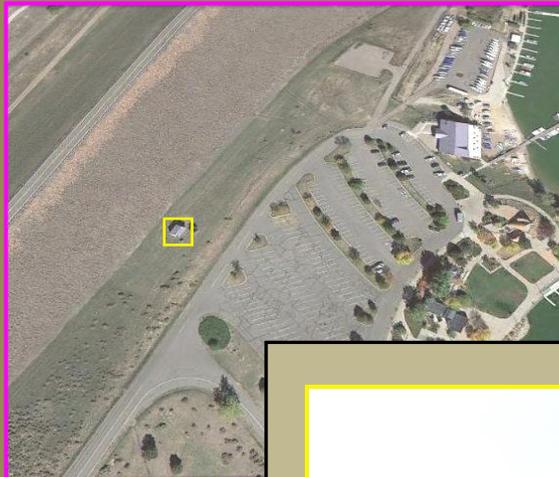

**CHERRY CREEK RESERVOIR
DESTRATIFICATION FACILITIES**

**OPERATION AND MAINTENANCE
ANNUAL REPORT
2018**



Prepared For:

**CHERRY CREEK BASIN WATER
QUALITY AUTHORITY**



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CHERRY CREEK BASIN WATER QUALITY AUTHORITY RESERVOIR DESTRATIFICATION FACILITIES OPERATION AND MAINTENANCE ANNUAL REPORT 2018

INTRODUCTION:

JRS Engineering Consultant LLC was retained under the "Pollutant Abatement Construction and Maintenance Manager" contract to operate, and coordinate maintenance of, the destratification system including the compressor and aeration system commonly referred to as the Cherry Creek Reservoir Destratification Facilities. This is the eleventh consecutive year for operation of the facilities.

START-UP PROCEDURE AND OPERATING POLICY HISTORY/UPDATE:

Prior to the beginning of the 2014 operating season, the Authority reviewed the prior year's Reservoir Destratification System operating policies and procedures considering the reservoir data collected from system operations for the years from 2008 through 2013. Data collected during this time period (2008 through 2013) indicated that the destratification system provided two primary benefits. One is the reduction in the dominance of blue-green algae as part of the whole algal assemblage and the second is the reduction in the periods when the reservoir is thermally stratified during the summer.¹

The data further suggested that operating the aeration system in early spring did not significantly affect blue-green algae (i.e.: cyanobacteria) growth, since the primary cyanobacteria growth period is from June through September when water temperatures are warmer². The aeration system additionally provides destratification of the reservoir reducing the tendency for the reservoir to "turn over" bringing up anoxic water and higher concentrations of nutrients from the reservoir floor. The data from 2008 through 2013 suggested that the reservoir begins to stratify in late-April to mid-May.

After review of the data, it was concluded that operation of the destratification system, beginning in 2014, shall be modified as follows:

- a. System start-up shall occur between the dates of May 1st and May 10th.
- b. System shut-down shall occur between the dates of November 1st and November 15th.

Additionally, operation of the destratification system shall be limited to those times when ice is not present on the reservoir, except under specific scenarios. The "Operation Policy Regarding Ice" policy adopted by the Authority's Board on February 20, 2014 is included in Appendix A. The

¹ CCBWQA January 28, 2013. *Compressor Design Basis - Daily Operation*, William P. Ruzzo, P.E., Craig Wolf, GEI.

² GEI, Consultants, Inc. January 2014. *Cherry Creek Reservoir 2013 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring*.

"Destratification System Compressor Start-up Procedure" approved by the Authority's Technical Advisory Committee on April 3, 2014 is included in Appendix B.

2018 START-UP:

Prior to the start of the 2014 operation of the destratification season, the question surfaced regarding whether, or not, the system should be started to allow for reservoir data to be collected with the destratification system in non-operational mode. This would provide additional water quality data to be collected for the in-progress reservoir modeling effort currently underway. The Authority's Technical Advisory Committee took this question under advisement and recommended to the Authority's Board that the system not operate during the 2014 season. The Authority's Board approved this change in the Destratification Operating Policy such that the system not be placed into operation for the entire 2014 aeration season.

Then in 2015 and again in 2016, the Authority's Technical Advisory Committee (TAC) took the question of whether the destratification system should operate under advisement and in each year recommended to the Authority's Board that the system not operate during the 2015 and 2016 aeration seasons in order to collect additional water quality data with the system turned off. The Authority's Board approved the TAC's recommendation each year.

During each of these three years when the destratification system didn't operate, one or more cyanobacteria blooms were observed within the reservoir. Prior to the 2017 aeration season, the Authority's Technical Advisory Committee (TAC) again took the question of whether the destratification system should operate in 2017. Since the reservoir modeling was complete, TAC recommended the destratification system operate from the first of May through the July 4th week-end to determine if this abbreviated aeration season would aide in prevention of a cyanobacteria bloom.

The Authority's Board approved TAC's recommendation and the destratification system was started on May 1, 2017. Following the system shut-down on July 1, 2017, the aeration system was operated (exercised) periodically to maintain it in a "ready state". In 2018, it was recommended by TAC, and approved by the Authority's Board to operate the destratification system in the same manner that it was operated in 2017.

One minor cyanobacteria bloom was reported in June 2018 at the marina. It is believed this bloom occurred independently of the destratification system operation. During the winter months of 2018, the marina installed a new break-water system to maintain quiescent water surface conditions within the marina area. The destratification system is located on the reservoir side of this break-water system and not within the marina area.

OPERATION PERIOD / INSPECTIONS:

The compressor exercise program (periodic system operations) was conducted from July into November of 2018, for varying lengths of time and at various "Unload" and "Load" air pressure settings.

Prior to each compressor exercise operation conducted outside of the above described operations season, an email was sent to Authority representatives, Cherry Creek State Park representatives and the Marina operator, notifying them that the compressor would be exercised that day and air would be



blown off to the atmosphere. Since this "blow off" is noisy and located adjacent to the dam trail (now open across the face of the dam for Park users) three orange cones were placed adjacent to the manholes directing trail users to the dam side of the trail. See photo.

The orange cones were set up each time the system was operated. The valves in the manholes were adjusted prior to each operation so that each was exercised regularly, and all compressed air was discharged through a selected aeration zone manhole blow-off. The orange cones were picked up following each system exercise.

The initial compressor start-up was performed on Tuesday, May 1, 2018 at 10:15 AM. The table in Appendix C - 2018 Aeration Equipment Data Summary and Log details the operating data recorded during the 2018 aeration season.

Prior to the equipment start-up, the electrical voltage was checked at the compressor. The amperage draw was checked during the compressor operation as well. This information is recorded on the table in Appendix D - 2018 Compressor Electrical Monitoring Log.

EQUIPMENT REPAIRS AND MAINTENANCE:

On April 23/24, 2018, Power Service of Colorado performed routine maintenance on the compressor. Maintenance included an oil change and replacement of the air filter, oil filter, seal rings, solenoid valve, inlet valve bushing, inlet diaphragm, and the crankcase breather filter. A copy of the service call repair order is included in Appendix E - 2018 Aeration System Maintenance Summary.

At the end of the 2017 aeration system, it was determined that the 18,000 BTU air conditioner installed in 2011 at the oil heat exchanger intake supply louver was no longer functioning. On April 24, 2018 the air conditioner was replaced with an equivalent 18,000 BTU unit. A copy of the service call work order is included in Appendix E - 2018 Aeration System Maintenance Summary.

On May 12, 2018, a call was received from the Marina Operator reporting that they observed an in-lake aeration system leak near the southeast corner of the boat dock area. JRS immediately responded to check out the reported leak. It appeared that installation of the new marina break water system had damaged the aeration system piping. The valve at aeration Zone 1 was closed at the manhole manifold located along the dam trail until such time the system could be repaired. Repair was completed on May 31st.

Aerator inspection, cleaning and maintenance of the in-lake system was performed this year during the late July / early August timeframe. Maintenance was last performed in 2015. Prior to 2015, in-lake maintenance was performed every other year. In 2018, the required in-lake system maintenance was more extensive than in previous years due to settlement of the piping deeper into the reservoir sediment along the bottom thus making retrieval of the aeration system piping more difficult and time consuming. Additionally, the deposits attached onto the aeration system components were heavier and more difficult to remove. A copy of the maintenance summary report is included in Appendix E - 2018 Aeration System Maintenance Summary.

The compressor experienced several high temperature shut-down events (Outlet Temperature reaching 509° F or Oil Temperature reaching 170° F) during the May 1, 2018 to July 4, 2018 aeration period. Following each high temperature shut-down, the system must cool down before it can be manually restarted. A copy of the 2018 High Temperature Compressor Shut-Down Occurrences is included in Appendix E - 2018 Aeration System Maintenance Summary.

It is believed that the aeration system leak discovered in May adjacent to the marina area may have contributed to some of the high temperature shutdowns early in the year.

ELECTRICAL USAGE / RATE SCHEDULE:

During the 2018 destratification system operation season, the Xcel electrical rate schedule continued through the destratification system exercise program under Schedule SGL.

Schedule SG (Secondary General Service) includes higher monthly demand charges and lower kilowatt usage rates. Operation under this billing rate schedule is more economical when operating the destratification system continuously.

Schedule SGL (Secondary General Low-load Factor) includes lower monthly demand charges and higher kilowatt usage rates. Operation under this billing rate schedule is more economical when operating the destratification system in the exercise mode.

RECOMMENDATIONS:

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

- Determine if the destratification system should operate in 2019 and, if so, what that operation procedure should be.
- Install a compressor building cooling system, including building modifications, to maintain air temperatures inside the building at air temperature levels that will allow the compressor to operate without overheating and routinely shutting down.
- Reinstate the two-year cycle for performance of the in-lake aeration system maintenance / cleaning work.

APPENDIX A - OPERATION POLICY REGARDING ICE

Cherry Creek Basin Water Quality Authority
Cherry Creek Reservoir Destratification System
Operation Policy Regarding Ice
Board Adopted Version
February 20, 2014

Operation of the Cherry Creek Reservoir Destratification System shall be limited to those times when ice is not present on the Reservoir, except under the following scenario:

- System Start-up before ice is off the Reservoir if either:
 1. The Authority has determined that doing so is in the best interest of the Authority to assist in protection of the constructed Pollutant Reduction Facilities (PRF's)¹.
 2. The Park Manager has determined that doing so is in the best interest of the Park to assist in protecting the Park facilities such as the marina, constructed PRF's, other Park improvements or the unprotected shoreline. Or, has determined that doing so would alleviate a dangerous condition/situation for Park users².

All start-up and shut-down notifications, decisions, procedures, detail, dates and conditions shall be documented in the Destratification Facilities - Operation and Maintenance Annual Report.

Start-up of the destratification system each year shall be performed in accordance with the "Compressor Start-up Procedures".

The Authority, at its sole discretion, may shut the destratification system down at any time during the aeration season if, or when, there is no water quality benefit to continued operation.

¹ If floating ice is observed on the Reservoir and it is believed that constructed PRF's will be damaged by the ice, the Authority, authorizes the Authority Manager after consultation with the Authority's engineering, water quality and legal consultant, and the TAC chair, to make the determination on start-up. Prior to start-up of the destratification system, the notification procedures outlined in the "Compressor Start-up Procedure" shall be completed and documented in writing (by email, letter or fax). All start-up decisions, detail and notifications shall be documented and included in the annual report. Board and TAC members shall be notified by email if the system is started under this condition.

² If the Park Manager notifies the Authority, in writing (by email, letter or fax), that starting the system while ice is on the Reservoir is in the best interest of the Park, the Authority Manager, with assistance of the Authority engineering and water quality consultants, will confirm that water quality conditions are satisfactory prior to start-up. The Park Manager shall then perform the notification procedures outlined in the "Compressor Start-up Procedure" and provide copies of the written notifications to the Authority Manager. All written notifications shall state the Reservoir conditions and concern prompting the request. Parks shall assist the Authority to confirm no persons are on the ice when the system is started. Once the ice condition is no longer an issue as determined by the Park Manager, the Authority, at its sole discretion, may elect to shut the destratification system down.

APPENDIX B - DESTRATIFICATION SYSTEM COMPRESSOR START-UP PROCEDURE

CHERRY CREEK BASIN WATER QUALITY AUTHORITY
CHERRY CREEK RESERVOIR DESTRATIFICATION SYSTEM
COMPRESSOR START-UP PROCEDURE
March 25, 2014

Start-up Criteria:

Operation of the Cherry Creek Reservoir Destratification System shall be in accordance with the terms, conditions and policy set forth in the Destratification System - Operation Policy Regarding Ice; adopted by the Authority's Board on February 20, 2014. This policy requires that operation of the system be limited to those times when ice is not present on the Reservoir, except when early start-up is determined necessary as outlined in the operation policy.

An on-site inspection shall be conducted by the Authority's System Operator to verify that ice is not present on the Reservoir prior to start-up. In the event that early start-up is required while ice is on the reservoir, the Authority's System Operator shall confirm that all notifications, responses and other details are completed in accordance with the Destratification System - Operation Policy Regarding Ice. The Authority's System Operator shall then log the detail of the start-up procedure in the Cherry Creek Reservoir Destratification Facilities Operation and Maintenance Annual Report.

Start-up Procedure:

The system shall be started, following the pre-start system check outlined in the Operation and Maintenance Manual, utilizing the soft-start procedure as follows:

Starting the system shall be accomplished by opening up one aeration zone at a time with some interval (i.e.: 2 to 4-hours) before opening the next zone. A soft start also includes a lower than normal unload / load pressure for start-up of the initial zone (typically 45.0 psi / 39.0 psi) and then increasing the pressure when each additional zone is brought on-line, over the start-up period as necessary to cause bubbles to rise to the surface, until the unload / load pressure reaches 52.0 psi / 48.0 psi with all five zones operating.

Start-up / Shut-down Schedule:

System start-up shall occur between the dates of May 1st and May 10th to provide the system operator flexibility in scheduling the start-up, unless early start-up is required.

System shut-down shall occur between the dates of November 1st and November 15th.

Start-up Conditions with Ice on the Reservoir:

When it becomes necessary to operate the system before ice is off the Reservoir then three conditions need to be considered during start up:

1. The rising bubbles may bring anoxic water from the bottom to the surface *under the ice*, trapping the fish in an unsafe habitat. Past experience has shown that by using the "soft start" approach, which starts the aeration lines one at a time under or near open water areas, then a hazardous fish environment was not created. Dissolved Oxygen profile information will be provided and analyzed as a part of the start-up procedure.
2. Starting the system prior to March 1 potentially creates problems for CCSP. The aquatic nuisance control program (i.e.: zebra and quagga mussel inspection) requires that all boats be inspected, which begins on March 1st.
3. Starting the system while ice is present on the Reservoir requires written notification to the following parties and written confirmation of their concurrence to start the system while ice is on the Reservoir. All written notifications and confirmations shall be in the form of email, fax or letter.
 - *Cherry Creek State Park (CCSP) Park Manager.*
 - *Colorado Parks and Wildlife (CPW) Sr. Aquatic Biologist; Platte Basin.*
 - *Marina Operator.*
 - *Cherry Creek Basin Water Quality Authority Manager.*



Memorandum

To: CCBWQA Technical Advisory Committee and Destratification Sub-committee
From: James R. Swanson, PE- JRS Engineering Consultant, LLC, William P. Ruzzo, PE, LLC
Date: March 18, 2014
Subject: Destratification System Compressor Start-up Procedure

Presented in the memorandum is a summary of the Authority's destratification system compressor start-up procedure, discussion of prior years practice, review and discussion of the water quality data from prior year's operation and resulting start-up procedure modifications to optimize water quality conditions and system operating efficiency.

Background:

The destratification system consists of a rotary screw air compressor, piping and 116 air diffusers placed at the floor of the deepest part of the reservoir. The system works by pumping air into the bottom of the reservoir providing mixing and oxygenation of the water. The Authority began operation of the destratification system on April 4, 2008. Prior to initial start-up in 2008, it was determined the aeration system would be operated for as long of a season as practical, typically from approximately March 1st through the end of November¹. In doing so, continued water quality data monitoring developed a consistent baseline from which to evaluate, and predict, the benefits of operating the aeration system and to manage various water quality parameters within the reservoir. Specific start-up and shut-down dates were previously determined annually based on the Reservoir water quality data, weather patterns, ice cover and other factors.

It was found the destratification system needed to operate for approximately two weeks to attain full development of the water column circulation pattern, thereby reducing thermal stratification.

Data collected during this time period (2008 through 2013) indicates that the destratification system provides two primary benefits. One is the reduction in the dominance of blue-green algae as part of the whole algal assemblage and the second is the reduction in the periods when the reservoir is thermally stratified during the summer.²

Data Results and Trends:

Water quality data collected from 2008 through 2013 suggests that operating the aeration system in early spring does not significantly affect blue-green algae (i.e.: cyanobacteria) growth, since the primary cyanobacteria growth period is from June through September when water temperatures are warmer³. A summary of this data is attached. Cyanobacteria are generally most active at temperature ranges above 15° C, which makes them most active in the summer months. This trend is supported by comparing chlorophyll a concentrations for pre and post-aeration system conditions, as shown in the attached data. Also, the daily maximum ambient temperatures near the reservoir are generally below 15° C from October through April (see attached data) providing further support for a later season system start date.

¹ March 1 is the start of the boating season. Allowing boater access to the Reservoir before March 1 required Parks to have their safety and ANS (Aquatic Nuisance Species, such as Quagga and Zebra mussels) inspection personnel in place sooner, which potentially created an administrative problem. Starting the system before March 1 could clear the ice cover on the Reservoir and allow boaters to launch before Parks was ready.

² CCBWQA January 28, 2013. *Compressor Design Basis - Daily Operation*, William P. Ruzzo, P.E., Craig Wolf, GEI.

³ GEI, Consultants, Inc. January 2014. *Cherry Creek Reservoir 2013 Water Year Aquatic Biological Nutrient Monitoring Study and Cottonwood Creek Pollutant Reduction Facilities Monitoring*.

The aeration system additionally provides destratification of the reservoir reducing the tendency for the reservoir to "turn over" bringing up anoxic water and higher concentrations of nutrients from the reservoir floor. The data from 2008 through 2013 suggests that the reservoir begins to stratify in late-April to mid-May. This varies from year-to-year, typically caused by an influx of snowmelt in the early spring and/or cold rainfall in the warm summer months causing temperature stratifications. It is noted that the aeration system is effective in minimizing stratification within the reservoir.

Conclusions:

1. The aeration system should be operational on, or about, May 15th to minimize the dominance of the blue-green algae (cyanobacteria) growth in the reservoir.
2. The aeration system should be started on, or about, May 1st to provide a fully developed water column circulation pattern by mid-May.
3. Operation of the destratification system beyond mid-November isn't supported by ambient temperature or algal population data for cyanobacteria or diatoms.

In summary, operation of the destratification system shall be modified as follows:

- a. System start-up shall occur between the dates of May 1st and May 10th.
- b. System shut-down shall occur between the dates of November 1st and November 15th.

APPENDIX C - 2018 AERATION EQUIPMENT OPERATING DATA LOG

APPENDIX C - 2018 AERATION EQUIPMENT OPERATING DATA LOG

DATE	DAY OF WEEK	TIME OF DAY	ELECTRIC METER KWHRS		UNIT HOURS				LOAD RELAY COUNTS (X1000)		UNIT STARTS	TEMPERATURE; DEGREES FAHRENHEIT (°F)						OUTLET PRESSURE	
			READING	USAGE	RUNNING	ELAPSED	LOADED	ELAPSED	TOTAL	ELAPSED		DAILY HIGH	OUTSIDE	AMBIENT	OUTLET	ELEMENT	OIL	UNLOAD	LOAD
1-May	Tuesday	10:15 AM	49266		36258		15884		5118		635	68	56					52.0	48.0
1-May	Tuesday	12:45 PM	0									68				509		52.0	48.0
2-May	Wednesday	11:20 AM	49276	10	36264	6	15887	3			637	52	70	68	82	441	142	50.0	46.5
5-May	Saturday	8:45 AM	49360	84	36315	51	15919	32	5125	7	637	74	58		53			50.0	47.0
5-May	Thursday	5:15 PM										74						49.5	46.5
7-May	Monday	12:05 PM										80	70					49.0	46.0
7-May	Monday	8:00 PM										80						48.5	45.5
9-May	Wednesday	7:00 PM										79						48.5	45.5
11-May	Friday	9:40 AM	49508	148								80						48.0	45.0
16-May	Wednesday	11:55 AM	49668	160								80						48.0	45.0
17-May	Thursday	7:55 PM										85						48.0	45.0
24-May	Thursday	8:30 AM	49916	248	36673	358	16119	200	5187	62	647	84	65	68	72	425	109	48.0	45.0
24-May	Thursday	7:25 PM										84						48.0	45.0
26-May	Thursday	7:45 AM										89						47.0	44.5
27-May	Sunday	6:55 AM										93						46.0	43.5
28-May	Monday	6:14 AM										86						46.0	43.5
31-May	Thursday	12:30 PM										90						40.0	37.5
1-Jun	Friday	6:30 AM										89						46.0	43.5
4-Jun	Monday	7:30 AM										91						46.0	43.5
5-Jun	Tuesday	8:20 PM										94						46.0	43.5
7-Jun	Thursday	8:15 AM										90						46.0	43.5
7-Jun	Thursday	7:43 PM										90						46.0	43.5
11-Jun	Monday	5:35 AM										95						46.0	43.5
12-Jun	Tuesday	5:35 AM										86						46.0	43.5
13-Jun	Monday	7:00 AM										91						46.0	43.5
14-Jun	Thursday	8:15 AM										94						45.0	42.5
16-Jun	Saturday	8:00 AM										93						45.0	42.5
16-Jun	Saturday	8:17 PM										93						45.0	42.5
18-Jun	Monday	5:45 AM										83						45.0	42.5
20-Jun	Wednesday	10:40 AM										77						45.0	42.5
22-Jun	Friday	7:00 AM										86						45.0	42.5
23-Jun	Saturday	8:10 AM										86						45.0	42.5
24-Jun	Sunday	7:18 AM										86						45.0	42.5
30-Jun	Saturday	5:53 AM										99						45.0	42.5
30-Jun	Saturday	6:02 PM										99						45.0	42.5
2-Jul	Monday	5:49 AM										94						45.0	42.5
2-Jul	Monday	9:15 PM										94						45.0	42.5
3-Jul	Tuesday	9:02 PM										94						45.0	42.5
13-Jul	Friday ¹	9:05 AM										89						37.5	34.0
21-Jul	Saturday ¹	7:25 AM										95						37.5	34.0
27-Jul	Friday ¹	7:48 AM										85						28.0	24.0
28-Jul	Saturday ¹	7:20 AM										76						28.0	24.0
10-Aug	Friday ¹	7:00 AM										87						28.0	24.0
16-Aug	Thursday ¹	7:42 AM										88						32.0	28.0
25-Sep	Tuesday ²	10:00 AM																	
12-Oct	Friday ³	11:00 AM	50548	632	37056	383	16314	195	5268	81	686							46.0	43.5

Footnote 1 - Aeration system operation to aide the in-lake aeration system maintenance work.

Footnote 2 - Aeration system operation to showcase the Authority's system to Lakewood staff & consultant (Bear Creek Reservoir).

Footnote 3 - Aeration system operation to aide consultant team (bubble plume & system upgrade) with on-site visit.

APPENDIX D – 2018 ELECTRICAL MONITORING LOG

APPENDIX D - 2018 COMPRESSOR ELECTRICAL MONITORING LOG

DATE	DAY OF WEEK	MOTOR VOLTAGE						MOTOR AMPERAGE						OUTLET PRESSURE	
								LOADING			UNLOADING				
		L ₁ - G	L ₂ - G	L ₃ - G	L ₁ - L ₂	L ₁ - L ₃	L ₂ - L ₃	L1	L2	L3	L1	L2	L3	UNLOAD	LOAD
1-May	Tuesday	286	287	287	496	497	496							52.0	48.0
2-May	Wednesday							119	112	116	69	62	64	50.0	46.5
16-May	Wednesday	286	286	288	497	497	496								
24-May	Thursday	284	284	286	495	495	493	122	114	117	71	66	67		

APPENDIX E - 2018 AERATION SYSTEM MAINTENANCE SUMMARY

DALCO Htg & A/C



Cherry Creek Basin Water Quality Authority

4201 S. Parker Rd,
Aurora, CO 80014

For Services Rendered



Invoice #214083915

From **DALCO Htg & A/C**
303-979-7541
mail@dalcohvac.com
www.dalcohvac.com
4610 S. Ulster St.,
Suite 150
Denver, CO 80237

Client Phone 303-726-5577
Bill To 4201 S. Parker Rd,
Aurora, CO 80014
Issued 04/24/2018
Due 05/24/2018

SERVICE / PRODUCT	DESCRIPTION	QTY.	UNIT COST	TOTAL
04/24/2018				
Air Conditioning	Replace Window air conditioner, 18,000 BTUH, Energy Star® certified. WINDOW AC 18K R410A 230V ELECTRONIC W/REMOTE Cooling Nom. BTUH 17,700/18,000 Heating Nom. BTUH N/A Voltage 208/230V 60Hz Efficiency Rating 11.8 EER Wireless Remote Yes Max. CFM 360 No. of Fan Speeds 3 Warranty 5 Yrs sealed system, 1 Yr other parts In-Home Service Yes Energy Star Yes Modes Cooling, dehumidification, fan only Humidity Removal (pts/hr) 3.8 Sound Rating (dBA) 60/57/54 Dimensions HxWxD (in.) 17.94 x 23.625 x 25.44 Installation Window mount Shipping Wt (lbs) 129 Test Listing UL US and Canada NOTE Electronic controls Item #:RADS-183P	1	\$1,060.00	\$1,060.00*

39067
OK to pay
[Signature]
5/15/18

* Non-taxable

Thank you for your business. Please contact us with any questions regarding this invoice.

Total	\$1,060.00
Account balance	\$1,060.00

2018 repairs to Cherry Creek aeration 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	Clean head	Replace	1	1	1	ok				thickness not checked	All qwik connects disassembled & cleaned
102	Clean head	Clean	ok	1	1	ok				thickness not checked	All qwik connects disassembled & cleaned
103	Clean head	Clean	ok	1	1	ok				thickness not checked	All qwik connects disassembled & cleaned
104	Clean head	Clean	ok	1	1	ok				thickness not checked	All qwik connects disassembled & cleaned, deteriorated vertical hose
105	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, moved, apparently hooked by boat anchor
106	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, moved, apparently hooked by boat anchor
107	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, moved, apparently hooked by boat anchor
108	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, moved, apparently hooked by boat anchor, blow-off
109	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
110	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
111	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
112	Clean head	Clean	ok	ok	1	ok				thickness not checked	All qwik connects disassembled & cleaned
113	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow off
114	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
115	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
116	Clean head	Clean	ok	1	1	ok				thickness not checked	All qwik connects disassembled & cleaned
117	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
118	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
119	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
120	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow off
121	Clean head	Clean	ok	ok	ok	ok	Replace cone			thickness not checked	All qwik connects disassembled & cleaned
122	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
123	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow off

Abandoned for parts											
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	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
202	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
203	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
204	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
205	Clean head	Replace	ok	ok	ok	ok	replace regulator			thickness not checked	All qwik connects disassembled & cleaned
206	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
207	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
208	Clean head	Clean	ok	1	ok	1				thickness not checked	All qwik connects disassembled & cleaned
209	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
210	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
211	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
212	Replace head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
213	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
214	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
215	Replace head	Clean	ok	ok	ok	ok	Replace head & cone			thickness not checked	All qwik connects disassembled & cleaned, replaced cone and head, apparently hit by boat anchor
216	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
217	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
218	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off
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	Clean head	Clean	ok	1	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
302	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned

303	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
304	Clean head	Clean	ok	ok	ok	ok	Used new black head				thickness not checked	All qwik connects disassembled & cleaned
305	Clean head	Clean	ok	ok	ok	ok	Used new black head				thickness not checked	All qwik connects disassembled & cleaned, blow off
306	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
307	Clean head	Replace	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
308	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
309	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned, blow off
310	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
311	Replace	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
312	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned, blow off
313	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
314	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
315	Clean head	Replace	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
316	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned, blow off
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	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
402	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
403	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
404	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
405	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
406	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
407	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
408	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
409	Clean head	Clean	ok	ok	ok	ok					thickness not checked	All qwik connects disassembled & cleaned
410	Clean head	Clean	ok	ok	ok	ok	Replace cone				thickness not checked	All qwik connects disassembled & cleaned

411	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off
412	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
413	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
414	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
415	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
416	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
417	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
418	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, replaced all fittings above the filter, heavy mineral build-up
419	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, heavy mineral build-up
420	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, heavy mineral build-up
421	Clean head	Clean	1	ok	1	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off
422	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
423	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
424	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
425	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
426	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
427	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
428	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
429	Clean head	Replace	2	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
430	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
431	Clean head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off
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	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
502	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
503	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned

504	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
505	Clean head	Clean	1	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
506	Clean head	Clean	1	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
507	Clean head	Clean	ok	ok	ok	1				thickness not checked	All qwik connects disassembled & cleaned
508	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
509	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
510	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
511	Replace head	Replace	1	ok	ok	ok	Replace cone			thickness not checked	All qwik connects disassembled & cleaned
512	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
513	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
514	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
515	Clean head	Clean	1	1	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
516	Replace head	Replace	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off
517	Clean head	Replace	1	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
518	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
519	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
520	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
521	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
522	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
523	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
524	Clean head	Replace	1	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
525	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
526	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned
527	Clean head	Clean	ok	ok	ok	ok				thickness not checked	All qwik connects disassembled & cleaned, blow-off

APPENDIX E - 2018 HIGH TEMPERATURE COMPRESSOR SHUT-DOWN OCCURANCES

DATE	DAY OF WEEK	START/RE-START TIME	SHUT-DOWN TIME	DAILY HIGH TEMPERATURE (° F)	COMMENTS
1-May	Tuesday	10:15 AM	12:45 PM	68	A/C wasn't started up for the season yet, due to cool temperatures
2-May	Wednesday	11:20 AM		52	A/C wasn't started up for the season yet, due to cool temperatures
4-May	Friday		2:21 PM	67	A/C wasn't started up for the season yet, due to cool temperatures
5-May	Saturday	8:45 AM	12:55 PM	74	High Temperature Shutdown. Element Temperature = 509° F.
		5:15 PM			
6-May	Sunday		1:00 PM	79	High Temperature Shutdown. Element Temperature = 509° F.
7-May	Monday	12:05 PM	3:35 PM	80	High Temperature Shutdown. Element Temperature = 509° F.
		8:00 PM			
9-May	Wednesday		2:09 PM	79	High Temperature Shutdown. Element Temperature = 509° F.
		7:00 PM			
10-May	Thursday		11:05 PM	88	High Temperature Shutdown. Element Temperature = 509° F.
11-May	Friday	9:40 AM	12:55 PM	80	High Temperature Shutdown. Element Temperature = 509° F.
		6:00 PM			
15-May	Tuesday		11:56 PM	74	Cause of Shutdown - unknown.
16-May	Wednesday	11:55 AM		80	
17-May	Thursday		1:00 PM	85	High Temperature Shutdown. Oil Temperature = 170° F.
		7:55 PM			
23-May	Wednesday		6:00 PM	82	High Temperature Shutdown. Oil Temperature = 170° F.
24-May	Thursday	8:30 AM	1:36 PM	84	High Temperature Shutdown. Oil Temperature = 170° F.
		7:25 AM			
25-May	Friday		12:43 PM	89	High Temperature Shutdown. Oil Temperature = 170° F.
26-May	Saturday	7:45 AM	11:47 AM	89	High Temperature Shutdown. Oil Temperature = 170° F.
27-May	Sunday	6:55 AM	2:00 PM	93	High Temperature Shutdown. Oil Temperature = 170° F.
28-May	Monday	6:14 AM		86	
30-May	Wednesday		7:20 PM	82	System Shutdown for In-lake System Repair.
31-May	Thursday	1:00 PM		90	
1-Jun	Friday		11:45 AM	89	High Temperature Shutdown. Oil Temperature = 170° F.
		4:45 PM			
4-Jun	Monday		11:50 AM	91	High Temperature Shutdown. Oil Temperature = 170° F.
5-Jun	Tuesday	8:20 AM	11:50 AM	94	High Temperature Shutdown. Oil Temperature = 170° F.
		8:18 PM			
6-Jun	Wednesday		12:35 PM	92	High Temperature Shutdown. Oil Temperature = 170° F.

DATE	DAY OF WEEK	START/RE-START TIME	SHUT-DOWN TIME	DAILY HIGH TEMPERATURE (° F)	COMMENTS
7-Jun	Thursday	8:15 AM	11:30 AM	90	High Temperature Shutdown. Oil Temperature = 170° F.
		7:43 PM	9:06 PM		
8-Jun	Friday			94	System left off due to extreme hot weather.
9-Jun	Saturday			94	System left off due to extreme hot weather.
10-Jun	Sunday			95	System left off due to extreme hot weather.
11-Jun	Monday	5:35 AM	1:15 PM	95	High Temperature Shutdown. Oil Temperature = 170° F.
12-Jun	Tuesday	5:35 AM	12:30 PM	86	High Temperature Shutdown. Oil Temperature = 170° F.
13-Jun	Wednesday	7:00 AM	10:30 AM	91	High Temperature Shutdown. Oil Temperature = 170° F.
14-Jun	Thursday	8:15 AM	10:09 AM	94	High Temperature Shutdown. Oil Temperature = 170° F.
15-Jun	Friday			93	High Temperature Shutdown. Oil Temperature = 170° F.
16-Jun	Saturday	8:00 AM	10:15 AM	93	High Temperature Shutdown. Oil Temperature = 170° F.
		8:17 AM			
17-Jun	Sunday		11:38 AM	72	High Temperature Shutdown. Oil Temperature = 170° F.
18-Jun	Monday	5:45 AM	2:00 PM	83	High Temperature Shutdown. Oil Temperature = 170° F.
19-Jun	Tuesday	5:30 AM	3:02 PM	78	High Temperature Shutdown. Oil Temperature = 170° F.
20-Jun	Wednesday	10:40 AM	1:53 PM	77	High Temperature Shutdown. Oil Temperature = 170° F.
21-Jun	Thursday			86	High Temperature Shutdown. Oil Temperature = 170° F.
22-Jun	Friday	7:00 AM	1:20 PM	86	High Temperature Shutdown. Oil Temperature = 170° F.
23-Jun	Saturday	8:10 AM	12:46 PM	86	High Temperature Shutdown. Oil Temperature = 170° F.
24-Jun	Sunday	7:18 AM		86	High Temperature Shutdown. Oil Temperature = 170° F.
25-Jun	Monday		2:58 PM	82	High Temperature Shutdown. Oil Temperature = 170° F.
26-Jun	Tuesday			95	System left off due to extreme hot weather.
27-Jun	Wednesday			98	System left off due to extreme hot weather.
28-Jun	Thursday			99	System left off due to extreme hot weather.
29-Jun	Friday			74	System left off due to extreme hot weather.
30-Jun	Saturday	5:53 AM	1:07 PM	99	High Temperature Shutdown. Oil Temperature = 170° F.
		6:02 PM			
1-Jul	Sunday		11:22 AM	88	High Temperature Shutdown. Oil Temperature = 170° F.
		6:00 PM			
2-Jul	Monday		10:15 AM	94	High Temperature Shutdown. Oil Temperature = 170° F.
		9:15 PM			
3-Jul	Tuesday		9:48 PM	94	High Temperature Shutdown. Oil Temperature = 170° F.
		9:00 PM			
4-Jul	Wednesday		9:46 AM		High Temperature Shutdown. Oil Temperature = 170° F.