Figure 12 shows the same data as Figure 11, with the tank pressure management time period expanded to show more detail. The start and end date/times in Figure 12 are the beginning and end of the pressure management period shown in Figure 11 previously.

Figure 12 – Tank 1 Pressure Management Detail



Note: X-axis shows time (date) and Y-axis shows the tank pressure (measured in IWC).

Figure 12 makes it clear that while the goal of pressure management was to achieve negative pressure on the tank, this was difficult to achieve in reality. This is evidenced by periods of slight positive pressure seen in Figure 12. Positive pressure indicates that emissions of vapors are escaping from within the tank to the atmosphere.

In each such instance of pressure management, it is clear that the pressure management could not and did not prevent the escape of VOC tank vapors to the atmosphere.

ii) **Tank emissions also resulted when slight negative tank pressure management was occurring if the tank had any damaged or broken vents**.

As noted earlier, each tank is very large in diameter, at 250 feet. It is estimated that the distance, along the circumference, between the vents is 30 to 40 feet. As previously mentioned, vapor outlet and inlet piping are all located in a central location on one side of the tank.

Pressure management, relying on the single measurement point in each tank opposite from the vapor outlet/inlet piping, is rendered difficult because of the large distances between the measurement location and the vents. As a metaphor, imagine trying to vacuum a pile of dust at the end of the hallway opposite the vacuum machine – it is extremely difficult to achieve unless the vacuum is located closer to the pile of dust. Likewise, this is the same case for the pressure management in this situation. Damaged vents opposite the central location of the pressure management system on the tanks provided an emissions pathway regardless of the negative pressure management instituted.

As further evidence for concern on the pressure management system design basis, as noted previously, the vapor outlet responsible for removing vapors from the tank via a 30-inch diameter vapor recovery line is positioned very close to the thief hatch. Thus, the measurements for each tank were taken via this single measurement location in close proximity to an outlet that was actively attempting to pull gases from the tank.

Given the thief hatch's location, the measurements are not necessarily representative of the entire tank headspace. It is entirely conceivable that vapors could be at positive pressure throughout the entire tank and escaping to ambient air, even when the thief hatch measurements indicate a negative pressure.

In other words, the measurable "reach" of the negative pressure at one location does not extend to the entire vapor space of the tank. **As a result, even if the pressure gauge was slightly negative, that does not ensure that vapors could not escape via a broken or damaged vent that is located at considerable distance away along the circumference of the tank.**

As further evidence, the fact that emissions occurred even when a tank was under negative pressure is documented. Consider this example from a terminal document:[7]

> "…3/13/2022, H vent valve was completely ripped off. HCC shoveled path to H's port. Put full face respirators on down at truck. Wind was blowing about 30 mph. Walked up gangway <u>and meters were chirping. PV confirmed tank vapor space was a slight negative…</u> Had to shovel a bit more snow (about 10 mins) to get the plug in. Line attendant gave us an extra 3' in the line which turned it into a fall arrest system. Installed plug tightened by hand. Then tightened with crescent. Couldn't tie off plug to anything, so left rope coiled in cavity. LEL and VOCs instantly dropped to <u>near zero</u> once plug was in place. HCC has to do a bit more shoveling in order for us to access port, so we can blind it. Toxirae Pro PID 732 total VOC readings, peak: 212 ppm; TWA: 3 ppm; STEL: .7 ppm. LDAR peaked at 16% LEL, I believe. Note: <u>meters</u>

[7] Page 38 of 72, WO Operation 221007906-20, OMS, 54-TK-2, Damaged and leaking vacuum vent valves, no WO actual start date listed.

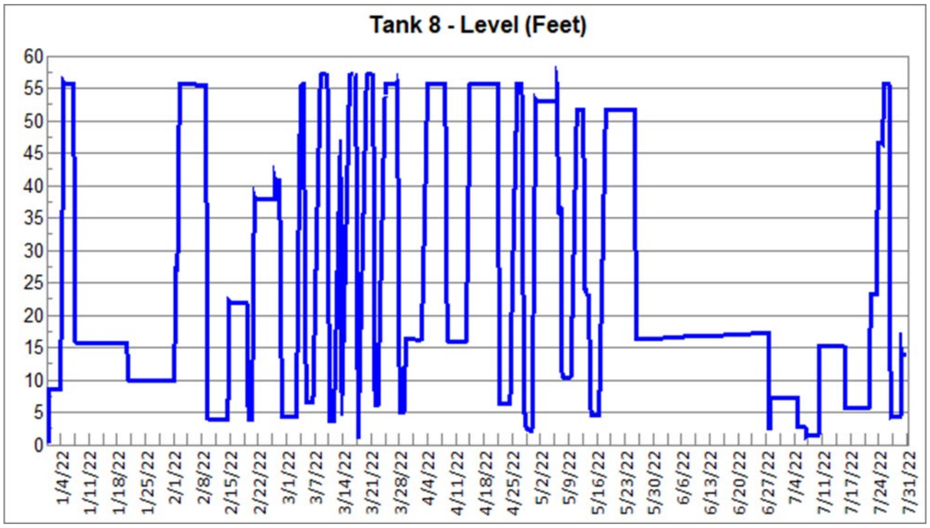
> chirping on tank top while slight negative pressure in tank, VOC peaked at 212 ppm and LEL peaked at 16% LEL " [emphasis added].

It is critical to note that pressure management of these systems is ultimately constrained by how much negative pressure a terminal operator could impose on a tank in order to keep all vapors within the tank, particularly in this case with broken/damaged vents. Trying to maintain too large a negative pressure or vacuum on the tank would mean that ambient air – and oxygen – would then enter the tank via the broken and damaged vents. This, of course, would present a safety hazard if too much oxygen infiltrates into the vapor space, potentially causing a flammable condition.

This constraint is more fully explored in a separate consultant report by Taku Engineering, LLC, titled "Crude Oil Storage Tank Vent Snow Damage," and dated June 2023, which concludes that even with the tank pressure management used during the snow removal/damage period, **that potential worker safety hazards could have occurred as a result of oxygen introduction into the tanks**. Unfortunately, given that a single oxygen measurement at the combined vapor header may be a fundamental design flaw, actual oxygen levels in each tank are not known.

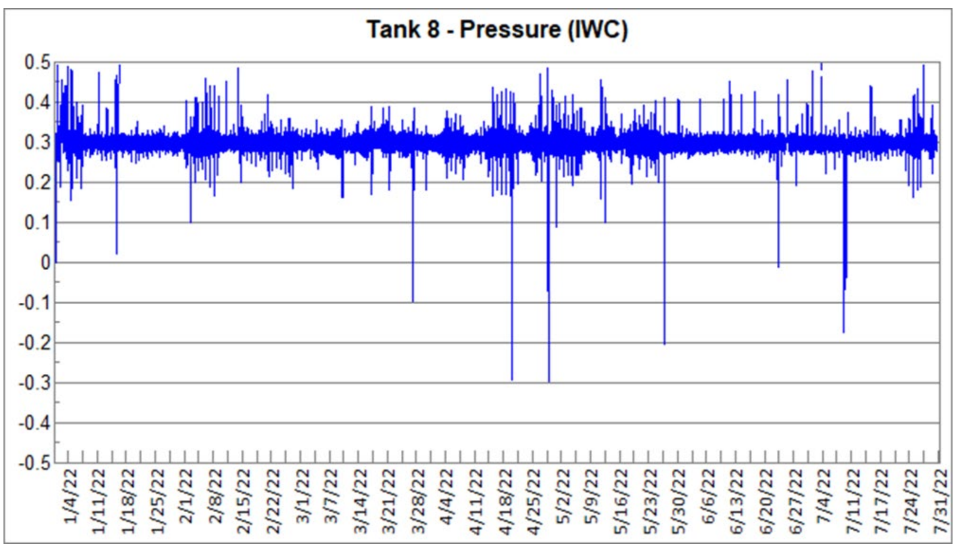
To close the discussion, Figures 13 and 14 show the liquid level and pressures in Tank 8. While Tank 8 vents supposedly did not leak even though some were damaged, as seen in Figure 7, there was no pressure management. The tank pressure was maintained at 0.3 IWC and liquid levels rose and fell as the tank was filled (from the pipeline) and emptied (into vessels), as needed. Even though the author did not include Tank 7 and 8 VOCs in these emission estimates, it is clear that there were such VOC emissions from these two tanks as well.

Figure 13 – Tank 8 Liquid Levels During January – July 2022



Note: X-axis shows time (date) and Y-axis shows the tank liquid height (in feet).

Figure 14 – Tank 8 Pressures During January – July 2022



Note: X-axis shows time (date) and Y-axis shows the tank pressure (measured in IWC).

Appendix B to this report contains liquid level and tank pressure charts, similar to Figures 10, 11, 12, 13, and 14, for each of the 14 tanks.

E. Summary of Methodology: EPA TANKS 5.0 Modeling and Conservative VOC Emissions Estimate During February Through May 2022

The data shown in the charts for each tank and standard EPA emissions calculation methods were used to determine the VOC emissions during the February through May 2022 time period when the tanks were known to have damaged/broken vents. It is not known if there have been any other professional or public attempts at such an estimation. **As such, these estimates as considered preliminary.**

The preliminary VOC emissions range is from an estimated 79 to 193 tons. The lower estimate is likely far too low given the low vapor pressure used as well as the conservative assumptions made and discussed previously. This report concludes that actual emissions are likely to have been substantially more than even the high end of the estimate (i.e., 193 tons).

Nonetheless, these estimates are considered to be conservative (i.e., that actual emissions are likely to have been substantially greater than estimates shown in this section).

The reasons for why actual VOC estimates are likely to have been greater are as follows:

(i) The author's estimate only accounts for "breathing" (or "standing") losses when the tank liquid level is assumed to not be changing, such as due to filling, for example. While terminal operators stopped filling the tanks during pressure management as described in Section D and as seen in the Appendix B charts, for certain tanks and certain time periods that was not the case. As a result, there would have been some working losses with additional VOCs during such tank filling time periods. That is not included in the current estimate.

(ii) The emission estimates do not include any contributions from Tanks 7 and 8, even though they were documented to have sustained damage from this event (Figure 7).

(iii) The author's estimate only accounts for the time period of pressure management (i.e., when pressure management is known to have begun and ended, in the late February through May 2022 time period, as noted by the terminal operator); it does not account for records that indicate leaking before and after this time period.

(iv) The author's emission estimate used EPA's approach/methodology for tank emissions estimates from AP-42 as coded in TANKS Version 5.0[8] available on EPA's

[8] https://www.epa.gov/air-emissions-factors-and-quantification/tanks-emissions-estimation-software-version-5

website. There are some indications that this methodology itself, based on empirical work conducted on small-scale tanks dating back to the 1950s and 1960s, likely underestimates VOC emissions.

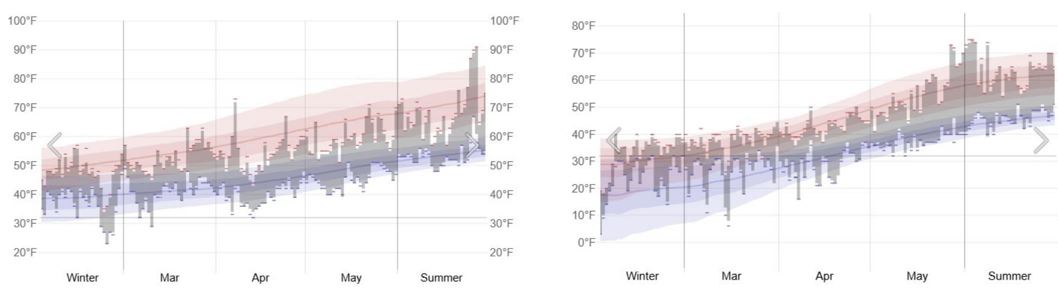
With caveats about why the emissions estimates are likely to be very conservative and that actual emissions are likely to have been substantially higher, the emission estimate used the following methodology:

(a) Used EPA TANKS 5.0 as noted above.

(b) Used tank geometry and capacity data for the tanks.

(c) Used a reasonable estimate of ambient conditions such as temperature; the EPA TANKS 5.0 Model does not have temperature settings for any Alaska cities. As such, the author used Seattle data, which had comparable temperatures to Valdez in winter 2022. See below for the respective graphs.

Figure 15



Right: Seattle Temperatures across Winter/Spring 2022; Left: Valdez Temperatures Across Winter/Spring 2022.[9]

(d) Used two different values for crude oil vapor pressure, an important input that drives the extent of VOC generation. One estimate used a value of 5.0 as the Reid Vapor Pressure (RVP), which is taken from AP-42 and is not specific to Alaska crude oils and is likely to be too low; the second used a value of 10.0, taken from an Exxon specification sheet for Alaska crudes. An excerpt of this is shown in Figure 16.

All of the documents relied upon or used in this analysis are cited in the body of the report or in footnotes. In addition, the author has also reviewed and considered numerous additional documents for context and background in order to provide his opinions.

[9] https://weatherspark.com/h/y/275/2022/Historical-Weather-during-2022-in-Valdez-Alaska-United-States

Figure 16 – Excerpt from Exxon Alaska North Slope Crude Specification

ExxonMobil

Reference: ANS17Y
Crude: Alaska North Slope

Crude Summary Report

General Information		Molecules (%wt on crude)		Whole Crude Properties	
Reference:	ANS17Y	methane + ethane	0.02	Density @ 15°C (g/cc)	0.8648
Name:	Alaska North Slope	propane	0.31	**API Gravity**	**32.1**
		isobutane	0.60	Total Sulfur (% wt)	0.96
Origin:	Alaska	n-butane	2.14	Pour Point (°C)	-49
		isopentane	1.06	Viscosity @ 20°C (cSt)	11.1
Assay Date:	8/15/2017	n-pentane	1.49	Viscosity @ 40°C (cSt)	6.4
		cyclopentane	0.19	Nickel (ppm)	11.6
Comments:		C6 paraffins	2.16	Vanadium (ppm)	27.7
		C6 naphthenes	1.34	Total Nitrogen (ppm)	1720
		benzene	0.35	Total Acid Number (mgKOH/g)	0.20
		C7 paraffins	1.88	Mercaptan Sulfur (ppm)	3.9
		C7 naphthenes	2.15	Hydrogen Sulfide (ppm)	0.0
		toluene	0.86	Reid Vapor Pressure (kPa)	73.0

The RVP of 73 kPa is 10.59 psi. We used 10.0 in the second set of VOC calculations.

(e) The TANKS calculations were done for the months of February, March, April, and May in 2022, while VMT records suggest leaks certainly predated the initial identified in late February 2022 and leaks continued well after May 2022.

Finally, Figures 17 and 18 show the two estimates of VOC emissions, for RVP = 5 and RVP = 10 vapor pressures, respectively.

Figure 17 – Preliminary VOC Estimate Using RVP = 5.0

RVP=5.0 Calcs

	Number of Leaking Days (All Tanks)	Average Daily Emissions (lb/day)	Emissions Total (lb)	
February - All Tanks	7	353	2471	
March - All Tanks	227.5	486	110672	
April - All Tanks	34	718	24427	
May - All Tanks	21	955	20052	
All			157621	pounds
All			**79**	tons

1. Since this only includes periods of pressure management, how long were the vents damaged/leaking before
Earliest Start Date of 2/25/2022
1a. In the pre-pressure management time period, there would be both breathing and working losses.
2. How long did leaks continue after
Last End Date of 5/21/2022

Figure 18 – Preliminary VOC Estimate Using RVP = 10.0

RVP=10 Calcs

	Number of Leaking Days (All Tanks)	Average Daily Emissions (lb/day)	Emissions Total (lb)	
February - All Tanks	7	861	6026	
March - All Tanks	227.5	1182	269004	
April - All Tanks	34	1772	60252	
May - All Tanks	21	2454	51538	
All			386819	pounds
All			**193**	tons

1. Since this only includes periods of pressure management, how long were the vents damaged/leaking before
Earliest Start Date of 2/25/2022
1a. In the pre-pressure management time period, there would be both breathing and working losses.
2. How long did leaks continue after
Last End Date of 5/21/2022

As Figures 17 and 18 show, the preliminary conservative VOC emission estimates range from an estimated 79 to 193 tons, with the actual emissions likely being substantially more than 193 tons.

Appendix A

Biographical Summary

Dr. Ranajit (Ron) Sahu has over 32 years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over 30 years of project management experience and has successfully managed and executed hundreds of projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

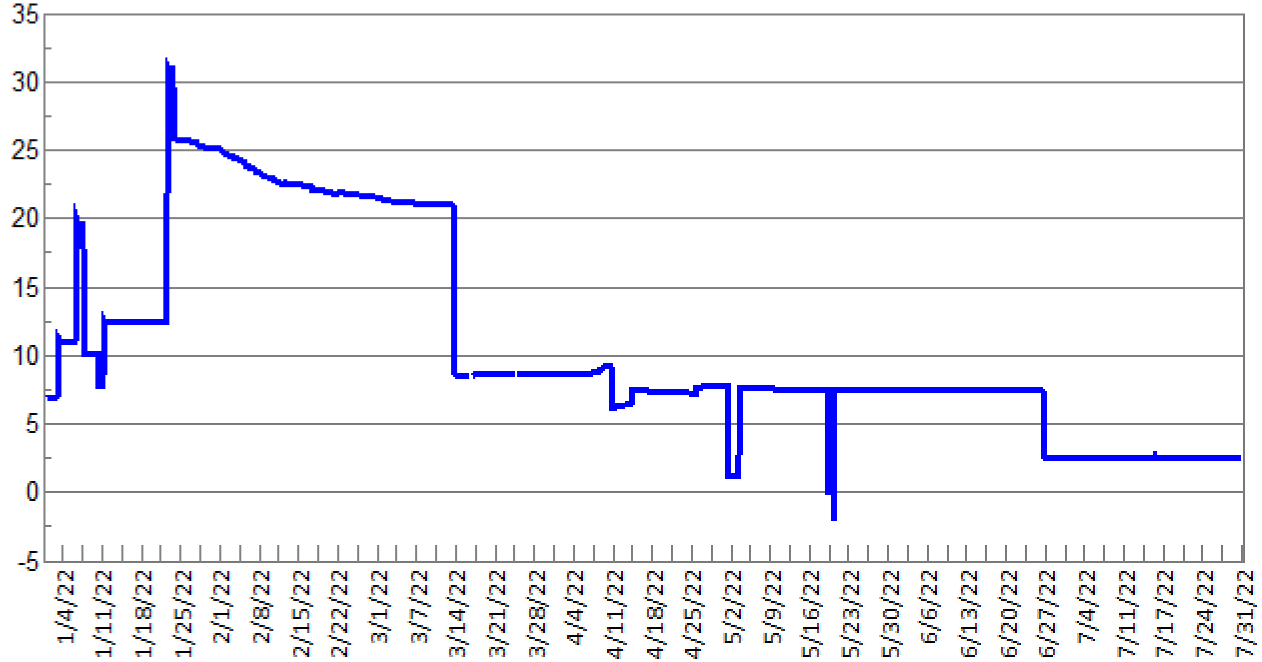
He has provided consulting services to numerous private sector, public sector, and public interest group clients. His major clients over the past three decades include various trade associations as well as individual companies such as steel mills, petroleum refineries, chemical plants, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, land development companies, and various entities in the public sector including EPA, the U.S. Dept. of Justice, several states (including New York, New Jersey, Connecticut, Kansas, Oregon, New Mexico, Pennsylvania, and others), various agencies such as the California DTSC, and various cities and municipalities. Dr. Sahu has executed projects in all 50 U.S. states, numerous local jurisdictions, and internationally.

In addition to consulting, for approximately two decades, Dr. Sahu taught numerous courses in several southern California universities as an adjunct faculty, including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management). He also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls), and at California State University, Fullerton (transportation and air quality).

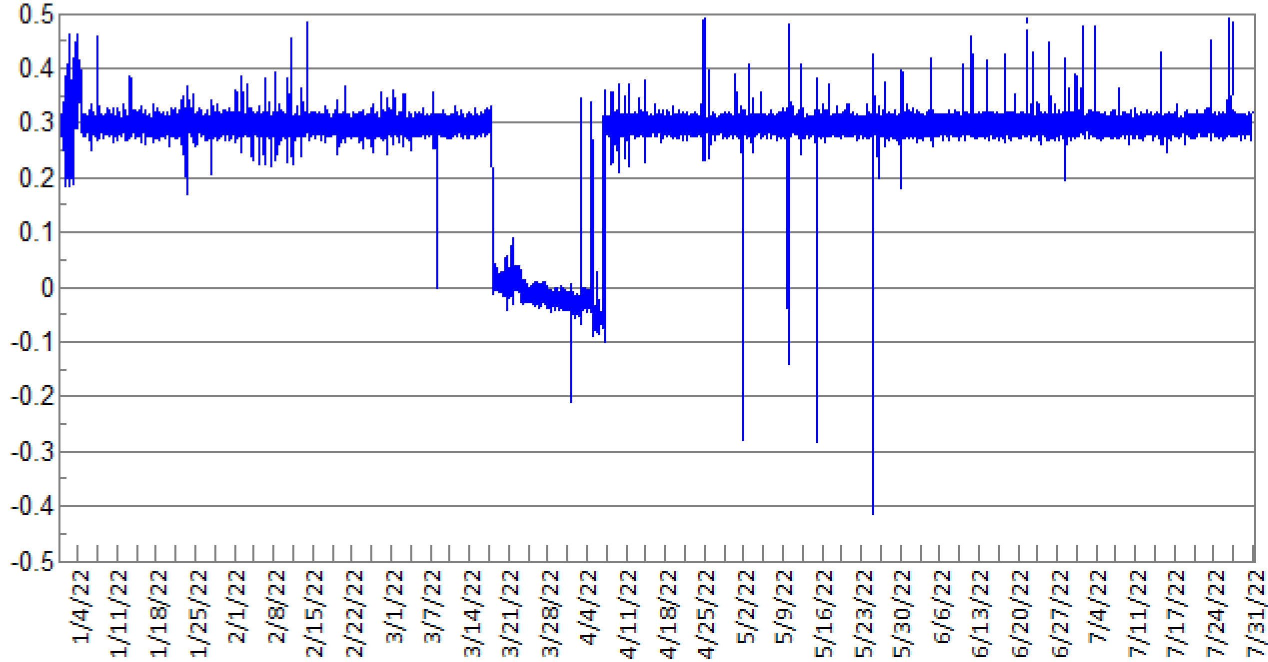
Dr. Sahu has and continues to provide expert witness services in a number of environmental and engineering areas discussed above in both state and federal courts as well as before administrative bodies.

Appendix B

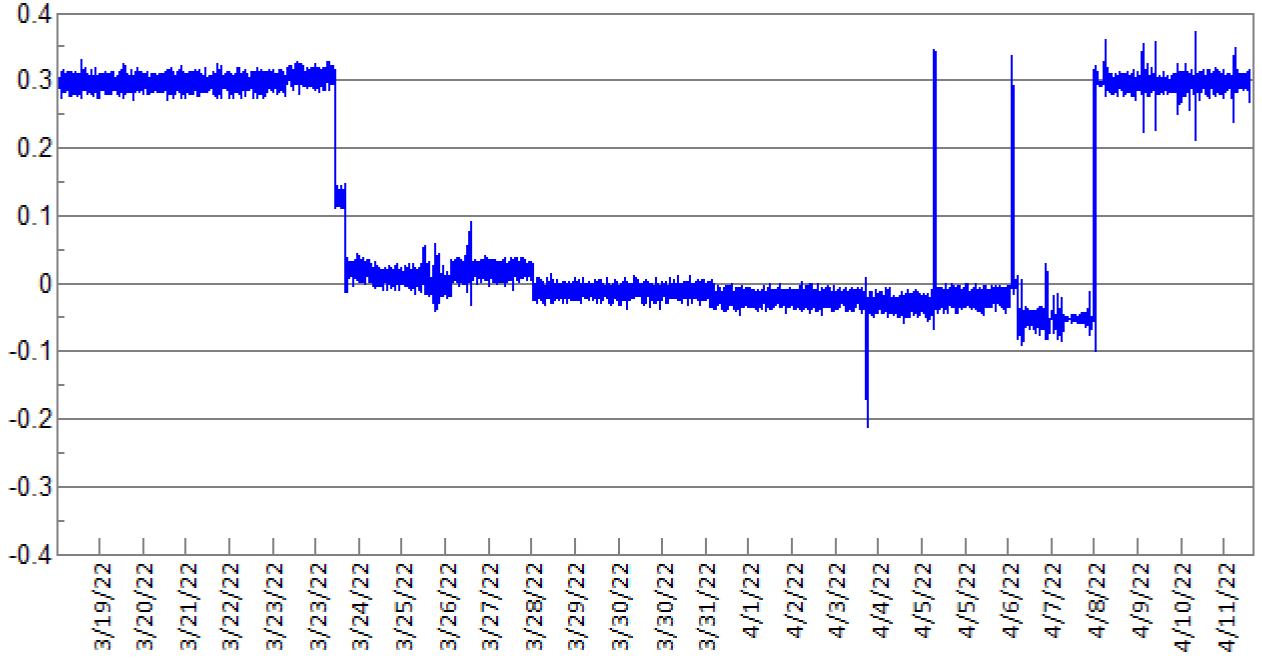
Tank Level and Pressure Charts



Tank 1 - Level (Feet)



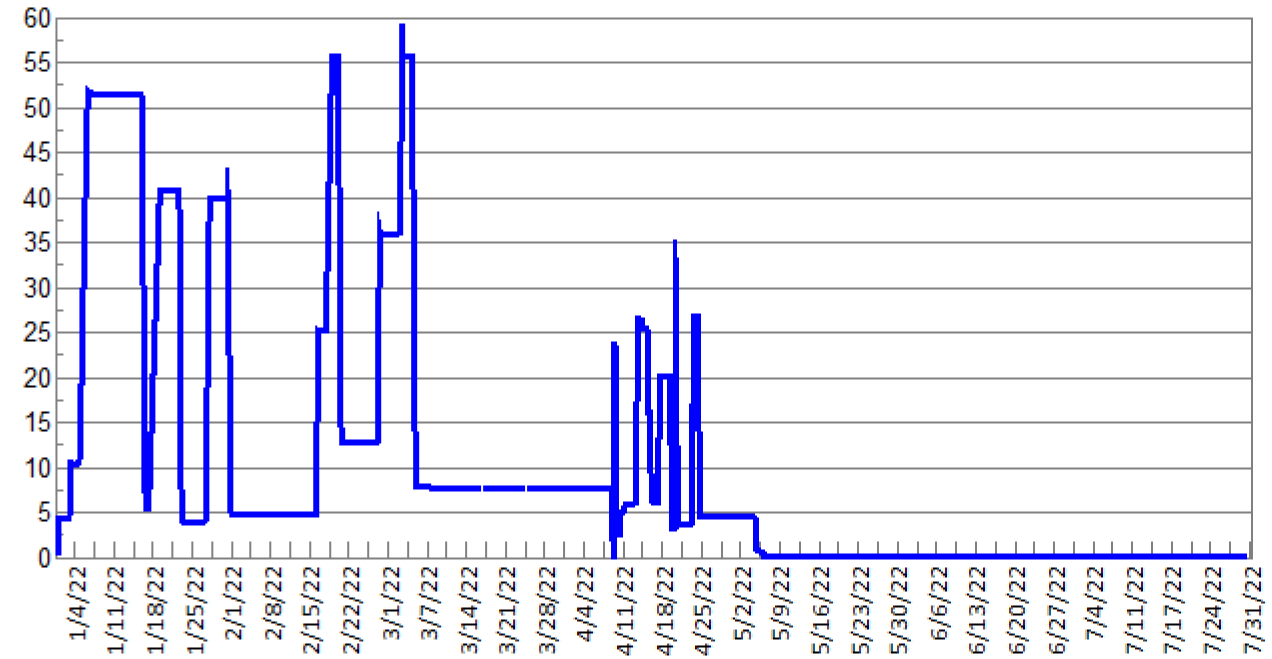
Tank 1 - Pressure (IWC)



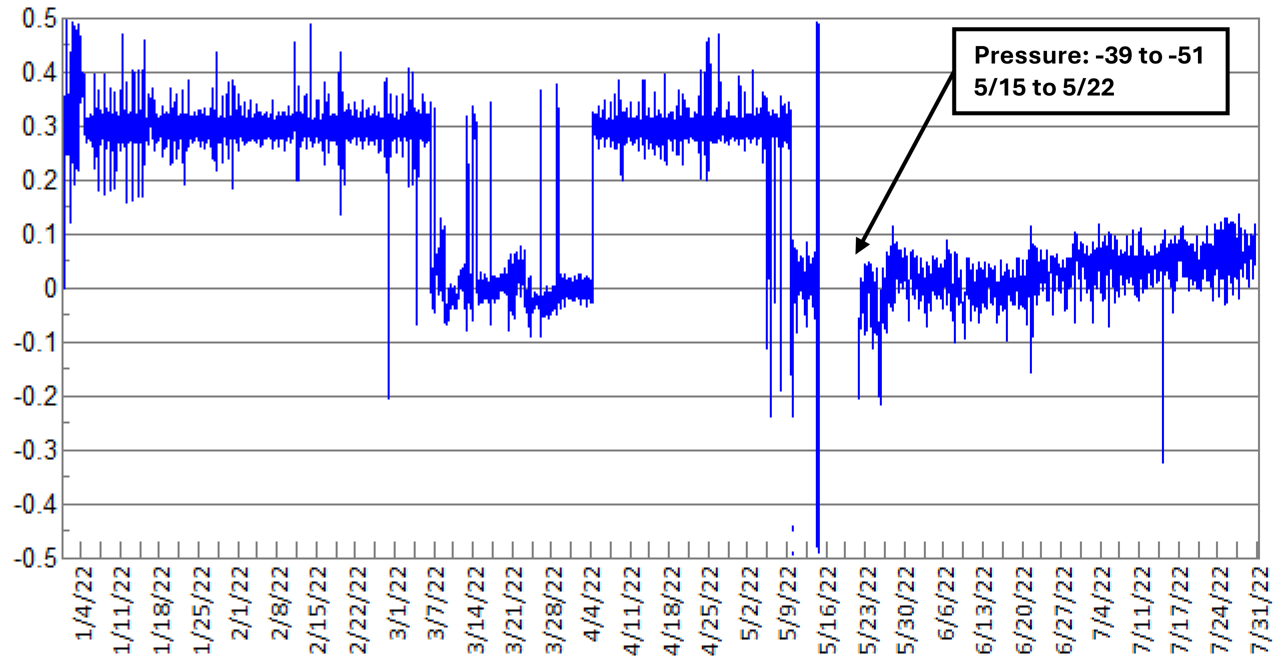
Tank 1 - Pressure (IWC)

NOTE (for graphs show on pages 35-49):
X-axis shows time (date)
Y-axis shows tank pressure, measured in inches of water column (IWC)

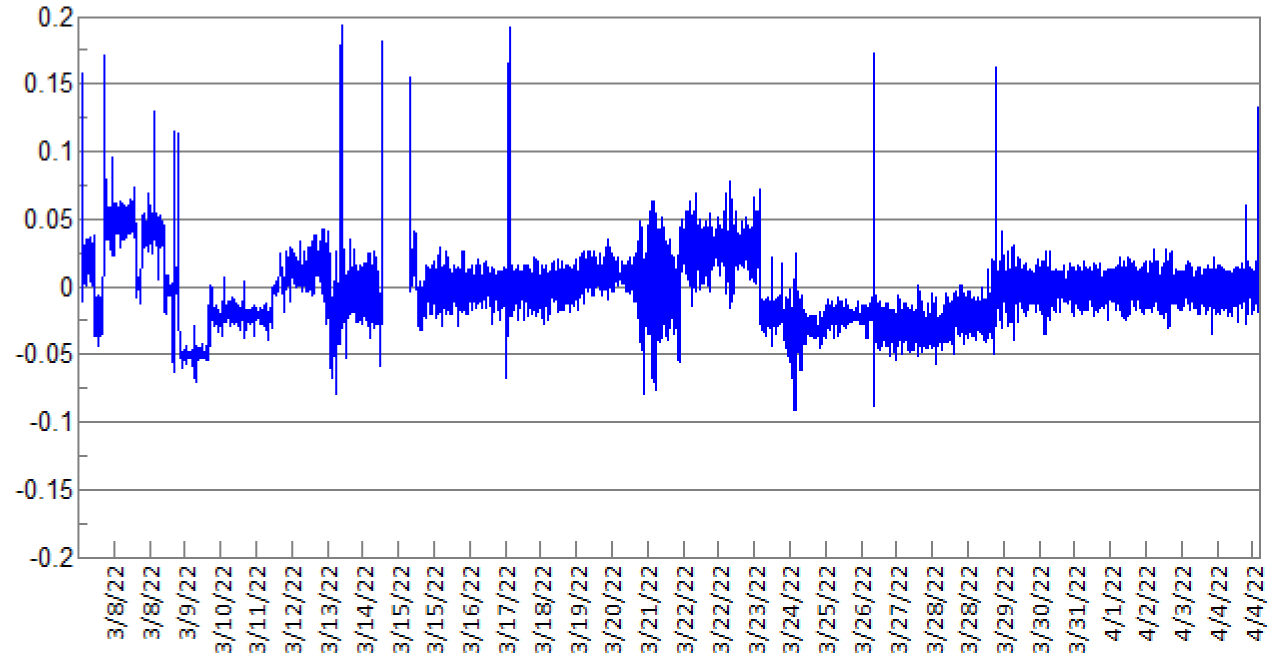
Tank 2 - Level (Feet)



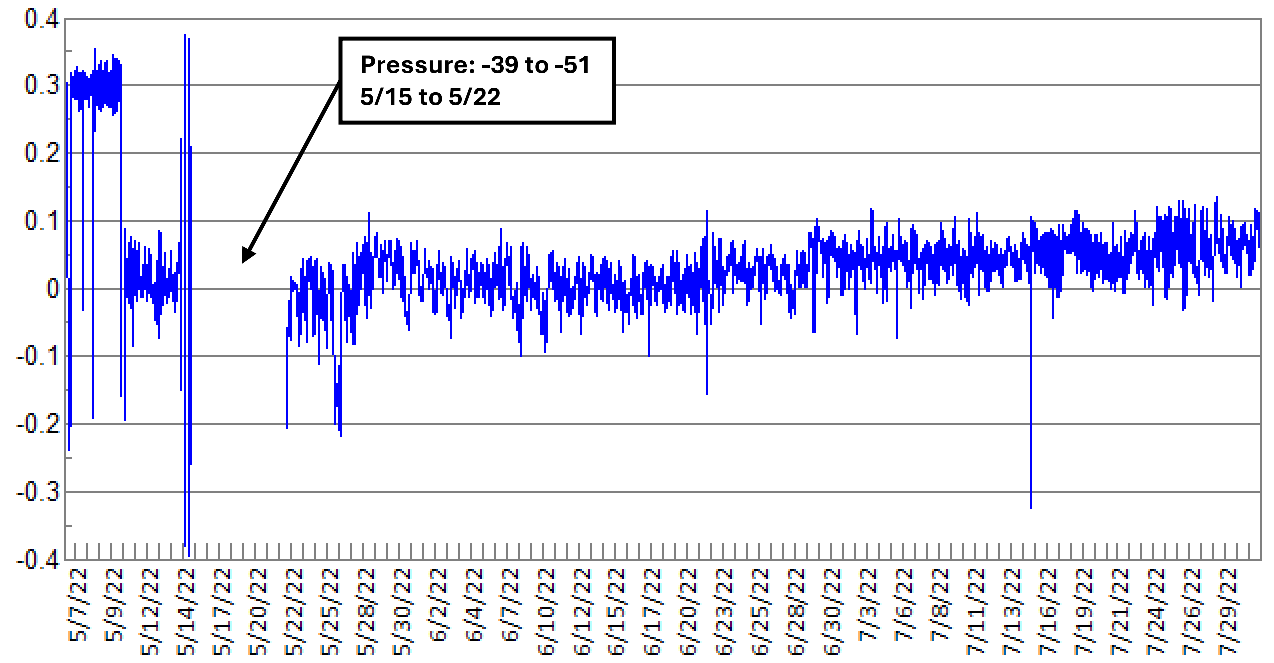
Tank 2 - Pressure (IWC)

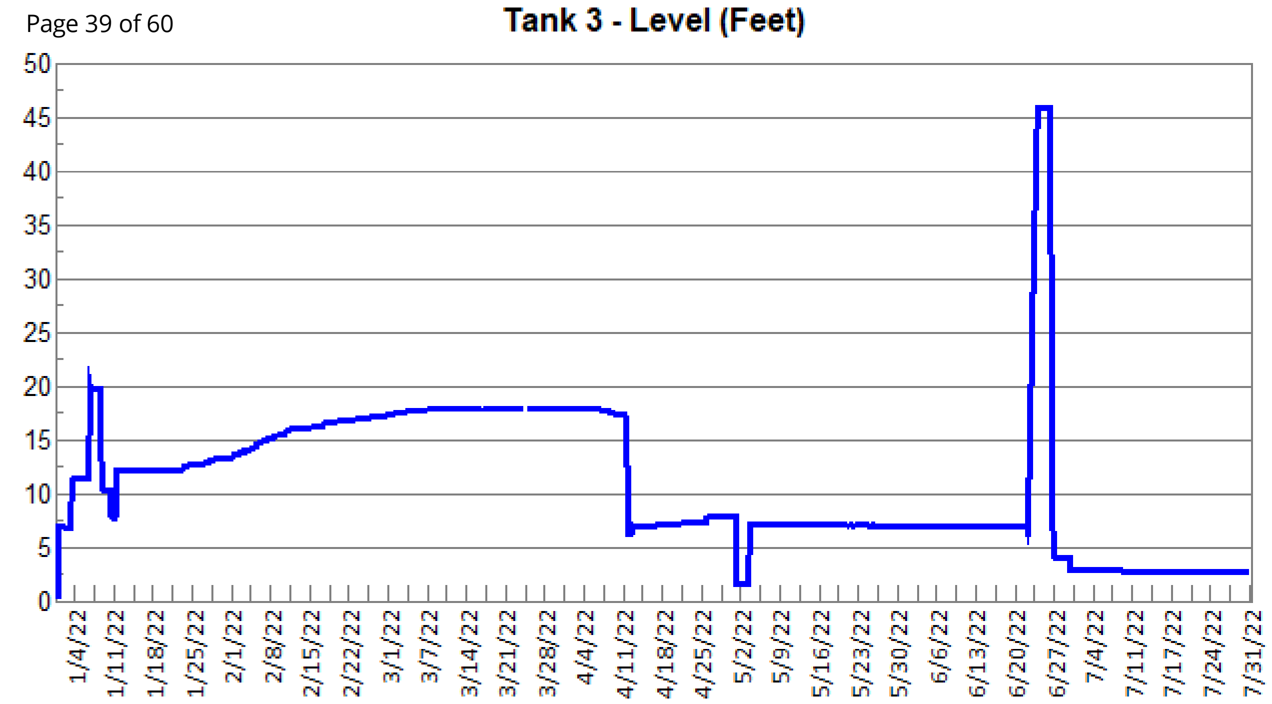


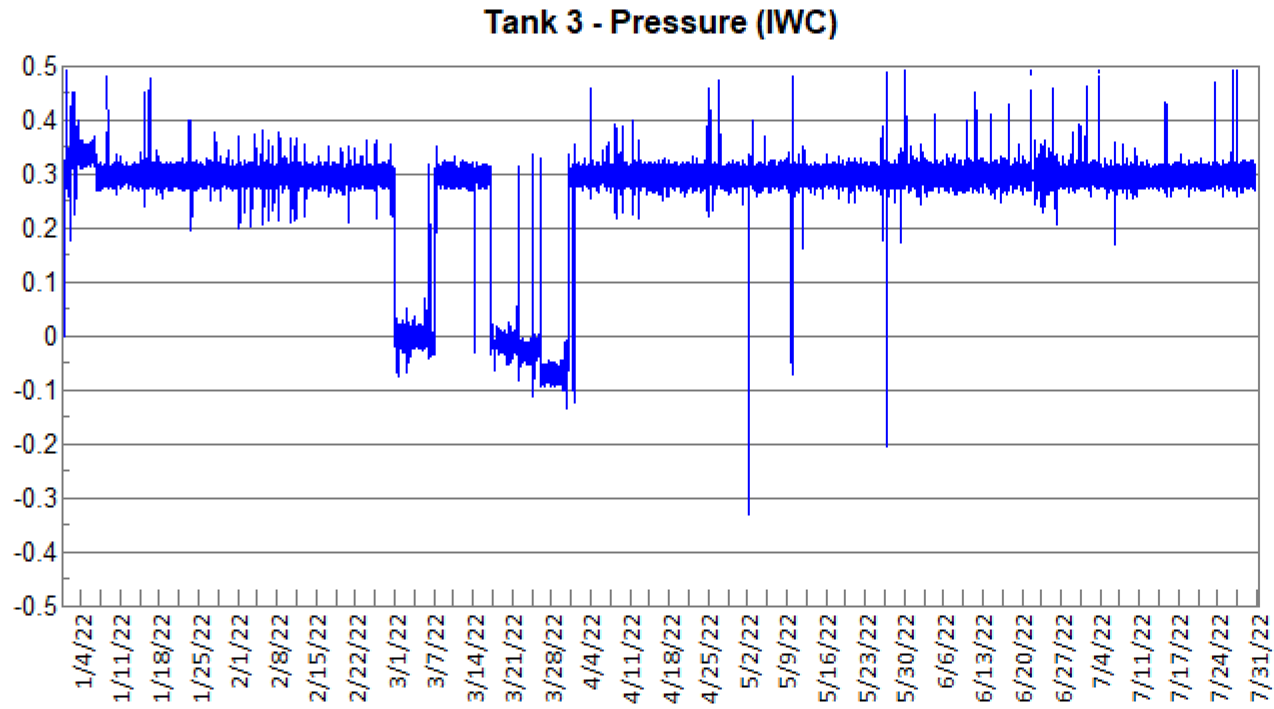
Tank 2 - Pressure (IWC)

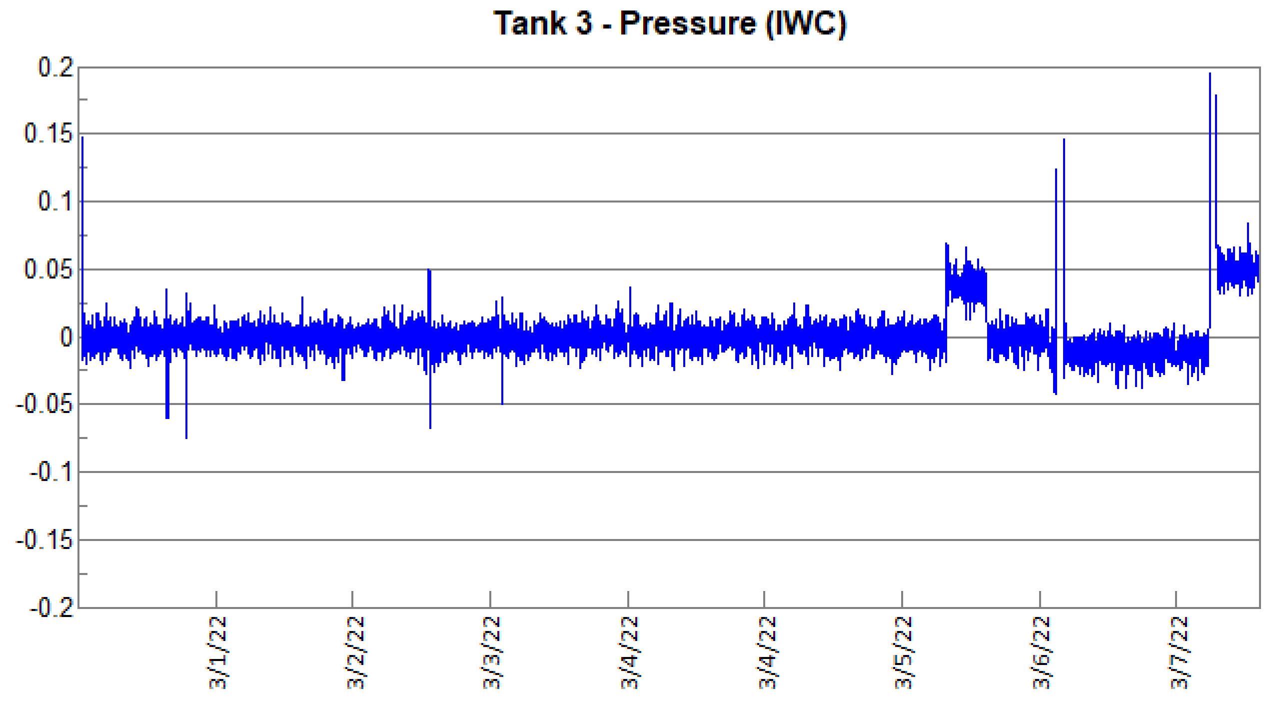


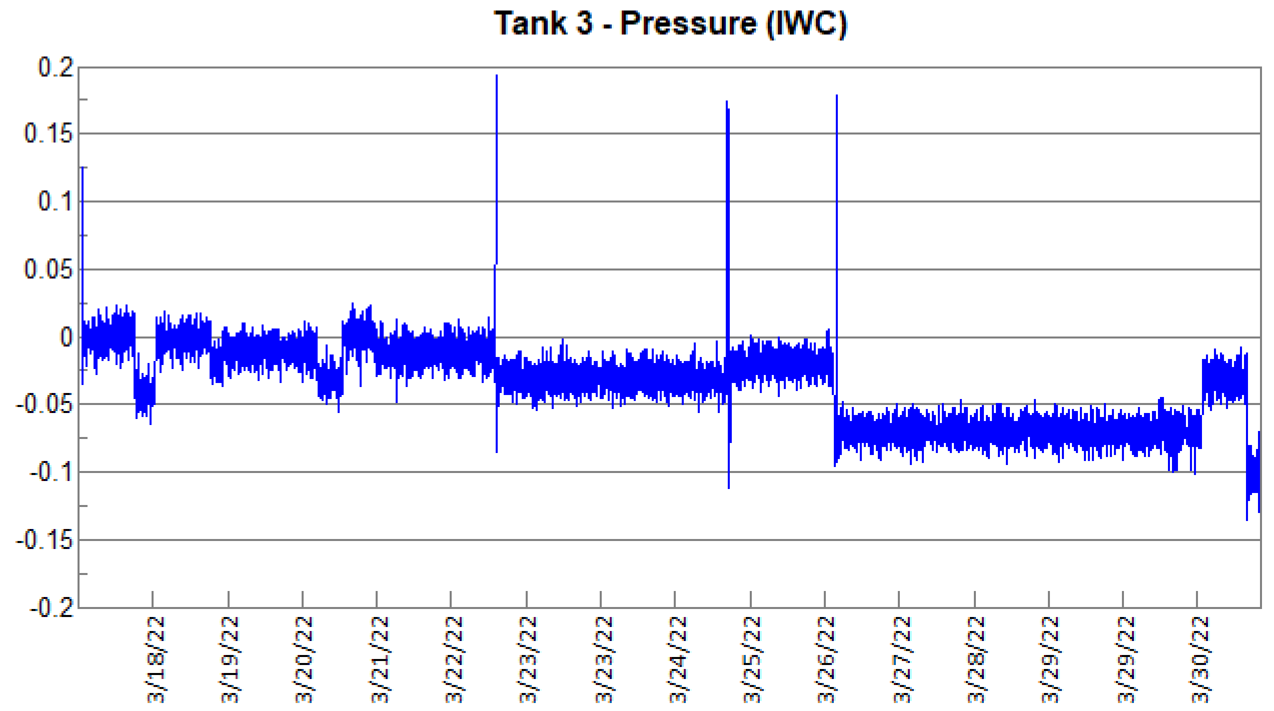
Tank 2 - Pressure (IWC)



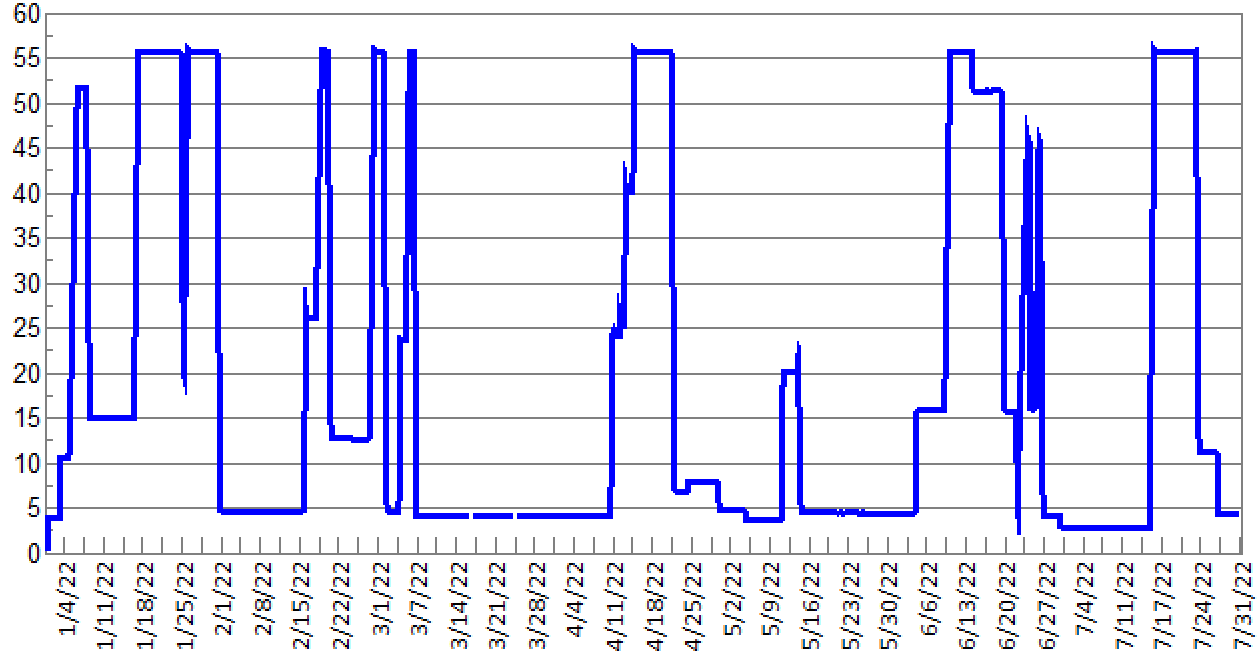

Tank 3 - Level (Feet)
50 45 40 35 30 25 20 15 10 5 0
1/4/22 1/11/22 1/18/22 1/25/22 2/1/22 2/8/22 2/15/22 2/22/22 3/1/22 3/7/22 3/14/22 3/21/22 3/28/22 4/4/22 4/11/22 4/18/22 4/25/22 5/2/22 5/9/22 5/16/22 5/23/22 5/30/22 6/6/22 6/13/22 6/20/22 6/27/22 7/4/22 7/11/22 7/17/22 7/24/22 7/31/22


Tank 3 - Pressure (IWC)
0.5 0.4 0.3 0.2 0.1 0 -0.1 -0.2 -0.3 -0.4 -0.5
1/4/22 1/11/22 1/18/22 1/25/22 2/1/22 2/8/22 2/15/22 2/22/22 3/1/22 3/7/22 3/14/22 3/21/22 3/28/22 4/4/22 4/11/22 4/18/22 4/25/22 5/2/22 5/9/22 5/16/22 5/23/22 5/30/22 6/6/22 6/13/22 6/20/22 6/27/22 7/4/22 7/11/22 7/17/22 7/24/22 7/31/22

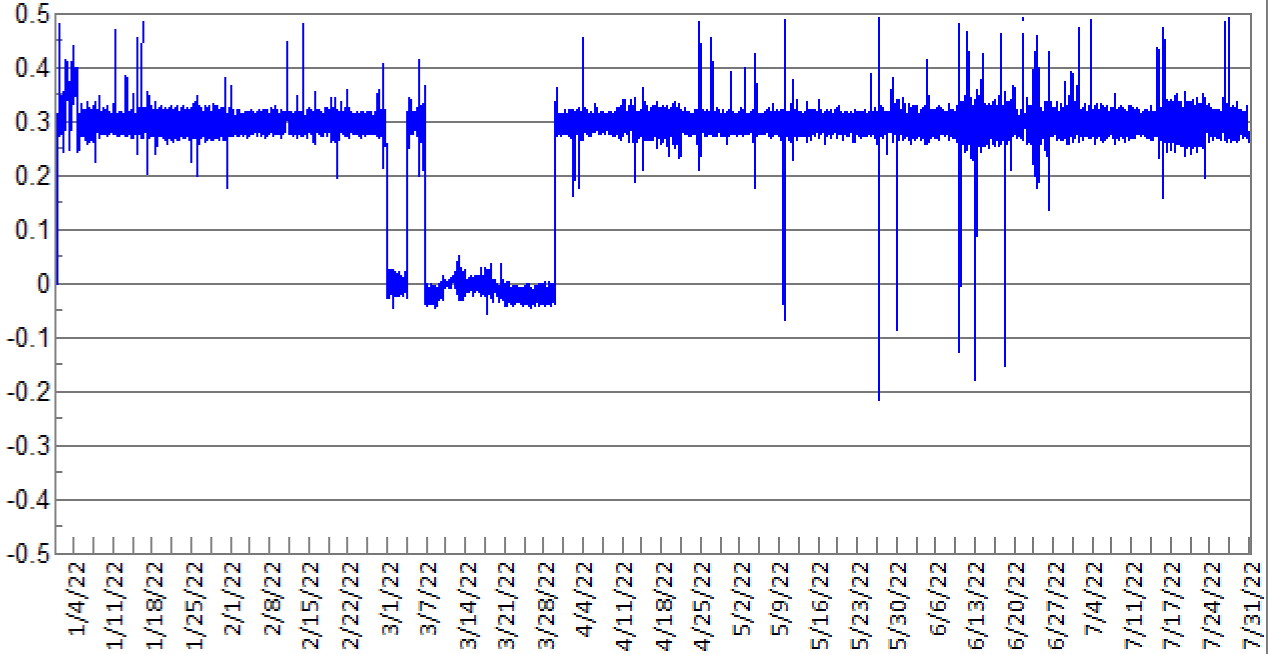

Tank 3 - Pressure (IWC)
0.2 0.15 0.1 0.05 0 -0.05 -0.1 -0.15 -0.2
3/1/22 3/2/22 3/3/22 3/4/22 3/4/22 3/5/22 3/6/22 3/7/22


Tank 3 - Pressure (IWC)
0.2 0.15 0.1 0.05 0 -0.05 -0.1 -0.15 -0.2
3/18/22 3/19/22 3/20/22 3/21/22 3/22/22 3/23/22 3/23/22 3/24/22 3/25/22 3/26/22 3/27/22 3/28/22 3/29/22 3/29/22 3/30/22

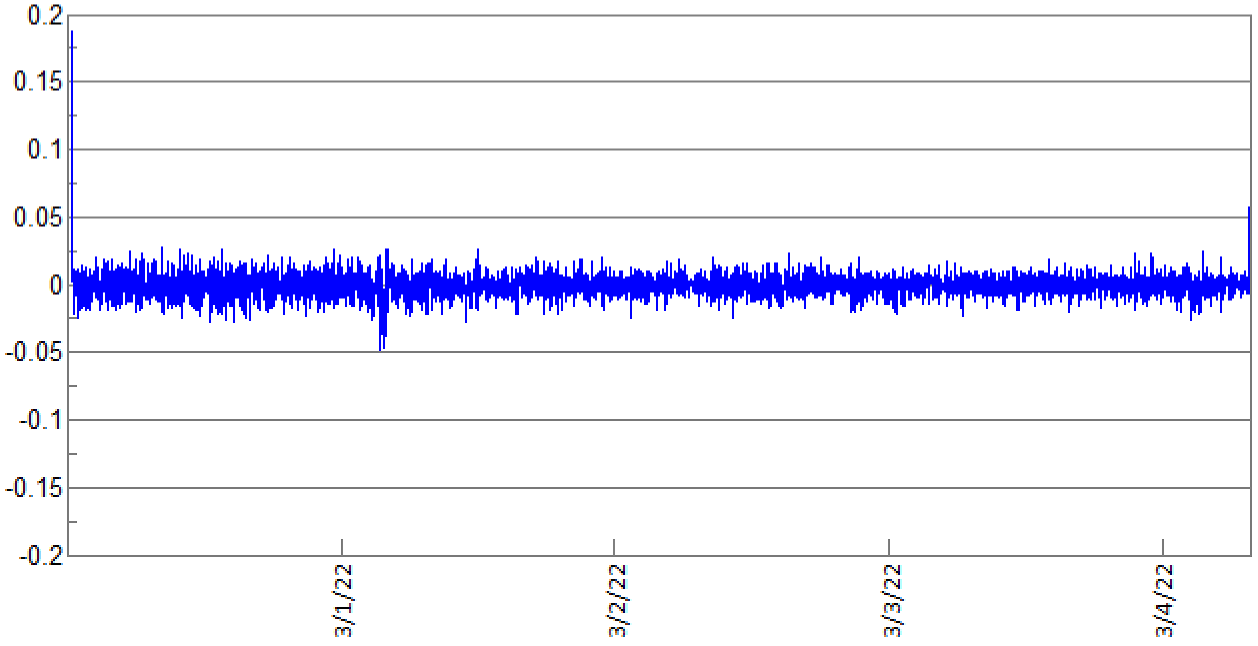
Tank 4 - Level (Feet)



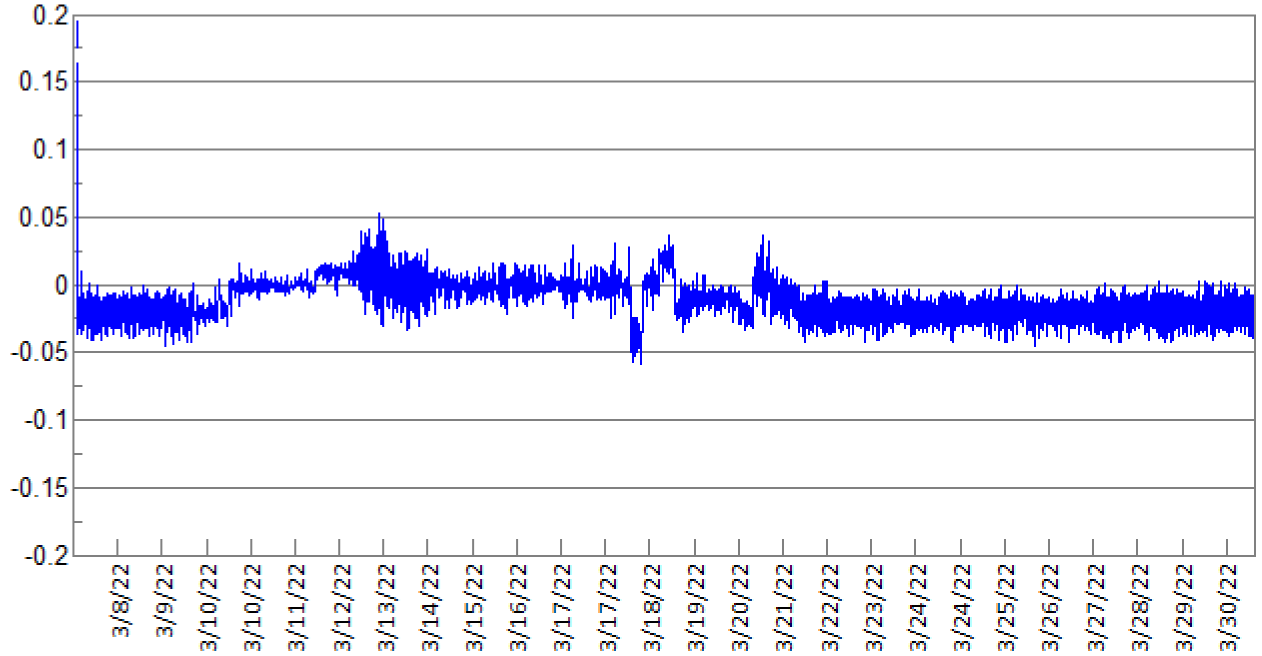
Tank 4 - Pressure (IWC)



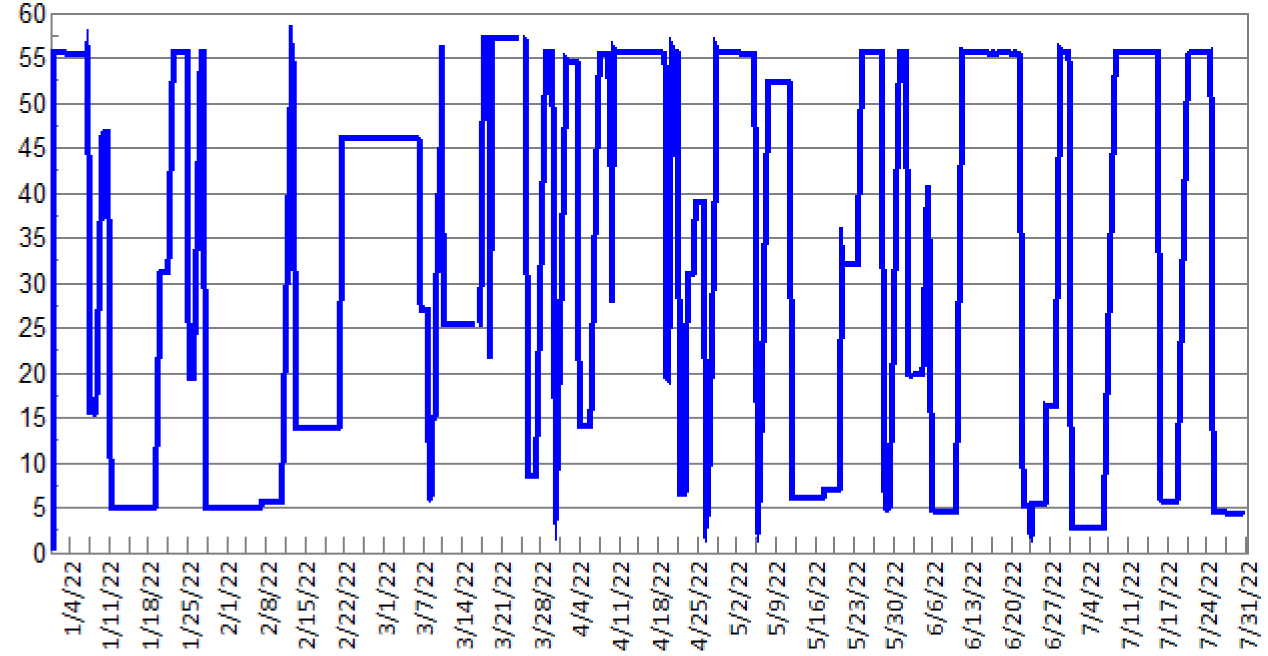
Tank 4 - Pressure (IWC)



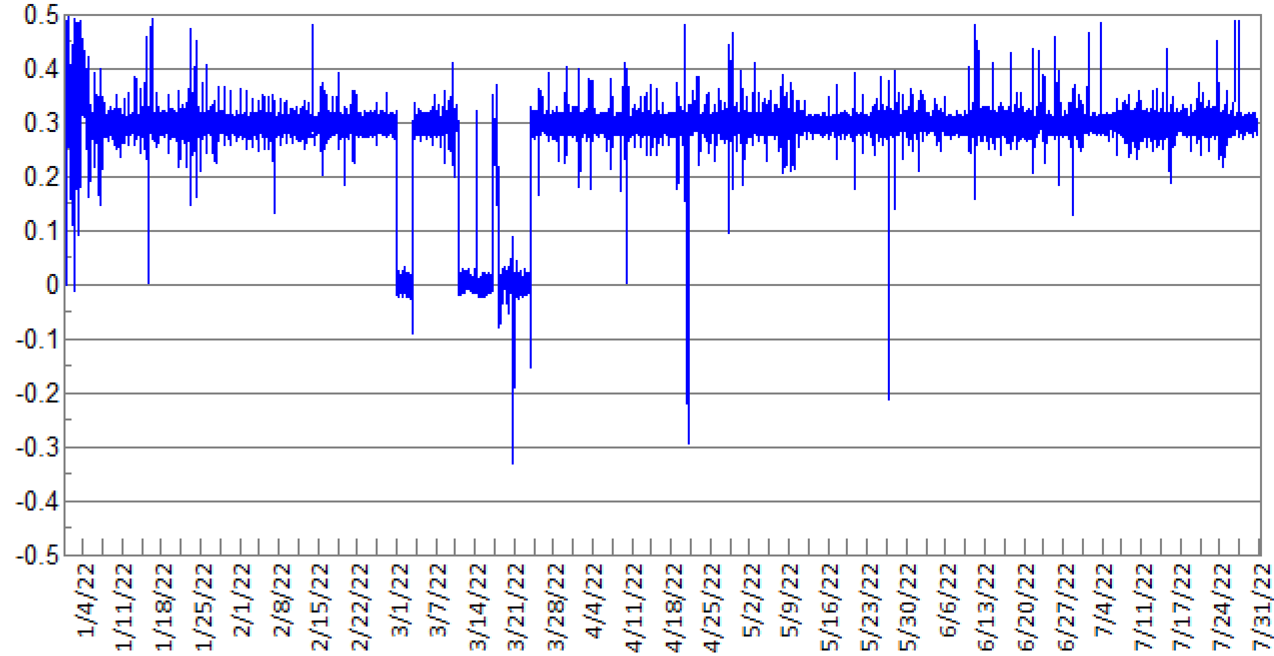
Tank 4 - Pressure (IWC)



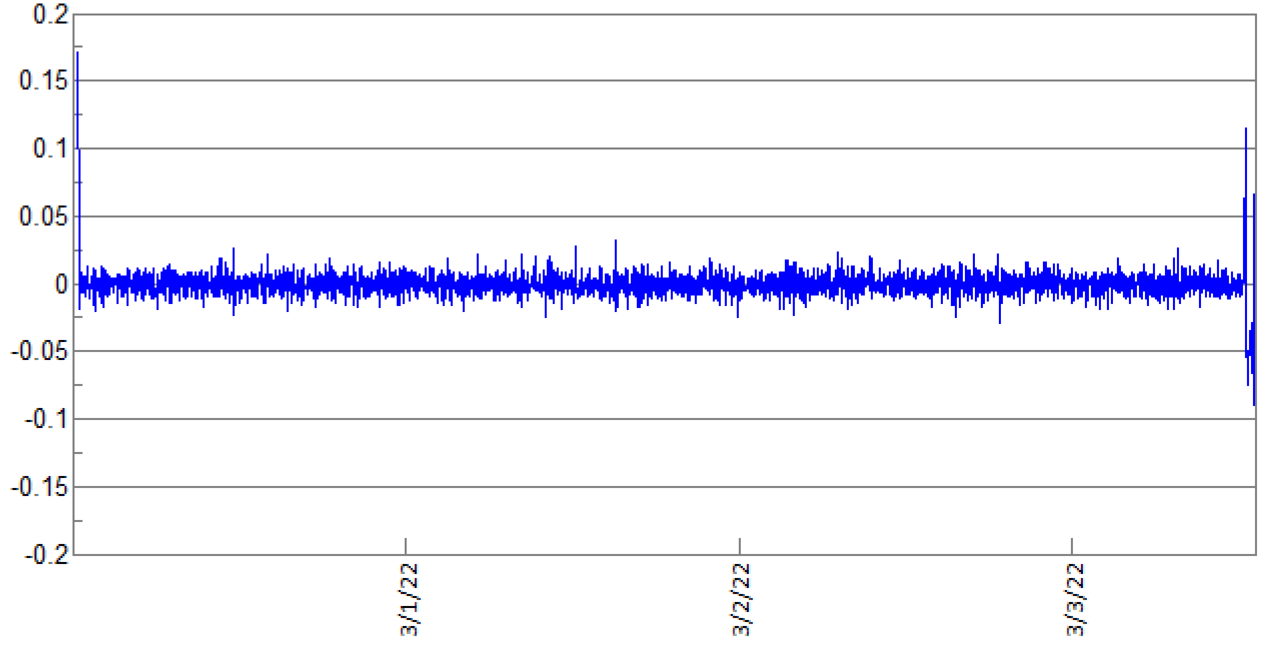
Tank 5 - Level (Feet)



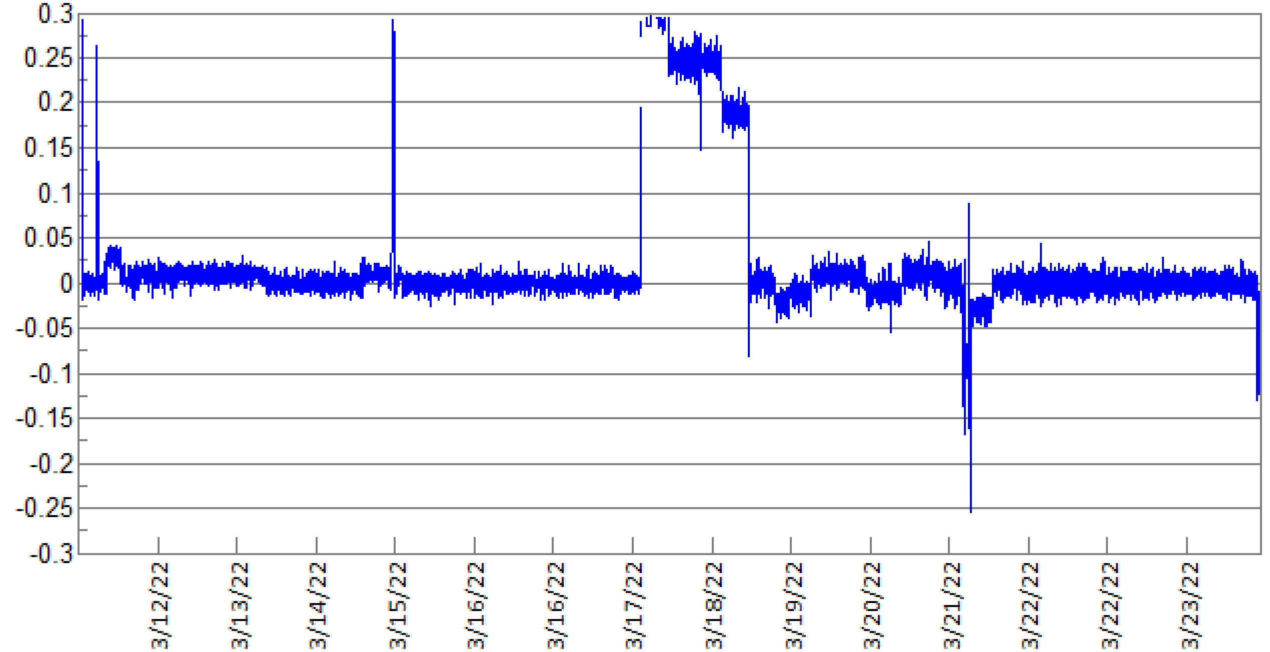
Tank 5 - Pressure (IWC)

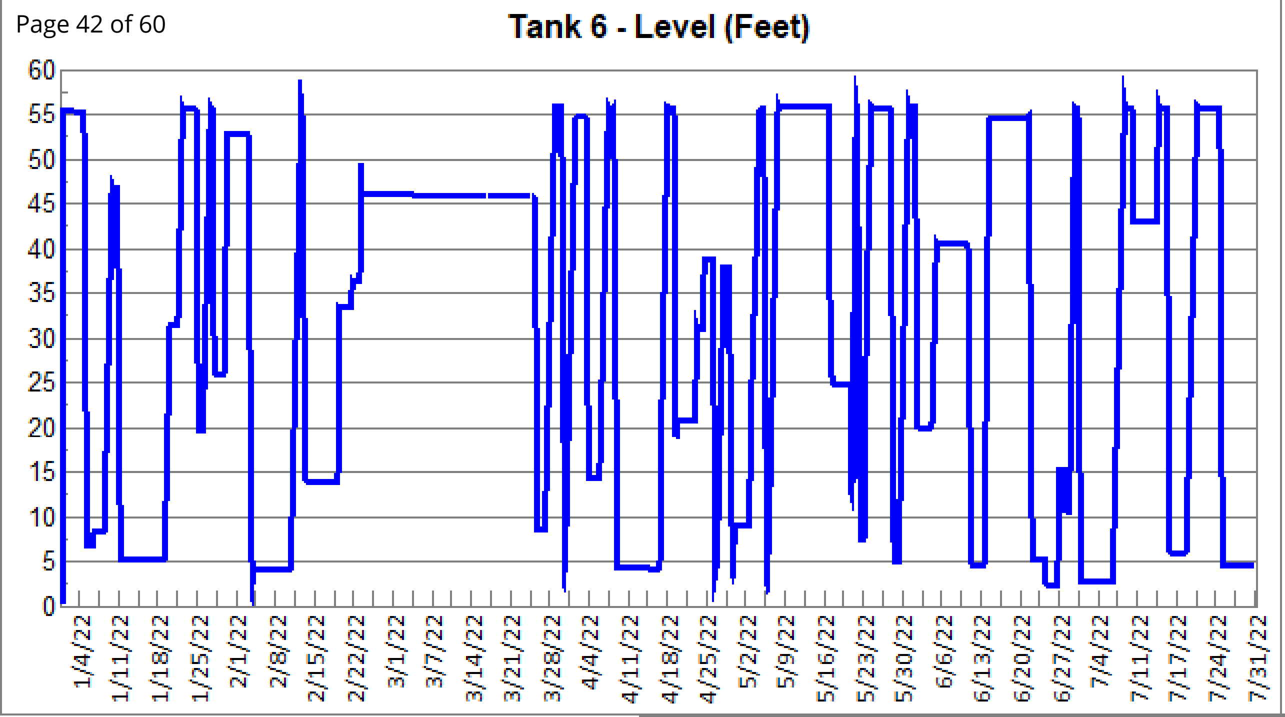


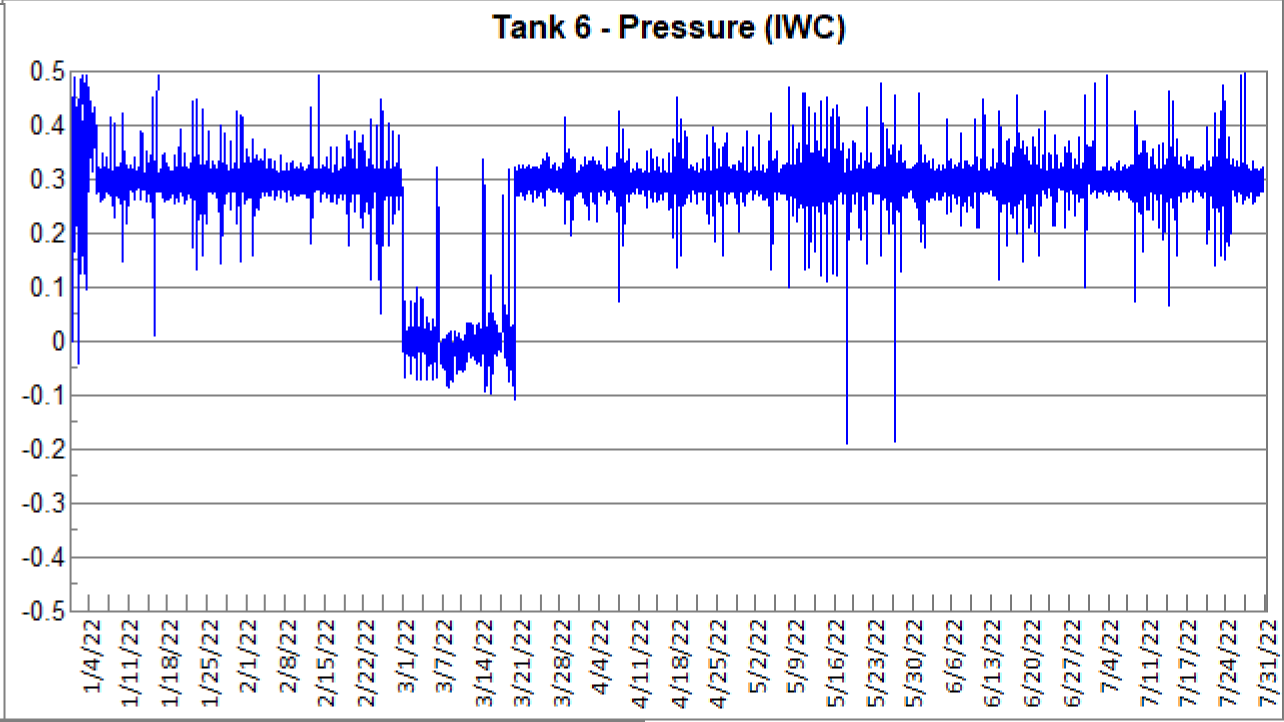
Tank 5 - Pressure (IWC)

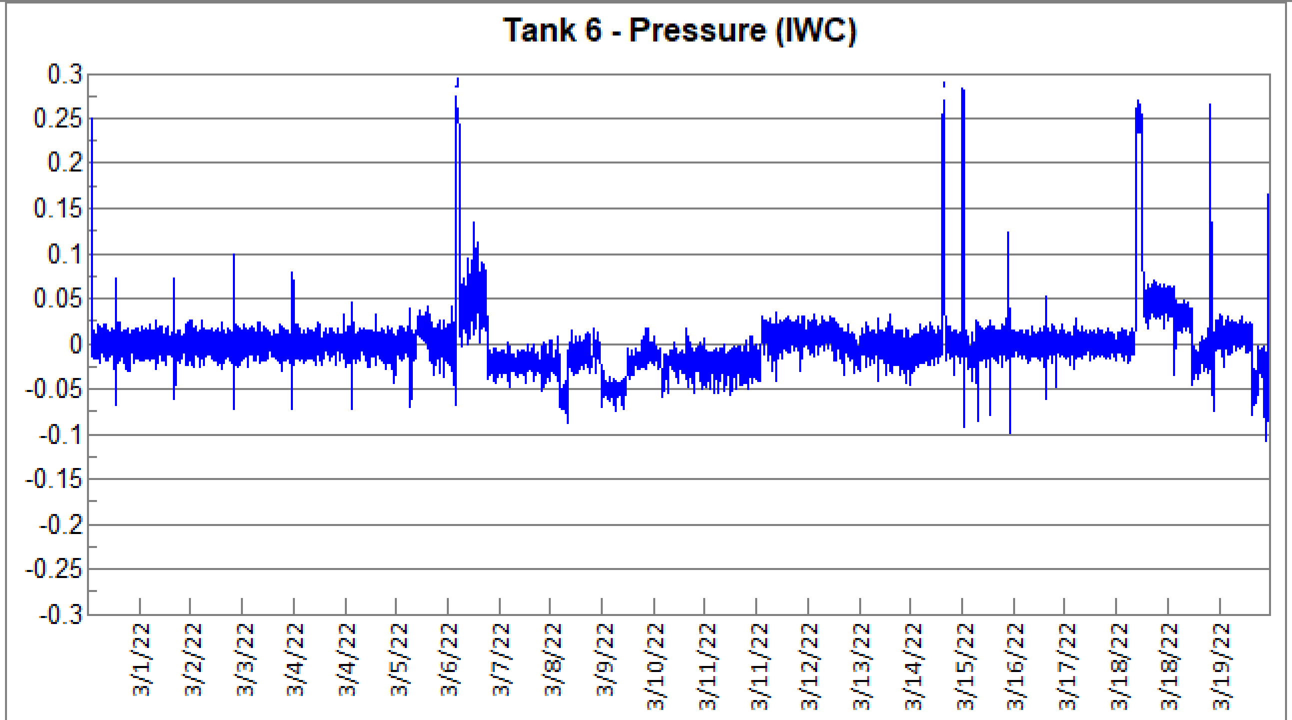


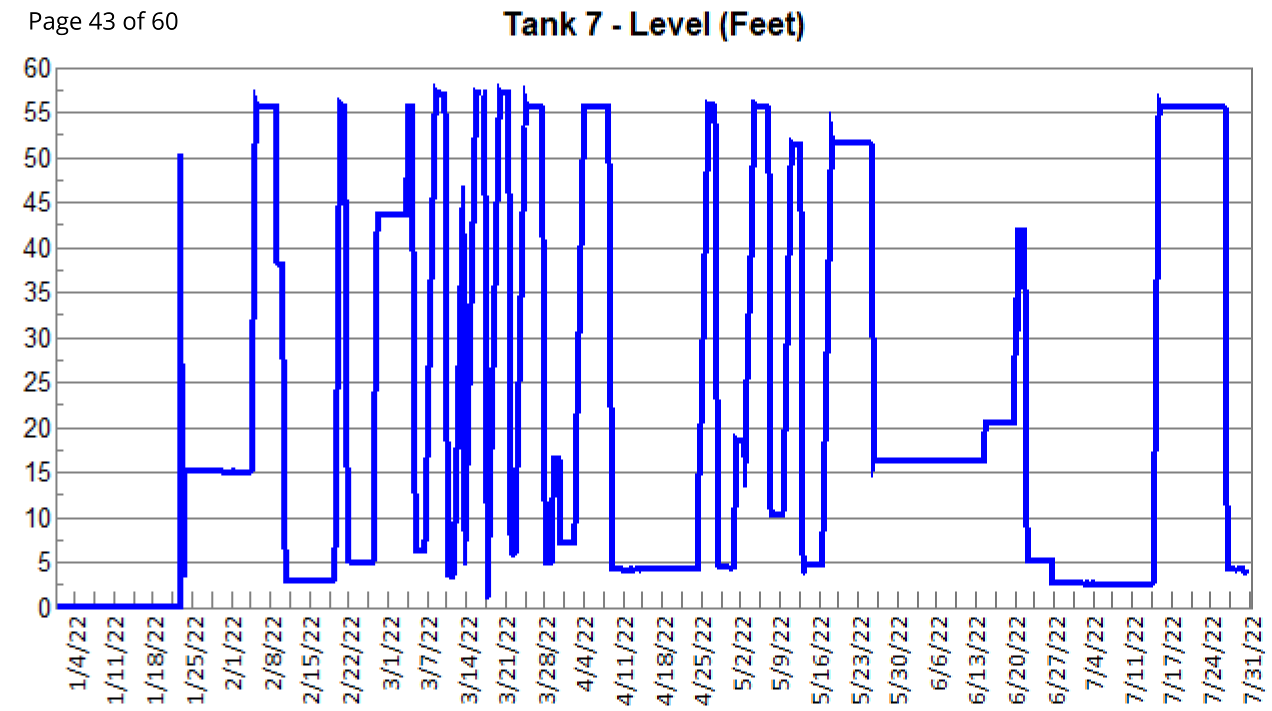
Tank 5 - Pressure (IWC)

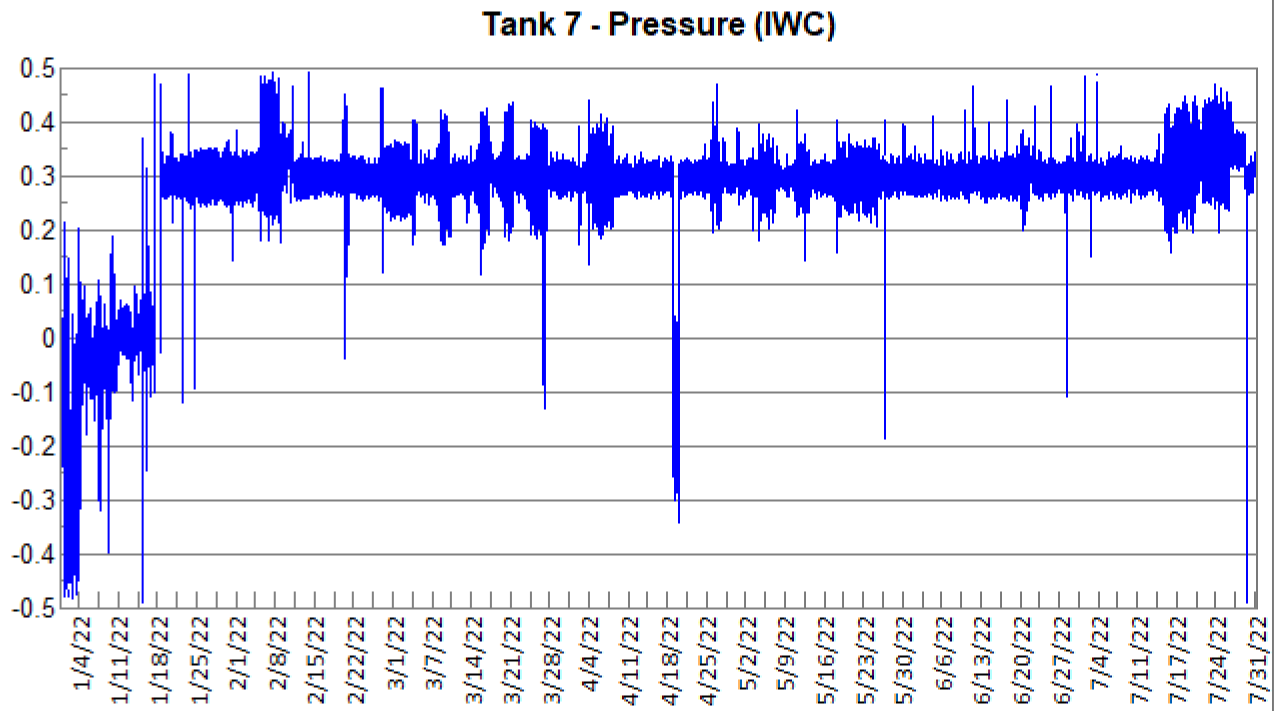



Tank 6 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

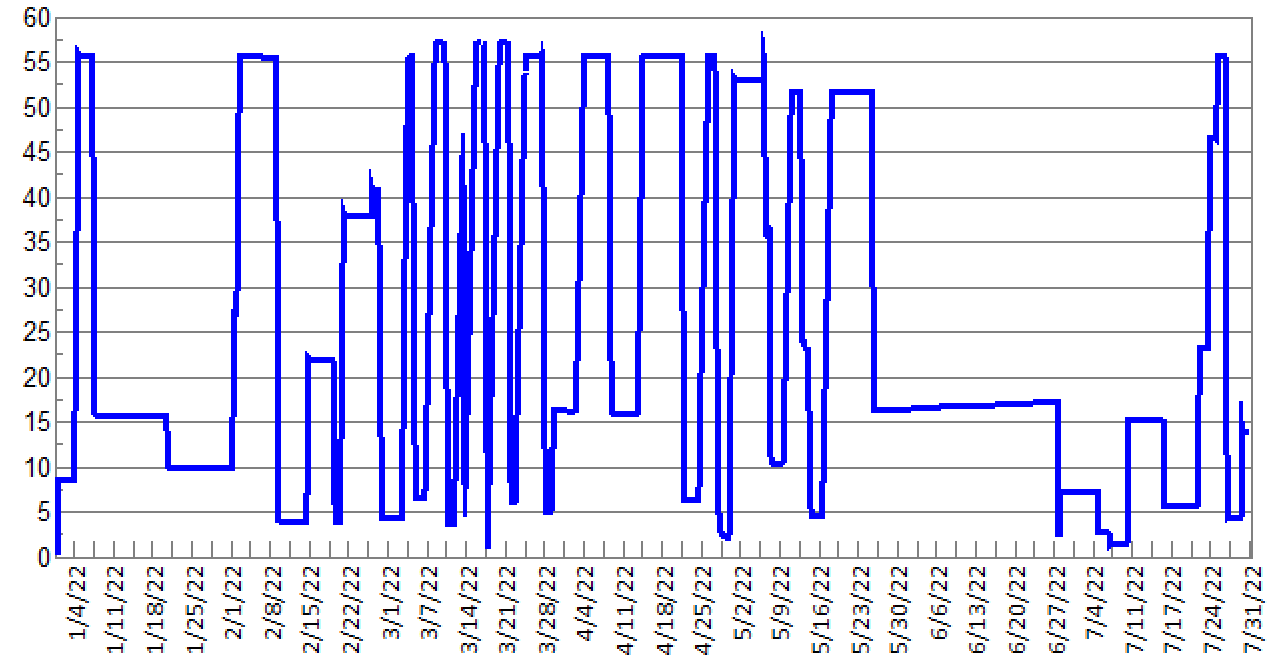

Tank 6 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 6 - Pressure (IWC)
0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
-0.3
3/1/22
3/2/22
3/3/22
3/4/22
3/4/22
3/5/22
3/6/22
3/7/22
3/8/22
3/9/22
3/10/22
3/11/22
3/11/22
3/12/22
3/13/22
3/14/22
3/15/22
3/16/22
3/17/22
3/18/22
3/18/22
3/19/22

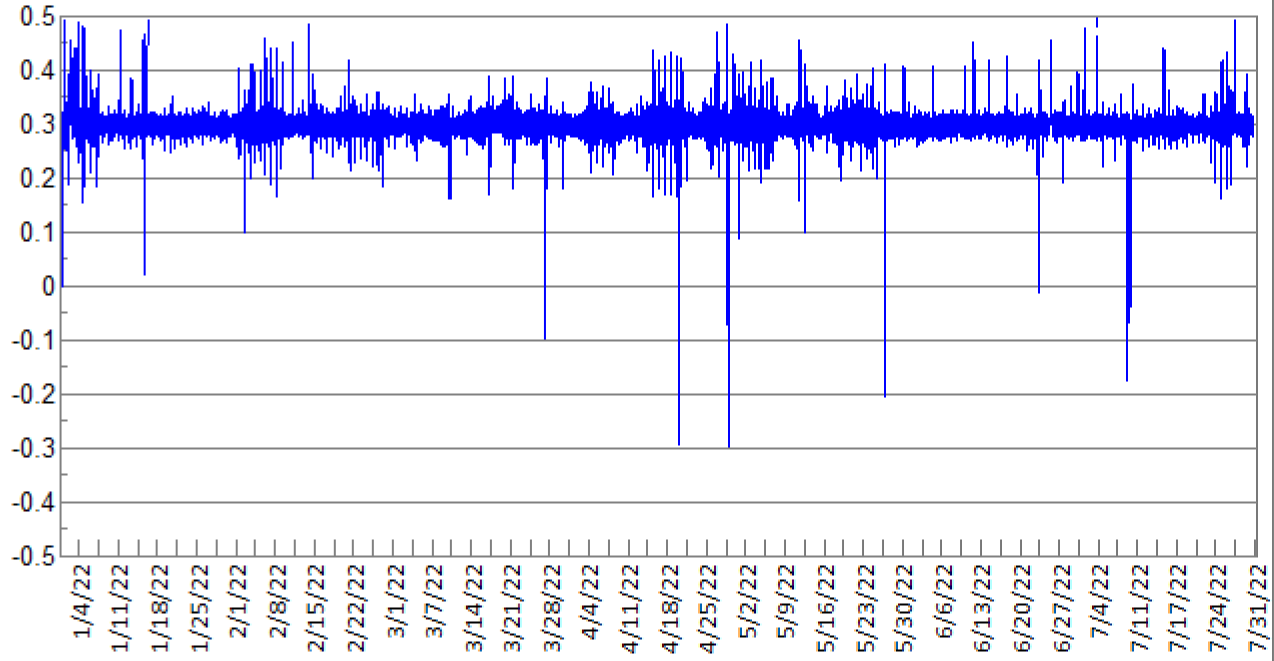

Tank 7 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

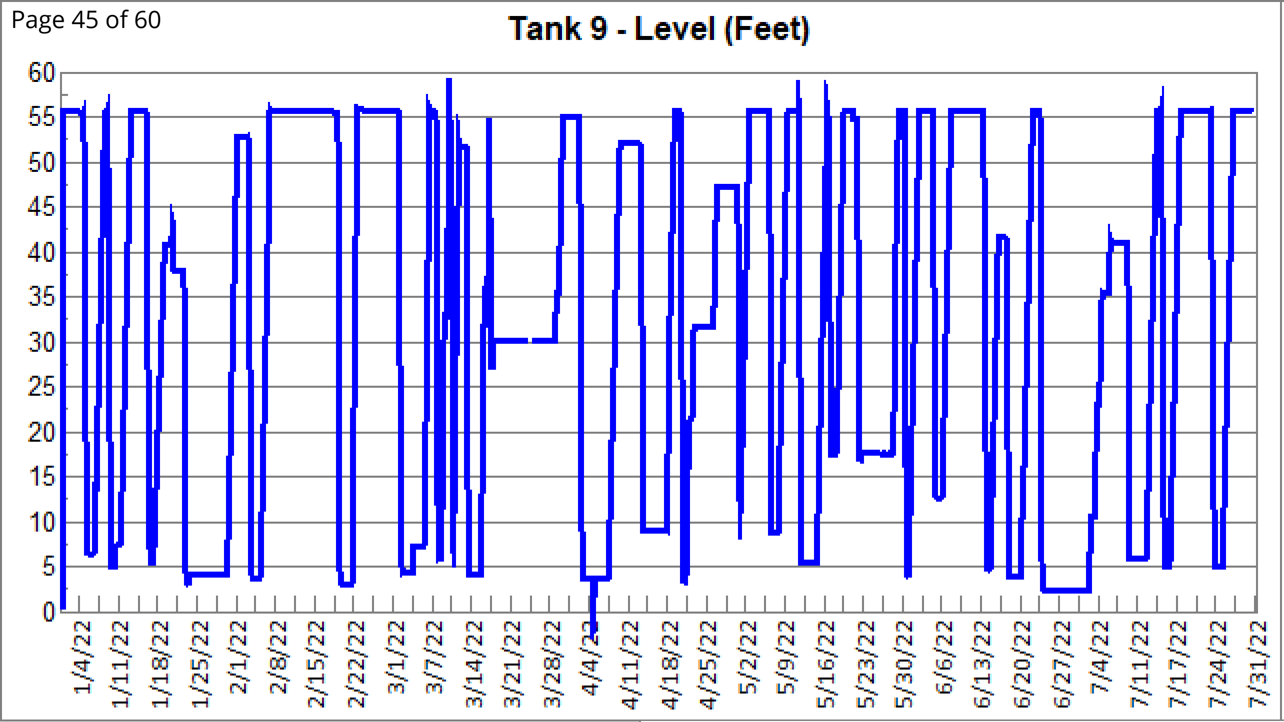

Tank 7 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

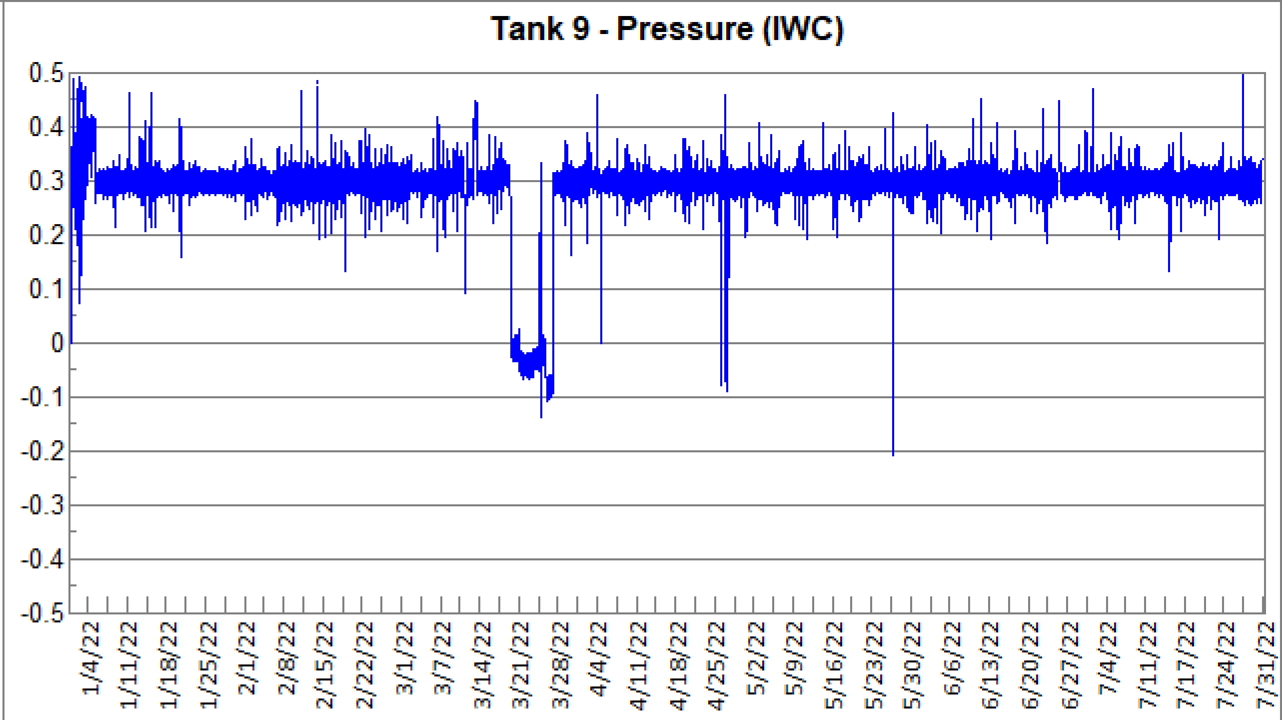
Tank 8 - Level (Feet)

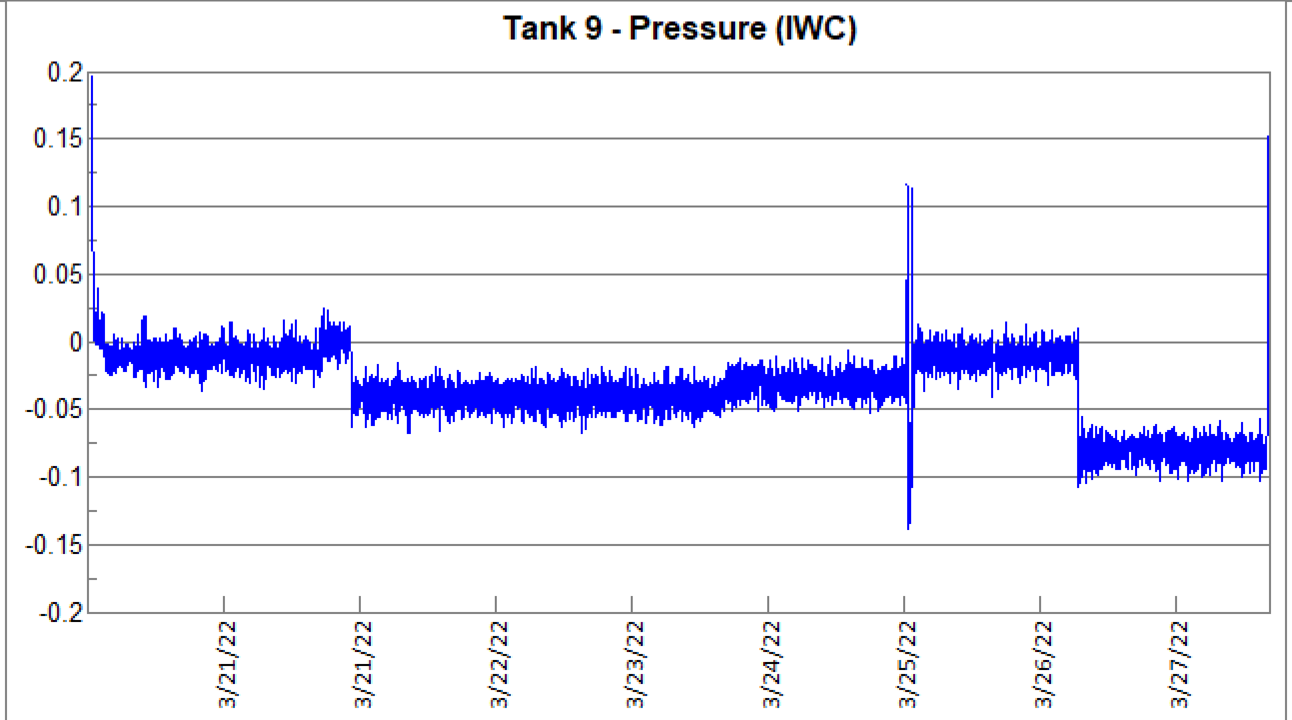


Tank 8 - Pressure (IWC)

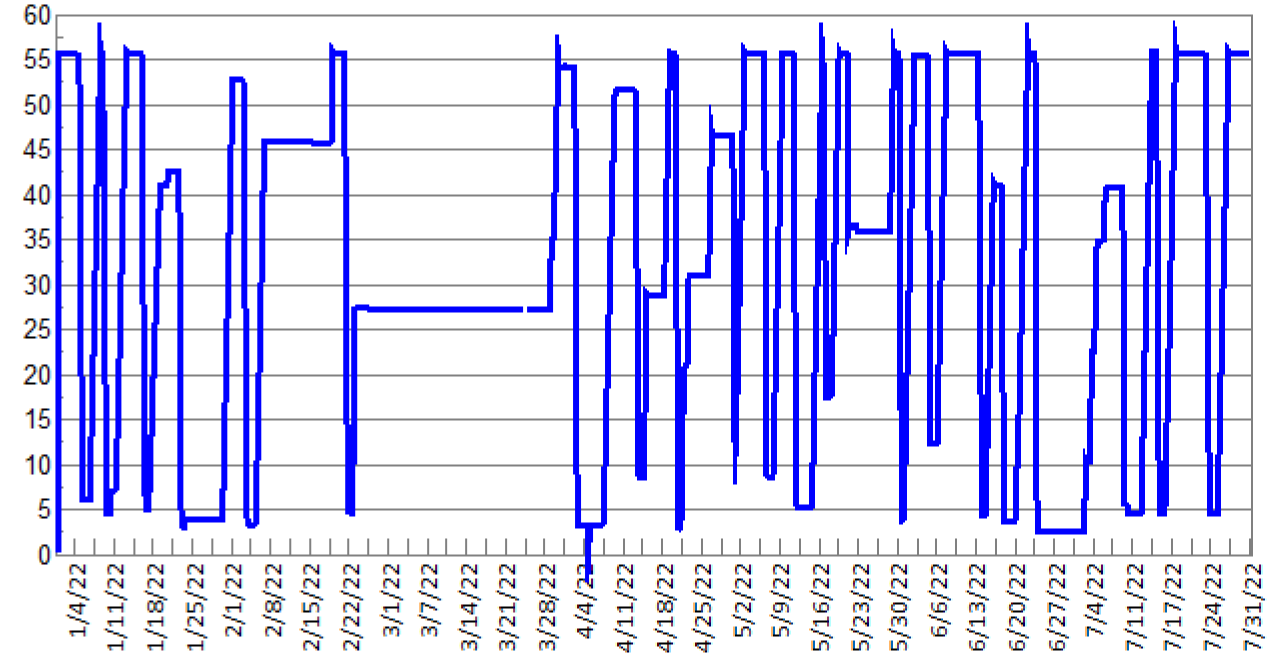



Tank 9 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

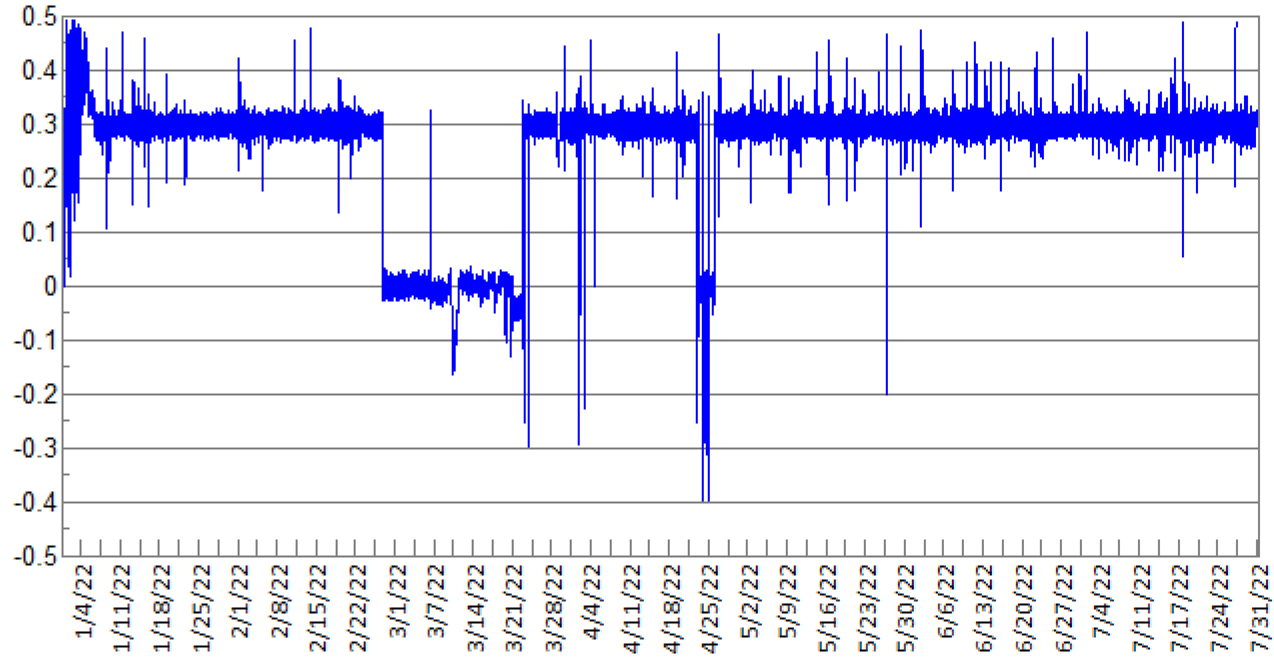

Tank 9 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 9 - Pressure (IWC)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
3/21/22
3/21/22
3/22/22
3/23/22
3/24/22
3/25/22
3/26/22
3/27/22

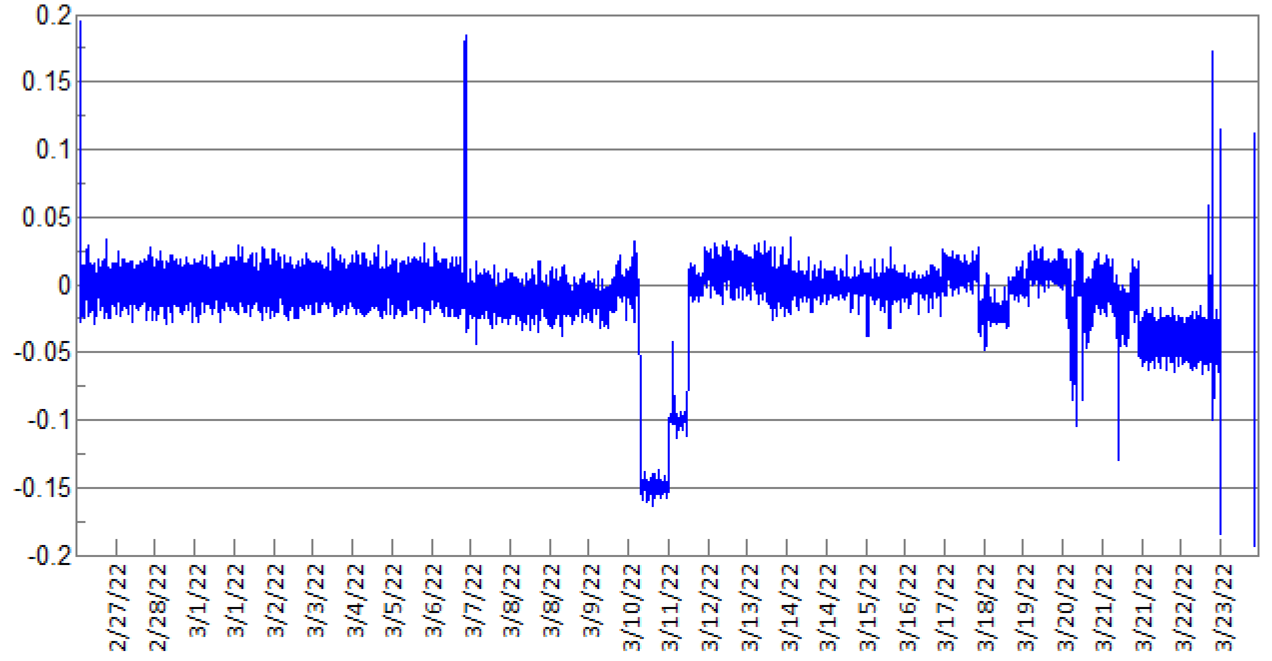
Tank 10 - Level (Feet)

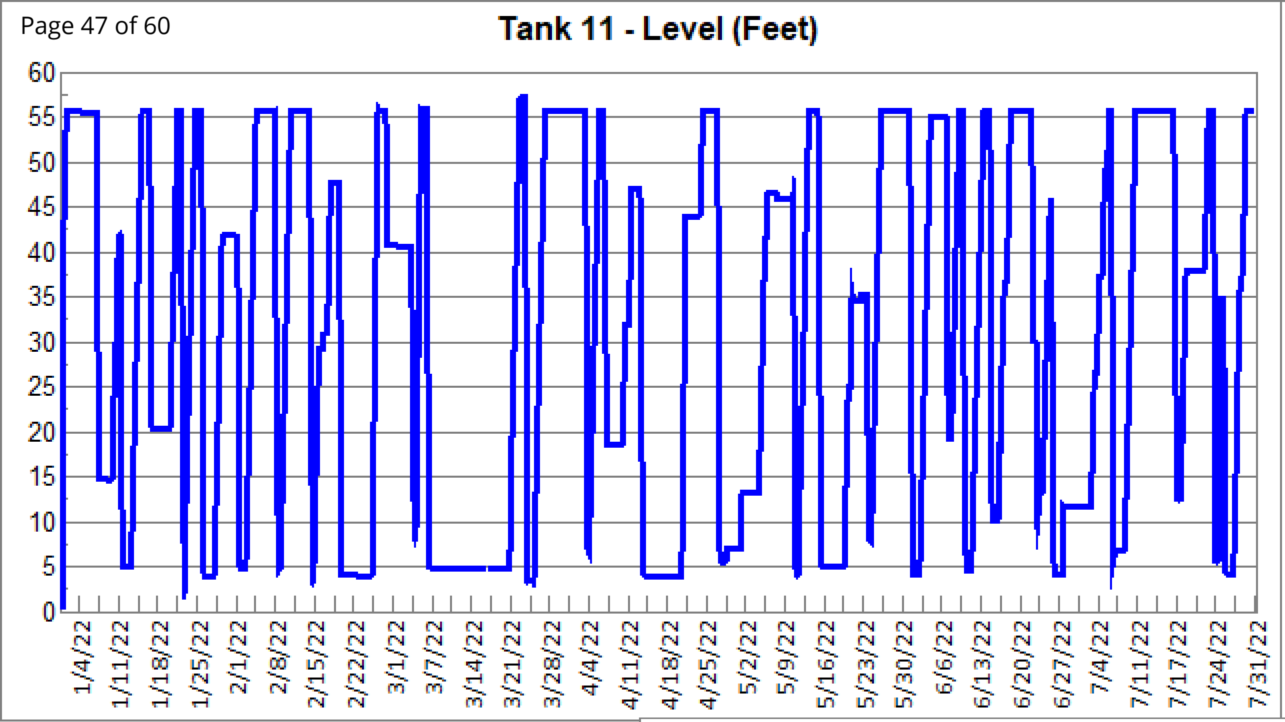


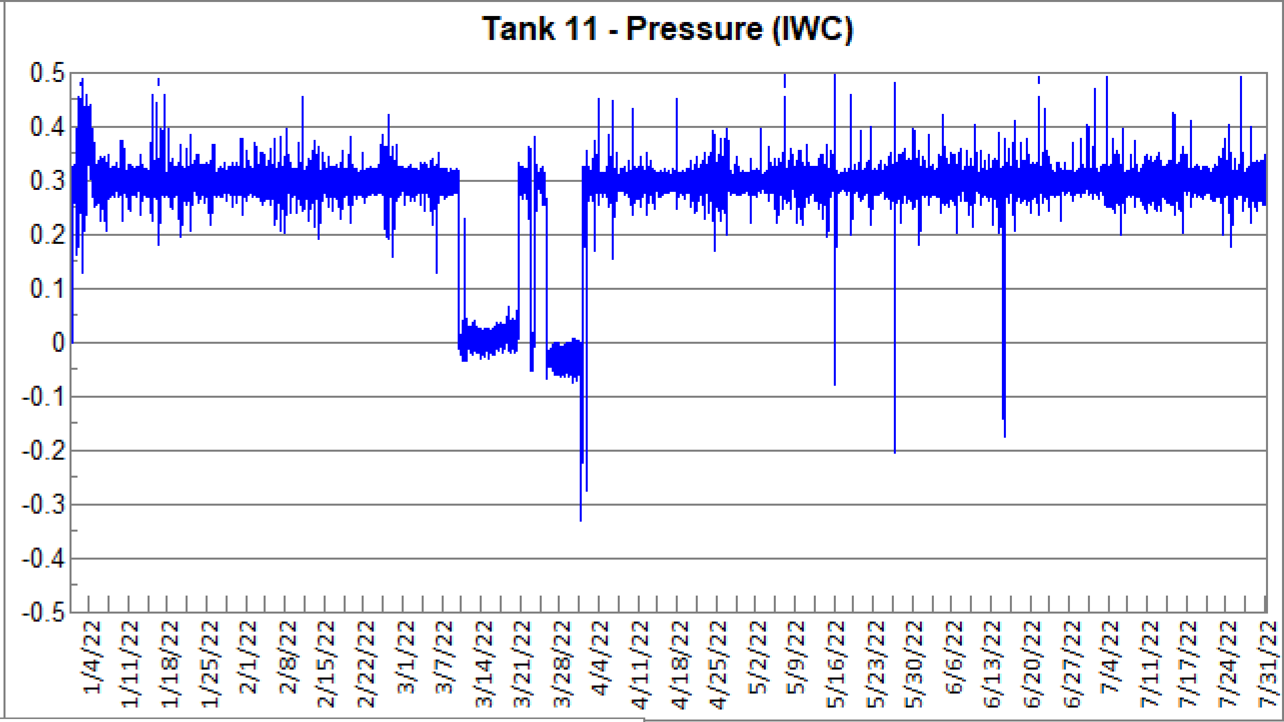
Tank 10 - Pressure (IWC)

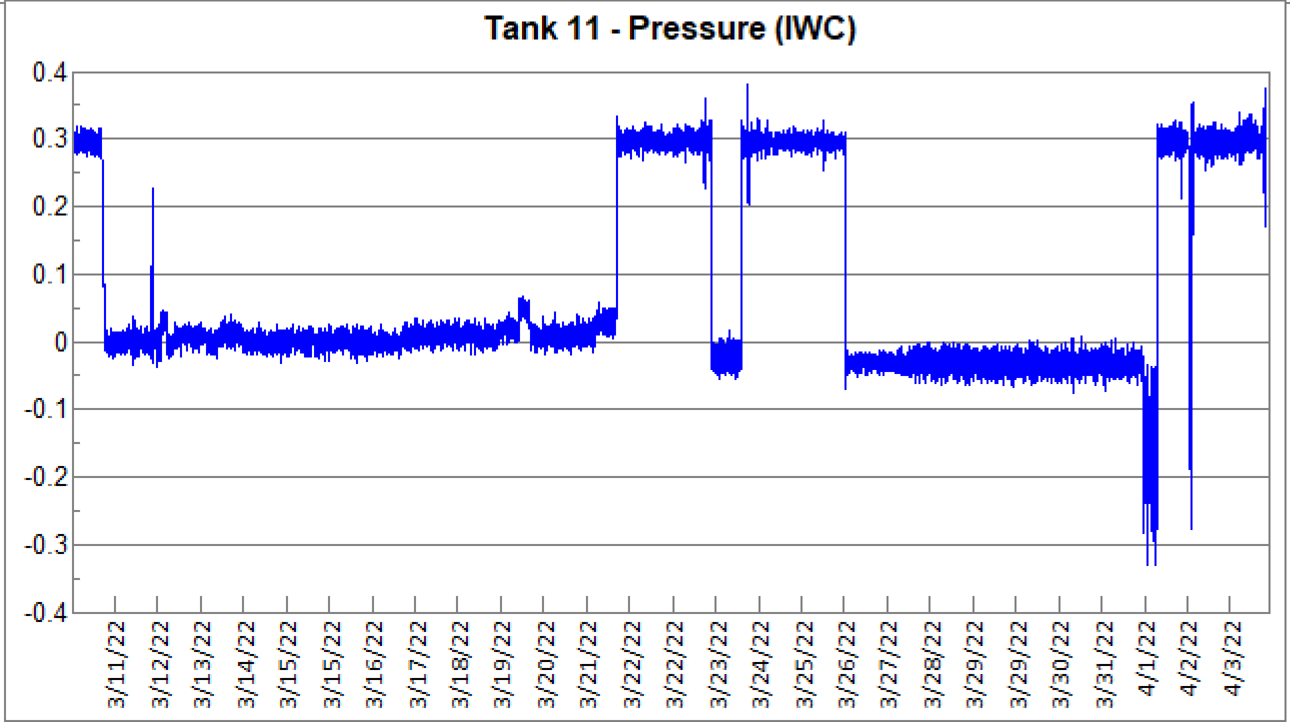


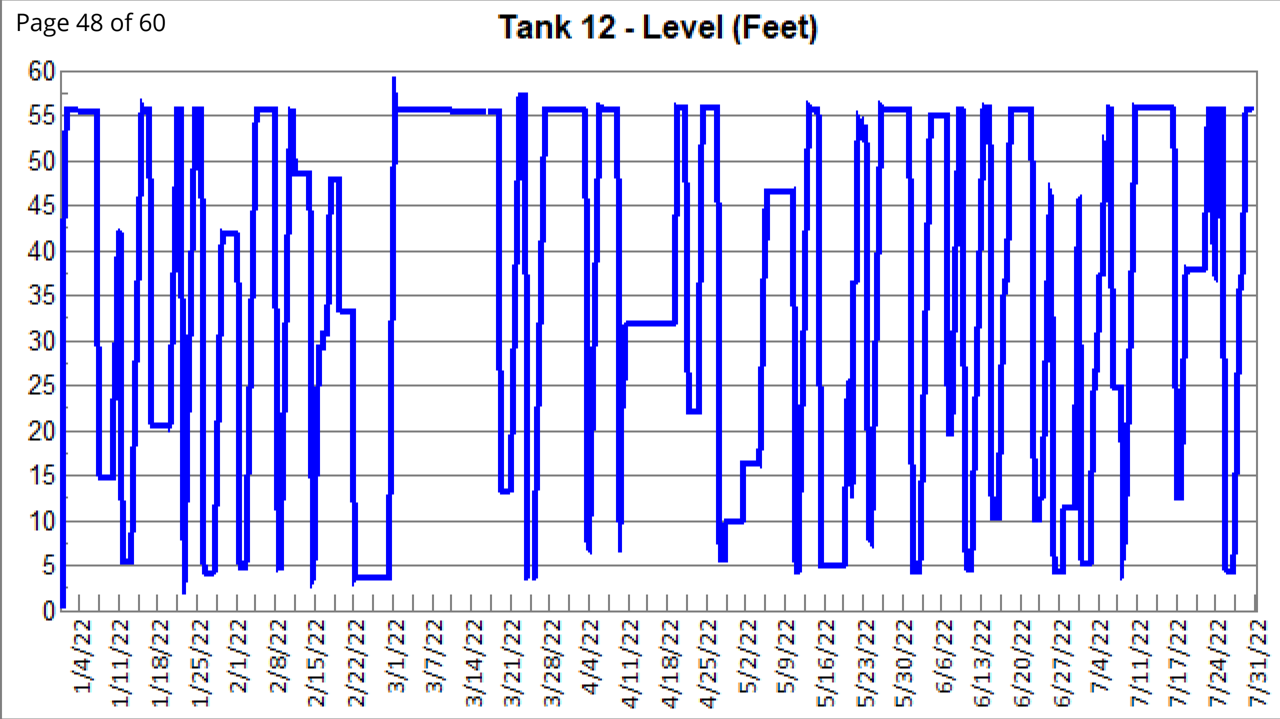
Tank 10 - Pressure (IWC)

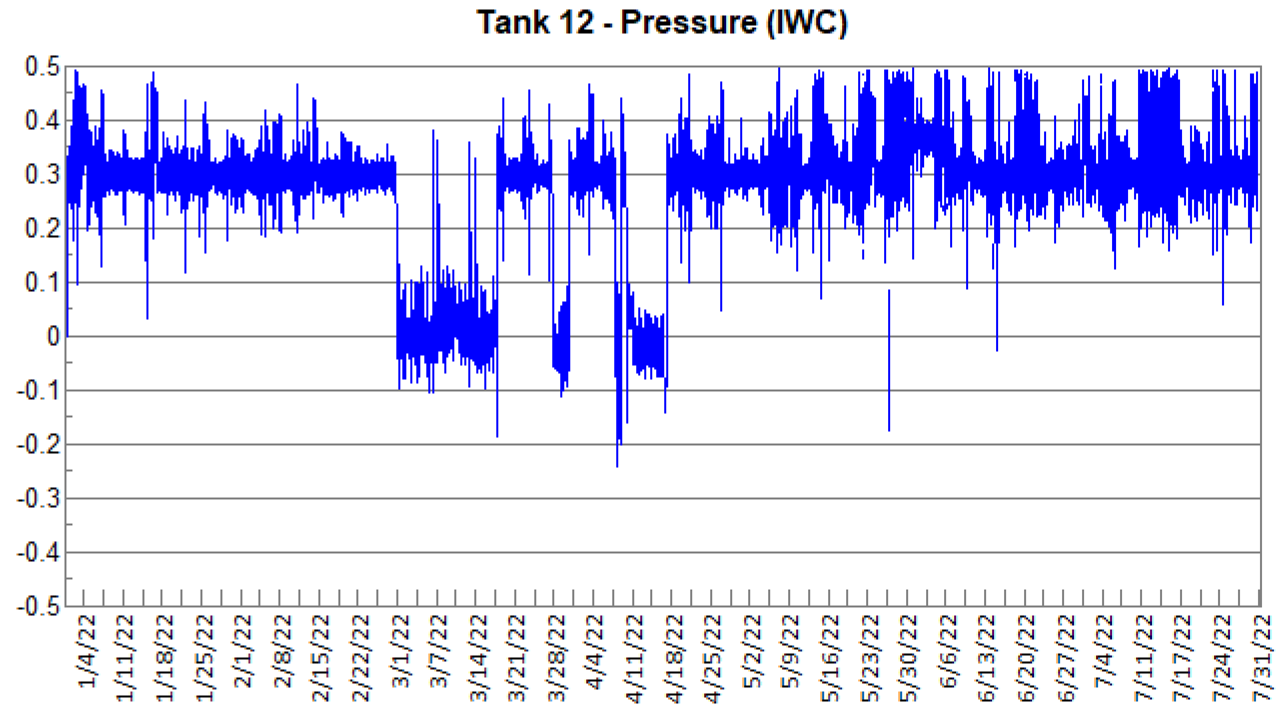


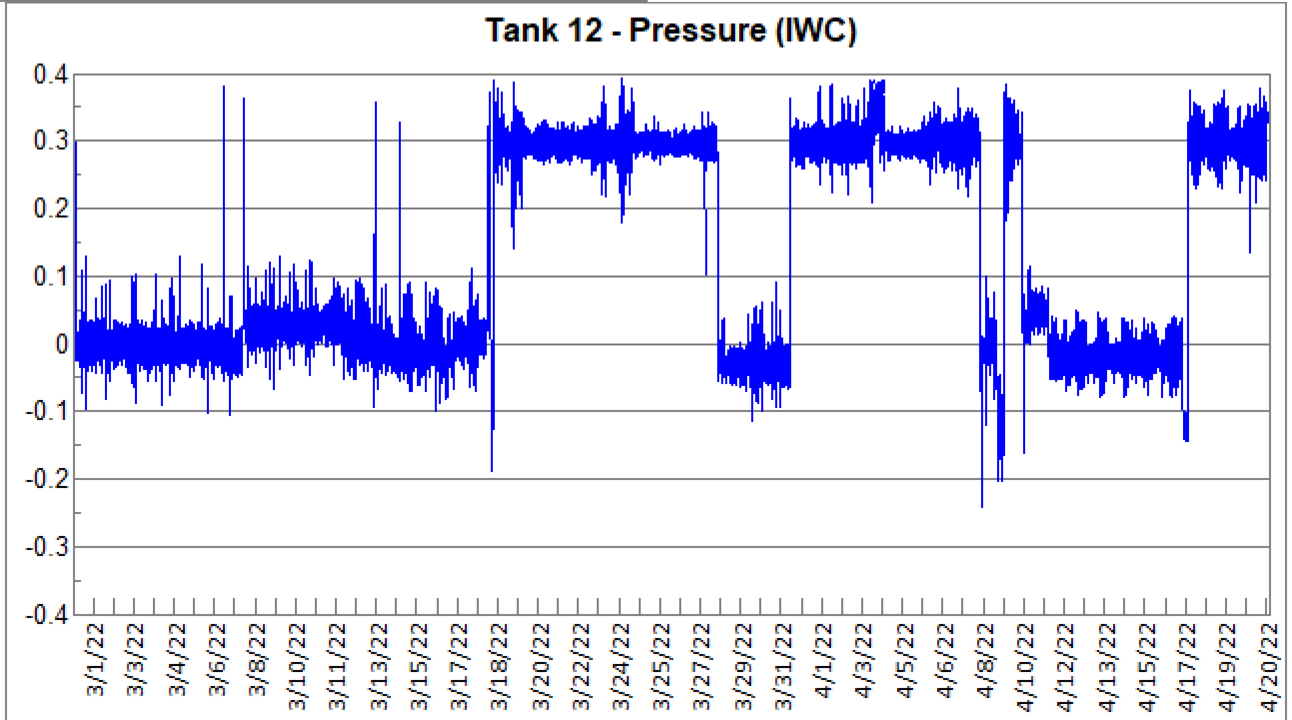

Tank 11 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 11 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

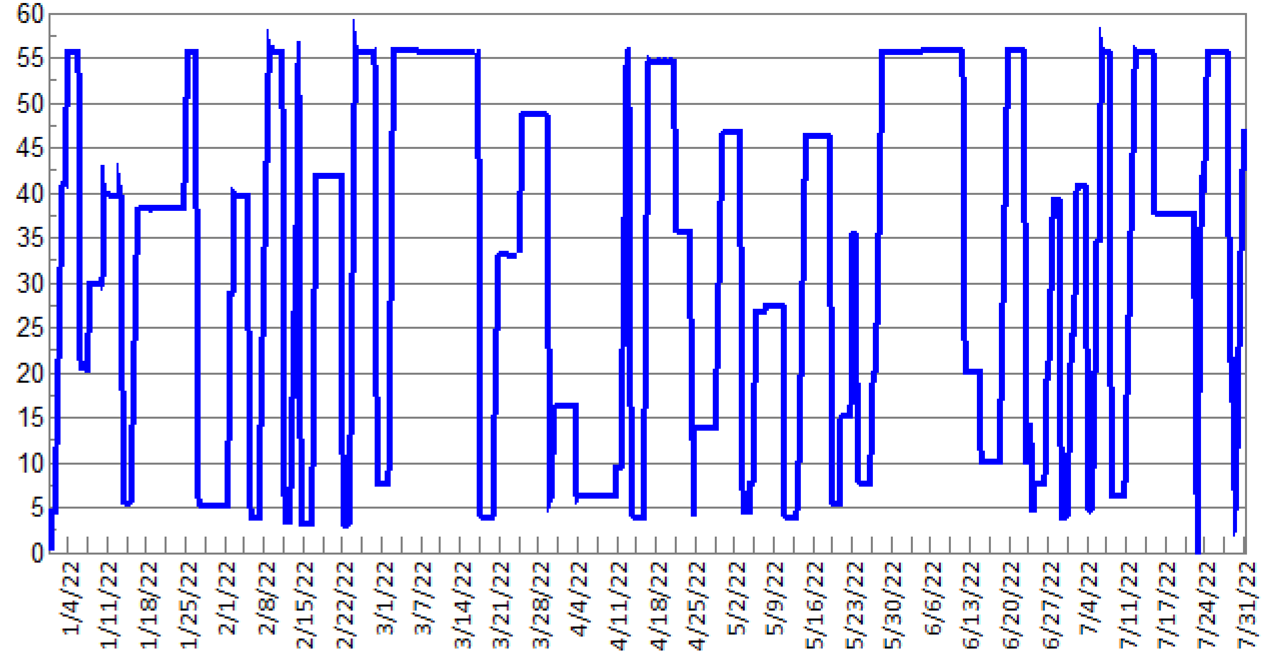

Tank 11 - Pressure (IWC)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
3/11/22
3/12/22
3/13/22
3/14/22
3/15/22
3/15/22
3/16/22
3/17/22
3/18/22
3/19/22
3/20/22
3/21/22
3/22/22
3/22/22
3/23/22
3/24/22
3/25/22
3/26/22
3/27/22
3/28/22
3/29/22
3/30/22
3/31/22
4/1/22
4/2/22
4/3/22


Tank 12 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22

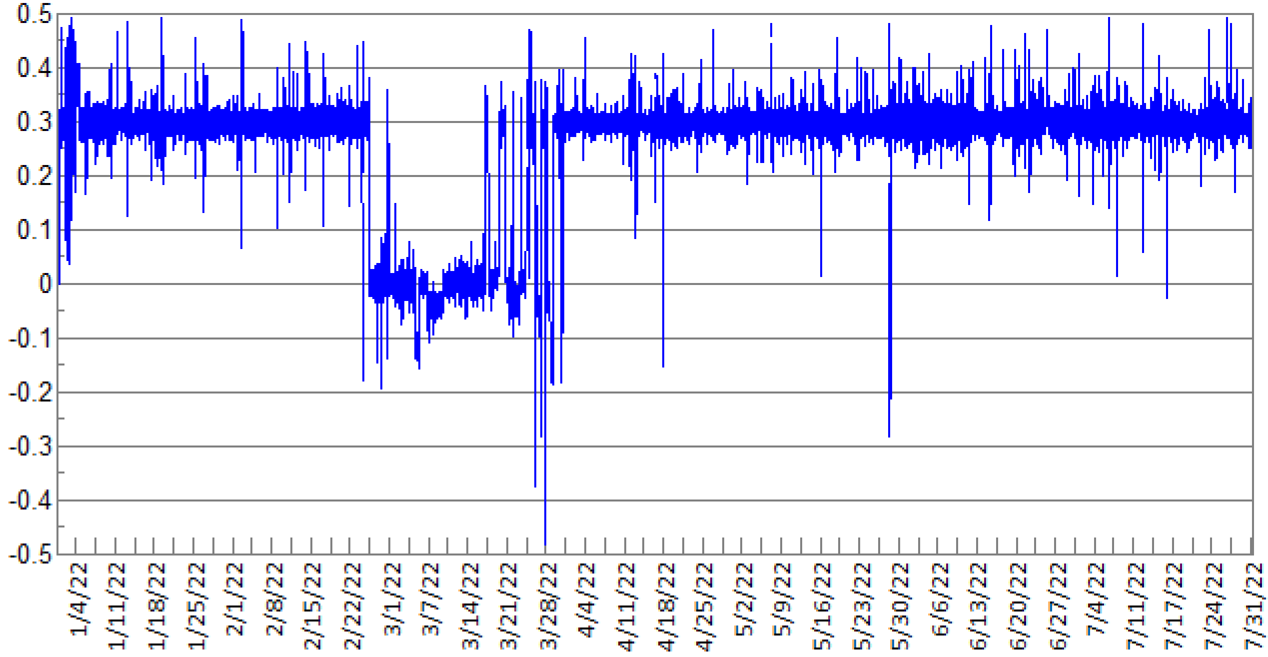

Tank 12 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 12 - Pressure (IWC)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
3/1/22
3/3/22
3/4/22
3/6/22
3/8/22
3/10/22
3/11/22
3/13/22
3/15/22
3/17/22
3/18/22
3/20/22
3/22/22
3/24/22
3/25/22
3/27/22
3/29/22
3/31/22
4/1/22
4/3/22
4/5/22
4/6/22
4/8/22
4/10/22
4/12/22
4/13/22
4/15/22
4/17/22
4/19/22
4/20/22

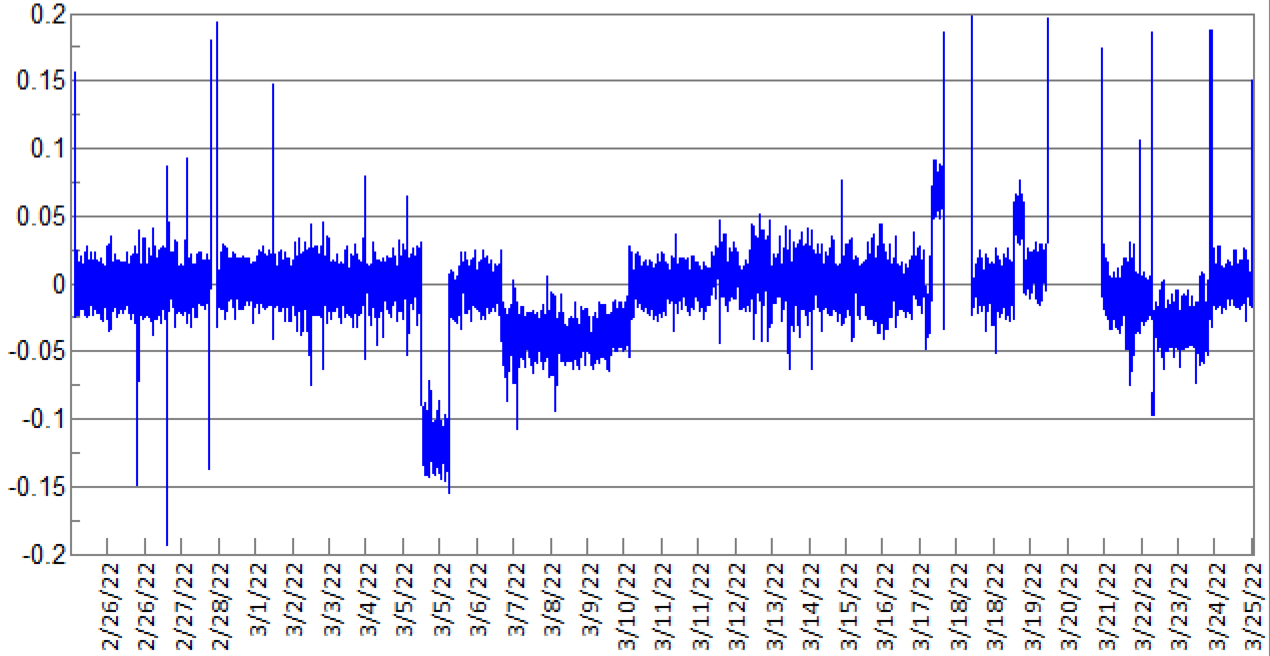
Tank 13 - Level (Feet)

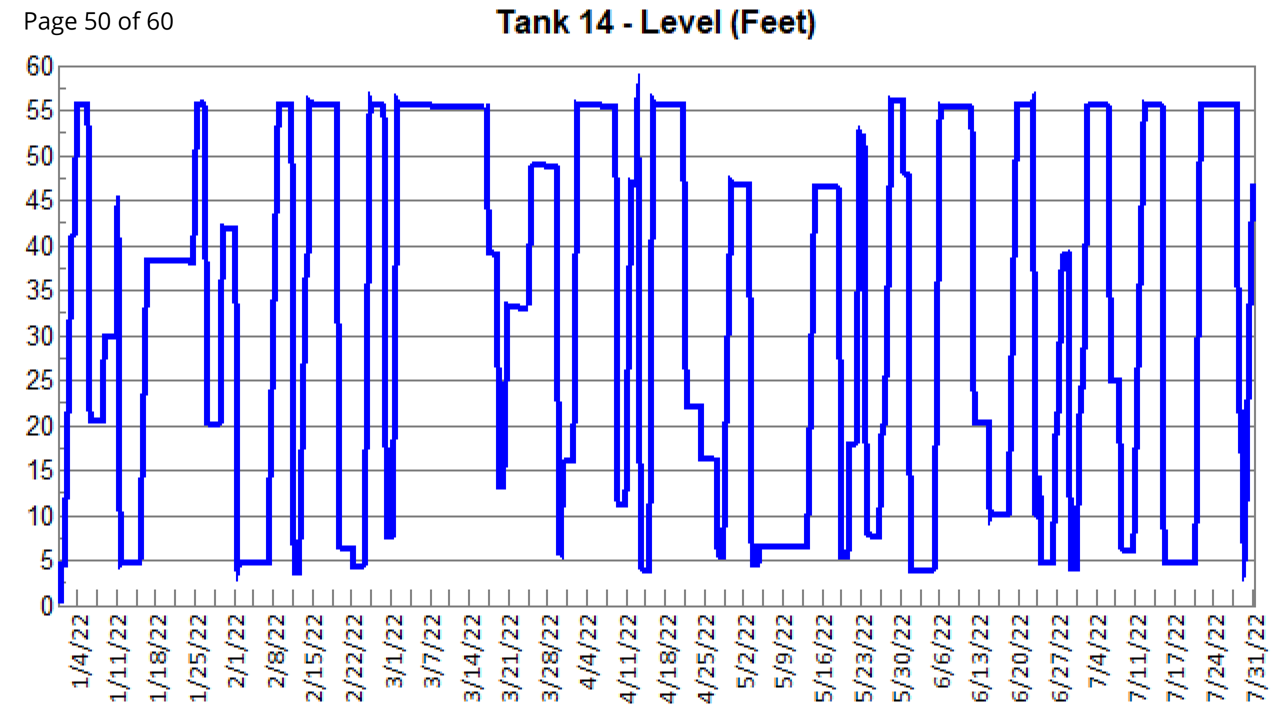


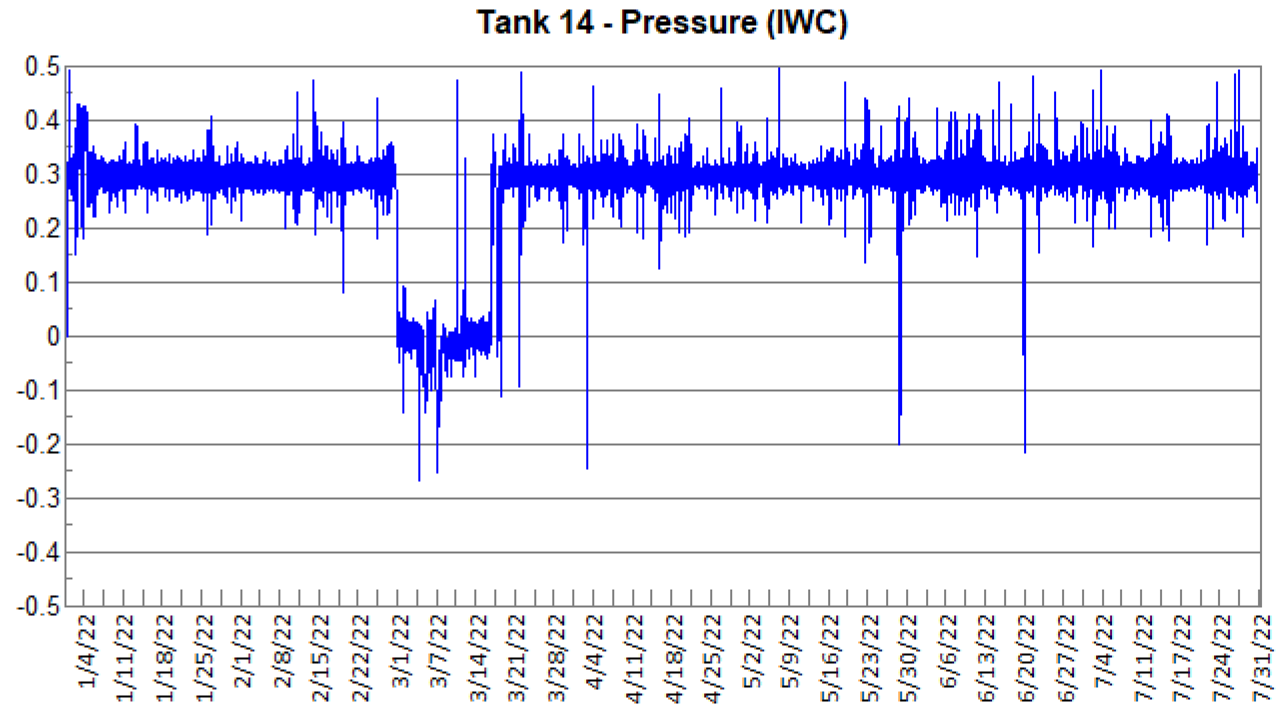
Tank 13 - Pressure (IWC)

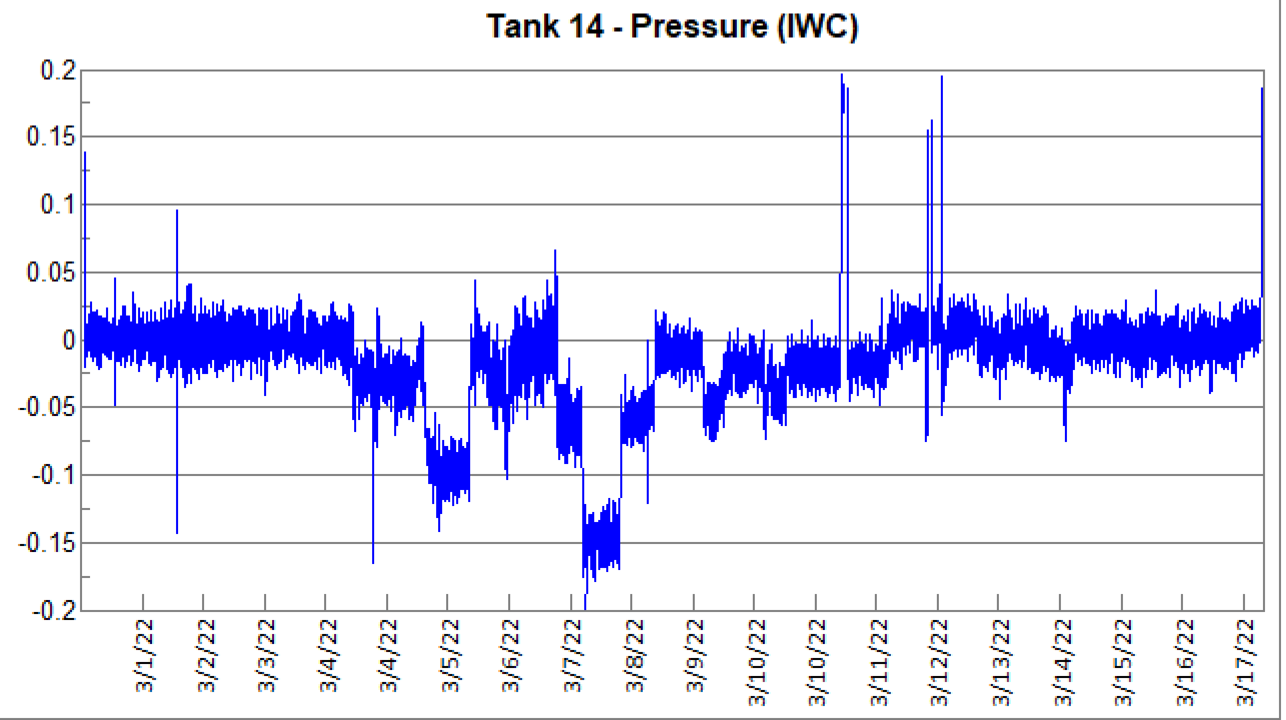


Tank 13 - Pressure (IWC)




Tank 14 - Level (Feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 14 - Pressure (IWC)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
1/4/22
1/11/22
1/18/22
1/25/22
2/1/22
2/8/22
2/15/22
2/22/22
3/1/22
3/7/22
3/14/22
3/21/22
3/28/22
4/4/22
4/11/22
4/18/22
4/25/22
5/2/22
5/9/22
5/16/22
5/23/22
5/30/22
6/6/22
6/13/22
6/20/22
6/27/22
7/4/22
7/11/22
7/17/22
7/24/22
7/31/22


Tank 14 - Pressure (IWC)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
3/1/22
3/2/22
3/3/22
3/4/22
3/4/22
3/5/22
3/6/22
3/7/22
3/8/22
3/9/22
3/10/22
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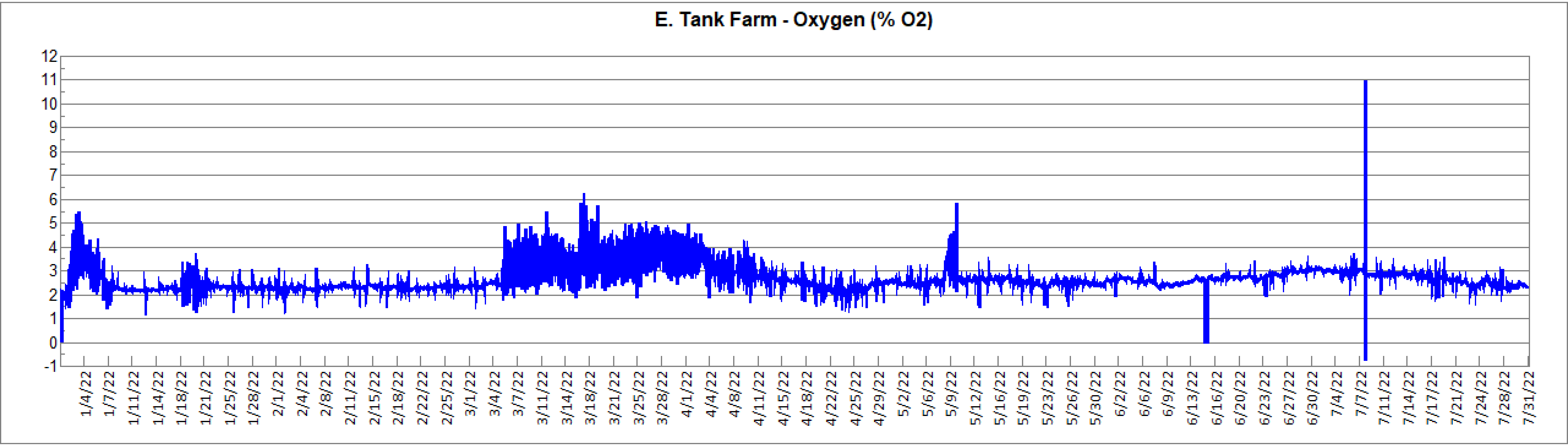
3/16/22
3/17/22



NOTE:
X-axis shows time (date)
Y-axis shows oxygen percentage in the VMT Tank Farm

Appendix C

Input/Outputs Data from TANKS 5.0 Model

Tank Inputs

tankType	{"tanTyp":"Vertical Fixed Roof Tank"}
tankIdentification	{"tankID":"Valdez Example 1","tankDescription":"","tankCity":"Valdez","tankState":"Alaska","company":"None"}
location	{"loc":"Seattle, WA","houAvgMinAmbTem":{"Jan":37.6,"Feb":37.8,"Mar":39.7,"Apr":42.8,"May":48,"Jun":52.4,"Jul":56.4,"Aug":56.5,"Sep":52.9,"Oct":46.5,"Nov":40.5,"Dec":36.8,"Ann":45.7},"houAvgMaxAmbTem":{"Jan":46.4,"Feb":49.4,"Mar":52.4,"Apr":57.2,"May":63.7,"Jun":68.5,"Jul":75.1,"Aug":74.8,"Sep":69.5,"Oct":58.6,"Nov":50.3,"Dec":45.4,"Ann":59.3},"avgWinSpe":{"Jan":8.5,"Feb":8.3,"Mar":8.5,"Apr":7.8,"May":7.6,"Jun":7.6,"Jul":7.2,"Aug":6.9,"Sep":6.7,"Oct":7.2,"Nov":8.1,"Dec":8.7,"Ann":7.8},"avgDaiTotInsFac":{"Jan":316,"Feb":595,"Mar":882,"Apr":1329,"May":1678,"Jun":1842,"Jul":1951,"Aug":1679,"Sep":1235,"Oct":671,"Nov":356,"Dec":267,"Ann":1067},"avgAtmPre":14.47}
tankChar	{"sheLen":"","sheHei":40,"sheDia":250,"maxLiqHei":15,"avgLiqHei":10,"minLiqHei":"","tanHea":"","maxHeaTem":"","avgHeaTem":"","minHeaTem":"","heaCyc":"","rooTyp":"Flat","vacSet":-0.03,"preSet":0.03,"vapSpaPre":0,"tanIns":"Not Insulated","tanConRooSlo":"","tanDomRooRad":"","conDev":"No Control Device","conEff":"","tanSha":"Cylinder","bulTemMet":"AP-42 Calculation","bulTem":"","sheLen2":"","bottomShape":"flat","bottomSlope":"","liqHeelType":"full","liqHeelHeight":3,"selSupRoo":"","numCol":"","effColDia":"","intSheCon":"","priSea":"","secSea":"","seaFit":"","decTyp":"","tanCon":"","decCon":"","decSea":"","decConWid":"","decConLen":""}
tankFit	{"accHatTyp":"","accHatCou":"","colWelTyp":"","colWelCou":"","unsGuiPolTyp":"","unsGuiPolCou":"","sloGuiPolTyp":"","sloGuiPolCou":"","gauFloWelTyp":"","gauFloWelCou":"","gauHatTyp":"","gauHatCou":"","vacBreTyp":"","vacBreCou":"","decDraTyp":"","decDraCou":"","decLegTyp":"","degLegCou":"","fixLegTyp":"","fixLegCou":"","rimVenTyp":"","rimVenCou":"","ladWelTyp":"","ladWelCou":"","ladSloGuiTyp":"","ladSloGuiCon":"","decLegPonTyp":"","degLegPonCou":"","decLegCenTyp":"","degLegCenCou":""}

tankContents	{"inputType":"Enter Monthly Values","tanCon":"Petroleum Liquids","liqLevMet":"AP-42 Calculation","worLossTurFacMet":"AP-42 Calculation","annData":{"chemName":"","annThr":"","speciation":"","components":[]},"monData":[{"month":"January","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"February","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"March","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"April","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"May","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"June","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"July","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"August","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"September","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"October","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"November","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]},{"month":"December","chemName":"Midcontinent Crude Oil RVP 5","thr":"100000","speciation":"","components":[]}]}
tanSolAbs	{"sheCol":"Aluminum - Diffuse","sheCon":"Average","tanSheSurSolAbs":0.64,"rooCol":"Aluminum - Diffuse","rooCon":"Average","tanRooSurSolAbs":0.64}
petChem	{"annData":{},"monData":{"0":{},"1":{},"2":{},"3":{},"4":{},"5":{},"6":{},"7":{},"8":{},"9":{},"10":{},"11":{}}}
petDist	{"annData":{},"monData":{"chemName":["Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5","Midcontinent Crude Oil RVP 5"],"vapMolWei":[50,50,50,50,50,50,50,50,50,50,50,50],"liqMolWei":[207,207,207,207,207,207,207,207,207,207,207,207],"liqDen":[7.1,7.1,7.1,7.1,7.1,7.1,7.1,7.1,7.1,7.1,7.1,7.1],"vapPreEquCon_A":[11.263,11.263,11.263,11.263,11.263,11.263,11.263,11.263,11.263,11.263,11.263,11.263],"vapPreEquCon_B":[5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9,5303.9],"crudeOil":["","","","","","","","","","","",""]}}

customOrganicLiquids	{}
customMixedOrganicLiquids	{}
customPetroleumLiquids	{}
customLocations	{}

Tank Outputs

Tank ID	Valdez Example 1
Tank Type	Vertical Fixed Roof Tank
Description	
City, State	Valdez, Alaska
Company	None
Emissions Type	Total VOC
Annual Standing Losses (lb/yr)	243176.7205
Annual Working Losses (lb/yr)	2981.353693
Annual Total Losses (lb/yr)	246158.0742
January Standing Losses (lb/yr)	6449.792332
January Working Losses (lb/yr)	190.1371315
January Total Losses (lb/yr)	6639.929464
February Standing Losses (lb/yr)	9882.592019
February Working Losses (lb/yr)	200.4417155
February Total Losses (lb/yr)	10083.03373
March Standing Losses (lb/yr)	15080.57845
March Working Losses (lb/yr)	214.6519767
March Total Losses (lb/yr)	15295.23043
April Standing Losses (lb/yr)	21553.28597
April Working Losses (lb/yr)	238.8916563
April Total Losses (lb/yr)	21792.17763
May Standing Losses (lb/yr)	29599.94154
May Working Losses (lb/yr)	272.1402743
May Total Losses (lb/yr)	29872.08182
June Standing Losses (lb/yr)	33089.59928
June Working Losses (lb/yr)	298.2589541
June Total Losses (lb/yr)	33387.85823
July Standing Losses (lb/yr)	40440.48228
July Working Losses (lb/yr)	328.7892149
July Total Losses (lb/yr)	40769.27149
August Standing Losses (lb/yr)	35572.77972
August Working Losses (lb/yr)	321.8935029
August Total Losses (lb/yr)	35894.67323
September Standing Losses (lb/yr)	24907.51699
September Working Losses (lb/yr)	288.9212431
September Total Losses (lb/yr)	25196.43823
October Standing Losses (lb/yr)	13400.68395
October Working Losses (lb/yr)	237.7045651
October Total Losses (lb/yr)	13638.38852
November Standing Losses (lb/yr)	7412.42507
November Working Losses (lb/yr)	203.358353

November Total Losses (lb/yr)	7615.783423
December Standing Losses (lb/yr)	5787.042936
December Working Losses (lb/yr)	186.1651056
December Total Losses (lb/yr)	5973.208042

Appendix D

Alyeska Letter (GL60146) dated March 7, 2025

Alyeska pipeline SERVICE COMPANY

P.O Box 196660 ANCHORAGE, ALASKA 99519-6660 TELEPHONE (907) 787-8700

March 7, 2025

Letter No. 60176
File 7.14.02

Donna Schantz
Executive Director
Prince William Sound Regional Citizens' Advisory Council
130 S. Meals, Ste. 202
Valdez, AK 99686

Attention: Donna Schantz, Executive Director

Subject: Response to Draft Report on VOC Emissions from the Snow Removal Incident at Alyeska's VMT in Early 2022, Dr. Ranajit Sahu, December 2024

Dear Ms. Schantz:

Thank you for sharing with us the Draft *Report on Volatile Organic Chemicals (VOC) Emissions from the Snow Removal Incident at Alyeska's Valdez Marine Terminal East Tank Farm in Early 2022*, dated December 2024, prepared by RCAC's consultant Dr. Ranajit Sahu (report). We appreciate your allowing us the opportunity to review and provide our own perspective concerning its analyses, findings and conclusions. As always, we value RCAC's feedback to assist us in ensuring the safe operation of the VMT and TAPS.

Alyeska has reviewed Dr. Sahu's report, and respectfully disagrees with many of its calculations and conclusions. The report recites and appears to rely upon several factual inaccuracies, including misstating PVV set points and incorrectly calculating the time-period during which PVVs were damaged before being plugged or repaired. Of particular significance is that the report inaccurately describes the operation and dynamics of the VMT's tank and vapor control system, which is fundamental to understanding how Alyeska maintained safe operations and mitigated impacts during these unprecedented events. We also note that the report does not include the modeling inputs and outputs, or other data relied upon by Dr. Sahu. In summary, we believe that the report makes unsupportable assumptions and overestimates the total volatile organic chemicals (VOC) tank emissions that may have occurred during the event. The report also disregards or discounts certain critical factors and conditions that do not support the conclusions drawn.

Thank you for the opportunity to provide feedback on this report. Alyeska looks forward to additional discussions with you.

Please direct all written correspondence to:

Andres Morales
Emergency Preparedness & Response
Alyeska Pipeline Service Company
P.O. Box 196660, MS 575
Anchorage, AK 99519

If you have any questions regarding this submittal, please contact Andres Morales at (907) 787-8303.

Sincerely,

Andres Morales
Emergency Preparedness and Response Director
Alyeska Pipeline Service Company