CITIZENS AWARENESS NETWORK BOX 83 SHELBURNE FALLS,
MA 01370
T/F: 413-339-8768

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Roxanne Summers
Senior Program Manager Analyst
ACRS and ACNW Sub Committee
NRC
11545 Rockville Pike
Rockville, MD
Fax : 301-415-5589

Dear Ms Summers,

This fax represents Citizens Awareness Network's comments on the Decommissioning Rule for nuclear power stations and our comments on the effects of low-level radiation. We request that these comments be entered into the record. In addition, we request that that the NRC Inspectors General's report Decommissioning Policy: NRC at the Crossroads be entered into the record.

Sincerely,

Deborah Katz
President
Citizens Awareness Network

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T/F: 413-339-8768

SACRIFICE COMMUNITIES

The question of how reactors decommission and how corporations will dispose of their waste is central to the issues of democracy, pollution prevention and reduction, and site remediation. It involves ethical issues concerning nuclear power. CAN must address these issues from the position of a contaminated community. We are not a national group. We speak for citizens in the effluent pathways of reactors and waste sites, poor communities, disenfranchised communities. We live within 17 miles of two reactors. Franklin County is the second poorest county in New England. Rowe, home to the Yankee Rowe reactor, was the poorest community in Franklin County. Now its the richest.

The communities chosen to suffer nuclear contamination are poor, rural and often people of color. As imiseration expands in the current political climate among disenfranchised people, be they Native Americans, Mexican Americans in Texas, the rural poor, or women who are disproportionately impacted by toxic pollution due to biological realities of the reproductive process, communities will be hard pressed to value health and safety over short-term financial relief. It is unacceptable to force people to choose between immediate economic survival and the sacrifice of future generations. Some of the ethical questions that polluted communities must confront concerning decommissioning are:

- Are communities served by enabling reactors to shut down and decommission rapidly by ignoring the problems of waste disposal and setting aside duly promulgated regulations?
- Are the processes of dismantlement less dangerous than standard operation and therefore less important to reactor communities?
- Is it acceptable for a corporation to control and contaminate our water and air on a routine and regular basis?
- Is it reasonable to contaminate the water, earth, and air of another community to clean our community up?
- Is it reasonable that radioactive pollution be an acceptable by-product of nuclear energy production and that communities in the effluent pathway, the pollution pathway, suffer increases in disease?
- Why are the communities chosen to suffer nuclear contamination routinely poor, rural and often people of color?

The mounting pressure to move rad waste off site, both low and high-level, comes from the failed policy of the Federal government and needs of the nuclear waste generators. Since 25 reactors face premature shut down and decommissioning in the next ten years, the closure of

reactors will open the floodgates for rad-waste throughout the country. This is the nuclear industry's crisis. The solutions proposed by utilities pit sacrifice community against sacrifice community, manipulate community's fears of contamination, support opportunism, and develop an illusory fallacy- reactors, clean when operating, are now dirty and dangerous if waste remains on-site as an interim or possible permanent solution to the waste problem. why is long term on-site storage and cool down, used routinely and regularly by reactors for years, now unacceptable?

Yankee Decommissioning

We are at a crossroads in decommissioning. At Yankee Rowe 90% of the radionuclide inventory was removed from the site without a decommissioning plan approved by the NRC. According to NRC regulations the plan is the only way to protect the health and safety of the workers and the public. Over 136,000 curies were removed from Rowe including four steam generators, the pressurizer, and reactor internals. A million curie baffle was cut under water and stored in the irradiated fuel pool.

Lack of Oversight

Because there was no on-site resident NRC inspector during component removal operations, our community was unprotected by NRC. Since there are no "safe" levels of exposure to radiation, the increase in illness that our community may suffer as the result of the CRP is unknown and disturbing. There is an ongoing health investigation with the Ma DPH concerning the epidemic of disease that already exists in our community. Although it is claimed that decommissioning poses a substantially lower risk than standard operation to public and worker health and safety, this claim is unsubstantiated. The decommissionings at Rowe and Trojan are experimental and only with the completion and study of the decommissioning of many reactors, will realistic data become available.

It was claimed that the exposures to the workers during the CRP would be substantially lower than standard operation. This proved to be inaccurate. The exposures were comparable to standard operation and substantially larger than originally predicted. In addition, the increased worker exposures (310 contamination events from 1/1/94-12/31/94) and lost-time accidents (the rate was higher than average construction industry rate) during the CRP/ Decommissioning might have been prevented had the NRC treated this decommissioning **as a major federal action and been on-site.**

There were 75 effluent releases into the Deerfield River during the CRP. 23 releases occurred in April and May. Although releases were in micro and millicuries, we are concerned with the cumulative doses incurred by local citizens over the 31 year release history of the reactor.

The Appellate Court Decision

CAN repeatedly requested hearings on the decommissioning process from the Fall, 1992, winter, 1992, Spring, 1993, Summer, 1993, Fall, 1993, winter, 1993 until CAN took the NRC to Federal District Court to seek relief from the violation of our due process rights. to stop the illegal decommissioning of the reactor. The precedent setting Component Removal Project

was **scathingly rejected** by Court. The Court ruled that the NRC was arbitrary, capricious, and utterly irrational in their approval of the experimental CRP without a decommissioning plan.

The Court attacked the "concerted bureaucratic effort {by NRC} to thwart the efforts of local citizens to be heard about an event that vitally affects them and their children .... The prospect that this tactic may be used nationally as more nuclear power plants shut down .....is, to put it mildly, disquieting" . In addition, the justices found the NRC actions irresponsible ... "An agency can not skirt NEPA or other statutory commands by exempting a licensee from compulsory compliance, and then simply labeling its decision "mere oversight" rather than a major federal action. NRC was found to be in violation of the National Environmental Policy Act, the Administrative Procedures Act, and the Atomic Energy Act.

The Appellate Court has opined that as long as radioactive materials remain on site, the issue is not moot to our community. It therefore remanded the case to the agency for remediation. The NRC Commissioners asked for comments from the community concerning the halting of major decommissioning activities at the reactor until an adjudicatory hearing was offered. Over 250 comments were received by the NRC from our community requesting that decommissioning activity be halted, a hearing be held in our community, and a citizen advisory board be convened to monitor decommissioning at the reactor. The NRC Commissioners met, issued an order halting the illegal decommissioning at Rowe. and posted a notice in the Federal Register offering an opportunity for an adjudicatory hearing. CAN requested the hearing and submitted 5 contentions to the NRC.

LESSONS LEARNED FROM YANKEE: STANDARDS FOR DECOMMISSIONING

The danger of technology is that it operates outside of human parameters; decision-making is based on mathematical formulations, but it is human beings that are stuck with the consequences. Therefore, Yankee Atomic can "clean Rowe up" by contaminating Barnwell, SC. This is illogical as well as unacceptable. Reactor communities are reevaluating rapid dismantlment. Long-term cool down provide the safest, cheapest, and sanest interim solution for the / nerican people.

Distinct Regulatory Categories. The NRC should retain its distinct categories between reactor operations and cessation. The Possession Only License should remain in place. it affords citizens the possibility for a hearing prior to reactor decommissioning. The hearing is an essential means for communities to participate in matters that vitally effect them given the dangers of enviro-toxic contamination inherent in the reactor cessation.

Decor ssioning: Major component removal (CRP) should not be authorized before the submission and approval of a decommissiong plan by the NRC. NRC must continue to define decommissioning as a major federal action and require NEPA compliance. The attempt to streamline the process for the utility and deregulate NRC requirements abdicates the NRC's responsibility to protect the health and safety of the workers, the public, the environment. and also undermines citizen due process.

Prior Notification. Utilities should provide prior notification to the public of any and all effluent releases into the water or the air and any transport shipments from the power station. Although

the effluent releases to the host community are smaller during decommissioning than during standard operation, at Rowe during decommissioning, there were over 70 releases into our river. Since reactor communities are concerned with long term exposure to low-level radiation, these releases were of great concern to our community.

On-site Resident Inspector: The presence of an on-site, resident NRC inspector is essential for decommissioning. The removal of highly irradiated components and internals pose a hazard to the host community and to the workers. The exposures to workers during decon are comparable to standard operation and substantially larger than originally predicted.

Site Remediation: The remediation of sites is central to reactor communities. It is essential that the community in the effluent pathway of reactors have the opportunity to participate in pollution reduction and prevention during decommissioning, and negotiate the issues concerning clean-up standards.

On-site storage: On-site storage, allowing long-term cool down, is the least dangerous expedient until a safer solution is developed. It limits the exposure of workers and the public to radiation. It reduces through natural radioactive decay the eventual burial volume of radioactive waste. Since the industry created the waste, they can maintain their responsibility for it and hold it on site. Some sites may require rapid dismantlement and the removal of waste. However, the radioactive waste should be stored as close to the site of generation as possible.

Advisory Boards: Site-specific Advisory Board are a mechanism for community participation during decommissioning. The Board would meet regularly to give meaningful input into decisions concerning health and safety, pollution prevention and reduction. The Board would function to educate the community regarding the impacts of the technology that exist in their neighborhood.

CITIZEN ADVISORY BOARDS

Worldwide advancement of industrial technology is occurring at an accelerating pace. This expansion is associated with environmental impacts. Structures for community involvement have not kept pace with technological advancement. In America, citizens depend on democratic structures to influence events that vitally effect them. Many have withdrawn from the process. This presents the prospect of vital decisions dictated outside of democratic safeguards. This has been characterized as the melt down of democracy. It is exemplified in the atomic power industry.

Citizens mistrust and fear advanced technological industries which pollute and the Federal regulatory agencies mandated to protect the public health and safety. This is due to potential ecological devastation, the inability for the nuclear industry and the Federal government to solve the problem of the nuclear waste stream, the increase in disease in the effluent pathway and the conflict between the cost of maintaining a profit for the utility and the cost of health and safety to the public.

It is essential that communities in the effluent pathway have the opportunity to participate in matters that effect them. This participation must be meaningful. The passive community

participation developed by the industry in which limited information is fed to citizens to allay their fears is ineffective. Citizens must create a substantive role for themselves in order to clarify, negotiate and protect their community's interests and to satisfy the requirements of a constitutional democracy. Ordinary citizens can understand the issues of the nuclear fuel cycle. The intimidation, created by science and technology, has led to the undermining of the democratic process.

Parameters and Education of Board:

The parameters of the board would be determined by the board after its inception. Initial education should be created by NRC to help a community determine its needs. If a community decides that an Advisory Board is needed, the NRC and convened stakeholders would determine a trusted organization in the community to initiate the process. This should occur before the decommissioning plan was written, possibly when the reactor announced closure, or at the application for the possession only license.
Parameters of the Board are:

- monitoring of effluents from decommissioning
- participation in the development of pollution prevention and reduction procedures
- investigating of health concerns in community

Participants:

Stakeholders should represent a broad perspective of community interest. Efforts must be made to reach out to the community to bring in minority points of view and minority groups who are often excluded from public participation.

- public interest groups and local representatives
- local government
- reactor representatives: blue collar and management
- DPH: monitoring and environmental health
- NRC/ DOE
- Native American Tribes

Framework and context:

The Board must become the educational forum for the community. This would entail the Board educating itself and in turn the community. It would negotiate with the utility, state and federal regulators in behalf of community's needs. It would create its own rules of order and conduct. Methods of accountability would be developed. It would hold regular meetings open to the public. A public comment period should be provided. The Board would issue reports on its work. Essential framework for the board should include:

- democratic process
- inclusive: effective outreach program developed to reach stakeholders
- creation of formalized group
- independent facilitation
- decision making by consensus with ability to vote if agreement unable to be reached
- educators and clarifiers of issues to community
- mutual respect maintained

- performance based

Potential Issues of Concern:

The Board should determine the issues of concern for the community. These will vary with individual sites. The Board may determine that issues relevant at the inception are no longer relevant. Through education, the Board may realize other issues are their primary concern. Therefore the Board should be seen as an experimental process rather than a rigid, unchanging structure.
Issues of importance for decommissioning are:

- DECON (rapid dismantlement) versus SAFSTOR (on site storage)
- worker and public exposure
- monitoring of effluent releases
- contamination, pollution reduction, prevention, and clean up
- future use
- preparation for decommissioning: economic impact /social impact
- monitored retrievable storage for irradiated fuel and irradiated fuel pool

Membership/ Selection Process

The selection of the composition of the board must be a democratic process. A respected and neutral local body determined on a site specific basis should convene the stakeholders after a determination that an advisory board is needed. The procedure for defining a selection process for board members should be developed from this convention. The Board should include a diverse array of community voices and concerns.

- representatives from community in effluent pathway
- representatives of public interest groups in community
- Ex-officio : NRC, DPH, DOE, EPA
- sustainable development specialists
- local government

Technical Assistance:

The Board must receive adequate funding to function. Funding should be provided in a timely fashion. Since there is the potential for the community to feel intimidated and inferior due to their inability to contribute monetarily to the project, community should provide services which contribute to the functioning of the Board. These services could include meeting space, an office, computer, secretarial services, etc. Should the Board be dead locked, a negotiator should be available to attempt to resolve the differences.

- funding for board to provide community education
- funding for technical experts
- funding for facilitation
- funding for negotiator if needed
- funding provided by: utility, NRC, DPH, DOE and community

GREEN POLICY FOR WASTE

A Green policy on radioactive waste must develop to protect the environment. It will be driven by the concerns of ordinary citizens needing to protect their children and future generations from expanding nuclear contamination.

- A democratic process must be initiated for an environmentally safe solution to be developed. **A Blue Ribbon Commission on Waste should be created by President Clinton.** Let us not sacrifice any more communities. The waste we ship out will return to haunt us.

- **Halt the production of rad-waste.** The DOE estimates 85,000 tons of irradiated fuel will be produced by the present generation of reactors alone. Only 30,000 tons has been produced so far.

- Return a percentage of the money in the Nuclear Waste Fund to the generators to maintain on-site storage. Acknowledge the truth. **Classify nuclear sites as superfund sites.** Provide funding to communities for education, medical training, monitoring, and other protective services.

- **The Nuclear Regulatory Commission should institute on site storage** as the preferred decommissioning option for radioactive debris. This would allow irradiated waste to remain on-site for thirty years. This is the essential first phase of waste reduction through natural decay. In thirty years the decommissioning waste needing removal to a rad waste dump would decrease by one order of magnitude.

THE FUTURE: DEMOCRACY IN THE USA

There is no pro or anti-nuclear. There is waste with no cost-free solution. It is America's problem, not just the industry's. Citizens must be included in the problem-solving process to determine the eventual storage for rad waste. To effectively participate in democracy, citizens must be presented with the full range of scientific opinion concerning low-level radiation, rad-waste, and nuclear power. If we can understand that the world is our neighbor, then we can end the cycle of contamination and sacrifice.

INTRODUCTION

Over the past two decades, residents of the Deerfield River Valley in Massachusetts suffered alarming health problems: an increased cancer rate, miscarriages, and a ten-fold increase in Down's syndrome (a congenital disease characterized by mental retardation and bodily malformation). Local health authorities were unable or unwilling to account for the region's growing pattern of health anomalies.

Attention soon turned to questionable safety of the procedures at the nearby Yankee Rowe nuclear power station—the nation's first "experimental" commercial reactor—and the effectiveness of the standard nuclear safety guidelines of the Nuclear Regulatory Commission [NRC]. During a series of public meetings, area residents learned that the Yankee Rowe reactor had used the nearby Deerfield River as a radioactive waste dump over the past thirty years.

Concerned citizens, realizing that the river had been widely used for well water, crop irrigation, and recreational purposes, began to question whether the increases in disease were due to the reactor's regular releases of radioactive materials into the river.

It was at this point that the Citizens Awareness Network [CAN] was formed as a grassroots organization primarily concerned with the health and safety of its community.

The Citizens Awareness Network began to investigate effluent releases from the Yankee Rowe reactor into the Deerfield River, and compiled a 30-year history of such releases. CAN found that large quantities of tritium had been released into the river, given its size and the degree of contact the community routinely had with its water.

The Massachusetts Department of Public Health [MADPH] initially denied that there was any cause for concern. After continuing pressure from CAN and the local community, MADPH agreed to a preliminary investigation of the diseases.

With the professional assistance of epidemiologist Dr. Sidney Cobb, and the work of concerned citizens, CAN coordinated research into state health statistics, effluent reports and meteorological data. Dr. Cobb analyzed the raw data and concluded that an epidemic indeed existed in the Deerfield River Valley, and that a full-scale epidemiological study was warranted.

An analysis of statewide statistics provided by MADPH confirmed a statistically significant increase in various types of cancer in the Deerfield River Valley.

CAN, community leaders and local legislators are working to create a new statewide birth defects registry, which was prompted by the deficiencies in MADPH's records for the incidence of Down's Syndrome.

INTRODUCTION

The Citizens Awareness Network has meanwhile continued its investigation of the nuclear reactor, leading to our current research on *tritium*, one of the nuclear isotopes regularly released into the Deerfield River.

We present this research with the experience of successfully influencing legislators and health officials thru thorough investigation and awareness. We believe that ordinary citizens can — and must — understand the scientific and social issues related to the production of nuclear power.

CAN believes that the standard operation of a nuclear power station causes untold harm, sickness and death. The focus on individual accidents results in misleading and diversionary arguments over the safety and effectiveness of existing technology. We believe that Yankee Rowe has been one of the "safest" reactors in the country, according to NRC guidelines. **It is the NRC guidelines that need re-evaluation.**

The epidemic of disease in the Deerfield River Valley did not become apparent until 25 to 30 years after operation began. We are now beginning to see the health effects of long-term exposure to low level radiation in our community, and in communities throughout the world.

We have all participated in an experiment without our knowledge or our consent. The data that can be ascertained from the investigation of Yankee Rowe and other nuclear facilities will provide the information to educate citizens as to the effects of radiation on the health of their generation and future generations.

TRITIUM

Tritium is a radionuclide emitted as waste from pressurized water reactors, heavy water nuclear reactors and the new generation of nuclear reactors. It has been an integral part of the nuclear weapons industry: tritium was released into the atmosphere as part of weapons testing in the 1950's and 60's. It is a beta emitter and has a half life of 12.5 years. It decays to an isotope of helium, releasing a neutrino and a beta particle (an electron). The electron is slow-moving and has a very short range.

Tritium was believed to be a relatively benign radionuclide because of the weakness of the beta radiation emitted when it decays. The beta electron is a small particle that passes readily through most barriers. The dangers of tritium come from inhalation, ingestion, and absorption.

Tritiated water (HTO) passes through the human body in 12 days. However, when the radionuclide unites with carbon in the human body, plants, or animals, it becomes organically bound (OBT) and can remain in the human body for 450 to 650 days. One study found traces of tritium in the body 10 years after exposure.[24]

As tritium makes its way up the food chain it may become more concentrated. [16] Pigs fed with tritiated food themselves became tritiated, as did their offspring. The blood, heart, and kidneys of the piglets were more tritiated than the food they were fed.[23]

Tritium is carcinogenic, mutagenic, and teratogenic. [21] Human beings can receive chronic exposure to OBT through the ingestion of plants and animals exposed in an effluent pathway, in addition to direct uptake through inhalation, absorption and drinking contaminated water. Especially sensitive to the effects of tritium are rapidly growing cells such as fetal tissue, genetic materials and blood forming organs.[2, 12, 19, 21, 20]

Tritium is dense and has a short track length. It releases all its activity at one time. This makes it more potent and similar to soft x-rays which are more effective than hard x-rays. [15] When and where it deposits its radioactivity, it creates at least one lesion in the cell. This lesion must be repaired within 24 hours or when the cell eventually divides, it will be carcinogenic.[26, 30] There may be a threshold below which the repair mechanism is not activated in the body; [13, 15, 27, 32] thereby, low levels of chronic radiation exposure can accumulate in the body without the repair system being activated. [11, 25, 27, 30, 32, 36]

Tritium has a transmutational effect which is mutagenic. After the particle releases its radioactivity into the cell, a helium ion is formed. The helium springs away from the ß-particle and severs the bond with the compound to which the tritium had attached itself. The compound acquires a positive charge and becomes chemically active.[22]

It then can attach itself to a ring of a protein precursor that will make up the chromosomal strands in the DNA. Depending on the ring it attaches to, it can affect the protein precursors and damage the DNA. This would create a mutational effect.[22]

TRITIUM

Radiological research has found a correlation between tritium and cumulative genetic injury. (21) There was found in successive generations a reduction in relative brain weight, reduction in litter size, and increased reabsorption of embryos. Correlations have been found in epidemiological research between tritium and Down's syndrome. Associations have also been found between low-level radiation and Down's syndrome.(6, 7, 8, 10, 31)

The Deerfield River Valley (DRV)

Nuclear power stations *must* dispose of waste to operate. For pressurized water reactors (such as Yankee Rowe), the main effluent release is into a body of water. Thus the Deerfield River Valley becomes a radiation waste dump for the Yankee Rowe. When tritium is released into such an environment, plant, animals, and human beings in the vicinity can be contaminated.(17, 24)

The Deerfield River is a small winding river in western Massachusetts. It has white water and is fast running. The valley through which the river runs is 800 feet on either side, creating a tunnel in which inversions are held. Fog hangs in the valley for days at a time. There are air inversions more than 34% of the time.

The river has been used for recreational purposes over the 31 year history of the Yankee Rowe reactor, the nation's first "experimental" commercial reactor. Citizens swim, fish and boat in the river. Wells and cropland are adjacent to the river, and in times of drought, river water is used to irrigate crops. Each year 500,000 people use the river .

For 31 years the Deerfield River has been a dumping ground for low-level radioactive waste. During the 1960s and early 70s, Yankee Rowe had problems with fuel rods and dumped large amounts of tritium into the river. Up to 1,800 curies a year were released, nominally within NRC guidelines.

During the time of operation the estimated concentrations of tritium were 1,000 times greater in the DRV than outside the valley. There were approximately 5 batch releases per month. People in the community were generally unaware that the river was radioactive, although it had been noted that since the reactor opened, the river had never frozen.

Epidemic of Disease in DRV

Increases in miscarriages, mental retardation, cancer and other health problems began to be noted in the 1980s through 1990s. There have been 10 children born with Down's syndrome since the 1980s, all to mothers under the age of forty. Affected families live within a three mile radius of each other in the effluent pathway, or have had extensive contact with the river during their pregnancies.

Down's syndrome occurs on average in one of 700 to 1,000 live births. Of the approximately 2,000 live births within the valley in the last 20 years, the incidence of Down's syndrome is closer to one in 100. There have been six chromosomally damaged children conceived during the same time

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period. Two of these children were born. One died at 6 months; the other five years old with Down's syndrome features. Another of the chromosomally damaged fetuses was trisomic. The Massachusetts Department of Public Health has begun a preliminary investigation of the environs around Yankee Rowe, in the pristine rural environmental of the DRV.

There is a 50% increase in five different cancers; a 40% increase in heart disease; and a 110% increase in infectious disease leading to mortality.

Citizens Awareness Network (CAN) and Nuclear Information Resource Service (NIRS) have demanded that NRC fund an independent epidemiological investigation of the DRV. This would entail an effluent pathway study of the river. We have also demanded that NRC reevaluate their inadequate and unfounded dosimetery standards for tritium.

To understand the effects of tritium exposure—the effects of organically bound tritium (OBT), and tritiated water (HTO) must be calculated. Since the effects of tritium are on a cellular level rather than an organ level, microdosimetry is required.

The issues raised in this report about the operation of the Yankee Rowe plant have been forwarded to the Inspector General of the Nuclear Regulatory Committee for investigation.

BIBLIOGRAPHY

Annotated bibliography of low-level radiation studies and tritium research

Down's syndrome

1 E. Alberman, J.A. Polani, Fraser Roberts, C.C. Spicer, M. Elliot, E. Armstrong. "Parental Exposure to X-Irradiation and Down's Syndrome." London: Ann. Him. Genet. 36 (1972) : 195.

Effect of radiation on increase in Down's syndrome was greatest in subgroup where X-rays were received more than ten years before conception. There was significant increase of "ever" X-rayed mothers in Down's syndrome group. The size or dose of X-ray was less important than the cumulative effect, as if damage was not followed by repair.

2 V. Beir, "Health Effects of Exposure to Low Levels of Ionizing Radiation." *National Academy Press*. 1990.

Report stated that there was no threshold for the effects of radiation when the brain is in its most sensitive stage of development. This was especially true from 8-15 weeks through 22 weeks of gestation.

3 Susan Harlap, "Down's syndrome in West Jerusalem." *American Journal Epidem*, 97, No. 4. pp. 225-232.

Research found that there were environmental factors involved in the etiology of Down's syndrome. Harlap compared rates of Down's syndrome in different groups in Israel. For mothers aged under 35, the age-adjusted risk of Down's syndrome is increased eightfold in one group who used the ritual baths while for older mothers difference in risk is less than threefold.

4 N. Kochupillai, I.C. Verma, M.S. Crewal, V. Remalinggaswami, "Down's syndrome and related abnormalities in an area of high background radiation in coastal Kerala." *Nature*, 262 (1976) : 60-61.

Research compared high background population to control with low background radiation. The observed frequency was higher than in controls and significant. Higher frequency of cases of Down's syndrome born to mothers aged 30-39. Association suggested between low dose radiation exposure of older maternal age dependence suggests that the damaging event accelerates oocyte aging and causes primary trisomy rather than translocation trisomy.

5 CN Rasmey, Ellis, and Zeally, "Down's syndrome in the Lothian Region of Scotland 1978 to 1979." *Biomed & Pharmacother* 45 (1991) : 267-272.

Observable increases in Down's syndrome were noted in Lothian Region of Scotland after the accident at Chernobyl. The highest rate of 27.12 in 1987 was significantly higher than average for t'e whole period. Increase in incidence peaked in late 1987 and subsequently returned to pre-1986 levels.

6 Sheehan, M. Patricia and B. Hillary Irene, "An Unusual Cluster of Babies with Down's syndrome Born to Former Pupils of an Irish Boarding School." *British Jour. Med.* 11 Dec. 1983 : 287.

Sheehan found a cluster of children born with Down's syndrome (8) to mothers who attended a girls school as adolescents, during the Windscale fire at that reprocessing reactor. The school was in the effluent pathway and the radionuclide released was tritium. There were 30 birth abnormalities in all in this small population.

BIBLIOGRAPHY

7 A.T. Sigler, *et al* "Radiation exposure in parents with children with mongolism (Down's syndrome)." *Bulletin of John Hopkins Hospita*, 2 (1968) : 1045-1049.

Radiation exposure increased the risk of mongolism in parents. There was validation of the view concerning cumulative radiation damage to genetic material. Exposure was result of fluroscopic and therapeutic radiation.

8 K. Sperlind, J. Pelz,RD. Wegner, I. Schulzke and E. Smuck, "Frequency of Trisomy 21 in Germany before and after the Chernobyl accident." *Biomed & Pharmacother* 45, (1991) : 255-262.

Increased in Down's syndrome were observed in Germany after the Chernobyl accident. There was a peak in incidence in January 1987. This peak is highly significant.

9 Irene and Elizabeth Uchida, and J. Curtis, "A Possible Association Between Maternal Radiation and Mongolism." *Lancet* (10/14/61) : 848-850.

There is a strong association between the incidence of mongolism and a history of maternal abdominal radiation. Radiation effect may be age-dependent.

10 T. Zuftan and W. Luxin, "An Epidemiological Investigation of Mutational Diseases in the High Background Radiation Area of Yangiang, China." *J. Radiat. Res.* 27 (1986) : 141-150.

There were increases in Down's syndrome found in high background radiation area. Increases in cancer were not found. Average background dose was 330 mR/yr and 114 mR/yr in control group. There was a higher rate of cancer in control group which had received a greater number of medical X-rays.

Tritium

11 D.F. Cahill and C.L. Yuile, "Tritium Irradiation of Mammalian Fetus." *Radiation Research* 44 (1970) : 727.

Offspring conceived by parents subjected to low level lifetime exposure manifest effects at HTO activity levels 10-100 times lower than those required during exposure in utero only.

12 L.A. Carsten and S.L. Cummerford, "Dominant Lethal Mutations in Mice Resulting from Chronic Tritiated Water Ingestion." *Radiation Research* 66 (1973) : 609.

Two successive generations of mice were exposed to continued ingestion of tritiated water. In second generation females, there was a significant reduction in the number of viable embryos.

13 A.L. Carsten, *et al*, " 1989 Summary Update of the Brookhaven Tritium Toxity Program with Emphasis on Recent Cytogenic and Lifetime—Shortening Studies in Proceedings of the Third Japan—US workshop on **Tritum Radiobiology and Health Physics.**" (Edited by S. Okada), Institute of Plasma Physics. Nagoya University, Nayoga, Japan. IPPJ-REV-3.

There may be an effect at very low doses where the radiation inhibits the repair mechanism. This may occur during tritium irradiation. Theory consistent with the track structure calculations of Goodhead using very weak X-rays. There was significant reduction in the number of viable embryos resulting from matings between animals maintained on tritium diet. There was no effect on breeding effectiveness.

14 R.L. Dobson and M.E. Cooper, "Tritium Toxity – Effects of low-level 3HOH Exposure in Developing Female Germ Cells in the Mouse," *Radiation Research* 58. p. 91.

Adult female mice were maintained on tritium levels 8.5, 0.85 and 0.085 Ci/ml of body water from day of fertilization. In female offspring exposed to tritium from conception and sacrificed at 14 days, primary oocytes were decreased below control number by 90% at 8.5, and significantly at 0.085 level.

BIBLIOGRAPHY

15 D.T. Goodhead and H. Nikjoo, "Current Status of Ultrasoft X-ray and Track Structure Analysis as Tools for Testing and Developing Biopysical Models of Radiation Action." *Radiat. Prot. Dos.* 31, No. 1/4 (1990) : 343-352.

Authors conclude that ultrasoft X-rays are more effective than equal doses of hard X-rays. Their RBEs increase with decreasing X-ray energy down to very small track lengths of 7 nm. Low energy electron track ends are a predominate cause of cell inactivation in all low LET radiations. (Ultrasoft X-rays are very similar in energies and track lengths to tritium B-radiation).

16 Kirchman, *et al*, "1973 Studies on the Food Chain Contamination by Tritium." *In Tritium*, editors Moghissi and Cater, Messenger Graphics, Phoenix, AZ, US.

Tritiated grass eaten by cows has been shown to be effectively transferred to their milk. OBT levels in their milk were 10 times higher in cows fed on tritiated grass than cows fed on HTO.

17 D. MacIntosh, S. Lung, F. Tsai and J. Spengler, "A Preliminary Assessment of the Potential Human Exposure to Tritium Emissions from the Yankee Atomic Electric Company Nuclear Power Facility Located Near Rowe MA." *Harvard University School of Public Health, Dept. of Environmental Health* 7 (1993).

Graduate students, under the supervision of J. Spengler, conducted a preliminary assessment of potential exposures and doses to the Deerfield River Valley residents to tritium, released from the Rowe nuclear power reactor. Concentrations of tritium were found to be 1,000 time greater in the valley than the surrounding area. Researchers suggested that an investigation be undertaken to study the effects of organically bound tritium, the effect of the river rapids and falls on HTO evaporation, and OBT aerosolization.

18 J.W. Laky, *et al*, "Some Effects of Lifetime Parental Exposure to Low-Levels of Tritium on the F2 Generation." *Radiation Research* 56, (1973) : 171.

Research done on effects of low-level exposure to tritiated water. Continues exposure calculated as whole body dose rates 3 to 3,000 mrads/day produced a 30% reduction in adult F1 male testes, but no impairment in growth or reproductive ability. Statistically significant effects on F2 neonates were: reduction in relative brain weight, decreased body weight, decreased litter size and increased resorption. Brain and testes contained approximately 100% and 50% greater tritium activities than the average in other tissues.

19 J.W. Lasky, and S.J. Bursian, *Radiation Research* 67, (1976) : 314.

Rats were exposed to constant tritium activities of 10 uCi/ml of body water for 42 days beginning first day of pregnancy or birth. In males exposed from birth or first day, there was a significant reduction in the testes weight and sperm content. In females exposed there was a significant reduction in F2 litter size and an increase in the number of reabsorbed embryos. The group most sensitive to low-level exposure was the one exposed from first day of pregnancy.

20 D.J. Mewissen, "Cumulative Genetic Effects from Exposure to Male Mice to Tritium for Ten Generations." IAEA Symposium on Biological Implications of Radionuclides Released from Nuclear Industries, (1979).

Data established the existence of cumulative genetic injury and the existence of cumulative genetic injury at the 9th generation. Their F2 offspring (unexposed) exhibited a significant increase in dominant lethal mutations resulting in a decrease in litter size.

21 T. Straume, "Health Risks from Exposure to Tritium." UCRL-LR-105088, Lawerence Livermore Laboratory, Livermore, California, US 94550, (1991).

Tritium is more hazardous to health than other types of low-level radiation. Tritium is about 1.5 times as carcinogenic, 2-5 times as mutagenic, and 2 times as teratogenic.

BIBLIOGRAPHY

22 C. Tislajar-Lentulis, P.Hennenberg and L.E. Feinendegen, "The Oxygen Enhancement Ratio for Single and Double Strand Breaks Induced by Tritium Incorporated in DNA of Cultured Human T1 Cells. Impact on the Transmutation Effect." *Radiation Research* 94, (1983) : 41-50.

Researchers found that a third of single strand DNA breaks caused by the decay of tritium in 6-thymidine were due to transmutation. This is over and above the radiational effect.

23 M. Van Hees, *et al*, "Retention in Young Pigs of OBT Given During Pregnancy and Lactation." *Radiat. Prot. dos.* 16, no 1-2, (1971) : 123-126.

Pigs fed with tritiated food themselves became tritiated. They passed on tritium to their offspring. The blood, heart, and kidneys of the young piglets were more tritiated than the tritiated foods fed their mother.

24 H. Wasserman, and K. Solomon, "Killing Our Own," N.Y. Dell. (1982) : 190-193.

There is a long residency period in the body of very low concentrations of tritium. A 1981 study of former American atomics workers showed a majority with tritium levels still ten times above normal. Study found that tritium can remain in the body for up to ten years.

Low-Level Radiation

25 K.F. Baverstock, D. Papworth, and J. Vennart, "Risk of Radiation at Low Dose Rates." *Lancet*, 1, (1981) : 430-433.

Researchers studied workers involved in assemblage of instrument-dials made luminescent with radium. Significance found for breast cancer induced by gamma radiation. Exposure at rate of 0.1 rad per 8 hours, allowing adequate time for repair from exposure. Although the luminizer appears to be a high dose study, it demonstrates the inability of the body to adequately repair after exposure to low-level radiation.

26 M.A. Bender, "Significance of Chromosome Abnormalities." (1984) : 281-289 in boice.

Bender investigated the repair of chromosome breaks incurred through exposure to radiation. In discussing repair of chromosome breaks, he reports repair half-times which are "typical of the order of 1 or 2 hours."

27 L.W. Brackenbush, and L.A. Brady, "Microdosimetric Basis for Exposure Limits. *Health Physics* 55, (1988) : 251-255.

Researchers state that "Since most cells repair radiation damage with a characteristic time ranging from a few minutes to a few hours, it is evident that irreparable or mispaired damage must dominate the low-LET radiation effect at low dose rates."

28 I.D. Bross, *et al*, "A Dosage Response Curve for the One Rad range: Adult Risk for Diagnostic Radiation." *Amer. Jour. Pub. Health*, 69, no. 2, (1979).

Bross investigated the effects of diagnostic medical trunk X-rays on 220 men with non-lymphatic leukemia and 270 controls. Research suggests that most heart disease is "prompted" by radiation exposure. The doubling dose of radiation for leukemia to be 5 Rems.

29 Sidney Cobb, MD MPH., "Health in the Deerfield River Valley. Some Preliminary Looks," (9/29/1992).

Dr. Cobb analyzed raw health statistics on the Deerfield River Valley to determine whether a full epidemiological investigation should be undertaken. cobb investigated available data for cancer incidence, Down syndrome, and mortality. He found a 50% greater overall mortality, a 50% greater mortality from cancer (5), a 40% greater mortality in heart disease, a 70% greater mortality from "other" causes in the Deerfield River Valley. There was suggestive evidence that there might be an excess in Down's syndrome. His conclusions were that the health problems deserve immediate attention. These problems were consistent with radiation injury incurred between 1960 and 1972.

BIBLIOGRAPHY

30 H.J. Evans, K.E. Buckton, G.E. Hamilton and A. Carothers, "Radiation-induced chromosome abberations in nuclear-dockyard workers." *Nature*, 277, (Dec. 1979) : 531-534.

Researchers demonstrated a significant dose-dependent increase in chromosome abberations in peripheral blood leukocyte chromosomes in a population of monitored nuclear-dockyard workers, subject to occupational radiation exposure within maximum permissible limits 5 rem per year. The observed increase in dicentric abberations is not large but is a direct expression of increased genetic damage caused by radiation exposure. It is possible to detect a biological effect at the chromosome level to ionizing radiation below the internationally agreed maximum permissible levels.

31 L.E. Feinendegen, *et al*, "Biochemical and Cellular Mechanisms of Low-Dose Radiation Effects." *International Journal of Radiation, Biology* 53, no. 1, (1988) : 23-27.

Researchers studied the ability of irradiated cells to repair themselves. Feinendgen states, "Whereas the majority of single-strand breaks and base changes are very efficiently and quickly repaired with half-times less than 1 hour, the reconstitution of a double-strand break probably lasts much longer, perhaps up to several hours, and not all double-strand breaks are fully repaired."

32 J. Gentry, *et al*, "An Epidemiological Study of Congenital Malformations in New York State." *Amer. Jour. Pub. Health*, 49, no. 4, (4/1959).

Congenital malformation rates were studied in association with high and low background areas in New York State. The areas with the highest background radiation had the highest rates of malformations (17.5). For unlikely rural areas the rate was 12.5. there was a relationship between malformation rate and use of water from wells and springs as opposed to large surface areas (lakes and rivers). A doubling of the prevalence of severe mental retardation was found. There was also a sharp increase in the incidence of Down's syndrome. AEC estimates that background radiation levels associated with igneous rock fromations ranged from .07 to .11 Rems/yr.

33 D.T. Goodhead, "Spatial and Temporal Distribution of Energy." *Health Physics*, 55, (1988) : 231-240.

Goodhead studied the ability of cells to repair themselves after exposure to radiation. He suggests that the repair system may need a "kick" to get started. He states: "...it is conceivable that the cell would repair relatively more efficiently if there were more damage to stimulate its repair process."

34 A.J. Grosovsky, and J. Little, "Evidence for linear response for the induction of mutations in the human cells by X-ray exposures below 10 rads." *Proc. Natl. Acad. Sci., USA*, Genetics 82, (April 1985) : 2092-2095.

The induction of thioguanine resistance was studied in continuous human lymphoblast cultures exposed to daily X-ray exposures of 1, 2.5, 5 or 10 rads for periods up to one month. The effects of small daily fractions were additive suggesting that doses as small as 1 rad are muagenic in human lymphoblasts. A linear increase in mutation frequency was observed over this dose range with no apparent threshold. Results suggest that for human lymphoblasts, the mutagenic risk of low dose of X-rays can be accurately estimated by linear extrapolation from high dose effects.

35 M. Otake, and W. Schull, "In utero exposure to A-bomb radiation and mental retardation; an assessment." *British Jour. Radiol.*, 57, (May 1984) : 409-414.

Otake and Schull studied the incidence of mental retardation in Japanese A-bomb survivors. They found that the 8th through the 15th week of gestation was especially significant. Implication that 1 rad absorbed by the fetus during this period may double the rate of mental retardation.

BIBLIOGRAPHY

36 A. Upton, "Prevention of Work-Related Injuries and Disease: Lessons from Experience with Ionizing Radiation." *Amer. Jour. Indust. Med.*, (1987) : 300-301.

Upton analyzed the effects of ionizing radiation and the incidence of breast cancer in women from different sources, i.e., A-bomb radiation, therapeutic irradiation for postpartum mastitis, multiple fluoroscopic examinations, exposure occupationally to external gamma radiation in the painting of luminous clock and dials. Upton states that "The similarity of the dose-incidence relationships in all four groups of women, in spite of marked differences....in the duration of exposure, implies that the carcinogenic effect of a small dose on the breast is largely irreparable and that the effect of successive doses are additive." He states "....there may be no threshold in the dose-incident relationship."

37 C. Waldren, *et al*, "Measurements of low-levels of X-ray mutagenesis in relation to human disease." *Genetics*, 83 : 4839-4843.

Waldren and coworkers studied the direct measurement of the effects of low doses of radiation and other mutagens. Extrapolation procedures were not used to estimate effects. The data demonstrate "that the true mutagenesis efficiency at low doses of ionizing radiation that approximate human exposures is more than 200 times greater than those obtained with conventional methods." With increasing dose, a point reached, where the mutational effect can not be detected in the chromosomes because the cell is killed off. Unequivocal mutagenesis took place for dose as low as 2.4 rads. Waldren states that "observed mutational efficiency at low doses is considerably higher than that observed at higher doses."

GLOSSARY

A

activity – The number of atoms of a radioactive substance that disintegrate per unit time.

air inversion – A condition in which a dense substance lies over a less dense substance. In an atmospheric temperature inversion, the air temperature increases and therefore the density decreases with height. Such inversions occur locally in very still air and tend to be stable because rising air, warmed at the surface, loses its buoyancy and is trapped when it meets air at the same temperature and density as itself so tending to reinforce the inversion. Pollutants entering the air close to the ground level are similarly trapped, and so temperature inversions are sometimes associated with severe pollution incidents.

alpha particle – A positively charged particle emitted by certain radioactive material consisting of two neutrons and two protons, the nucleus of a helium atom. A dangerous carcinogen when inhaled or ingested.

atom – The smallest unit of an element, consisting of a dense central, positively charged nucleus surrounded by a system of electrons. The structure is usually electrically neutral and is indivisible by chemical reactions.

atomic nucleus – The core of an atom, composed of protons and neutrons.

atomic waste – Radioactive solids; gases and contaminated liquids produced by nuclear reactions. Generally classed as high, intermediate, or low-level waste, dependent on curie per litter count.

B

background radiation – Ambient radiation from outer space [cosmic] and materials found at the surface of the earth.

beta – A type of radiation

beta-emitter – A radioactive element characterized by its beta radiation.

beta particle – A high energy electron emitted by decay in a radioactive nucleus. Can cause skin burns and, when ingested, cancer.

C

carcinogen – A cancer causing substance or agent.

chromosomal strands –

curies – (radiation units). Units of measurement used to express the activity of a radionuclide and the dose of ionizing radiation.

D

decay – Gradual disintegration of radioactive material over time.

DNA – (deoxyribonnucleic acid). The genetic material of most living organisms which is a major constituent of the chromosomes within the cell nucleus and plays a central role in the determination of hereditary characteristics.

dose – The amount of energy absorbed in a unit mass, organ, or individual from irradiation.

Down's syndrome – A congenital condition characterized by mental deficiency and related to the tripling of certain human chromosomes.

E

effluent – Liquid discharge from a nucleus.

effluent pathway – Fluid emitted from a source. A waste fluid produced by an agricultural or industrial process.

electron – A negatively charged atomic particle, lighter than a proton or neutron.

epidemiology – A branch of medical science that deals with the incidence, distribution and control of disease in a population.

GLOSSARY

etiology – All of the causes of a disease or abnormal condition.

exposure – Being exposed to radiation.

F

fission – The splitting of a nucleus into two lighter fragments, accompanied by the release of energy and generally one or more neutrons. Fission can occur either spontaneously or as a consequence of absorption of a neutron.

fluoroscope – An instrument used chiefly in industry and medical diagnosis for observing the internal structure of opaque objects (as the living body).

fuel rod – A single tube of cladding filled with uranium fuel pellets.

G

gamma ray – High energy, short wavelength, electromagnetic radiation emitted by a nucleus.

H

half-life – The time it takes for half of any radioactive substance to disintegrate. Half-lives range from seconds to millions of years.

I

ion – An atom, molecule, or elementary particle that has lost or gained one or more electrons, therefore taking on an electrical charge. A positive ion has lost one or more electrons; a negative ion has gained one or more electrons.

ionization – The process of adding or removing electrons so as to form ions. Ionization can be caused by high temperatures, electrical discharges, or nuclear radiation.

ionizing radiation – Alpha, beta, or gamma radiation, which, when passing through matter can ionize it. Ionizing radiation can cause cell damage as it passes through tissue.

irradiated – Having been exposed to or treated with radiation.

isotope – A radioactive variant of a common elements with a different atomic weight but equivalent atomic number. Isotopes are generally created by the fission process.

L

latent period – The amount of elapsed time between exposure and the first sign of disease symptoms.

low-level – Refers to radioactivity of low intensity.

M

microdosimetry – Dosimetry involving microdoses of radiation or minute amounts of radioactive materials.

millirem [mr] – One thousandth of a rem.

molecule – A group of atoms held together by chemical forces.

mongolism – See Down's syndrome.

mutation – A sudden variation; offspring differing from its parents in one or more heritable characteristics due to changes within the chromosome or the gene.

N

neutrino – A subatomic particle of negligible mass, named by Enrico Fermi.

neutron – An uncharged particle in the nucleus of every atom heavier than hydrogen. A free neutron is unstable. With half life of 13 minutes, it will decay into a proton, electron and a neutrino.

nondisjunction – Failure of two chromosomes to separate subsequent to meta phase in meiosis or mitosis so that one daughter cell has both and the other, neither of the chromosomes.

nuclide – Any atom that exists for a measurable length of time. A nuclide can be identified by its atomic weight, atomic number, and energy state.

GLOSSARY

O

oocyte – An egg before maturation: a fem.' gametocyte.

organically bound – Held in chemical or p' ical combination.

P

photon – A "packet" of energy with energy with no mass, which travels at the speed of light. Photons range from very low energies (such as infrared and visible light), moderate energies (ultraviolet and X-rays) to high energy (gamma).

pressurized water reactor (PWR) – A reactor in which the heat from the nuclear core is transferred to a heat exchanger under constant pressure to achieve a high water temperature without boiling. A secondary circuit produces steam for the generators.

proton – A elementary particle with a single positive charge that is a part of all neucli.

R

rad – A measure of exposure to, or the absorbed dose of radiation.

rad waste – radioactive waste.

radiation – The emission of neutrons, alpha particles, beta or gamma rays from a radioactive source.

rem – The unit measuring an absorbed dose of ionizing radiation in biological matter; abbreviated from "Reentgen Equivalen, Man."

S

soft x-rays – (soft radiation) Ionizing radiation of low penetrating power, usually used in reference to x-rays of long wavelerigth.

T

teratrogenic – (teratrogen) Any environmental factor that acts on a fetus to cause congenital abnormality

transmutational – The transformation of one element into another by bombardment of nucleus with particles. For example, plutonium is obtained by the neutron bombardment of uranium.

tritium – A radioactive nuclear by-product, also known as H^3, consisting of a hydrogen nucleus, or proton, with two additional neutrons.