



SUMMARY OF TENORM STUDY

The North Dakota Department of Health (NDDoH) commissioned Argonne National Laboratory (ANL) to determine landfill radiation limits that would be safe for workers and the public. NDDoH provided information on oilfield-related Technologically Enhanced Naturally Occurring Radioactive Material, or TENORM, including scale that forms on pipe and equipment, sludge, filter socks and proppant (synthetic sand). The study was financed exclusively with funds from the NDDoH, and NDDoH had sole control over the parameters of the study.

ANL was the first federal research laboratory and is an internationally-recognized scientific leader in the field of radiation. ANL developed the radiation exposure models used today in the U.S. ANL used the International Commission on Radiological Protection's (ICRP) maximum recommended public exposure of 100 millirems per year (mrems/year) to calculate an acceptable, safe disposal limit for North Dakota. The study examined exposure pathways of external radiation, inhalation and ingestion of contaminated material, and ingestion of food and water from a closed landfill.

Routine and accidental exposures for workers and the general public were also calculated for several scenarios not related to landfill disposal:

Individual	Scenario	Exposure Time, hours per year	Maximum Dose, millirems per year
Oilfield worker	Mixing hydraulic fracturing fluids	2000	2.2
Oilfield worker	Sludge treatment	2000	30
Oilfield worker	Pipe cleaning	2000	130
Driver	Hauling TENORM	2000	20
Child	Playing with used filter socks	24	0.42
Child	Playing with synthetic proppant	100	1.9
Public	Used filter socks in a garbage can	40	4.9
Public	Adjacent to operating landfill	8760	0.024

Oilfield Special Waste and Large Volume Industrial Landfills were studied to determine acceptable TENORM disposal limits. The volume of TENORM waste would be limited to 25,000 tons per year, with no TENORM permitted in the top ten feet of the landfill. After closure, the landfill was modeled for 1,000 years for surface exposure and 10,000 years for potential groundwater impact. For groundwater, the model used a worst-case scenario which assumed the bottom synthetic liner in the landfill was no longer functioning.

To determine a disposal limit, active and closed landfills were studied. For a closed landfill, the study considered a self-sufficient farmer living on the closed landfill, an industrial operation on the closed landfill, recreational use on the closed landfill and the proximity of off-site water wells. The study found that the limiting exposure to TENORM came from a worker employed at an active landfill. At a concentration of 51.6 picocuries per gram, a worker could potentially reach the 100 mrem/year exposure limit. The NDDoH used this result to propose a disposal limit of 50 picocuries per gram.