

**Appendix B  
Table of Radionuclides**

Radionuclide	Half Life	Decay Mode	Internal Toxicity Class	ALI (mCi)	Container Posting Level (mCi)	$\Gamma$ R/h @ 1 cm per mCi	TVL mm Pb	Radiation Types KeV (% per decay)
<sup>3</sup> H	12.35 Y	$\beta$	Low	80	1	-	-	Betas: 19 (100%)
<sup>11</sup> C	20.38 M	$\beta+$ , EC	Low	400	1	5.97	13.7	Positrons: 960 (99.7%) Gammas: 511 (199.5%)
<sup>13</sup> N	9.97 M	$\beta+$	Low		1	5.97	13.7	Positrons: 1,199 (99.8%) Gammas: 511 (199.6%)
<sup>14</sup> C	5,730 Y	$\beta$	Moderate	2	1	-	-	Betas: 156 (100%)
<sup>15</sup> O	122.24 S	$\beta+$	Low			5.97	13.7	Positrons: 1,732 (99.9%) Gammas: 511 (199.8%)
<sup>18</sup> F	109.77 M	$\beta+$	Low	70	1	5.8	13.7	Positrons: 634 (96.7%) Gammas: 511 (193.4%)
<sup>22</sup> Na	2.6 Y	$\beta+$ , EC	High	0.4	0.01	12	26.6	Positrons: 545 (89.8%) Gammas: 511 (180%) 1,275 (99.9%)
<sup>24</sup> Na	15 H	$\beta$	Moderate	4	0.1	18.4	52	Betas: 1,390 (99.9%) Gammas: 1,386 (100%) 2,754 (100%)
<sup>32</sup> P	14.29 D	$\beta$	High	0.4	0.01	-	-	Betas: 1,710 (100%)
<sup>33</sup> P	25.4 D	$\beta$	Moderate	3	0.1	-	-	Betas: 250 (100%)
<sup>35</sup> S	87.44 D	$\beta$	Moderate	2	0.1	-	-	Betas: 167 (100%)
<sup>36</sup> Cl	301,000 Y	$\beta$	High	0.2	0.010	-	-	Betas: 714 (98%)
<sup>40</sup> K	1.3 x 10 <sup>9</sup> Y	$\beta$ , EC	High	0.3	0.1	0.7	38.7	Betas: 1,312 (89.3%) Gammas: 1,460 (10.7%)
<sup>42</sup> K	12.36 H	$\beta$	Moderate	5	1	1.4	39.8	Betas: 1,996 (17.5%) 3,521 (82%) Gammas: 1,525 (18%)
DECAY MODES: $\alpha$ = Alpha Decay, $\beta$ = Beta Decay, $\beta+$ = Positron Decay, EC = Electron Capture, IT = Isomeric Transition (gamma) Decay, SF = Spontaneous Fission ALI = Annual Limit on Intake, $\Gamma$ = Specific Gamma Ray Constant, TVL = Tenth Value Layer								

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<sup>45</sup> Ca	163 D	$\beta$	Moderate	0.8	0.1	-	-	Betas: 257 (100%)
<sup>46</sup> Sc	83.83 D	$\beta$	High	0.2	0.01	10.9	29.1	Betas: 357 (100%) Electrons: 140 (38%) Gammas: 889 (100%) 1,121 (100%) 143 (62%)
<sup>47</sup> Ca	4.53 D	$\beta$	Moderate	0.8	0.1	5.7	34.4	Betas: 691 (81.7%) 1,988 (18%) Gammas: 489(7.0%) 808(6.9%) 1297(74.9%)
<sup>48</sup> V	16.24 D	$\beta^+$	Moderate	0.6	0.1	15.6	30.1	Positrons: 698 (50%) Gammas: 983 (100%) 1,312 (97.5%) 2,240 (2.4%) 511 (100%) 944 (7.7%)
<sup>51</sup> Cr	27.7 D	EC	Low	20	1	0.2	6.3	Gammas: 320 (9.8%)
<sup>54</sup> Mn	312.5 D	EC	Moderate	0.8	0.1	4.7	24.6	Gammas: 835 (100%)
<sup>55</sup> Fe	2.7 Y	EC	Moderate	2	0.1	-	-	X-rays: 6 (28%)
<sup>57</sup> Co	270.9 D	EC	Moderate	0.7	0.1	0.9	0.7	Gammas: 122 (85.5%) 136 (10.6%)
<sup>59</sup> Fe	44.53 D	$\beta$	High	0.3	0.01	6.4	33.6	Betas: 273 (45.2%) 465 (53.1%) Gammas: 192 (3.0%) 1,099 (56.5%) 1,292 (43.2%)
<sup>60</sup> Co	5.27 Y	$\beta$	High	0.030	0.001	13.2	34.8	Betas: 318 (100%) Gammas: 1,173 (100%) 1,332 (100%)
<sup>63</sup> Ni	96 Y	$\beta$	Moderate	0.8	0.1	-	-	Betas: 66 (100%)
<sup>67</sup> Ga	3.26 D	EC	Low	7	1	1.1	4.7	Electrons: 84 (26.8%) Gammas: 93 (36%) 185 (19.7%) 300 (15.9%) 394 (4.5%)
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<sup>68</sup> Ge	288 D	EC	High	0.1	0.010	5.51	14.4	Positrons: 836 (84%) Gammas: 511 (178%) 1,077 (3.3%) 1,883 (0.1%) X-rays: 9 (39%) 10 (5.5%)
<sup>74</sup> As	17.76 D	$\beta^+$	Moderate	0.8	0.1	4.4	16.8	Betas: 718 (16%) 1,353 (19%) Positrons: 944 (27%) 944 (27%) 945 (27%) Gammas: 10 (5.1%) 511 (59%) 596 (60%) 608 (5.5%)
<sup>75</sup> Se	119.8 D	EC	Moderate	0.5	0.1	2.1	4.6	Gammas: 121 (16.7%) 136 (59.2%) 265 (59.8%) 280 (25.2%) 401 (11.4%)
<sup>85</sup> Kr	10.72 Y	$\beta$			1	0.4	2.8	Betas: 687 (99.6%) Gammas: 51.4 (43.4%)
<sup>85</sup> Sr	64.84 D	EC	Moderate	2	0.1	3.0	13.9	Gammas: 514 (99.2%) 15 (8.7%)
<sup>86</sup> Rb	18.66 D	$\beta$	Moderate	0.5	0.1	0.5	31.3	Betas: 698 (8.8%) 1,774 (94%) Gammas: 1,076 (8.8%)
<sup>89</sup> Sr	50.5 D	$\beta$	High	0.1	0	-	26.8	Betas: 1,491 (100%)
<sup>90</sup> Sr/Y	29.12 Y	$\beta$	Very High	0.004	0.0001	-	-	Betas: 546 (100%) 2,284 (100%)
<sup>90</sup> Y	64.0 H	$\beta$	High	0.4	0.01	-	-	Betas: 2,284 (100%)
<sup>95</sup> Nb	35.15 D	$\beta$	Moderate	1	0.1	4.3	22.5	Betas: 160 (100%) Gammas: 766 (100%)
<sup>99</sup> Mo	2.75 D	$\beta$	Moderate	1	0.1	1.8	20.5	Betas: 436 (17.3%) 1,214 (82.7%) Gammas: 181 (6.2%) 740 (12.8%)
<sup>99m</sup> Tc	6.02 H	IT	Low	80	1	0.6	0.9	Electrons: 119 (8.8%) 137 (1.1%) Gammas: 140 (89%)
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<sup>103</sup> Pd	16.96 D	EC	Low	6	0.1	1.48	0.02	X-Rays: 20.1 (28.7%) 20.2 (54.4%) 22.7 (16.9%)
<sup>109</sup> Cd	464 D	EC	High	0.04	0.001	1.8	-	Electrons: 63 (42%) 84 (44%) 88 (10%) X-rays: 22 (84%) 25 (18%)
<sup>110m</sup> Ag	249.9 D	IT, $\beta$	High	0.09	0.01	-	-	Betas: 22 (67.3%) 531 (30.5%) Gammas: 658 (94.4%) 678 (10.7%) 687 (6.5%) 707 (16.7%) 764 (22.4%) 818 (7.3%) 885 (72.6%) 938 (34.3%) 1,384 (24.3%) 1,505 (13.1%)
<sup>111</sup> In	2.83 D	EC	Moderate	4	0.1	3.4	2.2	Electrons: 145 (8.4%) 219 (4.9%) Gammas: 171 (90.2%) 245 (94%) X-rays: 23 (68%) 26 (15%)
<sup>113</sup> Sn	115.1 D	IT	Moderate	0.5	0.1	1.7	0.05	Electrons: 20 (13%) X-rays: 24 (60%) 27 (13%)
<sup>115m</sup> Cd	44.6 D	$\beta$	High	0.05	0.01	0.2	30.1	Betas: 616 (98%) 1,621 (98%)
<sup>123</sup> I	13.2 H	EC	Moderate	3	0.1	1.3	1	Electrons: 127 (13.6%) Gammas: 159 (83%) X-rays: 27 (70.6%) 31 (16%)
<sup>125</sup> I	60.14 D	EC	High	0.04	0.001	0.7	0.06	Electrons: 23 (19.7%) 31 (12.3%) Gammas: 35 (6.5%) X-rays: 27 (112%) 31 (25.4%)
<sup>129</sup> I	1.6 x 10 <sup>7</sup> Y	$\beta$	High	0.005	0.001	0.6	0.08	Betas: 152 (100%) Electrons: 34 (11%) Gammas: 40 (7.5%) X-rays: 30 (57%) 34 (13%)

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<sup>131</sup> I	8.04 D	$\beta$	High	0.03	0.001	2.1	9.6	Betas: 334 (7.4%) 606 (89.3%) Gammas: 284 (6.2%) 364 (81.2%) 637 (7.3%)
<sup>133</sup> Ba	10.74 Y	EC	Moderate	0.7	0.1	2.4	5.8	Electrons: 45 (48%) 75 (7.4%) Gammas: 81 (33%) 276 (6.9%) 303 (17.8%) 356 (60%) 383 (8.7%) X-rays: 31 (97%) 35 (22.8%)
<sup>133</sup> Xe	5.25 D	$\beta$	-	-	1	0.1	0.4	Betas: 346 (99.3%) Electrons: 45 (53.3%) Gammas: 81 (36.5%) X-rays: 31 (38.9%)
<sup>137</sup> Cs	30.0 Y	$\beta$	High	0.1	0.01	3.5	18.9	Betas: 512 (94.6%) 1,173 (5.4%) Electrons: 624 (8.1%) Gammas: 662 (90%)
<sup>141</sup> Ce	32.5 D	$\beta$	Moderate	0.7	0.1	0.4	0.9	Betas: 435 (71%) 580 (29.5%) Electrons: 103 (18.8%) Gammas: 145 (48.4%) X-rays: 36 (13.8%)
<sup>150</sup> Eu	34.2 Y	EC	High	0.02	0.001	-	-	Electrons: 5 (45.9%) 5 (45.9%) 6 (27.1%) 1 (150%) Gammas: 334 (94%) 584 (51.5%) 737 (9.4%) 748 (5.1%) 1,049 (5.2%) X-rays: 40 (65.4%) 45 (8.3%)
<sup>152</sup> Eu	13.33 Y	$\beta$ , EC	High	0.02	0.001	-	-	Betas: 696 (13.6%) 1,475 (8.4%) Electrons: 5 (73.4%) 33 (5.7%) 75 (19.5%) 114 (10.6%)
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<sup>153</sup> Gd	242 D	EC	High	0.1	0.01	0.8	0.2	Electrons: 55 (32.2%) 49 (8.1%) 95 (5.1%) Gammas: 70 (2.6%) 97 (32%) 103 (22.2%) X-rays: 41 (100.5%) 47 (25.3%)
<sup>154</sup> Eu	8.8 Y	$\beta$ , EC	High	0.02	0.001	6.3	29.1	Betas: 247 (27.9%) 569 (36.5%) 839 (17.4%) 1,844 (11.4%) Gammas: 723 (19.7%) 873 (11.5%) 1,005 (17.9%) 127 (35.5%)
<sup>169</sup> Yb	32.01 D	EC	Moderate	0.7	0.1	1.8	1.6	Electrons: 50 (34.9%) 100 (5.6%) 118 (10.3%) 120 (51.6%) 139 (12.4%) Gammas: 63 (42%) 110 (17%) 131 (12%) 177 (22%) 197 (36%) 307 (10%) X-rays: 50 (147%) 58 (39%)
<sup>186</sup> Re	3.78 D	$\beta$	Moderate	2	0.1	0.2	0.8	Betas: 1,070 (94%) 1,076 (71%) Gammas: 137 (9.5%)
<sup>188</sup> Re	16.98 H	$\beta$	Moderate	2	0.1	0.3	16.8	Betas: 2,120 (71.4%) Gammas: 155 (15%)
<sup>192</sup> Ir	74.02 D	$\beta$ , EC	High	0.2	0.001	4.8	20	Betas: 536 (41.4%) 672 (48.3%) Gammas: 296 (29%) 308 (29.7%) 317 (82.8%) 468 (48%) 604 (8.2%) 612 (5.3%)
<sup>198</sup> Au	2.7 D	$\beta$	Moderate	1	0.1	2.4	10.1	Betas: 961 (98.6%) Gammas: 412 (95.5%)
<sup>201</sup> Tl	3.04 D	EC	Low	20	1	0.4	0.9	Electrons: 84 (15.4%) Gammas: 167 (10%) X-rays: 69 (27.4%) 71 (46.5%) 80 (20.5%)
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<sup>203</sup> Hg	46.6 D	$\beta$	Moderate	0.5	0.1	1.3	4.7	Betas: 212 (100%) Electrons: 194 (16.9%) 264 (4.4%) Gammas: 279 (77.3%) X-rays: 71 (4.7%) 73 (8.0%)
<sup>206</sup> Bi	6.24 D	EC	Moderate	0.6	0.1	17.2	26	Electrons: 96 (22.2%) 256 (5.6%) Gammas: 516 (40%) 803 (98.9%) 881 (66.2%) 1,719 (32%)
<sup>207</sup> Bi	38 Y	EC	High	0.4	0.01	8.3	25.8	Electrons: 976 (7.0%) Gammas: 570 (97.7%) 1,064 (75%) 1,770 (6.8%)
<sup>208</sup> Po	2.93 Y	$\alpha$	High	0.014	0.000001	-	-	Alphas: 5,110 (100%)
<sup>210</sup> Pb	22.3 Y	$\beta$	Very High	0.0002	0.00001	0.0	0.2	Betas: 17 (80.2%) 63 (19.8%) Electrons: 8 (33.6%) 30 (57.9%) 43 (18.1%) Gammas: 11 (24%)
<sup>210</sup> Po	138.38 D	$\alpha$	Very High	0.0006	0.0001	-	-	Alphas: 5,305 (100%)
<sup>222</sup> Rn	3.82 D	$\alpha$	High	0.1	0.001	-	-	Alphas: 5,490 (99.9%)
<sup>226</sup> Ra	1,600 Y	$\alpha$	Very High	0.0006	0.0001	-	-	Alphas: 4,602 (5.6%) 4,785 (94.6%)
<sup>228</sup> Th	1.91 Y	$\alpha$	Very High	0.00001	0.000001	-	-	Alphas: 5,341 (26.7%) 5,423 (72.7%) Electrons: 9 (9.6%) 65 (19.1%) 80 (5.2%) X-rays: 12 (9.6%)
<sup>238</sup> Pu	87.74 Y	$\alpha$ , SF	Very High	0.000007	0.000001	-	-	Alphas: 5,457 (28.3%) 5,499 (71.6%) Electrons: 10 (9.1%) 22 (20.7%) 38 (7.6%) X-rays: 14 (11.6%)
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<sup>238</sup> U	4.5 x 10 <sup>9</sup> Y	$\alpha$ , SF	Very High	0.00004	0.1	-	-	Alphas: 4,147 (23%) 4,196 (77%) Electrons: 10 (8.2%) 29 (16.8%) 44 (6.1%) X-rays: 13 (9%)
<sup>239</sup> Pu	24,065 Y	$\alpha$	Very High	0.000006	0.000001	-	-	Alphas: 5,105 (11.5%) 5,143 (15.1%) 5,155 (73.3%) Electrons: 7 (19%)
<sup>241</sup> Am	432.2 Y	$\alpha$	Very High	0.000006	0.000001	0.1	0.4	Alphas: 5,443 (12.8%) 5,486 (85.2%) Gammas: 60 (35.9%)
<sup>244</sup> Cm	18.11 Y	$\alpha$ , SF	Very High	0.00001	0.000001	-	-	Alphas: 5,763 (23.6%) 5,805 (76.4%) Electrons: 10 (6.9%) 20 (17.2%) 37 (6.3%) X-rays: 14 (10.3%)
<sup>250</sup> Cf	13.08 Y	$\alpha$	Very High	0.000009	0.000001	-	-	Alphas: 5,989 (16.2%) 6,031 (83.4%) Electrons: 18 (12%) X-rays: 15 (7.8%)
<sup>252</sup> Cf	2.638 Y	$\alpha$ , SF	Very High	0.00002	0.000001	-	-	Alphas: 6,076 (15.2%) 6,118 (81.6%) Electrons: 19 (11.2%) X-rays: 15 (7.3%)
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