Back to Table of Contents

Appendix E

Salinity Effects on Birds

TECHNICAL MEMORANDUM — CH2MHILL

Salinity Effects on Birds

PREPARED FOR: Randy Schulze/DEN
Tom Haislip/BOI
Lynn Foster/BOI

PREPARED BY: Christine Arenal/SAC
Harry Ohlendorf/SAC

DATE: December 11, 2002

An evaporation pond will be utilized during the normal operation of the Toquop power plant. Because this surface water body will be located within an established flyway in an area with few water sources, it may attract waterfowl, shorebirds, and other waterbirds, thereby creating possible exposures of birds to highly saline water at the power plant.

The estimated water chemistry for the Toquop evaporation pond is outlined in Table 1 and is based on the Toquop Case CT07 water balance. For this case, the only influent to the evaporation pond is brine from the brine concentrator (side-stream softener sludge is disposed of off-site). The brine concentrator takes the pH-adjusted influent (125 gpm) and concentrates it to 15 gpm that flows to the evaporation pond as a solution that is saturated with respect to gypsum (CaSO4.H2O). Further concentration of the evaporation pond influent occurs due to evaporation. It has been assumed that the extent of the evaporation is not to dryness, but rather to a very concentrated brine that is on the verge of precipitating halite (NaCl) at a concentration ratio of approximately 16.8. The water is in equilibrium with solids consisting of gypsum (CaSO4.2H2O), and mirabolite (Na2SO4.10H2O). If further concentration occurs, halite would form next, followed by magnesium chloride hexahydrate.

Salinity is not precisely equivalent to TDS, but for most purposes, they can be considered equal (USEPA 1986, USDI 1998). Therefore, based on the values in Table 1, the total dissolved solids (TDS) estimated for the evaporation pond is approximately 387,000 ppm. Conductivity can be estimated from TDS, with TDS equaling approximately 0.55 to 0.7 times the conductivity (USDI 1998). Using the equation presented in USDI (1998), a conductivity of 567,800 Φmhos/cm can be estimated for the Toquop evaporation pond. However, the equation is specific to conductances between 5,000 and 9,000 Φmhos/cm, and CH2M HILL (2002) found that the relationship between TDS and conductivity at Owens Lake, California was non-linear above TDS concentrations of 125,000 ppm. Moreover, TDS began to exceed conductivity in the Owens Lake study at TDS values greater than 100,000 ppm. Using this relationship, the estimated conductivity in the Toquop evaporation pond is about 170,000 Φmhos/cm at a TDS of approximately 387,000 ppm. Both estimates are for standard temperature (25° C). As temperature decreases, conductivity also decreases, reaching about half its value at 25° C by 0° C (CH2M HILL 2002). Therefore, the conductivity could drop to lows of 85,000 to 283,900 Φmhos/cm (using the two values estimated above) just prior to freezing.

The ions in the pond water (e.g., Na+, K+, Cl-, and SO_4-) are generally non-toxic and are not considered problematic to wildlife at normal environmental levels. However, the estimated TDS and sodium levels for the evaporation pond may pose risk to birds. Table 2 lists biological effects observed at various salinity concentrations. For sodium, levels as low as 821 ppm reduced growth in 1-day-old mallard ducklings exposed for 28 days (Mitcham and Wobeser 1988a). Mallard ducklings that drank water with 3,000 ppm of sodium had reduced thymus size and bone strength (Mitcham and Wobeser 1988b). No apparent effects were observed at concentrations up to 911 ppm in 14-day mallard duckling exposures, while concentrations between 8,800 and 12,000 ppm caused 100 percent mortality (Mitcham and Wobeser 1988a). In adult waterfowl, sodium concentrations of 17,000 ppm of sodium caused a die-off in North Dakota when fresh water was unavailable (Windingstad et al. 1987). Fry (2002) investigated waterfowl deaths near process ponds on Searles dry lake bed in California. Although brain sodium levels were high and sodium concentrations in pond waters averaged 89,567 ppm, the author could not rule out dehydration from lack of a freshwater source as the cause of the increased tissue levels of sodium.

Sodium toxicosis was also observed in ruddy ducks utilizing ponds located in an agricultural evaporation basin in California (Gordus et al. 2002). Sodium levels in the two ponds were 16,000 and 39,000 ppm, and associated electroconductivity values in the two ponds were 51,000 and 100,000 Φmhos/cm, respectively. These high levels of conductivity coupled with low ambient temperatures (<4° C) resulted in salt encrustation on the feathers of the ducks and reduced their ability to fly to freshwater sources. Salt encrustation on waterfowl feathers and mortality were also observed by Wobeser and Howard (1987) in a hypersaline wetland with high conductivity (77,000 Φmhos/cm) during periods of low temperature (3° C). Fry (2002) also reported encrustation of salt on waterfowl carcasses found near hypersaline processing ponds. Salt encrustation on the feathers of waterfowl or other waterbirds resulted in the inability of the birds to fly, which sometimes resulted in their death (possibly by drowning).

Concentrations of sodium (147,963 ppm) expected in the Toquop evaporation pond far exceed those associated with adverse effects in waterfowl; therefore, risk of mortality in waterfowl utilizing the pond is likely. Additionally, salt encrustation reportedly occurs when temperatures drop below 4° C and conductivity is at least 70,000 Φmhos/cm (Gordus et al. 2002). Even the lowest conductivity estimate (85,000 Φmhos/cm) exceeds this threshold. Therefore, salt encrustation of feathers, and ultimately death of birds, is likely to occur if birds use the evaporation pond.

We recommend that the evaporation pond should be monitored for waterbird use and possible effects on birds (i.e., salt encrustation or sick birds). This would be most important during spring and fall migration periods as well as during periods of cold weather. If birds are found to use the pond and exhibit salt encrustation on feathers or illness associated with salt exposure, an adaptive management program could be implemented. Covering ponds with netting and aggressive hazing programs were successful in reducing avian mortality around the processing ponds at Searles Lake, California (Fry 2002). Additionally, a brackish water pond was created near the processing ponds to provide a source of suitable drinking water. Gordus et al. (2002) also suggest aggressive hazing programs along with dilution of the ponds by adding low-salinity or freshwater to decrease salinity and addition of a brackish or freshwater wetland. Thus, hazing, providing alternative water sources, and netting of the evaporation pond could mitigate the effects of bird exposure to water in the evaporation pond. To facilitate netting of the ponds (in the event of unacceptable levels of bird mortality), we recommend that during final design of the pond, consideration be given to configuring the pond in such a way that it could be covered with netting in the future if it is needed to preclude bird use.

TABLE 1
Water Chemistry for the Toquop Power Plant Evaporation Pond Liquid at 16.8x Concentration Ratio

Constituent	Measurement
Total Alkalinity, ppm CaCO3	0
pH	7.0
Silica	150
Calcium, ppm Ca	330
Magnesium, ppm Mg	3,091
Potassium, ppm K	13,692
Sodium, ppm Na	147,963
Chloride, ppm Cl	220,000
Nitrate, ppm NO3	10,466
Sulfate, ppm SO4	1,975

TABLE 2
Salinity Toxicity Data (from Table 30 in USDI 1998)

Species	Salinity Concentration in Water (ppm)	Effects/Comments	Reference
Mallard	~ 11,000	Reduced growth	Swanson et al. 1984
	8,800 – 12,000 (as sodium)	100 percent mortality	Mitcham and Wobeser 1988a
	9,000 – 12, 000	No Effect	Nystrom and Pehrsson 1988
	10,000 – 15,000	Level of concern	Swanson et al. 1984
	15,000	100 percent mortality (7-day old ducklings)	Barnes and Nudds 1991
Mottled Duck	9,000	Threshold level for adverse effects	Moorman et al. 1991
	12,000	Reduced growth, 10% mortality	
	15,000	90% mortality	
	18,000	100% mortality	
Peking Duck	20,000	Level of concern	Nystrom and Pehrsson 1988

References

Barnes, G., and T.D. Nudds. 1991. Salt tolerance in American black ducks, mallards, and their F1 hybrids. *The Auk* 108:89-98.

CH2M HILL. 2002. Brine Properties. Technical Memorandum prepared for the Los Angeles Department of Water and Power. September.

Fry, D.M. 2002. Report on the Mortality of Birds at Searles Dry Lake Bed, and Evaluation of Searles Lake Bed as Avian Habitat. Report for the California Regional Water Quality Control Board. IMC Chemical, Trona, CA. February 27.

Gordus, A.G., H.L. Shivaprasad, and P.K. Swift. 2002. Salt toxicosis in ruddy ducks that winter on an agricultural evaporation basin in California. *Jo*urnal of *Wildlife Diseases* 38:124-131.

Mitcham, S.A., and G. Wobeser. 1988a. Toxic effects of natural saline waters on mallard ducklings. *Journal of Wildlife Disea*ses 24:45-50.

Mitcham, S.A., and G. Wobeser. 1988b. Effects of sodium and magnesium sulfate in drinking water on mallard ducklings. *Journal of Wildlife Diseases* 24:30-44.

Moorman, A.M., T.E. Moorman, G.A. Baldassarre, and D.M. Richard. 1991. Effects of saline water on growth and survival of mottled duck ducklings in Louisiana. *Journal of Wildlife Management* 55:471-476.

Nystrom, K.K.G., and O. Pehrsson. 1988. Salinity as a constraint affecting food and habitat choice of mussel-feeding diving ducks. *Ibis* 130:94-110.

Swanson, G.A., V.A. Adomaitis, F.B. Lee, J.R. Serie, and J.A. Shoesmith. 1984. Limnological conditions influencing duckling use of saline lakes in south-central North Dakota. *Journal of Wildlife Management* 48:340-349.

U.S. Department of the Interior (USDI). 1998. Guidelines for Interpretation of the Biological Effects of Selected Constituents in Biota, Water, and Sediment. National Irrigation Water Quality Program Information Report. No. 3. 198 p.

U.S. Environmental Protection Agency (USEPA). 1986. Quality Criteria for Water 1986. U.S. Environmental Protection Agency, Office of Water Regulations and Standards, Washington, D.C. EPA/440/5-86/001.

Windingstad, R.M., F.X. Kartch, and R.K. Stroud. 1987. Salt toxicosis in waterfowl in North Dakota. *Journal of Wildlife Diseases* 23:443-446.

Wobeser, G., and J. Howard. 1987. Mortality of waterfowl on a hypersaline wetland as a result of salt encrustation. *Journal of Wildlife Diseases* 23:127-134.