TC CONSULTING SERVICES

SYSTEM OPERATION AND MAINTENANCE

Cherry Creek Basin Water Quality Authority
% Chuck Reid
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December 3, 2012

Dear Messrs:

Please, find attached for your review the Cherry Creek Basin Water Quality Authority, Reservoir Destratification Facilities, Operation and Maintenance, Annual Report 2011.

Sincerely,

Terry Cunningham

CHERRY CREEK RESERVOIR DESTRATIFICATION FACILITIES

OPERATION AND MAINTENANCE ANNUAL REPORT 2011

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
2011

December 3, 2012

INTRODUCTION:

TC Consulting Services was retained in 2011 to operate and maintain the Cherry Creek Reservoir Destratification Facilities. This was the fourth consecutive year that the facilities were operated continuously during the spring, summer and fall seasons.

OPERATION PERIOD:

The compressor was turned ON Tuesday, February 24, 2011 at 3:00 PM. The equipment performed properly with no noted unusual or unordinary sounds or noticeable vibrations. The equipment was turned OFF for the season on Wednesday, November 23, 2011 at 3:45 PM

INSPECTIONS:

The facilities were inspected routinely throughout the operating season. Refer to **TABLE NO. 1 – 2011 AERATION EQUIPMENT LOG** below.

DATE	DAY OF WEEK	TIME OF DAY	ELECTRIC METER: KWHRS		UNIT HOURS				LOAD RELAY COUNTS X 1,000		% ON	UNIT STARTS	TEMPERATURE: DEGREES FAHRENHIET (°F)					OUTLET PRES-SURE (PSI)
			READING	USAGE	RUN-NING	ELAPS-ED	LOAD-ED	ELAPS-ED	TOTAL	ELAPS-ED			OUT-SIDE	AM-BIENT	OUT-LET	ELE-MENT	OIL	
02/24/11	TUE	3:00 PM	22,975		17,885		7,977		2,137			273	25	44	64	434	102	51.2
02/28/11	MON		23,092	117	17,975	90	8,009	32	2,146	9	36	273	46	48	66	430	104	52.2
06/05/11	MON	3:58 PM	26,320	3,345	20,309	2,424	8,949	972	2,440	303	40	274	87	93	101	487	135	52.0
06/06/11	MON	11:35 PM	26,320	0	20,309	0	8,949	0	2,440	0	40	274	87	93	101	487	135	52.0
06/07/11	TUE	12:00 PM	26,352	32	20,333	24	8,959	10	2,443	3	42	274	63	86	109	485	144	52.0
07/04/11	MON	4:40 PM	27,263	911	20,985	652	9,210	251	2,561	118	38	274	100	164	147	242	171	52.0
07/08/11	FRI	2:10 PM	27,407	144	21,073	88	9,248	38	2,594	33	43	275	65	96	127	456	171	52.0
07/15/11	FRI	7:50 PM	27,726	319	21,267	194	9,334	86	2,667	73	44	277	73	94	128	446	171	50.8
07/17/11	SUN	5:50 PM	27,754	28	21,284	17	9,342	8	2,673	6	47	278	97	98	126	466	171	51.0
07/18/11	MON	7:10 PM	27,787	33	21,304	20	9,351	9	2,681	8	45	279	88	97	126	467	171	49.6
07/19/11	TUE	6:00 PM	27,816	29	21,322	18	9,359	8	2,688	7	44	280	80	97	126	455	171	50.9
07/21/11	THU	5:10 PM	27,886	70	21,365	43	9,378	19	2,704	16	44	282	81	97	128	466	171	48.2
07/23/11	SAT	11:30 AM	27,920	34	21,384	19	9,387	9	2,712	8	47	283	91	97	128	471	171	48.4
07/29/11	FRI	10:45 AM	28,160	240	21,528	144	9,451	64	2,770	58	44	284	82	85	116	436	118	50.2
08/02/11	TUE	7:43 PM	28,310	150	21,628	100	9,497	46	2,787	17	46	285	77	167	94	103	11	50.0
08/04/11	THU	5:10 PM	28,376	66	21,673	45	9,518	21	2,797	10	47	287	73	80	97	457	112	49.8
08/05/11	FRI	2:58 PM	28,407	31	21,695	22	9,527	9	2,800	3	41	287	90	95	110	483	123	52.0
08/06/11	SAT	12:00 PM	28,436	29	21,716	21	9,535	8	2,802	2	38	287	86	92	108	479	120	52.2
08/12/11	FRI	3:00 PM	28,645	209	21,863	147	9,597	62	2,820	18	42	297	85	91	109	484	123	53.2
08/15/11	MON	7:16 PM	28,723	78	21,918	55	9,620	23	2,827	7	42	298	66	69	76	452	98	53.2
08/24/11	WED	4:00 PM	29,007	284	22,119	201	9,704	84	2,852	25	42	298	97	100	118	498	129	53.3
08/29/11	MON	9:20 AM	29,200	193	22,256	137	9,761	57	2,870	18	42	298	77	76	91	462	109	53.3
09/11/11	SUN	8:40 AM	29,628	428	22,566	310	9,890	129	2,908	38	42	298	63	53	71	388	100	49.9
09/15/11	THU	7:25 AM	29,747	119	22,652	86	9,927	37	2,919	11	43	299	52	56	73	411	101	50.5
09/16/11	FRI	10:20 AM	29,782	35	22,676	24	9,937	10	2,922	3	42	300	67	55	71	382	101	49.0
11/09/11	WED	8:05 AM	31,600	1,818	23,971	1,295	10,528	591	3,084	162	46	302	27	30	48	425	113	53.0
11/11/11	FRI	1:04 PM	31,676	76	24,022	51	10,544	16	3,089	5	31	303	62	64	81	468	104	53.1
11/23/11	WED	3:45 PM	32,096	496	24,312	341	10,704	176	3,119	35	52	307	66	81	93	491	113	53.0

The equipment operated with few interruptions and no internal part failures during 2011. A summary of the annual statistics are listed in **TABLE NO. 2 – 2011 ANNUAL OPERATION SUMMARY** below.

	KWHR	RUN (HOURS)	LOAD (HOURS)	LOAD RELAY COUNT	UNIT STARTS	TEMPERATURE: DEGREES FAHRENHIET (° F)					OUTLET PRESSURE (PSI)
						OUTSIDE	AMBIENT	OUTLET	ELEMENT	OIL	
TOTAL	9,121	6,427	2,727	982,000	34						
MINIMUM						25	30	48	103	11	48.2
MAXIMUM						100	167	147	498	171	53.3
AVERAGE						74	86	101	436	127	51.4

COMPARATIVE OPERATION SUMMARY:

An annual comparative summary is listed in **TABLE NO. 3 – 2011 ANNUAL OPERATION COMPARATIVE SUMMARY** below.

YEAR	DAYS IN SEASON	KWHR	RUN (HOURS)	LOAD (HOURS)	LOAD RELAY COUNT	UNIT STARTS	AVERAGE TEMPERATURE: DEGREES FAHRENHIET (° F)					OUTLET PRESSURE (PSI)
							OUT-SIDE	AM-BIENT	OUT-LET	ELE-MENT	OIL	
2008	259		5,119			77	50	78	102	421	109	53.2
2009	291	7,823	6,384	3,147	571,525	90	65	73	97	445	124	52.6
2010	255	8,257	6,025	2,485	658,000	14	65	72	94	462	122	51.7
2011	272	9,121	6,427	2,727	982,000	34	74	86	101	436	127	51.4

EQUIPMENT SHUTDOWNS:

The compressor operated uninterrupted except for (12) twelve shut downs. The unit shut down (8) eight times due to "High Oil Temperature". The "High Oil Temperature" faults usually occurred in the afternoons around 1:00 PM during the heat of the day. This was typical during the hottest month of July.

The unit had to sufficiently cool before it would run continuously. Customarily the unit was allowed to cool for approximately (5) five hours. The unit was restarted in the evening when the ambient temperatures had decreased adequately to allow a sustained operating temperature.

The unit shut down (3) three times due to uncontrolled circumstances. The fault each of these 3 times was "Starter Feedback Contact". Each "Starter Feedback Contact" fault seemed to coincide with rain accompanied by lightening. It was noted on one occasion that Xcel Energy was working on the underground electrical in the near proximity.

The length and duration of time that the unit was OFF each time is noted. The longest period of time that the equipment was OFF during the 2011 operating season was 23.5 hours due to "High Oil Temperature". The shutdowns are listed in **TABLE NO. 4 – 2011 EQUIPMENT SHUTDOWNS** below.

DATE	DAY OF WEEK	TIME OF DAY	SHUTDOWN DESCRIPTION	DURATION OFF (HOURS)
07/04/11	MON	4:30 PM	"High Oil Temperature", 171 °F. Pressure Settings Changed From 52.0/49.0 to 51.5/49.5	4.00
07/08/11	FRI	2:04 PM	"High Oil Temperature", 171 °F. Pressure Settings Changed From 51.5/49.5 to 51.0/49.0	4.00
07/15/11	FRI	5:11 PM	"High Oil Temperature", 171 °F.	2.75
07/17/11	SUN	12:51 PM	"High Oil Temperature", 171 °F.	5.00
07/18/11	MON	1:57 PM	"High Oil Temperature", 171 °F.	5.10
07/19/11	TUE	12:24 PM	"High Oil Temperature", 171 °F. Pressure Settings Changed From 51.0/49.0 to 50.0/48.5	5.50
07/21/11	THU	1:17 PM	"High Oil Temperature", 171 °F.	3.50
07/22/11	FRI	12:04 PM	"High Oil Temperature", 171 °F.	23.50
08/02/11	TUE	9:00 PM	Installed Air Conditioner	0.00
08/15/11	MON	12:13 PM	"High Element Temperature", 511 °F.	7.00
09/11/11	SUN	6:43 PM	"Starter Feedback Contact"	2.00
09/14/11	WED	10:18 PM	"Starter Feedback Contact"	8.10
09/16/11	FRI	7:59 PM	"Starter Feedback Contact"	2.20
11/23/11	WED	3:45 PM	Unit Turned OFF for the Season	

EQUIPMENT MODIFICATION:

AIR CONDITIONER

It can be observed from **TABLE NO. 4** that the majority of shut downs in 2011 occurred due to "High Oil Temperature". The shut downs were predicable. Whenever the ambient temperature increased above 95 °F it was more than likely that the unit would shut down due to "High Oil Temperature". The ambient temperatures are listed in **TABLE NO. 1**. It can be noted that most of the faults occurred in July on the days corresponding to the highest ambient temperatures.

A Technical Memorandum titled "Cherry Creek Reservoir Destratification Facilities Air Conditioner" dated 07/27/11 was prepared by TC Consulting Services recommending the installation of an air conditioner. The Cherry Creek Basin Water Quality Authority approved a proposal from TC Consulting Services to furnish and install the necessary equipment including a 230 volt electric circuit.

It was calculated that providing colder air than ambient to the oil heat exchanger supply would lower the oil operating temperature. Lowering the oil temperature provided sustained and continuous operation of the unit. It can be noted from **TABLE NO. 4** that there has not been "High Oil Temperature" shut downs subsequent to the installation of the air conditioner.

There are (2) two temperature faults that can cause a shut down. These are "High Oil Temperature" and "High Element Temperature". The temperature sensor for the oil is located in the oil circulation return line. The temperature sensor for the element is located on the top of the unit in the housing of the blower.

The oil is cooled by a heat exchanger to maintain its lubrication properties. High temperatures can cause oil to breakdown and lose some of the protection it provides to moving parts. This is especially true regarding organic lubricants. Due to the high temperatures that this unit operates at a synthetic lubricant has been used. Synthetic lubricants are not as prone to breakdown and provide greater protection and have a longer life. A hard fault occurs when the temperature of the oil reaches 171 °F.

A "High Element Temperature" fault occurs when the discharge housing of the compressor unit reaches 511 °F. This can occur when the unit "loads" for too long or the volume of air changes due to ambient conditions. When the amount of work produced by the blower increases due to load the temperature of the unit increases. The higher the discharge pressure the higher the operating temperature of the unit. It is a trying and difficult balance to select "load" and "unload" pressure setpoints that will accommodate and allow the unit to run continuously regardless of the ambient temperatures.

An 18,000 BTU air conditioner was purchased, installed and placed in service on 08/02/11. The air conditioner was installed at the oil heat exchanger intake air supply louver. **PHOTOGRAPH NO. 1** and **NO. 2** below show the finished installation. A temporary "blocking" panel was constructed from cardboard.

PHOTOGRAPH NO. 1 -
NEW AIR CONDITIONER
SIDE VIEW

PHOTOGRAPH NO. 2 –
NEW AIR CONDITIONER
BACK VIEW

EQUIPMENT REPAIRS AND MAINTENANCE:

ROUTINE SERVICE

The blower compressor was not serviced in 2011. The unit filters and oil had been replaced late in the season of 2010 just prior to shutting down the unit for the winter. The manufacturer's prescribed intervals for service is every 8,000 hours of operation.

HEAT EXCHANGER CLEANING

The oil and discharge air heat exchanger cooling fins were pressure washed in 2011. The shrouds and panels were removed first. The electric motors were covered with plastic to preclude moisture and water from entering the units.

Water was obtained from an outside hose bibb located at the marina. The water was transported in (3) three five gallon plastic containers. The water was then transferred to the water storage tank that was purchased last year for this purpose. A total of (30) thirty gallons of water was required to clean the cooling fins and the interior of the enclosure.

A new steel cart was purchased for the purpose of supporting and elevating the water storage tank. The cart stands (3') three feet tall. This provided sufficient flow of water to the pressure washer by gravity. The cart was selected to adequately support the weight of 30 gallons of water and provide mobility. The steel cart and the water containers are shown in **PHOTOGRAPH NO. 3.**

PHOTOGRAPH NO. 3 –
STEEL CART AND WATER CONTAINERS

TUBING REPLACEMENT

The shutters of the exhaust air louver are operated by (2) two pneumatic actuators. The pneumatic actuators require a minimum of (12 PSI) twelve pounds per square inch to open the shutters. The shutters must be open to allow the floor fans to exhaust hot air from the inside of building.

The actuator's air supply is provided by plastic tubing. The existing plastic tubing is constructed from vinyl. The vinyl tubing was originally routed along the top of the louver frame. The frame is constructed from thin gauge steel. The hot air from the heat exchanger is exhausted through a plenum that is in direct contact with the louver frame. The tubing did lie in contact with the metal frame. The existing tubing melted due to the surface temperature of the metal. It is estimated that the metal frame of the louver reaches temperatures of 200° F.

New reinforced tubing with a higher temperature rating was used as a replacement material. The new tubing was rerouted along the bottom of the louver frame. The temperature of the air at the bottom of the louver is much cooler than at the top. The floor fans actually discharge air over this area of the louver.

The frequency of the compressor "loading" and "unloading" was calculated and is presented in **TABLE NO. 5 – 2011 LOADING AND UNLOADING FREQUENCY SUMMARY** below.

YEAR	UNIT OPERATION AVERAGE DURATION (SECONDS)		TIME		CYCLES PER MINUTE	AVERAGE DISCHARGE PRESSURE (PSI)
	LOADED	UNLOADED	% ON	% OFF		
2009	21	27	44	56	1.3	52.6
2010	22	20	48	52	1.8	51.7
2011	14	17	46	54	1.9	51.3

EQUIPMENT PARAMETER CHECKS

The voltage and amperage draw of the motor was measured and recorded. These measurements are listed in **TABLE NO. 6 – 2011 ELECTRICAL MONITORING** below.

DATE	DAY OF WEEK	TIME OF DAY	MOTOR VOLTAGE		MOTOR AMPERAGE			UNIT OPERATION DURATION (SEC)		TIME		CYCLES PER MINUTE
			PHASE	VAC	PHASE	LOADED	UNLOADED	LOAD	UNLOAD	ON	OFF	
06/06/11	MON	11:35 AM	$L_1 - L_2$	481	L_1	114.8	61.7	49.0 PSI	52.0 PSI	39 %	61 %	1.9
			$L_1 - L_3$	479	L_2	126.6	70.5	12	19			
			$L_2 - L_3$	486	L_3	112.9	64.3					
11/09/11	WED	2:10 PM	$L_1 - L_2$	481	L_1	128.0	73.0	49.0 PSI	53.0 PSI	48 %	52 %	1.9
			$L_1 - L_3$	482	L_2	114.0	62.0	15	16			
			$L_2 - L_3$	487	L_3	123.0	65.0					
11/23/11	WED	3:45 PM	$L_1 - L_2$	487	L_1	127.0	73.0	49.0 PSI	53.0 PSI	50 %	50 %	1.9
			$L_1 - L_3$	485	L_2	115.0	63.0	16	16			
			$L_2 - L_3$	482	L_3	119.0	62.0					

RECOMMENDATIONS:

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

- Install a meter to measure and monitor the total volume and rate of air flow.
- Install a pressure switch on the discharge pipeline. The switch initiates an alarm when the discharge pressure decreases to a minimum setpoint.
- Incorporate the air conditioner or a form of mechanical cooling for the oil heat exchanger on a permanent basis.

Sincerely,

Terry Cunningham