Energy Probe's Submission to the Honourable Bud Wildman, Ontario Minister of Environment and Energy, concerning the Ontario Drinking Water Objective for Tritium and related issues

August 23, 1994

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Table of Contents

1. The Level of Public-Health Protection Suggested in the ACES Report -- Did ACES "go too far"?.....1

   More recent information, not available to ACES, justifies an even more aggressive reduction of tritium emissions to the environment than recommended by ACES.....1

   Comments on submissions from nuclear-industry sources.....4

      A. Should we or shouldn't we believe that there is a health risk from exposures to tritium at levels of 20-100 Bq/L of drinking water?.....4

      B. Is the issue exposure to tritium, or is it exposure to radiation?.....8

2. **Should we tolerate higher tritium levels, and higher cancer risks, because it's too hard and expensive to meet the ACES recommendations?**.....10

   Background: Why is this being discussed now?.....11

   How does the tritium get into the tap water, and how could it be kept out at least cost?.....11

      Sidebar: tritium emissions and emissions control at Chalk River.....12

   Should we avoid reducing the cancer risk from tritium because it may start a "domino effect" that will destroy the nuclear industry?.....15

   First process concern: Reliance on pollution-control data controlled by the polluters.....17

   Second process concern: Reliance on forecasts by unreliable forecasters.....18

   Energy Probe's Recommendations.....18

1. The Level of Public-Health Protection Suggested in the ACES Report -- Did ACES "go too far"?

We know that you and your staff have begun receiving submissions from Ontario Hydro, the Canadian Nuclear Society, a committee of the Royal Society and others, suggesting that the ACES recommendations go too far, or are based on an inappropriate approach to the subject. (See below for more specific comments on these submissions and arguments.) On the contrary, the facts show that ACES faithfully applied to tritium your Ministry's policy and approach to persistent toxic or carcinogenic substances. Indeed, in light of more recent information, not available to ACES, you should consider an even more aggressive reduction of tritium emissions to the environment than ACES recommended. (See below for details of the more recent information.)

We do, however, completely agree with your statement in the news release that accompanied the ACES report, that "The committee's recommendation represents a departure from current international approaches to drinking water guidelines for radionuclides. [emphasis added]" Indeed, ACES's approach to the protection of public health from carcinogenic pollutants, as their report acknowledges, is very different from that of the International Commission on Radiological Protection, the Atomic Energy Control Board, the World Health Organization, and Ontario Hydro -- at least where the carcinogenic pollutants are radioactive. But ACES's approach is identical to your own Ministry's policy and approach to persistent toxic or carcinogenic substances. In other words, it is those radiological approaches which "go too far", by imposing unacceptable cancer risks and other health risks on Ontario citizens whose only "risky" behaviour is drinking Ontario tap water.

More recent information, not available to ACES, justifies an even more aggressive reduction of tritium emissions to the environment than recommended by ACES.

± The newest evidence from Hiroshima and Nagasaki, reported very recently in the popular press (e.g., Globe & Mail August 4) after publication in the Journal of the American Medical Association, shows that radiation has caused a significant increase in autoimmune disease, and not just cancer. The ACES recommendation, like that of your Ministry staff in the Rationale Document, was essentially limited to concern over cancer, and primarily to fatal cancers, as this evidence had not yet come to light.

± The most recent and precise data now in Energy Probe's possession comparing average tritium levels in drinking water

around the province in 1992[1] show a relationship that we believe was not presented to or appreciated by ACES: The actual background tritium level in Ontario waters remote from nuclear facilities is not the same as "the Lake Ontario average of 8.7 Bq/L[2]", but is consistently in the range 3.9-4.9 Bq/L.[3] Higher annual average readings are found only in the water bodies that have a tritium-emitting nuclear facility located along them or upstream of them: 6.2, 6.9, and 7.7 on Lake Ontario, 5.8 and 6.5 in Lake Huron and Georgian Bay, and 7.0 in the Ottawa River (at Ottawa). In short, the same tritium emissions that bring the levels in the closest WTPs above 20 Bq/L clearly have, over the years, elevated by 50%-100% the "background" or ambient tritium levels in these enormous water bodies.[4]

± An Atomic Energy of Canada Limited (AECL) study just received in this office, and not presented to ACES, shows that use of tap water to irrigate produce, in farms or in home vegetable gardens, is apparently a much more important source of tritium exposure to the most exposed humans than drinking 2L per day of that same tap water-- in fact, twenty times more important than

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1. From Table 3.5.4 on p. 33 of Ontario Hydro's publication HSD-HP-93-9, ANNUAL SUMMARY AND ASSESSMENT OF ENVIRONMENTAL RADIOLOGICAL DATA FOR 1992. Copy attached.

2. ACES report, p. 10, quoting Ontario Hydro, in turn citing Great Lakes Water Quality Board figures.

3. We have generously included the Niagara River as one of the water bodies "remote from nuclear facilities". In fact, it is downstream from Lake Huron (and Bruce A and B stations), as well as many U.S. civilian and military nuclear facilities. Leaving it out, the water bodies remote from nuclear facilities have remarkably consistent tritium concentrations, ranging from only 3.9 to 4.5 Bq/L.

4. In addition to misleading Energy Probe, ACES, and others about the significance of Ontario Hydro's emissions to their neighbours, Ontario Hydro benefits from polluting Lakes Huron and Ontario in another way: In calculating the public tritium doses from its emissions, Hydro only counts the difference between the locally elevated tritium levels and the Hydro-elevated average figures! For example, in section 5.1.22 on p. 64 of publication HSD-HP-93-9, we read, "A background of 8.7 Bq/l was subtracted at Pickering and Darlington and a background of 9.1 Bq/l was subtracted at BNPD."

direct consumption of drinking water.[1] In our written submissions to ACES, we mentioned this exposure pathway as being an additional source of exposure, and a source of the more toxic Organically Bound Tritium[2], but we frankly did not suspect that this pathway was twenty times more important than direct consumption, even without including the impact of OBT. The ACES recommendation, like that of your Ministry staff in the Rationale Document, was essentially limited to the direct consumption of tap water, as drinking water.

± New evidence, just received in Energy Probe's office via federal Access to Information, in draft form, and not available to ACES, indicates that tritium in food is a significant additional source of tritium exposure to people who live near Pickering, and presumably also near Bruce, Darlington, and Chalk River. This tritium contamination is naturally highest in locally grown produce, but it is also present, at lower levels, in imported fruits and vegetables, which pick up tritium while sitting on the shelves in the market (and perhaps while being sprayed with tap water). The ACES report mentions foods "raised near nuclear generating stations" as a possible additional source of exposure, at pp. 9-10, but ACES could not know that

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1. In table 6.7, on p. 6-17 of publication AECL-7243 (J.F. Palmer, Derived Release Limits (DRL's) for Airborne and Liquid Effluents from the Chalk River Nuclear Laboratories During Normal Operations, February 1981), copy attached, the maximum permissible release rate for the "Veg. Ingestion - Spray Irrigation" pathway to adults in Petawawa is listed at 3.2E-01 (i.e., 0.32) Ci/second of HTO, one twentieth the size of the release limit for the "Water Ingestion" pathway to the same adults, which is listed at 6.4E+00 (i.e., 6.4) Ci/second of HTO. (A pathway that dictates a smaller release limit is, of course, a more important or effective pathway.) The former is also, appropriately, labeled with an asterisk, indicating that it is the "dominant pathway, i.e., the pathway resulting in the minimum value of [the permissible release rate]." We have not reviewed these calculations in great detail, but we note that the assumptions for some of the parameters seem non-conservative or even unrealistic, especially when translated into the context of southern Ontario locations like Pickering -- e.g., the rate of watering is taken at 2L per square metre per day (p. 5-30), which comes to about 0.5 inches of water per week, less than half the rate typically recommended. Similarly, the limit of garden watering to one fifth of the year, or 2.4 months, does not seem realistic, much less conservative.

2. See pp. 11-12 of our February 24th submission to ACES for a brief discussion of our concerns regarding this exposure pathway. It should be noted that the AECL calculation does not include an allowance for the conversion, in the vegetables, of tritiated water ("HTO") into the more toxic tritiated organic compounds collectively called "organically bound tritium" ("OBT").

the contamination extended to imported produce, or how extensive the contamination is, as that evidence had not yet arrived in Energy Probe's office.[1]

Given the logic of public-health protection, and your Ministry's policies on the control of persistent toxic and carcinogenic substances, each of the above factors argues for a lower tolerable level of tritium in drinking water (and in the environment) than ACES recommended.

Comments on submissions from nuclear-industry sources:

There are two specific claims that we know you are hearing, from those who argue that ACES "went too far", which are based on specious reasoning or misapplication of evidence, and are addressed in more detail below:

(A) The claim that there is no good scientific reason to believe, or to assume, that there is any cancer or health risk at all, from exposures to radioactive substances at these levels (i.e., corresponding to a lifetime of drinking water with 20-100 Bq/L of tritium in it).
(B) The claim that "The issue is exposure to radiation, not exposure to tritium."

A. Should we or shouldn't we believe that there is a health risk from exposures to tritium at levels of 20-100 Bq/L of drinking
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1. According to that evidence (the latest progress report from AECL to AECB on contract #87055-9-4070/01-55, submitted to AECB "on or about December 2, 1993" according to a fax to me from AECB's Hugh Spence), "The average tritium concentration of the free water of 10 main diet items from stores in the vicinity of Pickering NGS was 14 Bq/L, 3 times that of similar items grown at Perth, the background site. Produce grown in the Pickering area had a higher free water tritium content by a further factor of 5 [i.e., 70 Bq/L]." The report goes on to suggests that the total dose rate from maintaining an individual's total body water at the level of the locally grown produce would be "<2ÌSv/a" -- i.e., <140ÌSv = <0.14mSv over 70 years, which would correspond to a <7-per-million excess lifetime risk of fatal cancer. An individual's body burden of tritium would naturally be a function of both tritium in tap water and tritium in food, and would include a contribution from Organically Bound Tritium as well as free-water tritium. I enclose that latest one-page progress report, as well as the first progress report, dated June 1990. Both are entitled "Measurement of Tritium in Canadian Food Items". The earlier report is notable, in part, for the very significantly elevated levels of tritium (both as tritiated water [HTO] and as OBT) found in the liver of a moose killed at Chalk River Nuclear Labs in 1989 -- roughly 20,000 "Tritium Units", or 2400 Bq/L.

water?

To begin with, the question is not whether or not to employ mathematical modeling and extrapolation from higher doses in the setting of health-based standards like ODWOs; they are simply unavoidable.

It is mathematically obvious that we do not have, and presumably never will have, direct scientific proof of any environmental health risk at the level of one excess fatal cancer per million population over 70 years exposure to anything. Whether the carcinogen is tritium, or NDMA, or whatever, public-health protection at that level will always be based on mathematical models and extrapolations from higher doses received by laboratory animals or humans. (Direct proof, of course, would require exposing many millions of humans to the dose in question for 70 years, while an otherwise identical cohort of many millions of humans went unexposed for 70 years, then trying to detect the one-in-a-million difference in their cancer rates!) As a result, since the values of our society and your Ministry demand public-health protection to levels that are not susceptible to direct scientific verification, your Ministry routinely relies on mathematical modeling, a form of indirect scientific verification, to calculate exposures that correspond to those required levels of public-health risk. That is, for example, how the ODWO for NDMA was set, following consultation by ACES, and that is, in our opinion, how the ODWO for tritium should be set.

We believe that any submission to you that suggests that environmental health protection should be limited to the range of direct scientific evidence (e.g., the July 28 submission to you on behalf of the Canadian Nuclear Society) should be treated with the utmost suspicion, as this approach would lead to the dismantling of most of our society's, and your Ministry's, protection of public health from environmental carcinogens and other toxic materials.

Given that modeling and extrapolation are unavoidable, you have been told by some that the "linear" dose-response model for radiation exposure and cancer is not accurate at lower doses, and that it heroically overstates cancer causation. (E.g., the aforementioned CNS submission specifically claims that "many scientists" have come to the "realization that cancer cannot be attributed to low doses of radiation and that there exists a threshold level below which we need not worry about radiation." Similarly, the presentations by Ontario Hydro and AECL at a July 14th meeting at Ontario Hydro which your staff attended but from which I was barred by Ontario Hydro, refer to linearity, in overhead slides, as a "cautious assumption". The AECL presentation claims further that the "weight of evidence actually inveighs <u>against</u> linearity.")

The facts are otherwise, the protestations out of date.

At present, the most widely accepted scientific modeling of the human epidemiological evidence for radiation-induced cancer by "establishment" bodies (like the ICRP and the US National Academy of Science's BEIR-V committee) indicates that the cancer induced by low-level radiation is, generally, directly proportional to the dose. In other words, the best-fitting model, according to the international radiation-protection "establishment", generally shows a dose-response function that is linear at low doses. (At high doses, where massive cell-killing and prompt illness and fatality occur, the effects naturally become non-linear, primarily because neither a cell nor an organism can be killed more than once.)

It must be stressed that the acceptance of these linear models as the best-fit models for the human data is a relatively recent phenomenon, primarily published within the past 4 or 5 years. For example, the US National Academy of Science's BEIR-III committee, in 1980, accepted a semi-threshold model (called the "linear-quadratic" model) as the one that they believed best fit the human data for relatively penetrating radiation.[1] In that older-fashioned model, the carcinogenic effect of the "first few" units of radiation exposure was significantly lower than the carcinogenic effect of "later" units. (In other words, the 1980 consensus model suggested the existence of just the kind of "threshold" the CNS submission to you describes.) In the more modern linear model, now accepted by both ICRP and BEIR, each unit of radiation exposure in the low-dose range (i.e., below the range of prompt illness and fatality) brings the same amount of cancer risk as each other unit. In other words, the international scientific (or "establishment") consensus is, in 1994, that the best scientific model to fit the human data does not support the existence of a threshold, and does support linearity.[2]

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1. The technical term for the more penetrating forms is "Low Linear Energy Transfer", or "Low LET". For High LET radiation, notably alpha particles, even BEIR-III in 1980 accepted linear proportionality as the best fit to the data. (The human data, mathematically, actually suggest a somewhat higher effect per unit dose at very low doses -- a "supra-linear" effect.) Tritium emits the world's lowest-energy, least penetrating beta particle (or ray), and may fall somewhere between these two extremes.

2. On pp. 4-5 of Ontario Hydro's March 10, 1994, submission to ACES, in sections 4.1 ("Credibility of the Institutions that Recommend and Set Radiation Protection Limits") and 4.2 ("Disagreement among experts"), Ontario Hydro argues that "The vast majority of the scientific community supports the views expressed in ICRP/UNSCEAR/BEIR publications," and that "the published conclusions of the international committees should be accepted as the best current knowledge on the subject." Ironically, it is now the Canadian Nuclear Society that must argue (in defending high tritium levels) that ICRP and BEIR must

In this context, it is important to distinguish between the adoption of the linear dose-response model as a best-fit model for the human data and its adoption as an intentionally conservative regulatory assumption. The radiation establishment in Canada, to its credit, has since about the 1950's used the linear model for regulatory purposes, as a cautious assumption, believing that it understated the health effects at very low doses -- i.e., the kinds of doses that nuclear-facility neighbours would be exposed to. Many members of that establishment continue to argue (and perhaps also to believe), mistakenly, that this regulatory model is different from, and more protective than, the consensus scientific model of the human data itself. As discussed above, the two are now essentially the same, and there is no good scientific reason to believe that there is any more conservatism built into the dose-response carcinogenesis model for exposure to radionuclides than for carcinogenic chemicals like NDMA. In hindsight, the old "cautious assumption" wasn't really that cautious -- and, of course, it was applied with numerical risk coefficients that are now known to be far too low.[1]

In 1990, the US "BEIR-V" report recommended a general linear coefficient of risk between 4 and 8 fatal cancers per 100 person-Sieverts of population exposure to radiation. The latest (1991) ICRP report -- generally adopted by AECB -- suggests a general linear coefficient of risk of 5 fatal cancers per 100 person-Sieverts of population exposure to radiation -- often abbreviated as a risk of 5% per p-Sv. It is this latter coefficient that was used both by your Ministry's staff, in preparing the Rationale Document, and by ACES in A Standard for Tritium.

It is also that coefficient that allows the direct translation of the Rationale Document's 0.1 mSv/yr (corresponding to 2 L/day consumption at roughly 7,000 Bq/L of tritium) into a lifetime (70-year) fatal-cancer risk of 3.5×10^{-4} or 350 fatal cancers per million population (0.1 mSv/yr x 70yrs x 0.001 mSv/Sv x 0.05

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not be taken too literally, and that you should take seriously the suggestion that environmental exposure to radioactive substances may "reduce the likelihood of cancer." [ibid, p. 3, emphasis in original]!

1. Of course, the WHO's recommendation to decrease acceptable tritium levels in drinking water from 40,000 Bq/L to about 7,000 Bq/L is based on the most recent upward revision to those risk coefficients -- from just over 1% fatal cancer risk per Sievert to about 5% fatal cancer risk per Sievert (see discussion, immediately below).

fatal cancer risk/Sv = 3.5×10^{-4} fatal cancer risk).[1] Similarly, the coefficient translates 100 Bq/L into a risk of 5 fatal cancers per million population, and 20 Bq/L into a risk of 1 fatal cancer per million population, over a lifetime of drinking 2L/day.

In short, ACES used the most widely accepted, scientific-establishment-consensus model, and used it in precisely the way it should be used, and generally is used, to achieve our society's and your Ministry's standards for the protection of public health from environmental carcinogens and toxic materials.

B. Is the issue exposure to tritium, or is it exposure to radiation?

In the first overhead slide of his presentation to your Ministry's staff at the meeting of July 15th from which I was barred[2], Ontario Hydro's Ron Maruska writes:

"Background Information
Issue:
Exposure to Radiation
NOT
Exposure to Tritium".

Indeed, it is only by "lumping" all human exposures to radioactive pollution together with natural, unavoidable exposures to radiation like cosmic rays and radioactive Potassium (K^{40}) in the human body, that radioactive polluters and their traditional regulators believe they can justify exposing innocent members of the public to cancer risks most Ontarians would consider unacceptable. "Why go to any trouble at all to decrease these artificial exposures to radiation," they argue, "when

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1. More precisely, the risk from 0.1 mSv/yr over 70 years is estimated at 350 fatal cancers per million population, but that would correspond to 70 years of drinking 2L/day of water with a tritium level of 7610.35 Bq/L, or "approximately 7,600 Bq/L", as the Rationale Document presents it at p. 12. Using Ontario Hydro's dose conversion factor for ingested tritium -- 2.0×10^{-11} Sv/Bq -- rather than the 1.8×10^{-11} Sv/Bq used in the Rationale Document, produces a tritium level of 6849.32 Bq/L as equivalent to 0.1 mSv/yr.

2. According to my files, the attendees from MOEE or your office at this meeting included B. Thorpe, I. Jung, R. Gaghadar, R. MacKenzie, N. Thornton, F. Ursitti, and G. Jenkins.

natural exposures to radiation are significantly larger?"[1] Happily, this technique of lumping large miscellanies of "bad things" together, to justify artificial additions, does not seem to be part of your Ministry's policy toward setting Drinking Water Objectives for carcinogens. It is also not part of the policy of the police force in deciding whether or not to pursue murderers or reckless drivers (who, after all, kill far fewer people than natural causes and heart attacks).

Nor should it be, because in all these cases it confuses the real issues rather than clarifying them, and because it is morally bankrupt: the presence of unavoidable risks doesn't justify increasing avoidable exposures. (Indeed, voluntary exposures to risk by Ontarians cannot even be taken to justify involuntary exposures to risk.)

Indeed, had the CNS and Ontario Hydro gone further and included automobile accidents, suicide, and criminal activities in their "denominator", it would have been with about as much intellectual justification as what they have done. In fact, the "lumping" of the various forms of radiation into a common sum and a common unit is fraught with insurmountable scientific difficulties, which the "radiation-protection" community has not resolved, but has essentially ignored by convention.

See, for example, pp. 10-11 of Energy Probe's February submission to ACES for a discussion of the impossibility of scientifically establishing a single "exchange rate" or "conversion factor"[2] to relate the health effects of tritium to those of a "standard" form of radiation (hard X-rays). As discussed there, the experimental answer depends on the rate and amount of tritium administered, and also on the specific "biological end-point" --

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1. Of course, it would be even easier for tritium polluters and their friends to use this argument if Ontario Hydro's and AECL's tritium emissions, or the contamination levels they caused, were small compared to "natural" or "background" levels. Unfortunately for them, tritium contamination in Ontario is dominated by Ontario Hydro's and AECL's emissions, with left-over contamination from atmospheric nuclear-weapons testing in second place, and natural production a distant and trivial third. (In this regard, we are disappointed that both your Ministry's Rationale Document (pp. 3 and 4) and the May 27th News Release from your office implied that natural production is a significant source.)

2. The technical term of this conversion factor -- basically the ratio between the observed health harm from a specific form of radiation and the energy it delivers -- is Relative Biological Effectiveness, or RBE. The RBE of "hard" or high-energy X-rays is set at 1.0, and other forms of radiation (like tritium's low-energy beta particle) are compared to it.

i.e., the disease, the type of cancer, etc.[1] In my experience, members of the radiation-protection community are either honestly unaware of this scientific weakness in their "lumping" approach, or simply have not realized what a threat it poses to that approach: Tritium is significantly more effective than (say) x-rays, on a "per-Sievert" basis, at causing some diseases, and less effective at causing others. So combining exposures to : cosmic rays, x-rays, tritium, Strontium-90, radon, and Potassium-40 into one enormous and allegedly uniform category is scientifically naive as well as morally bankrupt. Each kind of exposure must be judged according to the harm it is expected to do, and according to the difficulty of avoiding it.

"The issue," in short, is that tritium is a persistent toxic and carcinogenic substance, and that it is in drinking water in some parts of Ontario at levels far above background, causing cancer risks (according to the widest scientific consensus) far above Ontario's acceptable cancer risk levels, because of emissions from heavy-water reactors and their associated waste facilities.

2. Should we tolerate higher tritium levels, and higher cancer risks, because it's too hard and expensive to meet the ACES recommendations?

This question will be dealt with in several sections, as follows:

(A) Background: Why is this being discussed now?
(B) How does the tritium get into the tap water, and how could it be kept out at least cost?
(C) Should we avoid reducing the cancer risk from tritium because it may start a "domino effect" that will destroy the nuclear industry?
(D) First process concern: Reliance on pollution-control data controlled by the polluters.
(E) Second process concern: Reliance on forecasts by unreliable forecasters.
(F) Energy Probe's Recommendations

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1. The radiation-community's response is to choose a single number out of this "cloud" of experimental data, call it the "quality factor" or "Q" of that form of radiation, then to use it to convert Grays of absorbed dose into Sieverts of "effective dose" as if it were the true Relative Biological Effectiveness of that form of radiation for any important health effects.
This same report also reported "a surprising decrease of time to death of animals without tumours ... in the irradiated groups of mice" [abstract, p. i.] and suggested [in the discussion of this issue at pp. 6-9] that further research might be warranted into "non-specific life shortening due to radiation exposure". It has not been done.

(A) Background: Why is this being discussed now?

Typically, your Ministry staff would have investigated and discussed the predicted socio-economic impacts of a change in a Drinking Water Objective for tritium in their Rationale Document proposing the change. Following that, these predicted impacts would have been the subject of public scrutiny, and submissions to ACES, and ACES deliberations. Unfortunately, as the ACES report explains on p. i, your Ministry staff's Rationale Document applied the acceptable-risk level of ICRP, WHO, and AECB, rather than the much more stringent acceptable-risk level of your Ministry.

Since these risk levels (which are unacceptably high, in our view, in ACES's view, and according to your own Ministry's guidelines) are already being met, without any incremental action by anybody at all, the issue of socio-economic impacts did not arise. Now that ACES has applied Ontario-appropriate risk levels to the subject of tritium in drinking water, the issue of socio-economic impacts does arise, because present practices of the two tritium emitters (Ontario Hydro and AECL) and of the Water Treatment Plants allow tritium levels at some WTPs to exceed 20 Bq/L frequently and routinely, and 100 Bq/L infrequently, following accidental releases.

As a result, we understand that your Ministry staff, under Ms. Beverly Thorpe, are preparing a document for you on this topic, to guide your decision. We fear that this document will be withheld from the public, under ? 12 of the Ontario Freedom of Information and Privacy Act. We present, below, some of our concerns related to this decision-making process.

(B) How does the tritium get into the tap water, and how could it be kept out at least cost?

We fully support ACES's recommendation that the new tritium standard "be applied as a health-based Maximum Acceptable Concentration, so that when the drinking water standard is exceeded, an alternative water supply should be made available." But we would be disappointed if the provision of alternative drinking water supplies became the principal response to high tritium levels in tap water. (See pp. 1-2 of Energy Probe's February 24, 1994 submission to ACES for more discussion on this issue.) Indeed, we do believe that this response is warranted by the projected health risks and by the rights of innocent Ontario citizens not to have carcinogenic pollutants placed in their drinking water. But we also expect this practice to be politically troublesome "at the boundaries" -- i.e., in the neighborhoods that are still drinking tap water (only slightly less tritium-contaminated than the necessarily arbitrary action level) while their neighbours on the other side of the street have been supplied with uncontaminated water.

Socially, politically, and environmentally, the best way (and

very likely the cheapest way, too) to keep tritium levels acceptably low in Ontario's Water Treatment Plants is to keep as much tritium as possible out of the water in the first place -- in other words, to reduce tritium emissions at their source. Indeed, "Stopping Pollution at its Source" is a well-established principle in your Ministry. It simply has never been applied to radioactive pollution before.[1]

Fortunately, there are very few ultimate sources of all these waterborne tritium emissions to control: Ontario Hydro's five Nuclear Generating Stations (Pickering A, Pickering B, Bruce A, Bruce B, and Darlington) and AECL's Chalk River Nuclear Laboratories.

Within each of those facilities, there seem to be only a few significant specific sites or sources of waterborne tritium emissions, as follows: Each of Hydro's nuclear stations has one effluent pipe or channel for Condenser Cooling Water (CCW), and each individual reactor or unit (four per station) has one outlet for its Moderator Heat Exchangers, which may or may not be separate from the CCW outlet. There are also several sumps and drains that apparently go directly into the adjacent lake, or at least did a few years ago[2].

The two dominant sources of waterborne tritium emissions from Ontario Hydro's Candu nuclear stations are apparently the frequent pump-outs of the so-called "[Radio-]Active Liquid Waste Management System", discussed below

Most of the waterborne tritium emissions from Chalk River Nuclear Laboratories go either from their "Process Sewer" directly into the Ottawa River, or drain from Chalk River's "waste management" areas into the Ottawa River, primarily by way of Perch Lake, Perch Creek, and Duke Stream.

Sidebar: tritium emissions and emissions control at Chalk River

> In 1992, tritium emissions from the four dominant sources at Chalk River totaled about 119 TBq or 119 trillion Bq of tritium. (That heroic amount constituted only 0.034 of one percent of Chalk River's annual waterborne tritium release limit from the AECB, which is a staggering 350 PBq -- 350

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1. That phrase has been used as the motto for Ontario's Municipal-Industrial Strategy for Abatement -- the MISA program -- which has thus far totally excluded all radioactive emissions from consideration, usually on questionable and legally untested jurisdictional grounds.

2. More specifically, one such drain a few years ago at the Bruce complex was responsible for turning a tritiated-water spill onto the tarmac in a loading area into a tritiated-water spill into Lake Huron.

quadrillion Bq -- per year.)

In 1993, tritium emissions from the four largest sources at Chalk River totaled about 82 TBq or 82 trillion Bq of tritium.

The relative contribution of each of the four sources to each year's total is as follows:

	1992	1993
The Process Sewer	35%	15%
Perch Creek Weir	26.5%	47%
Area "C" Drainage	20.5%	23.5%
The Storm Sewer	18%	14.5%

Modifications to decrease the emissions from Perch Creek Weir and Area "C" Drainage (via Duke Stream) would likely consist of (1) excavation and remediation of leaky old waste facilities, and (2) the discontinuance of ongoing substandard waste-disposal practices -- notably the ongoing use of "Liquid Dispersal Areas"[1] for the disposal of hundreds of trillions of Bq of tritium per year. These LDAs consist in part of shallow sandy wells or "pits" at a comfortable and convenient distance from the main buildings and staff of Chalk River, but uncomfortably close to water bodies that drain directly into the Ottawa River. We believe the Process Sewer is primarily contaminated from the operation of the NRU reactor, and we are puzzled at the extent of tritium contamination in the Storm Sewer -- described on p. 3-5 of AECL-7243 only as "contaminated ground water".

In any case, tritium emissions are now essentially uncontrolled, since AECB tritium-emission regulations -- even when taken as 1% of total permitted releases or "DRLs" -- are so enormous that they have prompted virtually no abatement activity. (See Energy Probe's February 16, 1994 submission to AECB entitled "The regulatory vacuum concerning 'routine' radioactive emissions", appended to Energy Probe's February 24, 1994 submission to ACES, following p. 17.) Whatever tritium-abatement activity has taken place has either been prompted by (a) the substantial cost of heavy water to Ontario Hydro (tritium is a contaminant formed in heavy water, which is generally lost whenever tritium is emitted), or (b) the need to decrease occupational exposures to tritium, and to decrease generating-station shutdowns due to ongoing tritium emissions. (These last two factors were the main motivations for the construction of the Darlington Tritium Removal Facility, which has apparently decreased Ontario Hydro's

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1. These are also called "Liquid Disposal Pits" -- e.g., on p. 3-7 of AECL-7243.

waterborne tritium emissions, but not necessarily its total tritium emissions. For example, in 1992, tritium emissions from the TRF to the air, at 1.1 quadrillion Bq, were very large--larger than the total tritium emissions from Darlington, and 52% and 35% of the waterborne tritium emissions from the eight Bruce reactors and the eight Pickering reactors, respectively.)

Of course, decisions made by earlier Ontario governments to exempt Ontario Hydro's radioactive emissions from the monitoring phase of the MISA process -- a process designed to stop water pollution at its source, unless the pollution is radioactive -- have helped to allow this regulatory vacuum to persist.

When assessing the costs of abating emissions, it is (paradoxically) good news that emissions are now essentially uncontrolled, because it means that we are still at the inexpensive part of the cost curve. Furthermore, because of the enormous dilution factors provided by Lake Ontario, Lake Huron, and the Ottawa River, the proposed 100 Bq/L limit at the Water Treatment Plant is not an onerous or heroic limit. Indeed, even though tritium emissions are now essentially uncontrolled, exceedences of 100 Bq/L tritium concentrations in drinking water have been relatively rare. And at least some of those exceedences are extremely unlikely to reoccur, because their root causes have already been successfully addressed. (For example, real-time emissions monitoring has since been installed in Pickering-A that would have detected the August 1992 moderator heat-exchanger leak at a very early stage.)

In short, we agree with ACES that a 100 Bq/L limit, even interpreted as a Maximum Acceptable Concentration, would very seldom be exceeded, and would therefore have very limited and affordable socio-economic impacts. This interim ODWO should therefore, in our submission, be implemented immediately, as ACES recommended.

As we reported to ACES, Energy Probe's candidate list of "economically achievable" tritium-abatement changes for CANDU stations (some or all of which would be necessary for the consistent attainment of the more stringent 20 Bq/L ODWO) would include improved or newly installed emissions monitors, improved procedures; improved hardware (especially moderator heat exchangers), and drains and sumps that don't drain directly into the lake. The improved procedures would certainly include a reassessment of the "[Radio-]Active Liquid Waste Management System", which consists primarily of a series of 75-tonne holding tanks, ten of which are pumped (unfiltered and without tritium removal) directly into Lake Ontario and Lake Huron on a typical day by Ontario Hydro.

Unfortunately, as we told ACES, we have consistently been told by Ontario Hydro that they have no good information on the contribution of each of the "pathways" within their stations to

the escape of tritium (or other radionuclides)[1]. But quite recently, I have been informed of the existence of a series of Heavy Water Loss Reduction Studies done at Ontario Hydro's nuclear stations, and Ontario Hydro Nuclear has agreed in principle to produce them to me. Unfortunately, I still haven't received any of them, more than three weeks later. Inquiries among several of your Ministry staff, in Head Office and the Regions, indicate that your Ministry staff also do not have copies of these studies, nor do they know much about the sources of Ontario Hydro's radioactive emissions, tritium or otherwise.[2] These Ontario Hydro studies, if indeed they exist, should help both us and your staff to assess the options to decrease emissions of tritium.

(C) <u>Should we avoid reducing the cancer risk from tritium because it may start a "domino effect" that will destroy the nuclear industry?</u>

It is certainly arguable that the largest socioeconomic impact of the ACES recommendations is that those recommendations -- especially if implemented -- will set a precedent for future decisions in Ontario and elsewhere concerning acceptable public exposures to radioactive pollution. For example, waterborne radioactive emissions from abandoned (and active) uranium mines may come under new scrutiny, as may waterborne emissions of fission products from operating reactors and from waste facilities like those at Chalk River, as well as public exposures to airborne emissions of tritium, tritiated water vapour, and noble gases from operating reactors and Ontario Hydro's radioactive-waste incinerator. Some members of the public may even feel free to question AECB's standard for tritium in milk -- currently set at 240,000 Bq/L. Pressure may grow to clean up large sources of environmental tritium (especially Chalk River), and of other radioactive pollution (especially Chalk River). Pressure may also grow for further study into the observed (and significant) excesses of Down's Syndrome around Pickering and of childhood leukemia around Pickering and Bruce. And AECL's concept for deep geological disposal of irradiated nuclear fuel (90% of it Ontario Hydro's) may be faced with public-health standards it cannot meet.

Even more speculatively speaking, support for uranium mining in

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1. See, for example, p. 144 of Energy Probe's 300-page "D/SP Exhibit 597" (sent under separate cover) for Ontario Hydro's December 1991 response to such a question.

2. This lack of knowledge might surprise an uninformed member of the public, but it is of course not at all surprising, given the consistent refusal of past Ministers of the Environment to exercise any regulatory authority over those radioactive emissions.

Saskatchewan may fall, as may interest in new Candu reactors in Saskatchewan and New Brunswick -- or even in foreign countries like South Korea and Romania.

In short, it is obviously very tempting to have consistent, high standards for public-health protection from carcinogens -- whether they happen to be radioactive or not -- and that temptation, that obvious attractiveness may well sweep through Queen's Park, Ottawa, and the rest of the world like an idea whose time has come, leaving nothing radioactive or nuclear unchanged in its wake.

That enormous socioeconomic impact, of course, is just what Energy Probe and Energy Probe's supporters hope will come to pass, and just what the nuclear polluters, their apologists, and their captive regulators most fear. How can this potentially enormous but highly speculative "impact" be assessed?

First, we would note that much of the impact may have already been committed. Environmental, energy, and anti-nuclear organizations, and neighbours of nuclear facilities have already been informed of the ACES investigation, and of their recommendation. Many have copies of the report, which speaks for itself, regardless of your government's decision. The attractive and eminently logical idea is already at large.

Second, we believe (as we believe your government does as well) that a phaseout and cleanup of the present generation of nuclear technology is ultimately inevitable -- the only issue is its timing. By accepting ACES's recommendations, you are probably directly or indirectly hastening the cleanup of the mess at Chalk River, and quite possibly the already accelerating shutdown of Ontario Hydro's Candu plants as well. But you would not be causing these things, just hastening them. So the impact on the cost side of the ledger is likely to be limited to the time value of the costs of cleanup and shutdown, and not the total costs. And the time value of those costs may be negative: for example, there are radioactive groundwater plumes at Chalk River now heading for wetlands, creeks, and rivers. The costs of retrieving those radio-toxic materials are obviously escalating much faster than inflation, yet AECL has submitted no plans and budgeted no funds to clean them up before they become much less retrievable. On the benefits side, the health impacts of public exposure to carcinogens cannot simply be deferred over time by adding inflation: the sooner these emissions stop, the fewer members of the Ontario public will suffer the physical and mental harm of exposure to toxins beyond their control.

Third, if the implementation of the ACES recommendations does speed up the phaseout of nuclear power in Ontario, or Canada, will that impact be net positive or negative? Candu reactors, as you well know, have had a disastrous effect on Ontario Hydro, its customers, and its employees, and Ontario Hydro has recently admitted that those reactors are worth $11-12 billion less than they cost, even after depreciation -- and all that with

permissive or non-existent emission regulations. It would seem logical to conclude that Ontario's economy would be more prosperous today if the ACES recommendations had been made and accepted twenty years ago. Since we expect the ultimate costs of the Chalk River cleanup will also dwarf any financial benefit AECL may have produced, we would argue that the permissive or non-existent emission regulation that allowed that mess to accumulate was also a net drain, not a boost, to the Canadian and Ontario economies.

(D) First process concern: Reliance on pollution-control data controlled by the polluters.

As you know, the history of pollution control in this Province -- e.g., of the control of Acid Gas from nickel smelters -- has often been characterized by frighteningly high or ad terrorem estimates, made by the polluters, of the costs, and socioeconomic consequences (including bankruptcies, plant closures, or relocations to other jurisdictions), of pollution reduction. Earlier Ontario governments often responded by delaying implementation of Control Orders. Ultimately, after lengthy delays, the feared pollution reduction was often achieved by those very same polluters at much lower cost, and in some cases even at a profit, in the case of Inco's ultimate reductions of SO_x emissions.

Clearly, whenever the costs to abate pollution are factored into government decisions to require abatement, as they apparently always are, it is in the polluter's best interests to overestimate those costs. Only after abatement is irrevocably required does it become in the polluter's best interests to find the truly least-cost way to achieve the required abatements.

In this case, Ontario's tritium emissions into water are entirely produced by two institutions, Ontario Hydro and Atomic Energy of Canada, and they are also the only two parties with direct access to their technology and cost data. As a result, we believe it will be very difficult for your government to ensure that the polluting parties' cost estimates are realistic. One helpful mechanism, of course, is already provided by the ACES process: If only your Ministry Staff had recommended an ODWO of 100 or 20 Bq/L, as would flow directly from your Ministry's policies on water pollution, then your Ministry Staff would also have had to assess the socio-economic impacts of adopting those ODWO levels. Through the ACES process, independent experts, including Energy Probe's, would have gained access to those assessments, and been able to share their expertise with ACES, which would then have judged the evidence and opinions it received. As discussed above, we concur with ACES in believing that the "immediate" level of 100 Bq/L can be achieved immediately, without significant socio-economic impacts, and that the five-year level of 20 Bq/L will require higher expenditures and more discussion. In this regard, we suggest that you consider a further reference to ACES specifically on the subject of the "five-year" 20 Bq/L level, preceded by a revised public assessment from your Ministry Staff,

in the form of a Rationale Document on socio-economic impacts.

(E) Second process concern: Reliance on forecasts by unreliable forecasters.

Even assuming, contrafactually, that there is no incentive for Ontario Hydro or AECL to overestimate the costs of abating their tritium emissions enough to meet ODWO levels of 100 or 20 Bq/L, any estimate of those costs is essentially a forecast, and both institutions, with all due respect, have repeatedly and consistently shown that they have absolutely no talent for making accurate forecasts of anything, including electricity demand in Ontario and neighbouring jurisdictions, nuclear power costs, reactor output, inflation, costs of non-utility generation, marginal cost of abating acid-gas emissions, etc., etc. It would obviously be imprudent to allow the actual levels of the health risk from any carcinogen in Ontario's drinking water to be determined by forecasts made by either Ontario Hydro or AECL. A review of all the available data by organizations with significantly better forecasting records (like Energy Probe) would seem a sensible precaution. A reference back to ACES to investigate the "five-year" 20 Bq/L objective, with a Ministry staff Rationale Document as a basis for consultation, would be one appropriate mechanism for that review.

(F) Energy Probe's Recommendations:

Energy Probe recommends that you adopt ACES's recommendation that the Ontario Drinking Water Objective for tritium be set at 100 Bq/L effective immediately, and that you also adopt ACES's recommendation that the level be considered a Maximum Acceptable Concentration, calling for alternative water supplies whenever it is exceeded at a Water Treatment Plant.

Energy Probe further recommends that you initiate a second reference to ACES, to investigate the socioeconomic impacts and technical feasibility of achieving ACES's "five-year" 20 Bq/L objective or lower, beginning with a Ministry staff Rationale Document on this subject to be released in advance to the public as the basis for ACES's consultation.

Knowing what we now know about the regulation and risks of tritium emissions from nuclear facilities, Energy Probe further recommends that you not approve the expansion of the Ajax Water Treatment Plant. It was, as you may recall, public concern over that expansion, supported by the Environmental Assessment Advisory Committee and by your predecessor the Honourable Ruth Grier, and now thoroughly vindicated by the Advisory Committee on Environmental Standards, that first brought this issue to Ministerial and broad public attention.