Analysis of West Cumbrian Beach Monitoring for Radioactive Particles and Stones between April 2006 to March 2012

Introduction

This analysis is compiled from the figures in Sellafield's Annual Beach Monitoring Report for 2008/09 and 2009/10 which was later renamed to Sellafield's Particles in the Environment Annual Reports for 2010/11 and 2011/12 which are produced in accordance to their fiscal calendar.

	2006/07		2007/08		2008/09		2009/10		2010/11		2011/12		
Area Surveyed / Per Fiscal Year	Particles	Stones	Particles	Stones	Particles	Stones	Particles	Stones	Particles	Stones	Particles	Stones	Total
St Bees	-	-	6	0	3	0	4	0	60	0	41	0	**114**
Braystones	3	0	2	0	4	0	68	0	115	0	60	0	**252**
Sellafield	4	5	129	204	79	141	102	50	142	35	146	13	**1050**
Seascale	-	-	7	0	10	3	17	0	10	0	2	0	**49**
Drigg	-	-	5	0	2	0	0	0	10	0	3	0	**20**
Allonby	-	-	-	-	1	0	-	-	0	0	1	0	**2**
Workington	-	-	-	-	1	0	-	-	-	-	-	-	**1**
Other	-	-	-	-	-	-	-	-	11	0	1	0	**12**
Total	**7**	**5**	**149**	**204**	**100**	**144**	**191**	**50**	**348**	**35**	**254**	**13**	
Total Finds Per Fiscal Year	**12**		**353**		**244**		**241**		**383**		**267**		
Total Finds Cumulative 2006-2011	**1500**												

Figure 1-1 – A table to show the radioactive particles and stones recovered from West Cumbria's beach monitoring programmes from 2006/07 through to 2011/12.

Hectares Covered in (ha) / Per Fiscal Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
St Bees	-	-	56.5	67.33	53.07	32.69
Braystones	-	-	34.7	65.17	76.59	59.19
Sellafield	-	-	108	69.69	67.13	58.73
Seascale	-	-	69	96.43	51.06	23.85
Drigg	-	-	39.2	37.65	41.81	19.14
Allonby	-	-	19.6	-	10.44	14.93
Workington	-	-	25.6	-	-	-
Other	-	-	-	-	-	5.46
Cumulative	**-**	**-**	**352.6**	**336.27**	**300.1**	**213.99**
Total Hectares Covered 2006-2011	**1202.96**					

Figure 1-2 – A table to show the hectare coverage (ha) of West Cumbrian beaches monitoring programme for each fiscal year.

Finds per Hectare / Per Fiscal Year	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
St Bees	-	-	0.05	0.06	1.13	1.25
Braystones	-	-	0.12	1.04	1.50	1.01
Sellafield	-	-	2.04	2.18	2.64	2.71
Seascale	-	-	0.19	0.18	0.20	0.08
Drigg	-	-	0.05	0.00	0.24	0.16
Allonby	-	-	0.05	-	0.00	0.07
Workington	-	-	0.04	-	-	-
Other	-	-	-	-	-	0.18
Cumulative	**-**	**-**	**0.69**	**0.72**	**1.28**	**1.25**

Figure 1-3 – A table to show the finds per hectare, per beach, for each fiscal year.

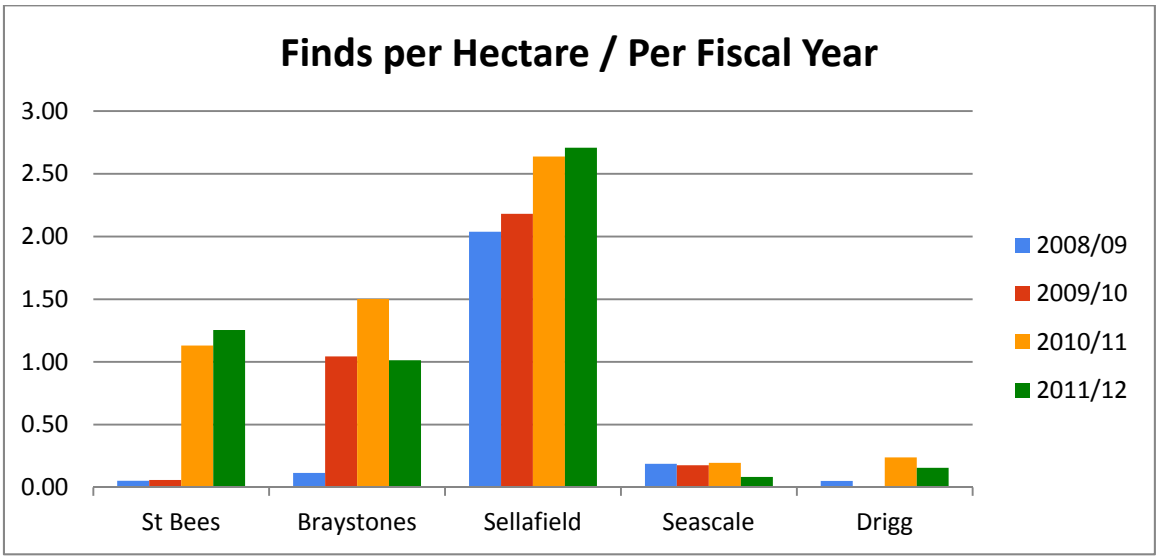

Figure 2-1 – A graph to show the Finds per Hectare for each fiscal year for the five main West Cumbrian beaches

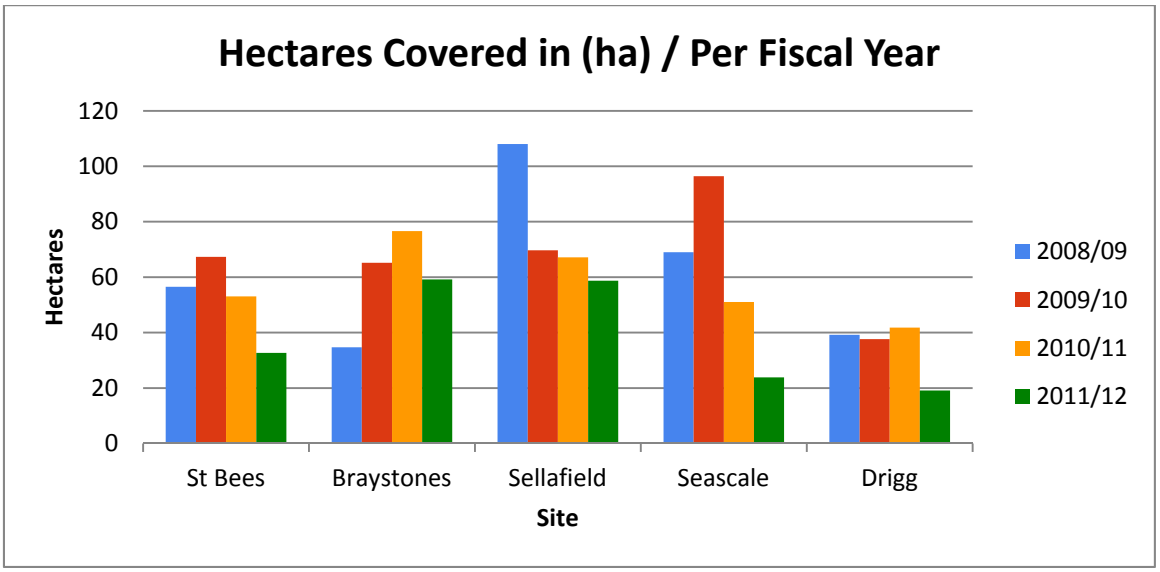

Figure 2-2 – A graph to show the Hectares Covered for each fiscal year for the five main West Cumbrian beaches

Figures 2-1 and 2-2 have been generated from the data shown on Figures 1-1 through to 1-3. These graphs show that while finds per hectare are increasing on some beaches, the number of hectares covered by Sellafield's monitoring programme continues to reduce.

Seascale (a high occupancy beach) observed a 53% reduction in hectares covered from 2010/11 to 2011/12 programme, whilst finds per hectare had increased 11% from 2009/10 to 2010/11.

At Sellafield beach hectares covered between 2008/09 to 2011/12 has been reduced by 46%, whilst finds per hectare had increased by 33% during the same period.

Braystones beach observed a 23% reduction in hectares covered from 2011 to 2012, whilst finds per hectare finds per hectare had increased 1203% from 2008/09 to 2010/11.

Drigg beach observed a 54% reduction in hectares covered from 2010/11 to 2011/12, whilst finds per hectare had increased from 0 (not quantifiable as a percentage) to 0.24 from 2009/10 to 2010/11.

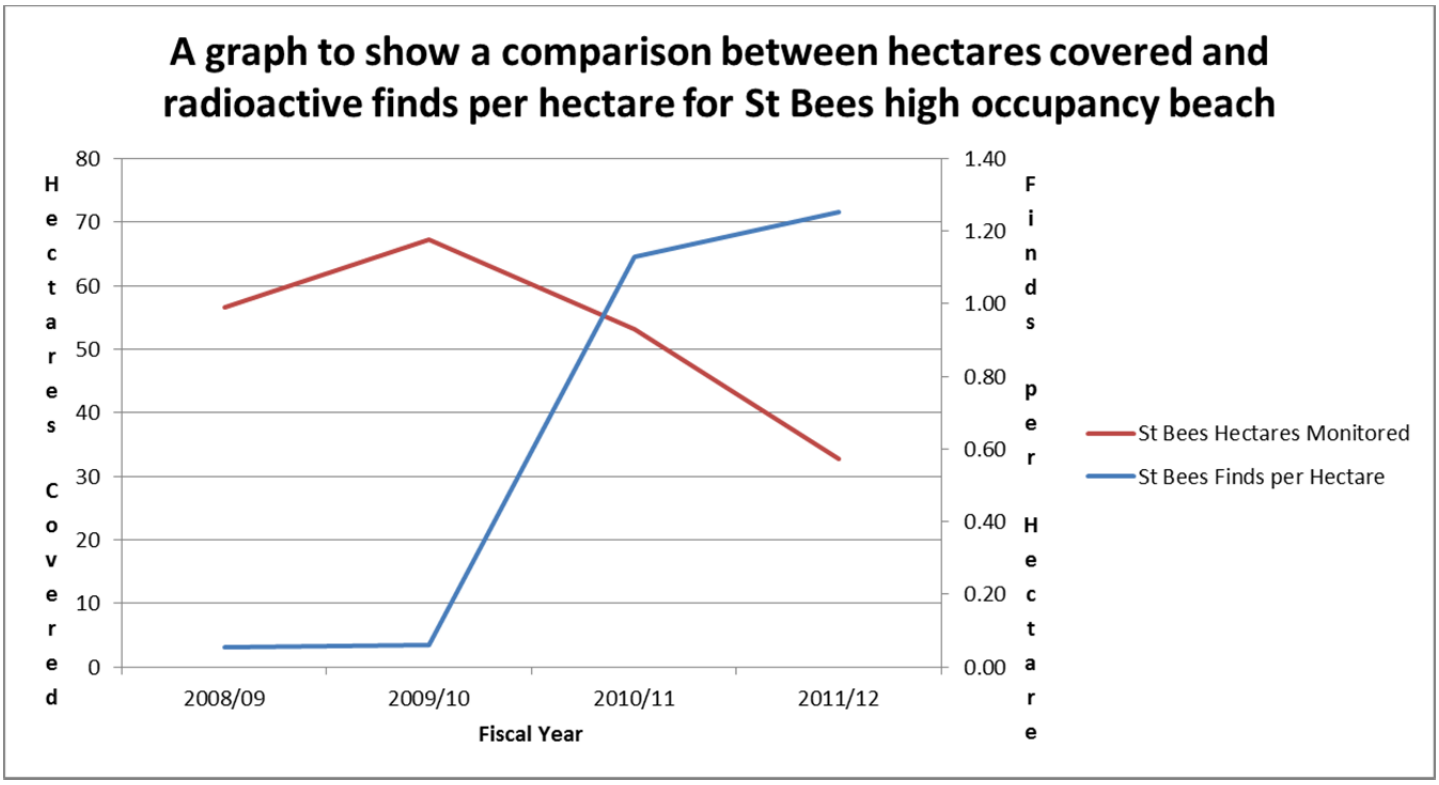

Figure 2-3 - A graph to show a comparison between hectares covered and radioactive finds per hectare for St Bees high occupancy beach

Figure 2-3 shows that St Bees, (a high occupancy beach) observed a 42% reduction in hectares covered from 2008/09 to 2011/12, whilst finds per hectare had increased significantly by 2262% during the same period.

Conclusions

The analysis shows that, whilst overall cumulative radioactive finds per hectare across the West Cumbrian coast have risen by 84% between 2008/09 and 2010/11, the total number of beach monitoring hectares has been reduced by 39% since 2008/09.

It is evident that an increase of finds on a particular beach one year, does not result in increased beach monitoring in future years. This is not only the case at the high occupancy beaches at St Bees and Seascale, but also at Sellafield, Braystones and Drigg.

Further Reading

I will close by drawing your attention to Appendix 1 (5 pages) of the Sellafield Beach Summary Report 2008, which explains Ionising Radiation and the health risks of the key Isotopes which are being found and retrieved on the West Cumbrian beaches.

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References

Figure 1-1 and Figure 1-2

Data within these tables have been extracted from the Sellafield reports released annually which are publically available to view at the links below:

http://www.sellafieldsites.com/wp-content/uploads/2012/08/Annual-Beach-Monitoring-Report-2008-9-Issue1-27-07-091.pdf

http://www.sellafieldsites.com/wp-content/uploads/2012/08/Annual-Beach-Monitoring-Report-2009-10-ISSUE-VERSION-30_07_10.pdf

http://www.sellafieldsites.com/wp-content/uploads/2012/08/Particles-in-the-Environment-Annual-Report-2010_11.pdf

http://www.sellafieldsites.com/wp-content/uploads/2012/08/Particles-in-the-Environment-Annual-Report-2011_12.pdf

Figure 1-3

Figure 1-3 uses this data, with a simple formula to add particles and stones together for the individual beach area and divide it by the hectares covered for that beach for that Fiscal monitoring programme, to provide a comparable figure based on the results of each year.

The cumulative value in Figure 1-3 divides the total finds per fiscal year in Figure 1-1 by the cumulative hectares covered during the same fiscal year from Figure 1-2, this gives the cumulative finds per hectare for each fiscal year.

Appendix 1 – Ionising Radiation and Key Isotopes,

Appendix 1 is taken from the Sellafield Ltd Summary Report: Detection and Recovery of Radioactive Particulate from Beaches associated with the Sellafield Nuclear Licensed Site. July 2003 to the end of March 2008. Issue 2. November 2008. 19th November 2008. SSEM/2008/64.

Appendix 1: Ionising Radiation & Key Isotopes

Ionising Radiation

Ionising radiation is defined, by the Oxford English Dictionary, as 'radiation consisting of particles, X-rays, or gamma rays which produce ions in the medium through which it passes'.

Ionising radiation is produced by the radioactive decay of unstable atomic nuclei; the most common forms of emitted ionising radiation generated by this process being alpha particles, beta-negative particles and gamma photons.

Ionisation of tissues can damage the structure and funcionality of the cells, causing organs and processes to lose malfunction or to break down. Ionising radiation can also induce DNA alteration by interfering with the genetic material of the cell. DNA double-strand breaks are generally accepted to be the most biologically significant lesion by which ionizing radiation causes cancer and hereditary disease.

Alpha Particles:

An alpha particle (α) consists of 2 protons and 2 neutrons, and is in essence a helium nucleus. Upon interaction with another atom, the alpha particle will attract and acquire an electron causing the other atom to become a positively charged ion.

Due to the relatively large size of the particle, the ionising effects of this form of ionising radiation are localised about the source. An alpha particle loses a portion of its energy each time it interacts with another particle and produces an ion; hence, the range of alpha radiation is only a few centimetres in air as the particle will lose its ionising influence due to interactions with the air itself.

Alpha particles cannot penetrate a single layer of skin and are therefore only a concern to health if introduced into a biological system directly, via inhalation, ingestion or into the bloodstream via an open wound. Again due to the relatively large size of the particle, once within the body the ionising effect on surrounding tissues is concentrated, with several MeV of energy being deposited in a small area, increasing the chance of cellular damage.

Beta Particles:

A beta particle (β) can be either negative β- (called an electron or negatron) or positive β+ (called a positron), generated by the conversion of a neutron to a proton or a proton to a neutron respectively. The strong attractive force which acts upon a negative beta particle when it passes close to an atom a will cause the beta-negative particle to lose energy in association with its deceleration via the emission of gamma photons (known as Bremsstrallung); when the beta-negative particle has lost a sufficient portion of its kinetic energy via this process it will associate with a neighbouring atom forming a negative ion.

A beta particle is much smaller than an alpha particle and therefore has an increased range in air, up to several metres, increasing in line with the initial energy of the beta particle.

Beta particles can penetrate the body to some extent (typically no more than a centimetre), again dependent on the initial energy of the beta particle, and therefore constitute a hazard (to skin and eye tissue in particular) whilst external to the body. If beta particles are introduced into the biological system via inhalation, ingestion or into the bloodstream via an open wound the resulting ionisation effects on surrounding tissues will be more widespread but less concentrated than those caused by alpha particles.

Gamma Photons:

A gamma photon (γ) is a form of electromagnetic radiation, a distinct bundle (quanta) of energy typically exceeding 0.1MeV, generated by transitions within atomic nuclei to release excess destabilising energy. Gamma photons are often produced as by-products of alpha or beta decay, which can each leave the nuclei in an excited state which requires the emission of excess energy.

Due to the high energy, high frequency and short wavelength of a gamma photon, their range in air is much greater than that for alpha or beta particles - up to several hundred metres, increasing in line with their energy.

Gamma photons can penetrate all tissues in the body, causing widespread ionisation, and generally passing through the body entirely.

Key Isotopes

The key isotopes described below are those which have been identified via analysis of the radioactive particulate recovered by the beach monitoring programme to date. The descriptions include the bio-availability of the identified isotopes and an initial consideration of their relative potential for harm.

Cobalt-60

^{60}Co is a beta emitting radioisotope, decaying via beta emission with an average beta-energy of 0.10 MeV and a maximum end-point beta-energy of 2.82 MeV. ^{60}Co has a half-life of approximately 5 years, decaying to form ^{60}Ni (Nickel-60) which is a stable isotope.

The beta decay of ^{60}Co is accompanied by the emission of 2 gamma photons with an approximate combined energy of 2.50 MeV. The gamma photon emission of ^{60}Co but has a high abundance, allowing for relatively consistent and effective detection of ^{60}Co radioactive particles by gamma photon detection techniques.

As a beta emitting isotope, ^{60}Co is a concern to health once inside the body, most commonly entering either via inhalation or ingestion. Approximately 10% of Cobalt is

absorbed via the gastrointestinal tract or alveolar wall, dependent on the cobalt compound(s) present; once within the body ^{60}Co is transported in the bloodstream and deposited in most tissues with the highest concentration accumulating in the liver. Cobalt is a primary component of the Vitamin B12 and as such can be retained within the body for an extended period of time. Of the ^{60}Co that reaches the bloodstream, around 50% will be removed by the kidneys and directly excreted from the body. Of the remaining 50% which deposits in various bodily tissues around 80% has a biological half-life of between 20 and 60 days, and the remaining 20% has a much longer biological half-life of over 2 years.

The majority of Cobalt is expected to be removed from the body in a relatively short period of time and therefore has only the potential to cause acute harm upon exposure to a high activity source. Dependent on the concentrations present, any ^{60}Co which remains within the body for an extended period of time has the potential to cause chronic harm, particularly due to the relatively high energy gamma photons emitted during the decay of this radioisotope.

Strontium-90:

^{90}Sr is a beta emitting radioisotope, decaying via pure beta emission with an average beta-energy of 0.20 MeV and a maximum end-point beta-energy of 0.54 MeV.

^{90}Sr has a half-life of approximately 29 years, decaying to form ^{90}Y (Yttrium-90). ^{90}Y is a second beta emitting isotope with a much shorter half-life of around 64 hours and a significantly higher average beta-energy of 0.94 MeV and maximum beta energy of 2.28 MeV. The gamma photon associated with the beta decay of ^{90}Y is low energy (average <0.001MeV, maximum 0.682 MeV), and low abundance, making the detection of ^{90}Sr/^{90}Y active particles using gamma photon detection methods difficult.

^{90}Sr, and many other beta emitting isotopes including ^{90}Y, may be detectable due to the gamma radiation induced by the interaction of the emitted beta electrons and the surrounding matter, an effect known as Bremsstrahlung.

As a beta emitting isotope, ^{90}Sr is a concern to health once inside the body, most commonly entering either via inhalation or ingestion. Strontium is a metabolic analogue of Calcium, rapidly absorbed via the gastrointestinal tract or alveolar wall and deposited in the bones; thereafter affecting bone growth and repair, and the formation of new blood cells. The detrimental health effects caused by the presence of ^{90}Sr, once associated to the bone tissues, are largely connected to the more energetic beta decay of its daughter, ^{90}Y.

^{90}Sr is also an isotope of particular concern due to its long ‘biological half-life’, the length of time for half the acquired isotope to be removed/excreted by natural biological processes, which in this case is approximately 49 years - meaning that the isotope remains in the body for an extended period of time and therefore has an increased potential to cause chronic harm to surrounding tissues.

Caesium-137:

^{137}Cs is a beta emitting radioisotope, decaying via pure beta emission with an average beta-energy of 0.19 MeV and a maximum end-point beta-energy of 1.18 MeV. ^{137}Cs has a half-life of approximately 30 years, decaying to form ^{137}Ba (Barium-90), which is a gamma emitting isotope with a much shorter half-life of around 2.6 minutes.

The gamma photon decay of ^{137}Ba is low energy (0.66 MeV), but has an abundance of 100%, allowing for relatively consistent and effective detection of ^{137}Cs/^{137}Ba active particles by gamma photon detection techniques.

As a beta emitting isotope, ^{137}Cs is a concern to health once inside the body, most commonly entering either via inhalation or ingestion. Caesium behaves similarly to Potassium upon intake into the body; approximately 40-60% is absorbed via the gastrointestinal tract or alveolar wall, transported in the bloodstream and deposited in most tissues with the highest concentration accumulating in the muscles.

^{137}Cs is an isotope of comparably less concern biologically, due to its much shorter biological half-life, which in this case is approximately 70 days - meaning that the isotope is removed from the body in a relatively short period of time and therefore has the potential to cause acute harm upon exposure to a high activity source but has a reduced potential to cause chronic harm.

Americium-241:

^{241}Am is an alpha emitter, decaying via alpha emission with an energy of 5.638MeV. The gamma photon associated with the alpha decay of ^{241}Am is low energy (average 0.03 MeV, maximum 0.059 MeV), but high in abundance, allowing for relatively consistent detection of ^{241}Am active particles using gamma photon detection methods.

^{241}Am has a half-life of approximately 432 years; decaying to form ^{237}Np (Neptunium-237), which is an alpha emitting isotope with a much longer half-life of around 2.1 million years.

As an alpha emitting isotope, ^{241}Am is only a concern to health once inside the body, most commonly entering either via inhalation or ingestion. Upon intake into the body; ^{241}Am is absorbed via the gastrointestinal tract or alveolar wall, transported in the bloodstream and concentrated in the bones, liver and muscles.

^{241}Am is also an isotope of particular concern due to its long 'biological half-life', which is approximately 50 years for ^{241}Am concentrated in bone tissues and 20 years in liver tissues - meaning that the isotope remains in the body for an extended period of time and therefore has an increased potential to cause chronic harm to surrounding tissues.

Plutonium-239, Plutonium-240 and Plutonium-241:

Plutonium isotopes are generated by fission processes and are therefore expected to be associated with any particle where ^{241}Am has been detected. All plutonium isotopes are radioactive and only an extremely small amount has ever been generated naturally in Earth's geology via sustained subterranean nuclear reactions approximately 1.9 billion years ago; therefore Plutonium is generally considered a synthetic or man-made radioisotope.

Plutonium isotopes generally decay by alpha or beta emission with very low energy associated gamma photons where present.

^{239}Pu has a long half-life of 24,110 years, decaying via alpha-emission with energy 5.245 MeV to ^{235}U; ^{235}U is a second alpha emitter with a very long half-life of 703,800,000 years.

^{240}Pu has a half-life of 6564 years, decaying via alpha emission with energy 5.256 MeV to ^{236}U; ^{236}U is a second alpha emitter, again with a long half-life of 23,420,000 years

^{241}Pu has a half-life of only 14.4 years, decaying via beta emission with energy 0.021 MeV to ^{241}Am and via alpha emission with energy 5.140 to ^{237}U.

As alpha and beta emitting isotopes, Plutonium is only a concern to health once inside the body, most commonly entering either via inhalation or ingestion. Plutonium is much more rapidly absorbed via the alveolar wall than via the gastrointestinal tract and is therefore much more hazardous upon inhalation than upon ingestion; thereafter depositing in the bones and liver, subsequently affecting bone growth and repair and liver function respectively.

Plutonium is also an substance of particular concern due to its long 'biological half-life', the length of time for half the acquired substance to be removed/excreted by natural biological processes, which in this case is approximately 50 years for that concentrated in bone tissues and 20 years in liver tissues - meaning that the isotopes remain in the body for an extended period of time and therefore have an increased potential to cause chronic harm to surrounding tissues.