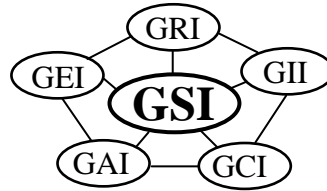


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**GRI White Paper #15**

**Survey of U.S. State Regulations on Allowable Leakage Rates in  
Liquid Impoundments and Wastewater Ponds**

by

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## GRI White Paper #15

### Survey of U. S. State Regulations on Allowable Leakage Rates in Liquid Impoundments and Wastewater Ponds

#### Background

Perhaps the greatest emphasis on leakage from geomembrane lined facilities has been with respect to leakage of leachate from solid waste landfills. Most national regulations have addressed (or struggled with) this situation. In this regard all national regulations to our knowledge limit the maximum leachate head on the base geomembrane liner to 300 mm (12 inches). That said, the use of double lined systems allows for quantification of the leakage through the primary liner system. The following table gives insight into the various landfill leakage amounts and subsequent strategies that have been discussed by the U. S. EPA over the years.

#### Various Leakage Amounts and Suggested Response Action Plans (RAP's) for Landfills

[An approximate units conversion is 10 liters/hectare-day (lphd) = 1.0 gallons/acre-day (gpad)]

(a) “de minimum” leakage = 10 lphd ( $\simeq$  1.0 gpad)

- the vapor diffusion through perfect geomembrane with no flaws ranges from 0.2 to 20 lphd ( $\simeq$  0.02 to 2.0 gpad); i.e., this represents the perfect liner

(b) typical action leakage rate (ALR) = 50 to 200 ( $\simeq$  5.0 to 20 gpad)

- continue monitoring
- assess liquid characteristics
- compare to primary leachate

(c) typical intermediate leakage rate (ILR) = 200 to 1000 ( $\simeq$  20 to 100 gpad)

- stop adding waste
- continue monitoring and testing of liquid characteristics

(d) typical rapid and large leak (RLL) > 1000 lphd (> 100 gpad)

- remove the overlying waste
- repair leak(s)

Note: All of the above RAP-values are for illustration only; they must be site specifically determined. Also note that the U.S. EPA only requires the establishment of an action leakage rate (ALR) value.

Contrasting liquid impoundments (such as ponds, lagoons, reservoirs, trenches, basins, etc.) to solid waste landfills, the hydraulic head is site specific and can be quite high. It is invariably much greater than 200 mm (12 inches). Thus, for a given number of leaks and their respective sizes, the seepage from a liquid impoundment will be much greater than with a solid waste landfill at such low value of hydraulic head. The following table indicates how leakage increases as the hydraulic head above the liner increases. Also the type of liner system (geomembrane by itself, or geomembrane over clay or GCL) is important. The data clearly indicates this to be the case. The data also indicates that, depending on site-specific conditions, the leakage can be enormous. It is potentially so high that various governmental agencies have recommended guidance as to maximum leakage allowed from various types of liquid impoundments and wastewater ponds. This survey is intended to report the state-of-the-practice insofar as regulatory guidance for maximum allowable leakage from liquid impoundments and wastewater ponds.

Table 1 - Generalized Leakage Rates Through Liners  
 (ref. Giroud and Bonaparte, Jour. G & G, 1989)

Type of Liner	Leakage Mechanism	Liquid height on top of the geomembrane			
		0.03 m	0.3 m	3 m	30 m
Geomembrane alone (between two sand layers)	Diffusion	0.01	1	10	300
	Small Holes*	300	1,000	3,000	10,000
	Large Holes*	10,000	30,000	100,000	300,000
Composite liner (poor field conditions, i.e., waves)	Diffusion	0.01	1	100	300
	Small Holes*	0.8	6	50	400
	Large Holes*	1	7	60	500
Composite liner (good field conditions, i.e., flat)	Diffusion	0.01	1	100	300
	Small Holes*	0.15	1	9	75
	Large Holes*	0.2	1.5	11	85
		Values of leakage rate are in lphd (values can be divided by approximately 10 to obtain values expressed in gpad)			

\*assumes 3 holes/ha (i.e., 1.0 hole/acre)

## Survey Protocol and Tabulated Results

The question of maximum allowable leakage from a liquid impoundments and wastewater ponds, whether they be unlined or lined, is quite common. Of course, the amount is related to the environmental consequences of the escaping liquid, but it should nevertheless be a quantified value.

All fifty states in the USA were investigated and most of the resulting information gathered was from their Internet websites since they are common to most agencies. That said, many state agencies were contacted directly so as to properly interpret their requirements. Ultimately, the regulations of thirty-seven state agencies (74% response) are included in the results. Regarding the nature of the various liquids being impounded, the following was determined insofar as states having such regulations, even though not all states specify allowable leakage rates.

- Sewage and/or wastewater ponds - 19 (48%) States have regulations
- Other liquid impoundments - 9 (18%) States have regulations
  - Municipal and Industrial Lagoons - 2 States have regulations
  - Livestock waste control - 2 States have regulations
  - Earthen impoundments - 1 State has regulations
  - In-situ leach mines - 1 State has regulations
  - Metal laden seepage water - 1 State has regulations
  - General aquifer - 1 State has regulations
  - Leakage collection pond - 1 State has regulations
- States that do not specify leakage rate in regulations - 9 (18%) States have regulations

Table 2 lists each governmental agency and the type of liquid impoundment from which the above tabulation was obtained. The leakage as specifically stated in the regulations is given and then the value was converted to the common unit of gallons per acre per day, or gal/acre-day (gpad). The tremendous variation between agencies is readily observed; i.e., from 13 gpad-to-6800 gpad. Perhaps it is more revealing to separate the maximum allowable leakage rate by the type of liquid being impounded. In this regard, the following was determined.

- Sewage/wastewater ponds from 13 to 3400 gal/acre-day
- Other liquid impoundments
  - Livestock waste control from 3400 to 6800 gal/acre-day
  - Municipal and Industrial Lagoons from 1700 to 3400 gal/acre-day
  - Earthen impoundments 13 gal/acre-day
  - In-situ leach mines 1700 gal/acre-day
  - Metal laden seepage water 480 gal/acre-day
  - General aquifer 550 gal/acre-day
  - Leakage collection pond 200 gal/acre-day

It should be noted that there does exist an Interagency Wastewater Committee of the Great Lakes/Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. Their members are Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Ontario, Pennsylvania and Wisconsin. The value of maximum leakage that has been set for wastewater collection and treatment facilities is 500 gal/acre-day.

Table 2 - Allowable Leakage Rates in Reservoirs and Ponds

STATE AGENCY	TYPE OF IMPOUNDMENT	LEAKAGE IN REGULATIONS	LEAKAGE IN GAL/ACRE-DAY
Alaska DEC - Division of Water	metal laden seepage water pond	$7.7 \times 10^{-6}$ gal/min/ft <sup>2</sup>	480 gal/acre-day
	wastewater treatment lagoon	$\leq 500$ gal/acre-day	500 gal/acre-day
Arizona DEQ - Groundwater	general aquifer	$\leq 550$ gal/acre-day	550 gal/acre-day
Arkansas DEQ -GL/UM River Board*	wastewater storage ponds	$\leq 500$ gal/acre-day	500 gal/acre-day
California Lagoon and Pond Require.	lagoons and retention ponds	do not specify leakage rate	n/a
Colorado Water Quality Control	sewage ponds	$\leq 10^{-6}$ cm/sec or permit is required	125 gal/acre-day
Delaware EPA- Water Pollution	reservoirs and ponds	do not specify leakage rate	n/a
Florida - GL/UM River Board*	storage ponds	lined to prevent measurable seepage	500 gal/acre-day
Georgia DNR - Engineering	preapplication treatment ponds	1/8 inch per day	3400 gal/acre-day
Great Lakes/Upper Mississippi River Board	wastewater storage ponds	$\leq 500$ gal/acre-day	500 gal/acre-day
Idaho Water Allocation Bureau	reservoirs and ponds	do not specify leakage rate	n/a
Illinois NRCS	waste storage ponds	$\leq 1 \times 10^{-7}$ cm per sec	13 gal/acre-day
Indiana DNR - Division of Water	wastewater storage ponds	$\leq 550$ gal/acre-day	550 gal/acre-day
Iowa DNR - Wastewater	municipal and industrial lagoons	1/16 inch per day at a water depth of 6 ft.	1700 gal/acre-day
Kansas DHE - Bureau of Water	wastewater lagoons	1/64" per day	425 gal/acre-day
Kentucky DEP - Division of Water	wastewater treatment lagoon	$\leq 500$ gal/acre-day	500 gal/acre-day
Maine EPA - Watershed Mgmt.	reservoirs and ponds	do not specify leakage rate	n/a
Maryland Code 378 Pond Standards	reservoirs and ponds	do not specify leakage rate	n/a
Michigan - GL/UM River Board*	wastewater storage ponds	$\leq 500$ gal/acre-day	500 gal/acre-day
Minnesota - GL/UM River Board*	wastewater storage ponds	$\leq 500$ gal/acre-day	500 gal/acre-day
Mississippi DEQ - Water	wastewater treatment ponds	$\leq 500$ gal/acre-day	500 gal/acre-day

Missouri - GL/UM River Board*	wastewater storage ponds	≤ 500 gal/acre-day	500 gal/acre-day
Nebraska DEQ	municipal and industrial lagoons	1/8" per day	3400 gal/acre-day
	livestock waste control	new facility = 0.13 inches/day	3400 gal/acre-day
	livestock waste control	prior to 2000 = 0.25 inches/day	6800 gal/acre/day
New Hampshire DES - Wastewater	wastewater lagoons	no numerical requirement	n/a
New York - GL/UM River Board*	wastewater storage ponds	≤ 500 gal/acre-day	500 gal/acre-day
North Carolina DNR	basins, lagoons, ponds, trenches	≤ 1X 10 <sup>-6</sup> cm per second	125 gal/acre-day
	earthen impoundments	≤ 1X 10 <sup>-7</sup> cm per second	13 gal/acre-day
Ohio - GL/UM River Board *	wastewater storage ponds	≤ 500 gal/acre-day	500 gal/acre-day
Oklahoma DEQ - Water Quality	retention lagoons	≤ 500 gal/acre-day	500 gal/acre-day
Oregon DEQ - Water Quality	existing lagoons	1/8" per day (No leakage allowed in new)	3400 gal/acre-day
Pennsylvania DEP	wastewater storage ponds	≤ 550 gal/acre-day	550 gal/acre-day
South Carolina DHEC	basins holding wastewater	≤ 10 <sup>-6</sup> cm/sec	125 gal/acre-day
South Dakota NR - Engineering	in-situ leach mines	shall not exceed 1/16 inch per day	1700 gal/acre-day
	reservoirs and ponds	case by case basis	case by case basis
Tennessee DEC- Water Supply	reservoirs and ponds	do not specify leakage rate	n/a
Texas TWDB	reservoirs and ponds	do not specify leakage rate	n/a
Utah EPA - Ground Water Protection	leak collection system	200 gal/acre-day	200 gal/acre-day
United States EPA	surface impoundments	≤ 32 gal/acre-day	32 gal/acre-day
Vermont DNR	wastewater ponds/lagoon	≤ 500 gal/acre-day	500 gal/acre-day
Virginia DEQ - Wastewater	storage lagoons	no referenced standard for lined lagoons	n/a
Wisconsin DNR - Wastewater	sludge storage/ treatment lagoons	≤ 500 gal/acre-day	500 gal/acre-day
	wastewater lagoons	≤ 1000 gal/acre-day	1000 gal/acre-day

\*GL/UM = Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers



## Summary

Converse to the uniformity of leakage regulations from lined solid waste landfills, the leakage regulations for lined liquid impoundments and wastewater ponds is extremely varied.

This is felt to be due to the following:

- (i) The environmental impacts of escaping liquids in impoundments and ponds varies from negligible to severe.
- (ii) The liquid depths (i.e., the hydraulic head) in impoundments and ponds varies from extremely low to very high.
- (iii) Unlike solid waste landfills regulations, which are always promulgated from a separate and unique department, regulations for impoundments and ponds come from various departments within a state agency.
- (iv) Other than the Great Lakes/Upper Mississippi River Board there are no interstate agencies presenting guidance of an interagency nature.
- (v) While the solid waste industry has organized itself into several independent service organizations (e.g., SWANA, NASWM, etc.) there are no comparable private organizations for impoundments and ponds.

In the context of the above comments, the allowable leakage rates for liquid impoundments and wastewater ponds is extremely varied.\* In reviewing regulations from thirty-seven (37) state agencies, the allowable leakage rates vary from 13 gpad-to-6800 gpad. By far the broadest classification is sewage and wastewater treatment ponds. In fact, it was extremely difficult to distinguish these two liquids from one another in reviewing the regulations. Thus they were grouped together. In this regard an owner or designer must carefully review the regulations so as

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\*To be noted is that we did a web-search of worldwide agencies and found essentially no regulations of this type regarding allowable leakage rates.

to gauge its applicability. There are, however, several classes of liquids specifically designated in the regulations. These are the following:

- Livestock waste control from 3400 to 6800 gal/acre-day
- Municipal and Industrial Lagoons from 1700 to 3400 gal/acre-day
- Earthen impoundments 13 gal/acre-day
- In-situ leach mines 1700 gal/acre-day
- Metal laden seepage water 480 gal/acre-day
- General aquifer 550 gal/acre-day
- Leakage collection pond 200 gal/acre-day

In conclusion, the message stemming from this survey is that the particular set of regulations in the state where a particular type of impoundment or pond is to be built must be carefully reviewed before contemplating a design insofar as selection of a liner system is concerned.