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Sonoran Energy Project

(02-AFC-01C)

Data Responses

(Responses to Water Workshop Data Requests)

Prepared for

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Contents

SECTION 1

Introduction

Attached are AltaGas Sonoran Energy Inc.'s (AltaGas or the Project Owner) responses to the California Energy Commission (CEC) requests issued during the Soil and Water Issues Resolution Workshop on April 21, 2016 regarding the Sonoran Energy Project (SEP) (02-AFC-01C) Petition to Amend (PTA). During the workshop, Commission staff requested that AltaGas provide information on the following three topics.

- Water Offset Strategies
- Engineering Evaluation confirming the Blythe Energy Project's (BEP) Evaporation Ponds are Sufficiently Sized
- Information Collected on the Feasibility of Zero Liquid Discharge Systems

The remainder of this document presents AltaGas's responses to these topics.

SECTION 2

Water Offset Strategy

As discussed at the Soil and Water Issues Resolution Workshop on April 21, 2016, the Project Owner has reconsidered the proposed voluntary water conservation offset program ("WCOP") as set forth in the existing Condition of Certification WaterRes-1/Soil&Water-7[1]. The Project Owner is no longer pursuing the canal lining offset proposal (see, Sonoran Energy Project Water Conservation Plan (TN# 210520)); and therefore, Staff can refrain from analyzing the canal lining proposal in its Final Staff Assessment. Rather, the Project Owner proposes minor modifications to Soil&Water-7, to create some flexibility regarding the implementation of an offset program that contemplates fallowing and/or similar reduction in agricultural water consumption (deficit irrigation), and requires offsetting actual consumptive water use of the project, calculated on a rolling 5-year average basis. (Sonoran Energy Project's Comments re Soil and Water Issues Resolution Workshop (TN# 211129).)

The Project Owner has investigated the ability to comply with a strict fallowing or retirement program to offset project water use, and determined that there is sufficient irrigated land available on the mesa in the Palo Verde Basin to offset project water use. As an alternative to strict fallowing or retirement, however, the Project Owner has also determined that an agricultural water management technique known as deficit irrigation could be used to offset project water use, and would potentially create greater flexibility and reduce impacts associated with strict fallowing or retirement of agricultural land.

2.1.1.1 Fallowing/Retirement

Within the Palo Verde Basin, lands are characterized as being either in the valley or on the mesa. (See 2005 Final Decision, p. 251 (TN# 36138).) Given that much irrigated farmland in the valley is classified as Important Farmland and/or under Williamson Act contract, fallowing on the mesa is preferable to fallowing land in the valley. (2005 Final Decision, pp. 127-128 (TN# 36138.) The 2005 Final Decision also prohibits retirement of agricultural land in the valley. (2005 Final Decision, p. 131 (TN# 36138).) The Project Owner has, therefore, investigated the availability of irrigated land on the mesa that could be fallowed or retired to offset project water use. Although Staff need not evaluate the ability of the Project Owner to comply with any particular Condition of Certification, the Project Owner provides the following information to demonstrate that Soil&Water-7 is a feasible condition.[2]

The surface area of the Palo Verde Mesa groundwater basin is 226,000 acres. Of that acreage, 26,800 acres are within Palo Verde Irrigation District (PVID). Based on 2015 PVID water delivery data, 13,500 acre-feet of PVID water was used to irrigate only 2,059 acres on the mesa. Other irrigated farmland on the mesa is irrigated with groundwater. To offset the project's maximum 2,800 acre feet per year water use, the Project Owner would need to fallow only approximately 546 acres.[3] Therefore, sufficient land is available on the mesa for the Project Owner to meet the fallowing requirement. Moreover, based on a comparison of the project to the existing Blythe Energy Project's water use, SEP will likely use less water than the maximum allowed so that achieving an offset of actual project water use, as proposed in the Project Owner's modified Soil&Water-7, would likely require much less land. (Sonoran Energy Project's Comments re Soil and Water Issues Resolution Workshop, pp. 1-2 (TN# 211129).)

[1] The PSA modifies the numbering of this Condition of Certification to Soil&Water-7. (Preliminary Staff Assessment, p. 4.9-23 (TN# 210090).) Hereafter, this Condition of Certification will be referred to as Soil&Water-7.

[2] It is important to note that the Project Owner does not contemplate participating in Palo Verde Irrigation District's fallowing program. Rather, the Project Owner would acquire rights to fallow currently irrigated land on the mesa.

[3] This calculation is based on the currently applicable irrigation water use rate of 5.13 acre-feet/acre. (Project Owner's Follow-up to PSA Workshop, p. 6 (TN# 210875).)

The Project Owner has also engaged in discussions with agricultural land brokers in the project area and identified land that may be available for acquisition and fallowing or retirement. The Project Owner has received information about at least 600 acres of agricultural land on the mesa, irrigated with groundwater, that could be acquired to meet the water offset requirements.

2.1.1.2 Deficit Irrigation

Deficit irrigation is an irrigation method for permanent crops that reduces water deliveries to levels below typical crop water needs. The objective is to cause partial stomatal closure, resulting in reduced evapotranspiration. In commercial applications, deficit irrigation is intended to purposely stress the trees at specific developmental stages such that there is little, if any, negative impact on the yield of marketable product and profitable operations. For SEP's purposes, deficit irrigation would focus on minimizing water use while maintaining limited on-farm activities. This is expected to result in the required water savings without the adverse effects associated with retirement, such as declining socioeconomic conditions and increased soil erosion. Deficit irrigation sufficient to reduce water use with no increase in tree mortality is expected to require about two to four times as much orchard land compared to a strict fallowing program.

Specific impacts associated with the strict fallowing program contemplated in the 2005 Final Decision include fugitive dust from erosion (2005 Final Decision, p. 23, 272), loss of agricultural land (2005 Final Decision, pp. 127-128, 269), and socioeconomic impacts (2005 Final Decision, p. 162) (TN# 36138), which would be minimized by deficit irrigation. Additionally, the 2005 Final Decision prohibits retirement of lands on the mesa in active orchard crop production. (2005 Final Decision, p. 131, see also, p. 127 (TN# 36138).) Deficit irrigation has the potential to allow the Project Owner to use orchards to meet the water offset condition, because it does not result in retirement of the orchards. Based on discussions with land brokers in the project area, there is currently over 450 acres of active orchard land available for sale, on which deficit irrigation could be employed.

Engineering Evaluation of the Blythe Energy Project's Evaporation Ponds

The Project Owner proposes to dispose of SEP wastewater in the adjacent Blythe Energy Project's (BEP) evaporation ponds (see TN# 210635). During the Soil and Water Issues Resolution Workshop on April 21, 2016, Colorado River Basin Regional Water Quality Control Board (RWQCB) staff (Ms. Jennie Snyder, P.E.) requested that the Project Owner submit an engineering evaluation that demonstrates that the BEP evaporation ponds are sufficiently sized to contain the total volume of wastewater from both SEP and BEP at their permitted discharge rates, consistent with the BEP's Waste Discharge Requirements (WDRs).

3.1 Evaporation Pond Description

BEP discharges two wastewater streams to the existing evaporation ponds. The primary wastewater stream is the cooling tower blowdown water treatment system designed to recover water for reuse. This stream consists of a high total dissolved solids (TDS) discharge with other nonhazardous constituents. The second wastewater stream is comprised of the steam-cycle blow-down, oil/water separator discharge, and the discharge from the water treatment system's reverse osmosis (RO) and demineralizer unit. SEP will discharge comparable wastewater to the BEP evaporation ponds. In addition, the SEP design will include 100 percent redundant wastewater treatment systems sized to accommodate the discharge from both SEP and BEP while operating at their rated capacities.

The two BEP evaporation ponds have a combined evaporation surface of approximately 16 acres of equal size and are 10 feet deep. The storage volume at high water level is approximately 91 acre-feet per pond with a water surface area of 7 acres per pond. The ponds designs include two high-density polyethylene liners, a drainage net system, and a geosynthetic clay liner. The evaporation pond design allows each pond to be taken out of service periodically to allow complete evaporation and removal of the brine sludge. The brine sludge is profiled and disposed of at an appropriate offsite solid waste disposal facility in accordance with local, state, and federal regulations.

3.2 Wave Run-Up Calculation

Wave run-up heights were estimated for the BEP evaporation ponds using weather data for Blythe, California. The maximum sustained wind velocity is 34 miles per hour. This value for velocity over land is multiplied by 1.03 to obtain wind velocity (Vw) of 35.0 miles per hour over water. The fetch (F) of each pond is assumed to be the longest length of approximately 1,000 feet.

The Figures 3-21 and 3-22 from the U.S. Army Shore Protection Manual[4] are forecasting curves for shallow-water waves in depths of 5 and 10 feet. Using a Fetch of 1,000 feet and a wind speed of 35 miles per hour, and interpolating between the values of these two figures based on an assumed average depth in the evaporation ponds of 7.5 feet, the height of a wave (H) is predicted to be 0.775 feet and the frequency (T) is predicted to be 1.65 seconds.

[4] U.S. Army Coastal Engineering Research Center – Shore Protection Manual, Second Edition 1975

Wave run-up is then calculated according to equation (2) on page 1086 of the referenced paper by Steven A. Hughes[5] as follows:

$$R/H = 2.3 \tan \alpha/(H/T^2)^{0.5}$$

Where:

R is the maximum run-up

H is the wave height

α is the slope angle of the embankment and tan α is (1 ÷ 3) or 0.33

T is wave period

Using this equation, wave run-up (R) = 1.1 feet.

3.3 Waste Discharge Requirements

The RWQCB issued the BEP WDRs on June 15, 2015 (ORDER R7-2015-0028). The WDRs include Discharge Specification 4, which defines the necessary capacity for each BEP evaporation pond. These discharge specifications are presented below.

4. The inside depth of each pond shall provide:
   a. Sufficient depth to provide storage of the entire discharge water and brine residue (sludge).
   b. Sufficient depth to provide for normal water level variation throughout the year due to variations in plant inflow, rainfall, and the evaporation rates.
   c. Sufficient additional depth to provide for the increase in water level that would occur when the evaporation rate is 90 percent of the mean evaporation rate for two (2) years in a row.
   d. Sufficient additional depth to provide additional storage capacity for increased inflow for a minimum of two (2) weeks, assuming the brine concentration and reverse osmosis (RO) equipment are both inoperable.
   e. Sufficient depth to provide an allowance for an increase in water level during pond maintenance, assuming one (1) cell will need maintenance for a two (2) month period.
   f. Sufficient additional depth to provide for the 100-year rainfall in addition to the maximum water level resulting from water level variations.
   g. Sufficient freeboard above the maximum water level to provide the greater of 24 inches or the height of the wind wave run-up plus 12 inches.

Based on the WDR discharge specifications b., f., and g., the BEP evaporation ponds are required to have a minimum of 2.39 feet of freeboard (12 inches plus the wave run-up height of 1.1 feet, plus the 0.29 feet of precipitation from a 100-year rain event).

This assessment is intended to demonstrate that discharging both the BEP and SEP wastewater to the BEP evaporation ponds can be accomplished in a manner consistent with the existing WDRs.

3.4 Wastewater Discharge

BEP has an annual operational limit based on thermal heat input of 31,852,800 million British thermal units (higher heating value) in any rolling 12-month period. Assuming each of the two combustion

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[5] Estimation of Wave Run-up on Smooth, Impermeable Slopes Using the Wave Momentum Flux Parameter, Steven A. Hughes, US Army Research and Development Center, 29 June 2004

turbines and fired heat recovery steam generators consumes 1,896 million British thermal units per hour, this equates to approximately 8,400 operating hours per year. Based on BEP historical wastewater discharge rates, the annual average wastewater flow rate is 16.7 gallons per minute (gpm) or approximately 8.4168 million gallons per year (mgy).

SEP is expected to operate 7,000 hours per year, with 5,500 hours per year under average ambient temperature and 1,500 hours per year at maximum ambient temperature (ambient temperature affects water consumption with higher temperatures requiring higher water use and ultimately higher wastewater discharge). Based on the SEP water balances, the annual average and maximum ambient temperature wastewater discharge flow rates are 14.4 gpm and 20.0 gpm, respectively. Combining the wastewater discharge rates and the expected operating hours, the annual wastewater discharge is approximately 6.552 mgy.

Tables 1 and 2 present a monthly and annual wastewater (including solids) discharge to the BEP evaporation ponds for two consecutive years. These discharge rates are based on either historic (for BEP) or projected operating profiles (for SEP) on a monthly basis and the wastewater discharge and operating rates shown above. The BEP/SEP solids contribution to the wastewater discharge are based on a well water TDS concentration of 1,100 parts per million and well water consumption of 2,200 gpm for BEP, plus 1,584 gpm for the average and 2,223 gpm for the high ambient temperature conditions for SEP.

Published pan evaporation rate[6], salinity factor, pond evaporation rate, and rainfall[7] data were used to calculate the monthly net evaporation from the BEP evaporation ponds. Tables 3 and 4 present the net monthly evaporation rates for the BEP ponds for two consecutive years.

Assuming at the beginning of SEP's operation, each BEP evaporation pond contains 3 feet of water/sludge and the combined BEP/SEP wastewater is discharged equally between the two ponds. After 10 months of operation, the water is pumped from BEP evaporation pond 1 to pond 2 and all of the wastewater is discharged to pond 2 while pond 1 is out of service for 2 months of maintenance. At the end of 2 months, the volume and height of the water/sludge in evaporation pond 2 would be 13.5019 million gallons and 5.92 feet (see Table 5). Once pond 1's maintenance is completed, half the contents of pond 2 would be transferred back to pond 1. After 10 months of BEP/SEP operation, the water in pond 2 is transferred to pond 1 and pond 2 undergoes 2 months of maintenance. The height and volume of the water/sludge in pond 1 would be 12.8284 million gallons and 5.62 feet. After the maintenance of pond 2 is complete, half the contents of pond 2 would be transferred back to pond 1 (see Table 6).

3.5 Conclusions

The BEP evaporation ponds are designed such that both BEP and SEP can discharge their permitted wastewater volumes to the ponds while complying with the existing WDRs. This analysis demonstrates compliance with the applicable WDRs.

Tables 5 and 6 demonstrate that each BEP evaporation pond is sized to store the entire combined BEP and SEP discharge (water and sludge) for normal water level variations, including rainfall and 90 percent of the mean evaporation rates for 2 years (WDR 4a., 4b., 4c., and 4f.). With the addition of the 100 percent redundant wastewater treatment system at SEP, the need to have sufficient additional depth for storage capacity to accommodate a 2-week outage of wastewater treatment system is no longer needed (WDR 4d.). Each pond can accommodate the entire BEP and SEP discharge for 2 months

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[6] Indio Fire Station, CA Evaporation - Average by Month 1927 – 2005 - http://www.wrcc.dri.edu/htmlfiles/westevap.final.html

[7] http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca0927

while maintenance is performed on the other pond (WDR 4e.), and still maintain the required freeboard of 2.39 feet (WDR 4g.).

Table 1 SEP/BEP Wastewater Discharge - First Year

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL FOR YEAR
BEP Hours of Operation	384	672	744	720	744	720	744	744	720	744	720	744	8,400
BEP Wastewater Discharge (gallons)	384,768	673,344	745,488	721,440	745,488	721,440	745,488	745,488	721,440	745,488	721,440	745,488	8,416,800
SEP Hours of Operation at Max. Temp	0	0	0	0	0	12	744	744	0	0	0	0	1,500
SEP Hours of Operation at Avg Temp	0	400	744	720	744	708	0	0	720	744	720	0	5,500
SEP Wastewater Discharge (gallons)	0	345,600	642,816	622,080	642,816	626,112	892,800	892,800	622,080	642,816	622,080	0	6,552,000
Total BEP and SEP Wastewater to Ponds (gallons)	384,768	1,018,944	1,388,304	1,343,520	1,388,304	1,347,552	1,638,288	1,638,288	1,343,520	1,388,304	1,343,520	745,488	14,968,800
Volume of Salt Sent to Ponds from BEP (gallons)	43,444	76,027	84,172	81,457	84,172	81,457	84,172	84,172	81,457	84,172	81,457	84,172	950,334
Volume of Salt Sent to Ponds from SEP (gallons)	0	32,583	60,604	58,649	60,604	59,044	85,052	85,052	58,649	60,604	58,649	0	619,491

Table 2 SEP/BEP Wastewater Discharge - Second Year

	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**TOTAL FOR YEAR**
BEP Hours of Operation	384	672	744	720	744	720	744	744	720	744	720	744	8,400
BEP Wastewater Discharge (gallons)	384,768	673,344	745,488	721,440	745,488	721,440	745,488	745,488	721,440	745,488	721440	745,488	8,416,800
SEP Hours of Operation at Max. Temp	0	0	0	0	0	12	744	744	0	0	0	0	1,500
SEP Hours of Operation at Avg Temp	0	400	744	720	744	708	0	0	720	744	720	0	5,500
SEP Wastewater Discharge (gallons)	0	345,600	642,816	622,080	642,816	626,112	892,800	892,800	622,080	642,816	622,080	0	6,552,000
Total BEP and SEP Wastewater to Ponds (gallons)	384,768	1,018,944	1,388,304	1,343,520	1,388,304	1,347,552	1,638,288	1,638,288	1,343,520	1,388,304	1,343,520	745,488	14,968,800
Volume of Salt Sent to Ponds from BEP (gallons)	43,444	76,027	84,172	81,457	84,172	81457	84172	84172	81457	84172	81457	84,172	950,334
Volume of Salt Sent to Ponds from SEP (gallons)	0	32,583	60,604	58,649	60,604	59,044	85,052	85,052	58,649	60,604	58,649	0	619,491

Table 3 BEP Evaporation Pond Evaporation Rate - First Year

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL FOR YEAR
Pan evap (inches)	2.85	4.38	7.15	9.98	12.73	14.85	14.95	13.59	10.8	7.6	3.98	2.49	105.35
90% of Mean Pan Evap (inches)	2.565	3.942	6.435	8.982	11.457	13.365	13.455	12.231	9.72	6.84	3.582	2.241	94.815
Pan Factor	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Salinity Factor	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Pond Evap (inches)	1.24	1.90	3.11	4.34	5.53	6.46	6.50	5.91	4.69	3.30	1.73	1.08	45.80
Rain Fall (inches)	0.48	0.44	0.35	0.15	0.02	0.02	0.28	0.6	0.34	0.26	0.19	0.41	3.54
Area of Each Pond (acres)	7	7	7	7	7	7	7	7	7	7	7	7	--
Net Loss From Each Pond (gallons)	144,241	278,255	524,224	796,058	1,047,977	1,223,136	1,181,981	1,008,793	827,695	578,510	292,723	127,801	8,031,395

Table 4 BEP Evaporation Pond Evaporation Rate - Second Year

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL FOR YEAR
Pan evap (inches)	2.85	4.38	7.15	9.98	12.73	14.85	14.95	13.59	10.8	7.6	3.98	2.49	105.35
90% of Mean Pan Evap (inches)	2.57	3.94	6.44	8.98	11.46	13.37	13.46	12.23	9.72	6.84	3.58	2.24	94.82
Pan Factor	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Salinity Factor	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
Pond Evap (inches)	1.24	1.90	3.11	4.34	5.53	6.46	6.50	5.91	4.69	3.30	1.73	1.08	45.80
Rain Fall (inches)	0.48	0.44	0.35	0.15	0.02	0.02	0.28	0.6	0.34	0.26	0.19	0.41	3.54
Area of Each Pond (acres)	7	7	7	7	7	7	7	7	7	7	7	7	--
Net Loss From Each Pond (gallons)	144,241	278,255	524,224	796,058	1,047,977	1,223,136	1,181,981	1,008,793	827,695	578,510	292,723	127,801	8,031,395

Table 5 BEP Evaporation Pond Water Volume and Height - First Year

	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Volume of Water in Pond 1 at End of Month (gallons)	6,698,164	6,929,381	7,099,309	6,975,011	6,621,186	6,071,826	5,708,989	5,519,339	5,363,404	5,479,046	0	0
Volume of Salt in Pond 1 at End of Month (gallons)	0	54305	126,693	196,746	269,135	339,385	423,997	508,610	578,663	651,051	325,526	0
Volume of Water and Salt in Pond 1 at End of Month (gallons)	6,698,164	6,983,686	7,226,002	7,171,757	6,890,320	6,411,211	6,132,986	6,027,949	5,942,067	6,130,097	325,526	0
Height of Water and Salt in Pond 1 at End of Month (feet)	2.94	3.06	3.17	3.14	3.02	2.81	2.69	2.64	2.61	2.69	0.14	0.00
Volume of Water in Pond 2 at End of Month (gallons)	6,698,164	6,929,381	7,099,309	6,975,011	6,621,186	6,071,826	5,708,989	5,519,339	5,363,404	5,479,046	12,008,889	12,626,576
Volume of Salt in Pond 2 at End of Month (gallons)	0	54,305	126,693	196,746	269,135	339,385	423,997	508,610	578,663	651,051	791,158	875,330
Volume of Water and Salt in Pond 2 at End of Month (gallons)	6,698,164	6,983,686	7,226,002	7,171,757	6,890,320	6,411,211	6,132,986	6,027,949	5,942,067	6,130,097	1,280,0047	13,501,906
Height of Water and Salt in Pond 2 at End of Month (feet)	2.94	3.06	3.17	3.14	3.02	2.81	2.69	2.64	2.61	2.69	5.61	5.92

Table 6 BEP Evaporation Pond Water Volume and Height - Second Year

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Volume of Water in Pond 1 at End of Month (gallons)	6,361,431	6,592,648	6,762,576	6,638,278	6,284,453	5,735,093	5,372,256	5,182,607	5,026,671	5,142,313	11,335,423	11,953,110
Volume of Salt in Pond 1 at End of Month (gallons)	0	54,305	126,693	196,746	269,135	339,385	423,997	508,610	578,663	651,051	791,158	875,330
Volume of Water and Salt in Pond 1 at End of Month (gallons)	6,361,431	6,646,953	6,889,269	6,835,024	6,553,587	6,074,478	5,796,253	5,691,216	5,605,334	5,793,364	12,126,581	12,828,440
Height of Water and Salt in Pond 1 at End of Month (feet)	2.79	2.91	3.02	3.00	2.87	2.66	2.54	2.50	2.46	2.54	5.32	5.62
Volume of Water in Pond 2 at End of Month (gallons)	6,361,431	6,592,648	6,762,576	6,638,278	6,284,453	5,735,093	5,372,256	5,182,607	5,026,671	5,142,313	0	0
Volume of Salt in Pond 2 at End of Month (gallons)	897,052	951,357	1,023,745	1,093,798	1,166,187	1,236,437	1,321,049	1,405,662	1,475,715	1,548,103	774,052	0
Volume of Water and Salt in Pond 2 at End of Month (gallons)	7,258,483	7,544,005	7,786,321	7,732,076	7,450,639	6,971,530	6,693,305	6,588,268	6,502,386	6,690,416	774,052	0
Height of Water and Salt in Pond 2 at End of Month (feet)	3.18	3.31	3.41	3.39	3.27	3.06	2.93	2.89	2.85	2.93	0.34	0.00

Zero-Liquid Discharge Operational Experience

The Energy Commission requested the Project Owner docket information regarding its review of California zero-liquid discharge system (ZLD) systems. The Project Owner conducted a review of ZLD installations at California power plants to determine the current state of operating experience. During this review, the Project Owner interviewed personnel (see Attachment 1) with experience commissioning and operating ZLD systems at four power plants, including the Colusa Generating Station (CGS), the Walnut Energy Center (WEC), Roseville Energy Park (REP), and Pastoria Energy Facility (PEF).

The results of the interviews show that under the best operating circumstances, ZLD systems were a challenge to operate and require a steep learning curve (up to a year from system commissioning) to proficiently operate these system. Furthermore, any changes in water quality or temperature could result in the ZLD system experiencing upset conditions. Starting up of a ZLD system is never routine but with detailed operating procedures the start up process is more manageable, but often takes up to a week to restart and stabilize the operation.

All of the operating ZLD systems require a dedicated, fulltime operating staff. The operating staff included up to four operators, a mechanic (50 to 75 percent), an instrumentation/control technician (50 to 75 percent), and a manager/chemist. One facility subcontracts out the ZLD system operation/maintenance, resulting in a $2.5 million cost (labor and consumables) and 1.5 megawatts of parasitic load.

In addition to interviewing ZLD operating personnel, a literature review was performed. Many of the recent articles focus on using ZLD systems at coal-fired power plants to recycle/dispose of flue gas desulfurization wastewater. Articles focused on natural gas fired power plant ZLD systems offer a mixed review. For instance, some articles describe ZLD systems operating successfully for some periods, but note that having a dedicated staff of trained folks to operate the system is beneficial[8]. However, later in the same article, another project abandoned its ZLD system in favor of developing an underground injection well for wastewater disposal.

In a 2006 Power Engineering article, the Magnolia Power Project's (MPP) – declared operational in September 2005 – ZLD system is described as "a work in progress," needing "more skilled operators and close monitoring to ensure consistent performance." The article notes that the high alloy metallurgy of the MPP's ZLD system's crystallizer makes the cost of installing redundant capacity high, which requires hauling waste brine offsite during process upsets or equipment breakdowns. On the positive side, the article describes one of the most important MPP ZLD system feature is its 90 percent water recovery rate.[9]

An article by Dan Sampson, considered an industry expert, notes that "even well designed ZLD systems are expensive, hard to operate, and exhibit poor reliability, and require high parasitic load." The article concludes with the following thoughts on ZLD systems.

- Most plants hate the ZLD systems they have, regardless of manufacturer.

[8] http://www.waterworld.com/articles/iww/print/volume-12/issue-05/feature-editorial/examining-zld-options-for-electric-power-facilities.html

[9] http://www.power-eng.com/articles/print/volume-110/issue-9/features/waste-not-water-not.html

- ZLD is a last resort. Discharge to others if possible. While capital cost may appear relatively low, most ZLD systems cost $25-$35 million dollars (USD) in net present value when manpower, maintenance, and consumables are factored into the equation. Use that money during development to avoid ZLD.
- Consider deep-well injection. It's easier and less expensive than ZLD.
- Minimize the use of intermediate processes requiring chemical precipitation and avoid completely, if possible. Minimize processes that require chemical feed.
- Move concentration as far back in the system as possible. Concentration in the cooling tower costs nothing and should be maximized.
- Reuse unconcentrated and low-concentration TDS waste streams in the cooling tower if water quality permits.
- Use the decision tree as a guideline only. Site-specific situations require site-specific designs.
- Consult experts and join users' groups. Martin Vanbee, a historian, said "Learn from the mistakes of others. You can't live long enough to make them all yourself." That's particularly relevant to ZLD systems.[10]

A 2013 article on Modesto Irrigation District's Ripon Generating Station notes that the District was selling its Aquatech water treatment system back to the manufacturer for 13 cents on the dollar.[11]

10 http://www.modernpowersystems.com/features/featurezero-liquid-discharge-methods-and-madness/

11 http://www.modbee.com/news/local/article3151510.html

Attachment 1
Contact Reports for Interviews

CH2MHILL® TELEPHONE CONVERSATION RECORD

Call To: Jim Moen/Pacific Gas and Electric Company Plant Engineer

Phone No.: (916) 899-2768 **Date:** 1/14/2016

Call From: Jerry Salamy/CH2M HILL **Time:** 1:00 pm

Subject: Experience with Zero Liquid Discharge Systems

Notes:

CH2M HILL spoke with Jim Moen, plant engineer at PG&E's Colusa Generating Station (CGS), regarding his experiences with zero liquid discharge systems (ZLD) on projects in California. Mr. Moen had been involved with the CGS, Turlock Irrigation District's Walnut Energy Center (WEC), and Roseville Electric's Roseville Energy Park (REP). Mr. Moen explained that the CGS is a dry cooled combined cycle project that uses fresh water from the Tehama Colusa canal and that the WEC and REP projects were combined cycle projects using recycled water and wet cooling. Mr. Moen noted that under the best normal operating circumstances, these three ZLD systems were a challenge to operate. Mr. Moen indicated that a ZLD system requires a very steep learning curve (up to a year from system commissioning) to proficiently operate the system and that any changes in water quality or temperature could result in upset conditions. Mr. Moen also indicated that starting up a ZLD system is never routine but detailed operating procedures can make the process more manageable.

Mr. Moen indicated that the CGS and WEC ZLD systems require a fulltime staff including 4 operators, a mechanic (50 to 75% workload), an instrumentation/control technician (50 to 75% workload), and a fulltime manager/chemist.

Overall, Mr. Moen indicated that a ZLD system should be a technology choice of last resort for wastewater disposal and that ZLD technology is 80 percent science and 20 percent magic.

CH2MHILL® TELEPHONE CONVERSATION RECORD

Call To: George Davies/Turlock Irrigation District Combustion Turbine Department Manager

Phone No.: (209) 883-3451 **Date:** 1/13/2016

Call From: Jerry Salamy/CH2M HILL **Time:** 10:00 am

Subject: Experience with Zero Liquid Discharge Systems

Notes:

CH2M HILL spoke with George Davies, Combustion Turbine Department Manager with Turlock Irrigation District (TID). Mr. Davies indicated that the Walnut Energy Center (WEC), which TID operates on behalf of the Walnut Energy Center Authority, is a wet-cooled combined cycle power plant that uses recycled water and a zero liquid discharge (ZLD) system to recover and re-use the Cooling Tower wastewater. The WEC ZLD system commenced operation in 2006. Initial performance of the ZLD system was poor, despite the system being designed and built to the state of the art technologies available at that time. Since commissioning, TID has invested countless man-hours, consultant hours, and Capital funds to achieve satisfactory operation of the ZLD system. While these efforts have improved the ZLD performance, the system continues to be a challenge for TID and the outside contractor tasked with ZLD operations. Mr. Davies stated that the operation costs are approximately $2 million per year for labor, $0.5 million for chemicals/consumables, with a parasitic load of 1.5 megawatts. Mr. Davies also indicated that the ZLD system does produce a solid filter cake which is disposed of in a Class II landfill, at a current average cost of $90/ton. The WEC operates approximately 8000 hours per year and Mr. Davies indicated the ZLD system takes approximately a week to restart and stabilize after a maintenance outage.

Mr. Davies provided several articles and presentations (attached) and included a presentation from Dan Sampson, a noted expert on ZLD systems. Mr. Davies also discussed that some power plant operators have scrapped their project's ZLD system after years of not being able to get the system to function satisfactorily.

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Water Management

Recycling, reuse define future plant designs

**Plant water management has never been more important—especially in the U.S. Southwest, where water supplies are dwindling even as po|
region are required to manage water as plants elsewhere manage fuel—by making every gallon count. The Redhawk Power Station uses te|
wastes with a zero liquid discharge system. Ten lessons learned, based on four years of experience, should be required reading for anyone**

By Mark Yarbrough, Arizona Public Service

The Valley of the Sun went off the water wagon on March 4, ending a record 136 consecutive days without measurable rainfall. Tha
day, only left residents yearning for more. But Mother Nature was only teasing, because the rest of March remained dry. On March
“extreme” due to nonexistent snow packs and one of the driest winters on record.

As the drought enters its 11th year, there are two pieces of good news. One is that the Colorado River, which supplies about one-t
flows. The other is that local reservoirs, which hit 30-year lows early in 2005, are on the mend. But the bad news is that water sup

Demographers tell us that Arizona was the second-fastest-growing U.S. state (Nevada was No. 1) in the 1990s. Today, it has just u
1980. The Arizona Department of Commerce predicts that the extraordinary growth will continue as the baby boom generation reti
2030.

This rapid growth will increasingly strain Arizona’s water management and power generation infrastructures, which are already quit
cranked up to “max cool” on a 110-degree-plus day, the city’s residents and businesses use more electricity than Manhattan. For th
will need another 5,000 MW of generating capacity over the next decade. A reliable source of power and water capable of keeping
thing separating the state’s desert dwellers from a future of hot, thirsty summers (Figure 1).

1. Too many people. Growing baseload and peak electricity demand in the U.S. Southwest through 2008 will be met by expanding gas-fired generating capacity. Source: Salt River Proje

1. Too many people. Growing baseload and peak electricity demand in the U.S. Southwest through 2008 will be met by expanding gas-fired generating capacity. Source: Salt River Project

Terrific template

Generating lots of megawatt-hours without consuming lots of water is a difficult trick to pull off, but the Redhawk Power Station (Fi
miles south of the Palo Verde Nuclear Generating Station, about 60 miles west of Phoenix.

2. Desert dweller. The Redhawk Power Station is 4 miles south of the Palo Verde Nuclear Generating Station, about 60 miles west of Phoenix. Source: POWER magazine

2. Desert dweller. The Redhawk Power Station is 4 miles south of the Palo Verde Nuclear Generating Station, about 60 miles west of Phoenix. Source: POWER magazine

The combined-cycle plant, which went commercial in 2002, has twin 530-MW power blocks. Each block consists of two General Ele
and a single 200-MW steam turbine from Alstom Power. Redhawk’s two heat-recovery steam generators (HRSGs), supplied by NEM
duct burners so they can supply an additional 15 MW apiece when peaking power is needed during summer days. A selective catal
ammonia injection, keeps NOx emissions under the permitted limit of 3.0 ppm. All in all, Redhawk is a very well designed and solid
factor during 2005.

Although Redhawk’s configuration is fairly standard, its water management systems—which reuse nearly 1 billion gallons of reclaim
water for all plant needs appreciably reduces the strain on already burdened local aquifers. In fact, Redhawk’s zero liquid discharg
plant. Plant designs like Redhawk’s that generate clean, low-cost electricity within local environmental constraints set the bar high f

More precious than power

The raw water makeup for the Redhawk plant begins its journey from the greater Phoenix area at the 91st Avenue Wastewater Tre
treated effluent from these cities undergoes secondary treatment. The makeup water is propelled by gravity for the first 28 miles o
reaching the Palo Verde Water Reclamation Facility (PVWRF), the wastewater is treated a third time and put into a 760-million-gall
Redhawk uses as plant makeup water.

From the PVWRF reservoir, a 4-mile-long, 36-inch-diameter pipeline brings the makeup water to Redhawk and dumps it into a 163-
The average conductivity of the makeup water in the Redhawk holding pond (Figure 3) is typically 1,400 to 1,800 microsiemens (m
source from the Water Reclamation Facility, Redhawk also has a water clarification system on standby, ready to be activated shoul
system has only been used during commissioning, and never during normal operation. Figure 4 is a complete flow diagram of Redh

3. Triple-treated. Makeup water pumped from the nearby Palo Verde Water Reclamation Facility is stored in a 163-million-gallon holding pond. Standby water clarification treatment equi

3. Triple-treated. Makeup water pumped from the nearby Palo Verde Water Reclamation Facility is stored in a 163-million-gallon holding pond. Standby water clarification treat
POWER magazine

4. Balancing act. The sources and uses of water at Redhawk power station. Source: Arizona Public Service

4. Balancing act. The sources and uses of water at Redhawk power station. Source: Arizona Public Service

Makeup water from the holding pond is the feedstock for the plant’s two cooling towers (one per power block) and single boiler wa
process begins with the pumping of 2,240 gpm to each nine-cell cooling tower (Figure 5). The water sent to the towers typically ha
its chemistry can cycle up to a maximum TDS of 20,000 mg/l. Cooling tower pH is maintained in the range of 6.9 to 7.5 by the inje

dose of 10 to 20 ppm. Enough defoaming agent also is injected to eliminate visible foam in the sump. A continuous free chlorine re

5. Dedicated cooling. Each power block at Redhawk is served by a nine-cell cooling tower. All plant waste drains come back to the tower sumps. A slipstream from the sumps goes to the

5. Dedicated cooling. Each power block at Redhawk is served by a nine-cell cooling tower. All plant waste drains come back to the tower sumps. A slipstream from the sumps
POWER magazine

The remaining 520 gpm from the original 5,000 gpm feed from the makeup pond is sent to a 60,000-gallon reverse osmosis (RO) f upstream of the boiler water treatment system.

No organics allowed

A key innovation in the Redhawk plant's water balance design is the routing of virtually all plant drains and liquid waste streams (in cooling tower sumps. One of the challenges of such a design is anticipating potential microbiological growth in these water lines. Fo such as the backwash from the multimedia filter (MMF)—must be carefully managed. Redhawk eliminates any potential problems ir MMF to maintain the concentration of free chlorine residual at 0.4 to 0.8 ppm. Downstream of the filter, sodium bisulfite is injected biocide and an antiscalant (Figure 6). Chlorine can destroy the thin-film RO membranes over time if it is not removed from the wate

6. Keeping bugs at bay. Several chemicals are added to the makeup water upstream and downstream of the multimedia filter to maintain residual chlorine levels. Source: POWER maga:

6. Keeping bugs at bay. Several chemicals are added to the makeup water upstream and downstream of the multimedia filter to maintain residual chlorine levels. Source: POW
magazine

The makeup water—now with a conductivity in the 1,400 to 1,800 μS/cm range—then enters the first of two passes of a three-trair recovery, 125 gpm of reject water (at 3,700 μS/cm) is sent to the cooling tower sump while 390 gpm goes to the break tank. The s product water (with a conductivity of 1 to 4 μS/cm) to the 60,000-gallon demineralizer feed tank. The remaining flow of 39 gpm of feed pump for reprocessing.

7. RO your boat. Two stages of reverse osmosis, with three trains per stage, follow the multimedia filter. Source: POWER magazine

7. RO your boat. Two stages of reverse osmosis, with three trains per stage, follow the multimedia filter. Source: POWER
magazine

RO-quality water is also stored in the service water tank for evaporative cooling of Redhawk's gas turbines at a rate of 50 gpm eacl the MMF.

Plenty of instruments

Boiler-quality water is derived from the RO unit's effluent by a set of six parallel (and portable) mixed bed demineralizer trains. Eacl "primary" and the second called the "polisher"), which means that 12 bottles can be in use at any particular time (Figure 8). Anothe water from the trains is stored in a 1-million-gallon demineralizer storage tank that serves as the source of boiler water makeup.

8. Don't drink this water. Portable demineralizer bottles are used to produce boiler-quality water. Source: POWER magazine

8. Don't drink this water. Portable demineralizer bottles are used to produce boiler-quality water. Source: POWER
magazine

A number of design features protect against resistivity breakthroughs that could contaminate the contents of the demin water stora each primary bottle, between each primary and polisher bottle, and at the exit of each polisher bottle of the six parallel trains. The MO/cm (<0.08 μS/cm conductivity). If an alarm sounds for the primary bottle of any train, that train's primary bottle is removed, th primary bottle, and a fresh bottle is moved into the polisher bottle position. This policy both affords excellent protection and stretch system performance.

A resistivity sensor also is installed at the trains' outlet manifold, alongside a silica sensor with an alarm setting of 10 ppb. Downstre demin storage tank's final protective element. All of the tank's instruments and HRSG boiler water-quality analyzers (Figure 9) are c

9. Panel of experts. All the conductivity and silica monitors in the reverse osmosis and demineralizer systems come to a single monitoring station. Also on the panel are the boiler water-c

9. Panel of experts. All the conductivity and silica monitors in the reverse osmosis and demineralizer systems come to a single monitoring station. Also on the panel are the boi
POWER magazine

Waste not, want not

Redhawk's water management systems are designed so that all boiler water makeup waste streams ultimately end up in the cooling designers then had to tackle another tough problem: designing slipstreams to remove buildups of soluble and insoluble compounds permit-limited cycles (about 20) of the compounds' concentration in the cooling towers.

The ZLD system uses a brine evaporation system (BES) to concentrate the soluble compounds in the blowdown stream until they p concentrated in a brine crystallizer system (BCS) where precipitated material is removed by a centrifuge and trucked from the plant that it allows reuse of the evaporated and condensed water by the plant.

Evaporate, wash, recycle, repeat

10. Precipitation likely. The brine evaporation system concentrates soluble compounds in cooling tower blowdown, producing a distillate stream that can be reused in the plant. Source: F

10. Precipitation likely. The brine evaporation system concentrates soluble compounds in cooling tower blowdown, producing a distillate stream that can be reused in the plant
POWER magazine

11. Spin, then dry. The brine evaporation system's flow diagram. Source: Arizona Public Service

11. Spin, then dry. The brine evaporation system's flow diagram. Source: Arizona Public Service

The blowdown entering the BES (Figures 10 and 11) has some alkalinity that must be removed to prevent calcium carbonate fouling step process entailing:

- Acidification. Metering sulfuric acid into the feed stream converts the carbonate and bicarbonate ions to CO2, which the deaerator can strip away.
- Preheating. This step kills two birds with one stone. It recovers heat from the outgoing process distillate steam and increases the concentration of dissolved CO2, makir
- Deaeration. Unvented CO2, if allowed to accumulate in the shell of the BES, can reduce some heat exchange surface and adversely affect the system's performance. U barely detectable.

The output of the BES carries 3.5% to 5.0% by weight of precipitated solids when the system is operating on spec. After most of th by a hydrocyclone (shown at the bottom right of Figure 13), some of the concentrated brine stream is sent to the seed recycle tank

In the hydrocyclone, TDS and TSS (total suspended solids) are separated using centrifugal force to remove suspended solids from t hydrocyclone and goes to the seed recycle tank. The seed recycle tank is used to pump the TSS back to the BES for reuse. The TDS feed tank (CFT), which is described later.

Evaporated water vapor in the BES is washed of any entrained brine droplets before entering a compressor, where the vapor pressu evaporator's heater shell. This desuperheating reduces scaling of heat transfer surfaces and improves the overall heat transfer coef surfaces.

Because the total mass flow of vapor returned from the compressor will be greater than that required by the evaporator, the excess Most of the vapor is condensed on the shell side of the heating element, discharged as distillate, and recycled to the cooling tower

Concentration of the brine feed in the evaporator precipitates calcium sulfate, which can cause scaling. However, although the rate slurry recirculation rate inside the evaporator, additional control is required to protect vessel and heat transfer surfaces.

The larger purpose of the seed recycle tank is to keep enough finely divided calcium sulfate in suspension to minimize scaling. In pr several orders of magnitude greater than the total surface area of the evaporator. The natural tendency of calcium sulfate to precip transfer surfaces. The initial feed is commercial gypsum or a hydrated form of calcium sulfate. The recycle of the seed increases gr active

Solid performer

The crystallizer vapor body (CVB) uses a recirculation pump to send the concentrated slurry through the heater, which uses steam t entering the CVB from the heater flash-boils and releases its heat as water vapor.

The vapor leaving the crystallizer is first cleaned by a chevron-type separator and then compressed by the crystallizer blower so it c evaporation in the CVB.

12. Liquid to solids. The brine crystallization system produces a waste product that can be landfilled. Source: POWER magazine

12. Liquid to solids. The brine crystallization system produces a waste product that can be landfilled. Source: POWER magazine

13. Condense, flash-boil, spin. Note in this flow diagram of the brine crystallization system how the compressor reuses heat that otherwise would be wasted. Source: Arizona Public Serv

13. Condense, flash-boil, spin. Note in this flow diagram of the brine crystallization system how the compressor reuses heat that otherwise would be wasted. Source: Arizona Public Service

The CFT feeds the CVB, where crystallization of the waste stream actually takes place (Figures 12 and 13). As the TSS in the syster centrate is separated from the remaining solids (which range in wetness from moist to sand-like, depending on the season), which centrate is returned to the CFT.

14. Have your cake. Solid wastes range in moisture content from wet to extremely dry, depending on the season. Source: POWER magazine

14. Have your cake. Solid wastes range in moisture content from wet to extremely dry, depending on the season. Source: POWER magazine

Theory to practice

Redhawk operators have been working for almost four years to perfect operation of the ZLD system. Along the way, there have bee works very well today, but getting to know the peculiarities of the system has taken some time. You can't go to college and get a d of hard knocks.

The Redhawk staff has had much success operating a ZLD system and has elected to share their collective experiences with the inc prescriptive pointers that will either help you operate your existing system more efficiently or make the selection of a system for yo

1. Include the vapor washer option. A large number of brine concentrators have mesh pads inside the structure just above the sum In addition, particulates can sometimes make it past the mesh pads and cause scaling problems on the evaporator fan blades. At R concentrator passes through the vapor washer (VW) on its way to the evaporator fan. This provides added fan protection.

Redhawk's VW is a co-current scrubber design (shown on the right of Figure 10). Water from the VW sump is sprayed into the inco droplets combine with the smaller entrained droplets, even larger, coalesced droplets form. As the vapor leaves the VW downcomer the vapor steam and fall to the sump area of the VW. The cleansed vapor then flows through a layer of mesh (which removes almo washer, and heads over to the suction of the evaporator fan/compressor. Access to the mesh pads for cleaning in a stand-alone ve with self-contained mesh pads.

2. Consider evaporator maintenance. In Redhawk's falling-film evaporator, two distribution plates sitting above 40-foot-long titaniur mechanical cleaning of the evaporator, these plates are unbolted and set aside to allow access for hydroblasting the tubes. In some holes distribute the brine down the tubes.

Our experience with the double distribution plate design is that it takes more effort to get to the tubes because the heavy plates mu plate design appears to be less prone to plugging with our type of water than the distributor cap design.

At another of our Arizona plants equipped with an evaporator with the distributor cap design we found a buildup of scale between t
instances of through-wall pitting and/or corrosion of the tubes in these locations.

3. Upgrade your crystallizer blower instrumentation. Almost all crystallizer systems have a propensity for foaming due to the nature
The original design of Redhawk's crystallizer blower included local pressure switches on the suction and discharge sides of the vess
pick up small pressure changes, foaming occurred after large load swings. In the end, Redhawk replaced the original pressure swit
them into the plant's distributed control system (DCS).

The upgrade enabled the protective trips on the blower to be set to respond to a foam carryover from the crystallizer vapor body. T
two reasons: because small operating pressure swings occur routinely and because the original setpoint could allow a swing into th
into the blower. Prior to the upgrade, the blower had to be removed from service and rebuilt several times during the first 18 mont
Finally, the liquor level in the crystallizer vapor body was lowered from 50% to 10%, lowering the foam level below the site glass a

4. Optimize centrifuge performance. The original plant design called for a centrifugal feed pump to control flow from the crystallizer
designs were tried, but all failed due to the challenging operating environment caused by the boiling crystallizer liquor/salt slurry. T
and use a combination of crystallizer pressure and gravity to feed the crystallizer slurry to the centrifuge.

This solved the centrifuge feed problem but did not offer a method for metering the flow rate. The Redhawk centrifuge is rated for
several occasions due to overfeed flowed by plugging. Plugging causes backup of the slurry, which eventually will find a path acros
the process. The solution: a flow meter and control valve was placed in the feed line upstream of the centrifuge and an automated
the centrifuge clean.

5. Test your solids. Redhawk's operators perform an ASV (apparent settled volume) test twice per shift. In this test, a sample from
graduated cylinders. After the samples are allowed to settle for 30 minutes, the ASV is determined by observing the change in volu
evaporator there is one salt level. If the settled volume were at 100 ml, then the ASV would be reported as 100/1,000 (10%) or 10

By experience, the ASV of the evaporator now is maintained in the 5 to 18 range. It is important not to go below 5 to maintain eno
tubes. If the ASV is greater than 18, the evaporator recirculation pump draws too much current, causing an alarm.

ASV is measured at two levels in the crystallizer. The heavier material found at the lower level is called "the salt" or "unders." The f
example, if the fines were at the 800-ml mark and the salt were at the 100-ml mark, the operator would report the crystallizer ASV
evaporator and crystallizer systems twice per shift. The evaporator TDS is maintained below 170,000 mg/l, and the crystallizer is m
these limits to avoid exceeding the boiling point rise for each system.

6. You may require a crystallizer purge stream. During the first year of ZLD system operation, the crystallizer system had to be shut
maintained. The reason was a mystery for some time. Optimizing centrifuge performance (see tip #4) and making the unit more re
more it ran the easier it was to stay ahead of solids buildup in the evaporator and crystallizer systems. Optimizing centrifuge perfor
problem.

One important point learned by the Redhawk plant staff while troubleshooting the system was that "the fines" level of the ASV coul
remove one type of particle-size range of solids. In our case, the centrifuge favors removal of salts but allows the fines to pass thro
crystallizer feed tank. The fines then re-enter the crystallizer vapor body and continue in this loop until they build to an "uppers" AS
plant design.

At one point, a cation polymer was used to help remove the fines. But the problem remained because periodic shutdowns followed
the system for several months and concluded that a small portion of the black liquor could not be processed in the ZLD system. He
from the system would be required to maintain the system solids-liquid balance. A purge line on the centrate return to the crystalliz
contained in the purge (Figure 11). When the dissolved-solids level in the crystallizer and/or the foaming in the vapor body get too
system.

7. Plan for ZLD maintenance. Outage planning for the ZLD system has to be taken just as seriously as outage planning for the pow
even months. Spare critical parts should be purchased and stored on-site. At Redhawk, a spare crystallizer blower, centrifuge, and

Redhawk plans for spring and fall outages so evaporator tubes, vapor washer mesh pads, and crystallizer heater tubes can be clea
Teflon crystallizer mesh pads are replaced rather than cleaned. The plant has learned that by performing two mechanical cleanings
longer. Mechanical cleaning can be done for $15,000 to $25,000 per outage, whereas a single chemical cleanings may cost upward
waste cleaning solution and how that waste has to be processed.

8. Expect water quality changes by season. The constituents of makeup water change during the year, and Redhawk's experience
system are different in summer and winter. For example, total organic carbon can be much higher during summer months due to a
organic carbon levels appear to put more demand on the ZLD system. Finally, nitrates also vary seasonally and can increase the bo

9. Consider adding a brine concentrator surge pond. Redhawk has a 28-acre-foot brine concentrator surge pond that provides for a
ZLD system outages. This pond gives the plant more flexibility than other ZLD plants without surge ponds.

10. Add a hydrocyclone on the seed recycle tank. At Redhawk, the evaporator blowdown is fed to a hydrocyclone which was install
or "seed" from the TDS. If the amount of seed material becomes too high (as measured by the ASV test), operators open the hydr
the crystallizer feed tank. Like the brine concentrator surge pond, the hydrocyclone gives Redhawk added flexibility, in this case, in

—Mark Yarbrough is the senior chemical control specialist for Redhawk Power Station. He can be reached at 602-407-7805 or mark.yarbrough@aps.com.

The Modesto Bee
modbee.com

Print This Article

Posted on Mon, May. 13, 2013

Modesto Irrigation District mulls sale of useless equipment

By Garth Stapleygstapley@modbee.com

last updated: May 14, 2013 12:45:36 AM

MODESTO --]

Modesto Irrigation District leaders this morning will discuss making the best of a bad business deal that cost ratepayers more than $2 million.

TRACY BARBUTES / tbarbutes@modbee.com The Modesto Irrigation District offices in downtown Modesto, Calif., on October 10, 2011. - Modesto Bee - Tracy Barbutes

Unloading useless 7-year-old power plant equipment for 13 cents on the dollar seems smarter than junking it for even less, says a report about a water treatment system that hasn't seen action in nearly two years.

The district paid $2.4 million for the equipment, which purified water for its $76.5 million "peaking" plant that opened in Ripon in 2006. The plant operates only to supplement electricity needs, usually during high-demand summer periods when people run air conditioners, about 600 hours per year.

Problems with the equipment and a new state water discharge law prompted the plant to change its water treatment process in June 2011. Aquatech International Corp., which manufactured the $2.4 million idled equipment, has offered $320,000 to buy it back.

That's better than scrapping it, which would fetch $50,000 at most, the report says.

"It is in MID's best interest to sell off the Aquatech equipment now, while it still has a reasonable salvage value," the document says.

Also today, the MID board will:

• Review an audit of the district's finances that turned up no major concerns

• Hear an update on plans for equipment to broadcast meetings, including video cameras and monitors. The district received bids from two unidentified companies for $205,000 and $230,000.

• Consider formal recognition of a new union representing mostly managers, to be called the Modesto Irrigation District Employees Association. Previously, those workers received labor terms bargained by three unions representing other employees.

The MID board is scheduled to meet at 9 a.m. today at the district office, 1231 11th St., Modesto. See the board's agenda at www.mid.org/about/board/agenda.

Bee staff writer Garth Stapley can be reached at gstapley@modbee.com or (209) 578-2390.
