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Date: 5/14/05 10:12AM
Subject: Church Rock Evaporation Pond Water Balance

Here is the technical memorandum with attachments that was promised in our May 5th meeting.

<<Tech Memo.doc>> <<Attachment A-Evap Pond Plans.pdf>> <<attachment B-Water level MMTS.pdf>>

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TECHNICAL MEMORANDUM

To:	Larry Bush, UNC
cc:	Mark Purcell, USEPA
	William von Till, NRC
Subject:	Evaporation Pond Water Balance, Church Rock Site, New Mexico
Date:	13 May 2005

During the February 2004 project meeting, UNC proposed to perform a water balance on the two evaporation ponds as a means to check the integrity of the liners. Concerns were expressed that there could be a continuing source of tailings seepage to the Southwest Alluvium if water leaked through the liners and through the tailings impoundment.

For a two month period, from March 10 through May 11, 2004, UNC collected daily water level measurements and precipitation quantity. There were no inflows to the ponds during this period other than through precipitation. Similarly, there were no outflows from the ponds other than what would occur via evaporation or leakage. Thus, any change in pond water levels (i.e. storage) that could not be accounted for by precipitation and evaporation must be attributable to leakage, by the equation:

$$\Delta S = P - ET - L$$

or

$$L = P - ET - \Delta S$$

where L=leakage, ΔS=change in pond storage, P=precipitation, and ET=evapotranspiration.

The closest long-term evaporation data is from a station in Farmington, New Mexico. Farmington represents a good location because, like church Rock, it lies within the San Juan Basin physiographic province of northwestern New Mexico at similar elevation, and data are available over a long period from 1914-1978. Average monthly pan evaporation for March, April and May is 3.83 inches, 6.88 inches, and 8.49 inches, respectively (www.wrcc.dri.edu/htmlfiles/westevap.final.html). It is necessary to convert pan evaporation to lake evaporation, and this term was conservatively taken as 0.96, 0.86, and 0.76 for the respective three months (New Mexico Climate Center, http://weather-mirror.nmsu.edu/hydrology/ratiopaneto.htm). The pan- to lake-evaporation correction factors were conservative in the sense that values were chosen that would tend to underestimate actual pond evaporation, which would then tend to bias the water balance toward a conclusion that more leakage takes place than actually does. The average monthly evaporation trend is plotted in Figure 1 as an orange line.

Water level data from the North and South ponds, corrected to subtract precipitation additions are also plotted on Figure 1 with corresponding polynomial trend lines included. With respect to the water balance equation the water level trends plotted in Figure 1 represent the term, $\Delta S - P$. The raw precipitation and pond water level data are contained in Attachment A. The catchment area for each pond is different than the water surface area (Attachment A); and therefore, it was necessary to apply correction factors to account for the difference (so that measurements units could remain one-dimensional, as feet, rather than volumetric). For the North pond, rainfall measurements were multiplied by 1.29, and for the South pond by 1.91. The factor is larger for the South pond because of structural differences between the construction of the two basins shown in the Attachment A as-builts, and because of the presence of windlblown sediment that has accumulated in the eastern third of the South pond. The correction factors for the catchment area to water surface area erred on the side of overestimating precipitation inflows, which would then tend to bias the water balance toward a conclusion that more leakage takes place than actually does.

There were storm events during the first two weeks of April that counteracted the evaporative process. The pond water level losses level-off during this period; and in fact, between April 4th and 5th, the precipitation-corrected water levels rose in the North pond by almost a tenth of a foot and by a few hundredths of a foot in the South pond. If the precipitation influence were perfectly characterized then there would not be an increase in water level such as is exhibited between April 4th and 5th. The trend lines smooth out the imprecision, and are perhaps a better representation of average tendencies taking place over the two-month period.

Comparisons between long-term , average evaporation and the water level declines observed in the ponds from Figure 1 lead to a conclusion that leakage from either pond, if occurring at all, is quantitatively insignificant. Observed decreases in pond water levels after subtracting precipitation ($\Delta S - P$) are matched closely by the decrease that would be accounted for by evaporation alone (-ET). The North pond almost exactly overlaps the average long-term condition, and the South pond water level has not decreased quite as much as evaporation alone would have predicted it would, despite the conservatism used in the analysis. Thus, there is no indication that leakage would be needed to explain the pond water levels. It is recognized that this analysis has not perfectly incorporated the precipitation influence that took place in early April, and also that comparisons are being made to a long-term, average condition that are not perfectly represented by conditions in 2004. Nonetheless, the slopes of the water level declines in each pond are nearly identical to long-term average evaporation during the second month of data collection when precipitation influences were minimal. More importantly, the slopes are essentially identical between the two ponds. It would be a remarkable coincidence if both ponds had ruptures in their liners that would have led to identical rates of leakage, which also just happened to coincide with long-term, average evaporation rates. With the inflows and outflows adequately accounted for, all water balance evidence points to a conclusion that the ponds are not leaking.

Evaporation Pond and Weather Station Readings

Date/Time:	NORTH POND Water Level Elevation:	Diff. From Prev. Elev.:	SOUTH POND Water Level Elevation:	Diff. From Prev. Elev.:	WEATHER STATION Present Temp.°F:	Prevs. Hi. Temp.°F:	Prevs. Lo. Temp.°F:	Rain Guage ":	C
3-9-04 / 1400	6958.76		6949.37		70	70	18	.26	RAINED OVERCAS
3-10-04 / 1530	6958.76	0	6949.37	0	70	70	30	0	
3-11-04 / 1135	6958.75	-.01	6949.36	-.01	62	66	34	0	
3-12-04 / 1142	6958.75	0	6949.36	0	52	67	30	.12	
3-15-04 / 1137	6958.72	-.03	6949.33	-.03	53	68	35	0	MEDIUM
3-16-04 / 1132	6958.70	-.02	6949.33	0	58	62	22	0	MILD B SUNNY
3-17-04 / 1318	6958.69	-.01	6949.31	-.02	64	67	22	0	MODERA CLEAR &
3-18-04 / 1125	6958.68	-.01	6949.31	0	64	67	22	0	MODERA CLEAR &
3-19-04 / 1135	6958.65	-.03	6949.29	-.02	68	70	27	0	MEDIUM & SUNNY.
3-22-04 / 1441	6958.58	-.07	6949.23	-.06	72	80	30	0	MODERAT OVER CA
3-23-04 / 1532	6958.58	0	6949.22	-.01	61	75	38	0	MODERAT OVERCAS
3-24-04 / 1330	6958.56	-.02	6949.21	-.01	62	65	35	0	STRONG CLOUDY, APPROXIMA

NOTE: POND ELEV. READINGS ARE IN TENTH OF A FOOT.

Evaporation Pond and Weather Station Readings

Date/Time:	NORTH POND Water Level Elevation:	NORTH POND Diff. From Prev. Elev.:	SOUTH POND Water Level Elevation:	SOUTH POND Diff. From Prev. Elev.:	WEATHER STATION Present Temp.°F:	Prevs. Hi. Temp.°F:	Prevs. Lo. Temp.°F:	Rain Guage ":	(
3-25-04 / 1403	6958.55	-.01	6949.20	-.01	69	70	37	0	STRONG WI
									CHOPPY WA
									ELEV. RE
3-26-04 / 1531	6958.52	-.03	6949.19	-.01	64	70	30	0	SAME CON
3-29-04 / 1144	6958.44	-.08	6949.14	-.05	55	64	20	0	MODERATE
									CLEAR/S
3-30-04 / 1420	6958.40	-.04	6949.12	-.02	72	72	20	0	LIGHT BR
3-31-04 / 1139	6958.38	-.02	6949.11	-.01	70	73	20	0	SAME CON
4-1-04 / 1455	6958.36	-.02	6949.10	-.01	50	78	40	.03 (TRACE)	MED. TO SI
									TTENTING
4-2-04 / 1150	6958.36	0	6949.10	0	42	52	42	.06	SAME CON
4-5-04 / 1153	6958.50	.14	6949.19	.09	46	52	34	.36	MODERATE
									CLOUDY &
									WEEK EN
4-6-04 / 1216	6958.50	0	6949.19	0	52	53	36	.03 (TRACE)	MODERATE
									CLOUDY.
4-7-04 / 1454	6958.50	0	6949.19	0	53	60	38	.02 (TRACE)	CALM &
4-8-04 / 1133	6958.50	0	6949.19	0	52	61	38	.12	MODERATE
4-12-04 / 1309	6958.56	.06	6949.25	.06	48	52	28	.42	STRONG WI
									CHOPPY WAT
									ELEV. REA

Evaporation Pond and Weather Station Readings

Date/Time:	NORTH POND Water Level Elevation:	NORTH POND Diff. From Prev. Elev.:	SOUTH POND Water Level Elevation:	SOUTH POND Diff. From Prev. Elev.:	WEATHER STATION Present Temp.°F:	Prevs. Hi. Temp.°F:	Prevs. Lo. Temp.°F:	Rain Guage ":	
4-13-04 / 1239	6958.57	.01	6949.26	.01	60	60	26	.02 (TRACE)	LIGHT BI
4-14-04 / 1404	6958.55	-.02	6949.20	-.06	63	68	32	0	STRONG
									CHOPPY
									ELEV. R
4-15-04 / 1309	6958.53	-.02	6949.19	-.01	60	65	33	0	STRONG
									CHOPPY
									ELEV. R
4-16-04 / 1157	6958.50	-.03	6949.19	0	62	67	27	0	MODERA
									CLOUDY.
4-19-04 / 1355	6958.40	-.10	6949.11	-.08	61	64	24	0	STRONG
									WATER
									ELEV.
4-20-04 / 0830	6958.37	-.03	6949.11	0	61	67	23	0	MODERAT
4-21-04 / 0850	6958.35	-.02	6949.10	-.01	48	61	26	0	MODERAT
4-22-04 / 0847	6958.31	-.04	6949.06	-.04	52	60	39	0	STRONG
									CHOPPY W.
									ELEV. R
4-23-04 / 0934	6958.28	-.03	6949.04	-.02	45	57	27	0	MEDIUM
4-26-04 / 0852	6958.26	-.02	6949.02	-.02	63	70	25	.01 (TRACE)	CALM & CL
4-27-04 / 1140	6958.24	-.02	6949.01	-.01	68	70	28	0	MEDIUM
4-28-04 / 0942	6958.23	-.01	6949.00	-.01	60	76	35	0	STRONG
									CHOPPY WA
									ELEV. RE

Evaporation Pond and Weather Station Readings

Date/Time:	NORTH POND Water Level Elevation:	Diff. From Prev. Elev.:	SOUTH POND Water Level Elevation:	Diff. From Prev. Elev.:	WEATHER STATION Present Temp.°F:	Prevs. Hi. Temp.°F:	Prevs. Lo. Temp.°F:	Rain Guage ":	
4-29-04/0850	6958.18	-.05	6948.97	-.03	56	70	47	0	STRONG
									CNOPPY
									ELEV. R
4-30-04/1030	6958.18	0	6948.95	-.02	47	60	27	.07	SLIGHT
									RAINED
5-3-04/0942	6958.15	-.03	6948.91	-.04	62	74	24	0	MODERAT
									& SUNN
5-4-04/0905	6958.14	-.01	6948.90	-.01	65	68	34	0	SLIGHT
									SUNNY.
5-5-04/1022	6958.10	-.04	6948.89	-.01	70	82	43	0	SAME C
5-6-04/0856	6958.09	-.01	6948.87	-.02	63	83	40	0	CONDITIO
5-7-04/0848	6958.05	-.04	6948.85	-.02	72	81	34	0	CONDITIO
5-10-04/0947	6958.00	-.05	6948.76	-.09	68	82	38	0	CONDITIO
5-11-04/0926	6957.99	-.01	6948.74	-.02	64	78	54	0	STRONG
									SUNNY