Lagoon Seepage and Mass Loading of Pollutants

Calculations for the Borba Dairy, Kern County, California
Prepared for the Protestants of the Borba Dairy
July 20, 2000

The following calculations were performed by Kathy J. Martin, PE of Martin Environmental Services, Norman, Oklahoma at the request of counsel for the Protestants of the Borba Dairy. Ms. Martin has a Master's Degree in Civil Engineering from the University of Oklahoma (1989) and is a licensed professional engineer in Oklahoma for Civil Engineering. Her resume is attached and includes work experience in the field of environmental permitting for industrial wastewater. She drafted the rules and regulations used by the State of Oklahoma since 1990 to regulate surface impoundments and land application as they relate to facilities that generate non-hazardous industrial wastewater. In addition, Ms. Martin has been working on CAFO related issues full-time since 1997 including CAFO permitting processes in Oklahoma, Kansas, Nebraska, Utah, Missouri, Arkansas, Iowa, and Wyoming. She has performed technical and regulatory reviews of permit applications for over 45 different CAFO facilities, including large-scale swine operations, liquid manure dairy systems, and related wastewater treatment systems used by poultry slaughtering facilities in West Virginia (ie., surface impoundments and land application). She is familiar with the federal and state regulations governing CAFOs, as well as the Clean Water Act and Water Quality Standards.

Volume of Seepage from Lagoons:
According to the application, there are 19.5 acres of lagoons per dairy "site". The lagoons are designed to have a seepage rate of 1×10^{-5} cm/sec, which is equivalent to 9236 gal/acre/day seepage:

1×10^{-5} cm/sec (in/2.54 cm)(gal/231 in^3)(3600 sec/hr)(24 hr/day)(144in^2/ft^2)(43560 ft2/acre)

The seepage rate is reported in volume per unit area, which is a rate of flow of wastewater through the saturated liner of the lagoon. According to the September 3, 1999 report to Kern County, Borba intends to construct the lagoons according to NRCS guidelines and will attempt to achieve this seepage rate. There are two types of seepage in lagoons -- vertical seepage along the bottom of the lagoon and a combination of vertical and horizontal seepage at the berms. One method to estimate seepage from a lagoon given minimal design information is to use the surface area at maximum liquid depth as an estimation of both vertical and horizontal seepage. Considering that horizontal seepage is much higher than vertical seepage when using a properly compacted clay liner, this broad method of estimation is conservative in that it can overestimate seepage due to only vertical

paths on the bottom of the lagoon (ie., a smaller surface area of flow). However, when attempting to protect groundwater, it is prudent to overestimate seepage rather than underestimate seepage. The seepage calculation does not include losses due to failure of the lagoon, which will be termed leakage in this report.
This seepage can be compared to the surface area of the lagoons at each site:

9236 gal/acre/day x 19.5 acres x 365 d/yr= 65.7 million gallons per year per facility

65.7 million gallons x 2 facilities = 131.47 million gallons per year

Mass Loading in Seepage
The mass loading of pollutants in the seepage can be calculated using average concentrations of salts as found in lagoon wastewater reported in "Seepage Rates and Ground Water Quality Impacts from Manure-Lined Dairy Waste Lagoons" published by the Environmental Improvement Division, Ground Water and Hazardous Waste Branch of the New Mexico Health and Environment Department (late 1980's).

Average values for total dissolved solids, bicarbonates, chlorides, sodium, ammonia, and total nitrogen were calculated using the following values from the report:

Waste Constituents in Dairy Lagoons (New Mexico data)						
Parameter	TDS (ppm)	Bicarb (ppm)	Ammonia (ppm)	TKN (ppm)	Chlorides (ppm)	Sodium (ppm)
	1300	663	22.2	75.3	123.6	147
	1295	1051.5	83.4	131	153.9	150
	5052	1978	73.7	87.2	910	449
	2869	1649	27.2	194	448	191
	2630	1565	219	257	706	435
	2280	1391	164	285	773	476
	3412		85	183		
			81	152		
			83.9	118		
			174.8	128.9		
				198		

average	2691	1383	101	164	519	308

Mass loading is calculated using the annual volume of seepage (million gallons/year) multiplied by the concentration (ppm) and a conversion factor (8.34 lbs/million gallons):

Total Dissolved Solids calculated at 681 tons per year per facility:
60.68 mil gal/yr x 2691 ppm x 8.34 lbs/mil gal = 1,361,837.5 lbs TDS/yr

Bicarbonate salts calculated at 350 tons per year per facility:
60.68 mil gal/yr x 1383 ppm x 8.34 lbs/mil gal = 699,896 lbs Bicarb/yr
Chloride salts calculated at 131 tons per year per facility:
60.68 mil gal/yr x 519 ppm x 8.34 lbs/mil gal = 262,650 lbs Na/yr

Sodium salts calculated at 78 tons per year per facility:
60.68 mil gal/yr x 308 ppm x 8.34 lbs/mil gal = 155,869 lbs Cl/yr

Total nitrogen compounds at 41 tons per year per facility:
60.68 mil gal/yr x 164 ppm x 8.34 lbs/mil gal = 82,995 lbs TKN/yr

Summary of mass loading is provided in the following table:

Mass Loading due to Seepage per Facility Groundwater Contamination Issues Assume a Design Life for Facility of 20 years				
Parameter	lbs/yr	tons/yr	lbs/design	tons/design
TDS	1,361,837.5	681	27,236,750	13,618
Bicarb	699,896	350	13,997,920	6,999
Chlorides	262,650	131	5,253,000	2,626
Sodium	155,869	78	3,117,380	1,559
Total Nitrogen	82,995	41	1,659,912	830
Combined Mass Loading -- Both Dairy Facilities Design Life of 20 years				
Parameter	lbs/yr	tons/yr	lbs/design	tons/design
TDS	2,723,675	1,362	54,473,500	27,237
Bicarb	1,399,792	700	27,995,840	13,998

Chlorides	525,300	263	10,506,000	5,253
Sodium	311,738	156	6,234,760	3,117
Total Nitrogen	165,990	83	3,319,800	1,660

These estimates of seepage do not include the seepage losses from the barns nor from the solids separation trenches located hydraulically prior to the waste lagoons. Therefore, the total seepage from this facility would be more than that indicated in the tables. It is important to note that whatever losses that do not occur from the lagoon(s) represent a volume of wastewater that must still be disposed of by land application. The mass loading of pollutants on the aquifer includes not only the mass loading in the allowable seepage from each lagoon at each facility, but also the mass loading due to disposal by land application for both facilities. That additional mass loading was not calculated in this report, but it is highly recommended that more study be made to determine the total loading on the aquifer system for nitrogen compounds and especially for total dissolved solids (salts).

Environmental Concerns

The Agency must evaluate the mass loading of these salts on the unconfined groundwater aquifer that is located beneath the facilities. This groundwater is already known to be contained with little or no egress, which causes salts to accumulate in the groundwater basin. The allowable seepage is extremely high as compared to that allowed for municipal lagoons (typically 500 gallons per acre per day). The seepage for the very concentrated dairy wastewater is more than 18 times that allowed for the more dilute domestic sanitary wastewater.

The EIR indicates more shallow groundwater systems than those admitted to at depths of 130 feet. The report includes reference to a sand layer underlain by a thick clay layer at the facility. This sand/clay interface apparently occurs at depths of 40 feet. A sand layer underlain by clay, albeit intermittent clay in this region, is considered by most hydrogeologists to be a "perched" aquifer. The perched aquifer may not accumulate enough water to be a "producing" aquifer, but it can be considered waters of the state and protected as such. The perched water can and will interact with underlying aquifers at the point of saturation of the intervening clay layer, or sooner with the horizontal movement of the perched water to the edge of the clay layer. This phenomena allows wastewater to travel laterally beyond the expected boundary of the lagoon. In other words, the wastewater will not just seep straight down to the aquifer, but may travel in a lateral direction dictated by the slope of the intervening clay layer and enter the underlying aquifer materials at some point different than that of the lagoon. Monitoring wells should be set up to detect this movement.

The use of existing water wells as the groundwater monitoring for this facility is a lax enforcement of groundwater quality standards. The wells built to produce large quantities of groundwater are not necessarily built to detect pollution. The non-nitrogen salt pollution will occur at different depths than the more mobile ammonia and nitrate pollution. The nitrogen pollution is proposed to be detected by "nitrates" instead of ammonia and nitrates. It is well known that ammonia and nitrate levels in the groundwater will be inversely proportional as the microbial community transforms dissolved ammonia into nitrite and nitrate. Therefore, the lack of detection of nitrates is not a proof-positive indicator of no pollution. The testing must include more conservative pollution parameters, such as chlorides, bicarbonates, and sodium in addition to ammonia, nitrates, and total nitrogen.

This report was prepared by Kathy J. Martin, PE in Norman, Oklahoma
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