Regarding: Texas Standards for Protection Against Radiation from Radioactive Material, 25 TAC §289.202(ggg) and the use of the term “short-lived radiocuclide.”

This discussion will use the list contained in 25 TAC §289.202(ggg)(7), “Concentration and activity limits of nuclides for disposal in a Type I municipal solid waste site or a hazardous waste facility”, as an example of what we consider to be a recurring scientific discrepancy in the Texas Administrative Code.

As implied, the list in 25 TAC §289.202(ggg)(7) outlines what radionuclides, and in what concentrations, may be sent to municipal landfills. The radionuclides listed are also referred to in other waste exemption scenarios, such as disposal into sewage systems via pouring down drains.

This list contains at least five isotopes which have short half life during their first transformation/decay, yet afterward turn into extremely long-lived daughter-product isotopes which do not decay for thousands, and in some cases millions of years. Despite this, these are still referred to as “short-lived” radioisotopes due to the half life length of the parent nuclide, which completely ignores the long term implications of radioactive decay.

Traditionally, ‘short lived’ is a label reserved for radioisotopes with half life below either 30 or 100 years depending upon the referring document). Recall that it is the half life and decay scheme, in addition to the radioactivity of the sample, which determine how low-level waste is classed (as federal Class A, B, C, or GTCC, or as Texas Category I, II, III)

Note: 25 TAC §289.202(ggg)(7) is available at [http://www.tdh.state.tx.us/radiation/PDFFILES/202cfno00.PDF]

Here are 5 of the listed isotopes followed by their half life and decay product demonstrating that these are not short-lived radionuclides:

Cd-115m	44.6 days	**In-115**	**5.1 +E15 years**		

5,100,000,000,000,000 year half life : Indium-115 - Direct daughter product of Cadmium-115m

Nd-147	10.98 days	Pm-147	2.6234 years	**Sm-147**	**1.06 +E11 years**

Samarium-147 – Second daughter product of Neodymium
106,000,000,000 year half life in the third decay sequence.

Te-129	69.6 minutes	I-129	1.57 +E7 years		

Tellurium-129 decays to Iodine-129, which has a half life of 15,700,000 years
Iodine-129 has a 15.7 million-year half life

I-123	13.2 hours	Te-123m	119.7 days	**Te-123**	**1 +E13 years**

Iodine-123 decays to Tellurium-123, which has a half life of 10,000,000,000,000
Tellurium-123 has a ten-trillion-year half life.

Both Molybdenum-99 and Technetium-99m are listed as separate isotopes in the list even thought they create the same long-lived daughter product:

Mo-99	66 hours	Tc-99m	6.02 hours	**Tc-99**	**2.13 +E5 years**
Tc-99m	6.02 hours	Tc-99	2.13 +E5 years		

(Technetium has a half life of 213,000 years)

We believe it is crucial that groups and individuals working on radioactive materials remember that half life is not limited to the primary decay sequence (or transformation). Considering that these tables outline allowances for the release of radioactive material into the natural environment (ie., not a licensed radioactive materials disposal or storage facility), we assert that the responsible course of action would be for these and similar radionuclides to be removed from such exemption guidelines used by regulatory authorities.

Attached pages include tables which look into radionuclides which are listed in 25 TAC §289.202(ggg)(7), and that have secondary and tertiary decay sequences. These display the total time period in years that the radioisotopes in question will decay to a stable mass.

Isotopes listed in TAC §289.202(ggg) which decay into other radioisotopes, with half life, decay chain, and actual decay periods (in years).

Listed Isotope - First Decay Sequence					*Second Decay Sequence*					*Third Decay Sequence*				
Isotope	*Halflife*	*Unit*	*In Years*	*Actual Decay*	*Daughter*	*Halflife*	*Unit*	*In Years*	*Actual Decay*	*Daughter*	*Halflife*	*Unit*	*In Years*	*Actual Decay*
Ca-47	1.43	days	3.9178E-03	3.9178E-02	Sc-47	3.351	days	9.1808E-03	9.1808E-02		STABLE		0	0
Zr-95	63.98	days	1.7529E-01	1.7529E+00	Nb-95m	86	hours	9.8174E-03	9.8174E-02	Nb-95	35.15	days	0.0963	0.9630137
Mo-99	66	hours	7.5342E-03	7.5342E-02	Tc-99m	6.02	hours	6.8721E-04	6.8721E-03	Tc-99	2.13E+05	years	213000	2130000
Tc-99m	6.02	hours	6.8721E-04	6.8721E-03	Tc-99	2.13E+05	years	2.1300E+05	2.1300E+06		STABLE		0	0
Te-129	69.6	min	1.3242E-04	1.3242E-03	I-129	1.57E+07	years	1.5700E+07	1.5700E+08		STABLE		0	0
I-123	13.2	hours	1.5068E-03	1.5068E-02	Te-123m	119.7	days	3.2795E-01	3.2795E+00	Te-123	1.00E+13	years	1E+13	1E+14
I-131	8.04	days	2.2027E-02	2.2027E-01	Xe-131m	11.9	days	3.2603E-02	3.2603E-01		STABLE		0	0
I-133	20.8	hours	2.3744E-03	2.3744E-02	Xe-133m	2.188	days	5.9945E-03	5.9945E-02	Xe-133	5.245	days	0.01436	0.1436987
Ba-140	12.74	days	3.4904E-02	3.4904E-01	La-140	40.272	hours	4.5973E-03	4.5973E-02		STABLE		0	0
Ce-144	284.3	days	7.7890E-01	7.7890E+00	Pr-144m	7.2	min	1.3699E-05	1.3699E-04	Pr-144	17.28	min	3.2877E-05	0.0003288
Nd-147	10.98	days	3.0082E-02	3.0082E-01	Pm-147	2.6234	years	2.6234E+00	2.6234E+01	Sm-147	1.06E+11	years	1.06E+11	1.06E+12
Ag-110m	249.9	days	6.8466E-01	6.8466E+00	Ag-110	24.5	sec	7.7689E-07	7.7689E-06		STABLE		0	0
Cd-115m	44.6	days	1.2219E-01	1.2219E+00	In-115	5.10E+15	years	5.10E+15	5.1000E+16		STABLE		0	0

Above, the original isotopes in TAC 289.202(ggg) are in first column on the left, with their half life. According to the ten half life rule, it takes a period ten times the half life for a radionuclide mass to decay into its daughter products. The column labeled “actual decay” reflects the duration of this time period. In the middle column, the decay product is listed, with the same data. Six radioisotopes listed decay in a third sequence beforebecoming stable, and they are listed in the column on the right. It is the sum of the actual decay periods which tells us how long a radioisotope mass will substantially complete its decay to a stable element, through all of the sequences in its decay chain.

The table on the bottom-right shows us this total sum decay period in both scientific and informal listing for each isotope listed. This demonstrates that the term “short-lived radionuclide” should be more carefully applied, and that isotopes which half a very short half life can transform into others with very long half life. These particularly need to be seriously considered when formulating a list of isotopes for disposal in municipal landfills or down drains into sewers.

Isotope	*In Years*	*More Readable*	
Ca-47	1.310E-01	47.81	days
Zr-95	2.814E+00	2.814	years
Mo-99	2.130E+06	2,130,000.082	years
Tc-99m	2.130E+06	2,130,000.007	years
Te-129	1.570E+08	157,000,000.001	years
I-123	1.000E+14	100,000,000,000,003	years
I-131	5.463E-01	199.4	days
I-133	2.274E-01	83	days
Ba-140	3.950E-01	144.18	days
Ce-144	7.790E+00	7.79	years
Nd-147	1.060E+12	1,060,000,000,026.53	years
Ag-110m	6.847E+00	6.847	years
Cd-115m	5.100E+16	51,000,000,000,000,000	years

Figure Two. Total decay time to achieve a stable mass, incorporating daughter products, cumulative half life to decay time using the ten-half life rule for radioactive decay.

(7) Concentration and activity limits of nuclides for disposal in a Type I municipal solid waste site or a hazardous waste facility (for use in subsection (fff) of this section). The following table contains concentration and activity limits of nuclides for disposal in a Type I municipal solid waste site or a hazardous waste facility.

Nuclides	Concentrations Limit (Ci/m^3)	Annual Generator Disposal Limit (Ci/yr)
F-18	3×10^{-1}	8
Si-31	$1 \times 10^{+2}$	$3 \times 10^{+3}$
Na-24	9×10^{-4}	2×10^{-2}
P-32	2	$5 \times 10^{+1}$
P-33	10	$3 \times 10^{+2}$
S-35	9	$2 \times 10^{+2}$
Ar-41	3×10^{-1}	8
K-42	2×10^{-2}	5×10^{-1}
Ca-45	4	$1 \times 10^{+2}$
Ca-47	2×10^{-2}	5×10^{-1}
Sc-46	2×10^{-3}	5×10^{-2}
Cr-51	6×10^{-1}	$2 \times 10^{+1}$
Fe-59	5×10^{-3}	1×10^{-1}
Co-57	6×10^{-2}	2
Co-58	1×10^{-2}	3×10^{-1}
Zn-65	7×10^{-3}	2×10^{-1}
Ga-67	3×10^{-1}	8
Se-75	5×10^{-2}	1
Br-82	2×10^{-3}	5×10^{-2}
Rb-86	4×10^{-2}	1
Sr-85	2×10^{-2}	5×10^{-1}
Sr-89	8	$2 \times 10^{+2}$
Y-90	4	$1 \times 10^{+2}$
Y-91	4×10^{-1}	10
Zr-95	8×10^{-3}	2×10^{-1}
Nb-95	8×10^{-3}	2×10^{-1}
Mo-99	5×10^{-2}	1
Tc-99m	1	$3 \times 10^{+1}$
Rh-106	1	$3 \times 10^{+1}$
Ag-110m	2×10^{-3}	5×10^{-2}
Cd-115m	2×10^{-1}	5
In-111	9×10^{-2}	2

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Nuclides	Concentrations Limit (Ci/m^3)	Annual Generator Disposal Limit (Ci/yr)
In-113m	9	$2 \times 10^{+2}$
Sn-113	6×10^{-2}	2
Sn-119	$2 \times 10^{+1}$	$5 \times 10^{+2}$
Sb-124	2×10^{-3}	5×10^{-2}
Te-129	2×10^{-1}	5
I-123	4×10^{-1}	$1 \times 10^{+1}$
I-125	7×10^{-1}	$2 \times 10^{+1}$
I-131	4×10^{-2}	1
I-133	2×10^{-2}	5×10^{-1}
Xe-127	8×10^{-2}	2
Xe-133	1	$3 \times 10^{+1}$
Ba-140	2×10^{-3}	5×10^{-2}
La-140	2×10^{-3}	5×10^{-2}
Ce-141	4×10^{-1}	$1 \times 10^{+1}$
Ce-144	1×10^{-3}	3×10^{-2}
Pr-143	6	$2 \times 10^{+2}$
Nd-147	7×10^{-2}	2
Yb-169	6×10^{-2}	2
Ir-192	1×10^{-2}	3×10^{-1}
Au-198	3×10^{-2}	8×10^{-1}
Hg-197	8×10^{-1}	$2 \times 10^{+1}$
Tl-201	4×10^{-1}	$1 \times 10^{+1}$
Hg-203	1×10^{-1}	3

NOTE: In any case where there is a mixture in waste of more than one radionuclide, the limiting values for purposes of this paragraph shall be determined as follows:

For each radionuclide in the mixture, calculate the ratio between the quantity present in the mixture and the limit established in this paragraph for the specific radionuclide when not in a mixture. The sum of such ratios for all the radionuclides in the mixture may not exceed "1" (i.e., "unity").