

**Comments on
“Radiation & Health In Durham Region”
Report 2007**

**By Dr. Rosalie Bertell for IICPH
2 July 2007**

“Radiation & Health In Durham Region” Report 2007 was prepared by the Durham Region Health Department, Whitby, Ontario, Canada, and was released for comment in April 2007.

1. Comments on **Background**, page 1, 2nd paragraph, line 8: “...and health outcomes not associated with radiation (e.g. pancreatic cancer)”

Pancreatic cancer can not be ruled out with respect to radiogenesis. Scientists are learning more daily about changes in DNA that cause cells in the pancreas to become cancerous. Inherited changes in genes such as BRCA2, and the genes responsible for hereditary non-polyposis colorectal cancer (HNPCC) can increase a person's risk of developing pancreatic cancer. Researchers are now looking at how these genes may be altered in cases of pancreatic cancers that do not seem to be inherited. Non-inherited pancreatic cancer, due to changes in genes, can be initiated or promoted by radiation.

Researchers are also looking at tests for detecting other acquired (not inherited) genetic changes in pancreatic cancer pre-cancerous conditions. One of the most common DNA changes in these conditions affects the K-ras oncogene and alters regulation of cell growth. New diagnostic tests are now often able to recognize this change in samples of pancreatic juice prior to clinical manifestation of pancreatic cancer.

“A single radiation track (the lowest dose and dose rate possible) traversing the nucleus of an appropriate target cell, has a finite probability, albeit low, of generating the specific damage that will result in tumour-initiating mutation...at low dose rates, the risk of inducing neoplasia rises as a simple function of dose and does not have a DNA damage or DNA repair-related threshold-like component.” NRPB, UK 1995 [Ref. 1].

Pancreatic cancer is the fifth leading cause of cancer death in North America as well as many other places around the world. Its incidence cuts across all racial and socio-economic barriers and is nearly always fatal. Some evidence exists to show a possible connection between pancreatic cancer and exposure to ionizing radiation. For example, this possible connection is supported by evidence from studies of workers at nuclear facilities who have been exposed to ionizing radiation. The U.S. National Research Council has determined that the pancreas is relatively insensitive to ionizing radiation; however, **pancreatic cancer is designated as a “specified”**

cancer under the Energy Employees Occupational Illness Compensation Program, U.S. Department of Energy [Ref. 2].

According to Japanese Researchers who have studied atomic bomb survivors:

“Recent development of sophisticated technology including molecular biology and stem cell purification began to make clear that **stem cells in each organ are the actual target cells for cancer induction and development.** Generic damage to chromosomes and DNA of stem cells elevate the probability of transformation to cancer stem cells by inducing genetic instability.When we incorporate the stem cell theory for general understanding of human carcinogenesis, we see that risks of solid cancer, leukemia and myelodysplastic syndromes (MDS) may persist over the entire lives of atomic bomb survivors because the atomic bomb irradiation targeted such stem cell damage at the DNA level....

“Our study of atomic bomb survivors, conducted by the joint teams of Nagasaki University, Hiroshima University, and Radiation Effect Research Foundation thus clearly indicate that the atomic bomb irradiation induced genetic damage persists over half a century and probably over the lifetime of the survivors.” [Ref. 3]

Conclusion: In my professional opinion, the Precautionary Principle demands that Pancreatic Cancer be included in any study of cancers potentially attributable to ionizing radiation. It is not clear in the text whether other cancers have been arbitrarily omitted from this health study.

2. The design and scope of this Health Study, in **Background**, pages 1-2:

Report 2007 is said to be an update of the *Radiation and Health in Durham* produced by the Durham Health Department in 1996. The 1996 report was an extension of the *Compendium of Statistical Tables for Durham, Halton Northumberland, Ontario*, rightly called a surveillance tool dating back to 1983. This surveillance tool is technically called an **ecological study**.

Pickering has experienced rapid growth in the post-World War II period. Between the 1996 and 2001 Census, for example, the municipality experienced a growth rate of 10 percent (78,989 people to 87,139). Population growth has slowed considerably in recent years, growing only slightly between the 2001 and 2006 census. This slowing of growth is due mainly to development restrictions on land in the northern portion of the City. Negotiations are ongoing to permit development in this area. Consequently, the City has estimated that by 2023, Pickering will be home to nearly 170,000 residents. The Province of Ontario has also designated Pickering as one of two municipalities in Durham Region as an Urban Growth Centre. Thus the Health Study may be significant for planning in the Durham Area! A significant portion of Pickering residents are classified as visible minorities. According to the 2001 Census, 9.3% of the City's population is Black, 7.0% South Asian, 2.2% Filipino and 2.0% East Asian. About 73.5% of the population identifies as Caucasian. When an ecological study is undertaken, it is impossible to distinguish between long time

residents of the area and new-comers, temporary workers, persons living up wind or upstream of the effluence of a nuclear generator, or each person's occupational and life-style exposures in addition to their potential exposure to nuclear radiation. This type of study is further complicated by the loss of persons from the area who have moved to other regions of Canada. In other words, the "exposed" population is not well identified. Hence the findings are not clear and are more than likely misleading.

These population problems do not appear to have been considered adequately in the design of this study. An epidemiological case-control study (discussed later in this critique) would have been more appropriate.

Moreover, since the Pickering "A" Nuclear Generator went on line in 1971, and the ecological health status study begins in 1983, there is no way for the reader to find any indication of changes in health status of long-term residents before and after radiation became a continuous pollutant in the area. The first ten years of reactor operation may well have been the most polluting, leaving a high baseline of ill health for comparison purposes. There have also been safety updates since the first reactor model built in 1971. These were incorporated in the Darlington reactor, but the Pickering reactors may not have been upgraded.

The type of test used by the Department of Health, geographically based statistical data, **is the weakest of all health study designs.**

Conclusion: Given the small population base of Durham, influx of new residents and outflow of long term residents, temporary workers during construction phases, the fact that Ontario does not have either a proper Cancer Register, with mandatory reporting at the time of diagnosis of cancer, or a proper Birth Defect Register recording all birth defects noted in the first eight days of life for each newborn, the probability of such an inadequate ecological health study (as the Durham Health Report 2007) showing a radiation/health problem in the area is negligible. Thus the assurance given to the people at risk of the nuclear radiation emitted routinely from these reactors may well be false and premature.

3. Figure 1, on page 3, mixes partial body dose (chest X-ray) with "effective dose in 2005" - which, I presume, is whole body gamma direct irradiation dose (excluding internal doses due to inhalation and ingestion) - with internal exposure to potassium 40, which is naturally occurring and cannot be avoided.

From a moral view these are three different situations:

- Presumably the chest X-ray, which is partial body exposure (not including exposure to the major blood forming organs), is agreed to by an individual for a specific personal benefit, as noted and explained by a physician.
- The whole body dose, including blood forming organs, from a nuclear reactor is "permitted" for some electrical generation needed by the community with no special benefit to or agreement by the individual affected. The individual may even choose a clean energy option and yet experience no life saving

effect of reduction of his/her exposure to the nuclear effluence from the reactor.

- Exposure to potassium 40, which occurs naturally on our planet, is unavoidable and not chosen or desired for any known beneficial purpose.

Conclusion: The listing of such diverse exposures in one table for dose comparison purpose is misleading to the public. The document appears to be intended as an assurance of responsible health management of ionizing radiation, yet it blurs the reality of a known human carcinogen being released into a residential area, guaranteeing neither a personal benefit nor a personal choice.

4. Hereditary effects of ionizing radiation: page 4, second paragraph line 8: “radiation exposure has never been shown to cause hereditary effects in humans”

This statement is incorrect. See, for example: “Heritable anomalies among the inhabitants of regions of normal and high background radiation in Kerala: results of a cohort study, 1988-1994”. Padmanabhan VT, Sugunan AP, Brahmaphuthran CK, Nandini K, Pavithran K. [Ref. 4]. The Abstract of this journal article state: “In a genetic epidemiological and fertility survey among 70,000 inhabitants in a high-background radiation region (HBRR) and normal radiation region (NRR) in Kerala, India, 985 persons were found to have heritable anomalies.There was a statistically significant increase of Down syndrome, autosomal dominant anomalies, and multifactorial diseases and an insignificant increase of autosomal recessive and X-linked recessive anomalies in the HBRR.”

I would note that Herman Muller demonstrated the mutagenic effect of ionizing radiation in fruit flies in 1928 [Ref. 5]; and in 1957 the World Health Organization identified the Kerala high background radiation (650 mrem/year equivalent to 6.5 mSv or 6,500 microSv) and the adjoining villages (normal background radiation) as the ideal setting for studying the radiation induced and spontaneous genetic load in human beings [Ref. 6]. The WHO recommended human genetic study was never undertaken by nuclear energy advocates or their governments, but was finally reported by independent concerned researchers in 2004. Absence of research does not prove there is no danger!

Conclusion: It seems that governments promoting nuclear energy are still failing to undertake, recognize or reference information on human genetic vulnerability to ionizing radiation when permitting human exposure to the ionizing radiation from nuclear industries. The claim that “genetic damage in humans has never been shown” shows negligence in addition to ignorance!

5. Page 4, paragraph 3: “...low levels of radiation, which might be defined as 100 mSv or less, ... The main health effect of concern is cancer.....Radiation doses received from X-rays or diagnostic procedures are generally not high enough to cause anomalies or growth impairment.”

Until this point in the text, the authors have used micro Sievert as their measure of radiation. The change to millisieverts is not explained in the report. [Note: one mSv = 1,000 micro Sv]. This change in units may be misleading to the reader. The older measurement of radiation, as used by the World Health Organization, namely the rem and millirem (written mrem). 1 mSv = 100 mrem = 1,000 microSv.

Medical X-ray doses range from 0.07 mSv (or 7 mrem) for a chest X-ray to 12 mSv (1,200 mrem) for a CT scan according to the Health Department Figure 1, page 3, of this Health Study Report. As was noted, [Ref. 7], human genetic damage after exposure to 650 mrem/year (6.5 mSv/year) has been demonstrated in Kerala, India. This exposure, which is known to cause genetic damage, is between 6 and 7% of the dose Durham Health Study considers to be “low dose” radiation, namely 100 mSv. I believe that offspring genetic effects, and not only cancer death as was assumed by the Durham Health Department, are a great concern to the people of Durham and most ordinary Canadians!

The authors imply that low dose radiation includes every dose up to 100 mSv, (this would be 100,000 micro Sv, in the original terminology used by the authors) which is the highest point on the chart of Figure 1, page 3. The doses given in Figure 1 for persons living in the vicinity of Pickering and Darlington are well below this level, and also well **above** the one track (lowest possible dose) mentioned by the NRPB [Ref. 8.] and BEIR VII, [Ref. 9] both of which maintain that every dose carries a probability of harm. Is the Department of Health implying that there is no risk to the patient from a CT scan? [Ref. 10, 11]

Since it is well established that radiation exposure depletes white and red blood cells, and can cause anemia and cardiovascular diseases, these effects may also be of concern to some residents of Durham County who are struggling with already existing problems with their cardio-vascular or hematological organs.

In the late 1980s, data emerged that older radiotherapy (RT) techniques used in the treatment of breast cancer, particularly after mastectomy, resulted in increased rates of both cardiac morbidity and mortality. In a meta-analysis involving 19,582 women with breast cancer enrolled onto 40 randomized trials begun before 1990, the Early Breast Cancer Trialists Collaborative Group found that RT reduced the annual mortality from breast cancer by 13% but increased the annual mortality rate from other causes by 21% and that this increase was due primarily to an excess number of deaths from vascular causes (death rate ratio, 1.3 [SE 0.09]) [Ref. 12]. In a similar meta-analysis, Cuzick et al [Ref. 13] reviewed individual patient-level data from 7,941 women enrolled onto 10 randomized trials of mastectomy, with or without RT, initiated before 1975 and found that the standardized mortality ratio was significantly higher for patients treated with RT compared with controls (1.11 v 0.69; $P < .001$).

While these examples are of high doses of external ionizing radiation therapy, there is also evidence of heart disease related to low dose internal exposure, especially from

alpha particles emitters, as is characteristics of particulate effluence from a nuclear reactor. [Ref. 14, 15]

The relationship between heavy metal radioactive particulates and depression of the monocyte white cells, with subsequent iron deficient anemia, is noted in my 1993 article [Ref. 16].

Simply declaring that cancer is the “main effect of concern” does not take away all other effects for which the Department of Health should show professional concern and provide for a remedy!

Nor, I hope, does the Department of Health expect to allow X-ray of pregnant women! This has long been banned in all hospitals and medical X-ray offices.

Conclusion: The Durham Department of Health does not have the authorization to declare any effect of a hazardous exposure “not of concern” by limiting its consideration to one biological endpoint, or minimizing the long recognized hazards radiation exposure poses to the gene pool and/or unborn child.

6. Page 4, paragraph 4: “Although radiation can cause cancers such as leukemia, and colorectal, lung, stomach and thyroid cancer, the vast majority of cancers are caused by other factors such as smoking, alcohol, and diet.”

Smoking, drinking and eating are activities which form a pathway between the individual and some environmental factor, known as a “carcinogen”, which actually causes or is a pre-cause of the cancer. Smoking, drinking or eating involve the necessary human actions of breathing and taking nourishment. Only when the air, water or land contains carcinogenic agents do these actions become remote “causes” of cancer. The tobacco leaf is affected by air pollution and by the contaminants in the phosphate fertilizer (including lead 210) used to increase its growth rate. These pollutants are incorporated into the tars which are then inhaled by the person. By not smoking, the individual interrupts the transmission of the carcinogens to his or her lungs. However, it is the environmental carcinogens, not smoking, which cause the cancer.

By focusing on the activity of the individual, rather than the environmental hazards, the Department of Health is perpetuating the “blame the victim” technique introduced in the 1970s when it was first revealed that most causes of cancer were environmental. This avoidance technique, shifting the blame to “life style”, is limited by the sustaining of life itself, and cannot ever truly solve our serious pollution problems. It is not reasonable to ask people not to breathe, drink or eat in order to avoid cancer!

Clearly not breathing the radioactive gases and particulates released from a nuclear generator, and not eating the fruits and vegetables which are contaminated by air fallout or irrigation, is a way to avoid radiation induced cancer. However, the fruits and vegetables grown down wind or down stream of the Pickering and Darlington

nuclear generators are distributed widely in Ontario and beyond. These contaminations of food and air form the principle routes by which the routine nuclear plant effluence reaches the public. These problems are not even mentioned in this Health Report 2007. Drawing a circle around the two nuclear generators does not even begin to capture the environmental transportation routes of nuclear contaminated air and water. Rather it includes some relatively unexposed persons and excludes others truly exposed to the carcinogens. It is a poor study design!

Since there is a counter-clock-wise circulation of the water in Lake Ontario, the liquid effluence of Pickering and Darlington will have direct access to the populations of the “golden horse-shoe” on the northern shore of the Lake. The air releases from Pickering and Darlington follow several air plumes at different heights above sea level, which plumes have been monitored as far away as Ottawa and the Hudson Bay. A serious health study might well attempt to match the recorded measurements of these air and water pollution levels with first trimester pregnancy outcomes of those pregnant women most likely to have been exposed! Other such study designs matching environmental change with biological endpoints are possible and preferable to this indeterminate study design.

Conclusion: Mentioning ways of disrupting the pathways between carcinogens and the public is a diversion from the serious issues at hand regarding radioactive pollution of the water, air and land and their natural distribution by earth’s air and water circulations. The daily carcinogenic and mutagenic effluence from the nuclear generators at Pickering and Darlington is measured, and its pathways through the environment are charted. The diversion, namely, focusing on “life style”, adds nothing to the value of the report. It avoids the real questions, posed by the population, concerning: who is actually exposed, when/how often they were exposed, what is their likely cumulative dose, and which potential biological outcomes should be linked to the exposure.

7. Page 5, the first full paragraph: “A recent study of nuclear power industry workers in 15 countries, including those at Ontario Power Generation, found a positive association between radiation exposure and mortality from leukemia (excluding chronic lymphocytic leukemia).” This is a reference to the IARC study, Cardis, E. et al. British Medical Journal 331; 7508, 2005.

The finding of the recent IARC investigation of the excess relative risk of cancer death (excluding leukemia), above what might be expected of a comparable age group of workers not exposed in nuclear industries, was 0.97 per Sievert. For comparison, the Hiroshima and Nagasaki survivors had a 0.32 excess relative risk of cancer death (excluding leukemia) per Sievert when compared with other Japanese not so exposed. This implies that a low chronic dose of ionizing radiation may be three times as carcinogenic as the high dose fast dose rate exposure from the atomic bomb. However, this finding did not hold true for all workers in nuclear reactors.

The IARC estimate of the excess relative risk of leukemia (except chronic lymphocytic leukemia) for the nuclear workers was 1.93 per Sievert, while for the atomic bomb survivors it was 1.54 to 3.15 per Sievert. The leukemia risk is in addition to the risk of solid cancer death risk, meaning about 3 excess cancer deaths per Sievert.

The average total worker exposure in the IARC study was only 19 mSv, well within the range called “low dose radiation” in the Durham Health Department Study. Prior to 1997, Canadian radiation control laws permitted the general public to receive up to five mSv/year ionizing radiation from nuclear activities. In 1997, with the Nuclear Control and Safety Act, this was reduced to 1 mSv per year. Residents living in the vicinity of Pickering prior to the 1997 Act, would have been permitted to accumulate 19 mSv in four years. Since 1997, it would take 19 years to accumulate this exposure. However, there is no guarantee that even these lowered doses are “safe”, since excess cancer deaths did occur for nuclear workers at these levels of exposure.

The IARC study included 407,391 workers, from 15 countries, who had worked for at least a year in a nuclear industry. Only workers wearing dosimeters were included, and the doses received during the last two years before diagnosis of leukemia, or ten years before a solid cancer, were not counted. There were about 24,443 deaths among these nuclear workers, of which 6,519 were solid cancer deaths (about 27%) and 196 deaths were from leukemia (about 3%). The difference between an epidemiological study like IARC’s, looking at individuals with known measured exposure and work history, and an ecological study such as is presented in Report 2007 from the Durham Department of Health, should be obvious.

The authors of the IARC Study state:

“The study suggests that there is a small increase in cancer death risk even at the low doses and dose-rates typically received by nuclear workers in this study.”

Cancer mortality differed among the 15 countries, with **Canada having the highest mortality**. The panel could find nothing that might account for this. However, “[O]nly when we excluded Canada was the excess relative risk no longer significantly different from zero,” the panel wrote. In other words, reviewing aggregated data from 14 of the 15 countries—including the United States—the study did not demonstrate an increased risk of cancer mortality for nuclear workers.” [Ref. 18]

Conclusion: The Durham Health Department was misleading to the public about research on low dose and slow dose rate exposure to ionizing radiation from the nuclear industry. Health effects under these conditions have been seen and are significant. They also failed to admit that Canadian CANDU workers had the highest risks of the 15 nuclear countries tested, for cancer death. The CANDU reactor releases more tritium (as radioactive water) and more radioactive carbon than do the other reactor types.

8. Page 8 to 15, Assumptions and limitations.

The Durham Department of Health was clearly aware of the many problems posed by their choice of methodology. However, they soldiered-on and reported the numbers they found without any doubts about the legitimacy of their findings.

Conclusion: I believe that this tactic significantly underestimated problems of nuclear radiation exposure and health effects. It also revealed scientific weakness in the Department of Health.

9. Page 17-19, Understanding the data:

The data was of uniformly poor quality which further undermines the reliability of the findings. Because small counts were eliminated, the data was biased against rural areas, where there was a higher probability of consumption on home-grown fruits and vegetable potentially contaminated from the nuclear reactor effluence.

Conclusion: Continuing with such an inefficient methodology and poor data base is deceitful.

10. Page 18: Rapid Risk Factor Surveillance System:

As I understand this process, one adult would be interviewed from a family with, for example, two young parents, children and the parent of one of the partners. The household answers would then be weighted because each of the three adults would have a smaller probability of selection than an adult in a two adult family household. No information on the weight used was given. Clearly, when the question pertained to whether or not the household eat locally produced fruits and vegetables, there would be no bias involved.

When looking for radiation related health effects, length of residence, age at first exposure, and frequent ingestion of locally grown produce are significant variables. Randomization of interviews is not appropriate for this study, although it may be appropriate for certain sociological research.

Conclusion: Apparently the Durham Health Department used this inappropriate random selection methodology for data between 2001 and 2005. The authors failed to say which variables were compiled using this randomized weighted methodology and what the weights were or why a random process was used. The impression was given that data was collected for other purposes and then use by the Department of Health in a radiation & health study.

11. It is not correct to assume that all variables in a small population will have a Normal Distribution. It may well be incorrect to use the Normal Distribution Standard Error and 95% confidence interval, as mentioned on page 19. For example, cancer incidence rates would be expected to follow a Poisson

Distribution, not a Normal Distribution. Some the problems and solutions in applying the relative risk methodology are given in my published paper: “Extensions of the Relative Risk Concept” [Ref. 19]. Only when numbers of cases are increased, as for the whole of Canada, can one use the Normal Distribution and appeal to The Law of Large Numbers [Ref. 20].

Conclusion: The Radiation & Health Study Report 2007 is a poor presentation on which to base any assessment of the health of the Canadian population affected by the radioactive effluence from the nuclear power reactors at Pickering or Darlington. The data and methodology are too fraught with errors and uncertainties to be of any value for public health guidance or urban planning.

12. Suggestions for a preferred Health Study Design:

There are three types of epidemiological observational studies: *cross-sectional* (prevalence), *cohort* (longitudinal), and *case-control*. There are specific rules to be followed for each type. The study must be careful to evaluate associations and causes. The following are some criteria to decide whether an association is causal.

1. **Strength.** A strong association is likely to be causal.
2. **Consistency.** The observation is repeatedly seen in different persons, at different places, at different times.
3. **Temporality.** The cause comes before the effect on the time line.
4. **Dose response relationship.** Increased exposure relates to increased risk of the condition being studied.
5. **Biologic plausibility.** The possible causative mechanism fits in with accepted biologic knowledge.
6. **Coherence.** Fits in with other evidence of trends in other factors associated.
7. **Analogy.** Similar to cause and effect established for equivalent exposure and disease.
8. **Specificity.** One cause linked to one effect.
9. **Experiment.** Removing the cause removes the effect.

These are commonly known as Hill’s Criteria after Sir Austin Bradford Hill (1897 - 1991). The study method used by the Durham Department of Health is not an Epidemiological Study, but rather an ecological study. Unlike most epidemiological studies, ecological studies employ information on groups, for example the residents of Durham County, not on individuals. Conclusions should be evaluated carefully as they can be misleading. Such studies do not have the ability to detect causal relationships between cancer or birth defects and ionizing radiation exposure [Ref. 21].

With respect criteria number 9, “experimental” closing of a nuclear reactor has already occurred. The 913 MW Pressurized Water Reactor at the Rancho Seco Nuclear Power Plant, located about 25 miles south of Sacramento, is owned by the Sacramento Municipal Utility District and was in operation from April 1975 to June 7, 1989. It was closed by public referendum. Located near the existing

Rancho Seco Nuclear Plant (now closed), Consumnes Power Project is constructing a 1,000 MW combined-cycle natural gas facility. Since the closing of this reactor, there has been a reported improvement in the public health [See Appendix A]. The Durham Department of Health would do well to investigate this experiment in more detail.

As is explained in my journal article, [Ref. 19] it is more efficient to use a case-control design, and to examine all cases (if possible) and randomly selected controls, matched for sex and age from Durham County. One can use realistic cut-offs for exposed vs not exposed. For example: the “exposed” might include those who live down wind of the air releases or down stream of the water releases of either facility and regularly or frequently consume local water, fruits and vegetables grown down wind or down stream. Those lacking these characteristics would be “not-exposed”. This could be used to derive a Relative Risk [Ref. 22].

A non-parametric dose response could be attempted, using an intermediate category having some but not all of the “exposed” conditions. A linear (non-parametric) dose response, such as increased rate of the biological endpoint with increased exposure (low to medium to high) might be achieved.

This work would be facilitated by Canadian Federal Legislation requiring physicians to report when diagnosing cancer, leukemia, and birth defects at the time of diagnosis. These biological endpoints have more relevance today than does the reporting of measles and mumps! This entire exercise would require no more time or energy than is put into the indirect and error prone methodology used to prepare Radiation & Health Report 2007.

References:

1. National Radiation Protection Board, U.K. 1995.
2. The U.S. Energy Employees Occupational Illness Compensation Program Act was first passed in August, 2004, to assist workers at U.S. government nuclear weapon facilities, their contractors and sub-contractors, exposed to nuclear materials. It has been amended, October 28, 2004, to include radiation exposures, including benefits for certain beneficiaries of Section Five of the Radiation Exposure Compensation Act. Cancers to be compensated under this act are:
 - bone cancer;
 - renal cancer;
 - leukemia (other than chronic lymphocytic leukemia) provided that the onset of the disease was at least two years after first exposure;
 - lung cancer (other than in situ lung cancer that is discovered during or after a post-mortem exam);One of the following diseases, provided onset was at least five years after the first exposure:
 - multiple myeloma
 - lymphomas (other than Hodgkin’s disease)
 - Primary cancer of the:
 - i. thyroid

- ii. male or female breast
- iii. esophagus
- iv. stomach
- v. pharynx
- vi. small intestine
- vii. pancreas
- viii. bile ducts
- ix. gall bladder
- x. salivary gland
- xi. urinary bladder
- xii. brain
- xiii. colon
- xiv. ovary
- xv. liver (except if cirrhosis or hepatitis B is indicated)

3. "Late Medical Effects of Atomic Bombs still Persisting Over Sixty Years", Maseo Tomonaga, M.D., Ph. D. in PUGWASH Newsletter Vol. 42 No. 2, p.60, 2005.
4. International Journal of Health Services 2004; 34(3): pages 483-515. "Heritable anomalies among the inhabitants of regions of normal and high background radiation in Kerala: results of a cohort study, 1988-1994". Padmanabhan VT, Sugunan AP, Brahmaphuran CK, Nandini K, Pavithran K.
5. Muller, H.J. "The Effects of X-radiation on Genes and Chromosomes", Science 67: 82, 1928.
6. WHO *Effects of Radiation on Human Heredity* Study Group Report, Geneva, 1957.
7. ibid Ref. 4.
8. ibid. Ref 1.
9. In June 2005, the US National Academy of Science released its report from the Biological Effects of Ionizing Radiation Committee VII. The BEIR VII report —"Health Risks From Exposure to Low Levels of Ionizing Radiation"—is the updated scientific basis for radiation safety standards in the United States.
10. Bertell, R., LH Ehrle, I Scgmitz-Feuerhake, "Pediatric CT Research elevates Public Health Concerns: Low Dose Radiation Issues are Highly Politicized", International Journal of Health Services, 37 (3), 419-439, 2007.
11. Okada, M. et al., "Single Extreme Low Dose/Low Dose Rate Irradiation causes Alteration in Lifespan and Genomic Instability in Primary Human Cells", British Journal of Cancer 96,1707-1710, 2007.
12. Favourable and unfavourable effects on long-term survival of radiotherapy for early breast cancer: An overview of the randomised trials—Early Breast Cancer Trialists' Collaborative Group. Lancet 355:1757-1770, 2000.
13. Cuzick J, Stewart H, Rutqvist L, et al: Cause-specific mortality in long-term survivors of breast cancer who participated in trials of radiotherapy. J Clin Oncol 12:447-453, 1994.
14. Elkles, Arthur, "Metabolic Behavior of Alpha-ray Activity in Large Human Arteries. Relationship to Atherosclerosis." Journal of the American Geriatric Society, 25 (4) 1977.

15. Cohen, N. "Discussion of possible mechanisms involved in the apparent concentration of ^{228}Ra and ^{210}Pb in aorta and thyroid", *NYU Annual Report USAEC Contract AT(30-1) 3086*. Editors: Eisenbud, M. and H. Petrow. 1986.
16. Bertell, R., "Internal bone seeking radionuclides and monocyte counts", *International Perspectives in Public Health*, Vol. 9, 1993.
17. IARC study, Cardis, E. et al. *British Medical Journal* 331; 7508, 2005.
18. <http://www.nei.org/index.asp?catnum=3&catid=310> Web site of the U.S. Nuclear Energy Institute.
19. Bertell, R. "Extensions of the Relative Risk Concept," *Experientia*, Vol. 131, January 1975.
20. Feller, W. "Laws of Large Numbers." Ch. 10 in *An Introduction to Probability Theory and Its Applications, Vol. 1, 3rd ed.* New York: Wiley, pp. 228-247, 1968.
21. ***Toxic Exposures & Causality in Illnesses, Part II. Epidemiology***, by Leslie J. Hutchinson, M.D., M.P.H. & Sanford S. Leffingwell, M.D., M.P.H.. Dr. Hutchinson, is on the faculty of Emory Univ. and a consulting firm CEO, while Dr. Leffingwell is a consultant to government, industry & insurers and serves as a member of two National Research Council Committees. Both specialize in toxicology, epidemiology, public health, and preventive, occupational and environmental medicine.
22. *ibid.* Ref. 19.

APPENDIX A:

“We looked at the four counties in California that are under 40 miles and downwind (east) of the plant. These counties are Sacramento, El Dorado, Placer, and Amador, with a total population of nearly 2 million.

We documented immediate and sharp reductions in:

- Cancer incidence in children age 0-4
- Infant and neonatal mortality
- Age-adjusted cancer mortality (all ages)” Personal note TO Dr. Rosalie Bertell, from Joseph Mangano, M.P.H., 1 July 2007.

Cancer Death Rates for Counties East and under 40 miles from Rancho Seco Nuclear Reactor: [Including: Amador, El Dorado, Placer and Sacramento, a population of just under 2 million]

Period before shutdown	Cancer deaths		%Above/Below US rate	
	Number	Rate	US rate	Comparison
1979-1983	9,212	215.6	210.3	+2.52 %
1984-1989	13,609	222.7	215.0	+3.56%
After shutdown				
1990-1998	24,138	204.9	213.1	-3.86%
1999-2003	15,968	197.1	200.6	-1.77%

Source: U.S. Centers for Disease Control and Prevention, underlying cause of death. Uses ICD 9 cancer codes 140.0 - 239.9 for 1979-1998 and ICD 10 cancer codes C00-D48.9 for 1999 - 2003.

See also:

"Infant Death and Childhood Cancer Reductions After Nuclear Plant Closing in the U.S.," *Archives of Environmental Health*, Spring 2002.

“Improvements in Local Infant Health After Nuclear Power Reactor Closing,” *Journal of Environmental Epidemiology and Toxicology*, Spring 2000.