Second Priority Substances List (PSL2) Comments on the Assessment of Releases of Radionuclides from Nuclear Facilities (Impact on Non-human Biota)

Comments on the *Canadian Environmental Protection Act, 1999* (CEPA 1999) PSL2 Draft Assessment Report on Releases of Radionuclides from Nuclear Facilities (Impact on Non-Human Biota) were provided by:

1. Advisory Committee on Radiological Protection
2. Atomic Energy of Canada Limited
3. BEAK International Inc. — on behalf of COGEMA, Rio Algom and Denison Mines Limited
4. Cameco
5. COGEMA Resources Inc.
6. Denison Mines Limited
7 Inter-Church Uranium Committee Educational Co-operative
8. A citizen from Saskatchewan
9. New Brunswick Power Corporation
10. Rio Algom
11. Ontario Power Generation
12. Saskatchewan Environment and Resource Management
13. Saskatchewan Mining Association
14. SENES Consultants — on behalf of Rio Algom and Denison Mines Limited

Comments and responses are summarized below by Environment Canada. (All were based on the English version of the report.)

Comment ***(source)***	**Response**
General	
1. Industry is already strictly regulated under federal and provincial legislation, including the Canadian Nuclear Safety Commission (CNSC) and the *Nuclear Safety and Control Act* (NSCA 2000) *(4,5,13)*.	Protection of the environment was not part of the *Atomic Energy Control Act* (1948). Because of this, members of the public were able to demonstrate to the Ministers' Expert Advisory Panel that the potential risks of radionuclide releases from nuclear facilities to non-human species warranted an ecological assessment under CEPA. In the revised assessment report, it is acknowledged that the NSCA 2000 gives the CNSC the legal responsibility to protect the environment. The new mandate of the CNSC will be considered by the Ministers when deciding how to manage risks associated with radionuclide releases from nuclear facilities
2. Conclusions are in conflict with joint federal/provincial	The federal/provincial assessment of new uranium mines and mills recognized that

Comment *(source)*	**Response**
environmental assessment and licensing and permitting activities, which determined that uranium mines and mills pose no significant risk to the environment *(4,5,13)*.	effects from whole effluents would occur in the near field, but concluded that mines and mills could be operated without significant environmental risk to the far field.
3. Does the proposal that waste management areas be considered CEPA toxic mean that power reactor waste management areas are also CEPA toxic *(10)*?	Releases from all sources at five nuclear generating stations were assessed together and found to represent little risk to the environment. The waste management areas at these sites did not in fact influence the risk quotients, because they are designed to have no releases to the environment. In the revised report, it is concluded that releases of radionuclides from "stand-alone" waste management areas are not causing environmental harm.
4. No recognition of the use of nuclear fuel versus oil or coal *(13)*.	This is outside the scope of this risk assessment.
5. There are socio-economic repercussions of declaring a substance CEPA toxic *(13)*.	This is outside the scope of this risk assessment.
Scientific and Technical	
6. Lack of meaningful consultation or input from uranium mine and mill operators. *(2,4,5,6,10,13)*.	The availability of accurate entry information from existing CNSC data and reports explains, in part, the lower level of stakeholder involvement in this assessment. Stakeholders had an opportunity to review the data used to assess each of their facilities and provide input on the draft-supporting document. In addition, stakeholders were able to present new information at the December 2000 stakeholders' meeting and three one-day workshops in March 2001 that discussed technical issues.
7. The assessment does not include adequate information for risk management decisions *(13,14)*.	The assessment document, together with the supporting document, provides information on which taxa are most likely to be harmed at each site, the location of potential harm, an indication of the spatial distribution of potential harm, an estimate of the magnitude of potential harm and an indication of which radionuclides are of concern.
8. Lack of independent review *(1,2,3,4,5,6,8,10,11,13,14)*.	An independent peer review was undertaken in parallel with the 60-day period for stakeholder and public comment. The names of the independent reviewers and their comments were made available to stakeholders for their evaluation. The names of the independent reviewers are included in the revised assessment report.
9. Inclusion of data on releases of radionuclides from within the project boundaries as if they were representative of the receiving environment *(2,4,5,13)*.	Since aquatic biota may occur in surface water systems near outfall pipes, concentration data from these areas may be used to estimate exposure. For this reason, lakes receiving effluents within the near field/mixing zone were included in the assessment. Similar evidence of on-site and/or relatively local impacts has been used in other CEPA assessments to support a conclusion of CEPA toxic.

Comment *(source)*	**Response**
10. Heavy reliance on data from historic mining and milling areas (Beaverlodge Lake and Serpent River) *(4,13)*, and exclusion of areas under the responsibility of the Government of Canada (Port Radium) *(13)*.	By definition, nuclear facilities are licensed by the Atomic Energy Control Board (AECB)/CNSC. Therefore, the assessment was restricted only to those facilities licensed by the AECB/CNSC at the time PSL2 was announced in 1995. It is for this reason that Port Radium was excluded. Since the Beaverlodge and Serpent River sites were no longer operating and are decommissioned facilities, evidence of potential impacts at these sites is not critical to a determination of CEPA toxic.
11. Exclusion of two new state-of-the-art operations *(4,5,13)*.	These new facilities, at McClean Lake and McArthur River, were licensed to operate in 1999 and had not been in operation long enough to have relevant effluent and environmental monitoring data when the initial scoping for this assessment was done. Since then, such data have been identified and included in the final assessment report.
12. Unclear why substantially more data are presented on northern Saskatchewan uranium mining and milling facilities than on other nuclear facilities *(12)*.	More data are presented on northern Saskatchewan facilities than on most other facilities because of the nature of the assessment, the location/nature of the study sites and the availability of data. Uranium toxicity was a concern at uranium mining facilities, but was not an issue at nuclear generating stations and at Chalk River Laboratories waste management areas, so no uranium data were presented for these latter facilities. Furthermore, receiving environments for the latter are simpler systems than for uranium mines, hence fewer data are required for monitoring.
13. There were a number of errors • uranium concentration data for fish *(3)*; • value for uranium at Port Hope in Table 5.27 *(3)*; • other data used (by 3 orders of magnitude) *(3)*; • dose conversion factor (DCF) for Cs *(3)*; • Tier 1 RQ in Ottawa River *(3)*; • ENEV for mammals: RBE correction for tritium *(3)*.	These have been corrected. Other errors identified have been checked and corrected as appropriate. Spreadsheets of the final calculations were provided to representatives of each facility for quality assurance purposes and further revisions were made where needed.
14. The estimated no-effects value (ENEV) for uranium is based on the most conservative critical toxicity value (CTV) for protection against minor reversible kidney effects in humans and has no relevance to protection of animal survival or reproduction *(3)*.	Published data on uranium toxicity to the kidney are extensive and support the relevance of kidney effects. However, in re-evaluating the uranium toxicity data discussed at the March 2001 workshop, it was realized that the most sensitive and unambiguous wildlife endpoint was mortality to the newborn mouse. Therefore, the ENEV is now based on mortality to the newborn mouse instead of permanent kidney damage.
15. The uranium ENEV derived for bison is not appropriate to represent small mammals and birds *(3)*.	The ENEV for uranium toxicity to wildlife was revised and is now based on mortality to the newborn mouse. The ENEV for mortality of offspring in mice was scaled to the body size of the muskrat, mink and red fox. In the revised report, it is

Comment *(source)*	Response
	noted that, because of the lack of acceptable data on effects on birds, an ENEV could not be determined.
16. Bosshard *et al*. (1992)[1] cited as supporting a 0.5 mg/kg threshold for uranium is not correct (threshold >2 mg/kg and no effects <1 mg/kg) *(3)*.	Now that the ENEV for wildlife is based on mortality of offspring in mice, the comment is less relevant. Nevertheless, Bosshard *et al.* (1992)[1] state "that histopathological changes do not usually occur in kidney with U organ concentration <0.5 mg/kg." They also state that "a no-observed-effect level (NOEL) for U of 1 mg/kg bw/d is estimated."
17. Uranium ENEV for terrestrial plants is too conservative and should be based on germination *(14)*.	After re-evaluating data on uranium toxicity following the March 2001 Technical Working Group meetings, it was decided to set the ENEV for terrestrial plants equal to the NOEL of 300 mg/kg dw reported in a germination study.
18. Uranium ENEVs for *Daphnia* and *Ceriodaphnia* are too conservative, and original studies are difficult to obtain *(3).*	The studies on the toxicity of uranium to *Ceriodaphnia* and *Daphnia* are available from the CNSC library through inter-library loan. The ENEV has been revised to one value for plankton representing both zooplankton and phytoplankton (algae) based on the average value of the ENEVs for *Ceriodaphnia*, *Daphnia* and freshwater algae in four studies in soft water. A second ENEV was derived for moderately hard water based on effects data for *Daphnia*. In all cases, the application factor used was as small as possible (i.e., 1.0).
19. Uranium ENEV for benthic invertebrates based on the lowest effect level screening concentration for northern Saskatchewan and uranium-spiked sediment toxicity by BEAK *(3,5).* The BEAK International Inc. (1998)[1] value of 57 mg/kg should be used for the ENEV *(14).*	The ENEV for benthic invertebrates was revised following discussions at the March 2001 workshop. The revised ENEV is 104 mg/kg dw, based on the screening-level concentration approach and using an application factor of 1. This value is within the range of low effect levels reported in laboratory toxicity tests, including the study of BEAK International Inc. (1998)[1]. This ENEV is also above typical background concentrations in northern Saskatchewan and the Elliot Lake region of Ontario.
20. 100-fold error in background concentration for uranium, which is carried over to the uranium toxicity assessment *(3).*	The background concentration is correct. Appropriate footnotes have been added to Table 6 to provide sources for the data and assumptions used.
21. Substantial error in background sediment uranium concentration in northern Saskatchewan *(3)*.	The background value is correct. The sources for the data and assumptions used are indicated in the footnote to Table 6.
22. Risks to benthos from exposure to uranium are overstated *(3)*.	As indicated in Table 7 of the final assessment report, changes to the estimated exposure value (EEV) and ENEV have resulted in an RQ of 0.03 for benthos in Dunlop Lake, a reference location in the Serpent River basin. However, seven other lakes that have received releases from uranium mines and mills have values marginally greater than 1 (1.05–2.6) based on Serpent River Watershed Monitoring Program data collected in 1999.

Comment ***(source)***	**Response**
23. Risk to osprey and mink in Island Lake driven by uranium sediment concentrations *(3).*	It is assumed that wildlife are exposed to littoral sediments with the same uranium concentration as that measured in sediments at the specific monitoring site. In calculating the uranium concentration of wet sediment, the measured moisture content of the sediment was used if available; otherwise default values were used. In the revised assessment report the risk quotient for osprey has been removed.
24. Uranium toxicity should be adjusted for hardness *(3).* Discussion on water chemistry with hardness should be added *(3).*	The revised assessment report includes a discussion of the influence of hardness and alkalinity on uranium bioavailability and toxicity. In the absence of experimental toxicity data derived under conditions representative of waters receiving treated effluent, two ENEVs were derived for plankton: one (11 µg/L) representative of soft water conditions (hardness <100 mg/L), and the other (218 µ g/L) representative of water with hardness greater than 100 mg/L. For fish, data were available to derive only one ENEV (160 µg/L), applicable primarily to softer water (hardness <100 mg/L).
25. Other contaminants besides uranium are in Port Hope Harbour, including perhaps those resulting from the use of the harbour for solid process wastes during early years of operation *(3).*	This is beyond the scope of the assessment, which focuses strictly on radiation effects and uranium toxicity.
26. Source of uranium concentration data in Elliot Lake *(14)?*	The data sources are clarified in the final assessment report.
27. Historical uranium data not considered for sediment beyond SENES Consultants Ltd. and NEA Inc. (1994)[1] data *(14).*	Risk was assessed for present conditions, not historical ones, to the extent possible, based on the data available. Higher concentrations are seen in earlier data than are usually seen today, and hence higher, less representative RQs would be calculated if historical data were used.
28. Most recent uranium data for McCabe Lake and Dunlop Lake from BEAK International Inc. (1996)[1] not included *(3,14).*	These data have been incorporated.
29. Sediment uranium data based on values generated no matter what the digestion *(14).*	All available data on sediment uranium content were used, regardless of whether they were obtained using aqua regia or other means. The implications of this are discussed in the revised assessment report.
30. Application factors do not follow the guidance manual, i.e., the application factor should be 100 not 10 for the acute uranium toxicity data for fathead minnow and closer to 1 for the earthworm, since earthworms are similar *(14).*	In the revised assessment report, the factor of 10 applied to the LC_{50} for fathead minnow is now described as an acute:chronic ratio. After re-evaluation of the toxicity data for earthworms, it has been decided that these data are insufficient to derive a reliable ENEV. More explanation of how application factors were chosen is provided in the revised assessment report.

Comment *(source)*	**Response**
31. Use of conservative EEVs *(2,3,5,14)*. Selection of maximum rather than average exposure concentrations and assessment of "composite" environments representative of worst-case conditions from several receiving environments in a region are a major departure from realism in the Tier 2 assessment *(3,5,6,7,10,12,14)*. Use of single maximum values for consideration in exposure *(3)*.	The assessment report has been revised and now provides more realistic scenarios and does not include assessments of "composite" environments. In the revised assessment report, conservative to hyperconservative EEVs were used to screen for potential toxic effects. If these values resulted in conservative RQs <1 for the taxa of concern, releases were considered to be not harmful. If the RQs were >1 for any given taxonomic group, then a second (more realistic) set of calculations was performed for that taxonomic group using more realistic EEVs.
32. Concerns about using Tier 1 radiation EEVs for calculation of RQs for nuclear generating stations *(3,9,11)*.	As indicated in Table 29 of the assessment report, conservative RQs for effects of ionizing radiation at nuclear generating stations are typically much less than 1.0. Consequently, there was no need to proceed to more realistic risk estimates.
33. Use of the term realistic for Tier 1 radiation EEVs at nuclear generating stations *(3)*.	A footnote has been added to Table 29 of the revised report explaining that these measured EEVs are considered to be "more realistic" than EEVs calculated using conservative assumptions.
34. Calculation of radiation dose to fish the sum of dose to bone plus dose to flesh *(3)*.	This approach was identified as too conservative. Therefore, dose calculations for fish were revised. Where data are presented only for concentrations in tissues (bone and flesh), the tissue with the highest concentration (i.e., bone) was used to represent the concentration in whole fish. This change, which may still be somewhat conservative, lowered the estimated dose to fish and subsequently the RQs for the effects of ionizing radiation on fish.
35. For benthos, the generic biota sediment accumulation factor is too high *(3)*.	It is acknowledged that the accumulation factor of 1.0 that was used may be somewhat conservative. In calculating the radionuclide concentration of wet sediment, measured sediment moisture content was used when available; otherwise, default values were used, as discussed in the final assessment report.
36. No data to support sediment uptake data for benthic invertebrates *(3)*.	An expanded rationale is provided in Section 3.4.1.7 of the revised assessment report.
37. Radiation dose to macrophytes inexplicably ignores macrophyte concentration data *(3)*.	The conservative analysis using maximum concentrations in lake water in the watershed and CRs for macrophytes gave an RQ slightly greater than 1. The more realistic calculation presented in the revised report using macrophyte concentration data, demonstrated that there was little likelihood of harmful effects on aquatic macrophytes.
38. Documentation in converting measurements for ^{14}C from Bq per unit C to Bq wet weight fish *(3)*.	The assessment report has been revised (see Section 3.4.2.3) to include the conversion factors used and their source.
39. Use of non-detects (i.e., values at or below detection limits) to	The use of the detection limit to put an upper bound on the dose is reasonable. In

Comment *(source)*	Response
drive the radiation dose estimate is inappropriate *(3).*	no circumstance will the use of detection limits result in a dose with an RQ of more than 1, especially in a more realistic calculation. This is discussed further in the revised assessment report.
40. The radiation RQ of 0.001 for macrophytes at Point Lepreau (Table 22) is not traceable *(3).*	The internal dose to macrophytes was combined with the external dose from water and from sediment (last page of Bird *et al.*, 2000); dividing by the ENEV of 1.0, this gives a revised RQ of 0.0002, as indicated in Table 29 of the final report.
41. Application of the ^{90}Sr DCF to gross beta *(3).*	This is the standard regulatory practice when individual radionuclides are not identified and quantified.
42. DCF for ^{90}Sr does not include ^{90}Y *(3).*	This is correct. Amiro (1997)[1] lists separate DCFs for ^{90}Sr and ^{90}Y. The dose calculations from ^{90}Sr have been revised to include the radiation dose from ^{90}Y assuming that half the measured radioactivity is from ^{90}Sr and the other half from ^{90}Y.
43. Traceability of risk quotients for Duke Swamp *(3).*	Estimates of dose to biota in Duke Swamp were made by AECL (1999)[1] using the DCFs of Amiro (1997)[1]. These dose values were divided by the appropriate ENEV to give the RQ. This is explained in more detail in the final assessment report. There may, however, be problems with these dose calculations, because of the CR used to estimate dose from ^{14}C (see “questionable bioconcentration factor for ^{14}C” below).
44. Selection of “questionable” bioconcentration factor for ^{14}C to calculate dose to invertebrates and small mammals at Chalk River Laboratories waste management areas. Specificity model should be used.	The calculations presented in the report were taken directly from AECL (1999)[1]. The selection of the ^{14}C CR from Bird and Schwartz (1996)[1] to calculate the radiation dose to benthic invertebrates may have been overly conservative. Furthermore, it was not clear what the CR for mammals (muskrat) was or its source, in the dose calculation by AECL (1999)[1]. In the revised assessment report, the radiation dose to biota was also calculated using the specific activity model approach.
45. Selection process for ENEVs does not focus on endpoints that are ecologically significant *(3).*	The measurement endpoints used to derive ENEVs have been reviewed, and in some cases (e.g., mammal ENEV for uranium, fish ENEV for radiation), revised. Survival, growth, reproduction and factors that affect these are ecologically relevant endpoints.
46. Use of conservative ENEVs *(3).* Remove the excessively conservative Tier 1 ENEVs from the assessment, since they have potential impacts on future assessments *(10)*.	The assessment report has been revised to include only one set of ENEVs, which incorporate a minimum of conservatism, for potentially exposed sensitive species.
47. Tier 1 ENEVs go well beyond any reasonable definition of hyperconservative *(3).*	Hyperconservative ENEVs have been removed. All ENEVs used in the revised assessment are considered to incorporate a minimum of conservatism and to be

Comment *(source)*	Response
	close to effect thresholds for sensitive species.
48. The Tier 1 ENEV application factor of 10 applied to the CTV of 1 mGy/d, killing some oocytes in monkeys, is in conflict with the guidance manual (Environment Canada, 1997) *(3)*.	The revised assessment report includes only one set of ENEVs, which incorporate a minimum of conservatism. The same ENEV is used for all RQ calculations. For the case in question, a revised ENEV of 3 mGy/d (1 Gy/a) is derived by applying an application factor of 1 and an RBE factor of 3 to the CTV of 1 mGy/d.
49. Tier 1 radiation ENEV for aquatic plants does not represent reproductive or population impairment *(3)*.	The revised assessment report uses only one set of ENEVs for all RQ calculations. The ENEV for aquatic plants of 1 Gy/a is now based on the ENEV for terrestrial plants, because of the scarcity of data for chronic radiation effects on aquatic plants.
50. Significant overestimation of the potential for effects in the receiving environment *(3)*.	In the revised assessment report, use of ENEVs that incorporate a minimum of conservatism, correction of calculation errors, mean annual aqueous contaminant concentrations, mean sediment concentrations (where more than one sediment sample was collected) and mean contaminant concentrations in fish and macrophytes (where data were available) reduces the likelihood that risks are significantly overestimated. The use of geometric mean concentration ratios in calculating the dose to biota for the more realistic assessment also reduces overestimation. However, the use of site-specific CRs, had they been available, would have resulted in a more accurate estimate of the dose.
51. ENEV for birds: no reproductive effect at 0.05 Gy/a does not justify acceptance of this dose rate as a threshold level for effects *(3)*.	This has been corrected. Upon review of the effects information for birds, it has been decided that data are at present insufficient to reliably estimate a radiation ENEV for birds.
52. Weight-of-evidence approach not used; site monitoring data not used in the assessment indicate that there are no negative effects from current uranium releases, or even higher earlier releases, on the species assessed to have high RQs in Island Lake, Cluff Lake Project — i.e., increase in *Ceriodaphnia recurvata* population in Island Lake with uranium concentration (*Ceriodaphnia* flourishes in Island Lake at 0.54 mg U/L); Gunnar Pit recolonized by biota, including fish; and invertebrate community structure in Agnes Lake similar to that of reference lake, despite 111 mg U/kg dw sediment *(5)*.	The ENEV in question has been revised and is now intended to represent plankton species in general. *Ceriodaphnia recurvata* may not be as sensitive to uranium toxicity as other plankton species. Available data from Island Lake suggest that there has been a substantial shift in the zooplankton composition, indicating a mine effluent effect. In Gunnar Pit, speciation modelling shows that >99% of the uranium would be associated with carbonates and would be non-toxic. Uranium sediment concentrations in Agnes Lake are elevated, but not quite to the point where harmful effects are expected (RQ < 1).
53. Lack of consideration of field data represents a fundamental flaw in the assessment methodology *(13)*.	Limited field data on effects are taken into consideration in the final assessment report. For example, through the use of the screening-level concentration approach to determine the ENEV for benthic organisms.
54. Ecologically relevant field data do not support the measurement endpoints *(14)*.	Because of ambiguities, field data on effects are often not considered in this assessment. Near-field environmental effects data do not demonstrate that the

Comment *(source)*	Response
	effects are due specifically to uranium toxicity or exposure to radiation, because other contaminants are also released from these facilities. Likewise, the presence of some organisms at certain contaminated sites does not mean that the organisms are not stressed and that other organisms have not been eliminated.
55. ENEVs that are not gamma equivalent should be adjusted for their relative biological effectiveness (RBE) *(3)*.	ENEVs have been corrected for the RBE factors used in calculating dose, 3 for tritium and 40 for alpha, where appropriate. In certain instances, this correction resulted in another study becoming the most sensitive study, and subsequently data from the most sensitive study were used for the CTV and in setting the ENEV.
56. Radiation ENEV for fish is based on no observed population-level effects for a non-indigenous species *(3,14)*. International consensus for ENEVs: 10 mGy/d for aquatic organisms and 1 mGy/d for terrestrial organisms *(1,2,3,4,10,14)*. ENEV for fish should be 8.8 Gy/a or 17.6 Gy/a based on international data *(2)*.	In the revised assessment report, the ENEV for fish has been changed to 0.2 Gy/a and is now based on data for reproductive effects in the carp in the Chernobyl cooling pond. There are few studies on the effects of chronic radiation exposure on endemic fish species, and no studies in Canada. For this reason, because carp are present in Canada, and because of the high quality of the Chernobyl studies, the ENEV for fish is based on Chernobyl research (although the possibility that factors other than radiation may have contributed to effects observed at Chernobyl is acknowledged). The suggested doses would not protect the most sensitive species in the wild.
57. Radiation ENEV for the aquatic invertebrate based on an experiment that suffered methodological problems and a marine organism *(3)*.	To our knowledge, there are no data available to demonstrate that freshwater invertebrates differ in radiosensitivity from marine invertebrates, such as the goose barnacle. However, because of poor growth/moulting of controls in the study with the goose barnacle, it was decided not to use this study to derive an ENEV. Based on the data for the polychaete worm (*Neanthes arenaceodentata*), a revised ENEV of 2 Gy/a has been derived.
58. Radiation ENEV for amphibians is too low, as it is lower than the ENEV developed for mammals, which are widely understood to be more sensitive to radiation *(3,14)*. Amphibians should have been used as an assessment endpoint *(14)*.	As noted the revised report, it was decided not to derive a radiation ENEV for amphibians. This was done because they are not monitored at the facilities, so no measured concentrations were available, and because little information is available on CRs for amphibians. There would be much greater uncertainty in the EEVs for amphibians than for the other organisms used.
59. Radiation ENEV for terrestrial invertebrates: 3 orders of magnitude error from literature, and value not adjusted for RBE factor of 40 *(3)*.	There was not a 3 order of magnitude error. However, due to uncertainty in the radiation source and dose estimates in the key studies with earthworms, it was agreed at the March 2001 workshop that the ENEV for terrestrial invertebrates should be based on that for aquatic invertebrates. Hence, the ENEV was revised accordingly.
60. Larger animals are more sensitive than small animals; difficult to reconcile *(14)*.	Larger, long-lived animals accumulate a larger radiation dose over their life cycle and are slower to reproduce than smaller, short-lived species, and therefore are

Comment *(source)*	Response
	assumed to be more vulnerable.
61. The long-term consequences of serious spills at Cluff Lake do not appear to have been taken into consideration *(8)*.	The assessment considered the most recent annual data in lake water, sediment, soil and biota to estimate risk to biota. This included the ^{226}Ra accidental addition to Snake Lake, in the Cluff lake area.
62. The long-term consequences of in-growth of ^{238}U and ^{230}Th daughters need to be considered *(7,8)*.	Radionuclide concentrations were assumed to be at equilibrium; thus, they were assumed to be at or near their maximum values during the operational phase of these mining operations.
63. There has been no analysis of internal damage to biota from alpha radiation at the mine sites, despite 20 years of mining high-grade uranium *(8)*.	To our knowledge, this statement is correct.
64. Values for ^{210}Po in water, sediment, fish, macrophytes and small mammals in Table 6.29 for Cluff Lake in the supporting document are not given *(8)*.	Values for ^{210}Po were not given because they were not measured. In these cases, the ^{210}Po concentration is estimated, assuming secular equilibrium with its parent, ^{210}Pb.
65. Adjustments for regional tolerance should be applied to the ENEV *(5,12,14)*.	It is acknowledged that there are uncertainties associated with the chosen ENEVs. However, in view of the absence of convincing data to justify its use, the assessment does not consider regional differences in sensitivity. Adjustments for regional tolerance should be applied to the ENEV only where this is demonstrated. It is also possible that organisms have limited tolerance, and elevated levels may stress organisms (i.e., the organisms may already be near their upper limit of tolerance), and therefore low ENEVs should be used to protect these organisms.
66. The Tier 3 analysis requires adjusting the effects characterization to take into account the tolerance of organisms normally found in naturally enriched areas *(14)*.	To our knowledge, no information is available on the enhanced tolerance of organisms found in naturally uranium-enriched areas in Canada. An equally likely scenario is that organisms at naturally enriched areas may not be particularly tolerant and may therefore already be stressed, such that further releases of contaminants may place even greater stress on these organisms. As indicated in the revised assessment report, all of the ENEVs are well above the 90th-percentile natural background uranium concentration.
67. Temporal, seasonal and spatial variability should be considered for Duke Swamp *(2)*.	The mean annual concentration was used to estimate dose, so seasonal variability is accounted for, as is temporal variability over a year. Since we are most interested in present conditions, data from the most recent sampling year (i.e., 1998) are appropriate. Spatial variability cannot be considered to any greater extent than AECL (1999)[1] did in their calculations, considering that no data are available to accurately estimate dilution in Duke Swamp. A mean and upper RQ are now given in the revised assessment report. The upper value is not a maximum value, but reflects reasonable concentrations to which benthic invertebrates may be

Comment *(source)*	Response
	exposed in the plume.
68. Spatial and temporal variation not accounted for *(2,3,5,6,10,14)*.	At most sites, mean annual values were used for water concentrations. Where only maximum concentrations were used and resulting RQs were >1.0, the assessment was revised by using mean concentration values. Generally, the most recent annual data were used, but in a few cases, particularly when there was considerable year-to-year variability in the data, an annual running mean was used. It is believed that using the most recent annual mean values results in a more accurate EEV that is representative of recent chronic exposures. Spatial variation was largely accounted for by using mean values for samples collected at different sites and by assessing potential toxicity in the more realistic assessment starting at the receiving lake or site with the highest mean concentrations and proceeding downstream until the RQ for the taxa of concern became <1.
69. Lack of consideration of animal movements and home ranges confined to unrealistically small area, e.g., vent raises at mines and small water bodies *(3)*.	The data for the vent raise in Table 26 clearly illustrate that even under this extreme condition, inhalation of radon does not result in significant doses in small mammals. Hence, there is no need to estimate these risks in a more realistic manner. In the revised assessment report, no home range adjustment was applied to mink or muskrat because of their limited home ranges. The red fox was assumed to spend 25% of its time at the contaminated water body, and its RQs were divided by 4 to reflect the potential effect of home range on the RQ.
70. A Tier 3 assessment was not performed *(1,2,3,4,5,6,9,10,11, 12,13,14)*. Had a Tier 3 assessment been performed, uranium would (likely) not have been found to be CEPA toxic *(3)*.	The assessment report has been revised to include deterministic (conservative and more realistic) assessments and a partial probabilistic assessment. The partial probabilistic assessment focused on the three older operating mines and mills in Saskatchewan: Rabbit Lake, Key Lake and Cluff Lake. Results of the probabilistic assessment were in agreement with those for the more realistic, deterministic assessment. This is because the more realistic deterministic assessments were based on measured concentrations for water, sediment, fish and macrophytes.
71. Samuels (1966)[1] reports an RBE of 50, not 80 *(3)*.	Samuels (1966)[1] states that the RBE for ^{210}Po alpha-particles may be as high as 50 or more compared with ^{60}Co gamma-rays. A straight line with a maximum RBE of 100 at 0.01 rad total dose is compatible with the data. The highest value of 400 is probably too high. Most values for RBE in Table 3 of Samuels (1966)[1] were about 80.
72. Haematopoiesis and sperm head aberration are not relevant endpoints for population success *(3)*.	Both endpoints are relevant to population success. The former is related to immune function, and the latter to reproduction.

Comment *(source)*	**Response**
73. Overall basis for selection of 40 as an RBE is not sufficiently substantiated *(3,14)*.	This section of the report has been rewritten for clarification and is supported by . Pentreath and Woodhead (2000, 2001).
74. For tritium, an RBE of 2 would be more representative of an average of the values presented in Straume and Carsten (1993) [2] *(3)*.	A value of 3 is a representative high-end value, based on available data using gamma rays as the reference radiation.
75. Pentreath (1998)[3] recommended an RBE of 3 for tritium. He cites values of 1.8–3.8, but no recommendation statement *(3)*.	This is correct.
76. Conservative RBE values unacceptable for a Tier 2 calculation *(3)*.	RBE factors of 40 and 3 for alpha emitters and tritium, respectively, are not believed to be very conservative. In the case of tritium, 3 is a representative high-end value based on available data. In the case of alpha emitters, an RBE of 40 is approximately a geometric mean value and takes into account the production of deterministic effects at low dose rates, but does not go to the extreme values of 200 or greater that arise at very low dose rates, due to the increasing ineffectiveness of the reference x- or gamma radiation.
77. The level of interest is population survival, not individuals *(3)*.	This is acknowledged, and this point is made with greater clarity in the revised assessment report. However, it should be noted that individuals make up populations. If a sufficient number of individuals are affected, this will ultimately be reflected at the population level.

[1] Please consult the Reference section of the assessment report for reference information.

[2] Straume, T. and A.L. Carsten. 1993. Tritium radiobiology and relative biological effectiveness. Health Phys. 65: 657–672.

[3] Pentreath, R.J. 1998. Radiological protection criteria for the natural environment. Radiat. Prot. Dosim. 75: 175–179.