Tourmaline Oil Corporation (Bonavista Energy Corporation)

Alt-FEMP Full-Scale Program
2024 Final Performance Report

Date: 4th April 2025

Submitted by:

Jason Wilshusen
Senior HSER Advisor, Tourmaline Oil Corp.

Kevin Fritz
Technical Lead, Arolytics

Fatima Mehboob
Emissions Engineer, Arolytics

arolytics.com
info@arolytics.com

Table of Contents

Figures & Tables

Executive Summary

In November 2023 Tourmaline Oil Corporation completed the corporate acquisition of Bonavista Energy Corporation (Bonavista); Bonavista was a Western Canadian upstream oil and gas producer that owned and operated 846 active facilities in Alberta, located on 625 legal subdivisions (LSDs). The acquisition resulted in acquiring all the facilities within the Bonavista full scale alternative fugitive emissions management program (alt-FEMP). The acquired alt-FEMP covered two full compliance years from April 2023 to December 2024 and Tourmaline continued the program for all acquired facilities.

For methane detection, this alt-FEMP utilized Vertex Resources (Vertex) optical gas imaging cameras (OGI) along with two different site-level emission-screening technologies: Bridger Photonics, Inc.'s (Bridger) aerial-based technology and QUBE's "Continuous Emissions Monitoring Stations" (CEMS).

This report summarizes data collected during the alt-FEMP programs, including screenings, follow-up OGI surveys and CEMS data. The schedule of the program was as follows:

Quarter-Year	* Site Level Screening	** OGI Surveys	Status
Q2 2023	Aerial-based site-level screening by Bridger Photonics Inc. using their aerial Gas Mapping LiDAR technology to screen 840 of the facilities (625 LSDs).	Followed by Vertex OGI follow-up surveys at the top 40% of screened LSDs ranked by total emission rate for fugitive emission localization and repair.	Completed
Q3 2023	-	Independent OGI survey campaign by Vertex at 152 triannual facilities for fugitive emission localization and repair.	Completed
Q1 2024	-	Independent OGI survey campaign by Vertex at 152 triannual facilities for fugitive emission localization and repair.	Completed
Q2 2024	Aerial-based site-level screening by Bridger Photonics Inc. using their aerial Gas Mapping LiDAR technology to screen 840 of the facilities (625 LSDs).	Followed by Vertex OGI follow-up surveys at the top 40% of screened LSDs ranked by total emission rate for fugitive emission localization and repair.	Completed
Q2 2024	Aerial-based site-level screening by Bridger Photonics Inc. using their aerial Gas Mapping LiDAR technology to screen 840 of the facilities (625 LSDs).	Followed by Vertex OGI follow-up surveys at the top 40% of screened LSDs ranked by total emission rate.	Completed

1. Screening Data

Table 1 summarizes various statistics regarding the screening campaigns across the alt-FEMP. Please note emissions detected during the screenings can be a combination of fugitive, vented and sporadic operations-related emissions. The detailed screening data is provided in an Excel attachment with this report, and the tables summarizing each site's total and individual emissions detected during each screening are provided in Appendix B and C, respectively.

Table 1. Combined summary of screening data for 2023 and 2024, where one screening was conducted in 2023 and two screenings were conducted in 2024.

Parameter	**2023 (One screening)**	**2024 (Two Screenings)**
Number of sites screened	596	1,210
Number of screened sites with detections	183	432
Number of detections during screenings	188	750
Percentage of screened sites with detections (%)	31%	36%
Average emissions per screened site with a detection (m^3/day)	330	307
Total emission rate identified (m^3/day)	60,429	132,701
Number of sites followed-up on	250	464
Percentage of sites followed-up on vs. screened (%)	42%	38%
Number of follow-up sites with no screening detections	67	68
Number of follow-up emissions with emission source not detected by the screening technology	184	729
Average time between detection and follow-up to site (days)	76	70

Percentage of follow-up sites that are recurring (%)	N/A	71%
Number of emissions from the screenings that were followed-up on	188	687
Number of emissions from the screenings that were followed-up and identified as fugitive emissions	114	667
Total emission rate of fugitives identified and fixed for the calendar year (m^3/day)	1,597	9,261

2. Follow-up Data

Table 2 summarizes statistics regarding the OGI follow-up surveys of the alt-FEMP region conducted after a screening campaign. The raw detailed follow-up data is provided in an Excel attachment with this report.

OGI has the capability to localize emissions to a source-level. Also, the OGI operator can normally determine the emission type. Table 3 shows the emission source equipment types for all identified emissions including the number and volume of emissions for each equipment type.

Table 2. Summary of OGI follow-up data.

Year		2023 (One Follow-up)	2024 (Two Follow-ups)
Number of sites followed-up on for the year		250	464
Percentage of screened sites followed-up on (%)		42%	38%
Percentage of sites with screening detections followed-up on (%)		72%	90%
Number of follow-up surveys where no emissions were found		99	3
Average time between detection and follow-up to site (days)		76	70
Percentage of follow-up sites that are recurring (for the calendar year – following-up on a site more than once)		N/A	71%
Number of detections by emission source type (n)	**Fugitives**	485	2,681
	Vents	496	2,773
	Total	981	5,454
Volume of detections by emission source type (m^3/day)	**Fugitives**	2,596	9,904
	Vents	3,898	18,512
	Total	6,493	28,417
Identified emission source equipment types per follow-up per screening campaign (e.g., tank, compressor seal)		See Table 3	See Table 3
Number of recurring leaks observed (if the leak occurred more than once per year)		42	N/A
Total emission rate of fugitives identified and fixed for the calendar year (m^3/day)		1,597	9,261

Table 3. Number and volume (m^3/d) of emission detections by equipment type.

Identified emission source equipment types	2023		2024	
	Number of detections by equipment type (n)	Volume of detections by equipment type (m^3/d)	Number of detections by equipment type (n)	Volume of detections by equipment type (m^3/d)
controlled tank	0	0	0	0
dehydrator	54	347	296	1,489
flare stack	1	22	63	1,491
header	3	9	3	15
heater	3	5	8	29
meter	4	5	45	120
other	184	1,056	1,576	8,164
pig sender/receiver	0	0	0	0
pipeline - aboveground	0	0	0	0
pipeline - buried	0	0	0	0
pneumatic instrument	5	10	0	0
pneumatic pump	36	137	0	0
reciprocating compressor	242	1,239	0	0
screw compressor	18	55	0	0
separator	300	795	2,604	9,763
surface casing vent	0	0	0	0
sweetening process	5	21	17	35
treater	0	0	4	10
uncontrolled tank	122	1,327	309	5,077
vent stack	41	310	0	0
wellhead	62	1,156	529	2,223
Total	**1,080**	**6,494**	**5,454**	**28,416**

3. Independent OGI Survey Data

Table 4 summarizes statistics regarding the Independent OGI survey of the alt-FEMP region conducted in 2024. The raw detailed survey data is provided in an Excel attachment with this report.

OGI has the capability to localize emissions to a source-level. Also, the OGI operator can normally determine the emission type. Table 5 shows the emission source equipment types for all identified fugitive and vent emissions including the number and volume of emissions for each equipment type.

Table 4. *Summary of Independent OGI survey data.*

Year		**2023**	**2024**
Number of sites surveyed		104	131
Number of sites with detections		77	77
Percentage of sites with detections (%)		74%	59%
Number of detections		545	650
Number of surveys where no emissions were found		4	0
Number of detections by emission source type (n)	**Fugitives**	208	301
	Vents	329	349
Volume of detections by emission source type (m^3/day)	**Fugitives**	743	528
	Vents	2,577	4,030
Total number of detections (n)		537	650
Total volume of detections (m^3/day)		3,320	4,558
Average time between survey date and repair (days)		42	102
Volume of fugitives identified and fixed for the calendar year (m^3)		620	13

Table 5. Number and volume (m^3/d) of emission detections by equipment type.

Identified emission source equipment types	2023		2024	
	Number of detections by equipment type (n)	Volume of detections by equipment type (m^3/d)	Number of detections by equipment type (n)	Volume of detections by equipment type (m^3/d)
controlled tank	72	1,122	5	13
dehydrator	6	23	16	78
flare stack	0	0	0	0
header	1	1	0	0
heater	2	6	7	9
meter	1	4	1	1
other	21	44	65	1,095
pig sender/receiver	0	0	1	1
pipeline - aboveground	0	0	0	0
pipeline - buried	0	0	0	0
pneumatic instrument	2	5	169	779
pneumatic pump	169	745	0	0
reciprocating compressor	207	1,116	254	817
screw compressor	23	200	6	64
separator	33	54	44	53
surface casing vent	0	0	0	0
sweetening process	0	0	0	0
treater	0	0	1	2
uncontrolled tank	0	0	77	1,643
vent stack	0	0	0	0
wellhead	0	0	3	2
Total	**537**	**3,320**	**650**	**4,558**

4. Continuous Monitoring Survey Data

Tourmaline/Bonavista has deployed 26 QUBE industrial internet of things (IIoT) continuous monitoring (CM) devices at six sites to continuously monitor for methane emissions. Table 6 shows details about the continuously monitored sites including the number of devices and data transmission dates for each site.

Table 6: Summary of continuously monitored sites and QUBE IIoT device information.

Site IDs	Number of devices per site (n)	CM data transmission start date	Alarm thresholds for sensors (kg/hr.)
03-28-041-04W5	5	July 20, 2023	30
05-34-037-08W5	4	July 25, 2023	30
10-34-040-06W5	4	July 25, 2023	30
11-35-042-01W5	4	July 26, 2023	30
11-10-053-19W5	4	August 15, 2023	30
07-20-053-15W5	5	August 15, 2023	5

Table 7 summarizes the total emissions quantified for each month starting from July through Dec 2024. It also shows sensor operational hrs, number of detection events per year per site and potential fugitive emissions identified per site. The QUBE sensors currently do not have the ability to classify the triggered emission events above the set threshold as fugitive or vent. Hence, Tourmaline/Bonavista has verified with their operational activities if the alarm was triggered by a fugitive or vented emission.

Table 7: Summary of continuously monitored site data Jan - Dec 2024.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Total emissions quantified for the month (m^3)	1,948	2,863	5,403	7,726	10,741	4,363	3,205	4,397	2,874	2,532	1,366	1,143
Site pressurized hours per month per site (hrs)												
03-28-041-04W5	744	696	740	720	744	719	743	744	664	744	719	744
05-34-037-08W5	740	694	733	341	4	0	0	209	128	383	712	744

07-20-053-15W5	729	693	729	613	716	714	717	743	501	732	708	720
10-34-040-06W5	732	695	740	718	722	714	737	730	662	743	710	699
11-10-053-19W5	743	693	735	711	742	720	728	744	640	717	714	741
11-35-042-01W5	744	691	717	715	741	714	744	740	696	726	720	737
Sensor operational hours per month (hrs)	13,944	18,006	19,344	18,720	19,344	18,720	19,344	19,344	18,720	19,272	16,314	13,944
Number of detection events per month	2,045	2,922	3,139	2,787	5,663	3,218	3,022	5,985	3,012	3,086	2,590	2,386
Number of detection events per month per site												
03-28-041-04W5	281	295	284	290	633	332	367	718	352	334	264	329
05-34-037-08W5	292	247	263	199	322	383	286	491	232	244	312	290
07-20-053-15W5	178	309	326	339	852	406	370	666	317	289	194	191
10-34-040-06W5	248	287	323	275	530	335	274	624	297	290	219	294
11-10-053-19W5	278	411	440	339	545	277	338	646	332	300	249	158
11-35-042-01W5	217	305	279	259	500	302	372	594	338	423	272	339
Total for all sites	**1,495**	**1,854**	**1,915**	**1,701**	**3,382**	**2,035**	**2,007**	**3,739**	**1,868**	**1,880**	**1,510**	**1,601**
Number of detection events classified as potential fugitive emission sources per site	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

5. Emissions Summary

5.1 Screening Summary

Figure 1 shows the distribution for site-total methane emission rates detected during screening campaigns in 2023 and 2024, capturing all types of methane emissions (fugitives, vents, methane slip and others). The graph allows one to discern how many site-total emission measurements reported emission rates within a certain range (e.g. emissions with rates between 0 and 100 m^3/day where individual emissions on a single site from one screening are summed).

Figure 2 shows the distribution for individual emission rates detected during the 2023 and 2024 screening campaigns. Screening technologies are generally unable to determine the type of methane emission measured (fugitives, vents, methane slip and others). The graph allows one to discern how many individual emission measurements had an emission rate within a certain range (e.g., emissions with rates between 0 and 100 m^3/day).

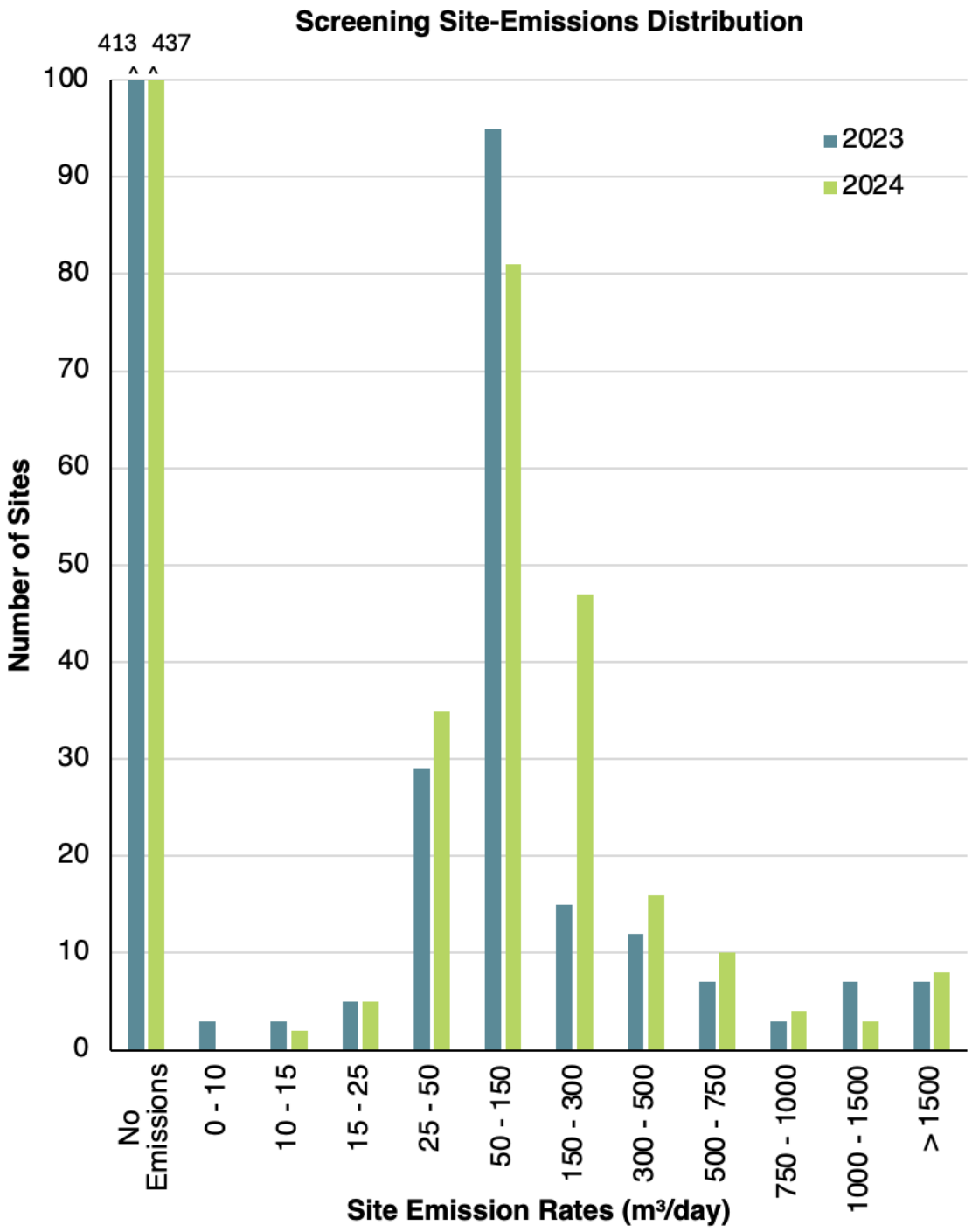

Figure 1: Distribution of site-total emission rates measured during screening campaigns.

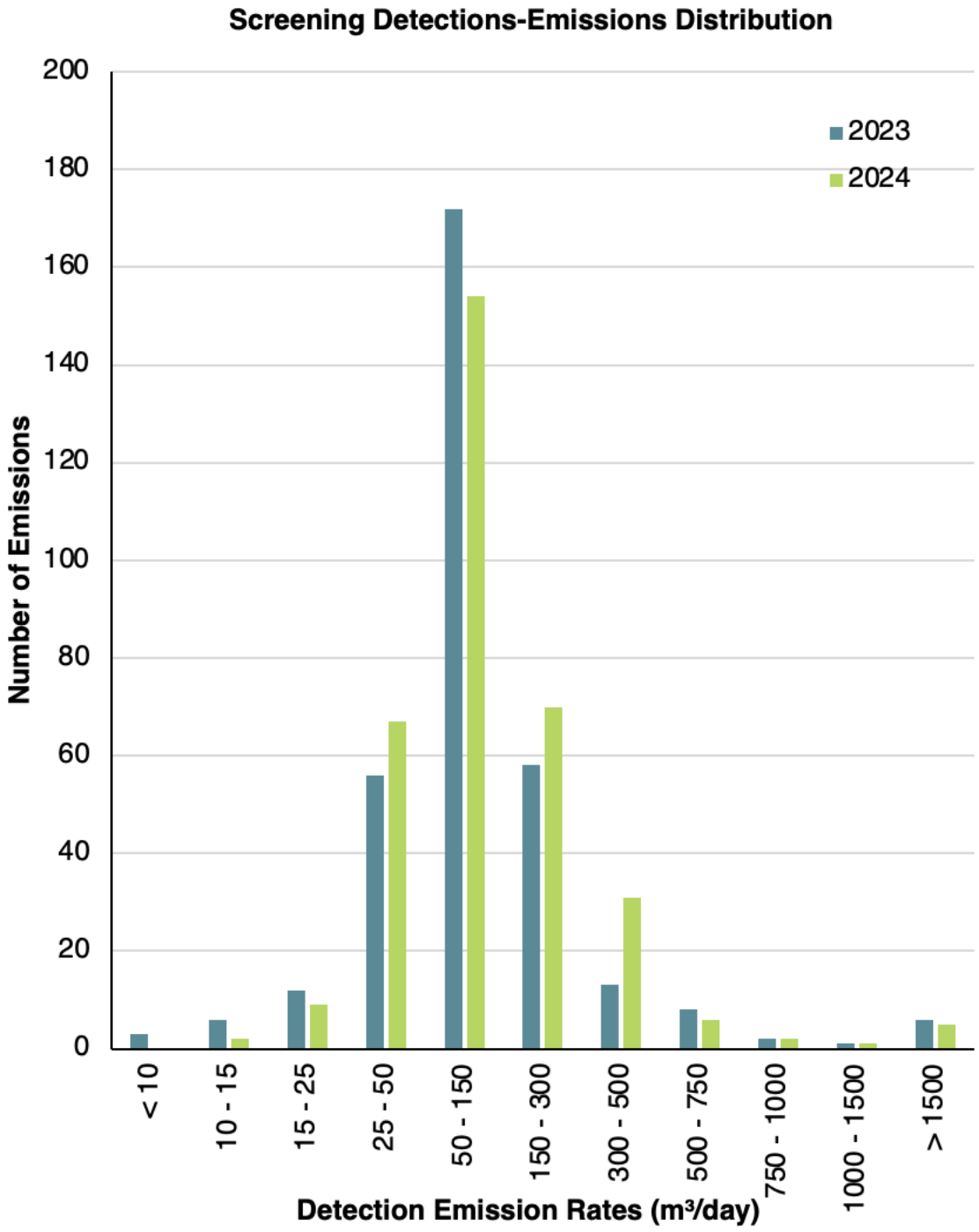

Figure 2: Distribution of individual emissions, by rate, measured during screening campaigns.

In general, screening technologies cannot discern fugitive emissions from other emission types, thus a graph depicting the emissions distribution specifically for fugitives detected during screenings could not be generated.

5.2 OGI Survey Summary

Figure 3 shows the emission rate distribution for site-total emissions detected during 2023 and 2024 OGI survey campaigns, aggregating all methane emissions measured during that OGI campaign. The graph allows one to discern how many site-total emission measurements, by OGI, reported an emission rate within a certain range.

Figure 4 shows the emission rate distribution for individual emission rates detected during the 2023 and 2024 OGI survey campaigns of the alt-FEMP region. The graph allows one to discern how many individual emission measurements, by OGI, reported an emission rate within a certain range.

Figure 5 shows the emission rate distribution for individual fugitive emissions detected during OGI survey campaigns. The graph allows one to discern how many individual fugitive emission measurements reported an emission rate within a certain range.

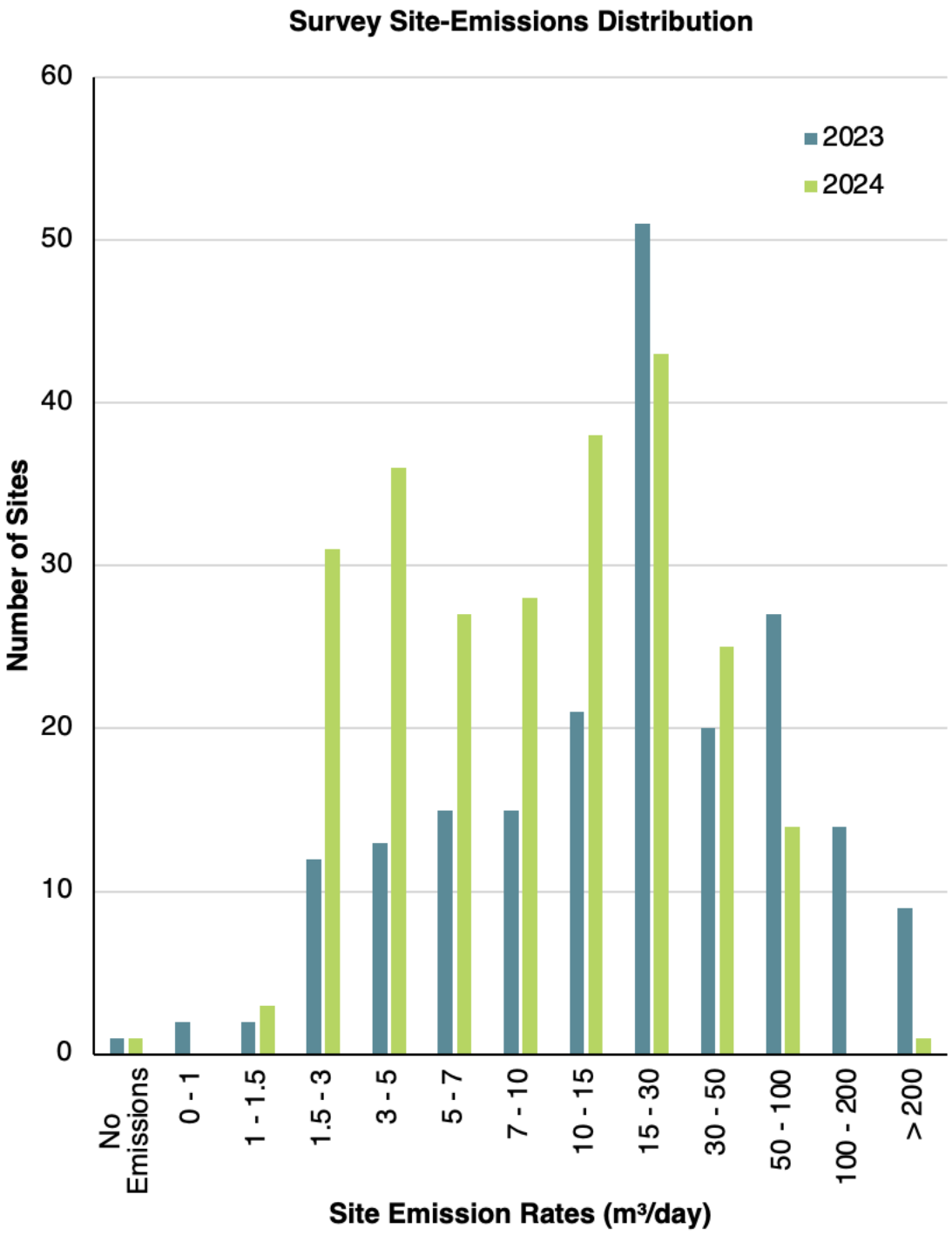

Figure 3: Distribution of site-total emission rates measured during OGI survey campaigns (e.g. follow-up and independent campaigns) of the alt-FEMP region.

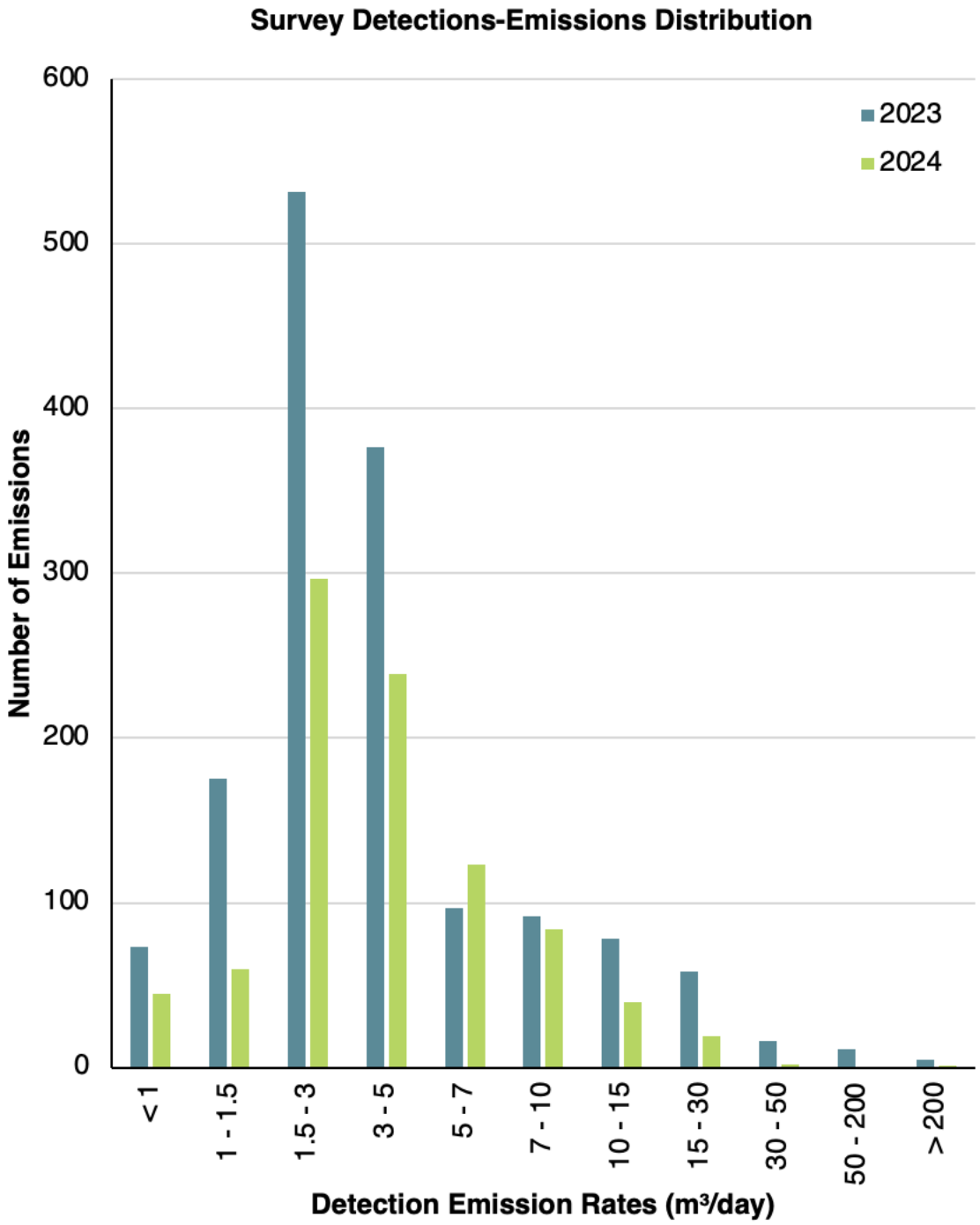

Figure 4: Distribution of individual emissions, by rate, measured during OGI survey campaigns (e.g. follow-up and independent campaigns) of the alt-FEMP region.

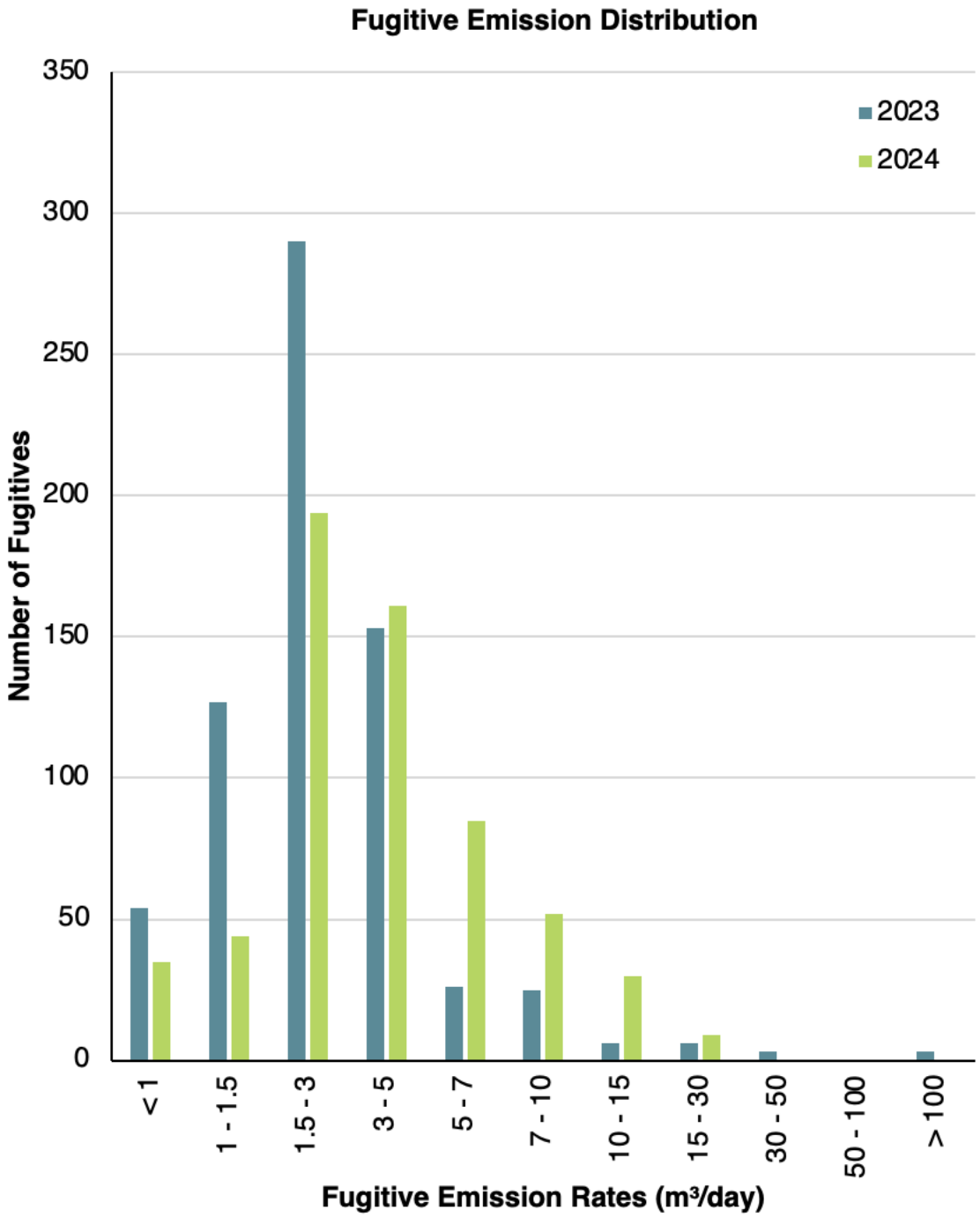

Figure 5: Distribution of fugitive emissions, by rate, measured during OGI survey campaigns (e.g. follow-up) of the alt-FEMP region.

6. Emission Reduction Summary

The fugitive emission data collected during the alt-FEMP was used to generate the as-found “measured fugitive emission distribution”. This consisted of all fugitive emissions recorded during both alt-FEMP follow-up surveys and independent OGI surveys. Figure 6 shows a comparison of the as-found “measured fugitive emission distribution” to the “assumed fugitive emission distribution” employed in the modelling initially used to design the approved alt-FEMP. Additionally, the minimum detection limit (MDL) at 90% probability of detection (PoD) for the screening technology is displayed for reference.

A default Directive 060 FEMP program and the executed Tourmaline/Bonavista alt-FEMP program were re-modelled using the as-found fugitive distribution using the AroFEMP software (Arolytics). Using these updated inputs the traditional default FEMP was predicted to emit 12% more fugitive methane than the alt-FEMP suggesting that the executed alt-FEMP successfully reduced more fugitive methane than the default FEMP would have over the last two years.

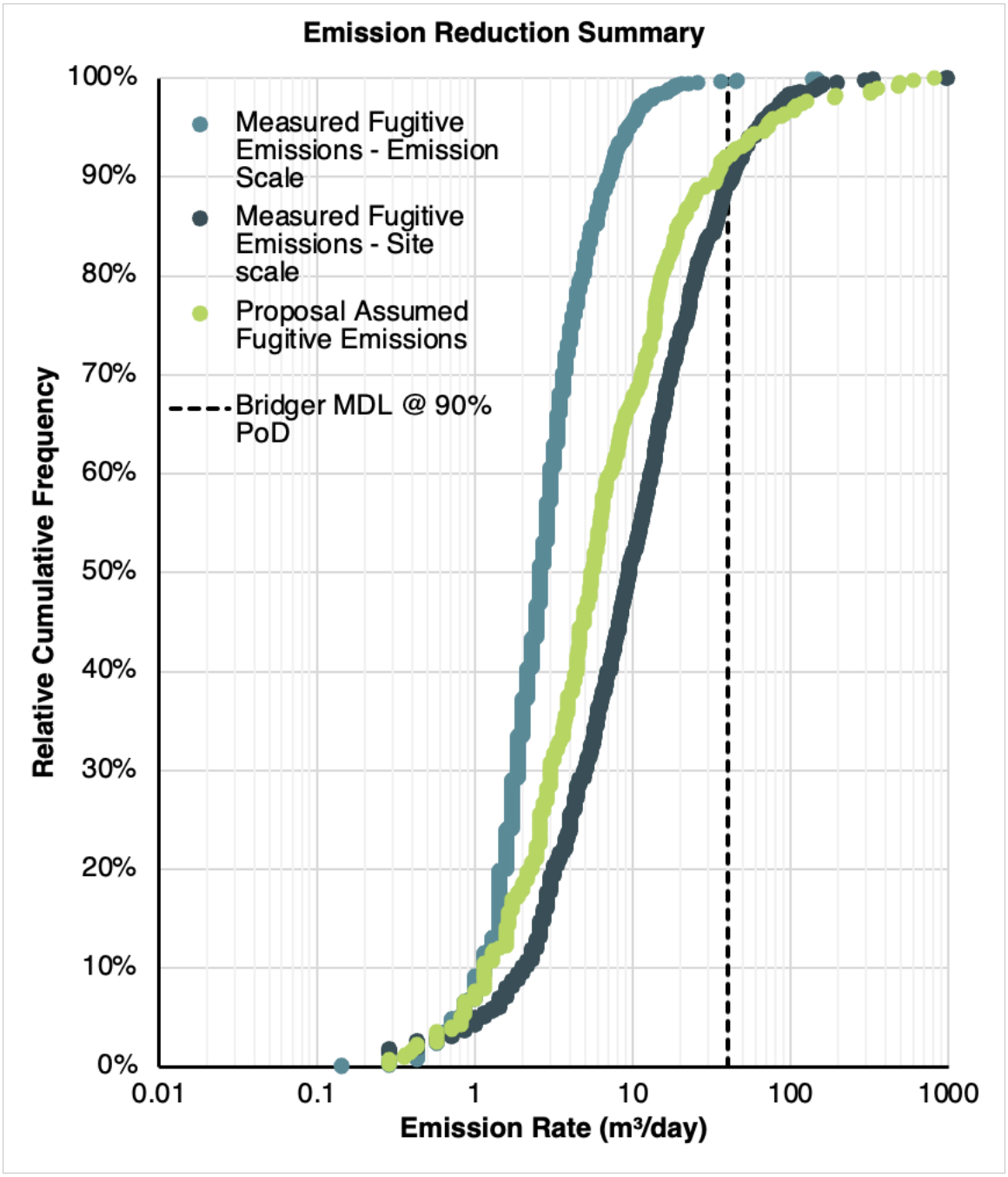

Figure 6: Comparison of relative cumulative frequencies for the "as-found" measured fugitive emissions versus the proposal-assumed fugitive emissions.

7. Technology Limitations

Bridger's detection sensitivity depends on factors including flight speed, flight altitude, measurement swath width, and wind speed. Many of these factors can be controlled by Bridger to tighten or loosen the sensitivity as required. Bridger's GML is an active, laser-based system, rather than a passive remote sensor that relies on the environment, so conditions such as cloud cover or shadows that can impair other aerial sensor technologies do not negatively impact GML. Regarding operations at northern latitudes, GML is moderately limited by snow cover and standing water. While GML will detect methane when there is snow on the ground, the detection sensitivity of the data is degraded. With standing water, Bridger's laser 'bounces' off and, as a result, no measurement is made. In several areas of Alberta, the muskeg landscape holds pockets of water in the warmer months. Based on testing and commercial projects completed in Alberta, the muskeg landscape has not negatively impacted Bridger's GML measurements. As a result of high winds rapidly dispersing emissions, Bridger limits its survey operations to ground wind speeds less than or equal to 25 mph. Bridger also implements a wind speed protocol to detect emissions at the lower end of GML's detection sensitivity. To avoid Bridger's limitations in snow, Bridger will only implement GML in snow-free months (between late Spring and early Winter). Bridger will also limit its survey operations to average ground wind speeds less than or equal to 25 mph.

7.1 Weather Effects:

Due to the smoke conditions and no-fly zones created by wildfires, the Bridger screening campaign in 2023 could not be completed in one campaign. The first part of the screening took place in May 2023 to screen all accessible sites and approximately 60 sites were screened in July 2023 after the no-fly zones were lifted. However, the 2024 Bridger campaigns were conducted as planned without any issues in May and October 2024.

It is well understood that Bridger's GML technology cannot currently detect and measure methane emissions if there is snow on the ground. As the screenings were conducted in the months of May, July and October with no snow, this limitation did not cause any disruptions to the screenings or interfere with the screening data collected by Bridger.

The OGI survey data collection was reported to be collected smoothly and showed no issues with sensitivities to cloud cover, precipitation, snow cover, wind speed, or extreme cold.

7.2 Measurements:

Both technologies deployed for emission detection and quantification (Bridger, OGI) detected and quantified numerous methane emissions below the stated 90% PoD for the respective technologies. This does not provide a reason to suspect that the performance of the technologies in this alt-FEMP was less than expected.

8. Success of the alt-FEMP

The alt-FEMP was successfully executed as planned, including the screening and follow-up campaigns as well as the CM sensors. The one variation from the designed alt-FEMP was the delay of the screening and subsequent follow-up in 2023 due to wildfire conditions. Tourmaline/Bonavista met the 40% follow-up requirement in both years of the alt-FEMP and repaired 79% of all detected fugitives by the time of this report.

9. Nonperforming Program Elements

The follow-up surveys were intended to occur at the top 40% of the highest emitting sites as determined by Bridger, however Bridger only detected emissions at ~30% of the surveyed sites in each of the screening campaigns. All sites with detectable emissions were tasked to be followed-up. As Tourmaline/Bonavista's full-scale alt-FEMP program was designed utilizing the key learnings from its pilot (alt-FEMP 2021- 2022), additional sites were added to the follow-up campaigns to meet the 40% follow-up requirement set out in the Alt-FEMP even if less than 40% of sites were found to be emitting by the screening campaigns.

10. Additional Control Measures

Any sites that were missed during screenings were automatically added to be followed-up on by OGI survey. Following acquisitions / divestitures and site activation / deactivation during the alt-FEMP, Tourmaline/Bonavista adjusted the sites in the alt-FEMP to ensure that all appropriate sites were included.

11. Additional Information

In November 2023 Tourmaline Oil Corporation completed the corporate acquisition of Bonavista Energy Corporation. The acquisition resulted in acquiring all the facilities within the Bonavista alt-FEMP. The

acquired Bonavista full scale alt-FEMP covered two full compliance years from April 2023 to December 2024 and Tourmaline continued the program for all the facilities that they acquired.

12. Key Performance Indicators

- Tourmaline/Bonavista was successful in implementing alternative technologies to conduct LDAR screening, where emissions were detected at 432 of the 1210 screened sites in 2024.
- In 2023, a total of 132,701 m^3/day of methane was found to be emitting by screening technologies on 750 detections. Of which, 9,904 m^3/day was identified as fugitive emissions when followed-up with OGI.
- On average, leak repairs were completed 61 days after an OGI follow-up under the alt-FEMP with a maximum repair time of 177 days.
- 79% of fugitive emissions sources were repaired under the alt-FEMP.
- See Table 8 below for additional key performance indicators.

Table 8: Key performance indicators for the 2024 year of the alt-FEMP.

Key Performance Indicator	2024 Follow-Up
Number of sites surveyed	464
Number of sites with emissions detected via OGI	461
Percentage of sites with emissions detected via OGI (%)	99%
Number of fugitives and vents detected via OGI	5,454
Number of sites with fugitives detected via OGI	426
Percentage of sites with fugitives detected via OGI (%)	92%
Number of fugitives detected via OGI	2,681
Number of vents detected via OGI	2,773
Total emission rate of detected emissions (m^3/day)	28,416
Total emission rate of detected fugitives (m^3/day)	9,904
Total emission rate of detected vents (m^3/day)	18,512
Average fugitive rate per site with fugitives (m^3/day)	23.2
Average emission rate for detected fugitives (m^3/day)	5.2
Number of fugitives repaired	2,513
Percentage of fugitives repaired (%)	94%

Appendix A: Raw Detailed Data

Please refer to the attached excel file of the raw data collected during the screening and follow-up surveys titled “BVTRM-2024 AER Data Template.xlsx”.

Appendix B: Screening Data – Site-total Emissions by Campaign

Please refer to the attached excel file of the site-total emissions data collected during the screening surveys titled “Appendix_B.xlsx”.

Appendix C: Screening Data – Individual Emissions

Please refer to the attached excel file of the individual emissions data collected during the screening surveys titled “Appendix_C.xlsx”.