

**Table 1. API-Proposed Voluntary Concentration Limits for the Disposal of NORM Waste.** API (2002) citing contractor report by Rogers and Associates (1990). The Rogers and Associates reference was not immediately available for review at the time this paper was prepared. Surface spreading and dilution NORM waste is now mostly disallowed in States with NORM regulations (Zielinski and Otton, 1999, p. 3).

Disposal Scenario		Disposal Depth (ft)	Radium Concentration Limit (pCi/g)		Comments
Soil (In Situ)	No Dilution	~1	scale/ sludge	120	Spreading on land surface with no mixing. Maximum thickness of sludge/scale is 0.25 inches. Unrestricted land use afterwards.
	With Dilution	~1	scale/ sludge	260	Mechanical mixing on land surface. Maximum thickness of 1 inch of sludge/ scale mixed with 7 inches of topsoil. Unrestricted land use afterwards.
Buried Pipe		<5	scale	2700	In-situ disposal of non-recoverable pipe below the ground surface. Unrestricted land use afterwards likely. Depth estimated.
			sludge	6700	
Shallow Landfill Burial		≥ 15	scale	29	Unrestricted land use envisioned after site is closed. Possibly comparable to a RCRA landfill model. Depth estimated.
			sludge	130	
			equipment	440	
Commercial Oil Industry Waste Landfill		≥ 15	scale	410	Concentration limit based on the assumption that NORM waste represents less than 7 percent of total waste volume in disposal scenario. Landfill may or may not be lined. Restricted land use and monitoring envisioned after site is closed. Oil and gas wastes are generally exempt from RCRA. See EPA (2002).
			sludge	1800	
			equipment	6200	
Commercial NORM Disposal Facility		0 – 50	scale	1000	Likely a Class-A Part 61 or RCRA landfill model relying on restricted land use and monitoring after site is closed. State-owned site.
			sludge	4500	
			equipment	68,000	

Disposal Scenario	Disposal Depth (ft)	Radium Concentration Limit (pCi/g)		Comments
Commercial LLW Disposal Facility	0 – 50	scale	50,000	NRC Part 61 LLW disposal facility relying on certain design features and restrictions listed in the regulation. Also relies on restricted land use and monitoring after site is closed.
		sludge	50,000	
		equipment	50,000	
Abandoned Oil Well	~10 <sup>3</sup>	scale	100,000	Equipment limited to goods with tubular geometries. Well plugged after waste emplacement. Depth estimated.
		sludge	100,000	
		equipment	100,000	
Well Injection Associated with Hydraulic Fracturing	~10 <sup>3</sup>	scale	100,000	Relies on geologic/stratigraphic confinement to protect underground sources of drinking water. Depth estimated.
		sludge	100,000	
Salt Dome	~10 <sup>4</sup>	not specified		Relies on geologic confinement to protect underground sources of drinking water. Likely a Waste Isolation Pilot Plant-type model relying on restricted land use and monitoring after site is closed. See DOE (1990). State-owned site. Depth estimated.

**Table 2. Commercial Subtitle C Hazardous Landfills.** Selected site and operational information. Information compiled from the Internet and limited telephone interviews. A small but unknown number of disposal facilities not listed in this table have been closed, capped with an impermeable cover system, and are now being monitored. Arid/semi-arid sites are generally defined by precipitation amounts less than 20 inches per year. Humid sites can be considered with precipitation amounts greater than 20 inches per year.

Landfill	Location	Annual Precipitation (inches)	Operator	Status	LAW Disposal Authority	
Emelle	Sumter Co	Alabama	52	Chemical Waste Management	Active	NORM
Buttonwillow	Kern Co.	California	5	Clean Harbors	Active	NORM/TENORM
Kettleman City	Kings Co.	California	7	Chemical Waste Management	Active	NORM
Westmorland	Imperial Co.	California	3	Clean Harbors	Inactive	NORM
Deer Trail	Adams Co.	Colorado	14	Clean Harbors	Active	NORM/TENORM
Grand View	Owyhee Co.	Idaho	7	American Ecology	Active	NORM
Pottstown (PDC#1 landfill)	Peoria Co.	Illinois	30	Peoria Disposal Company	Active	None
Calumet City	Cook Co.	Illinois	38	Chemical Waste Management	Inactive	None
Roachdale	Putnam Co.	Indiana	39	Heritage Environmental Services	Active	None
Fort Wayne	Allen Co.	Indiana	36	Chemical Waste Management	Inactive	None
Lake Charles (Carlyss)	Calcasieu Parish	Louisiana	57	Chemical Waste Management	Active	NORM
Belleville	Wayne Co.	Michigan	33	Wayne Disposal	Active	NORM/TENORM
Beatty	Nye County	Nevada	4	American Ecology	Active	None
Model City	Niagara Co.	New York	36	Chemical Waste Management	Active	None
Oregon	Lucas Co.	Ohio	34	Envirosafe Services of Ohio	Active	NORM
Lone Mountain (Waynoka)	Woods Co.	Oklahoma	25	Clean Harbors	Active	None
Arlington	Gilliam Co.	Oregon	23	Chemical Waste Management	Active	None
Yukon (Pittsburgh)	Westmoreland Co.	Pennsylvania	38	MAX Environmental Technologies	Active	None

<b>Landfill</b>	<b>Location</b>		<b>Annual Precipitation (inches)</b>	<b>Operator</b>	<b>Status</b>	<b>LAW Disposal Authority</b>
Deer Park	Harris Co.	Texas	54	Clean Harbors	Active	NORM/TENORM
Port Arthur	Jefferson Co.	Texas	57	Veolia Environmental Services	Active	None
Robstown	Nueces Co.	Texas	30	American Ecology	Active	NORM
WSC Andrews County	Andrews Co.	Texas	15	Waste Control Specialists	Inactive	NORM
Grassy Mountain	Toole Co.	Utah	6	Clean Harbors	Active	None

**Figure 1. Graphic Depiction of NORM Management Options.** Adopted from API (1992, p. 45). Surface spreading and dilution NORM waste is now mostly disallowed in States with NORM regulations (Zielinski and Otton, 1999, p. 3).

