CHERRY CREEK RESERVOIR DESTRATIFICATION SYSTEM

OPERATION AND MAINTENANCE ANNUAL REPORT 2023

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CHERRY CREEK BASIN WATER QUALITY AUTHORITY
RESERVOIR DESTRATIFICATION SYSTEM
OPERATION AND MAINTENANCE
ANNUAL REPORT
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INTRODUCTION

RG and Associates, LLC (RGA) has been retained to manage the operation and maintenance of the compressor and aeration system commonly referred to as the Cherry Creek Reservoir Destratification System (RDS). The RDS began operation in April 2008.

RDS OPERATIONS POLICY

At its January 20, 2022, meeting, the CCBWQA Board of Directors (Board) adopted a restated amended Policy for the Operation of the RDS (Policy) by resolution 2022-1-2 which recognized that the RDS historically has shown to reduce the summer Chlorophyll *a* average by 0.8 to 4.7 ug/l. As such, the board established a new operating season of approximately mid-April through approximately the end of September.

In accordance with this policy, then, RGA started the RDS on April 17, 2023, and shut it down at 11:28 am on October 5, 2023.

SYSTEM OPERATION

The RDS operated almost trouble-free in 2023, with only 21 hours of down-time, less than one day, as compared to 9 days in 2022. Part of this was due to the fact that there were no calls during the operating season for heads inadvertently broken by boat anchors, causing a system upset, and part was due to implementation of the RMS, the remote monitoring system, whereby we and the IR team were able to get almost immediate notification that the system was not operating and allowing repair teams to get out repairs immediately make repairs or adjustments. The operating log of the system is contained in the Appendix for more information.

REPAIRS TO THE SYSTEM

Repairs to the system were minimal in 2023. At the beginning of April, it was discovered that the lower pressure regulator and some of its piping had frozen and broken during the winter due to water that had accumulated during the past year of operation. IR repaired the broken pipe, installed drip-legs to allow accumulated water to be blown off, and installed a new pressure reducer.

The second repair was done in the second week of April, when at start-up testing of the system, it was found that two of the aerators were not operating correctly, by allowing too much air to pass through them. B&RW repaired these aerators by replacing parts and had them operational on April 17, for official seasonal start-up.

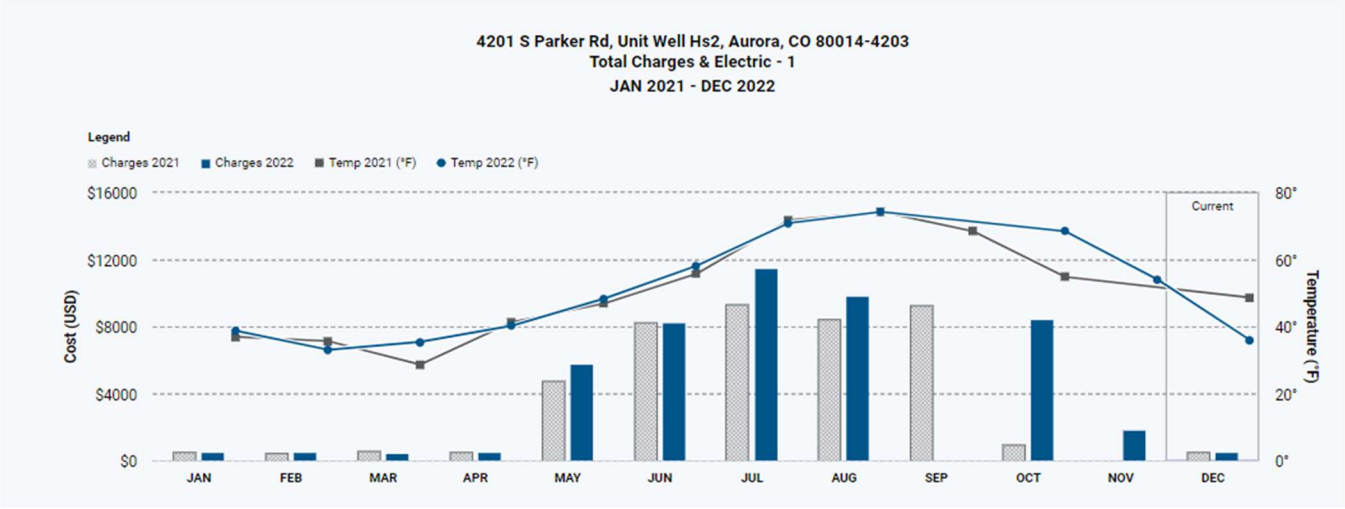
No other repairs were necessary throughout the operating season.

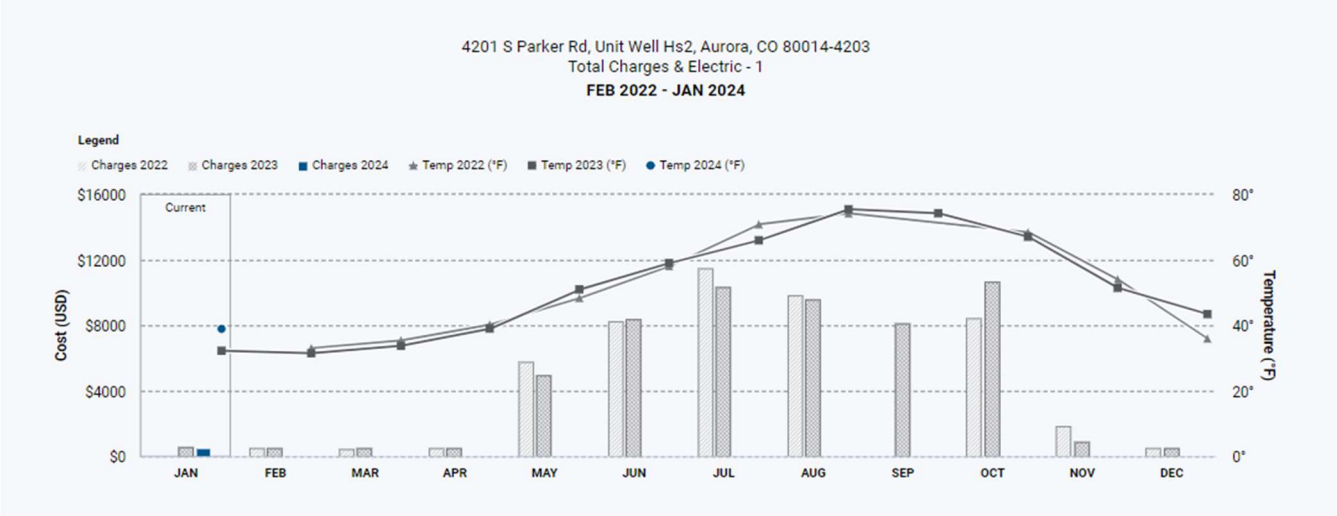
MAINTENANCE ON THE SYSTEM

Routine maintenance was performed three times on the system on-schedule by Ingersoll Rand, in February, June and October, under their PerformanceCare maintenance contract with the Authority. One unscheduled maintenance event was done by the IR team on August 21, when we were alerted by the RMS that the compressor had shut down due to overheating. That maintenance included blowing accumulated dust off of the oil coolers to allow them to provide adequate cooling.

The final scheduled maintenance event was performed between October 3rd and 5th by Foster Dirt and Construction Co. Foster Dirt replaced B&RW during the year due to Blair Wacha's desire to retire and transition the business to Justin Foster of Foster Dirt and Construction Co. Blair stayed on the team during the year to assist and lend his expertise to the Foster Dirt Team. During this final maintenance, a few cam levers, cam pins and flow regulators were replaced due to corrosion on the old parts and the flow regulators were cleaned, but nothing of great consequence was noted. A complete log of the maintenance performed can be found in the Appendix of this report, for more detailed information regarding this maintenance event.

2023 ELECTRICAL USAGE AND CHARGES





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Xcel Energy provided two graphs shown above, graphing monthly data for the electrical charges and ambient temperatures for a two-year period of time, one superimposed on the other for comparison's sake. One graph is for the 2021-2022 period and the other is for the 2022-2023 period. Note that there is information missing September 2022, which may be a result of the meter not having been read. When the corresponding data is summarized, the total electrical usage for 2023 was 202,240 kWh at a cost of $55,592.31 compared with 2022 that used 181,720 kWh at a cost of $48,088.50.

The energy use of the RDS increased in 2023 as compared to 2022 as shown on the charts below. While the 2023 season was shorter than 2022 by 3 days, when comparing startup and stop dates for each year, April 17 to October 5, 2023 (171 days) versus April 15 to October 6, 2022 (174 days), 2023 only had less than one day of shutdown (21 hours) due to mechanical issues, versus 9 days in 2022, yielding 170 net operating days in 2023 versus 163 net operating days in 2022. The increase in operating time in 2023 equates to a 4.3 % increase in operating time, yet the actual power usage in 2023 increased by 11.8%. While there is no readily apparent reason for this difference, it may be a result of different weather patterns, or, more likely, the greater amount of average water depth in the reservoir due to the spring storms. It is recommended, as was last year, that the energy use be monitored going forward to determine whether there are any developing performance issues with the RDS.

System power Costs 2022-2033

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
Charges 2022		$481.62	$473.83	$486.83	$5,802.56	$8,276.05	$11,497.55	$9,826.91		$8,420.90	$1,820.20	$504.77	$47,591.22
Charges 2023	$546.82	$520.39	$511.15	$483.99	$4,977.13	$8,403.07	$10,340.82	$9,578.53	$8,136.47	$10,666.11	$896.45	$531.38	$55,592.31
Charges 2024	$532.55												
Temp 2022 (Â°F)		33.06667	35.39655	40.25806	48.39655	58.13334	70.913795	74.25		68.46774	54.06452	36	
Temp 2023 (Â°F)	32.25714	31.5	33.76667	39.03571	51.01724	59.07576	66.01667	75.5	74.29311	67.09091	51.48276	43.46875	
Temp 2024 (Â°F)	38.90625												

System Power Usage 2022-2023

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total KW-HR
Energy Usage 2022 (kWh)		800	760	800	26,200	38,240	41,600	35,160		29,760	6,640	880	180,840
Energy Usage 2023 (kWh)	1,080	960	920	800	21,440	37,080	36,680	34,240	28,600	37,680	1,920	840	202,240
Energy Usage 2024 (kWh)	840												
Temp 2022 (Â°F)		33.06667	35.39655	40.25806	48.39655	58.13334	70.9138	74.25		68.46774	54.06452	36	
Temp 2023 (Â°F)	32.25714	31.5	33.76667	39.03571	51.01724	59.07576	66.01667	75.5	74.29311	67.09091	51.48276	43.46875	

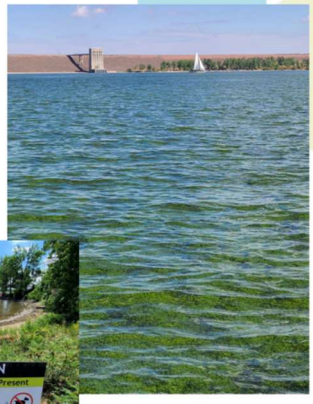
RDS EFFECT ON WATER QUALITY

One of the goals of the RDS is to disrupt the natural buoyancy of cyanobacteria to reduce the frequency and severity of blooms. The updates to the RDS system in 2022 which allow for a full season of operation, likely provide additional benefit during the seasonal chlorophyll-a standard assessment period (July-September) and may also have helped to more quickly disrupt blooms that typically occur later in the season.

RESERVOIR WATER QUALITY

- Cyanobacteria blooms are variable
- Species responsible for closures due to toxin production occur but not every year
- 2023 - Cyano bloom in late July tested positive for toxin and affected areas were closed to contact for few days - within 2 weeks the bloom had dissipated and no toxin was detected (Microcystis - non N-fixer)

Year	Bloom	Toxin/ Closure
2014	Yes - Severe	Yes/ Yes
2015	Yes - Moderate	Not Detected/ No
2016	Yes - Severe	Yes/ Yes
2017	Yes	- / No
2018	Yes - Mild	Not Detected/ No
2019	Yes - Moderate	Not Detected/ Caution
2020	Yes - Severe	Yes/ extended
2021	No	
2022	Yes - multiple	Yes/ Yes
2023	Yes - multiple	Yes/ Yes



Cyanobacteria Activity-Courtesy of LRE Water

OVERALL HEALTH OF THE SYSTEM

Generally, the RDS is in sound condition, especially since the compressor was replaced in January of 2020, four years ago. The life of a system like that should be upwards of 20-30 years, with the compressor being the most sensitive to wear and tear. The compressor is the only active part of the system and is only three years into its life span. The aerators and piping are passive parts, meaning they have no moving parts, and in the opinion of Foster Dirt and Construction Co., the aeration system is a “Cadillac” system, and should have at least five to ten years of life left. The only problems that we have had with the aeration system is from corrosion of the stainless-steel parts.

RECOMMENDATIONS

The following recommendations are provided for consideration to improve system operation.

- To prevent the compressor oil coolers from clogging with dust and overheating, as occurred on August 21, to have Ingersoll Rand (IR) clean compressor coolers in April and in August, in between their three current contracted maintenance dates to minimize the chances of another high temperature shutdown. Jeff Handley has already quoted that to add this maintenance to their current contract would cost an additional $1,750 and they are ready to implement this at any time.

- It is recommended to continue monitoring the annual energy consumption and look for any trends that may point to developing issues or concerns with the compressor.

- It is recommended that the authority begin an analysis to determine whether the current aerator assemblies will be able to be replaced in the coming years, if necessary, due to availability, and if not available, what other heads might be available as replacements.

- After completion of the reservoir/watershed modeling efforts, slated to be completed this year, it is recommended that data be analyzed from the results of that modeling work as to whether it is warranted to increase the aeration system output, and if so, how much to increase it, analyze how much the existing system output can be increased by either changing the flow control orifices or changing out the heads with new, higher output heads, how much the existing compressor’s output can be increased, all to determine if the existing system can be modified at all to meet future needs, augmented or whether it would need to be completely replaced.

Appendices

SUMMARY of 2023 OPERATIONS DETAILS, REPAIRS and MAINTENANCE

SUMMARY of 2023 OPERATIONS DETAILS, REPAIRS and MAINTENANCE

April 7-

- Rich Borchardt, Erin Stewart and Rick Goncalves met at the compressor building to begin season startup procedures.
- Found the compressor building open, doors ajar, and the lower pressure regulator and its piping disassembled.
- With no entries on the Maintenance log explaining what had happened, we decided to cancel the test until we could find out what the situation was.
- After contacting Ingersoll Rand, I found out, from Jeff Handley of IR that the maintenance personnel who were working at the facility had been let go for doing poor work, at our compressor as well as elsewhere and he said he would go out to check out and start the compressor.
- I related to CPW that vandalism was not the problem with the doors.
- Later in the day, Jeff called to say that the compressor was “good to go” and that the aerators were pumping air into the reservoir.
- He also said that he would arrange to get the piping and pressure regulator reinstalled, and leave the compressor shut off. He also said that the problem with the piping and lower regulator was caused by poor piping design that allowed water that is naturally produced by compressing air to accumulate at the low spots in the pipe then freeze and break the pipe and regulator.

April 14-

- Started the compressor at 12:30 pm then proceeded with Erin Stewart to inspect the aerator plumes by boat.
- Found two aerators out of order and established their locations by GPS to forward to B&RW for repair.
- Blair Wacha of B&RW was contacted and related to me that he would be out early morning on April 17 to repair the faulty aerators.
- Finished our inspection of the system and shut the compressor off at 1:45pm.

Broken aerator

Broken aerator

Marking broken aerator by GPS

April 17-

- B&RW finished its repair of the two identified aerators and a third that he had found.
- Blair called me to give details of the repairs, all of which were situations where the plastic flow regulators had been blown out of place by back-pressure, probably caused by too rapid a shutdown during shutdown last year.
- We will be revising our shutdown procedures for the end of the operating season.

- With notice that the system was operating in good condition, I directed Blair to leave the compressor on at 40 psi.
- I then notified CCBWQA staff, Parks personnel and managers that the RDS was on and operating for the season.

April 19-

- Went out to the reservoir twice to perform the final two pressure step increases to 50 psi and 55 psi which were performed at least 4 hours apart, as per Authority Operations Policy.

April 20-

- Received a quote from Ingersoll Rand for $2,992.45 to repair the compressor piping to and from the lower pressure regulator that was damaged by water that is normal in air compression that accumulated, froze, and broke the pipe and regulator, replace the broken pressure regulator, and revise the piping to provide drop-legs with purge valves to prevent accumulated water from freezing and breaking the pipes again.
- This repair is not covered under warranty, as the warranty only covers the compressor itself.
- The entire system was designed to meet Authority directed operating parameters of “between April and November” and the building heater was designed to produce enough heat within those parameters to allow the compressor to work with at a minimum of 38 degrees. No one anticipated needing the building to be heated during the off season, as there would have been no need to. Except for accumulated water in the pipes? No one anticipated that either. Heating the building to prevent accumulated water from freezing would not have been the prudent solution. Providing drop legs and purging the water at the end of the operating season is.

April 24-

- The repair cost was approved by the Executive Committee and a work order prepared and issued to Ingersoll Rand.

May 8-

- Ingersoll Rand repaired the broken compressor piping and pressure reducing valve.

May 18-

- At the May 18th board meeting, the question was raised as to whether the broken piping and pressure reducing valve repairs should be paid for by Ingersoll Rand under warranty or not. Based on the analysis of the contract documents and maintenance agreement report that all warranties had expired, and, principally, that the damage to the compressor piping and pressure reducing valve had been due to the compressor piping not being sufficiently protected from freezing, through no fault of Ingersoll Rand, Ingersoll Rand was paid for the repairs.

June 14-

- Made a spot inspection of the compressor and visual inspection of the aeration pattern in the reservoir. Found the aeration pattern in the reservoir satisfactory, the compressor running at its 100 psi satisfactorily, but the pressure reducer gauge was showing only 45psi. Figuring that it had been adjusted during the piping repair, I adjusted it back up to 55 psi. Everything was good.

Initial pressure at 45 psi


Compressor pressure at 100 psi

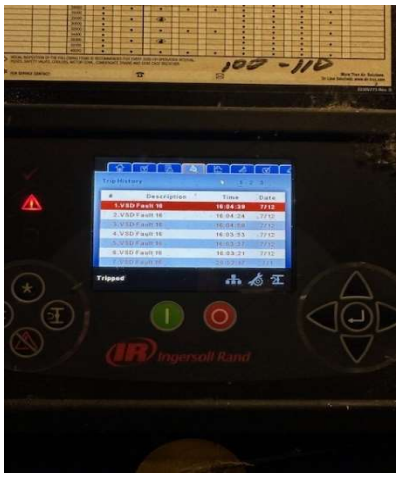
Reset pressure to 55 psi

July 5-

- Made another spot RDS inspection. Lake aerator pattern still showed no aerator issues. The compressor pressures were still good, but outlet pressure was down to 50 psi. Re-adjusted the pressure to 55 psi. Suspect that the changing reservoir levels due to the floods are affecting the pressures. Will continue to watch for any problems.

July 13-

- On 7/13/23 at 8:15 I performed a random visual inspection of the diffuser pattern on the reservoir and found that was no pattern, meaning that no air was getting to the aerators in the reservoir.
- Upon an inspection of the compressor, I found that it was off, with a fault indication reading “VSD Fault 16” at 4:18 pm, the day before, 7/12/23. This meant that the compressor had been off for about a day and a half.
- I called Jeff Handley at Ingersoll Rand, who indicated that IR had just received a fault notice, and that it was safe to restart the compressor, which was done.
- The compressor started immediately with no issue. Jeff said the fault had been caused by a voltage drop, probably from local area heavy air conditioning usage, or possibly caused by an electrical contractor known to have been working nearby.



July 19-

- I made another spot inspection. Reservoir aeration pattern was satisfactory, but discharge pressure was down to 50 psi. Pressure was adjusted to 55 psi. All else looked good. I checked aeration manholes for flood damage. Except for a piece of driftwood that floated into one of the manholes, there was little evidence that reservoir high flood levels had affected the manholes or the aeration piping at all, and there was definitely no damage.



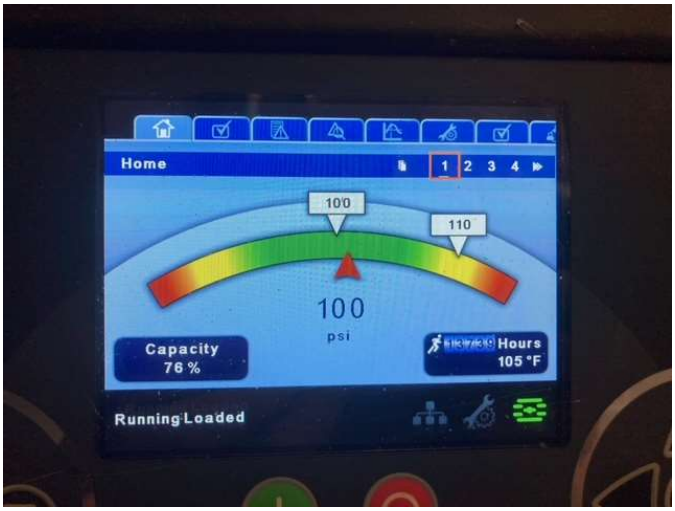
July 26-

- I had Ingersoll Rand put the Authority on the IR Remote Monitoring System (RMS) so as to get notifications on compressor failure relatively quickly to minimize RDS down time.

August 21-

- Even though out of the country, I received an alarm by text message from the newly implemented RMS indicating that the compressor had shut down due to excessive bearing temperature. When I immediately called Ingersoll Rand, they said that they had received the same alarm and had someone already on it.
- The compressor had shut down because of excessive oil temperature caused by excessive dust build-up on the oil cooler. IR cleaned the oil cooler, and had the compressor back on line in 3 hours and 15 minutes from the time of the shutdown, substantiating the value of setting up the RMS process.

Trip notification



Compressor back in operation

Dust buildup on the oil cooler

Oil cooler after cleaning

October 4

- The yearly inspection and maintenance of the aeration system was done and completed on October 4, 2023, by Foster, Dirt and Construction. Its inspection report is contained in the Appendix of this report.
- Foster Dirt has taken over the duties that Blair Wacha with B&RW had previously done for the last number of years.
- No major issues were encountered. A few of the cam lock levers and pins were replaced due to corrosion.
- It appears that more pins and cams have been replaced in the area of the reservoir where Cottonwood Creek drains into it than any other place in the reservoir.
- This could be caused by wastewater effluent presence in Cottonwood Creek drainage from the upstream wastewater treatment plants.

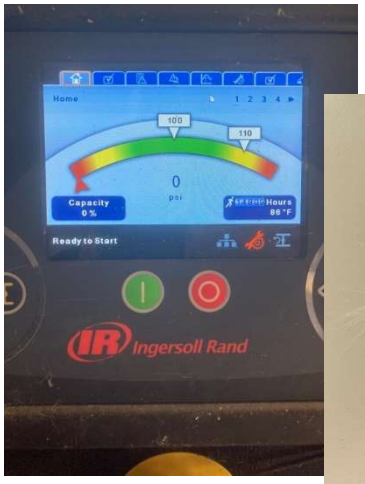
Corroded flow regulator

Corroded cam lever

Corroded pin

October 5

- On October 5th, 2023, the process for compressor was shut down in accordance with Authority Policies and Procedures was begun.
- The newly installed drip legs were released of accumulated water to prevent water freezing in the pressure reducers.
- Water was blown off from the compressor and the regulator tank.
- A new procedure whereby the air discharge valves downstream of the pressure reducers were shut down very slowly while the compressor was still running to shut off the air to the aeration system gradually to prevent a sudden back pressure on the aeration system heads that has caused some of the O-rings to blow out in the past.
- After the valves were shut, the compressor was shut down for the winter at 8:15 am.



Foster Dirt Report from 2023 Annual Maintenance

Foster Dirt Report from 2023 Annual Maintenance

September 2023 repairs to Cherry Creek aereation system											
Head location	Clean head & adjust position, check fitting tightness	Clean or replace filter	Upper cam pins replaced	Lower cam pins replaced	Replace cam levers	Replace O Ring	Replace other broken parts	Actual latitude N 39 deg, xx.xxx min	Actual longitude W 104 deg, xx.xxx min	Stainless Steel Band Clamp Thickness (new .025") / End of Line Blow Off Valve Pressure (distribution vault pressure 47 psi)	Notes
101	x	clean	0	0	0	0	0	38.507	51.912		
102	x	clean	0	0	0	0	0	38.477	51.894		
103	x	clean	0	0	0	0	0	38.446	51.879		
104	x	clean	1	0	0	0	0	38.413	51.870		
105	x	clean	0	0	0	0	0	38.373	51.875		
106	x	clean	0	0	0	0	0	38.357	51.899		
107	x	clean	0	0	0	0	0	38.338	51.931		
108		x	clean	0	0	0	0	38.327	51.956		
109	x	clean	0	0	0	0	0	38.361	51.823		
110	x	clean	0	0	0	0	0	38.338	51.830		
111	x	clean	0	0	0	0	0	38.322	51.842		
112	x	clean	0	0	0	0	0	38.298	51.870		
113	x	clean	0	1	0	0	0	38.277	51.891		
114	x	clean	0	0	0	0	0	38.349	51.786		
115	x	clean	0	2	0	0	0	38.337	51.740		Apparently moved by boater 50 ft. We moved back
116	x	clean	0	0	0	0	0	38.332	51.710		Apparently moved by boater 100 ft. We moved back
117	x	clean	1	2	0	0	0	38.327	51.669		Apparently moved by boater 50 ft. We moved back
118	x	replace	1	0	0	0	0	38.320	51.626		Heavy filter build up, filter taken for cleaning/repair
119	x	clean	0	1	0	0	0	38.314	51.584		Apparently moved by boater 50 ft. We moved back
120	x	clean	0	0	0	0	0	38.307	51.549		Apparently moved by boater 100 ft. We moved back
121	x	clean	0	0	0	0	0	38.477	51.998		
122	x	clean	0	0	0	0	0	38.452	52.043		
123	x	clean	0	0	0	0	0	38.431	52.077		
124											out of service since 2018
Head location	Clean head & adjust position, check fitting tightness	Clean or replace filter	Upper cam pins replaced	Lower cam pins replaced	Replace cam levers	Replace O Ring	Replace other broken parts	Actual latitude N 39 deg, xx.xxx min	Actual longitude W 104 deg, xx.xxx min	Stainless Steel Band Clamp Thickness/ End of Line Blow Off Valve Pressure (distribution vault pressure 47 psi)	Notes
201	x	clean	0	0	0	0	0	38.543	51.840		
202	x	clean	0	0	0	0	0	38.514	51.817		
203	x	clean	0	0	0	0	0	38.489	51.793		
204	x	clean	0	1	0	0	0	38.467	51.769		
205	x	clean	0	0	0	0	0	38.444	51.741		
206	x	clean	0	0	0	0	0	38.418	51.715		
207	x	clean	0	0	0	0	0	38.389	51.673		
208	x	clean	1	0	0	0	0	38.364	51.607		
209	x	clean	0	0	0	0	0	38.351	51.553		
210	x	replace	0	0	0	0	0	38.332	51.488		Heavy filter build up, filter taken for cleaning/repair
211	x	clean	0	0	0	0	0	38.339	51.428		Apparently moved by boater 50 ft. We moved back
212	x	clean	0	0	0	0	0	38.357	51.296		Apparently moved by boater 200 ft. We moved back
213	x	clean	0	0	0	0	0	38.384	51.254		Apparently moved by boater 50 ft. We moved back
214	x	clean	0	0	0	0	0	38.432	51.192		
215	x	clean	0	0	0	0	0	38.474	51.142		Mineral build up on fittings
216	x	clean	0	0	0	0	0	38.513	51.097		Mineral build up on fittings
217	x	clean	0	0	0	0	0	38.551	51.062		Mineral build up on fittings
218	x	clean	0	0	0	0	0	38.601	51.029		Blow off at end

Head location	Clean head & adjust position, check fitting tightness	Clean or replace filter	Upper cam pins replaced	Lower cam pins replaced	Replace cam levers	Replace O Ring	Replace other broken parts	Actual latitude N 39 deg, xx.xxx min	Actual longitude W 104 deg, xx.xxx min	Stainless Steel Band Clamp Thickness/ End of Line Blow Off Valve Pressure (distribution vault pressure 47 psi)	Notes
301	x	clean	0	0	0	0	0	38.427	51.578		
302	x	clean	0	0	0	0	0	38.448	51.526		Mineral build up on fittings
303	x	clean	0	0	0	0	0	38.473	51.603		Mineral build up on fittings
304	x	clean	0	0	0	0	0	38.447	51.438		Mineral build up on fittings
305	x	clean	0	1	0	0	0	38.420	51.416		Blow off at end
306	x	clean	0	0	0	0	0	38.493	51.427		
307	x	clean	0	0	0	0	0	38.475	51.390		
308	x	clean	0	0	0	0	0	38.433	51.362		Blow off at end
309	x	clean	0	0	0	0	0	38.401	51.323		
310	x	replace	0	0	0	0	0	38.507	51.358		Heavy filter build up, filter taken for cleaning/repair
311	x	clean	0	0	0	0	0	38.485	51.342		
312	x	clean	0	0	0	0	0	38.456	51.293		Blow off at end
313	x	clean	0	0	0	0	0	38.542	51.323		
314	x	clean	0	0	0	0	0	38.571	51.276		Leaking fitting tightened
315	x	clean	0	0	0	0	0	38.601	51.220		Leaking fitting tightened
316	x	clean	0	0	0	0	0	38.627	51.170		Blow off at end

Head location	Clean head & adjust position, check fitting tightness	Clean or replace filter	Upper cam pins replaced	Lower cam pins replaced	Replace cam levers	Replace O Ring	Replace other broken parts	Actual latitude N 39 deg, xx.xxx min	Actual longitude W 104 deg, xx.xxx min	Stainless Steel Band Clamp Thickness/ End of Line Blow Off Valve Pressure (distribution vault pressure 15 psi)	Notes
401	x	clean	0	0	0	0	0	38.525	51.633		
402	x	clean	0	0	0	0	0	38.536	51.604		
403	x	clean	0	0	0	0	0	38.556	51.559		
404	x	clean	0	0	0	0	0	38.580	51.512		
405	x	clean	0	0	0	0	0	38.606	51.462		
406	x	clean	0	0	0	0	0	38.634	51.408		
407	x	clean	0	0	0	0	0	38.660	51.347		
408	x	clean	0	0	0	0	0	38.689	51.300		
409	x	clean	0	0	0	0	0	38.709	51.250		
410	x	clean	0	2	1	0	0	38.740	51.192		
411	x	clean	0	1	0	0	0	38.761	51.152		Blow off at end
412	x	clean	0	0	0	0	0	38.492	51.570		
413	x	replace	0	0	0	0	0	38.502	51.543		Heavy filter build up, filter taken for cleaning/repair
414	x	clean	0	0	0	0	0	38.528	51.491		
415	x	clean	0	0	0	0	0	38.547	51.455		
416	x	clean	0	0	0	0	0	38.575	51.390		
417	x	clean	0	0	0	0	0	38.604	51.338		
418	x	clean	0	0	0	0	0	38.630	51.289		
419	x	clean	0	0	0	0	0	38.661	51.237		
420	x	clean	0	0	0	0	0	38.689	51.178		Mineral build up on fittings
421	x	clean	0	0	0	0	0	38.711	51.134		Blow off at end
422	x	clean	0	0	0	0	0	38.540	51.679		
423	x	clean	0	1	0	0	0	38.559	51.625		
424	x	clean	0	0	0	0	0	38.585	51.575		
425	x	clean	0	1	0	0	0	38.612	51.521		
426	x	clean	0	0	0	0	0	38.640	51.466		
427	x	clean	0	0	0	0	0	38.667	51.415		
428	x	clean	0	1	0	0	0	38.692	51.361		
429	x	clean	1	0	0	0	0	38.718	51.305		
430	x	clean	0	0	0	0	0	38.745	51.250		
431	x	clean	0	0	0	0	0	38.771	51.201		Blow off at end

Head location	Clean head & adjust position, check fitting tightness	Clean or replace filter	Upper cam pins replaced	Lower cam pins replaced	Replace cam levers	Replace O Ring	Replace other broken parts	Actual latitude N 39 deg, xx.xxx min	Actual longitude W 104 deg, xx.xxx min	Stainless Steel Band Clamp Thickness/ End of Line Blow Off Valve Pressure (distribution vault pressure 47 psi)	Notes
501	x	clean	0	0	0	0	0	38.608	51.716		
502	x	clean	0	0	0	0	0	38.646	61.759		Replace corroded SS fitting
503	x	clean	0	0	0	0	0	38.684	51.581		
504	x	clean	0	0	0	0	0	38.710	51.534		
505	x	clean	0	0	0	0	0	38.733	51.488		
506	x	clean	0	0	0	0	0	38.756	51.440		
507	x	clean	0	0	0	0	0	38.779	51.393		
508	x	clean	0	0	0	0	0	38.811	51.321		
509	x	clean	1	0	0	0	0	38.831	51.271		
510	x	clean	0	0	0	0	0	38.850	51.226		
511	x	clean	0	0	0	0	0	38.638	51.108		
512	x	clean	0	0	0	0	0	38.615	51.110		
513	x	clean	0	1	0	0	0	38.574	51.145		
514	x	clean	0	0	0	0	0	38.549	51.183		
515	x	clean	0	0	1 upper	0	0	38.526	51.232		
516	x	clean	0	0	0	0	0	38.507	51.276		
517	x	clean	0	1	0	0	0	38.573	51.678		
518	x	clean	0	0	0	0	0	38.591	51.633		
519	x	clean	0	0	0	0	0	38.614	51.587		
520	x	clean	0	0	0	0	0	38.641	51.530		
521	x	clean	0	0	0	0	0	38.661	51.484		
522	x	clean	0	0	0	0	0	38.693	51.427		
523	x	clean	0	0	0	0	0	38.723	51.368		Abnormally dirty filter
524	x	clean	0	0	0	0	0	38.747	51.325		Plugged filter
525	x	clean	0	0	0	0	0	38.774	51.267		
526	x	clean	0	0	0	0	0	38.802	51.213		
527	x	clean	0	0	0	0	0	38.821	51.162		Blow off at end