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- B-3 Public Radiological Safety Analysis of Used Fuel Transportation

B-4 Natural Environment Analysis of Used Fuel Transportation
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GLOSSARY

# GLOSSARY

**ABNORMAL CONDITIONS:**
1. Situations that are planned for in the operation of a system, but are not encountered on a day to day basis. 2. Accidents.

**ABSORBED DOSE RATE:**
The amount of energy absorbed by a mass of irradiated substance per unit time. It is expressed in SI units as $Gy \cdot a^{-1}$ or $Gy \cdot h^{-1}$.

**ACCIDENT:**
A substantial deviation from the normal operating conditions of a nuclear facility or transportation system when relevant engineered safety features do not function according to design. Accident conditions could lead to the release of radioactive materials.

**ACCIDENT CONDITION:**
A substantial deviation from the normal operating conditions of a nuclear facility or transportation system when relevant engineered safety features do not function according to design. Accident conditions could lead to the release of radioactive materials.

**ACCIDENT RATE:**
For each transportation mode, the number of reportable accidents occurring annually on a particular section of a transportation route for every million vehicle (truck, train or vessel) kilometres travelled on that section during that period.

**ACCIDENT SEVERITY CATEGORIES:**
The categories into which transportation accidents are classified, depending on fire duration and the net velocity change experienced by a transport package as a direct result of an accident.

**ACTIVATION PRODUCT:**
A radionuclide formed when the nucleus of an atom captures a neutron. For example, used nuclear fuel bundles contain activation products of uranium (actinides), of zircaloy cladding, and of fuel impurities.

**ACTIVE AREA:**
Any area within the facility greater than or equal to 25 $mSv \cdot h^{-1}$ of radiation level.

**AECB:**
See "Atomic Energy Control Board".

**AECL:**
See "Atomic Energy of Canada Limited".

**AIRBORNE EMISSIONS:**
Gaseous or particulate material released into the air.

**AIRLOCK:**
It is a chamber which provides means by which equipment and personnel can enter into containment areas without impairing the containment integrity. It is basically a room with hinged doors at two opposite sides to allow entry into the containment area. The doors with their inflatable seals are interlocked such that only one door can be opened at any one time. Door operation is semi-automatic, interlocked and self-contained in the event of external air failure. It is important to note that an airlock has adjustable air pressure (ie., area separating high and low pressures).

**ALGORITHM:**
A set of well-defined rules or procedures for the solution of a mathematical problem in a finite number of steps.

**ALPHA PARTICLE ($\alpha$):**
The nucleus of a helium atom, consisting of two protons and two neutrons. It has a charge equal to two electrons but with the opposite (positive) sign. Alpha particles are commonly emitted from heavy radionuclides such as plutonium-239 when they decay. In general, upon interaction with materials, these particles transfer their energy in a very short distance and are readily stopped by a piece of paper or the dead layer of human skin.

**ALPHA-BEARING WASTE:**
Waste containing one or more alpha-emitting radionuclides, usually actinides, in quantities above regulatory limits for uncontrolled release.

**AMERICIUM (Am):**
One of the chemical elements; the isotope with mass 241 has a half-life of 433 years.

**ANADROMOUS:**
Term used to describe fish that migrate upstream, from lake to river, or from saltwater to fresh water, for the purposes of spawning.

**ANIMAL PRODUCE:**
In the PREAC computer code, animal produce consists of milk, beef, pork, eggs and poultry.

**ANNUAL DOSE:**
An abbreviation for 'annual effective dose equivalent'. See that term.

**ANNUAL DOSE EQUIVALENT:**
The sum, over one year, of the effective dose equivalent resulting from external exposure and the committed effective dose equivalent from that year's intake of radionuclides for a member of the critical group. It is the effective exposure over one year to low doses of ionizing radiation, and takes into account different types of radiation and the potential effects on different organs (see 'dose equivalent' and 'effective dose equivalent'). It is frequently abbreviated as 'annual dose' in EIS Primary References. The SI unit of measurement of annual dose is sieverts per year ($Sv \cdot a^{-1}$).

**ANSI:**
See "<u>A</u>reas of <u>N</u>atural and <u>S</u>cientific <u>I</u>nterest".

**ANTIMONY (Sb):**
One of the chemical elements; the isotope with mass 125 has a half-life of 2.77 years.

**AREAS OF NATURAL AND SCIENTIFIC INTEREST:**
Areas of Natural and Scientific Interest are those areas that have been designated by the Ministry of Natural Resources (Province of Ontario) to be representative of "provincially significant elements of the natural and cultural landscape of Ontario". These areas comprise the spectrum of natural landscapes, environments and biotic communities in Ontario.

**ATMOSPHERIC DISPERSION FACTOR:**
A component relating the airborne concentration of a substance to the release rate (or release), dependent on site-related data and meteorological parameters such as wind speed and atmospheric stability.

**ATMOSPHERIC STABILITY:**
A measure of the atmosphere's ability, at a given time and place to enhance or damp out vertical motion and hence affect pollutant dispersal. Stability is often divided into six classes (Pasquill stability classes), from very unstable (Pasquill class A) to very stable (Pasquill class F).

**ATOMIC ENERGY CONTROL BOARD (AECB):**
The Canadian federal regulatory agency which has jurisdiction over nuclear facilities and nuclear materials, and exerts regulatory control through a comprehensive licensing system. Established in 1946, the organization's mandate is to "to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment". Through its licensing and inspection systems, the AECB provides control and supervision of the development, application and use of atomic energy in Canada, and participates on behalf of Canada in international measures of control.

**ATOMIC ENERGY OF CANADA LIMITED (AECL):**
A Canadian Crown corporation created on April 1, 1952, to develop nuclear technology for peaceful uses.

**ATOMIC RADIATION WORKER:**
As provided by the Atomic Energy Control Regulations, any person who in the course of his/her work, business or occupation, is likely to receive a dose of ionizing radiation or an exposure to radon daughters in excess of the maximum permissable limits for the general public.

**BACKGROUND RADIATION:**
Radiation doses received by the public from sources other than nuclear facilities. These sources can be broadly categorized as: 1. naturally occurring radiation (see 'natural background radiation'), 2. fallout from nuclear weapons testing, 3. radionuclides present in the environment due to technological processes other than the operations of nuclear facilities, 4. irradiation from consumer products and services and, 5. medical diagnostic and therapeutic radiological processes.

**BALLAST:**
Any solid or liquid weight placed in a ship to increase the draft, to change the trim, or to regulate the stability.

**BALLAST TANK:**
Watertight compartment to hold water ballast.

**BARGE:**
An unpowered vessel used to transport freight over water.

**BARRIER:**
A feature of a disposal system which delays or prevents radionuclides from escaping from the disposal vault and migrating into the biosphere. A "natural barrier" is a feature of the geosphere in which the disposal vault is located. An "engineered barrier" is a feature made by or altered by man and is typically part of the waste package or part of the disposal vault. See "multibarrier".

**BECQUEREL (Bq):**
The SI derived unit of radioactivity for measuring the rate of decay of a radioactive substance. It is equivalent to the disintegration of one radioactive nucleus per second.

**BENTHIC COMMUNITY:**
An aggregation of organisms of, pertaining to, or living in the bottom or at the greatest depths of a large body of water.

**BENTONITE:**
Absorptive colloidal clay consisting of altered volcanic ash. Sodium-rich bentonite has a particular attraction for water and swells when wet. It is being considered as a major component of the buffer material used in a disposal vault.

**BETA PARTICLE (ß):**
A negatively charged particle, with the mass and charge of an electron, emitted by certain radionuclides during radioactive decay.

**BIOACCUMULATION:**
The collection and retention of a chemical and/or radioactive element or compound by a living organism resulting in its internal concentration being greater than its ambient concentration.

**BIOLOGICAL COMPARTMENTS:**
Divisions of the biosphere treated as simple blocks or boxes that are internally uniform in content and behaviour.

**BIOPHYSICAL ENVIRONMENT:**
See "biosphere", the preferred term in the CNFWMP.

**BIOSPHERE:**
Although usually defined as the portion of the earth inhabited by living organisms, in the CNFWMP this word has a more specific meaning. In aquatic areas the biosphere/geosphere interface occurs between the deep compacted and the shallow mixed sediments, and in terrestrial areas the interface is formed by the water table. Thus, the biosphere includes mixed sediments, surface waters and fish, soils, plants, animals and humans, and the lower parts of the local atmosphere.

**BOLLARD:**
Short metal column for securing wires and ropes to attach a vessel to a wharf or tug.

**BOW THRUSTER:**
Propulsion motor located at the front of the barge to enhance manoeuvrability.

**BULKHEAD:**
A term applied t the vertical partition walls which subdivide the interior of a ship into compartments or rooms.

**BUNDLE VERIFICATION:**
Processes by which it is verified that a bundle really contains used fuel and that it has not been replaced by a copy.

**BURNUP:**
In reactor physics, a measure of the degree to which the fissile material in fuel has been consumed as a result of irradiation in the reactor. The units are gigajoules per kilogram of uranium ($GJ \cdot kgU^{-1}$). It is also measured in units of megawatt-days per tonne ($MWD \cdot t^{-1}$).

**CANADIAN NUCLEAR FUEL WASTE MANAGEMENT PROGRAM (CNFWMP):**
A program established by a 1978 Joint Statement by the Federal Government and the Government of Ontario "...to assure the safe and permanent disposal" of nuclear fuel waste. AECL was made responsible for researching and developing the concept of disposal of nuclear fuel waste in a deep underground repository in intrusive igneous rock in the Canadian Shield. Ontario Hydro was made responsible for studying interim storage and transportation of used fuel. Other organizations that have contributed to the program over the years include Energy, Mines and Resources Canada, Environment Canada, universities and companies in the private sector. A second Joint Statement in 1981 imposed the restriction that no site could be selected before the concept had been assessed, reviewed and accepted.

**CANADIAN SHIELD:**
An extensive area of Precambrian rocks exposed over large parts of central and eastern Canada. Approximately, it lies to the east of a line passing through Great Bear Lake, Great Slave Lake, Lake Athabasca and Lake Winnipeg, and to the north of the continuation of this line through Lake Superior, Lake Huron and the St. Lawrence River. It is composed of metamorphic and igneous rocks. Orogenic events have occurred over different parts of the Shield at various times but some parts have been free of such activity for about 2.5 billion years. Almost the entire Shield has been stable for the last 900 million years.

**CANDIDATE AREA:**
After characterization of the candidate regions, further characterization would entail progressively detailed studies of progressively smaller geographic areas. Approximate size: greater than 400 $km^2$. Investigation duration: 3 - 5 years.

**CANDIDATE REGION:**
Candidate regions are those that contain potentially suitable plutonic rock bodies and are in the vicinity of communities that expressed willingness to participate in the siting process. Approximate size: greater than 1000 $km^2$. Investigation duration: 2 - 5 years.

**CANDIDATE SITE:**
Using the information obtained during the characterization of the candidate areas, one or more smaller sites within these areas would be selected for very thorough surface and subsurface characterization. The final characterization step in site evaluation would include subsurface-based work done in exploratory shafts and tunnels at the preferred site. Approximate size: about 25 $km^2$. Investigation duration: 4 - 9 years, plus investigation of potential vault (4 - 8 years).

**CARBON (C):**
One of the chemical elements; the isotope with mass 14 has a half-life of 5 730 years.

**CASK:**
See "container cask" or "transportation cask", the terms used in the CNFWMP.

**CATCHMENT AREA:**
See "drainage basin".

**CENTROID:**
See "geometric centre".

**CERIUM (Ce):**
One of the chemical elements; the isotope with mass 144 has a half-life of 0.778 years.

**CESIUM (Cs):**
One of the chemical elements; the isotope with mass 137 has a half-life of 30.1 years.

**CHARACTERIZATION:**
In the CNFWMP, the surface and subsurface investigation of a region, area, or site to determine the conditions in the geosphere, biosphere, and human communities. For potential disposal sites, the data obtained would be used for site selection, facility design, and performance assessment. Many of the measurement instruments installed for characterization would also be used for monitoring. Characterization would be a major activity during the siting stage, and would continue at the selected site during the construction, operation, decommissioning, and any extended monitoring stages.

**CHRONIC EMISSION:**
Emissions that re-occur or are of long duration resulting from normal operation of a disposal facility or the transportation system associated with it.

**CHRONIC HAZARD:**
Any natural or man-made, non-radiological or radiological source of a potentially harmful effect of long duration, from the normal operation of a disposal facility or the transportation system.

**CHRONIC RADIATION EXPOSURE:**
Exposure, over a long period of time, of a person, animal, plant or material to an environment containing radiation.

**CLADDING:**
An external, usually metallic, layer directly surrounding nuclear fuel or other substances that seals and protects it from the environment and protects the environment from radioactive materials produced during irradiation. Also known as "clad".

**CLASS A ROAD:**
In general, a paved road where heavy traffic is allowed by municipal or provincial bylaws.

**CLASSED SHIP:**
Classed with a classification society; this provides a guarantee that the vessel has the necessary strength and seaworthiness for its intended service.

**CLAY:**
Minerals that are essentially hydrous aluminium silicates or occasionally hydrous magnesium silicates, with sodium, calcium, potassium and magnesium cations. Also denotes a natural material with plastic properties which is essentially made up of fine to very fine particles. Because of good sorption characteristics, certain types of clay are being considered by some countries as a barrier around the waste emplaced in a disposal vault.

**CNFWMP:**
See "Canadian Nuclear Fuel Waste Management Program".

**COBALT (Co):**
One of the chemical elements; the isotope with mass 60 has a half-life of 5.27 years.

**CODE:**
1. As used by the IAEA, a set of advisory or regulatory statements and regulatory bodies which establish for particular activities the minimum requirements which, in the light of experience and/or the current state of technology and knowledge, should be fulfilled to ensure adequate safety. 2. In computing, one or more statements of a computer language, such as FORTRAN or PASCAL; a general term that, depending on the context, could refer to computer programs, subroutines, functions or a part of any of these. For instance, SYVAC and PREAC are computer codes.

**COLLECTIVE DOSE:**
See 'collective dose equivalent commitment' or 'collective effective dose equivalent'.

**COLLECTIVE DOSE EQUIVALENT COMMITMENT:**
Also called 'collective effective dose equivalent commitment' or 'collective dose'. A measure of the total present and future dose to a human population expected to result from some decision, practice or operation involving human exposure to radiation; it is calculated as the integral over all future time of the average (effective) individual dose equivalent commitment multiplied by the number of individuals in the specified population. The SI unit of measurement is the person-sievert (person-Sv). Note that for disposal of radioactive materials, the integral may involve the accumulation of very low lifetime doses to individuals over very long times.

**COLLECTIVE EFFECTIVE DOSE EQUIVALENT:**
A measure of the total dose to a group of people from radiation exposure. It is calculated by multiplying the number of individuals in the group by the average dose to an individual. Also called 'collective dose'. The SI unit of measurement is the person-sievert (person-Sv).

**COMMISSIONING PHASE:**
Phase of the project between construction and operation where all systems are tested and prepared for full operation.

**COMMON MODE EVENTS:**
Those events that could cause system/equipment failures if they are not protected against. These events can range from natural phenomena such as hurricanes, earthquakes, tornadoes, temperature extremes, precipitation, floods and fires, to anthropogenic events such as fires, explosions and aircraft disasters. Also synonymous with common cause events.

**CONCEPT, WASTE MANAGEMENT:**
A set of ideas and principles, and their associated technologies, that constitute a practical method for the disposal of nuclear fuel waste.

**CONCEPTUAL DESIGN:**
A comprehensive technical description consisting of the facilities, processes, procedures and services needed to handle, package and dispose of nuclear fuel waste. A conceptual design was produced for specific uses in the CNFWMP. See "Used-Fuel Disposal Centre".

**CONSEQUENCE:**
The results or effects of an event, decision or action. For the postclosure assessment in the EIS, the consequence of most concern is the mean annual effective dose equivalent received by an individual in the critical group at selected times. Other consequences are concerned with potential chemical toxicity impacts.

**CONTAINER:**
A durable receptacle for enclosing and isolating radioactive wastes for disposal. In a disposal vault, the containers would serve as one barrier between the waste form and the human population. Sometimes called "waste container" and "disposal container".

**CONTAINER CASK:**
A heavy shielding vessel in which disposal containers would be transported within a used-fuel disposal facility. It would provide radiological protection during the transfer of the disposal containers from the surface packaging plant to the underground emplacement boreholes.

**CONTAINMENT:**
1. For a waste disposal system, the retention a radioactive material in such a way that it is effectively prevented from being dispersed into the environment, or released only at an acceptable rate. 2. The structure(s) used to effect such retention.

**CONTAINMENT/SURVEILLANCE MEASURES:**
The application of containment and/or surveillance (C/S); an important safeguards measure complimenting nuclear material account. The application of C/S measures is aimed at verifying information on movement of nuclear or other materials, devices and samples or preservation of the integrity of safeguards relevant data. In many instances, C/S measures cover the periods when the inspection is absent and this contributes to cost effectiveness. C/S measures are applied, for instance;

1. To ensure during flow and inventory verification that each term is inventoried without duplication and that the integrity of samples is preserved;

2. To ensure that IAEA instruments, devices, working paper and supplies are not tampered with;

3. To check the validity of previous measure and thereby reduce the need for remeasuring previously verified items.

The indication of an anomaly by C/S measures doesn't necessarily by itself indicate that material has been removed. The ultimate resolution of C/S anomalies (eg. broken seals) is provided by nuclear materials account.

If any C/S measures has been, or may have to be, compounded, the IAEA shall, if not agreed otherwise, be notified by the fastest means available. Examples might be seals which have been broken inadvertently or in an emergency, or seals of which the possibilities of removal after advance notification to the IAEA has been agreed between the IAEA and the operation.

**CONTAMINATION, RADIOACTIVE:**
The presence of a radioactive substance in or on a material or place where it is undesirable or could be harmful.

**CONVENTIONAL HAZARD:**
A natural or man-made non-radioactive source of a potential harmful effect.

**CONVENTIONAL RISK:**
The non-radiological risk of activities associated with a disposal system.

**COSMIC RAYS:**
Cosmic Rays are highly energetic particles with high penetrating powers. They bombard the earth from all directions and are in part responsible for the ionization of the atmosphere.

Primary Cosmic Rays are energetic particles that are generated by high energy cosmic processes such as super-novas and solar flares. These Primary Cosmic Rays can originate outside of our solar system (galactic) or be emitted by the sun (solar).

Secondary Cosmic Rays are a result of the transmutations that take place to Primary Cosmic Particles due to contact and interaction with the earth's atmosphere.

**CRASH TEST:**
In the CNFWMP, a deliberate collision conducted to check a transportation cask for resistance to damage.

**CRITERIA:**
Principles or standards on which a decision or judgement can be based. They may be qualitative or quantitative. Objective criteria are specified in terms of the environmental consequences of radioactive releases. Derived criteria are cast in terms of the physical characteristics of a specific facility and site, and of any releases of radioactivity from it.

**CRITICAL GROUP:**
For a given radiation source, a group (hypothetical or otherwise) composed of members of the public whose exposure is reasonably homogeneous and who are typical of individuals expected to receive the highest effective dose equivalent or dose equivalent from the source.

**CRITICAL INDIVIDUAL:**
For a given radiation exposure, the person considered to be receiving the highest doses.

**CRITICAL PATHWAY:**
The dominant chain of environmental processes through which it is expected that the critical group would receive the highest exposures due to radioactive releases from a disposal vault.

**CRITICALITY:**
The conditions in which a system is capable of sustaining a chain reaction of nuclear fission without an additional source of neutrons; that is, the rate of production of neutrons is precisely equal to the rate of loss of neutrons. A supercriticality condition occurs when the chain reaction produces more neutrons at each step than are consumed; the chain reaction is then divergent and the power being released may increase very rapidly. A subcritical condition occurs when each stage of the chain reaction produces fewer neutrons than it consumes.

**CURIUM (Cm):**
One of the chemical elements; the isotope with mass 244 has a half-life of 18.2 years.

**DECAY:**
See "radioactive decay".

**DECAY CONSTANT:**
For a radionuclide in a particular energy state, the rate at which it undergoes radioactive decay. The SI units of measurement of the decay constant are $s^{-1}$. It is related to the radioactive half-life by the equation:

$$\text{decay constant} = \ln 2 / \text{half-life}$$

where ln 2 = 0.69315 is the natural logarithm of 2.

**DECAY HEAT:**
The heat which continues to be generated by disintegrating radionuclides in used fuel after its removal from the reactor core.

**DECIBEL (dB):**
The standard measure of noise or sound pressure level, expressed as a logarithmic ratio of the sound pressure of a given noise with respect to a reference sound pressure which is commonly taken as 0.0002 microbars in the context of sound and human hearing. For many types of noise sources found in urban or industrial areas, a frequency weighting scale designated as "A" gives good correlation between measured noise levels and judged human annoyance. Readings using this scale are reported as A-levels in decibels, abbreviated dB(A).

**DECK:**
A platform in a ship corresponding to a floor in a building. It is the plating planking, or covering of any tier of beams either in the hull or superstructure of a ship.

**DECOMMISSIONING:**
The actions required, in the interests of health, safety, security and protection of the environment, to permanently retire a nuclear facility from active service, possible including decontamination of the site. In the CNFWMP, decommissioning of disposal facilities includes the work required to permanently retire the surface facility and surrounding site at the used-fuel disposal centre, leaving it in an end-state that protects the health and safety of the general public and the environment.

**DECONTAMINATION:**
The removal of radioactive contaminants with the objective of reducing the residual radioactivity level in or on materials, persons or the environment.

**DECONTAMINATION FACTOR:**
The initial amount of contaminating radioactive material divided by the final amount following a decontamination process. The term may refer to a specified radionuclide or to gross radioactivity.

**DEDICATED TRAIN:**
A train that will carry only transportation casks loaded with used fuel, and no other cargo.

**DEFECTED FUEL:**
Reactor fuel elements in which defects penetrate the wall of the fuel cladding.

**DEPOSITION VELOCITY:**
The radionuclide flux of particles or gases to a specified surface (such as vegetation or soil) divided by the radionuclide concentration in air above the surface. The units are $m.s^{-1}$.

**DERIVED RELEASE LIMIT (DRL):**
Estimates of the maximum permissible average release rates if compliance with the maximum permissible dose for members of the public is to be ensured.

**DIFFUSION BONDED WELDING:**
Resistance diffusion bonding is a welding process in which two metal surfaces are electrically heated to the temperature at which rapid diffusion occurs. Heating is achieved through electrical resistance in the gap between the surfaces to be joined.

**DIRECT IMPACT:**
The "direct economic impact" of investment and operation derives from the "first-round" expenditures by Ontario on equipment, labour, and all other inputs used in designing, constructing, operating and decommissioning the conceptual UFDC.

**DISPERSION:**
1. The combined effect of transport, diffusion and mixing which tend to distribute materials from wastes or effluents through an increasing volume of water, air or soil, with the ultimate effect of diluting the materials. 2. In hydrogeology, the diffusing and mixing of two fluids of different composition due to velocity variations in a geologic medium.

**DISPOSAL:**
A permanent method of long-term management of radioactive wastes in which there is no intention of retrieval and which, ideally, uses techniques and designs that do not rely for their successes on long-term institutional control beyond a reasonable period of time.

**DISPOSAL CENTRE:**
See "Used Fuel Disposal Centre".

**DISPOSAL FACILITY:**
Similar to Used Fuel Disposal Centre but more general. In simple terms, a disposal vault and the supporting surface facilities.

**DISPOSAL SYSTEM:**
The components and activities by which the safe disposal of waste is achieved. In the preclosure phase, a facility for the safe, permanent isolation of nuclear fuel waste plus the transportation facilities needed to bring the waste to it from interim storage sites.

**DISPOSAL VAULT:**
A network of horizontal tunnels and disposal rooms excavated deep in the rock, with vertical shafts extending from the surface to the tunnels, for the purpose of disposing of nuclear fuel waste. In the preclosure phase, the disposal vault would include the underground excavations in plutonic rock, the access shafts,access tunnels, underground service areas and installations, and disposal rooms. In the postclosure phase, it would include the disposal rooms and associated access tunnels, the nuclear fuel waste and the engineered barrier systems used to contain the waste and seal all openings.

**DISTANCE WEIGHTED AVERAGE:**

Average value of a parameter along a route of length d, calculated as follows:

$$P = \sum_{i=1}^{n} \frac{p_i\, d_i}{d}$$

where $p_i$ is the value of the parameter along a segment of length $d_i$ along the route.

**DOSE:**

A general term denoting the quantity of radiation or radiation energy absorbed by a specified mass of a substance. "Dose" is often qualified to refer to specific quantities, and to an individual versus a group of people; examples are: absorbed dose, dose equivalent, effective dose equivalent, committed effective dose equivalent, and collective dose. The SI unit of measurement of dose is the sievert (Sv). In the EIS preclosure and postclosure assessments, dose is frequently encountered in expressions such as "annual dose" and "dose per year". In these cases, it is an abbreviation of "annual effective dose equivalent commitment".

**DOSE CONVERSION FACTOR:**

A multiplicative quantity used to convert intake of radioactivity to a committed effective dose equivalent (internal dose), or external exposure to radioactivity to an effective dose equivalent (external dose). The SI unit for the dose conversion factor is sieverts per becquerel ($Sv \cdot Bq^{-1}$) for internal doses, and Sv per radionuclide concentration in the exposing media ($Bq \cdot L^{-1}$, $Bq \cdot m^{-2}$, $Bq \cdot m^{-3}$) for external doses.

**DOSE EQUIVALENT ($H_T$):**

The strict definition of radiological dose is the energy absorbed per unit mass of tissue exposed to ionizing radiation, measured in gray (Gy). The dose equivalent, measured in sievert (Sv), is the product of the dose and a radiation weighting factor. This weighting factor is a function of how a certain type of radiation deposits its energy within the body. Radiations with high weighting factors deposit a lot of energy in a short distance, whereas those with lower factors deposit less energy in a short distance, whereas those with lower factors deposit less energy over the same distance. For example, alpha radiation has a weighting factor of 20, whereas beta radiation and gamma radiation have a value of 1. The dose equivalent accounts for the fact that different types of radiations react differently within the body. See also radiological dose, effective dose equivalent and 'committed effective dose equivalent'.

**DOSE EQUIVALENT, EFFECTIVE:**

See "effective dose equivalent".

**DOSE RATE:**

See "absorbed dose rate".

**DOSE RATE FACTOR:**

See "pathway dose rate factor".

**DOSE-RESPONSE RELATIONSHIP, LINEAR:**

The hypothesis that the detriment to human health from exposure to radiation increases directly with the dose. The hypothesis is generally accepted, except for very low doses.

**DOUBLE BOTTOM:**
Compartments at the bottom of a ship between inner bottom and the shell plating, used for ballast water, fresh water, fuel oil, etc.

**DOWNWARD CUMULATIVE PROBABILITY CURVE:**
Graphic representation of the probability per year that the dose received by an individual or a group of individuals be smaller than a given value D.

**DRAFT:**
The depth applied to the ship's body forward of amidships.

**DRAINAGE BASIN:**
An area of land drained by a river, or on which precipitation will potentially flow to a given point. Also known as "catchment area", "drainage area" or "hydrographic basin".

**DRIFT:**
In a geological disposal vault, a horizontal passage from one working place to another parallel to the principal direction of access.

**DROP TEST, CASK:**
In the CNFWMP, a test to study the impact behaviour of used-fuel transportation casks when released to fall to the ground from specified heights. Criteria for the test are specified by the AECB for Canadian Type B(U) casks, the transportation cask proposed for the CNFWMP.

**DRY UNLOADING:**
A disposal facility procedure for removing fuel modules from a transportation cask, in which all handling is done in air.

**EARP:**
Environmental Assessment and Review Process, the procedure established by the Canadian Federal Government to examine proposed projects having a potential environmental impact.

**ECONOMY-WIDE IMPACT:**
Evaluation of the direct, indirect and induced effects allows for a full economy-wide assessment of the economic impacts stemming from a conceptual UFDC. That is, the "economy-wide impact" is the sum of the direct, indirect and induced impacts. Results presented in this study are at the direct and economy-wide level of aggregation.

**ECOSYSTEM:**
The organisms of a locality, together with the functionally-related parts of the supporting environment, considered as a single entity.

**EFFECTIVE DOSE EQUIVALENT:**
The measure of radiation exposure that is the summation of the dose equivalent that each particular tissue and organ of the body has received multiplied by a weighting factor for each. This summation usually considers the entire body. The tissue weighting factors represent the relative radiosensitivities of each organ. The effective dose equivalent is used to accurately determine the detrimental effect of a particular dose to the body, accounting for the fact that some organs are more sensitive to the effects of radiation exposure than others. The unit of dose is the sievert (Sv).

**EIS:**
See "Environmental Impact Statement".

**EMPLACEMENT PANEL UPCAST VENTILATION SHAFT:**
This shaft is 3.95 m in diameter and is lined with 0.15 m of concrete to facilitate decontamination if the shaft becomes radioactively contaminated and to prevent the movement of radionuclides into the geosphere. It provides exhaust ventilation at a rate of 178 $m^3 \cdot s^{-1}$ for the panels where container emplacement and associated activities are occurring, and the exhaust air is classified as potentially radioactive.

**ENVIRONMENT:**
The circumstances, objects, or conditions surrounding an organism or facility. In the case of a human, the environment includes:
- air, land, water, plants, and animals (the natural environment)
- humans
- social and economic systems created by humans (human communities or the socioeconomic environment)
- physical objects created by humans, including buildings and machines
- materials, emissions, and vibrations resulting from human activities.

Often qualified by preceding words such as "natural", "biophysical", "socio-economic" and so on.

**ENVIRONMENT, BIOPHYSICAL:**
See "biosphere", the preferred term in the CNFWMP.

**ENVIRONMENT, NATURAL:**
All the conditions and influences, not human-derived, surrounding an organism, human or otherwise, that affect its life, survival, and development, excepting, in the case of humans, those factors covered under "social environment". It includes the biosphere and geosphere.

**ENVIRONMENT, SOCIAL:**
For the purpose of the EIS, the socio-economic and cultural characteristics of the people living in nearby communities or along the transportation routes that would be affected by the presence of a waste disposal facility or its transportation system.

**ENVIRONMENTAL ASSESSMENT PANEL:**
A group of individuals appointed by the federal Minister of the Environment under the EARP (see this term) to examine an environmental issue or a project with potential environmental consequences.

**ENVIRONMENTAL EFFECT:**
For the EIS preclosure assessment, a change to the social and/or natural environment caused by the activities associated with the transportation or disposal of nuclear fuel waste. Social (or socio-economic) effect which are considered to be significant, by the affected community(s), are referred to as impacts. See also 'environmental impact' and 'radiological impact'.

**ENVIRONMENTAL IMPACT:**
Often used interchangeably with 'environmental effect'. For purposes of this assessment, impact generally refers to a socio-economic effect which is considered to be significant by the affected community(s). See also 'radiological impact'.

**ENVIRONMENTAL IMPACT STATEMENT (EIS):**
In the CNFWMP, the Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste, a general Summary and the supporting Primary References are the documents recording the results of the Canadian Nuclear Fuel Waste Management Program for assessing a waste disposal concept and the environmental impacts of its implementation. The documents are to conform with the requirements specified in the Guidelines issued by the Environmental Assessment Panel reviewing the concept.

**ENVIRONMENTAL PATHWAY:**
The route by which a radionuclide is transferred from one environmental compartment to another in the biosphere.

**ENVIRONMENTALLY SENSITIVE AREAS:**
Biophysical and historical features of a locality which are either provincially or regionally unique or rare, are considered to be of importance from a socio-economic, natural or aesthetic perspective, and are susceptible to degradation or displacement as a result of human activities.

**EUROPIUM (Eu):**
One of the chemical elements; the isotope with mass 154 has a half-life of 8.5 years.

**EVENT-TREE ANALYSIS:**
In applied mathematics, a probabilistic technique for examining the reliability of a system. One starts by assuming that one of a set of selected component failures has occurred, and then deduces whether or not other components of the system in turn will fail, and decides whether or not the system as a whole will fail. An "event tree" is a diagram illustrating the alternative consequence or outcomes of the specified initiating event (see "fault-tree analysis").

**EXPOSURE:**
Irradiation of persons or materials. Exposure of persons to ionizing radiation may be either external, from sources outside the body, or internal, from sources inside the body.

**EXPOSURE PATHWAYS:**
The routes by which radioactive materials in the biosphere come into contact with man. For EIS purposes, atmospheric, food chain and aquatic pathways are considered.

**EXPOSURE RATE:**
The increment of radiation received in a specific time interval.

**EXTENSIVE RECREATION USE CAPABILITY:**
Those lands capable of supporting dispersed, low density recreation use (e.g., hiking, canoeing, remote cottaging).

**EXTERNAL DOSE:**
Irradiation resulting from exposure to radiation sources outside the body. The SI unit of measurement of dose is the sievert (Sv).

**EXTERNAL RADIATION:**
In the preclosure assessment, the amount of radiation that is emitted from the used fuel within a transportation cask, taking into account the shielding provided by the cask.

**FALLOUT:**
The radioactive material that descends to and settles on the earth as a result of radionuclides released from nuclear weapons testing.

**FAULT-TREE ANALYSIS:**
A probabilistic analysis technique for examining the reliability of a system. One starts by assuming that a specific system failure has occurred, and deduces which component faults or combinations of faults could have caused the system failure. A fault tree is the diagram illustrating the faults is a tree-like structure. (See "event-tree analysis".)

**FENDER:**
The term applied to the devices built into or hung over the sides of a vessel or dock to prevent the shell plating from rubbing or chaffing against other ships or piers.

**FISSION PRODUCT:**
A nuclide produced either directly by nuclear fission or by the subsequent radioactive decay of a radionuclide produced by fission.

**FIXED AREA MONITORS:**
Gamma radiation detectors installed primarily to alert personnel by means of audio and visual alarms to changes in the radiological conditions of an area which could result in unacceptable doses of radiation. A secondary function is to provide information on dose rates at the location of the detectors.

**FOOD CHAIN:**
In ecology, the dependence for food of organisms upon others in a series, beginning with plants or scavenging organisms and ending with the largest or most efficient carnivores.

**FORECASTLE:**
A superstructure fitted at the extreme forward end of the upper deck.

**FUEL:**
See "nuclear reactor fuel".

**FUEL ASSEMBLY:**
See "fuel bundle", the term used in the CNFWMP.

**FUEL BAY:**
See "water-pool facility", the term used in the CNFWMP.

**FUEL BUNDLE:**
A number of fuel elements held together by end plates and separated by spacers attached to the fuel cladding near the middle of the bundle.

**FUEL CYCLE:**
See "nuclear fuel cycle".

**FUEL DEFECT:**
Any flaw in the fuel or cladding from manufacturing or as a result of operational history that could lead to cladding failure and potential radioactive releases.

**FUEL ELEMENT:**
In a CANDU fuel bundle, the unit which consists of a tube of zirconium alloy containing ceramic fuel pellets of uranium dioxide and sealed at the end with welded zirconium alloy plugs.

**FUEL FAILURE:**
Breach of the fuel cladding which allows escape of radioactivity and/or fuel material.

**FUEL MODULE:**
A lattice structure used to restrain and space used-fuel bundles during storage at a nuclear generating station and also in transportation casks.

**FUEL RECYCLING:**
Reprocessing used nuclear fuel and recovering the useful materials, such as plutonium and uranium, to make new fuel which could then be used in a reactor to produce electricity.

**FUEL WASTE:**
See "nuclear fuel waste".

**GAMMA RAY ($\gamma$):**
A high-energy, highly-penetrating photon of short wave length commonly emitted by the nucleus of a radioactive atom during radioactive decay as a result of a transition from one of its excited energy levels to a lower level.

**GAUSSIAN PLUME MODEL:**
A mathematical model for the dispersion and dilution of contaminants in the environment (air, water, soil) based on advective transport and classical diffusion theory.

**GENERIC ANALYSIS:**
Examination of the expected performance of a type of nuclear facility. In the CNFWMP, it involves assessing a case study comprising a hypothetical disposal vault located at a specific site selected as an example for demonstration purposes only.

**GENERIC EFFECT:**
A change induced by radiation which manifests itself in the descendants of the exposed individual.

**GEOGRAPHICAL INFORMATION SYSTEM (GIS):**
A set of computer-based tools for the input, storage, analysis and output of geographical information. A GIS was used to provide a framework for the preclosure "reference environment" assessment.

**GEOLOGICAL DISPOSAL:**
All approaches to the long-term management of nuclear fuel wastes that depend upon placing the wastes underground in a selected host medium to isolate the wastes from humans and the environment.

**GEOMETRIC CENTRE:**
For purposes of the used-fuel transportation assessment, the Ontario portion of the Canadian Shield was divided into three simple polygons. The hypothetical site for a nuclear fuel waste disposal facility for each of the three regions is located where lines drawn from the four corners of each polygon intersect in the geometric centre of that polygon. The geometric centres are used to estimate the distances from the nuclear generating stations to a disposal facility.

**GLACIAL LAKE CLAY:**
Weathered soils originating from deposits made in glacial lakes (ponding generally occurred as a result of damming action of the ice). Glacial lake deposits range from coarse and delta materials near the shore to fine silts and clay in the deeper and stiller waters.

**GRANITE:**
A coarse-grained igneous rock consisting mostly of quartz (20-40%), alkali feldspar and mica. A number of accessory minerals may be present.

**GRAY (Gy):**
The SI unit of absorbed dose for ionizing radiation, equal to 1 joule of radiation energy absorbed in 1 kilogram of the material of interest (1 Gy = 100 rad).

**GROSS DOMESTIC PRODUCT AND EMPLOYMENT:**
"Real value added" is defined here as the constant dollar amount that Ontario producers contribute towards the final value of goods manufactured, processed or sold in the Province. GDP is measured as real value-added plus depreciation and interest (on net assets) and is expressed in millions of real 1987 dollars. Employment is derived from real value-added using job-to-shipments ratios and may vary depending on the capital intensity and local content of the activity. "Employment" is measured in number of person-years of work at 1987 productivity levels.

**GROUNDSHINE:**
External beta and gamma radiation from the surface of the earth, often conservatively assumed to be infinite in extent.

**GROUNDWATER:**
Water beneath the earth's surface in soils and geologic formations. The water may rise from a deep magmatic source or come from rainfall soaking into the earth.

**GRUBBING:**
Grubbing is the removal of trees, vegetation and often surface soil layers to expose the mineral layers. This is generally done during construction, road building and gravel extraction.

**HAZARD:**
Any natural or man-made source of a potential deleterious effect.

**HELIUM LEAK TEST:**
The Helium Leak Test is a quality control step to assure that no unintended cracks, holes or porosity exists in the disposal container that will allow the admission or escape of fluids or gases. Helium Leak Testing utilizes sophisticated leak detector instruments designed to locate and/or measure leaks in the range of $10^{-3}$ to $10^{-8}$ std cc/sec.

**HERPTILES:**
A term used to refer to both amphibians and reptiles.

**HOLD:**
The internal part of a vessel into which cargo can be stowed.

**HOT CELL:**
Shielded and individually ventilated enclosures, fitted with remote manipulation systems that allow an operator to perform tasks involving radioactive materials without being exposed to radiation beyond a specified allowable dose. The facility provides containment, shielding, remote handling and viewing.

**HULL:**
The structural body of a ship, including shell, framing, decks, bulkheads, etc.

**HYDROGEN (H):**
One of the chemical elements; the isotope with mass 3, often called tritium, has a half-life of 12.3 years.

**IAEA:**
See "International Atomic Energy Agency".

**ICRP:**
International Commission on Radiological Protection.

**ICRP LIMIT:**
A maximum dose equivalent not to be exceeded, as recommended by the International Commission on Radiological Protection (ICRP). Dosimetric models may be used to derive the Annual Limit on Intake (ALI) and Derived Air Concentration (DAC).

**IMMOBILIZATION (OF WASTE):**
See "waste immobilization".

**IMPACT LIMITER:**
Used on the road cask. This device provides impact protection and serves as thermal insulation to protect the seals between the cask lid and body under accident conditions. It is constructed of blocks of redwood encased in a stainless steel sheath, and adds on additional 1.1 tonnes to the payload.

**IN-ROOM EMPLACEMENT:**
The placing of disposal containers into boreholes drilled in a bed of compacted buffer material, filling the tops of the holes with further buffer material and filling the room with dense, swelling backfill material.

**INCLINED ELEVATOR:**
An inclined elevator is essentially an escalator. It is used in two places: receiving surge storage pool and the headframe surge storage pool. For the receiving surge storage pool, the inclined elevator moves the used fuel shipping/storage modules into and out of the pool. For the headframe surge storage pool, the inclined elevator moves the disposal containers into and out of the pool.

**INCOME AND EMPLOYMENT MULTIPLIERS:**
In this study, "<u>multipliers</u>" are defined to be the ratio of the direct and economy-wide impact to the expenditures of designing, constructing, operating, and decommissioning a conceptual UFDC. The income multipliers (GDP) measure the extent to which an initial injection of spending is amplified through the economy, as the initial outlay stimulates further spending and income. The multiplier is expressed in dollars (1987) of value-added per dollar (1987) spent. Similarly, employment multipliers are expressed in number of person-years at 1987 productivity levels per million dollars (1987) spent.

**INDIRECT AND INDUCED IMPACTS:**
<u>"Indirect economic impacts"</u> are those associated with the subsequent inter-industry production linkages, as successive rounds of supplier and sub-supplier industries participate in the economic activity. For example, the indirect impact of constructing various buildings and structures in a conceptual UFDC would include the stimulus to the cement industry, the metal fabricating industry, and of course to the construction industry. "<u>Leakages</u>" of economic activity out of Ontario, as well as the effect of activity originating outside Ontario and flowing back into the province are also taken into account. For example, if some of the cranes and other special equipment needed to

construct the buildings and structures were manufactured in another province, then the imports of the special equipment represents a leakage of economic activity; this is accounted for by the economic impacts in the Rest of Canada. In turn, importing equipment may create activity in Ontario if, say, the manufacture of cranes uses steel from Ontario.

"Induced impacts" result from the re-spending of labour and corporate incomes, as well as any government spending which is incremental to economic activity. For example, the induced effects through labour include the "ripple effect" resulting from the initial spending of wages and salaries by construction workers, engineers and so on. Corporate income is re-spent out of net cash flow to materials and service-supplying firms. Government spending derives from the collection of personal and corporate income tax as well as other tax revenues. Again, leakages of economic activity are accounted for here by the economic impacts on the rest of Canada. The re-spending amount of income in Ontario is determined via a matrix of "average propensities to spend" with respect to goods and services.

**INDIRECT ECONOMIC IMPACTS:**
In the preclosure assessment documents, those effects associated with the subsequent inter-industry production linkages, as successive rounds of supplier and sub-supplier industries participate in an economic activity. "Leakages" of economic activity out of Ontario and flowing back into the province are also taken into account.

**INDIRECT EMPLOYMENT:**
Employment increases caused by a project, not inside the project itself, but in other businesses or activities required by the project.

**INDIVIDUAL DOSE RATE:**
The quantity of nuclear radiation received per unit time by a member of the population.

**INDUCED IMPACTS:**
In the preclosure assessment documents, the effects from the responding of labour and corporate incomes, as well as any government spending which is incremental to economic activity. The respent amount of income in Ontario is determined via a matrix of "average propensities to spend" with respect to goods and services.

**INPUT PARAMETER:**
A variable in a model (usually a computer model) which must be defined (input) before the model is used to generate a solution. In SYVAC simulations of a disposal system, one value of each input parameter is selected from the range of its possible values for each simulation run.

**INSTITUTIONAL CONTROLS:**
Continuing actions and precautions by society to ensure the continued implementation and achievement of a desired course of action. These controls could include monitoring, surveillance, maintenance, keeping records, and imposing land-use restrictions.

**INTENSIVE RECREATION USE CAPABILITY:**
Lands capable of providing outdoor recreational opportunities for large numbers of people (e.g., bathing, camping, downhill skiing).

**INTERMODAL TRANSPORTATION:**
A transportation system using a combination of road, rail and water.

**INTERNAL DOSE:**
Quantity of radiation received from sources inside the body.

**INTERNATIONAL ATOMIC ENERGY AGENCY (IAEA):**
The organization established in 1957 by the United Nations as the international body responsible for on-site nuclear reactor inspections and safeguards measures that assist the member states of the Agency to demonstrate that no nuclear material is diverted to non-peaceful purposes from safeguarded nuclear facilities.

**INTERTRAN:**
A computer code developed by the IAEA and based on the SANDIA code RADTRAN-II. It is used to assess the radiological impacts from transporting radioactive materials.

**IODINE (I):**
One of the chemical elements; the isotope with mass 129 has a half-life of 16 000 000 years.

**IONIZING RADIATION:**
The transfer of energy through space in the form of either electronic waves or subatomic particles that have sufficient energy to displace electrons from atoms or molecules, thereby producing ions in and imparting energy to the matter through which they pass.

**IRON (Fe):**
One of the chemical elements; the isotope with mass 55 has a half-life of 2.7 years.

**IRRADIATED FUEL:**
See "**USED FUEL**".

**ISOTOPE:**
An atom. Different isotopes of an element have the same atomic number (or number of protons) but a different mass number (protons plus neutrons). Some elements have many isotopes. All isotopes of an element have the same chemical properties, but slightly different physical properties. Radioactive isotopes are called radioisotopes.

**KNOT:**
A unit of speed, equalling one nautical mile per hour, the international nautical mile is 1852 m (6076.1 ft).

**KRYPTON (Kr):**
One of the chemical elements; the isotope with mass 85 has a half-life of 10.8 years.

**LAYDOWN:**
Simply an area in which to lay down (set in place) something (ie., disposal container).

**LICENSE:**
In the nuclear industry, a formal document issued by a regulatory agency for major stages in the development of a nuclear facility which permits the implementing organization to perform specified activities.

**LINEAR DOSE-RESPONSE RELATIONSHIP:**
See "dose-response relationship, linear".

**LONG-LIVED WASTE:**
Radioactive refuse that will not decay to an acceptable activity level in a period of time during which administrative controls are expected to last.

**LONG-TERM:**
In waste management, refers to periods of time which exceed the time during which administrative controls can be expected to last.

**LORAN C:**
Radio beacon device for position fixing.

**LOW-LEVEL WASTE (LLW):**
Waste which, because of its low radionuclide content, does not require shielding during normal handling and transportation. See "alpha-bearing waste" and "long-lived waste" for other possible limitations.

**MATERIAL BALANCE AREA (MBA):**
Zones into which a nuclear facility is divided to establish an inventory and to facilitate measurement of all nuclear material transfers between the zones. The division takes account of specific technical and physical aspects of the nuclear facility.

**MAXIMUM PERMISSIBLE CONCENTRATION (MPC):**
The highest levels of radioactivity in drinking water or in air to which occupational workers may be exposed, as established by national authorities, usually based on the current ICRP recommendations. Levels ten times lower are generally set for the public. However, new ICRP recommendations for limiting the intakes of radionuclides by workers (ICRP Publication 30) no longer include the MPC concept for drinking water; instead, annual limits on intake (ALI) are used. The derived air concentration (DAC) is the new parameter for air.

**MITIGATE:**
To reduce or offset negative socio-economic or biophysical environmental effects.

**MITIGATIVE MEASURES:**
Actions taken to alleviate the detrimental impacts of an event or continuing activity. They can include actions to avoid, minimize, correct, eliminate or compensate for negative impacts.

**MODEL:**
An analytical or mathematical representation or quantification of a real system and the ways that the phenomena occur within the system. Individual or sub-system models can be combined to give system models. In SYVAC3-CC3, for example, the system model consists of the vault, geosphere and biosphere models.

**MODELLING:**
The creation or application of a mathematical representation of a physical, biological or geological system. The mathematical representation is often converted into computer code so that the system can be examined in more detail.

**MONITORING:**
In the CNFWMP, monitoring would consist of the continuous or intermittent measurement of conditions in the region influenced, or potentially influenced, by the presence of the disposal facility and associated transportation system. Monitoring would be done to determine baseline conditions and to identify any changes from baseline conditions. Parameters indicating conditions in the disposal vault, geosphere, biosphere, and human communities would be measured. Monitoring would be initiated early in the siting stage and would be continued until closure. It could also be continued after closure if required by regulators and/or the public, provided that institutional controls would not be required to maintain the safety of the vault.

**MOORING:**
Securing a ship at a wharf or elsewhere by several lines or cables so as to limit movement.

**MULTIBARRIER:**
In a disposal vault, a system using two or more independent means for isolating waste from the biosphere. These can include the waste form, the container, other engineered barriers and the emplacement medium and its environment. See also "barrier".

**NATURAL BACKGROUND DOSE EQUIVALENT:**
The amount of radiation received from environmental sources of radiation, which include cosmic rays (from outside the solar system and from the sun), and radionuclides in the earth's crust, in the air, and in the human body.

**NATURAL BACKGROUND RADIATION:**
The various types of radiation not made by man, including: 1. "External" sources of extra-terrestrial (cosmic rays) and terrestrial origin (the radioactive isotopes present in the crust of the earth, the water and the air), and 2. "Internal" sources, i.e. the radioactive isotopes of potassium and carbon, which are normal constituents of the human body, and other isotopes, such as radium-226 and thorium-232 and their decay products, which are ingested from the environment and retained in the human body.

**NATURAL BARRIER:**
See "barrier".

**NET PRESENT VALUE (NPV):**
A criterion for evaluating investments in which the total cash flow for a project (the UFDC or Used-Fuel Transportation System) is assessed. The calculation of NPV of a project provides the actual dollar values for cash inflows and outflows over the life of the project. These cash flows are discounted back to the present by using Ontario Hydro's Corporation discount rate.

**NFWMP:**
Nuclear Fuel Waste Management Program. See "Canadian Nuclear Fuel Waste Management Program" (CNFWMP).

**NGS:**
See "Nuclear Generating Station".

**NICKEL (Ni):**
One of the chemical elements; the isotope with mass 59 has a half-life of 75 000 years; the isotope with mass 63 has a half-life of 100 years.

**NIOBIUM (Nb):**
One of the chemical elements; the isotope with mass 94 has a half-life of 20 000 years.

**NPT:**
Non-Proliferation Treaty. See "Treaty on the Non-Proliferation of Nuclear Weapons".

**NUCLEAR FACILITY:**
A facility and its associated land, buildings and equipment in which radioactive or fissionable substances are produced, processed or handled on such a scale that considerations of nuclear safety are required.

**NUCLEAR FUEL CYCLE:**
The fuel handling processes required for power production, including obtaining, using, storing, reprocessing and disposing of the nuclear materials used in the operation of nuclear reactors. Also called "fuel cycle".

**NUCLEAR FUEL WASTE:**
A solid that is either the fuel that has been used in a nuclear power reactor (used fuel) or a waste form incorporating the highly radioactive waste that would be removed from the fuel if the fuel were to be recycled.

**NUCLEAR GENERATING STATION (NGS):**
One or more nuclear reactors, together with the structures, systems and components necessary for safety, and for the production of power in the form of heat or electricity. Also called 'nuclear power plant'.

**NUCLEAR INSTALLATION:**
See "nuclear facility".

**NUCLEAR REACTOR:**
A structure in which a chain reaction of nuclear fission is initiated and controlled with the consequent production of heat, which is typically used for power generation. Another product may be radioactive products for experimental or medical purposes.

**NUCLEAR REACTOR FUEL:**
Fissionable and/or fertile material which is the source of energy when placed in a near-critical arrangement in the core of a nuclear reactor. CANDU fuel consists of uranium dioxide pellets, stacked and sealed inside metal tubes. As many as 37 tubes are then welded together to make a fuel bundle.

**NUCLEAR SAFETY:**
The protection of people and property from the harmful effects of radioactive contamination, exposure to ionizing radiation, or a criticality excursion. In this context, the term 'ionizing radiation' may or may not include X-radiation produced by an X-ray machine, depending on national usage. Also known as 'radiological safety'.

**NUCLIDE:**
A species of atom characterized by the constitution of its nucleus: the number of protons, the number of neutrons, and the mass.

**OCCUPATIONAL DOSE:**
The amount of radiation received by an individual due to the operations performed and materials handled in his or her profession. Also called 'occupational exposure'.

**OH:**
Ontario Hydro, the public utility responsible for supplying electricity in the province of Ontario, and for the preclosure portion of the Canadian Nuclear Fuel Waste Management Program.

**OH - 2 BUNDLE CASK:**
Type b container detaining an AECB certificate to transport either two irradiated fuel bundles or activated core components

**OPERATIONAL PERIOD:**
The time during which a nuclear facility is used for its intended purpose until it is shut down and decommissioned.

**OPTIMIZATION:**
The use of protective measures to reduce the expected harm to a population from exposure to radiation resulting from some activity involving radioactive materials, to a level as low as reasonably achievable, economic and social factors being taken into account. See also 'ALARA'.

**ORIGEN:**
The ORNL Isotope GENeration and Depletion Code, a computer code developed by the Oak Ridge Nuclear Laboratory, which calculates the inventory in used fuel, taking into account radioisotope generation, in-growth and radioactive decay.

**PACKAGING:**
The packaging of nuclear fuel waste to conform to radioactive material shipping regulations established to prevent loss, release or dispersion of radioactive material.

**PAD EYES:**
Engagement mechanism on the deck of the barge to accept the hydraulic ram from the tug.

**PARAMETER:**
A characteristic of a system.

**PARAMETER APPROACH:**
A methodology employed to characterize the environment using individuals parameters.

**PARAMETER VARIATION:**
See 'sensitivity analysis'.

**PASQUILL WEATHER CATEGORY:**
Classification of weather conditions according to their dispersive properties. They are based on solar insulation, surface wind speed and cloud cover.

**PATHWAY:**
In performance assessment, the route through the biosphere taken by contaminants as they move from a source to a receptor, such as an individual.

**PATHWAY ANALYSIS:**
Calculation of the dose to human and non-human biota from a source of radiation by estimating the contribution from different routes or pathways through the biosphere that the radionuclides may take.

**PATHWAY DOSE RATE FACTOR:**
The annual dose rate from exposure to a unit radionuclide concentration for a given pathway. The units in PREAC are ($Sv.a^{-1}.Bq^{-1}.m^3$) for the air pathways, and ($Sv.a^{-1}.Bq^{-1}.L$) for the water pathways.

**PERMANENT MARKER:**
After decommissioning and the site has been cleared, stationary identifiers, indicating the presence of the underground disposal vault, will be positioned at ground level. The marker will clearly display symbols that are internationally recognized as representing a potential risk to humans and the environment.

**PERSON-SIEVERT (person-Sv):**
The SI unit of collective dose equivalent commitment to a population.

**PERSON YEAR:**
In industry, a unit of work equal to one year of work done by one person.

**PERTURBATION ANALYSIS:**
See 'sensitivity analysis'.

**pH:**
Potential of Hydrogen, a measure of the acidity or alkalinity of a solution. A solution of pH between 0 and 7 is acid, pH 7 is neutral, and of pH between 7 and 14 is alkaline.

**PLUME:**
In environmental assessment, the pattern of a material released into the environment and dispersed by a fluid.

**PLUME DEPLETION:**
Removal of material from an airborne plume to ground; usually ignored in atmospheric transport models over short distances (few tens of kilometres).

**PLUTON:**
An individual body of igneous rock formed beneath the surface of the earth by consolidation of magma. Similar to 'batholith' except that it is smaller in size.

**PLUTONIC ROCK:**
Intrusive igneous rock formed at considerable depth beneath the surface of the earth by cooling of magma. Also called "intrusive igneous rock" and "crystalline rock".

**PLUTONIUM (PU):**
One of the chemical elements; the isotope with mass 238 has a half-life of 87.8 years; the isotope with mass 239 has a half-life of 24 100 years; the isotope with mass 240 has a half-life of 6 570 years; the isotope with mass 241 has a half-life of 14.4 years.

**PODSOLS:**
Podsolic soils are imperfectly drained soils that have developed under coniferous and mixed-forest vegetation, mostly in cold to temperate climates and on acid parent materials. Below the organic debris layer, these soils are acid (usually pH 5.5) and the organic matter in combination with iron and aluminum forms coatings on soil particles.

**POPULATION DOSE:**
See 'collective dose equivalent commitment'.

**POPULATION ZONES:**
For purposes of the EIS, three typical population distributions (rural, suburban and urban) found in the Ontario region of the Canadian shield, whose characteristics have been used to assess the potential impacts of the transportation system on communities which may be located along the shipment route.

**PREAC:**
Preclosure Radiological Environmental Assessment Code. A computer program written by Ontario Hydro to calculate the individual and collective dose to members of the public from the operation of a hypothetical Used Fuel Disposal Centre in the Ontario portion of the Canadian Shield.

**PRECAMBRIAN SHIELD:**
See "Canadian Shield".

**PRECLOSURE:**
Pertaining to the period of time covering the construction, operation and decommissioning of a disposal vault up to and including the final shaft sealing and surface facility decommissioning. The transportation of used fuel from nuclear generating stations to the disposal facility is also part of the preclosure period.

**PRECLOSURE ASSESSMENT:**
Safety analysis of the waste disposal system that deals with potential impacts during construction, operation and decommissioning of a disposal facility. It includes an assessment of the transportation of used fuel from nuclear generating stations to the disposal facility.

**PROBABILISTIC ANALYSIS:**
A statistical method for studying the expected behaviour of a system defined in terms of parameters whose exact values are given as a probability distribution, events whose occurrences are random and/or features which may or may not be present. The analysis gives a corresponding probability distribution of results. See 'deterministic analysis'.

**PROBABILITY:**
A measure of the degree of belief or frequency of observing the value of a variable in a particular interval (for a continuous variable), or equal to one of a set of discrete values (for a discrete variable). An <u>absolute probability</u> is defined with respect to an exhaustive list of the possible values of the variable; <u>relative probabilities</u> are defined with respect to one another. <u>Frequentist</u> (or "<u>objective</u>") <u>probabilities</u> refer to the expected frequencies of observing different values by continuing a series of identical experiments or samplings; <u>subjective</u> probabilities are defined as the subject's degree of belief that the different values will be observed in a single future observation.

**PROBABILITY DISTRIBUTION:**
For continuous variables, a function which is the integrated form of the probability density function. For a discrete variable, the set of probabilities of observing each of the possible values of the variable.

**PROMETHIUM (Pm):**
One of the chemical elements; the isotope with mass 147 has a half-life of 2.62 years.

**PUBLIC CONSULTATION PROGRAM:**
The activities designed to identify and address social issues and public concerns, and to provide the public with an opportunity to have input into the CNFWMP. The Program included a series of consultative meetings with public interest groups and an interactive workshop.

**PUBLIC INTEREST GROUP:**
An organization or group of people having a shared concern in some issue, that attempts to influence political decisions that might affect its members.

**PUBLIC PARTICIPATION:**
The public consultation program, sociological research, and all of the public interaction activities undertaken by AECL directed at informing the public about the CNFWM research program, and seeking feedback from the public. The public interaction activities include production and dissemination of information material, provision of public speakers,

displays, briefings, attendance at public meetings, school visits, public information offices, direct mailings and advertising.

**PUNCH TEST, CASK:**
A test which studies the effects on a used-fuel transportation cask when it is dropped on a fixed steel rod from certain heights.

**Q.A.:**
See 'Quality Assurance'.

**QUALITY ASSURANCE:**
Procedures used to provide evidence or demonstrate that the stated degree of quality in a product has, in fact, been achieved. It includes all those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given needs.

**QUALITY CONTROL:**
Actions which provide a means to fix and measure the characteristics of an item, process, facility or person in accordance with quality assurance requirements.

**RADIAL INTERVAL:**
Annular areas between circles of radius r and $r + \Delta r$

**RADIATION:**
The very fast nuclear particles and/or photons emitted by nuclei. In the CNFWMP, taken to be synonymous with ionizing radiation. The four major forms of radiation are alpha and beta particles, neutrons and gamma rays.

**RADIATION DAMAGE:**
Harmful changes in the physical or chemical properties of a material resulting from exposure to ionizing radiation. This term is not applied to biological systems.

**RADIATION PROTECTION:**
Measures associated with limiting the harmful effects of ionizing radiation on people, such as limiting external exposure or bodily incorporation of radionuclides, as well as the prophylactic limitation of bodily injury resulting from either of these. Also, all measures designed to limit radiation-induced chemical and physical damage in materials. Also called 'radiological protection'.

**RADIOACTIVE:**
Emitting radiation. See 'radiation'.

**RADIOACTIVE DECAY:**
The changing and progressive decrease in the number of unstable atoms in a substance due to their spontaneous nuclear disintegration or transformation into different atoms during which particles and/or electromagnetic radiation are emitted. Also called 'decay'.

**RADIOACTIVE DECAY CHAIN:**
A series of unstable (radioactive) nuclides. Each radionuclide in a decay chain produces daughter products by spontaneous disintegration or radioactive decay. There are three long radioactive decay chains found in nature. The starting nuclides are generally taken to be the actinides uranium-238, uranium-235 and thorium-232. In a nuclear reactor, a fourth long radioactive decay chain occurs due to neutron

activation of the actinides; its starting nuclide may be taken to be neptunium-237. The final member of these series, usually an isotope of lead, is stable. Other (generally shorter) radioactive decay chains may form during the fissioning process.

**RADIOACTIVE MATERIAL:**
A substance containing one or more constituents which exhibit radioactivity. For special purposes such as regulations, this term may be restricted to radioactive material with a radioactivity level or specific activity greater than a specified value.

**RADIOACTIVE SOURCE TERM:**
1. In an analysis of the movement and transfer of radionuclides in the environment, the activities and amounts of the different radionuclides per unit time leaving a nuclear installation or facility and entering the environment or an environmental compartment. 2. An expression used to denote information about the actual or potential release of radioactive material from a given source, which may include a specification of the composition, the amount, the rate and the mode of release.

**RADIOACTIVE WASTE:**
Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the 'exempt quantities' established by the regulatory agencies and for which no use is foreseen.

**RADIOACTIVITY:**
The spontaneous emission of radiation, either directly from unstable atomic nuclei, or as a result of a nuclear reaction.

**RADIOLOGICAL IMPACT:**
The estimated annual dose and consequent health risks from exposure to radionuclides in the environment.

**RADIONUCLIDE:**
An unstable nuclide that undergoes radioactive decay.

**RADIONUCLIDE FLUX:**
In PREAC, the area-integrated flux of radionuclides to surface water as a result of airborne deposition. The units are $Bq \cdot s^{-1}$.

**RADON (Ra):**
One of the chemical elements; the isotope of mass 222 has a half-life of 38 seconds.

**RADON DAUGHTERS:**
The following short-lived radioactive decay products of radio-222: polonium-218 (radium A), lead-214 (radium B), bismuth-214 (radium C) and polonium-214 (radium C').

**RADWASTE:**
See 'radioactive waste'. This term is not recommended for use in the EIS.

**RECYCLING:**
The re-use of fissionable and fertile material after it has been recovered from used nuclear fuel by chemical reprocessing. Also refers to re-use of non-renewable resources. See also "fuel recycling".

**REFERENCE BUFFER MATERIAL:**
In the CNFWMP, the reference buffer material is a compacted sand-bentonite mixture of a particular composition.

**REFERENCE CONTAINER:**
In the CNFWMP, an enclosed cylindrical vessel of titanium alloy which would hold 72 bundles of used nuclear fuel. Glass beads would be compacted around the fuel bundles inside the container to support the container walls. See also 'packed particulate container'.

**REFERENCE ENVIRONMENT:**
For the purpose of the EIS, generalized regional data that represent and typify three regions and communities (southern, central and northern) in the Ontario portion of the Canadian Shield.

**REFERENCE MAN:**
A model of a hypothetical "average" person for whom anatomical and physiological characteristics and data are specified in the report of the ICRP Task Group on Reference Man (ICRP Publication No. 23 and IAEA Safety Guides, Safety Series No. 76). Its name notwithstanding, reference man includes both male and female characteristics relevant to calculation of radiological dose. The age of reference man is defined as 20 to 30 years. The model is used to estimate the radiation dose to the human body, whether from external or internal sources. To permit the calculation of infant dose, the models and data for reference man were adapted for a one-year old.

**REGION CENTROID:**
Geometric centre of an area in the Canadian Shield.

**REGIONAL ENVIRONMENTS:**
For EIS purposes, the three regions (northern, central and southern) of the Ontario portion of the Canadian Shield into which demographic and biophysical conditions have been categorized.

**REGULATORY AGENCY:**
An organization or group of organizations designated by the Government as having the legal responsibility for conducting the licensing process, for issuing licenses and thereby for regulating the siting, design, construction, commissioning, operation, shut-down, decommissioning and subsequent control of nuclear facilities (e.g. disposal vaults) or specific aspects thereof. For the nuclear industry in Canada, this role is assigned to the Atomic Energy Control Board (AECB). Also known as 'regulatory authority'.

**REGULATORY LIMIT:**
The maximum amount of radioactive material that can be released to the environment from a nuclear installation. The limit is established by a national or international regulatory authority.

**RELEASE:**
In waste management, the discharge of radionuclides from a radioactive source.

**RELEASE SCENARIO:**
See 'scenario analysis'.

**RELIABILITY, EXPECTED OR PROBABLE:**
The probability that a device, system or facility will perform its intended function satisfactorily for a specified time or a specified number of activations under stated operating conditions.

**RETRIEVABILITY:**
A measure of the capability to remove waste from where it has been emplaced.

**RISK:**
The term risk is commonly used in different ways and is understood in different ways by various segments of society. As used in the CNFWMP, within context, it is the probability that a serious health effect will be suffered by an individual.

**RISK ANALYSIS:**
A quantified examination of the hazards associated with a practice wherein the possible events and their probabilities of occurrence are considered together with their potential consequences, the distribution of these consequences within the population(s) affected, their distribution over time, and the uncertainties of these estimates.

**RISK FACTOR:**
A quantity used to convert dose to risk. The ICRP risk factor of 7.2 x $10^{-2}$ $Sv^{-1}$ is the risk associated with developing a serious health effect (fatal cancer, non-fatal cancer and serious genetic effect) averaged over age and sex.

**RISK PERCEPTION:**
The intuitive understanding and evaluation of potentially harmful conditions and/or situations. The term is most often used in relation to public attitudes, but is also applicable to experts' perceptions of a wide range of risks.

**RISK, CONVENTIONAL:**
The non-radiological harmful effects expected from an activity.

**ROCKBURST:**
A rockburst is the rupture due to natural forces of a volume of rock *in situ* is such a manner that the energy release can be recorded as a distinct and abnormal seismic event. Rockbursts have been classified in practice as: rockbursts related to a single opening; rockbursts related to geological structure; and rockbursts related to pillar structures.

**RUNOFF:**
Something, such as rain, that runs off the ground, due to it being in excess of the amount absorbed by the ground.

**RUTHENIUM (Ru):**
One of the chemical elements; the isotope with mass 106 has a half-life of 1.01 years.

**SAFEGUARDS:**
The verification measures taken to detect the diversion of used nuclear fuel or other nuclear materials for weapons manufacture or for unknown purposes. The system is designed to deter diversion through the risk and consequences of early detection by giving timely notification to the International Atomic Energy Agency. This falls within the framework of international non-proliferation policy entrusted to the IAEA in its statute and by the Treaty on the Non-Proliferation of Nuclear Weapons.

**SAFETY ANALYSIS:**
The examination and calculation of the potential hazards (risks) associated with the implementation of a proposed activity.

**SAFETY ASSESSMENT:**

Critical appraisal or evaluation in terms of one or more safety standards. In the CNFWMP, the entire disposal system is being assessed, and one acceptability criterion is a limit on radiological risk to individuals of the critical group.

**SAFETY REPORT:**

In IAEA usage, a document required from the implementing organization by the regulatory authority containing information concerning a nuclear installation (e.g. a disposal vault), the site characteristics, design, operational procedures, etc., together with a safety analysis and details of any needed provisions to restrict the risk to the site personnel and to the public.

**SAFETY SYSTEM:**

Plans and methods required to assure safe operation in normal circumstances and/or limit the effects of abnormal occurrences or accidents.

**SCENARIO:**

In the CNFWM program, a combination of factors (features, events and processes) that could affect the performance of the disposal facility in immobilizing and isolating nuclear fuel wastes. The 'central scenario' (or normal evolution scenario) is the most probable combination of factors. Alternative scenarios define less probable, but potentially significant scenarios. Other possible scenarios that might be defined include a worst case scenario, which is intended to represent the most severe situation conceivable on the basis of pessimistic assumptions. Agreement on what constitutes a credible and meaningful worst case may be difficult.

**SCENARIO ANALYSIS:**

In the CNFWMP, part of a safety assessment that systematically and comprehensively identifies all sets of factors that must be considered in the assessment process. The two main functions are: 1. to identify and define all factors (features, events and processes) that could affect the performance of the disposal facility; and 2. to provide a systematic framework within which the importance of each factor may be evaluated.

**SCUFF:**

System Costing of Used-Fuel Facility, a computer developed by Ontario Hydro to calculate logistics and costs based on the material flows from the nuclear generating stations to a disposal facility. It is employed in the assessment of used-fuel transportation.

**SECTOR-AVERAGED ATMOSPHERIC DISPERSION:**

The radioactive emissions are dispersed along sixteen wind directions according to the climatological fraction of time the wind is blowing in each direction.

**SECURITY AREA:**

A location within a nuclear site established for the purpose of physical protection of the facility or the materials contained therein, and secured in a manner designed to prevent or delay unlawful access.

**SEISMICITY:**

Movement within the earth caused by earthquakes or ground vibration.

**SHAFT:**
A vertical access passage excavated from surface to subsurface facilities, and used for transferring personnel, equipment and materials, for ventilation, or for transporting the materials mined or buried.

**SHIELDING:**
A material interposed between a source of radiation and persons or equipment, etc., to protect them from radiation. Common shielding materials are concrete, water, earth and lead.

**SHIELDING FACTOR:**
Ratio of the dose with a barrier to the dose without the barrier present.

**SHUT-DOWN AND SEALING:**
For a disposal vault, the actions taken, after disposal operations have ceased, to isolate and prepare the facility for minimum or no surveillance.

**SIEVERT (Sv):**
The SI derived unit of dose equivalent ($1\ Sv = 1\ J \cdot kg^{-1}$)

**SITE CHARACTERIZATION:**
See 'characterization'.

**SITE SCREENING:**
In the CNFWMP, the process of identifying a small number of areas that have characteristics desirable for disposal and thus warrant detailed investigation. The activities would include analyzing existing regional scale data (characterization), and developing and applying criteria for accepting or rejecting an area for further investigation.

**SITING:**
The process of selecting a suitable location for a facility, including appropriate assessment and definition of the related design bases, and numerous other factors.

**SMOOTH-WALL BLASTING TECHNIQUES:**
Carefully controlled explosive mining methods that can be used to excavate the access tunnels and emplacement rooms of a disposal vault. Use of these methods reduces the fracturing and cracking of the rock walls caused by blasting. This simplifies sealing of the access tunnels and emplacement rooms against escape of radionuclides from the containers into the rock, reduces the amount of ground control and the number of supporting structures, and improves the safety for personnel working in the vault.

**SOCIAL ENVIRONMENT:**
See 'environment, social'.

**SOCIAL IMPACT:**
The significant socio-economic and cultural effects of a waste disposal facility and transportation systems on nearby individuals, communities and regions.

**SOCIAL IMPACT ASSESSMENT:**
Part of an environmental impact assessment. A systematic identification and evaluation of the socio-economic and cultural impacts that might occur with the implementation of a project, e.g. the construction,operation and closure of a nuclear fuel waste disposal facility and the transportation of used fuel from a nuclear generating station to the facility.

**SODIUM BENTONITE CLAY:**
A clay formed from volcanic ash decomposition and largely composed of montmorillonite and beidellite.

**SOURCE TERM:**
See 'radioactive source term'.

**SPENT FUEL:**
See 'used fuel', the preferred term in the CNFWMP.

**STORAGE POOL:**
See 'water-pool facility', the term used in the CNFWMP.

**STRONTIUM (Sr):**
One of the chemical elements; the isotope with mass 90 has a half-life of 28.5 years.

**SUPERSTRUCTURE:**
A deck-over structure above the upper deck, the outboard sides of which are formed by the shell plating as distinguished from a deckhouse that does not extend outboard to the ship's sides.

**SURFACE CONTAMINATION:**
Radioactive material deposited on the outside of an item, measured by the amount of radioactivity per unit area of surface. The surface contamination can be fixed (not removable) or non-fixed (removable).

**SURGE STORAGE POOL:**
A holding area capable of accepting a temporary excess of nuclear materials for stockpiling during equipment outages or a period of restricted handling capacity.

**SURVEILLANCE:**
(i) All planned activities performed to ensure that the conditions at a nuclear installation remain within the prescribed limits; it should detect in a timely manner any unsafe condition or degradation of structures, systems and components which could later result in an unsafe condition arising. These activities can be classified as (a) monitoring of individual parameters and system status; (b) checks and calculations of instrumentation; (c) testing and inspection of structures, systems and components; (ii) As used with IAEA Safeguards, the collection of information through devices and/or inspector observation in order to detect undeclared movements of nuclear material, tampering with containment, falsification of information relating to locations and quantities of nuclear material, or tampering with IAEA safeguard devices.

**TADS:**
An Ontario Hydro computer code used for the calculation of individual and collective doses under transportation accident conditions, and for combining the doses with the accident frequency.

**TESTED CONDITIONS:**

A series of tests (water spray, free drop, compression and penetration) defined by the AECB that the used-fuel transportation cask (Type B(U) package) must pass to be granted a design approval certificate by the Atomic Energy Control Board. These tests are designed to ensure that the cask will safely contain radioactive material under normal and rough handling conditions.

**THORON:**

A radioactive isotope of radon (Rn) with mass 220 which originates from the decay of thorium (Th), one of the chemical elements. The half-life of thoron (Rn-220) is 55.6 seconds.

**TIMBER USE CAPABILITY (HIGH, MODERATE and LOW):**

In this classification system, used in the Canada Land Inventory, all mineral and organic soils are grouped into one of seven classes based upon their inherent ability to grow commercial timber. The best lands of Canada for commercial tree growth will be found in Class 1 and those in Class 7 cannot be expected to yield timber in commercial quantities.

HIGH: Lands that have none to moderate limitations to the growth of commercial forests. Productivity is greater than 71 cubic feet per acre per year. This denotes CLI classes 1, 2 and 3.

MODERATE: Lands that have moderately severe to severe limitations to the growth of commercial forests. Productivity ranges between 31 - 70 cubic feet per acre per year. This denotes CLI classes 4 and 5.

LOW: Lands that have severe limitations to the growth of commercial forests, or those that have severe limitations which preclude the growth of commercial forests. Productivity is less than 30 cubic feet per acre per year. This denotes CLI classes 6 and 7.

**TITANIUM (Ti):**

A malleable and ductile metallic element resembling iron. In the CNFWMP, the reference container is fabricated from commercially pure titanium.

**TONNAGE, GROSS:**

Under vessel measurement rules of various nations, the Panama Canal and the Suez Canal, a measure of internal volume of spaces within a vessel in which 1 ton is equivalent to 2.83 $m^3$ or 100 $ft^3$.

**TONNAGE, NET:**

Net tonnage according to national and canal rules is derived from gross tonnage by deducting an allowance for the propelling machinery space and certain other spaces.

**TOPOGRAPHY:**

The detailed and exact physical configuration of a place or region.

**TRAFFIC:**

A number representing a twenty-four hour count of the number of vehicles passing a given position in either direction averaged over one year.

**TRANSFER FACILITY:**

In intermodal transportation, a site for the moving of transportation casks from a ship or barge to either a road or rail vehicle. See also 'transportation mode'.

**TRANSFER PARAMETERS:**
Single-valued constants used to calculate the transfer of radioactivity from one biological compartment to another in the environment.

**TRANSPORT SCENARIO:**
See 'scenario analysis'.

**TRANSPORTATION CASK:**
A robust shielding vessel which dissipates heat, provides physical containment and radiological protection during the transportation and handling of nuclear fuel waste. In the CNFWMP, transportation casks are assumed to carry used nuclear fuel from generating stations to a disposal facility. Compare with 'container cask'.

**TRANSPORTATION LOGISTICS:**
The quantity of transportation hardware (number of trucks, casks, trailers, trains, etc.) required for each year of the project, and the return trip time.

**TRANSPORTATION MODES:**
The three systems being assessed for carrying used fuel from nuclear generating stations to a disposal facility. They are:
1) road mode - truck tractor/trailer
2) water mode - tug/barge
3) rail mode - locomotive/flat cars

**TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS (NPT):**
The most significant landmark in the development of safeguards for nuclear materials, this Treaty was created in 1968. Article III of the Treaty specifies that non-nuclear weapons states signing the Treaty must accept safeguards on all source or special fissionable materials "in all their peaceful nuclear activities".

**TREPANNING AUGER:**
This is a hollow auger that drills out an annulus around the container, after which the buried disposal container can be retrieved intact.

**TRIM:**
The difference between the draft forward and the draft aft.

**TRITIUM (H):**
An isotope of the element hydrogen with two neutrons in its nucleus. See "hydrogen".

**TURBIDITY:**
Any condition of the atmosphere which reduces its transparency to radiation, especially to visible radiation.

**UFDC:**
See "Used-Fuel Disposal Centre".

**ULTRASONIC INSPECTION (TESTING):**
Ultrasonic testing is an inspection tool used to find flaws and/or measure material thicknesses. In the test, ultrasonic transducers emit and receive high frequency sound waves which penetrate materials.

**UNDERGROUND DISPOSAL:**
See 'geological disposal', the preferred term in the CNFWMP.

**UNDERGROUND RESEARCH LABORATORY (URL):**
An AECL experimental facility excavated in a granite batholith near the Whiteshell Laboratories, Manitoba. It is used for carrying out subsurface experiments related to rock mechanics, hydrogeology and other disciplines and to demonstrate the technology necessary for safe disposal of nuclear fuel waste. The URL resembles a mine, with a shaft sunk to a depth of about 440m. The main working level is at a depth of 240 m.

**UNLOADING CELL:**
Shielded area in which used-fuel waste is removed from transportation casks and immobilized in containers. See 'hot cells'.

**URL:**
See "<u>U</u>nderground <u>R</u>esearch <u>L</u>aboratory".

**USED FUEL:**
Nuclear reactor fuel that has undergone fission in a reactor to the point where its further use is no longer efficient due to the buildup of atomic species that hinder the production of heat in the reactor. Sometimes called "irradiated fuel".

**USED FUEL DISPOSAL CENTRE (UFDC):**
The land within the disposal site boundaries, the surface and underground site, workings, structures, processes and systems necessary to receive used nuclear fuel in transportation casks, package it in disposal containers, emplace and seal it in a geological medium and provide all the supporting services and systems to do so in a safe and acceptable manner. In the CNFWMP, it is a conceptual design of a used-fuel disposal facility developed for use in concept assessment. The design was used by AECL and Ontario Hydro to assess the engineering feasibility, costs, safety and potential environmental impact of disposing of used nuclear fuel in the manner described in the EIS documents.

**VAULT, DISPOSAL:**
See "disposal vault".

**VERIFICATION:**
The process by which one provides evidence or increased confidence that a computer code correctly executes the calculations it is asserted to perform. A verified computer code is one that has correctly translated a specified algorithm into code. Verification can be carried out, for example, by comparing the results of a computer code with results produced by other computer codes or by analytical solutions. Compare with validation.

**WASTE DISPOSAL SYSTEM:**
The engineered systems (e.g., disposal containers, buffer and backfilled tunnels and rooms, sealed shafts and boreholes) and natural surroundings (e.g., rock and rubble-filled fractures) and local surface biosphere involved in forestalling, retarding and minimizing the effects of any release of waste substances from permanent isolation.

**WASTE SHAFT:**
In a disposal vault, the vertical passage down which container casks of waste are lowered from the surface facility.

**WATER TABLE:**
The upper surface of a zone saturated with groundwater; the surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

**WEATHER FREQUENCY DATA $f_{ijk}$:**
Measure meteorological data associated with the frequency of occurrence of Pasquill stability class i, blowing into the direction j with a wind speed in wind interval k.

**WET LOADING:**
A procedure for putting fuel modules into transportation casks in which the cask is first lowered into the water-filled storage pool.

**WINCH:**
A machine, usually steam or electric, used primarily for handling cargo and mooring purposes.

**WORKING LEVEL:**
The exposure of radon progeny is described in terms of the "Working Level". A Working Level is defined as "any combination of the short-lived decay products of radon ($^{218}Po$, $^{214}Pb$, $^{214}Bi$ and $^{214}Po$) in one litre of air which will result in the ultimate emission by them of $1.3 \times 10^5$ Mev of alpha particle energy". For calculation:

$$RnWL = ((13.68xc_1)+(7.68xC_2)+(7.68xC_3))/1.3x10^5$$

where $C_1$,$C_2$ and $C_3$ are the concentrations of $^{218}Ra$, $^{214}Pb$ and $^{214}Bi$, respectively, in atoms per litre.

**WORKING LEVEL MONTH:**
A Working Level Month (WLM) is the exposure to radon progeny accumulated over 1 working month (170 working hours). To determine the exposure to radon progeny in WLMs, the Working Level is multiplied by the period of exposure in (working) months.

**WORST CASE (ACCIDENT) SCENARIO:**
A hypothesized sequence of events involving the release and transport of radionuclides from a nuclear installation or facility (e.g. a waste storage or disposal site) to the biosphere. It is intended to represent the most severe accident situation conceivable on the basis of pessimistic assumptions. Agreement on what constitutes 'worst case' scenarios may be difficult. Thus, a set of 'conservative but realistic scenarios' is frequently used instead to define a set of scenarios that may be more useful in sensitivity and uncertainty analyses for safety assessment purposes.

APPENDICES

# APPENDIX A

## SUMMARY OF PUBLIC VIEWS

# Appendix A

## Summary of Public Views Related to Preclosure Phase

This appendix is a summary of public views related to the Preclosure Environmental and Safety Assessment. A more extensive description of public views regarding nuclear fuel waste management in general is presented in a companion primary reference document (Greber et al, 1994). This summary extracted information primarily from three documents:

1. A report prepared by Hardy Stevenson and Associates (1992) documenting research conducted and/or used by Ontario Hydro in the assessment;

2. A report prepared by Greber and Anderson (1989) identifying the issues raised by the public during AECL Public Consultation program; and

3. A report prepared by Dowell (1991) summarizing the issues raised by the public at the FEARO Scoping Meetings on the Review of Nuclear Fuel Waste Management and Disposal.

Public views included in these three documents include general public/societal views, views of individuals, groups and agencies, views of members of communities living near current storage facilities, views of northern residents and Aboriginal groups. These views were documented through primary research, such as focus group discussions and public opinion surveys, and, secondary research, for example, commissions and inquiries, newspaper review and content analysis, case studies and literature review.

### 1. Public Views on the Development of the Used Fuel Disposal Concept and the Nuclear Fuel Waste Management Program

a) Retrievability

As a result of public consultation in Ontario, it was recognized that while permanent disposal might be environmentally optimum, some members of the public believe retrievability is preferable in case future generations need to use the energy in the used fuel. It was recommended that both options be pursued (RCEPP 1980).

During consultation with interest groups across Canada, concerns were raised about the absence of mechanisms for postclosure retrievability. These were seen as necessary in the event of an accident or in case recycling became viable in the future (Greber and Anderson 1989).

During the FEARO scoping meetings, the issue of retrievability was raised: "Since future generations may need to repair the repository or retrieve the used fuel as an energy or material resource, consideration should be given to making any repository accessible to them. This will also give future generations the opportunity to use future technologies which may enable them to more safely manage, neutralize, or otherwise render the used fuel harmless" (Dowell 1991).

b) Extended Monitoring

Discussions with interest groups across Canada identified concerns about the absence of postclosure monitoring in the early design of the disposal concept. Postclosure monitoring was seen as the only way of knowing what was happening with the waste and proving that in fact the disposal method was safe. It was thought that postclosure monitoring might be necessary for hundred of years (Greber and Anderson 1989).

2. <u>Attributes of the Concept</u>

a) Emergency Response

During public consultation with interest groups across Canada, the issue of developing a plan of action to deal with all potential incidents was raised. It was also considered very important to provide education and training to local emergency response personnel (Greber and Anderson 1989).

b) Monitoring

Consultation with theologians, philosophers, physicists, and engineers confirmed that monitoring was an important issue and that informed collective consent with respect to monitoring was extremely important ( Hardy Stevenson and Associates 1991).

Focus groups in Northern Ontario indicated that the only way to control the potential health and environmental effects was to have the used fuel stored in a place where it could be seen and easily monitored (Goldfarb Consultants 1991).

During public consultation with interest groups across Canada, monitoring was identified as a necessity due to potential health hazards, in order that remedial actions be taken in the event of an accident. It was thought that monitoring would also improve the level of knowledge about nuclear fuel waste disposal. Subsurface as well as surface monitoring were considered important (Greber and Anderson 1989).

During the FEARO scoping meetings, the issue of monitoring the environment for signs of corrosion of the containers was raised (Dowell 1991).

c) Potential Risk to Human and Ecosystem Health

Aboriginal groups discussed the importance of protecting the natural environment and their relationship to the land during the FEARO scoping meetings:

"The Native people believe that this land was given to them by their creator and that they were given this land to live off and to pass on to future generations in pretty well the same condition as they got it" (Dowell 1991);

"We have a special relationship with the land. We have a spiritual relationship with the land and exploitation of natural resources is something that we abhor, we don't agree with. But with new concepts, non-Native concepts being introduced to a native community, concepts for employment, concepts for economic development, those views are slowly changing" (Dowell 1991);

"The land, the water, and air are sacred to us. We understand the fragile link between ourselves and the earth, but what we cannot understand is putting waste so deadly that it can kill, putting it in the ground, and that ground to us is sacred" (Dowell 1991).

d) Socio-economic Impacts

After extensive public consultation across Ontario, it was concluded that the social, educational and psychological aspects of the nuclear fuel waste management issue were even more significant than the scientific, engineering and economic aspects (RCEPP 1980);

During the FEARO scoping meetings, aboriginal groups discussed impacts to their traditional lifestyle:

"Of great concern to the people I talked to is a destruction of traditional lifestyles. There are still quite extensive traditional activities taking place in northern Saskatchewan. Even though there are very few people that actually make a living at hunting, fishing and trapping, there are a lot of people who do, to a certain extent, use traditional activities" (Dowell 1991);

"Essentially Native people have lived off the land for centuries, and within the past hundred years, Natives have seen their traditional way of life slowly deteriorating because of external events. Now these external events caused their land to be taken away and what is left is slowly being polluted, as everywhere else is being polluted. But more than any other group of people that live in Northern Ontario, Natives, still rely heavily on fishing and hunting for the bulk of their diet" (Dowell 1991);

"Over time we have seen many of our traditional activities harmed by the activities of white people, both private individuals and government, who come onto our land and flood our reserves, cut down our trees and cause other impacts, the extent of which we do not know. All of these activities together create impacts that are generally overlooked when a new activity is planned which will affect our territory. The AECL concept for nuclear waste disposal is yet another one of these proposed activities that will affect us" (Dowell 1991).

e) Equity

During a FEARO workshop on Aboriginal issues and concerns, representatives of First Nations stated that they did not accept the principle of energy production for use in the South and disposal in the North, and raised the issue of maintaining the waste in storage for a longer period of time, close to where it is being produced (Hardy Stevenson Associates 1992).

3. <u>Transportation</u>

a) Potential Risk to Human and Ecosystem Health

Focus groups in Northern Ontario felt that the major reason for opposition to the Concept was the fear of an accident during transportation (Goldfarb Consultants 1991).

One of the comments made during presentations by groups and individuals throughout Ontario and Canada during the Scoping Meetings was that the potential risk of transportation was one of the reasons for many wishing the used fuel to remain in the south (Dowell 1991).

During the hearings of the Interfaith Program for Public Awareness of Nuclear Issues (IPPANI), where individuals and interests groups in Ontario participated, it was concluded that burying the waste far away from where it was created increases the risk associated with transportation (IPPANI 1985).

Eighty-eight percent of survey respondents in an Ontario survey said that they would find transportation of used fuel acceptable if government approval of safety was required (Decima Research Limited 1986). This survey also indicated that public views on risk from transportation accident are related to the likelihood of such accident, and to the extent and seriousness of the consequences. Respondents believed that government, the general public, communities, scientists and companies should be involved in determining the acceptability of risk.

In the same survey as mentioned above, northerners were found to be less concerned about the security of the containers and emergency, and rural residents were found to be less concerned about the ability to design a safe container and manufacture it to standards.

b) Cask Design and Testing

Focus group research in Ontario (Pieroni 1984), indicated that terrorist activities should be taken into consideration in the design of the cask and that human error was a concern. This research also suggested: a greater margin of safety between operating levels and cask design requirements; lower radiation levels at cask surface; occupational dose levels equal to public dose levels; and strict enforcement of regulations.

An Ontario-wide opinion survey (Decima Research Limited 1986) indicated that an important component of the public's assessment of the transportation of used fuel by truck was concerns about the design and safety of the container. Also, eighty-two percent of respondents would find the knowledge that the containers passed certain tests convincing about its safety, even if the tests were carried out on a half-scale replica.

Focus groups in Ontario (Pieroni 1981) commented on accident testing conditions, other measures that might reduce health and safety concerns, and advantages and disadvantages of various truck and cask designs in terms of safety.

c) Alternative Modes

Focus group research (Pieroni 1981) with representatives from 3 types of Southern Ontario communities (urban, rural/agriculture, cottage/recreation) indicated a preference for train transportation on the basis of their view of risk.

An Ontario Wide survey (Decima Research Limited 1986) indicated a preference for transportation by train (38%) as compared to road (24%) and water (20%). The reason for the concern about road transportation was that it could potentially affect more densely populated areas.

d) Alternative Routes

An Ontario-wide opinion survey (Decima Research Limited 1986) indicated that the majority of respondents who were concerned about the transportation of used fuel were less concerned if one route was chosen and notification given to officials. Also, a slight majority preferred use of less well maintained highways farther from emergency services , if they were farther from population centres.

Another opinion survey (Goldfarb 1987) identified three most important factors for selecting a road transportation route: low population density along the route, good road conditions, and limited amount of traffic on the route (Goldfarb 1987).

Some of the major findings of focus group research of communities near candidate routes were that: densely populated areas should be avoided, residents will be upset, political pressure will be initiated, property values will depreciate, and there will be psychological effects. In terms of route selection, it was felt that it should be based on the most efficient route, condition of the roads, amount of traffic and populations densities (Pieroni 1981).

Eight focus groups along a potential transportation route in southern Ontario raised concerns about transportation of used fuel, talked about potential bypasses, and identified information that would assist in reducing concerns: selection, design and test criteria for the cask and vehicle; successful pretesting of cask and vehicle; driver testing and competence checks, truck escort, etc.; route selection and general scheduling information; safety and emergency procedures for normal and accident conditions (Pieroni 1988).

Northern Ontario residents who appeared at the Scoping Hearings were concerned about the safety risks of transporting used fuel on the Trans-Canada Highway in Northwestern Ontario (Dowell 1991).

Aboriginal groups who appeared at the Scoping Hearings commented that if the waste was maintained in storage longer where it is produced, then it would not have to be transported greater distances (Dowell 1991).

e) Emergency Response

During public consultation with interest groups across Canada, the necessity of an emergency response plan in the event of accidents, regardless of the mode of transportation, was raised as an issue (Greber and Anderson 1989).

An Ontario-wide opinion survey indicated that the level of concern with used fuel transportation would be reduced if one route with specialized emergency services was used and/or if local officials were given advance notification of shipments (Decima 1986).

REFERENCES FOR APPENDIX A


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**APPENDIX B**

LEGISLATION, GUIDELINES
AND ENVIRONMENTAL POLICY PRINCIPLES

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# APPENDIX B

# LEGISLATION, GUIDELINES AND ENVIRONMENTAL POLICY PRINCIPLES

This Appendix contains a description of the legislation and other regulatory requirements that are referred to in the supporting analyses to the present assessment. It also describes some of the legislation that would be applicable at the site-specific stage, such as the Ontario Environmental Assessment Act, if a disposal site were located in Ontario. Guiding principles for the establishment of an environmental policy during implementation of the concept are also included in the last section (B.5).

The following sections discuss only some major regulatory requirements applicable to the preclosure phase of the disposal concept. This Appendix is not intended to be an exhaustive listing of legislation or other regulatory requirements. Municipalities, which derive their authority from provincial legislation, may also have relevant requirements. In addition, directives, policies or procedures of the governments or their agencies might have to be considered.

The regulations applicable to transportation are discussed separately under Section B.4.

Although it is recognized that new or amended legislation, regulatory documents, guidelines, and plans may apply in the future when a disposal facility might be built, Ontario Hydro used current requirements to indicate the significance of some of the environmental effects that were estimated in the preclosure assessment. For provincial legislative requirements, only those of Ontario were considered, except in assessing the transportation of used fuel, for which the legislative requirements of Quebec and New Brunswick were also considered.

## B.1 FEDERAL LEGISLATION

In addition to the AECB's specific regulatory policy (R-71) (AECB 1985) for concept assessment in the Canadian NFWMP discussed in Section B.1.1 below, there are three other major pieces of federal legislation that would apply to the preclosure assessment of the disposal concept:

1) the Atomic Energy Control (AEC) Act;
2) the Canadian Environmental Protection Act (CEPA); and
3) the Transportation of Dangerous Goods (TDG) Act.

Other federal legislations that are potentially applicable are also discussed here.

References for each of the following legislations and regulations are included at the end of this appendix.

### B.1.1 Atomic Energy Control Act

The AEC Act (Government of Canada 1985a) applies to all persons and organizations engaged in the production, import, export, transportation, refining, possession, ownership, use or sale of radioactive materials.

The AECB is the federal agency which administers the AEC Act. Regulations promulgated under the AEC Act specify the licensing requirements with respect to ownership and possession of radioactive materials, and operation of nuclear facilities.

1. Regulations for Fixed Facilities

The major regulations covering nuclear facilities under the Atomic Energy Control Act are:

i) the Atomic Energy Control Regulations; and
ii) the Physical Security Regulations.

General amendments to the Atomic Energy Control Regulations (AECB 1991a) have been proposed, and are expected to be implemented in the near future. Many of the changes reflect the consolidation of practices that have evolved during the period since the last extensive revision of the regulations which occurred in 1974. For example, a number of licensing conditions have become standardized, and have been incorporated in the General Amendments. A major feature in the General Amendments is the introduction of a requirement for a site licence, replacing a previous informal process. This allows for environmental review early in the planning process.

Under the General Amendments, before a nuclear facility can be designed, constructed and permitted to operate, the proponent must obtain (in sequential order from the AECB):

i) site approval;
ii) construction approval; and
iii) operating licences.

A decommissioning plan must be in place when applying for the operating license. Before the start of decommissioning the proponent must obtain a decommissioning licence from the AECB.

Some of the main points of the regulations for nuclear facilities under the AEC Act are:

i) Protection of public health and safety should be ensured by controlling the annual radiation dose received by atomic radiation workers and members of the public to limits specified in the Regulations (see Table B-1). These limits are based on recommendations of the International Commission on Radiological Protection (ICRP) which in turn are based on analyses of the data on the Japanese atomic bomb survivors and other epidemiological studies. This data has been recently re-analyzed and the ICRP recommendations on radiation risk revised accordingly (ICRP 1991). The AECB in its consultative document C-122 (AECB 1991a) is proposing reductions in the radiation dose limits based on the revised ICRP recommendations, in accordance with which the dose limit for members of the public will be reduced from 5 mSv per year to 1 mSv per year, and the dose limit for workers from 50 mSv per year to 20 mSv per year.

ii) Appropriate administrative control procedures must be established to ensure that proper operating procedures are followed and all appropriate precautions are taken to protect the safety of plant personnel and members of the public. This includes establishing controls covering a diversity of

TABLE B-1
Maximum Permissible Doses[a] (mSv)

| Organ or Tissue | Atomic Radiation Worker[e] | | Any Other Person[e] |
|---|---|---|---|
| | Per Quarter Year | Per Year | Per Year |
| Whole body, gonads, bone marrow | 30[b] | 50[b] | 5 |
| Bone, skin, thyroid[f] | 150 | 300 | 30[c] |
| Any tissue of hands, forearms, feet and ankles[f] | 380 | 750 | 75 |
| Lungs[d] and other single organs or tissues[f] | 80 | 150 | 15 |

[a] In determining the dose, the contribution from sources of ionizing radiation both inside and outside the body shall be included.

[b] The dose to the abdomen of a pregnant atomic radiation worker after the licensee is informed of the pregnancy of that worker shall not exceed a total of 10 mSv, accumulating at a rate of not more than 0.6 mSv per two weeks.

[c] The dose to the thyroid of a person under the age of sixteen years shall not exceed 15 mSv per year.

[d] For exposures to radon daughters, the maximum permissible exposures (in Working Level Months) apply instead of the maximum permissible doses for the lungs (in mSv).

[e] These limits apply to doses above background.

[f] Revised organ and tissue limits are given in the General Amendments.

Source: (AECB 1986)

maintaining records, maintaining adequate safeguards and as labelling security, posting of appropriate active-area warning signs and labelling containers and vehicles carrying radioactive materials.

The AECB are also responsible for the administration of the Nuclear Liability Act (see Section B1.13), which covers prescription of the mount of insurance to be maintained by the operator of a nuclear facility.

2. Regulation for Mobile Facilities

The major regulation covering mobile facilities is the:

i. Transport Packaging of Radioactive Materials (TPRM) Regulations

The Transport Packaging Regulations (AECB 1991b) are the basis for controlling the packaging, preparation for shipment and receipt of radioactive materials. The AECB advises Transport Canada on the requirements for the carriage of radioactive material specified in the TDG Act (Government of Canada 1985r). The TPRM regulations are based on the International Atomic Energy Agency Regulations (IAEA 1979, revised 1985, amended 1990). The TPRMR regulations allow package designs to be approved under either the existing TPRMR regulations requirements,or the IAEA Regulations, 1985 edition (as amended 1990). The regulations specify design requirements for the transportation package. These are summarized in Table B-2.

**TABLE B-2**
**Summary of AECB Regulatory Design Criteria for Type B(U) Packages**

A. TESTED CONDITIONS (to represent rough handling conditions)

The cask must survive the following tests without loss of containment or shielding (see C):

1. Water Spray Test
The exposed surface of the package is uniformly subjected to a spray equivalent to a rainfall of 50 $mm \bullet h^{1}$ impinging at an angle of 45° over a period of at least one hour. A water spray test must precede each of the following tests.
2. Free Drop Test
The package is dropped onto a flat, essentially unyielding horizontal surface, striking the surface in a manner that results in maximum damage to the package. The height of fall measured from the lowest point of the package to the surface is not less than 0.3 m for a package that weighs in excess of 15 000 kg.
3. Compression Test
The package is subjected for a continuous period of 24 hours to a compressive load equal to the greater of 5 times the weight of the actual package or 1300 $kg \bullet m^{-2}$ multiplied by the maximum horizontal cross-section of the package. The load is applied uniformly against the top and bottom of the package in the position in which the package would normally be transported.
4. Penetration Test
The package is positioned on a flat essentially unyielding horizontal surface. A steel bar of 32 mm diameter with a hemispherical end and weighing 6 kg is dropped from a height of 1 m onto the exposed surface of the package that is the most vulnerable to puncture.

B. ACCIDENT CONDITIONS

The cask must survive the following tests without unacceptable loss of containment or shielding (see C below):

1. Mechanical Test
Two drops in the most damaging orientation onto a target in the order which results in damage leading to maximum damage and subsequent thermal conditions:
- 9 m onto a flat, essentially unyielding horizontal surface
- 1 m onto the top end of a 15 cm diameter steel bar
- edge of top of bar is rounded off to a radius of not more than 6 mm. Bar's length is 20 cm unless longer would produce greater damage.
2. Thermal Test
Thermal conditions following the drops:
- exposure for 30 minutes of the entire package to a thermal radiation environment of 800°C with an emissivity coefficient of 0.9, with no artificial cooling for three hours.
3. Water Immersion
Immersion in water at a depth of 15 m for eight hours (Note that this condition is replaced in the most recent IAEA regulations by immersion at 200 m for one hour).

C. REQUIREMENTS FOR CONTAINMENT AND SHIELDING

The package is required to meet the following limits:

1. Under tested conditions of transport, the activity of radioactive contents lost from the package shall not be greater than $A_2 \times 10^{-6}$ per hour taking into account any non-fixed radioactive material on the external surface of the package ($A_2$ is a level of radioactivity specified for each nuclide).
2. Under accident conditions of transport, the activity of radioactive contents lost from the package shall not be greater than $A_2 \times 10^{-3}$ in a period of seven days; the package should retain sufficient radiation shielding to ensure that the radiation level at 1 m from the surface of the package does not exceed 10 $mSv \bullet h^{1}$.

Source: (AECB 1991b)

The radioactive content of the used fuel requires that it be transported in a type B package. The TPRM regulations allow for two classes of type B packages: type B(U) and type B(M). Type B(U) packages must meet additional requirements over and above those for all type B packages. The used fuel transportation casks (road and rail) are designed to meet the requirements for type B(U) packages. The TPRM regulations specifyfunctions, such as training personnel, the design and testing requirements for type B(U) packages, as well and marking of loaded and empty packages. Chapter 7 presents the regulatory transportation cask design and testing criteria.

3. Regulatory Policy and Guides on High-Level Nuclear Fuel Waste Management

In addition to the AEC Regulations, the AECB issues Regulatory Policy Statements governing requirements on specific types of projects. The management of high-level nuclear fuel waste is the subject of Regulatory Policy Statements R-71 and R-104, and Regulatory Guide R-72 (AECB 1985, 1987b and 1987a). R-71 is specifically applicable to the preclosure phase. The goal of the AECB policy is to ensure that people and the environment are protected during the present and future generations.

Regulatory document R-71 provides some guidance for what documentation is required for an adequate regulatory review. The following statements from R-71 (AECB 1985) were used in developing the Preclosure Assessment methodology:

i) "The exact nature and magnitude of actual site variables and other information necessary for detailed component design will not be available during Concept Assessment. Therefore, the spectrum of potential site variables and their respective ranges likely to be encountered at any specific site proposed for a repository will have been considered during Concept Assessment".

ii) "During Concept Assessment, it is only necessary to examine variables to the level of detail needed to establish confidence in the acceptability of the proposed concept".

iii) "The AECB must be satisfied, within the constraints of a generic study, that deep geological disposal in a pluton can be a safe, adequate and feasible method for long-term management of nuclear fuel waste".

iv) "In the preclosure period, the disposal system must meet applicable regulations regarding:
   a) radiological health and safety;
   b) conventional health and safety:
   c) environmental protection;
   d) safeguards and security; and
   e) transportation of radioactive materials".

v) "The chosen concept must be shown to be technically feasible with available technology or with reasonably achievable developments".

vi) "Annual effective dose equivalents must be estimated. Dose calculations must be made for occupational exposures during the preclosure phase and for members of the public during both the preclosure and postclosure phases. Dose calculations for members of the public must include the identification of reference critical groups, and a thorough consideration of possible release mechanisms and of subsequent transfer of radionuclides through the environment".

vii) "The significance of inadvertent human intrusion into the repository during the postclosure period must be addressed. Selection of a repository host rock that does not contain commercial grade minerals and that is generally common to the region will reduce, but not eliminate the probability of human intrusion".

viii) "The Concept Assessment Document must properly address both the short-term and long-term aspects of the environmental impacts resulting from the disposal of nuclear fuel waste, recognizing that the impacts will be different in the preclosure and postclosure phases, and that mitigative action, if necessary, would still be possible in the preclosure phase".

ix) "Socio-economic impacts resulting from a deep geological disposal facility for nuclear fuel waste must be addressed. Factors that should be addressed are:

a) public perception of the risk associated with radioactive waste disposal;
b) the availability of natural resources and capital;
c) transportation;
d) the availability of persons with the necessary skills required for each step in the life of the facility;
e) secondary job creation;
f) additional community services needed; and
g) impact on property value".

The regulatory policy presented in R-104 (AECB 1987b) has also been applied to the assessment. In general, R-104 specifies that:

i) no adverse impacts on humans or the environment should result from used nuclear fuel disposal;
ii) the regulations and criteria of the AECB must be met; and
iii) no responsibility should be imposed on future generations for the maintenance of the disposal site (AECB 1985b).

### B.1.2 Canadian Environmental Protection Act

The Canadian Environmental Protection Act (CEPA) was promulgated on June 30, 1988. It consolidates the environmental protection powers of the Clear Air Act, the Environmental Contaminants Act, the Canada Water Act, Part III of the Ocean Dumping Control Act, and the Department of Environment Act, Subsection 6(2). Environmental protection provided by the various legislations being consolidated are being continued under the CEPA. The core of the legislation controls and regulates toxic substances through their full life cycle, from research and development, to production, to use in the marketplace, through to final disposal as waste.

The Canadian Environmental Protection Act (Government of Canada 1985f) would, therefore, apply to all stages of the disposal facility life cycle.

Under this legislation, a toxic substance is defined as a substance that if it enters the environment in a given quantity or concentration or under given conditions:

a) has or may have an immediate or long-term harmful effect on the environment;
b) constitutes or may constitute a danger to the environment on which human life depends; or
c) constitutes or may constitute a danger in Canada to human life or health.

A List of Toxic Substances is maintained under the Act. Regulations may be made with respect to substances included in the List to control, among other things, processing methods and quantities, and quantities that may be released into the environment.

The CEPA also provides for control of dumping in oceans and inland waters.

### B.1.3 Transportation of Dangerous Goods (TDG) Act

The TDG regulations, promulgated under the TDG Act, specify the responsibilities of:

i) the sender with respect to preparation for transport, documentation and notification;
ii) the carrier with respect to documentation, handling of the used fuel shipment, and reporting of dangerous occurrences; and
iii) the receiver with respect to documentation.

The regulations also specify training and registration requirements for all personnel involved in used fuel transportation and require preparation and submission of an emergency response plan for used fuel transportation.

The TDG Regulations refer to the AECB Transport Packaging of Radioactive Materials Regulations for packaging of radioactive materials.

### B.1.4 Canada Shipping Act

This Act (Government of Canada 1985c) would apply to the water mode of transportation of used fuel. All hazardous material discharges from a ship in Canadian waters must be reported. The Governor in Council may impound damaged and polluting vessels as well as their cargo. The regulations under the Shipping Act cover methods of transport, storage, maximum quantities, types of cargo, instrumentation (of the equipment on board a ship), personnel (number and level of expertise), practices, loading procedures, equipment maintenance, air pollution, traffic noises, etc. (see Section B.4 for details).

### B.1.5 Canada Water Act

This Act (Government of Canada 1985d) may be applicable at the site-specific stage. Under this Act, any waters may be designated as water quality management areas through a federal-provincial agreement, and an agency or corporation set up to manage it. No deposition of waste in any form is allowed into a water quality management area or in such a manner that it may eventually enter such an area.

### B.1.6 National Parks Act

This Act (Government of Canada 1985e) covers the use of lands designated as national parks and regulates the activities allowed within the boundaries of the parks. It would prevent siting of a UFDC in a National Park, and impose restrictions on transportation of used fuel across a National Park.

(1) General Regulations

No tree removal is permitted without the written permission of the Superintendent. Approval is required before the removal of any rock, mineral or fossil will be permitted. No pollution or use of any waterbody will be permitted except as authorized by the Director.

With regard to explosives, the regulations prohibit the possession, storage, use, manufacture or selling of these within the park except if a permit has been issued by the Superintendent or if these materials are being transported through the park in accordance with the Railway or Explosives Act.

(2) National Parks Building Regulations

A permit is necessary when constructing a building within a national park.

(3) National Parks Businesses Regulations

Licences are required and the businesses must be only those described in the regulations.

(4) National Parks Highway Traffic Regulations

No vehicles are permitted off the roadways except by special permission. Load limits can be established on all roads.

(5) National Parks Lease and Licence of Occupation Regulations

Leases may be obtained for up to 42 years for residential and affiliated use within a national park.

### B.1.7 Canada Wildlife Act

This Act (Government of Ontario 1985e) may apply at the site-specific stage. Any lands acquired for the purposes of the above Act cannot be used except for the provisions outlined by the regulations. Any land can be acquired at any time for the purpose of preserving the habitat or otherwise protecting wildlife or migratory birds.

Within any area protected by the Act, none of the following activities may take place unless it can be shown to the Minister that it will not interfere with wildlife conservation:

(1) removal or damage to vegetation;
(2) commercial or industrial activities;
(3) disturbance of soil, sand, gravel or other material; and
(4) dumping or depositing of any substance.

B.1.8 Fisheries Act

This Act (Government of Canada 1985i) may apply at the site-specific stage. Under this Act, no destruction of fish is allowed other than by fishing. No one shall allow the introduction of a fish destroying

TABLE B-3
Monthly Mean Concentrations of Deleterious Substances

| SUBSTANCE | MONTHLY MEAN CONCENTRATION |
|---|---|
| Arsenic | 0.5 $mg \cdot L^{-1}$ |
| Copper | 0.3 $mg \cdot L^{-1}$ |
| Lead | 0.2 $mg \cdot L^{-1}$ |
| Nickel | 0.5 $mg \cdot L^{-1}$ |
| Zinc | 0.5 $mg \cdot L^{-1}$ |
| Total Suspended Matter | 25.0 $mg \cdot L^{-1}$ |
| Radium 226 | 10.0 $pCi \cdot L^{-1}$ |

substance into a body of water inhabited by fish or a body of water leading into one in which fish inhabits except as provided for within the regulations. Spills of any deleterious substances into fish inhabited waterbodies must be reported to the Federal Ministry of the Environment. These include spills on land which may be washed into a watercourse containing fish. Spills which occur aboard ships are to be reported to the Canadian Coast Guard. Anyone responsible for the spill is also responsible for the cleanup. Under the Fisheries Act, the substances that are considered deleterious, and their concentrations, are shown in Table B-3.

B.1.9 Migratory Birds Convention Act

This Act (Government of Canada 1985j) may apply at the site-specific stage. It protects all migratory birds which inhabit Canada during any part of the year. The regulations under the Act specify that no one shall deposit any harmful substances into waters or habitat of any migratory birds except as prescribed. Permits are required to hunt, disturb or destroy nests, or be in the possession of a bird carcass, nest or egg within the bounds of a sanctuary.

B.1.10 Navigable Waters Protection Act

The Navigable Waters Protection Act (Government of Canada 1985m) is a federal statute designed to protect the public right of navigation in navigable waters by prohibiting the building or placement of any "work" in, upon, over, under, through, or across, navigable water without the approval of the Minister of Transport. The Act is administered by the Canadian Coast Guard organization of Transport Canada. Navigable waters include any body of water capable, in its natural state, of being navigated by floating vessels for the purpose of transportation, recreation or commerce. The authority to determine the navigability of waterways rests with the Minister of Transport. This act could have implications for the construction of the water supply system tothe UFDC, for the construction of an access road or railway if it crosses a navigable waterway and for the construction of the transfer facility for the water mode of used fuel transportation.

### B.1.11 Canada Labour Code

Industries or undertakings that are interprovincial, national or international in scope are under federal authority. This Act (Government of Canada 1985b) provides for employment standards, human rights, trade unions, collective bargaining, occupational health and safety and unemployment insurance. The Act is under the jurisdiction of the Labour Canada.

### B.1.12 Nuclear Liability Act

Any "nuclear damages" arising from the transport of used fuel or from operation of the UFDC is subjected to the Nuclear Liabilities Act (Government of Canada 1985n). This Act is under the jurisdiction of the AECB. It establishes that the licensed operator of a nuclear facility shall bear absolute liability for damages arising from any "nuclear incident" involving radioactive materials owned by the operator, except those resulting from war or unlawful acts. The Act also establishes a monetary limit to the liability.

### B.1.13 Canadian Environmental Assessment Act

This legislation (Government of Canada 1992) establishes a framework for the environmental assessment process for projects requiring a federal decision or approval. It would, therefore, be applicable in an eventual implementation of the concept.

A project within the scope of this legislation must be either screened by the responsible authority, or it may automatically undergo a comprehensive study. In either case, when it is uncertain whether significant adverse environmental effects will occur, or when there is sufficient public concern, the project may be referred to the Minister of the Environment and subsequently undergo a panel review or mediation.

### B.1.14 Examples of Federal Permits, Licences and Approvals for the UFDC and Transportation Systems

The federal environmental permits, licences and approvals that would typically be required at the site-specific stage were reviewed. They are listed in Table B-4.

### B.1.15 Water Quality Guidelines

Water quality guidelines and objectives are used by Canadian provincial, territorial and federal agencies in their efforts to assess water quality and to manage competing uses of water resources. Canadian Water Quality Guidelines for inland waters were prepared by the Canadian Council of Resource and Environment Ministers, based on a review of the Canadian provincial, territorial and federal agencies, and other sources (adapted to Canadian conditions where necessary) (Environment Canada 1987b). Application of these guidelines to the disposal facility life-cycle activities would be required at the site-specific stage.

These guidelines contain recommendations for chemical, physical, radiological and biological parameters necessary to protect the quality of water for the following uses:

TABLE B-4

Typical Federal Environmental Permits, Licences, and Approvals Required in a Site-Specific Case

| Government Department/Permit | Statute[1] |
|---|---|
| AECB | |
| • Licence for site, construction operation and decommissioning | Atomic Energy Control Act |
| • Design certificate for used fuel transportation cask | |
| FEARO | |
| • Approval to dredge the access channel to the Transfer Facility | Canadian Environmental Assessment Act (Government of Canada 1992) |
| Fisheries and Oceans | |
| • Approval to dredge | Fisheries Act |
| Department of Transport | |
| • Licence to dredge and pump for shoreline excavation and construction | Navigable Water Protection Act |
| • Approval to dredge and construct intake and discharge channels | Navigable Water Protection Act |
| • Approval of shoreline construction if basin is to be emptied for navigational safety | Navigable Water Protection Act |
| • Registration of dangerous goods shipments | Transportation of Dangerous Goods Act |
| Environment Canada | |
| • Discharge of substances deleterious to fish, or removal of fish habitat | Canada Fisheries Act |
| Department of Energy Mines and Resources | |
| • Upon request, provide information regarding any shoreline alteration | Resources and Technical Surveys Act<br>Canadian Land Surveys Act |
| • Licence for temporary storage of explosives on site | Explosives Act |

[1] These acts can be found in the Statutes of Canada, 1985.

i) raw water for drinking water supply;
ii) recreational water quality and aesthetics;
iii) freshwater aquatic life;
iv) agriculture uses; and
v) industrial water supplies.These guidelines are revised on a routine basis. The federal government is committed to the introduction of a Safe Drinking Water Act. Under this Act, it is likely that there will be regulations for drinking waterquality at federal facilities and crown corporations. This could affect the UFDC operation. The guidelines for Canadian Drinking Water Quality are included in and Grondin and Fearn-Duffy (1993).

B.1.16 Environment Canada Codes of Practice

The Environment Codes of Practice for Steam Electric Power Generation consist of a series of documents which will identify (when completed) good environmental protection practices for various phases of a steam electric power project. Although the UFDC does not fall under this category, the codes of practice are relevant and can still be used as guidelines for the present assessment. They would help achieve a high degree of environmental protection at the concept implementation stage.

These codes of practice, being prepared under the auspices of Environment Canada, in consultation with a federal-provincial-industry task force, have no legal status. They are an expression of environmental concernsand environmental protection opportunities for new or modified steam electric plants. They cover the siting, design, construction, operationand decommissioning phase of a project (the operation and decommissioning phase codes are still under development). The contents of each code are outlined below:

i) The Siting Phase Code (Environment Canada 1987b) consists of a series of criteria related to land use, terrestrial ecology, surface water and groundwater, aquatic ecology and the atmospheric environment. These criteria would minimize the detrimental environmental effects of: once-through cooling water systems; wastewaters discharged to surface waters and groundwaters; solid waste disposal sites; and atmospheric emissions. These criteria are developed in three stages beginning with general screening or avoidance criteria in Phase I and ending with very detailed selection criteria for the site in Phase III. A list of the Phase I avoidance criteria is contained in Table B-5.

ii) The Design Phase Code (Environment Canada 1985) reviews the environmental concerns associated with water related and solid waste activities. Design recommendations are presented that will minimize the detrimental environmental effects of once-through cooling water systems, of wastewaters discharged to surface waters and groundwaters, and of solid waste disposal sites. Recommendations are also presented for the design of water-related monitoring systems and programs.

iii) The Construction Phase Code (Environment Canada 1989) reviews the environmental concerns associated with construction activities at stations. Practices are recommended for the protection of terrestrial and aquatic life, the preservation of archaeological and historical resources, erosion and siltation control, control of wastewater discharges and spills, management of solid wastes, control of air pollution and noise, and for environmental auditing, monitoring and

TABLE B-5
Siting Code of Practice - Environmental Criteria

| ENVIRONMENTAL AREA | RECOMMENDATION |
|---|---|
| LAND USE | |
| Agricultural Lands | As much as possible, avoid areas which have prime agricultural capability on a regional scale |
| Forest Lands | As much as possible, avoid areas within or adjacent to blocks of intensively managed forest lands |
| Recreational Lands | As much as possible avoid areas adjacent to relatively large designated or formally proposed federal, provincial or regional parks |
| TERRESTRIAL ECOLOGY | |
| Dedicated Ecological Lands | As much as possible, avoid all federal, provincial and regional lands dedicated to the protection of flora, fauna and unique natural, historical and archaeological features |
| Wetlands | As much as possible, avoid all large wetlands or wetlands in southern Canada |
| Rare or Endangered Species and Critical Wildlife Habitat | As much as possible,<br>- avoid all known concentration areas of rare and endangered floral and faunal species, and provide a buffer one appropriate to the sensitivity of the individual species;<br>- avoid rare and endangered species habitat, other critical wildlife habitat including wildlife corridors, critical nesting areas and winter ungulate concentration areas and provide a buffer zone appropriate to the sensitivity of the species |
| SURFACE WATER AND GROUNDWATER | |
| Surface Water | As much as possible,<br>- avoid areas along shallow lakes<br>- avoid areas adjacent to broken shorelines or coastlines<br>- avoid areas along small lakes or small closed bays |
| Groundwater | As much as possible,<br>- avoid areas of highly fractured bedrock<br>- avoid areas of thick, highly permeable sands and gravels<br>- avoid areas of major recharge which are upgradient to major groundwater users |
| AQUATIC ECOLOGY | |
| Major Fisheries and Spawning Grounds | As much as possible, avoid areas near a major fishery or spawning ground |
| Unique Sensitive Aquatic Species | As much as possible,<br>- avoid all areas from the portion of water body containing known concentrations of unique or sensitive species<br>- avoid areas adjacent to anadromous salmon streams |
| ATMOSPHERIC ENVIRONMENT | |
| Officially Designated Areas and International Boundaries | As much as possible, avoid areas close to the boundary of preserved national, provincial or other designated parklands or dedicated and international borders. |
| Poor Air Quality Area | As much as possible, avoid areas where existing air quality is near or exceeds national or provincial air quality objectives, criteria and/or regulations |
| Urban Population Centres | As much as possible, avoid locating near large urban centres |
| Unfavourable Topographic Areas | As much as possible, avoid areas with poor atmospheric dispersion characteristics due to the influence of terrain features |

Source: Environment Canada (1987a)

reporting. These practices are intended to mitigate or eliminate adverse environmental effects due to construction or modification of steam electric power stations.

iv) The Operation Phase Code (Government Canada 1992a) identifies the major environmental issues and practices associated with the operation of stations. It also identifies sound environmental practices related to operations.

v) The Decommissioning Phase Code (Enviornment Canada 1992b) identifies environmental concerns associated with non-operating stations and propose environmentally appropriate decommissioning measures.

## B.2 PROVINCIAL LEGISLATION

Since the preclosure assessment assumes that the disposal facility would be located in the Ontario portion of the Canadian Shield, the applicable legislation in the province of Ontario were reviewed. The two major pieces of Ontario legislation that would apply to the preclosure phase of the Disposal Concept are the Environment Protection Act (EP Act) and the Occupational Health and Safety Act. Other potentially applicable environmental legislation and regulations are also discussed. Applicable Quebec and New Brunswick legislation pertaining to transportation are also briefly described.

### B.2.1 Dangerous Goods Transportation Act

This Act (Government of Ontario 1990f) would apply to the transportation of used fuel to the disposal facility. Ontario's complementary Dangerous Goods Transportation Act adopted the regulations under the Federal Transportation of Dangerous Goods Act for application in Ontario. As for the federal TDG regulations, the Ontario regulations acknowledge the authority of the AECB regulations for the transportation of radioactive materials.

The provincial statute is not as broad in scope as the federal legislation. While the federal legislation applies to those who "handles, offer for transport or transport any dangerous goods", the Ontario legislation applies solely to the transportation of dangerous goods, and then only "in a vehicle on a highway". By virtue of provincial regulation O. Reg. 460/89, the federal Regulations under the Transportation of Dangerous Goods Act have been substantially adopted (e.g., it is a provincial offence to transport dangerous goods on a highway unless there is compliance with the federal regulations).

### B.2.2 Ontario Water Resources Act

This Act (Government of Ontario 1990t) has implications on water quality, wells, water and sewage works. It prohibits pollutant discharge into a water body and requires notification of inadvertent pollutant release. It regulates water intake from a water body (i.e. it requires a permit for water withdrawal of more than 50 000 L/day and protects defined water supply areas. The water quality guidelines for Ontario are included in Grondin and Fearn-Duffy (1993).

The Act would apply to all stages of the disposal facility life-cycle. It provides guidelines and criteria for water quality management in Ontario. The provincial water quality objectives established under the Act are:

1) a limit of 25% on the decrease in the alkalinity in a discharge (pH maintained within 6.5 - 8.5);
2) un-ionized ammonia concentrations of less than 0.02 $mg \cdot L^{-1}$ for the protection of aquatic life;
3) a total residual chlorine of less than 0.02 $mg \cdot L^{-1}$;
4) free cyanide of less than 0.005 $mg \cdot L^{-1}$;
5) dissolved gases of less than 110% of saturation values;
6) dissolved oxygen, never less than 54% saturation (57% at 20°C, 63% at 25°C) for cold water biota, 47% (48% at 25°C) for warm water biota;
7) undissolved hydrogen sulphide concentrations of less than 0.002 $mg \cdot L^{-1}$;
8) oil and grease should not be detectable by taste, odour or visibility;
9) concentrations of phenols of less than 1 $\mu g \cdot L^{-1}$;
10) total phosphorous less than 10 $\mu g \cdot L^{-1}$ in lakes and 30 $\mu g \cdot L^{-1}$ in streams;
11) thermal discharge should never exceed 10°C increase in temperature over the normal background ambient temperature at the edge of a mixing zone (or a maximum temperature at any time of 30°C); and
12) suspended solids should not change the Secchi disk reading by greater than 10%.

For other toxic substances, the Priority Pollutant list, issued as part of MISA, applies.

### B.2.3 Ontario Environmental Protection Act

This Act (Government of Ontario 1990j) is administered by the Ministry of Environment and Energy (MOEE) of Ontario. It would apply to all stages of the disposal facility life-cycle. The criteria under the Act are based on human health effects and/or potential environmental and property damage.

Regulations under the Act must be adhered to by anyone involved in any activity which may potentially result in emissions to the environment.

1. Regulation 347 (Waste Management)

Regulation 347 (formerly Regulation 309) under the EP Act requires that all hazardous waste storage and disposal sites be approved by MOEE. Used fuel bundles are classified as hazardous waste under this regulation (Government of Ontario 1990e).

2. Regulation 346 (Air Quality)

This regulation (Government of Ontario 1990k) specifies that no person shall allow or cause the emission of any air pollutant which may damage the environment or cause discomfort to anyone or loss of enjoyment of the environment. This includes improper storage of material leading to a release of a contaminant. Schedule 1 of the Regulation contains a list of the maximum concentrations of air contaminants at point of impingement. New soures are subject to control by this regulation and Certificates of Approval must be obtained from the MOEE.

## 3. Model Municipal Noise Control By-Law

Sound and vibration have been defined as contaminants under the EP Act. A Model Municipal Noise Control By-Law (MOE 1978) was produced to facilitate noise control. It was made available to municipalities in Ontario, with sufficient legal authority under the EP Act for them to adopt it. It establishes limits on equivalent noise levels for various equipment and land uses, as shown in Table B-6 and B-7 respectively.

TABLE B-6
Sound Level Limit
on Various Equipment

| Source | Limit |
|---|---|
| Portable Air Compressors | 70 dB(A) in a quiet zone<br>76 dB(A) in a residential zone |
| Tracked Drills | 100 dB(A) in a quiet or residential zone |
| Heavy Diesel Vehicles | 95 dB(A) |
| **Receptor Point** | **Limit ($L_{eq}$)** |
| Indoors | 40 to 50 dB(A) depending on the type of space and hours of day |
| Outdoor Recreational Area | 55 dB(A) (day)<br>50 dB(A) (night) |

TABLE B-7

## Noise Levels Guidelines in the Ontario Model Municipal Noise Control By-Law

| SOURCE | LIMIT |
|---|---|
| Equivalent sound levels below that limit are excluded from the by-law | 40 dB(A) |
| Quiet zone and residential area sound emission standards for excavation equipment, dozers, loaders, backhoes or other equipment capable of being used for similar application | Equipment's power rating < 75 kW: 83 dB(A)<br>Equipment's power rating > 75 kW: 85 dB(A) |
| Sound emissions standards for portable air compressors | For quiet zone: 70 dB(A)<br>For residential area: 76 dB(A) |
| Sound emission standards for heavy vehicles with diesel engines | 95 dB(A) |
| Indoor Sound Level Limits<br>- bedrooms, sleeping quarter, hospitals etc., 23h00 to 7h00<br>- living rooms, hotels, motels etc., 7h00 to 23h00<br>- individual or semi-private office, small conference rooms, classrooms, etc., 7h00 to 23h00<br>- general office, reception areas, retail shops and stores, 7h00 to 23h00 | Equivalent Sound Level ($L_{eq}$)<br>40 dB(A)<br>45 dB(A)<br>45 dB(A)<br>50 dB(A) |
| Sound Level Limits for Outdoor Recreational Areas 7h00 to 23h00 | $L_{50}$ 52 dB(A)<br>$L_{eq}$ 55 dB(A) |
| Sound Level Limits for Outdoor Areas 23h00 to 7h00 | $L_{50}$ 47 dB(A)<br>$L_{eq}$ 50 dB(A) |
| In a rural area, within 30 m of a dwelling or a camping area,<br>- in any hour, the equivalent sound level ($L_{eq}$) of a stationary source<br>- in any hour, the ninetieth percentile sound level ($L_{90}$) of a stationary source<br>- the impulse sound level from a stationary source which is not a planned blasting operation in a mine, quarry or construction | - should not exceed the ninetieth percentile sound level ($L_{90}$) of the natural environment by more than 10 dB<br>- should not exceed the ninetieth percentile sound level ($L_{90}$) of the natural environment by more than 5 dB<br>- should not exceed 100 dBAI |

4. Model Sewer Use By-Law

The provincial government issued this model by-law (MOE 1988) to provide a uniform basis to regulating sanitary, combined and storm sewers across Ontario. This by-law is a temporary measure, as it is anticipated that in the near future such discharges will be included within the indirect discharges component of the MISA program. The allowable concentrations for discharges to sanitary and combined sewers, and to storm sewers are included in Grondin and Fearn-Duffy (1993). This by-law expressly prohibits dilution to achieve those limits.

5. Effluent Monitoring: General (Regulation 695/88)

This regulation provides general information on parameters to be monitored in industrial effluents and methods of monitoring. It is the first regulation developed under Ontario's Municipal/Industrial Strategy for Abatement Program (MISA), and was established to develop regulations for management and abatement of industrial effluents. Further regulations developed under MISA and registered under the Act will provide criteria, specific for each industrial sector, on concentration and amounts of toxic materials in the effluents.

MISA is based on the following three main principles:

i) zero discharge of persistent, toxic substances;
ii) pollution and prevention; and
iii) multi-media (water, air and land) approach to environmental management.

MISA's goal for virtual elimination of persistent toxic contaminants from discharges to Ontario's waterways would be achieved by applying pollution prevention strategies (MOE 1991). These strategies include:

i) zero discharge of specific, water-based persistent toxic substances;
ii) reduction of persistent toxic substances which are not slated for zero discharge (and which do not have effluent limits);
iii) effluent limits for a list of sector-specific parameters; and
iv) no acute concentrations of toxic substances (short-term) in effluents.

6. Spill Legislation

Part X of the EP Act (Government of Ontario 1990j) states that, if a spill of hazardous material occurs, the Ministry of Environment and Energy, the municipal regulatory body, the owner of the property and the person in charge of the pollutant must be informed. The owner of the pollutant has the responsibility (financially and otherwise) to cleanup the spill and restore the environment as much as possible to its former state.

B.2.4 Waste Management Act

The Waste Management Act (Government of Ontario 1992) came into effect in April 1992. It has two main thrusts: province-wide and Greater-Toronto. The province-wide provisions involve amendments to the Environmental Protection Act to broaden government's power to reduce waste at the source by:

1) regulating packaging and products;
2) requiring waste audits and work plans for waste reduction by companies, municipalities, institutions, and other generators of waste;
3) extending the 3Rs (reduce, reuse and recycle) program; and
4) making approvals easier for 3Rs facilities such as recycling depots, municipal composting depots and material recovery facilities.

This legislation would come into play to reduce waste during all stages of the preclosure phase.

B.2.5 Occupational Health and Safety Act

This Act (Government of Ontario 1990r) covers occupational safety throughout each stage of a project. Specific regulations have been issued for various industrial sectors because of the different hazards faced by workers in these industries. Among regulations under the Act, the following are expected to have a wide application in the preclosure phase:

1) Regulations for Mines and Mining Plants (expected to apply to the UFDC underground vault construction and operation);
2) Regulations for Industrial Establishments (expected to apply to the UFDC surface facilities operation);
3) Regulations for Construction Projects (expected to apply to the UFDC construction);
4) Regulation Respecting Silica (expected to apply to the UFDC underground facilities);
5) Workplace Hazardous Materials Information System - under this regulation, the employer has a general duty to have available to the workers current material safety data sheets ($MSDS_s$) for hazardous materials in the workplace. Specific workers training and labelling requirements are also part of the regulations.

B.2.6 Endangered Species Act

This Act (Government of Ontario 1990h) may apply at the site-specific stage depending on the location. Any flora or fauna may be added to the list of any time if it is threatened with extinction. If any species appears on the list, no person shall in any way further endanger the species either through direct destruction or through habitat destruction.

B.2.7 Ontario Environmental Assessment Act

Assuming that the disposal site would be located in the Ontario portion of the Canadian Shield, application of the Ontario Environmental Assessment (EA) Act (Government of Ontario 1990i) would likely be required at the implementation stage (major plans and projects undertaken by the Ontario Government and/or crown corporations are subject to the EA Act and review process). The Act emphasizes early identification and evaluation of potential environmental effects. To satisfy the requirements under the Act, the implementation stage environmental assessment would need to include:

a) a description of the purpose and need (rationale) for the undertaking;
b) a description of alternatives to the undertaking and alternative methods of carrying out the undertaking, sufficient to justify the proposed undertaking;
c) a description of the proposed undertaking in sufficient detail to permit a thorough analysis and assessment of its environmental impact, including its energy and resource requirements;
d) a description of the environment which may be affected, directly or indirectly; by definition, "environment" includes humans and the social, economic and cultural conditions which influence the life of humans or a community, in addition to the natural or physical aspects such as ecology, air, water, land, mineral resources etc.;
e) an account of environmental and occupational health effects which may reasonably be expected to result from the undertaking, including an assessment of their significance;
f) an indication of any tendency of the undertaking to encourage industrialization, commercialization, urbanization, population change, economic change and related kinds of growth;
g) a description of measures available to avoid, minimize, mitigate or remedy the effects on the environment;
h) an account of any irreversible or irretrievable commitments of energy or resources which would likely result from the undertaking, including an assessment of the extent to which this may curtail the range of beneficial uses of the environment;
i) an assessment of the overall environmental advantages and disadvantages (including benefits and costs) of the proposed undertaking, sufficient to conclude that no unacceptable effects or risks will result to humans or their environment.

More detailed requirements are defined in Guidelines for Preparing Environmental Assessments issued by the Ontario Ministry of Environment and Energy, the Ministry of Transportation and other Ontario Ministries.

### B.2.8 Ontario Consolidated Hearings Act

The Consolidated Hearings Act (CHA) (Government of Ontario 1990d) provides the proponent with the option to have only one hearing for a number of specific Acts. A committee is formed, comprised of members from the individual review boards of the Acts which apply to the undertaking. It is still possible that this committee could refer any part of the undertaking to the individual review board to which it applies. The Acts that may be heard under the CHA include: Environmental Assessment Act, Environmental Protection Act, Expropriation Act, Ontario Municipal Board Act, Ontario Water Resources Act, Parkway Belt Planning and Development Act, and Planning Act. This Act could apply if the disposal facility site is in Ontario.

### B.2.9 Ontario Planning Act

This Act (Government of Ontario 1990v) could apply if the disposal facility site is in Ontario. The Ontario Planning Act establishes the land use planning rules, and how those land uses should be controlled by using Official Plans and zoning by-laws. Official plans are used as general objectives of the municipality and zoning by-laws manage land uses on a day to day basis. It considers the management of the following areas: protected lands, natural resources, subdivision of land, minor variances of land use, land severance and agricultural land. If the zoned land use of the site location is not for a disposal centre, then an application must be prepared to have the Official Plan and/or the zoning by-law amended by the municipal board. This only applies at the site-specific stage. Appeals of the municipal decision may be heard by the Ontario Municipal Board.

### B.2.10 Ontario Emergency Plans Act

Under this Act (Government of Ontario 1990g), each ministry of the government of Ontario (and branch or agency, board, commission etc.) must develop a relevant plan that is operational in the event of an emergency. It also gives the municipalities the power to adopt an emergency plan by-law.

### B.2.11 Ontario Labour Relations Act

The establishment of this Act (Government of Ontario 1990p) is to provide, in the public interest, for harmonious relations between employers and employees. This should be done by encouraging the practice and procedure of collective bargaining between employers and trade unions as the freely designated representatives of the employees. It pertains to such matters as membership, the establishment of bargaining rights by certification, negotiations of collective agreements, contents of such agreements, operations of these agreements, termination of rights, and unfair practices amongst others.

### B.2.12 Ontario Crown Timber Act

The purpose of this Act (Government of Ontario 1990c) is to provide for the management of timber on crown lands. It covers such aspects as the granting of licences to cut crown timber, the sale of crown timber, liens for crown charges, forest management practices and management plans, the licensing of mills, and penalties. It is administered by the Ministry of Natural Resources.

### B.2.13 Ontario Public Lands Act

The function of this Act (Government of Ontario 1990x) is to allow the Minister of Natural Resources to be in charge of the management, sale, and disposition of the public lands and forests. It covers such aspects as the administration of the Act, the exercise of powers, grants, sales and licences of occupation, the granting of easements, the establishment of roads on public lands, and the construction of dams.

### B.2.14 Ontario Forest Fires Prevention Act

Administered by the Ministry of Natural Resources, this Act (Government of Ontario 1990m) provides for the control and extinguishing of fires in fire regions only and covers such aspects as administration, right of entry, appointments of fire wardens, fire permits, the establishment of restricted zones, work permits, and conditions thereof, prevention measures, offenses and penalties.

### B.2.15 Ontario Heritage Act

The purpose of this Act (Government of Ontario 1990s) is to provide for the policies, priorities and programs, for the conservation, protection and preservation of the heritage of Ontario. It covers such aspects as the administration of the Ontario Heritage Foundation, the Conservation Review Board, the Conservation of Buildings of Historic Value or Architectural Value, the Heritage Conservation Districts, and the conservation of Resources of Archaeological Value.

### B.2.16 Ontario Aggregate Resources Act

The purposes of this Act (Government of Ontario 1990a) are to provide for the management of the aggregate resources of Ontario, to control aggregate operations on both crown and private land, to require the rehabilitation of land after extraction, and to minimize the environmental impacts from such operations. The Ministry of Natural Resources is responsible for its administration.

### B.2.17 Ontario Pesticides Act

This Act (Government of Ontario 1990u) deals with issues relating to pesticides and the control of persons discharging pesticides into the environment in order to ensure that pesticides are handled in an approved manner. It is administered by the Ministry of Environment and Energy.

### B.2.18 Ontario Gasoline Handling Act

This Act (Government of Ontario 1990n) applies to the handling of gasoline and associated products, the containers in which it is transported and the storage both above and below ground. It also applies to vehicles, dispensing pumps and transfer facilities, as well as equipment and maintenance. The products it applies to include leaded and unleaded automotive gasoline, diesel fuel, kerosene, lighting naphtha, and dry cleaning solvent. It is administered by the Ministry of Consumer and Commercial Relations.

### B.2.19 Ontario Lakes and Rivers Improvement Act

The purpose of this Act (Government of Ontario 1990q) is to provide for the use of waters of the lakes and rivers of Ontario and to regulate improvements in them. This Act also provides for such matters as preservation of public rights, the protection of interest of riparian owners, the use and management of fish, wildlife and other natural resources on such waters and the preservation of natural amenities on the banks.

### B.2.20 Ontario Conservation Authorities Act

The purpose of this Act (Government of Ontario 1990c) is to provide a mechanism for establishing an authority for a watershed that lies in two or more municipalities. The Act also pertains to the administration of a conservation authority in such matters as members.

### B.2.21 Typical Ontario Environmental Permits

Table B-8 presents a list of the environmental permits, licences and approvals that would likely be required during implementation.

TABLE B-8

Typical Ontario Environmental Permits, Licences, and Approvals Required in a Site-Specific Case

| Permit | Statute |
|---|---|
| MINISTRY OF ENVIRONMENT AND ENERGY | |
| • approval to proceed with an undertaking or exemption from the Act | Environmental Assessment Act |
| • Certificate of Approval - Waste Disposal, for domestic and construction garbage disposal | Environmental Protection (EP) Act |
| • Certificate of Approval - Waste Disposal, for dredge soil and soil disposal | EP Act |
| • Certificate of Approval - Sewage, for construction of construction camp sewage | EP Act |
| • Certificate of Approval - Sewage, for the concrete wash areas for trucks | EP Act |
| • Certificate of Approval - Air for diesel generator operation during construction | EP Act |
| • Approval for potential sources of noise and vibrations | EP Act |
| • Approval for open fire burning | EP Act |
| • Certificate of Approval - Water, for liquid effluent from the facility operation | EP Act |
| • Certificate of Approval - Air, for operational airborne emissions | EP Act |
| • Permit for any larviciding and fogging operation | Pesticides Act |
| • Certificate of Approval - Water Works, for construction of the domestic water system and fire water system for construction camp and disposal facility | Ontario Water Resources Act |
| MINISTRY OF NATURAL RESOURCES | |
| • Operational licence to maintain, close and rehabilitate gravel pits | Aggregate Resources Act |
| • A Quarry permit for impervious material borrow area excavation | Aggregate Resources Act |
| • Licence for taking of earth, gravel and stone from the bed, bank, beach, shore, or water of any lake, river or stream | Aggregate Resources Act |
| • Licence or permission to place or dump fill at any designated location within a particular Conservation Authority area | Conservation Authority Act |
| • A Licence to cut wood on Crown Land, including access ways clearing | Crown Timber Act |
| • Permit for open fire | Forest Fire Prevention Act |
| • Approval for channel improvements and erosion control works | Lakes and Rivers Improvement Act |
| • Patent for water lots | Public Lands Act |
| MINISTRY OF CONSUMER AND COMMERCIAL RELATIONS | |
| • Approval to install and operate equipment for handling, transporting and storing gasoline or associated products | Gasoline Handling Act |
| MINISTRY OF CITIZENSHIP AND CULTURE | |
| • Permit for excavation or alteration of archaeological and historical sites | Ontario Heritage Act |

## B.2.22 Ontario Policies and Guidelines

The following Ontario policies and guidelines may come into play at the site-specific stage:

### Ontario Wetland Policy

In 1992, the province of Ontario issued a policy statement on planning for the protection of wetlands (Government of Ontario 1992a). The policy statement applies to "Provincially Significant Wetlands" as defined by the Ministry of Natural Resources.

This policy statement requires that:

1) All planning jurisdictions, including municipalities and planning boards, consider the implications of their actions on the protection of Provincially Significant Wetlands.
2) Development is prohibited within Provincially Significant Wetlands in the Great Lakes - St. Lawrence Region. New land uses are prohibited within Provincially Significant Wetlands in the Great Lakes - St. Lawrence Region unless they do not:
    a) result in a loss of wetland functions;
    b) create a subsequent demand for measures which will negatively impact on existing wetland functions;
    c) conflict with existing site-specific wetland management practices; and
    d) result in a loss of area of wetland.

3) New land uses and development are generally prohibited within Provincially Significant Wetlands in the Boreal Region. However, new compatible land uses or development may be permitted provided that an Environmental Impact Study is carried out by a proponent and approved by the Ministry of Natural Resources.

4) Despite Policy 2, on lands separating wetland areas within a wetland complex in Provincially Significant Wetlands:
    a) new compatible land uses or development may be permitted in the Great Lakes - St. Lawrence Region if they do not result in a loss of area of wetland; and
    b) new compatible land uses or development may be permitted in the Boreal Region.

5) On adjacent lands:
    a) in the Great Lakes - St. Lawrence Region, new compatible land uses or development which do not result in a loss of area of wetland may be permitted; and
    b) in the Boreal Region, new compatible land uses or development may be permitted.

6) New public utilities/facilities be located outside Provincially Significant Wetlands wherever possible. If unavoidable, the approval authorities shall refer to the policies of this Policy Statement and determine the measures to be taken to minimize negative impacts on wetland functions.

### Ontario and First Nations Political Relationship

The statement of political relationship recognizes that the First Nations in Ontario have an inherent right to be self-governing within the Canadian Constitution. The document is a commitment by Ontario that it will deal with the First Nations as governments (Government of Ontario 1991).

Clean Air Program - Open Burning Guidelines

Requirements for open burning activities have been included in the clean air program draft regulations (Ontario MOE 1990). They include specifications about the type of material that can be burned, the burning procedures, the location of the burn with respect to residences, highways, etc. and the type of land on which open burning is allowed.

Guidelines for the Decommissioning and Cleanup of Sites in Ontario

These guidelines (MOE 1989) provide an efficient and effective process to decommission facilities and clean-up the environment.

(1) Process

The guidelines detail a process for meeting MOEE requirements and outline management and technical procedures in this regard. The guidelines recommend that the decommissioning process be as follows:

- Phase I : Planning the Decommissioning/Site Clean-up
- Phase II : Designing and Implementing the Decommissioning/Site Clean-up
- Phase III: Verifying Completion of a Satisfactory Decommissioning/Site Clean-Up
- Phase IV : Signing Off

Also in these guidelines are considerations for documentation, public communications, preliminary inventories and other relevant legislative criteria.

(2) Clean-up Standards

The development of criteria for setting clean-up standards to be adopted at decommissioning and clean-up sites in Ontario is on-going. There are at present criteria guidelines for soil, surface water, ground water and air contamination.

**Soils Upper Levels of Normal Data and Clean-up Guidelines**

Table B-9 lists upper limits of normal concentrations in soils for a range of heavy metals. Tables B-10 and B-11 list soil clean-up guidelines that may be used to assist in developing clean-up criteria at sites to be decommissioned or cleaned-up. These guidelines relate predominantly to inorganic materials.

**Groundwater and Surface Water Contamination Criteria**

Objectives for groundwater and surface water in Ontario are given in "Water Management: Goals, Policies, Objectives and Implementation Procedures" (MOE 1984).

**Air Contamination Criteria**

Regulation 346 (formerly Regulation 308) of the Environmental Protection Act governs air quality in Ontario. The limits established by this regulation would apply to decommissioning.

Policy for Management of Excess Soil, Rock and Like Materials

The Ontario Ministry of Environment and Energy has developed a draft policy (MOE 1992) to provide a consistent approach for the management of excess soil, rock and like materials (such as those that would be produced from

TABLE B-9
Contaminant Guidelines Representing Upper Limits of Normal Concentrations in Ontario Surface Soil

| Parameter | Urban ($\mu g \cdot g^{-1}$ or as indicated) | Rural ($\mu g \cdot g^{-1}$ or as indicated) |
|---|---|---|
| Antimony | 8 | 1 |
| Arsenic | 20 | 10 |
| Boron | 15 | 10 |
| Cadmium | 4 | 3 (south) 4 (north) |
| Chromium | 50 | 50 |
| Cobalt | 25 | 25 |
| Copper | 100 | 60 |
| Iron (%) | 3.5 | 3.5 |
| Lead | 500 | 150 |
| Magnesium (%) | - | 1 |
| Manganese | 700 | 700 (south) 1000 (north) |
| Mercury | 0.5 | 0.15 |
| Molybdenum | 3 | 2 |
| Nickel | 60 | 60 |
| Selenium | 2 | 2 |
| Sulphur (%) | - | 0.1 |
| Vanadium | 70 | 70 |
| Zinc | 500 | 500 |

Source: MOE 1989

TABLE B-10
Clean-up Guidelines for Soils

| Parameter (all units in $\mu g \cdot g^{-1}$ or as indicated) | Criteria for Proposed Land Use | | | |
|---|---|---|---|---|
| | Agricultural/residential/parkland | | Commercial/industrial | |
| | Medium & Fine Textured Soil | Coarse[1] Textured Soils | Medium & Fine Textured Soils | Coarse[1] Textured Soils |
| pH (recommended range) | 6-8 | 6-8 | 6-8 | 6-8 |
| Electrical conductivity ($mS \cdot cm^{-1}$) | 2 | 2 | 4 | 4 |
| Sodium adsorption ratio | 5 | 5 | 12 | 12 |
| Arsenic | 25 | 20 | 50 | 40 |
| Cadmium | 4 | 3 | 8 | 6 |
| Chromium (VI) | 10 | 8 | 10 | 8 |
| Chromium (total) | 1 000 | 750 | 1 000 | 750 |
| Cobalt | 50 | 40 | 100 | 80 |
| Copper | 200 | 150 | 300 | 225 |
| Lead | 500 | 375 | 1 000 | 750 |
| Mercury | 1 | 0.8 | 2 | 1.5 |
| Molybdenum | 5 | 5 | 40 | 40 |
| Nickel | 200 | 150 | 200 | 150 |
| Nitrogen (%) | 0.5 | 0.5 | 0.6 | 0.6 |
| Oil and Grease (%) | 1 | 1 | 1 | 1 |
| Selenium | 2 | 2 | 10 | 10 |
| Silver | 25 | 20 | 50 | 40 |
| Zinc | 800 | 600 | 800 | 600 |

1 Defined as greater than 70% sand and less than 17% organic matter

Source: MOE 1989

TABLE B-11
Provisional Clean-up Guidelines For Soils

| Parameter (all units in $\mu g \cdot g^{-1}$ or as indicated) | Criteria for Proposed Land Use | | | |
|---|---|---|---|---|
| | Agricultural/residential/parkland | | Commercial/industrial | |
| | Medium & Fine Textured Soil | Coarse[1] Textured Soils | Medium & Fine Textured Soils | Coarse[1] Textured Soils |
| Antimony | 25 | 20 | 50 | 40 |
| Barium | 1 000 | 750 | 2 000 | 1 500 |
| Beryllium | 5 | 4 | 10 | 8 |
| Vanadium | 250 | 200 | 250 | 200 |

1 Defined as greater than 70% sand and less than 17% organic matter

Source: MOE 1989

decommissioning and closing of the facility). The key component of the proposed policy is a classification scheme, which segregates excess materials into 4 categories:

- inert fill: material whose chemical parameters have concentrations at or below the rural background concentrations;
- urban-residential fill: materials that are lower in value than background concentrations of inorganic and organic contaminants in undisturbed urban park surface soils;
- urban-industrial fill: materials that have parameters measured beyond the guidelines based on established effects on human or ecological health, or have values which are twice the value for urban-residential fill; and
- controlled fill: materials that have parameters measured against the:
  1) effects-based guidelines multiplied by 10, or
  2) urban/residential fill guidelines multiplied by 20.

For each of these fill categories, there are specific guidelines for testing and sampling, as well as disposal sites. The appropriate disposal sites for each fill category are:

- inert fill: any site without approval under this policy;
- urban-residential fill: any permit-by-rule site;
- urban-industrial fill: any fully serviced and appropriately zoned urban-industrial site;
- controlled: any controlled fill site.

Although it is the generator of the fill's responsibility to determine the exact nature and category of the waste, the policy regulates some materials. The following materials that would be generated during decommissioning of the facility are regulated under the policy:

- old concrete;
- old asphalt;
- dredge materials; and
- excavated rock and soil.

<u>Ontario Sediment Quality Guidelines</u>

The purpose of the Sediment Quality Guidelines (MOEE 1993) is to protect the aquatic environment by setting safe levels of metals, nutrients and organic compounds. The guidelines established three levels of effect:

- <u>the no effect level</u>: a level at which no toxic effects have been observed on aquatic organisms. This is the level at which no biomagnification through the food chain is expected. Other water quality and use guidelines will also be met at this level;

- <u>the lowest effect level</u>: a level of sediment contamination that can be tolerated by the majority of benthic organisms; and

- <u>the severe effect level</u>: a level at which pronounced disturbance of the sediment-dwelling community can be expected. This is the sediment concentration of a compound that would be detrimental to the majority of benthic species.

The Lowest Effect Level and Severe Effect Level are based on the long-term effects which the contaminants may have on the sediment-dwelling organisms. The No Effect Level is based on levels of chemicals which are so low that no contaminants are passed through the food chain.

TABLE B-12

Provincial Sediment Quality Guidelines for Metals and Nutrients
(values in $\mu g \cdot g^{-1}$ (ppm) dry weight unless otherwise noted)

| Metals | No Effect Level | Lowest Effect Level | Severe Effect Level |
|---|---|---|---|
| Arsenic | -* | 6 | 33 |
| Cadmium | - | 0.6 | 10 |
| Chromium | - | 26 | 110 |
| Copper | - | 16 | 110 |
| Iron (%) | - | 2 | 4 |
| Lead | - | 31 | 250 |
| Manganese | - | 460 | 1100 |
| Mercury | - | 0.2 | 2 |
| Nickel | - | 16 | 75 |
| Zinc | - | 120 | 820 |
| Nutrients | | | |
| Total Organic Carbon (%) | - | 1 | 10 |
| Total Kjeldahl Nitrogen | - | 550 | 4800 |
| Total Phosphorous | - | 600 | 2000 |

* "-" denotes insufficient data
(Source: MOEE 1993)

TABLE B-13
Provincial Sediment Quality Guidelines for Organic Compounds
(values in $\mu g \cdot g^{-1}$ (ppm) dry weight unless otherwise noted)

| Compound | No Effect Level | Lowest Effect Level | Severe Effect Level ($\mu g \cdot g^{-1}$ organic carbon*) |
|---|---|---|---|
| Aldrin | -** | 0.002 | 8 |
| BHC | - | 0.003 | 12 |
| α-BHC | - | 0.006 | 10 |
| ß-BHC | - | 0.005 | 21 |
| τ-BHC | 0.0002 | (0.003) | (1) |
| Chlordane | 0.005 | 0.007 | 6 |
| DDT (total) | - | 0.007 | 12 |
| op+pp-DDT | - | 0.008 | 71 |
| pp-DDD | - | 0.008 | 6 |
| pp-DDE | - | 0.005 | 19 |
| Dieldrin | 0.0006 | 0.002 | 91 |
| Endrin | 0.0005 | 0.003 | 130 |
| HCB | 0.01 | 0.02 | 24 |
| Heptachlor | 0.0003 | - | - |
| Hepoxide | - | 0.005 | 5 |
| Mirex | - | 0.007 | 130 |
| PCB (total) | 0.01 | 0.07 | 530 |
| PCB 1254 | - | (0.06) | (34) |
| PCB 1248 | - | (0.03) | (150) |
| PCB 1016 | - | (0.007) | (53) |
| PCB 1260 | - | (0.005) | (24) |
| PAH (total) | - | (2) | (11 000) |

( ) denotes tentative guidelines

* Numbers in this column are to be converted to bulk sediment values by multiplying by the actual Total Organic Carbon concentration of the sediments (to a maximum of 10%), e.g., analysis of sediment sample gave a PCB value of 30 ppm and a TOC of 5%. The value for PCB in the Severe Effects column is first converted to a bulk sediment value for a sediment with 5% Total Organic Carbon by multiplying 530 by 0.05: 25.5 ppm is then the Severe Effect Level guidelines for that sediment. The measured value of 30 ppm is then compared with this bulk sediment value and is found to exceed the guideline.

** Insufficient data to calculate guideline

(Source: MOEE 1993)

Tables B-12 and B-13 present the various effect levels for the parameters of interest.

B2.23 Legislation of Other Provinces

Transportation of used fuel from Quebec and New Brunswick would have to comply to the transportation legislation for road, rail and water transportation through these provinces.

1) Quebec Transportation Legislation

The Quebec Transportation of Dangerous Goods regulations (Gouvernement du Quebec 1983) adopt the procedures and requirements of the federal TDG legislation and regulations.

For road transportation in Quebec, no special permits would be necessary for the vehicle hauling the cask, i.e., the vehicle would not be overweight or oversized.

For rail transportation, no special permit would be necessary for used fuel movements across Quebec in excess of the requirements already applied to the Ontario rail transportation system, since the railway system is administered by the same company across the country (i.e., the trains would not be overweight).

Since shipping is a federally-regulated activity, transportation of used nuclear fuel by water from Quebec should not impose any requirement other than those already applied to the Ontario water transportation system.

2) New Brunswick Transportation Legislation

In New Brunswick, the handling and transportation of dangerous materials is subjected to the provincial Transportation of Dangerous Goods Act (Government of New Brunswick 1988), which also adopts the federal requirements and procedures.

For road transportation in New Brunswick, special permits would be required. Regulation 83/42 under New Brunswick's Motor Vehicle Act places a 50 tonne limit on vehicles demonstrating the axle configuration and size of the tractor-trailer outlined within the reference transportation system design.

For rail transportation, no special permit would be necessary for used fuel movements across New Brunswick in excess of the requirements already applied to the Ontario rail transportation system, since the railway system is administered by the same company across the country (i.e., the trains would not be overweight).

Since shipping is a federally-regulated activity, transportation of used nuclear fuel by water from New Brunswick should not impose any requirement other than those already applied to the Ontario water transportation system.

B.3 INTERNATIONAL REGULATIONS

International regulations are applicable for the international safeguards agreement and for used fuel transportation, where part of the route is in United States water.

### B.3.1 International Atomic Energy Agency (IAEA) Safeguards Requirements

Canada, having signed an agreement with the IAEA (1972) on nuclear safeguards, has an obligation to fulfil IAEA safeguards requirements for nuclear material. The objective of these safeguards requirements is timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons and other nuclear explosive devices, or for purposes unknown and the consequent deterrence of such a diversion by the risk of early detection.

### B.3.2 IAEA Radioactive Materials Transportation Regulations

The AECB TPRM regulations are based on the IAEA Regulations for Safe Transport of Radioactive Materials (IAEA 1990), and take precedence over them in Canada. National regulations in most countries, and international regulations, are based on the IAEA Regulations.

### B.3.3 International Maritime Organization (IMO) Regulations

The IMO is the United Nations' Agency for marine safety. This body consists of a number of committees of experts on all aspects of marine transportation. One such committee meets on the carriage of dangerous goods, and their regulations are contained in the International Maritime Dangerous Goods Code (IMDG Code). The code is based on the IAEA regulations.

The IMO is currently drafting a new code, the "International Maritime Organisation Draft Code for the Safe Carriage of Irradiated Nuclear Fuel in Flasks on Board Ships (IMO/IAEA 1992). The code would apply to new and existing ships regardless of size, including cargo ships of less than 500 tons gross tonnage, engaged in the carriage of irradiated nuclear fuel in flasks approved in accordance with the applicable Regulations for the Safe Transport of Radioactive Materials adopted by the International Atomic Energy Agency and carried in accordance with Class 7 of the International Maritime Dangerous Goods (IMDG) Code. It specifies requirements for damage stability, fire protection, temperature control of the cargo spaces, structural integrity, cargo security arrangement, electrical supplies and radiological protection equipment.

### B.3.4 U.S. Regulations

Travel on the Great Lakes may necessitate transit through American owned waters. A bilateral agreement, defined in the USA Code of Federal Regulations (49 CRF) (1991) is in place. Shipments of radioactive materials being transported from one location in Canada to another location in Canada are accepted in the U.S. provided the shipment meets the requirements of the Transportation of Dangerous Goods Regulations and the IAEA Regulations for the Safe Transport of Radioactive Materials, and the package design approval certificate is revalidated by the U.S. Department of Transport.

## B.4 REGULATIONS SPECIFIC TO TRANSPORTATION

The following subsections outline some acts and regulations pertaining specifically to transportation. This is not intended to be an exhaustive listing. Section B.2.7 refers to Guidelines for Preparing Environmental Assessments issued by the Ontario Ministry of Transportation.

### B.4.1 Road Specific Regulations

The Labour Regulations Act (Government of Ontario 1990p), administered by the Ontario Ministry of Labour, specifies the working conditions for truck drivers such as length of non-stop driving time, and total length of trip. The Ontario Highway Traffic Act (Government of Ontario 1990o) regulates loads on specific types of road. All vehicles will have to be licensed with the Ontario Ministry of Transportation.

### B.4.2 Rail Specific Regulations

(1) Rail Transportation of Dangerous Commodities (TDC) Regulations

The Rail TDC regulations, promulgated under the TDG Act, are administered by the Railway Transport Committee of the National Transportation Agency (NTA).

These regulations specify the packaging requirements for rail transport of dangerous commodities, and establish NTA inspection authorities. They apply to the consignor with respect to the responsibility for preparation for transport, transport container maintenance and inspection, documentation, reporting and notification.

They also apply to the railway carrier with respect to operation, maintenance and inspection of the railway system and equipment for used fuel transportation.

(2) Railway Act and National Transportation Act

The National Transportation Act, administered by the National Transportation Agency (NTA), place the NTA in charge of the administration of the Railway Act and all associated regulations.

The Railway Act (Government of Canada 1985o) applies to the carrier railway with respect to the design, operation and maintenance of railway systems and railway equipment. It applies to Ontario Hydro with respect to the design, operation and maintenance of the flat cars designed to carry used fuel transportation casks.

### B.4.3 Water Specific Regulations

There are no specific Canadian requirements for the design of vessels to carry radioactive materials. There are, however, specific rules for the design and construction of Canadian built and operated vessels and especially in the transport of dangerous goods. This section identifies applicable Canadian regulations which apply to transportation within the Great Lakes and briefly describes the regulatory implications of crossing into United States waters.

(1) Canadian Regulations

The design and construction of any vessel and the transportation of any cargo on the Great Lakes must be achieved while adhering to the rules and regulations of:

(a) The Canada Shipping Act

The Coast Guard is the federal agency which administers the Canada Shipping Act (CSA) (Government of Canada 1985c). They are responsible for waterborne safety and enforce rules and regulations that pertain to vessel design and operation, manning, casualty investigation, navigational aids, vessel inspection, search and rescue, and ice breaking operations. The local and regional Coast Guard offices are the ones en route with which the shipper of radioactive materials should deal with.

The specific Canada Shipping Act regulations, to which the design, operation, inspection and crewing of a tug and barge must comply, are the following: Air Pollution (CSA #2), Boat and Fire Drill (CSA #4), Certification of Able Seamen (CSA #8), Certification of Lifeboat Men (CSA #9), Inspection of Classed Ships (CSA #13), Collision (CSA #14), Crew Accommodation (CSA #15), Dangerous Goods Shipping (CSA #16), Fire Detection and Extinguishing (CSA #20), Great Lakes Navigation Safety (CSA #25), Great Lakes Sewage Pollution Prevention (CSA #26), Home Trade, Inland and Minor Water Voyages (CSA #27), Hull Construction and Inspection (CSA #28 and #29), Lifesaving Equipment (CSA #32), Loadline (CSA #36), Navigating Appliances and Equipment (CSA #45), Oil Pollution Prevention (CSA #49), Safe Manning (CSA #56), St. Clair and Detroit River Navigation Safety (CSA #59), Ship's Deck Watch (CSA #70), Steamship Machinery Inspections (CSA #79), and VHF Radiotelephone Practices and Procedures (CSA #96).

(b) St. Lawrence Seaway Authority Act

The St. Lawrence Seaway Authority created under the St. Lawrence Seaway Authority Act (Government of Canada 1985q), is the Canadian Federal Agency that operates and sets the policy, fees and regulations for the entire Canadian section of the Seaway. The equivalent U.S. body is the St. Lawrence Seaway Development Corporation and the Seaway Regulations are administered by both these bodies.

These rules and regulations apply to every vessel using the locks or any section of the Seaway system on a regular basis. Special requirements needed for vessels carrying any quantity of radioactive substances are: display a special flag at the mast head, report the number to the SLSA and issue date of AECB certificate for the transportation cask. Various design requirements needed for all vessels using the Seaway are also specified.

During the design phase of any vessel, drawings are submitted to SLSA for review and approval. When in operation, vessels are subjected to regular inspections by the Seaway inspectors.

(2) United States Regulations

U.S. regulations have to be considered here because travel through the Great Lakes from Lake Ontario to Lake Superior necessitates transit into American owned waters. A special bilateral agreement exists between the U.S. and Canada for the cross border transportation of dangerous goods. The United States Regulations 49 CFR (1991) define this agreement. The U.S. will accept the shipments provided:

- i) they are classed, packaged, marked, labelled, placarded and described on shipping papers in accordance with the Canadian Transportation of Dangerous Goods Regulations (TDG);
- ii) the goods are packaged in accordance with the IAEA Regulations for the Safe Transport of Radioactive Materials;
- iii) type B packages have their competent authority (AECB) certification revalidated by the U.S. competent authority (Materials Transportation Bureau, Office of Hazardous Materials Regulation, U.S. Department of Transport, Washington D.C.,); and
- iv) the shipping papers conform to some limited American nomenclature standards as defined in 49 CRF.

The last two points are the only additional requirements because the TDG and IAEA regulations (through the AECB TPRM regulations) are already being met to satisfy Canadian regulations.

## (3) International Regulations and Guidelines

### a) International Maritime Organization (IMO) Regulations

The IMO is the United Nations' Agency for marine safety. This body consists of a number of committees of experts on all aspects of marine transportation. These bodies meet regularly to discuss and formulate recommendations and regulations for the safety of ships, their crews and the public. One such committee meets on the carriage of dangerous goods and their regulations are contained in the International Maritime Dangerous Goods Code (IMDG Code). This code sets out the various classes of dangerous goods, for example, radioactive substances are Class 7. The code is based on the IAEA regulations.

### b) Classification Societies Regulations

Several Classification Societies operate throughout the world, all of which publish regulations relating primarily to the structural efficiency of a ship and the reliability of its machinery.

Classification is entirely voluntary on the part of the shipowner, and the only penalty that can be imposed for noncompliance with the Rules is suspension or cancellation of class. Even in the case of unclassed vessels, it is not unusual for the specifications to require that the vessel be built to the rule requirements of some Classification Society. In reality, acceptance of classification rules as suitable standard for merchant-ship construction can be said to be universal. The classification of a vessel by a society is a guarantee that the vessel has the necessary strength and seaworthiness for its intended service. This makes it easier for the vessel to be accepted as a fair risk by insurance underwriters.

### c) Convention on Environmental Impact Assessment in a Transboundary Context

Canada is a signatory to this convention. The convention stipulates that proponents should:

1) Take all appropriate and effective measures to prevent, reduce and control significant adverse transboundary environmental impacts from proposed activities.

2) Establish an environmental impact assessment procedure that permits public participation and preparation of the environmental impact assessment documentation, and undertake such an assessment prior to a decision to authorize or undertake a proposed activity that is likely to cause a significant adverse transboundary impact.

3) Notify all potentially affected parties of the proposed activity.

### d) The Great Lakes Water Quality Agreement

In 1987, a Protocol (IJC 1978) was signed between Canada and the United States amending the 1978 Canada-U.S. Great Lakes Water Quality Agreement. The objectives of the Protocol were to, in a concerted effort, restore and protect the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem. In Canada, both the federal and the Ontario provincial governments work together in implementing responsibilities under the Great Lakes Water Quality Agreement, through the Canada-Ontario Agreement Respecting Great Lakes Water Quality (COA). Members participating in COA include the Federal Departments of the Environment, Agriculture, Fisheries and Oceans, and the Ontario Ministries of the Environment, Agriculture and Food, and Natural Resources.

Under the 1987 Protocol, the International Joint Commission (IJC) is assigned an evaluative role, reporting every two years to both countries.

Under the Protocol, the Shipping Activities component of the Great Lakes Preservation program addresses pollution associated with marine transportation and related activities.

## B.5 GUIDING PRINCIPLES FOR AN ENVIRONMENTAL POLICY AT THE IMPLEMENTATION STAGE

It is assumed that if the Government decides that the disposal concept is acceptable, an implementing organization will be established immediately following this decision. It is further assumed that the environmental principles stated below will be adopted by the organization and will apply to all its employees and contractors.

**GOVERNING PRINCIPLE:**

The implementing organization will manage all activities that affect the environment such that the community and the public at large will receive the greatest overall long-term benefit.

**SPECIFIC ENVIRONMENTAL PRINCIPLES:**

### 1. Exercising Leadership

The implementing organization will exercise environmental leadership by setting high industry standards and striving for continuous improvement in its performance.

As well, the agency will take a lead role in the development and application of new technology to minimize adverse effects on the environment.

### 2. Making Balanced Decisions

The implementing organization will integrate environmental and socio-economic factors into its decision-making process, and ensure that they are balanced with technical and economic factors.

### 3. Following Regulations

The implementing organization will meet all requirements of environmental legislation and will develop more appropriate standards wherever practical.

Where specific regulations do not exist, the implementing organization will operate such that adverse effects on the environment are as low as reasonably achievable.

### 4. Using Resources Wisely

The implementing organization will place a strong emphasis on reduction, re-use and recycling of materials.

### 5. Providing Offsetting Benefits When Necessary

The implementing organization will avoid adverse environmental effects whenever possible, mitigate any remaining effects, and finally compensate for effects that cannot be mitigated (residual effects) by offering suitable offsetting benefits.

**6. Listening Carefully**

The implementing organization will encourage timely consultation with individuals and organizations who are stakeholders in its environmental performance. These would include employees, customers, regulators and the general public.

**7. Remaining Accountable**

The implementing organization will ensure that all its employees and business partners are accountable for the environmental effects of their activities.

**8. Auditing Performance**

The implementing organization will be responsible to government and the people in the affected community for its environmental performance. To ensure this performance, the agency will conduct periodic audits of its environmental management and take remedial action where necessary.

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# APPENDIX C

## INDICATORS USED TO DETERMINE SIGNIFICANCE OF EFFECTS

# APPENDIX C

## INDICATORS USED TO DETERMINE SIGNIFICANCE OF EFFECTS

Appendix C provides a summary of factors and considerations that were used in this concept assessment to indicate significance of environmental effects. They were derived from legislative requirements, industrial standards/targets, and case-studies and industrial practices. It is important to emphasize that these factors were used as indicators of significance for concept assessment purposes. For implementation purposes, the actual significance of a given effect would be determined in full consultation with regulatory staff, the affected public, and with the knowledge of the site-specific baseline conditions and ecological context.

## APPENDIX C
## INDICATORS USED TO DETERMINE SIGNIFICANCE OF EFFECTS

| Categories of Significance Indicators Used/Assumed | Relevant to UFDC Stages* | C□ | I◇ |
|---|---|---|---|
| **LEGISLATION, REGULATIONS AND GUIDELINES** (see Appendix B for details and references) | | | |
| • Ontario Occupational Health and Safety Act<br>Reg 854 Mines and Mining Plants<br>Reg 851 Inustrial Establishments<br>Reg 833 Control of Exposure to Biological or Chemical Agents<br>Reg 850 Hazardous Materials Inventories<br>Reg 860 Workplace Hazardous Materials Information System | • S,C,O,T,D | ✓ | ✓ |
| • Ontario Occupational Health and Safety Act<br>Reg 213/91 Construction Projects<br>Reg 833 Control of Exposure to Biological or Chemical Agents<br>Reg 850 Hazardous Materials Inventories<br>Reg 860 Workplace Hazardous Materials Information System | • C | | ✓ |
| • Ontario Occupational Health and Safety Act<br>Reg 854 Mines and Mining Plants<br>Reg 213/91 Construction Projects<br>Reg 833 Control of Exposure to Biological or Chemical Agents<br>Reg 850 Hazardous Materials Inventories<br>Reg 860 Workplace Hazardous Materials Information System | • D | | ✓ |
| • Ontario Occupational Health and Safety Act<br>Reg 854 Mines and Mining Plants | • S,T | | ✓ |
| • Environment Canada Codes of Practice for Siting of Electricity Steam Generating Stations | • S | ✓ | |
| • Environment Canada Codes of Practice for Design of Electricity Steam Generating Stations | • C,O | ✓ | |
| • Environment Canada Codes of Practice for Construction of Electricity Steam Generating Stations | • C | ✓ | |
| • Environment Canada Codes of Practice for Operation of Electricity Steam Generating Stations | • O | ✓ | ✓ |
| • Environment Canada Codes of Practice for Decommissioning of Electricity Steam Generating Stations | • D | ✓ | ✓ |
| • Ontario Ministry of the Environment - Model Municipal Noise Control Bylaw | • S,C,O,T,D | ✓ | ✓ |
| • Ontario Ministry of the Environment - Model Sewer Use Bylaw | • S,C,O,T,D | | ✓ |
| • Ontario Ministry of the Environment - Water Quality Objectives | • S,C,D | ✓ | ✓ |
| • Ontario Ministry of the Environment - Air Quality Standards | • S,C,O,T,D | ✓ | ✓ |
| • Ontario Ministry of the Environment - Marine Construction Guidelines | • C | | ✓ |
| • Ontario Ministry of the Environment - Sediment Quality Guidelines | • C | ✓ | ✓ |
| • Ontario Ministry of the Environment - Proposed Policy for Managing Excess Soil, Rock and Similar Material | • C | ✓ | ✓ |
| • Ontario Ministry of the Environment - Waste Management Regulation (347) under the Environmental Protection Act | • D | | ✓ |
| • Ontario Ministry of the Environment - Guidelines for the Decommissioning and Cleanup of Sites in Ontario | • D | ✓ | ✓ |
| • Ontario Ministry of the Environment - Waste Soil Guidelines | • O | ✓ | ✓ |
| • Ontario Ministry of Transportation Noise Guidelines | • T | ✓ | |

| Categories of Significance Indicators Used/Assumed | Relevant to UFDC Stages* | C□ | I◇ |
|---|---|---|---|
| • Ontario Conservation Authority Act | • S,C | | ✓ |
| • Ontario Heritage Act | • S,C | | ✓ |
| • Ontario Aggregate Resources Act | • S,C | | ✓ |
| • Ontario Pesticides Act | • S,C,O | | ✓ |
| • Ontario Water Resources Act | • S,C,O,T,D | | ✓ |
| • Ontario Waste Management Act and draft regulations | • S,C,O,T,D | | ✓ |
| • Ontario Wetlands Policy | • S,C,O | | ✓ |
| • Ontario Lakes and Rivers Improvement Act | • C | | ✓ |
| • Endangered Species Act | • S,C | ✓ | ✓ |
| • Migratory Birds Convention Act | • S,C | | ✓ |
| • Forest Fire Prevention Act | • S,C | | ✓ |
| • Gasoline Handling Act | • S,C,0 | | ✓ |
| • National Parks Act | • S | | ✓ |
| • Crown Timber Act | • S,C | | ✓ |
| • Ontario Nuclear Emergency Response Plan - Protective Action Levels | • O,T,D | ✓ | ✓ |
| • Canadian Water Quality Guidelines | • S,C,O,D | ✓ | ✓ |
| • Canada Wildlife Act | • S,C | | ✓ |
| • Canada Shipping Act | • T | ✓ | ✓ |
| • Canadian Transportation of Dangerous Goods (TDG) Act | • O,D | ✓ | ✓ |
| • Fisheries Act | • S,C,O | | ✓ |
| • Indian Act | • S | | ✓ |
| • Navigable Waters Protection Act | • C | | ✓ |
| • Highway Traffic Act | • T | ✓ | ✓ |
| • Allowable Radon Concentrations Underground | • O | | ✓ |
| • AECB Atomic Radiation Worker Dose Limit - Normal Conditions | • O,T,D | ✓ | ✓ |
| • AECB Licensing Limits for Darlington - Accident Conditions | • O,T,D | ✓ | ✓ |
| • AECB Transport Packaging of Radioactive Materials Regulations | • O, T | ✓ | ✓ |
| • AECB Security Requirements | • O,T | ✓ | ✓ |
| • AECB and IAEA Safeguards Requirements | • O,T | ✓ | ✓ |
| • AECB dose rate limits from type B(U) package | • T | ✓ | ✓ |
| INDUSTRIAL TARGETS | | | |
| • World Health Organization, 1980: Environmental Health Criteria 12: Noise | • S,C | ✓ | ✓ |
| • American Industrial Hygiene Association | • S,C,O,T,D | | ✓ |
| • Ontario Hydro Dose Targets for Atomic Radiation Worker - Accident Conditions (Tong 1984; Zeya 1992) | • O | ✓ | ✓ |

| Categories of Significance Indicators Used/Assumed | Relevant to UFDC Stages* | C□ | I◇ |
|---|---|---|---|
| **CASE STUDIES AND INDUSTRIAL PRACTICES** | | | |
| • Environmental Protection Practices for the development of Hydraulic Dams (Ratchord and Chubbuck 1983) | • S | ✓ | |
| • Environmental Protection Practices for the construction of access roads (MNR 1982) | • S,C | ✓ | ✓ |
| • Environmental Protection Practices for mining exploration (CANMET 1977) | • S | ✓ | |
| • Environmental Protection Practices for the construction of fossil and nuclear stations (Prinoski et al.) | • C | ✓ | |
| • Environmental Protection Practices for road maintenance (MNR 1982) | • O | ✓ | ✓ |
| • Environmental Protection Practices during operation of nuclear facilities | • O | ✓ | |
| • Summary of impacts and environmental protection practices for mining (Marshall 1982; Ripley et al., 1978) | • S,C,O | ✓ | |
| • AECL Underground Research Lab Environmental Impact Statement and Experience | • S,C,O | ✓ | |
| • Socio-economic impact case studies presented in Appendix D | • S,C,O,T,D | ✓ | |
| • Average traffic from lumbering and mining operations | • C,O,T | ✓ | |
| • Effects of once-through cooling at thermal generating stations (Ontario Hydro 1981) | • O | ✓ | |
| • Acid mine drainage in Ontario (Hawley 1977) | • O | ✓ | |
| • Hazardous Material Traffic in Ontario and Canada | • T | ✓ | |
| • Plan for Decommissioning of Ontario Hydro Nuclear Generating Stations | • D | ✓ | |
| • Decommissioning experience at Gentilly I and Douglas Point | • D | ✓ | |
| **OTHER INDICATORS** | | | |
| • Land Use in the Three Regions | • S,T | ✓ | |
| • Reserves of Non-renewable Materials used in construction and operation, and transportation | • C,O,T | ✓ | ✓ |
| • Total regional emissions of air pollutants | • C,O,T | ✓ | ✓ |
| • Natural radon emissions from the soil | • C | ✓ | ✓ |
| • Threshold of radiological impacts on non-human biota | • O,T | ✓ | ✓ |
| • Environmental Concentration of Radionuclide in Air | • O | ✓ | ✓ |
| • Environmental Concentration of Radionuclide in Water | • O | ✓ | ✓ |
| • Environmental Concentration of Radionuclide in Soil and Sediments | • O | ✓ | ✓ |
| • Average existing traffic on the reference routes | • T | ✓ | |

FOOTNOTES:

* S = Siting; C = Construction; T = Transportation; O = Operation; D = Decommissioning & Closure

□ C = Specifically applied in the assessment of the concept

◇ I = The assessment assumed that the implementing agency would comply with the legislation and regulations, or develop the facility consistent with the guideslines, industry targets, best practices etc.

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**APPENDIX D**

CASE STUDIES USED IN THE PRECLOSURE ASSESSMENT

# APPENDIX D

## CASE STUDIES USED IN THE PRECLOSURE ASSESSMENT

This appendix presents a list of the case studies and industrial experience used in the natural environment analysis, radiological safety analysis, used fuel transportation assessment, and socio-economic impact assessment.

This appendix is only intended to present an overview of case studies and practical experience referred to in the assessment. It is not intended to present details of lessons learned or other evaluation. These are incorporated throughout the main text.

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| Table D-1 | Natural Environment Analysis |
| Table D-2 | Radiological Safety Analyis |
| Table D-3 | Used Fuel Transportation Assessment |
| Table D-4)<br>Table D-5)<br>and )<br>Table D-6) | Socio-Economic Impact Assessment |

Table D-1
Case Studies and Industrial Experience
Used in the Natural Environment Analysis

| Stage | Case Study and Industrial Experience | Used in |
|---|---|---|
| Siting | | |
| | Study of Impacts from Geological Exploration for mining projects (Bates et al. 1980) | Impacts from geological characterization of the site. |
| | Early Stages of Hydraulic dam construction (Ratchford and Chubbuck 1983) | " " |
| | Land Use and Mining (Marshall 1982) | " " |
| | Environmental impact of mining (Ripley et al. 1979) | Effects of characterization activities |
| | Application of a Post-EA study process in the electricity generation industry (Jerome and Rowsell 1992) | Monitoring approach |
| Construction | | |
| | Study of Impacts on the Water Table from Excavation of the Underground Research Laboratory in Lake DuBonnet, Manitoba (Pollock and Barrados 1983) | Impacts on the water table and surrounding wells from excavation of the UFDC underground facilities |
| | Environmental Effects of Mining (Ripley et al. 1979) | Effects of underground excavation |
| | Land Use and Mining (Marshall 1982) | " " |
| | Chat Falls GS, impacts of once-through cooling system (Knox 1978) | Effects of water withdrawal |
| | Biological effects of once-through cooling systems at Ontario Hydro generating stations (Ontario Hydro 1981) | " " |
| | Effects of Ontario Hydro Construction of Fossil Nuclear or Hydroelectric GS (Prinoski et al 1983; Ratchford and Chubbuck 1983) | Effects of construction on the natural environment and mitigation measures |
| | Noise from Darlington construction (Ontario Hydro 1987b) | Effects of construction |
| | Wetland management on the sites of Ontario Hydro nuclear generating stations (Sears and Chubbuck 1988) | Effects if a wetland is on or near the site and mitigation |
| | Endangered species relocation at Little Jackfish (Ontario Hydro 1988) | Management measure if endangered species are encountered |
| | URL rock leaching from URL monitoring reports (Lemire and Acres 1990) | Leaching from rock disposal area |
| | Ontario Ministry of Natural Resources construction and mitigation practices (MNR 1983) | Effects of construction and mitigation measures |
| | Ontario Ministry of Natural Resources Class EA for Access Roads (MNR 1986) | Effects and mitigation measures for access roads |
| | Characteristics of mine tailings (Hawley 1977; 1979) | Effects of rock disposal area |
| Operation | | |
| | Fish entrapment in NGS intakes (Ontario Hydro 1981) | Effects on aquatic life of water supply intake |

| Stage | Case Study and Industrial Experience | Used in |
|---|---|---|
| | Atikokan post-operational studies<br>(Ecological Services for Planning 1992) | Environmental effects of operation |
| | Environmental effects of mining (Ripley 1979) | Effects of underground excavation |
| | Bird kills at Ontario Hydro thermal generating stations (Broughton 1977) | Environmental effects |
| | Ontario Hydro Corporate Noise Control and Hearing Protection Program (Ontario Hydro 1984) | Occupational safety |
| | Mine rescue operations<br>Ministry of Labour 1984 | Occupational safety and emergency response |
| Decommissioning | | |
| | Conceptual plan for decommissioning Pickering, Bruce and Darlington NGS (Dowell 1991) | Effects on natural environment |
| | Land use and mine reclamations<br>(Marshall 1983) | Effects of mine reclamations on the environment |

Table D-2
Case Studies and Industrial Experience
Used in the Radiological Safety Analyses

| Stage | Case Study and Industrial Experience | Used in |
|---|---|---|
| Construction | | |
| | Release of radon from underground vault in granite (US DOE 1980) | Release of radon from the site |
| Operation | | |
| | Yucca Mountain (Jackson et al. 1985) | Public safety |
| | Study of possible aircraft strike at Pickering (Manning and Aitchison 1974) | Public safety (accident conditions) |
| | Darlington Occupational Radiation Management Project (Kabir and Burchartz 1984) | Occupational safety |
| | Pickering Radiation Protection Procedures (Ontario Hydro 1992) | Occupational safety |
| | Bruce NGS Safety analysis (Ontario Hydro 1991) | Public safety |
| | Fission products releases for an end-fitting failure (Pon and Archinoff 1983) | Public safety |
| | Effects on the Great Lakes of radionuclides released from nuclear generating stations (Russell 1991) | Effects of radionuclides releases |
| Decommissioning | | |
| | Cost Evaluation for Bruce Heavy Water Plant A Demolition (Delsan-Cleveland Inc. 1991) | Effects of decommissioning |
| | Gentilly-1 Station Decontamination (Le and Denault 1986) | Effects of decontamination |

Table D-3
Case Studies and Industrial Experience
Used in the Used Fuel Transportation Assessment

| Case Study and Industrial Experience | Used in |
|---|---|
| Ontario Hydro Radioactive Materials Transportation Emergency Response Plan (Karmali 1991) | Emergency response provisions |
| Radioactive material transportation ships (Spink 1983) | Public safety analysis |
| Traffic on Access Road to a Mine in Northern Ontario (MTC Ontario 1983) | Comparing to UFT traffic |
| Traffic on Access Road to a Lumber Mill in Northern Ontario (MTC Ontario 1983) | Comparing to UFT traffic |
| Effects of channel dredging (Hirsch et al 1978) | Effects of maintenance dredging |
| Ontario Ministry of Natural Resources Class EA on small scale projects (MNR 1986) | Effects of TF and access road construction |
| Construction of Fossil, Nuclear and Hydroelectric Generating Stations (Ratchford and Chubbuck 1983;Prinoski et al. 1983) | Effects of TF construction |
| Studies of Flask Transport Impact Hazards, and resistance of Spent Magnox Fuel Transport Flasks<br>(Cook, Miles and Shears, 1985)<br>(Hart et. al. 1985b)<br>(Holt 1985)<br>(Mummery 1985) | Public safety analysis |
| Evaluation of Doses to Workers and the General Public from the Carriage of Radiopharmaceuticals<br>(De Marco, Mancippi, Piermattei and Scarpa 1983). | Public safety analysis |
| Shipping Container Response to Highways and Railway accident conditions<br>(Fischer et al 1987) | Public safety analysis |
| Transportation of Dangerous Goods by rail in Toronto (CTC 1983) | Traffic and safety |

Table D-4
Case Studies and Industrial Experience
Used in the Socio-Economic Impact Assessment
for the Identification of Project and Community Characteristics
that Determine the Nature and Significance of Socio-Economic Impacts

| Case Study and Industrial Experience | Used in |
|---|---|
| Restart of Three Miles Island 1<br>(Sorensen et al. 1987) | Stigma, stress |
| Mississauga Derailment (Whyte and Burton, 1982) | Concern about risk |
| Conventional Accident at the Gorleben "pilot site" in Germany (Peters and Hennen 1988) | Characteristics of the individuals (public reaction to accidental events) |
| Power Plants (Gilmore et al 1982) | Labour force (wage competition)<br>Level of economic development (income multipliers)<br>Effect of population size and density<br>Adequacy of public sector infrastructure |
| Town of Marathon and the Hemlo Gold Mine Project (Dumbrell and Butler 1987) | Level of economic development (cycle of spending and re-spending and effect on local income) |
| Coal Development in the Northern Great Plains (Temple (1978) | Effect of proximity to larger urban centres |
| Western Coal Producing Counties in the US (Bender, Humphrey and Thieme (1973)) | Effects of proximity to larger urban centres |
| Boom towns (Murdock, Leistritz and Schriner 1982) | Effect of population size and density<br>Effect on community cohesion |
| B.C. Hydro - Revelstoke Dam Project (The DPA Group Inc. 1986) | Effect of population composition<br>Adequacy of public sector infrastructure |
| Energy Resource Development in Rural Areas in the West (Albrecht, 1978) | Effect of population composition (re: elderly residents)<br>Community cohesion |
| Boom town (Freudenberg, 1986) | Effect of population composition (re: youth)<br>Adequacy of public sector infrastructure (re: conflict between new and long time residents)<br>Community cohesion |
| Norman Wells Pipeline Project<br>(Green and Bone 1987) | Effect of population composition (re: women) |
| Northern BC Single Industry Resource Communities (Baker and Kotarski 1977) | Effect of population composition (re: women) |
| Two Colorado Case Studies<br>(Moen et al. 1981) | Effect of population composition (re: women) |
| Northern Canadian Resource Towns (Gill 1983) | Effect of population composition (re: women) |
| Boom towns (Gilmore 1976) | Adequacy of public sector infrastructure (re: business interest)<br>Community cohesion |
| Rural areas in the Great Plains<br>(Murdock et al 1980) | Adequacy of public sector infrastructure (re: quality of housing and services) |
| Boom towns (Cortese and Jones 1977) | Planning and administrative capability<br>Community cohesion |

| Case Study and Industrial Experience | Used in |
|---|---|
| Specific Communities Immobilization from Environmental Quality (Bridgeland and Sofranko 1975) | Effects of past experience |
| Dangerous communities (Baum et al. 1981) | Residents views and attitudes (vs risk) |
| Middle-Aged community sample (Folkman and Lazarus 1980) | Residents views and attitudes (vs risk) |
| Mackenzie Valley Pipeline (Berger 1977) | Community culture |
| Alaska Highway Pipeline (Lysyk 1977) (Strong 1979) | Community culture |
| "The social impact assessment of rapid resource development on native peoples" (Geisler et al. 1982) | Community culture |
| Energy Development and Native Americans (Jorgensen 1984) | Community culture |
| The Yupik Eskimos of St. Lawrence Island Alaska and a proposed energy development (Little and Robbins 1986) | Community culture |
| Elk Valley Settlement, Victoria BC (Suzanne Veit and Associates 1979) | Community stability |

Table D-5
Case Studies and Industrial Experience
Used in the Socio-Economic Impact Assessment
for the Identification of Potential Impacts

| Case Study and Industrial Experience | Used in |
|---|---|
| Huntly Power Project in New Zealand (Vautier 1977) | Business activity (local businesses & services, economic leakage)<br>Iincome and price structure |
| Hemlo Gold Mine in Marathon, Ont.(Okun Hill 1987) | Business activity (services & businesses) |
| B.C. Hydro, Revelstoke Dam Project, (DPA Group 1986; BC Hydro 1986) | Business activity (business community)<br>Business developments plans and potential<br>Income and price structure<br>Existing environmental facilities, services and utilities<br>Educational facilities and services<br>Health services<br>Fire-fighting services |
| Energy projects in the U.S. (Denver Research Institute 1984) | Business activity (retail trade, services) |
| Bruce Nuclear Power Dev.<br>(Bruce County Joint Manpower Assessment and Planning Committee<br>1985; Schwass 1980;<br>Ontario Hydro 1983;<br>Ketcheson 1985;<br>Eldorado Nuclear Limited 1977; Dillon 1974) | Business activity (services, local business community)<br>Business development plans and potential<br>Income and price structure<br>Project employment<br>Availability of housing<br>Property value<br>Existing and new forms of transportation and communication<br>Educational facilities and services<br>Health services<br>Police services<br>Fire-fighting services<br>Land use<br>Municipal capital and operating costs<br>Property taxes and service charges<br>Community culture and social structure |
| U.S. Projects (Murdock 1986) | Business activity (growth of stores, retail, services)<br>Project employment |
| Native participation in Mining (Sub-committee of the Intergovernmental Working Group on the Mineral Industry 1991) | Business activity (Aboriginal impacts) |
| Closing down of the Ontario Hydro Deep River Training Centre | Business activity |
| Power Station in North Dakota (Leistritz and Maki 1981) | Business development plans and potential (labour creation)<br>Income and price structure<br>Health and safety facilities and services<br>Health services |
| Two Ontario Hydro thermal generating stations (University of Toronto 1977) | Business development plans and potential (labour costs etc.) |

| Case Study and Industrial Experience | Used in |
|---|---|
| Town of Marathon<br>(Dumbrell and Butler 1987) | Business development plans and potential<br>Secondary employment opportunities<br>Existing environmental facilities, services and utilities<br>Existing and new forms of transportation and communication<br>Rcreational and community features<br>Education<br>Health services<br>Police services<br>Existing and new forms of social services<br>Land use<br>Municipal capital and operating costs<br>Community cohesion |
| American Nuclear Power Plants (Van Zele 1976) | Business development plans and potential (services) |
| Celgar Expansion, B.C.<br>(Celgar Expansion Review Panel 1991) | Business development plans and potential |
| U.S. Power Plants<br>(Gilmore et al. 1982) | Project employment<br>Educational facilities and services<br>Police services<br>Fire-fighting services |
| Construction projects in Atlantic Canada including Offshore Hydrocarbon Developments, Pt Lepreau, Glace Bay Heavy Water Plant (Gardner 1985) | Project employment<br>Labour organizations |
| Atikokan Generating Station Construction | Project employment |
| Darlington Generating Station Construction<br>(Ontario Hydro 1987a) | Project employment<br>Availability of housing |
| Mining industry in Northern Ontario (C.N Watson & Assoc. 1983) | Secondary employment opportunities |
| Effect of decline in forestry industry on secondary employment in Thunder Bay (Ont. Hydro 1984b) | Secondary employment opportunities |
| Ontario Waste Management Corporation Siting Studies (Laventhol and Horwath 1985; Clayton Research Associates 1985; Institute of Environmental Research 1988) | Tourism-related activities<br>Property values<br>Resident activities, use and enjoyment of property (nuisance effects)<br>Health and safety (stress)<br>Satisfaction with the community and voluntary out-migration<br>Potential social and cultural impacts - abnormal conditions |
| Three Mile Island Re-Start (Sorensen et al.1987) | Tourism-related activities<br>Abnormal conditions (accident & evacuation)<br>Potential economic impacts<br>Community services impacts - abnormal conditions<br>Health and safety<br>Community satisfaction and voluntary out-migration<br>Family stability and organisation (family tensions)<br>Potential social and cultural impacts - abnormal conditions |
| Little Jackfish Hydro-electric Station near Armstrong Ontario (Social and Community Studies 1988; Coles 1988) | Tourism development plans and potential<br>Police services |
| Mississauga Derailment<br>(Whyte et al. 1979;<br>Institute for Environmental Studies 1981) | Potential economic impacts (accident)<br>Potential community infrastructure impacts - abnormal conditions<br>Potential community services impacts - abnormal conditions<br>Potential fiscal and administrative impacts - abnormal conditions<br>Potential social and cultural impacts- abnormal conditions |

| Case Study and Industrial Experience | Used in |
|---|---|
| Three Miles Island Accident (Governors Office on Policy and Planning 1980) | Potential economic impacts (accident) |
| Accident involving radioactive material in Goiana, Brazil (Petterson 1988) | Potential economic impacts (radioactive accident)<br>Potential social and cultural impacts - accident conditions |
| Atikokan : Closure of 2 iron mines and construction of Atikokan GS (Hancock et al. 1986) | Availability of housing<br>Health services |
| Single industry towns: Marathon and Manitouadge (Strafford and McMillan 1987) | Availability of housing<br>Adequacy of housing |
| Impacted Area of Wyoming (Massey 1977) | Adequacy of housing |
| Deaf Smith County, Texas (Stewart & Prichard 1987) | Property values |
| West Lincoln, Ont (OWMC site) (St. Catharines Standard Oct. 10, 1987; Future Urban Research 1987) | Property values<br>Existing environmental facilities, services and utilities<br>Municipal capital and operating costs<br>Property taxes and service charges |
| Proposed sanitary landfill in Windsor, Ont. (Ontario Municipal Board Decision: Hamilton Wentworth 1984) | Property values |
| Dallas Texas (Clayton Research Assoc. 1985) | Property values |
| Aggregate mining operation (McClellan 1983) | Property values |
| North Chicago Power Station (Blomquist 1983) | Property values |
| U.S. Nuclear Power Plants (Gamble et al. 1979) | Property values |
| Federal Airport Facilities (Beattie 1983) | Property values<br>Community infrastructure impacts - abnormal conditions (property values) |
| U.S. Nuclear Power Plants (U.S. Nuclear Regulatory Commission; Curry et al. 1977) | Existing environmental facilities, services and utilities (community infrastructure) |
| Oil Sands Mining Project (Alsands Project Group 1979) | Existing and new forms of transportation and communication<br>Family stability and organization |
| Western U.S. Coal Development, e.g. Colstrip, Montana (Greene and Curry 1977) | Educational facilities and services |
| Energy Projects in North Dakota (Halstead et al. 1983) | Educational facilities and services |
| Hat Creek Project (Strong, Hall and Associates 1978) | Educational facilities and services<br>Student drop out rate<br>Community cohesion |
| Northern Great Plains Resources Program, (Strong Hall & Assoc. 1978) | Educational facilities and services |
| Peace River Site - A Hydroelectric development (Lattey and Associates 1980) | Student drop out rate |
| The town of Fairbanks with regards to the Trans-Alaska Oil Pipeline (Dixon 1978) | Student drop out rate<br>Health and safety<br>Community cohesion |

| Case Study and Industrial Experience | Used in |
|---|---|
| Boom towns (Cortese and Jones 1979) | Existing and new forms of social services<br>Health and safety<br>Public interest and citizen organizations<br>Community culture and social structure<br>Community stability |
| Military base in Watertown, N.Y., (Sheehan 1988) | Local planning and administrative services (urban growth) |
| Town of Deep River and Chalk River Nuclear Laboratory | Municipal capital and operating costs |
| Closure of an iron ore mine in Scheffeville, Que. (Canada Employment and Immigration Advisory Council 1987) | Municipal capital and operating costs |
| Al Turi landfill facility, for waste form New Jersey & New York States (Edelstein undated) | Resident activities, use and enjoyment of property (nuisances) |
| Boom town (Finsterbusch 1982) | Resident displacement<br>Health and safety<br>Family stability and organization |
| Energy development in Wyoming (Weisz 1979) | Health and safety |
| Boom town growth in 4 western Colorado communities (Freudenberg 1979) | Health and safety<br>Family stability and organization |
| Low level radioactive waste facility in West Chicago (Williams & Olshansky 1987) | Health and safety (stress) |
| Energy Resource Developments in Rural areas in the west (Albrecht 1978) | Health and safety |
| Boom town (Gilmore 1976) | Health and safety (stress) |
| Boom Town of Gillette, Wyoming (Weisz 1980) | Health and safety (stress) |
| Hartsville Nuclear Power Development (Sundstrom et al. 1977) | Satisfaction with community and voluntary out-migration |
| Love Canal, New York,<br>(Toronto Daily Star, 1988; Holden 1980) | Satisfaction with community and voluntary out-migration<br>Potential social and cultural impact - accident conditions |
| Shutdown at Youngstown<br>(Buss and Redburn 1983) | Family stability and organization |
| James Bay project (Berkes 1988) | Land use & resource management (aboriginals) |
| MacKenzie Valley Pipeline (Berger 1977) | Traditional life style and culture |
| Boom Town (England and Albrecth 1984) | Community culture and social structure |
| Pilgrim and Millstone, two host communities for operating reactors (Peele 1976) | Community cohesion |
| Rock Springs - Green River, Wyoming, boomtowns (Gilmore and Duff 1975) | Community stability |
| Ontario Hydro Colonies<br>(Robson 1986) | Community stability |

| Case Study and Industrial Experience | Used in |
|---|---|
| Norman Wells Oil Expansion and Pipeline Project (Governor's Office of Policy and Planning 1980) | To incorporate **employment practices** that helped minimize the impact of the influx of the workforce:<br>- the Federal Government insisted on every effort to employ northerners and Aboriginal people;<br>- air commuting system spread job benefits without affecting Aboriginal communities;<br>- use of self-contained work camps for temporary workers;<br>- to incorporate a **continuous socio-economic monitoring** while the project is being implemented. |
| Elk Valley Settlement<br>(Suzanne Veit and Associates 1979) | Community stability |

Table D-6
Case Studies and Industrial Experience
Used in the Socio-Economic Impact Assessment
for the Identification of Potential Impact Management Measures

| Case Study and Industrial Experience | Used in |
|---|---|
| Low-Level Radioactive Waste (LLRW) facilities: Midwest Compact, Texas LLRW Authority, State of Massachusetts and the province of Ontario. (Energy Systems Research Group, 1987; The Siting Task Force on LLRW Disposal, (1989) | VOLUNTARY SITING APPROACH AND COMMUNITY LIAISON<br>- Federal LLRWD Siting Task Force report was a key reference for development of siting approach. All cases referred to here will likely involve community liaison committees. |
| Manitoba Hazardous Waste Management Corporation<br>Siting and implementation of a hazardous waste treatment facility (Castle, 1993) | VOLUNTARY SITING APPROACH AND COOPERATIVE IMPACT MANAGEMENT<br>- This case demonstrated effectiveness of voluntary siting process and "co-management" approach to impact management. |
| Alberta Special Waste Management Corporation/BOVAR Inc.<br>Siting and implementation of a hazardous waste treatment facility (M. Payne and Associates 1993) | VOLUNTARY SITING APPROACH AND COMMUNITY LIAISON MEASURES<br>- Key element in siting approach was voluntarism. Open communication and participation/educational programs important in implementation of facility. |
| Ontario Waste Management Corporation<br>Siting a hazardous waste management facility<br>(Laventhol and Horwath 1985; Clayton Research Associates 1985; Institute of Environmental Research 1988) | LIAISON COMMITTEES<br>- Joint community\proponent monitoring committee, comprised of local mun. authorities, local residents, government agencies and public interest groups. |
| Keephills Power Project,<br>a coal-fired power generating station in Alberta (Krawetz and MacDonald 1987) | LIAISON COMMITTEES<br>- Formal steering committee (a broad range of community interests participated) and community liaison committee (only local residents were members). |
| South Bay, Ontario<br>impacts of a mine closure (Robb Ogilvie Associates, 1981) | LIAISON COMMITTEES<br>- Manpower adjustment committee, comprised of company, labour and other interests. Committee was instrumental in the development and implementation of the Selco South Bay Closure Plan. |
| TVA's Hartsville Nuclear Power Plant | LIAISON COMMITTEES<br>- Committees with similar functions to the above were established |
| Hartsville Nuclear Power Facility, TVA<br>Provision of transportation for workers to the facility construction site. | MEASURES TO ENCOURAGE COMMUTING<br>- TVA purchased 31 buses and 150 vans at a cost of $3.5 million. Approximately 56% of workforce utilized this service. |
| South Texas Nuclear Project, provision of transportation for workers. (Leistritz and Murdock, 1981) | MEASURES TO ENCOURAGE COMMUTING<br>- A proponent sponsored transportation system helped 1,250 workers commute from distances up to 100 miles. |
| AECL, Provision of transportation for workers. | MEASURES TO ENCOURAGE COMMUTING<br>- AECL provides a bus service between Pembroke and its research facilities at Chalk River. |
| Ontario Hydro, Provision of transportation for workers. | MEASURES TO ENCOURAGE COMMUTING<br>- Hydro provides bus service from Port Elgin and Kincardine to the Bruce Nuclear Power Development. |
| Saskatchewan, uranium mine workers, workforce rotation system | MEASURES TO ENCOURAGE LONG DISTANCE COMMUTING<br>- Fly-in systems have been used since 1975 |

| Case Study and Industrial Experience | Used in |
|---|---|
| Northwest Territories, frontier oil and gas exploration projects (Robinson & Newton, 1987) | MEASURES TO ENCOURAGE LONG DISTANCE COMMUTING<br>- Utilize a workforce rotation fly-in system. |
| Canadian gold, uranium and lead/zinc mines, (36%) offer fly-in and schedule arrangements. (Storey & Shrimpton, 1988) | MEASURES TO ENCOURAGE LONG DISTANCE COMMUTING<br>- Fly-in arrangements and 14 companies indicate a wide variety or schedule combinations. Currently in use for workforces ranging from 45 to 440 employees. |
| Construction work camps:<br>Churchill Falls Hydroelectric Project development; Port lepreau Nuclear Power Station;<br>AECL's Glace Bay Heavy Water Plant; Come,By.Chance Refinery;Venture and Hibernia, on-shore camps for the off-shore hydrocarbon projects;<br>Bruce Nuclear Power Development; Atikokan Generating Station (Gardner 1985) | PROVISION OF TEMPORARY ACCOMMODATION<br>- Construction workcamps varying in size from 200 to 6,000 persons. |
| Many cases,relating primarily to isolated single-industry communities associated with mining developments:<br><br>- Tumbler Ridge<br>- Elliott Lake and South Bay, Ont.<br>- Uranium City, Sask.<br>- Fort MacMurray, Alberta.<br>- Thompson, Lynn Lake and Leaf Rapids, Manitoba,<br>- Labrador City, Nfld. | NEW TOWN DEVELOPMENT<br><br>- In all of these cases, the workforce was housed in a fully-serviced residential townsite located within commuting distance of the facility. |
| Ontario Waste Management Corporation for the development of a hazardous waste facility. | NUISANCE EFFECT MANAGEMENT MEASURES<br>- Has proposed the double glazing of windows and the provision of air conditioning as mitigative measures for properties within their severe impact zone. |
| Ontario Hydro<br>In general, and specifically at Nanticoke Generating Station. | NUISANCE EFFECT MANAGEMENT MEASURES<br>- Hydro routinely cleans properties affected by blowing coal dust near their generating stations. An industrial influence area was established around Nanticoke GS which restricts the levels of residential development and incompatible land use |
| Ontario Hydro<br><br>At Darlington and Wesleyville projects, at the Bruce NPD and at Atikokan. It is common practice for Hydro to improve and modify access routes as a form of impact management. | ACCESS MODIFICATIONS AND RESTRICTIONS<br>- Hydro has built special interchanges on limited access highways to provide direct routes to Darlington and Wesleyville projects, and minimize use of local roads. Roads in Bruce county were upgraded to standards to handle large volumes of traffic created by BNPD.<br><br>A municipal road was extended to provide access to Atikokan GS. |
| Ontario Waste Management Corporation<br><br>West Lincoln Facility | ACCESS MODIFICATIONS AND RESTRICTIONS<br>- OWMC intends to fund road modifications to improve safety and traffic flow along access routes to its West Lincoln facility.<br>It also intends to enforce use of designated access routes to its facility through contractual arrangements with carriers. |
| Ontario Hydro<br>Atikokan Generating Station<br>(Hancock et al. 1986)<br><br>(Also Bruce and Darlington NGS) | IMPACT ASSISTANCE GRANTS<br>- Atikokan agreement allowed for advance payments to the community for road improvements and maintenance. Assistance also provided for crisis housing, library facilities, medical clinic. Other special Grants also administered. Payments made over 9 years totalled $1 375 694.<br><br>- Similar but less extensive assistance provided at Darlington and Bruce NPD. |

| Case Study and Industrial Experience | Used in |
|---|---|
| Texas, LLRW facility<br><br>Similar agreements for LLRWF in Massachusetts, the Mid-West and Appalachian compacts.(Energy Systems Research Group 1987) | IMPACT ASSISTANCE GRANTS<br>- A program administered by a citizens advisory committee calls for annual payments for offset documented impacts to public service costs.<br>- Similar for LLRWF in Massachusetts. |
| Elliott Lake, local mining companies. (ELECT 1986) | IMPACT ASSISTANCE GRANTS<br>- Cost of water and sewage facilities split between the town ($11 million), the province ($11 million), and local mining companies ($5.7 million) |
| Ontario Hydro: Atikokan<br>(Hancock et al. 1986) | LOCAL PLANNING AND TECHNICAL ASSISTANCE<br><br>- At Atikokan, Hydro funded the hiring of a planning coordinator, the development of an official plan and development of municipal finance studies. |
| Ontario Hydro: Darlington | - At Darlington, the CIA with the town of Newcastle calls for Hydro to provide financial assistance for the development of a strategy, studies and monitoring for impact assessment. Also for legal and consulting fees. |
| Ontario Hydro: Bruce | - At Bruce, Hydro has provided funds for the preparation of official plan documents for Bruce Twp. |
| Tennessee Valley Authority<br>(Halstead et al., 1982) | LOCAL PLANNING AND TECHNICAL ASSISTANCE<br>- TVA provides funds to offset planning staff costs and provides staff assistance in preparing plans and ordinances for the local government. |
| Ontario Hydro at its Bruce Nuclear Power Development | PROPERTY VALUE PROTECTION<br>- In 1974 Hydro established a guaranteed purchase program for an area 8km from on-site facilities. No termination date set for the program, but in 1983 it was cancelled when no decline in property values occurred. Purchased properties were resold by Hydro on the open market. |
| Ontario Waste Management Corporation<br>for hazardous waste treatment and disposal centre at West Lincoln, Ont.<br>(Armour, 1987) | PROPERTY VALUE PROTECTION<br>- A proposed program which includes provisions for guaranteed purchases and a buy-out option for certain properties within a projected nuisance impact area where adverse effects are likely to occur. |
| LLRW facilities in New York and Massachusetts and the Mid-West Compact<br>(Energy Systems Research Group Inc., 1987) | PROPERTY VALUE PROTECTION<br>- Proposed programs, similar to the two above. The program could form part of the operating contract between the proponent and the community. |
| Ontario Ministry of Government Services<br>for Parkway Belt Planning Areas. | PROPERTY VALUE PROTECTION<br>- Program was intended to offset the potential financial hardships and uncertainty of property owners affected by the imposition of strict land use controls within Parkway Belt Planning Areas. The Ministry would purchase the property if several criteria were met. |
| Ontario Hydro<br>Bruce Nuclear Generating Station<br>- for Port Elgin | COMMUNITY HOUSING DEVELOPMENT<br>- Hydro provided full guarantees of full occupancy for a negotiated time period to private developers to stimulate apartment style housing in Port Elgin. |

| Case Study and Industrial Experience | Used in |
|---|---|
| Mining Companies in North America.<br>Eg. Rio Algom Mines,<br>Denison Mines in Elliott Lake | COMMUNITY HOUSING DEVELOPMENT<br>- Activities tended to focus on direct investment or the construction of housing units. Rio Algom and Denison built 3,600 housing units at Elliott Lake in the early 80's. |
| Ontario Hydro and AECL in Deep River for Des Joachims | COMMUNITY HOUSING DEVELOPMENT<br>- OH and AECL both built and maintained housing in Deep River to accommodate staff. Hydro built a 40 unit subdivision to accommodate staff at Des Joachims GS. |
| Manitoba Hydro, Norther Flood Agreement for Hydroelectric development (Halstead et al., 1983; Northern Flood Agreement, 1977) | DIRECT FINANCIAL COMPENSATION ETC.<br>- A clause in the agreement stipulates that each acre of Indian land affected by the development shall be replace by not less than four acres of other lands. Also Manitoba Hydro has agreed to assume responsibilities for dock replacement and new roads, houses and other facilities. |
| Hydro Quebec, impact agreement for the James Bay Project | DIRECT FINANCIAL COMPENSATION ETC.<br>- Provides local trappers and loggers with access to new areas in order to replace their loss due to flooding or environmental disruption. |
| Skagit County, Washington. Siting of two Nuclear Power Plants. (U.S. EPA, 1982) | DIRECT FINANCIAL COMPENSATION ETC.<br>- Proponent agreed to construct a fish hatchery to address the issue of fish kills on the Skagit River. |
| Canadian Mining Companies and Aboriginal Peoples.<br>(Sub-Committee of the Intergovernmental Working Group on the Mineral Industry, 1991) | DIRECT FINANCIAL COMPENSATION ETC.<br>- Compensation clauses for the direct losses due to mining related operations included in socio-economic agreements between mining companies and Aboriginals. |
| British Columbia, aggregates company<br>(Sub-Committee of the Intergovernmental Working Group on the Mineral Industry, 1991) | DIRECT FINANCIAL COMPENSATION ETC.<br>- Pays lease rental fees for its plant located on an Aboriginal Reserve, royalties and riparian fees along with transportation fees for travel across their lands. |
| LLRW facilities<br>-Massachusetts (Energy Systems Research Group, 1987) | DIRECT FINANCIAL COMPENSATION ETC.<br>- One dollar per curie, one dollar per cubic foot, and four percent of the annual gross revenues of the plant are paid to the host community, plus one percent is divided among neighbouring communities. |
| Anaconda Company, closure of a smelting operation near Butte Montana in 1980 and resulting in the loss of 1,000 jobs. | DEVELOPMENT OF UFDC CLOSURE PLAN<br>- To offset the decline, the company made a grant of $5 million to three area cities. Grant used for development of industrial parks, low interest loans to industries and the establishment of economic development offices. |
| U.S. Department of Defense, closure of defense bases (and cancellation of defense contracts) by an Economic Adjustment Committee. | DEVELOPMENT OF UFDC CLOSURE PLAN<br>- Committee assists with the planning of revitalization efforts and when a base closes, property and facilities are often turned over to the local municipality. |
| TVA's cancellation of their:<br>- Phipps Bend,<br>- Yellow Creek, and<br>- Hartsville Nuclear Stations in the early 1980's. Eliminated 10,000 construction jobs | DEVELOPMENT OF UFDC CLOSURE PLAN<br>- TVA implemented a program provided funds and training to assist workers in skills development. More specifically: funding for training, funded portion of economic development office, interest free loans for investment etc. Total cost of program $6 million ($3.2 million recoverable from loan payments) |

| Case Study and Industrial Experience | Used in |
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| Township of Atikokan, and Provincial and Federal Governments, when faced with mine closure and loss of 1,000 jobs | DEVELOPMENT OF UFDC CLOSURE PLAN<br>Developed:<br>- Atikokan Industrial Dev. Committee (73)<br>- Economic Dev. Commissioner,hired in 78<br>- Joint manpower Assess. and Plan. Committee '78<br>- Atikokan Dev. Corp, est. '78<br>- Tourism Coordinator '80<br>- Various studies on economic development. |
| Ontario Hydro and government and Community Leaders, eg. Selco South Bay Mine Closure (Robb Ogilvie Associates Ltd., 1988) | DEVELOPMENT OF UFDC CLOSURE PLAN<br>- Developed a 5 yr program designed to offset problems created by loss of 3 500 construction jobs. Program focused on industrial and commercial expansion, tourism and real estate promotion. |
| Government of Saskatchewan | PREFERENTIAL HIRING<br>- Requires that Northern Mining companies maximize the employment of residents of norther communities and reserves. |
| Limestone Project, A hydroelectric facility in Manitoba, Manitoba Hydro. (Manitoba Hydro 1986) | PREFERENTIAL HIRING<br>- In 1983 Manitoba Hydro initiated a review of all collective agreements for hydroelectric development, projects. Negotiations with unions resulted in strengthening the preference clauses. It stipulated the number of northerners and Natives to hire in each job category. This case resulted in the negotiation of the Canada-Manitoba Limestone Project Employment and training Agreement, to coordinate services and programs. |
| LLRW facilities in :<br>- Mid-West Compact<br>- Texas LLRW Authority<br>- State of New York<br>- State of Massachusetts.<br>(Energy Systems Research Group Inc., 1987) | PREFERENTIAL HIRING<br>- Local hiring programs are proposed at these LLRW management facilities. |
| Limestone Project, Hydroelectric facility in Manitoba.<br>By Manitoba Hydro and the federal government. | OCCUPATIONAL TRAINING<br>- Community based training was established in 7 norther communities. A variety of institutional based programs were established. The Limestone Training and Employment Agency with the Ministry of Education oversees the training program. Costs of program covered by formal agreement (the Canada-Manitoba Limestone Project Employment and Training Agreement) |
| Mining companies in Northern Saskatchewan.<br>With Saskatchewan Education, as a condition of their Surface Leases must negotiate a Human Resource development Agreement.<br>Also Dome Exploration Canada Ltd.<br>(Sub-committee of the Intergovernmental Working Group on the Mineral Industry, 1991) | OCCUPATIONAL TRAINING<br>- A wide variety of occupational training programs instituted i.e. Mine-Mill Pre-Employment Programs, Underground Miner Helper Program, Transitional Apprenticeship Training.<br><br>- Similar programs also instituted by Dome Exploration Canada Ltd. |
| Limestone Hydroelectric Project in Northern Manitoba.<br>Under a Canada-Manitoba Agreement<br>(Manitoba Department of Employment Services, Northern Employment Support Services, NESS) (Manitoba Hydro, 1986) | EMPLOYMENT SUPPORT SERVICES<br>- NESS coordinated placement/referral services through regional offices, established a counselling centre at project site and hired counselling staff. NESS staff also prepared families for the project by orientation sessions etc. |
| Ontario Hydro, Little Jackfish Hydroelectric Project near Armstrong. | EMPLOYMENT SUPPORT SERVICES<br>- Hydro has proposed to assist Prov. and Fed. Gov't in the provision of union membership cost assistance. Hydro plans to hire community Liaison officer for assisting local residents. Hydro has also done similar at Bruce NPD where qualified construction phase workers were offered operations jobs. |

| Case Study and Industrial Experience | Used in |
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| Dome Exploration, Canada Ltd.<br>(Subcommittee of the Intergovernmental Working Group on the Mineral Industry, 1991) | EMPLOYMENT SUPPORT SERVICES<br>- Dome provides special work schedules to allow Aboriginal employees to engage in traditional activities and offers choice of language for employment interviews. |
| Manitoba Hydro for its Limestone Hydroelectric Project Including its contractors ie. Canadian General Electric.<br>(Manitoba Hydro, 1986) | BUSINESS ACTIVITY ENHANCEMENT<br>- Manitoba Hydro requires that all project contractors identify their suppliers and sub-contractors. Northern and native content in these tenders is given consideration. A business info centre and regional communication strategy have also been established. They have also secured commitments from major contractors to make investments and purchases within the province ie. Canadian General Electric has committed $2 million for such assistance until 1994. |
| Hydro Quebec for the James Bay hydroelectric Project<br>(Halstead et al., 1983) | BUSINESS ACTIVITY ENHANCEMENT<br>- An agreement between Hydro Quebec, Northern Native org's and the fed. gov't in the early '70's formed the James Bay Native Development Corporation. The corporation assists and promotes businesses and industries in the James Bay Area. |
| Mobil Oil Canada Ltd.<br>-off-shore loading platforms<br>(Leistritz and Murdock, 1981) | OFF-SITE FABRICATION OF COMPONENTS<br>- Mobil has proposed to fabricate its off-shore loading platforms at a distant shipyard and then move components for final assembly on-site |
| Idaho, USA, Hazardous Waste Management Facility. - Wes-Con Inc.<br>(Texas Advisory Commission on Intergovernmental Relations, 1985) | CO-USE MEASURES AND ACQUIRED PROPERTY MANAGEMENT<br>- In siting, Wes-Con made its fire-fighting equipment available to qualified residents. |
| Ontario Hydro at its Pickering and Darlington Sites. | CO-USE MEASURES AND ACQUIRED PROPERTY MANAGEMENT<br>- The information centres at these sites are made available for other community activities. |
| Hydro Quebec<br>In general and specifically at the James Bay Hydroelectric Project | CORPORATE DONATIONS<br>- They allow a maximum budget of 1% of the construction costs of transmission lines and substations, and 2% of the const. costs of gen. stations for funding of enhancement initiatives, over and above regulatory and impact management requirements. |
| Wes-Con Inc.<br>in siting a hazardous waste mgmt. facility in Idaho USA.<br>(Texas Advisory Commission on Intergovernmental Relations, 1985) | CORPORATE DONATIONS<br>- Wes-Con made donations to local charities and helped support recreation events. Other targeted areas are scholarships for local students,educational and health equipment, seminars and conferences. |
| Uranium operators in Norther Saskatchewan<br>eg. Hudson Bay Mining and Smelting Company<br>(Sub-committee of the Intergovernmental Working Group of the Mineral Industry, 1991) | CORPORATE DONATIONS<br>- In 1990, two uranium operators offered $40,000 in scholarships and plan to increase future contributions.<br><br>- Specifically, the Hudson Bay Mining and Smelting Company has established a scholarship fund. |
| Appalachian Compact<br>(Energy Systems Research Group Inc., 1987) | COMMUNITY LIAISON MEASURES<br>- Will provide funding for the host community to hire a full time independent inspector for their proposed low level radioactive waste facilities. |

| Case Study and Industrial Experience | Used in |
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| Ontario Hydro, and other utilities, for communities near power-generating stations. | COMMUNITY LIAISON MEASURES<br>- Conduct a diverse range of information/education activities in the nearby communities, as well as, along transportation routes and throughout the province. |
| Oil sands Mining Project, Alberta.<br>(Alsands Project Group, 1979 | COMMUNITY LIAISON MEASURES<br>- A neighbourhood aid program was proposed for a new town development associated with the mining project. |
| Ontario Hydro, at its Nuclear Stations.<br>(Other examples are provided in various resource development agreements between First Nations, the Canadian and provincial governments.) | NOTIFICATION<br>- Hydro has developed informal notification procedures at nuclear stations that are designed to ensure that the local community is kept informed of the nature and circumstance of on-site events. |
| Chemical Producers Association.<br>(Chemical Producers Association, undated) | EDUCATION AND AWARENESS PROGRAMS<br>- Have developed a "community right-to-know" policy and codes of practice regarding community awareness and emergency response for its member companies. Community awareness programs are implemented at each research, chemical manufacturing, storage, handling and disposal sites. |

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# APPENDIX E

## HUMAN HEALTH EFFECTS FROM EXPOSURE TO IONIZING RADIATION

# APPENDIX E

# HUMAN HEALTH EFFECTS FROM EXPOSURE TO IONIZING RADIATION

## 1.0 INTRODUCTION

The purpose of this Appendix is to summarize the health effects that may be associated with human exposure to ionizing radiation. Ionizing radiation can disrupt molecules within cells, and cause a variety of biological changes. But, since life has evolved in an environment where significant exposure to ionizing radiation has always been present, adaptive responses have also developed which repair most of this molecular damage, so that gross changes are rarely seen.

The effects of radiation exposure[1] on the whole organism depend on many factors including the form of radiation; the degree of exposure, or dose; the rate of delivery of the dose, whether "acute" or "chronic" (prolonged over time); and the organ or tissue exposed. Detailed reviews of the biological effects of radiation exposure can be found in recent reports of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR 1986, 1988), the Committee on the Biological Effects of Ionizing Radiations of the U.S. National Academy of Sciences (BEIR V 1990) and the International Commission on Radiological Protection (ICRP 1991), among others.

Large radiation doses can damage or kill plants, trees and animals, as well as humans. In general, the doses required to affect large mammals are similar to those which harm humans; lower species are increasingly more resistant.

Environmental radiation protection practices are based on the premise that the standard of control necessary to protect humans will ensure that other species are not put at risk. These practices may occasionally allow individual members of non-human species to be harmed, but will not endanger whole species, or create an imbalance between species (ICRP 1991).

The biological effects of radiation exposure can be divided into two general classes, termed by the ICRP "stochastic" and "deterministic".

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1 In this appendix, radiation exposure is to be taken to imply exposure to ionizing radiation.

## 2.0 STOCHASTIC EFFECTS

The main concerns arising from exposures to low doses of radiation are changes in a living cell that produce gross effects such as cancers and heritable (genetic) damage. The deposition of energy by ionizing radiation is a random (stochastic) process, so that even at very low average doses sufficient energy can be deposited in critical sites within a cell to cause changes in its function. When unrepaired changes remain in the programme structure (the DNA) of even a single cell, gross effects on the whole animal, such as cancer or a genetic change, may result. These effects have therefore been called stochastic, and it has been assumed that when large populations are exposed to low doses, a few individuals may develop cancers or genetic damage.

However, it is not possible to distinguish the effects caused by low doses of ionizing radiation from the large number of cancers and genetic changes arising from other causes. As a result it is presently impossible to demonstrate a dose-response relationship at low doses, and, in particular, a level below which no effects are caused (a threshold). In this Report, Ontario Hydro follows the Recommendations of the ICRP and when making risk calculations, assumes that the risks of stochastic effects remain at the lowest doses received.

### 2.1 Cancers

The chief form of stochastic radiation damage is the development of cancers. Clear evidence of an increased incidence of human cancer following exposure to doses of radiation greater than 0.2 Gy [2] is found in studies of the survivors of the atomic bombings of Hiroshima and Nagasaki in 1945. This population, containing full age ranges of both sexes, exposed to a wide range of doses and followed now for more than 40 years, is the foundation of human radiation risk estimation for low dose exposure. Additional valuable information derives from studies of populations irradiated in the course of medical treatment, or exposed in an occupational environment. However, these studies lack statistical power, or have other methodological weaknesses that limit their usefulness.

Recent analyses of the cancer experience of these populations by UNSCEAR (1988), BEIR V (1990) and ICRP (1991) have led to estimates of risk several-fold greater than those accepted in 1977, when the last general recommendations of the ICRP (1977) were issued. This increase, from a (worker-age and sex) averaged value of $1.25 \times 10^{-2}$ $Sv^{-1}$ to $4 \times 10^{-2}$ $Sv^{-1}$ is due mainly to three factors: (1) new estimates of dose to the survivor population only some 50 to 70% of those of previous estimates; (2) increased numbers of cancers following 11 additional years of follow-up, beyond those projected in 1977; and (3) improved methods of statistical and biological modelling, and particularly the acceptance of relative rather than absolute risk models for projection of risk to end of life.

2 Gray gives the amount of energy absorbed in tissue, whereas sievert represents the absorbed dose times a biological effectiveness factor, which is 1 for photons and electrons, and 20 for alpha particles.

Risk of radiation-induced fatal cancer depends strongly on age at time of exposure, and is generally higher for younger ages. The overall risk, however, is not markedly different between males and females. Table E-1 summarizes the age-specific risks given by ICRP (1991); UNSCEAR (1988) and BEIR (1990) findings are not significantly different. Table E-2 divides the overall risk into estimates of cancers caused in the most sensitive organs and tissues. Much more detail can be found in the references previously cited.

ICRP (1991) has recommended estimates of the overall risk of radiation-induced fatal cancers, for human populations under conditions most commonly found in the workplace, or as a result of environmental exposure. For a worker age distribution the risk is $4 \times 10^{-2}$ $Sv^{-1}$. For the general public the risk is $5 \times 10^{-2}$ $Sv^{-1}$.

The risks given in Table E-2, which apply for lifetime exposure at low dose rates, have been reduced from the values derived directly from the Japanese data by a factor of 2, as were those accepted in 1977. A major source of uncertainty in the application of data derived from studies of populations irradiated acutely to high doses to the low dose and dose rate exposures found in occupational or environmental conditions is the choice of an appropriate value for the Dose and Dose Rate Effectiveness Factor (DDREF). In numerous studies of experimental laboratory animals irradiated under a variety of exposure conditions, the effectiveness of high dose and dose-rate exposure has been shown to be a factor of 2-10 times greater for the induction of cancers than that of low dose/dose rate conditions. Little human data is available from which to derive a comparable estimate, and the value of 2 has been generally accepted as reasonable (NCRP 1980; UNSCEAR 1988; ICRP 1991).

This extrapolation constitutes one of the major sources of uncertainty in the present estimates of risk of radiation-induced cancer, although other sources, such as the need to project risk over the remaining lifetime of study populations, also contribute significantly. Overall risk estimates are now believed to be uncertain by no more than a factor of about 2 or 3, significantly less than the order-of-magnitude uncertainty accepted in 1977.

A special form of cancer risk arises from the inhalation of radon, a radioactive gas which, together with its short-lived, $\alpha$ particle-emitting progeny, is associated with deposits of uranium, and is of particular concern in enclosed mining environments. An elevated mortality from bronchial (lung) cancer observed in various miner populations has been attributed, in large part, to their chronic exposures to high radon concentrations. Historically, the unit of radon exposure is the Working Level Month (WLM), which corresponds to 170 h of exposure in an atmosphere containing $1.3 \times 10^5$ MeV of potential $\alpha$-particle energy per litre (nominally 100 $pCi \cdot L^{-1}$ radon in equilibrium with its decay progeny). The relevant dosimetry, and the epidemiological analyses of these special populations are complex, and risk estimates continue to evolve. BEIR IV (1988) provides a thorough review of these data, and estimates the average lifetime lung cancer mortality risk to be $3.5 \times 10^{-4}$ per WLM. This report uses $3 \times 10^{-4}$ per WLM, the value recommended by ACRP-12 (1990).

**TABLE E-1**

**Lifetime Excess Cancer Mortality After Exposure to 0.1 Sv Acute Whole Body Irradiation**

| | Probability of Death ($10^{-3}$) | |
|---|---|---|
| Age at Exposure | Males | Females |
| 5 | 12.8 | 15.3 |
| 15 | 11.4 | 15.7 |
| 25 | 9.2 | 11.8 |
| 35 | 5.7 | 5.6 |
| 45 | 6.0 | 5.4 |
| 55 | 6.2 | 5.1 |
| 65 | 4.8 | 3.9 |
| 75 | 2.6 | 2.3 |
| 85 | 1.1 | 0.9 |
| Average for a Worker Age Distribution | 7.7 | 8.1 |

References: BEIR V (1990); ICRP (1991). This Table describes the distribution of cancer mortality with age following an acute exposure to a moderately high dose of ionizing radiation, and does not include the reduction factor (DDREF) expected to apply at low doses and dose rates.

**TABLE E-2**

**Age-Averaged Lifetime Excess Cancer Mortality After Exposure to Low Doses of Uniform Whole Body Radiation**

| Organ or Tissue | Probability of Death ($10^{-4}$ $Sv^{-1}$) | Relative Importance |
|---|---|---|
| Bladder | 30 | 0.06 |
| Bone Marrow | 50 | 0.10 |
| Bone Surface | 5 | 0.01 |
| Breast | 20 | 0.04 |
| Colon | 85 | 0.17 |
| Liver | 15 | 0.03 |
| Lung | 85 | 0.17 |
| Oesophagus | 30 | 0.06 |
| Ovary | 10 | 0.02 |
| Skin | 2 | 0.00 |
| Stomach | 110 | 0.22 |
| Thyroid | 8 | 0.02 |
| Other Organs | 50 | 0.10 |
| TOTAL | 500 | 1.00 |

Reference: ICRP (1991). This Table describes the distribution of cancer mortality for a full population age-distribution by cancer site following exposure to ionizing radiation at low doses and dose rates. The value of DDREF recommended by the ICRP (DDREF = 2) has been applied.

## 2.2 Genetic Damage

Detailed reviews of radiation-induced genetic risk can be found in UNSCEAR (1986; 1988), BEIR V (1990) and ICRP (1991).

Genetic changes have not been demonstrated in irradiated human populations. For example, there has been no statistically detectable increase in heritable defects in more than 30 000 children born of parents who received average gonad doses greater than 0.4 Gy in the bombings of Hiroshima and Nagasaki in 1945. However, extensive studies of large numbers of highly irradiated experimental animals (mainly mice) have demonstrated the possibility of such changes. The estimates of risk derived from these studies are believed to be conservative when applied to man.

Heritable changes include both gene mutations and gross chromosomal aberrations. In its recent recommendations the ICRP assumes a risk of genetically-significant harm of $1.0 \times 10^{-2}$ $Sv^{-1}$ for the general public and, because of the restricted age distribution, $0.6 \times 10^{-2}$ $Sv^{-1}$ for a worker population. These values can be compared to the values of $0.4 \times 10^{-2}$ $Sv^{-1}$ for genetic harm expressed in the first 2 generations, and about twice that value for all succeeding generations, contained in the 1977 Recommendations. The similarity of these estimates reflects the lack of significant new information during the period, and the continued reliance on animal data. The relative importance of genetic damage to the overall risk at low doses and dose rates is now somewhat less (only about 15%) than was estimated in 1977. This remains, however, an area of continuing research.

Risk estimates derived mainly from experimental studies with laboratory animals are complicated by the differences in reproduction and development between rodents and man. In general, in these species, there is no evidence that exposure of the mother prior to conception carries any greater risk of genetically-transmitted harm than that of the father. Similarly there is no consistent evidence of a large differential sensitivity for mutation induction between the various stages of development of the germ cells, but this remains an area of study. All of these risks, however, are likely to be very small under most exposure conditions, in comparison to the "natural" prevalence of inherited disorders in man, for mutations, at least 1% of live births, and 6% for all congenital anomalies.

## 2.3 Overall Risk of Stochastic Detriment

The nominal risk coefficients derived by the ICRP (1991) for the overall detriment from stochastic effects are $5.6 \times 10^{-2}$ $Sv^{-1}$ and $7.3 \times 10^{-2}$ Sv for worker and general public populations, respectively. These estimates are increased about 20% from the sums of the risks discussed in Section 2.1 and 2.2 to allow for other less serious forms of detriment, such as non-fatal cancers.

## 3.0 DETERMINISTIC EFFECTS

Large doses of radiation produce sufficient damage in a cell to cause its death. Death of one or a small number of cells in a tissue will usually be of no consequence, but when sufficient fractions of the cells are killed, changes in the function of the organ will be detectable. The level of damage, and therefore dose, required to effect detectable change constitutes a threshold, and depends both on the organ or tissue, and on the chosen level of injury. As dose increases beyond the threshold, increasing severity of effect will be observed. Such injuries that result from the collective killing of a substantial number of cells are termed non-stochastic, or deterministic, and are associated only with high levels of exposure.

Therefore, the effects described in this section occur only at doses much greater than those received by radiation workers, and are many orders of magnitude greater than those that could be received by any member of the public as a result of normal operating conditions.

Most important organs of the body suffer significant functional changes following exposure to sufficiently high doses of radiation. UNSCEAR (1982) and ICRP Publication 41 (1984) describe diverse effects that have been observed, largely in medical patients who have received very high doses of therapeutic radiation. These effects occur, most importantly, in the skin, haematopoietic (blood forming) system, gastrointestinal tract, thyroid, eye and reproductive organs. The threshold for clinically significant damage to any of these organs is high, more than 1 Gy, even when the doses are received acutely.

When exposure is prolonged over periods of weeks or longer, or when exposure results from the retention of radioactive materials in the body, repair and repopulation of these tissues increases these thresholds substantially. For example, the radiation dose required to cause mild erythema (reddening) of the skin is about 6 to 8 Gy acutely received, but more than 30 Gy when exposure is distributed over a month or more. Similarly, the threshold for hypothyroidism resulting from intakes of radioiodines is at least 7 Gy, even for young children, and much greater for an adult. In comparison the limit allowed for the exposure of any single organ of a worker is no more than 0.5 Gy per year, and much less for many organs. For the public the limits are generally 10-fold less. Table E-3 summarizes the thresholds of response for deterministic effects in the major organs and tissues of interest.

Of special concern are the early effects in man that could result from exposure to high doses of whole body radiation, such as could occur during a hypothetical reactor or transportation accident. UNSCEAR (1988) describes current knowledge of these effects in a detailed Annex, which also incorporates information derived from the Chernobyl disaster. Blood cells are among the most radiosensitive indicators of radiation exposure in the human body, and measurable changes can be observed within minutes after acute doses in excess of 1 Gy. Chromosome aberrations in these cells are detectable at much lower doses, down to about 0.1 Gy, but these aberrations are not associated with immediate, life threatening effects. At doses up to about 2 Gy, gross blood system damage is reversible, and a healthy individual normally recovers fully. At higher doses the probability of death occurring over the following few weeks increases, depending on the state of health of the individual and the standard of supportive medical care available, so that the mean lethal whole body dose of about 2.5 Gy for an untreated individual rises to 5 Gy or more with appropriate medical treatment. At doses of about 9 Gy or greater damage to the lungs, GI tract or, at the highest doses, the central nervous system would likely cause death, even with the best medical treatment.

A special class of deterministic effects applies to exposures which occur before birth. These effects are described separately in Section 4.

**TABLE E-3**

**Thresholds for Deterministic Effects in Major Organs Following Acute Radiation Exposure[1]**

| Organ or Tissue | | Effect | Approximate Acute Threshold (Gy) |
|---|---|---|---|
| Skin | | mild burn | 6-8 |
| Bone marrow (blood system) | | WBC depression | 1 |
| GI Tract: | stomach<br>intestines | nausea<br>ulceration | 1<br>10 |
| Gonads: | testis<br>ovary | sterility<br>sterility | 3-5<br>2-3 |
| Thyroid: | (adult)<br>(child) | hypothyroidism<br>hypothyroidism | 25-30[1]<br>7-14[1] |
| Eye lens | | cataract | 2 |
| Lung | | fibrosis | 8-10 |
| Bone: | (adult)<br>(child) | fracture<br>arrested growth | 60[1]<br>20[1] |
| Central nervous system | | myelitis | 30[1] |

[1] except as noted, where only prolonged exposure data are available

Reference: UNSCEAR(1982)
ICRP(1984)

## 4.0 DAMAGE RESULTING FROM IN UTERO EXPOSURES

For many years the human embryo and fetus have been recognized to be highly sensitive to the effects of radiation exposure. Because of rapid cell proliferation and migration, and the fine coordination of events that must occur in the development of complex tissue structures, many opportunities for disruption of these patterns arise.

UNSCEAR (1986) and ICRP (1986) are important references to an understanding of these effects. In general, three distinct biological effects are of concern lethality, malformations and cancers.

### 4.1 Early Lethality

High doses during the pre-implantation period, corresponding in man to the first 2-2.5 weeks after conception, result in loss of the early embryo. In rodents there exists a threshold in dose of at least 0.05-0.10 Gy for this loss. Offspring, however, that survive exposure at this time appear undamaged, as events leading to teratogenesis appear incompatible with survival at this stage.

### 4.2 Malformations

In the following period of major organogenesis, ending in man at approximately 8 weeks after conception, exposure of rodents beyond a similar threshold of about 0.05-0.10 Gy leads to gross malformations, particularly skeletal defects. Malformations of this kind have not been observed in human populations irradiated in utero. However, related effects on the development of the brain have been clearly demonstrated. Severe mental retardation (SMR) and less serious forms of mental deficiencies have been observed in the populations irradiated in utero during the bombings of Hiroshima and Nagasaki. A detailed analysis of these observations is summarized in ICRP Publication 49 (1986). Risk estimates for SMR derived from these data are 0.4 $Gy^{-1}$ for exposure in the 8-15 weeks after conception, with a lesser risk of 0.1 $Gy^{-1}$ in the following period from 16-25 weeks. No elevated risk is seen outside this period of maximum development of brain structure, and particularly in the period earlier than 8 weeks after conception. A corresponding risk of lesser degrees of brain damage has been estimated as 30 IQ points per gray in the 8-15 week period. Although the data are consistent with a threshold up to 0.2 Gy, present mechanistic knowledge is insufficient to support such a conclusion, and radiation protection practices now assume some risk at all levels of exposure.

### 4.3 Induced Cancers

The risk of post-natal cancer as a result of in utero radiation exposure has been a subject of controversy since, more than 30 years ago, Stewart et al. (1958) reported an elevated risk of childhood cancer, mainly leukemia, occurring in the first 10 years of life, among children in England whose mothers had received diagnostic x-ray exposure during pregnancy. Subsequent studies of medically-irradiated populations have tended to confirm these results. The smaller risks seen in the approximately 1 600 children exposed in utero to higher doses at Hiroshima and Nagasaki are only marginally at variance with these results.

Risk estimates accepted by ICRP (1991) assume that the risk of childhood cancers induced in utero is similar to that for irradiation at a young age, and probably several-fold greater than the risk of cancer induction in adults. None of these studies, however, has followed these pre-natally exposed populations for sufficient time to demonstrate the risk for the induction of cancers later in life, when most cancers occur.

Some early analyses have suggested a variation in sensitivity for the induction of post-natal cancers with variation in time of exposure through gestation, with the greatest sensitivity occurring during the first trimester. These conclusions are no longer accepted by many experts in the study of radiation effects. The ICRP (1991) assumes constancy of risk throughout pregnancy.

## 5.0 RECENT DEVELOPMENTS

Three general groups of studies, only recently reported or still underway, deserve discussion.

### 5.1 Studies of Cancer in Populations Living Near Nuclear Facilities

Increasingly in the years since 1983, concern has been directed at the risk of cancer in populations living near nuclear facilities. In that year a television documentary in the UK revealed that in the period 1950-83, in the small town of Seascale near the nuclear complex Sellafield (formerly Windscale), 5 cases of childhood leukemia had been diagnosed when, on the basis of national rates, only 0.5 would be expected. A subsequent government inquiry confirmed this high rate, and recommended additional studies to determine the cause of this elevated risk, some of which continue. Similar surveys were soon conducted around other nuclear facilities in Britain and other countries, which showed that the overall risk of cancer in these areas was not different from that in non-nuclear communities. In England, leukemia in persons under 25 was a possible exception, with a small but statistically elevated risk of 1.25 fold (Cook-Mozaffari et al. 1989). However, this excess risk also appeared in areas where no nuclear associations were evident.

In the United States, similar studies have been carried out and reported recently by Jablon (1991) of the National Cancer Institute. Cancer rates in each of the counties surrounding 62 nuclear facilities were compared to those of matched control counties, and a risk ratio of 1.0 was determined. In fact, the risk ratio in these counties before start-up of the facilities was slightly higher than after operations began. The authors concluded that any excess cancer risk was too small to be detected by the methods used.

In Canada a study by the Ontario Cancer Treatment and Research Foundation (OCTRF) of childhood leukemia rates in areas surrounding 5 Ontario nuclear facilities was commissioned by the Atomic Energy Control Board (AECB). Phase I of this study, which considered leukemia developing before the age of 5, was reported in 1989 (Clarke et al. (1989)), and found relative risks which varied about 1.0 in the different areas, no differences achieving statistical significance. Because such a result could have occurred partly because of the low power of a study based on small numbers of cases, a Phase II which extended the age range to 14 was initiated in 1989. The results of this extended study published in June 1991 (Clarke et al. 1991), reached similar conclusions.

## 5.2 Effects of Pre-Conception Exposures

In 1990 Gardner et al reported the results of a case-control study investigating the causes of childhood leukemias in the area surrounding Seascale, the focus of the government inquiry described in Section 5.1. Significant differences were found between cases and controls with respect to people living within 5 km of Sellafield (not unexpected, since Seascale is included), but also for fathers working at the facility. A relative risk of 6.4 was observed for fathers who had received at least 0.1 Sv prior to conception of the child, and a similar risk was found for those who had received more than 0.01 Sv in the 6 months immediately prior to the conception. Both results were statistically significant, and naturally raised concerns among radiation workers. However, other findings also have not been explained, such as a statistically elevated risk among iron and steel workers.

Statistical associations are not necessarily causal, and follow-up studies have been designed to investigate, among other things, consistency with results derived from other similar populations, and plausible biological mechanisms. Recently Urquhart et al. (1991) have reported results of a case-control study of childhood leukemia occurring in a population living near Dounreay, a Scottish nuclear facility where a similar significant excess had been reported. No association with parental radiation exposure was detected. Similarly McKinney et al (1991) have studied the association between childhood leukemias and parental occupations in the north of England. Although an association with parental occupations involving exposure to ionizing radiation was reported, this result depended on some of the same cases as were described by Gardner.

In Canada, the study commissioned by the AECB referred to above was followed up by a case-control study carried out by the OCTRF. The purpose of this study was to search for an association between childhood leukemia and parental occupational radiation exposure, using the cases identified in Phases I and II. Results of this study were published in AECB Document No. INFO 0424 (AECB, 1992), and no significant associations were detected.

## 5.3 Birth Defects in Populations Living Near Pickering NGS

In 1988 Durham Nuclear Awareness (DNA) issued a report prepared by David McArthur which compared infant mortality and birth defects in the population living near Pickering NGS with tritium releases to air and water from the plant. A strong correlation was claimed, but subsequent reviews of the report by the Ontario Ministry of Health and Ontario Hydro have challenged the methods that led to this conclusion. A later review, commissioned from B.E. Lambert of the UK by Greenpeace, concluded that while there seemed to be some unexplained variations in the defect rates, the relation with tritium releases had not been established.

Only recently a report for the AECB by Health and Welfare Canada (Johnson and Rouleau (1991)) has been published. This study found no evidence overall of increased rates of stillbirth, neonatal mortality or infant mortality since the start-up of the station in 1971. Only 1 of 22 diagnostic categories (Down's Syndrome) showed a statistically-elevated increase. This increase did not appear to correlate with concentrations of tritium released into the environment, and could, in the opinion of the authors, have resulted by chance, since many comparisons were made.

One positive consequence of the report was the identification of possible weaknesses in the Ontario health effects records system. This issue was addressed by the Darlington Pre-Baseline Health Effects Study Committee, a group composed of representatives from Ontario Hydro and DNA, and concerned citizens, chaired by the Medical Officer of Health of Durham Region. The group's recommendations were presented to Durham Region Council in January 1991. Prominent among these recommendations were requests to change some aspects of health record keeping so that better independent analyses, based on publicly-available information, would be possible.

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**APPENDIX F**

FOREST FIRES PROTECTION /
PREVENTION CONSIDERATIONS

# APPENDIX F

## Forest Fires Protection/Prevention Considerations

This appendix presents the considerations that would need to be taken into account for the design and layout of the UFDC, to ensure adequate forest fire protection for the facility (Table F-1). The UFDC would also need to comply with regulations under the Forest Fire Prevention Act during all preclosure activities. These regulations are summarized in Table F-2.

TABLE F-1
Considerations for Design and Layout of UFDC
for Forest Fire Protection Purposes

| | |
|---|---|
| PROVISION OF A PRIMARY FUEL BREAK | This break covers all ground within 5 metres of buildings:<br>1) lower branches of trees should be pruned to height of 3 metres above ground level<br>2) trees should be spaced so that crowns are at least 5 metres apart<br>3) flammable materials (grass, branches) should be completely removed |
| PROVISION OF A SECONDARY FUEL BREAK | This break extends at least 15 metres in all directions from all buildings, and should be extended to 25 metres down slope from any building on a sloping site:<br>1) increase spacing between trees to decrease spreading into tree crowns<br>2) mix of deciduous and coniferous trees is ideal |
| LAYOUT CONSTRAINTS | Avoid building on steep slopes which are covered with trees. Fire spreads rapidly uphill. |
| DESIGN CONSIDERATIONS | Enclose any projections such as wide eaves, balconies etc.<br><br>Provide a facility for personal cache of fire fighting equipment: fire extinguishers, ladders, water pails, shovels, axes, portable fire pumps and hoses |
| PREVENTION TECHNIQUES | Establish fire prevention program (three components)<br>1) education<br>2) enforcement<br>3) engineering |
| MITIGATION MEASURES | A variety of mitigation measures exist:<br>1) Removal or reduction of fire hazards<br>2) Thinning, pruning, cutting and removing vegetation<br>3) Specially constructed designs for disposal of coals, ash, burned materials<br>4) Removal of flammable grasses and bushes along right-of-ways, ditches etc.<br>5) Detailed emergency planning, contingency plans, backup support networks (auxiliaries) |

TABLE F-2
Applicable regulations within the
Forest Fires Prevention Act (Government of Ontario 1990)

| | |
|---|---|
| Chapter 173 Section 15(1) | Except under the authority of a work permit no person shall, in or within 300 metres of a forest or woodland,<br>a) carry on any logging, mining or industrial operation<br>b) clear land<br>c) construct a dam, bridge or camp<br>d) operate a mill for the purpose of manufacturing timber<br>e) carry on any operation liable to cause the accumulation of slash or debris |
| Chapter 173 Section 16(1) | Every person clearing land shall, subject to the provisions of this Act respecting fire permits, pile and burn all brush, debris, non-merchantable timber and other flammable material cut or accumulated. |
| Chapter 173 Section 17 | Every person having charge of a camp, mine, mill for purpose of manufacturing timber, or a garbage dump that is located in or within 300 metres of a forest or woodland shall have the area surrounding the camp, mine, mill or dump cleared of flammable debris for the distance of at least 30 metres and such further distance as may be ordered by an officer. |
| Chapter 173 Section 27 | No person shall within 800 metres of a village, town or city accumulate flammable debris or permit any such accumulation to remain on any property owned by him or under his control. |
| Chapter 173 Section 28 | No person shall smoke while walking or working in a forest or woodland during the fire season (April 1 to October 31) |
| Chapter 173 Section 33 | No person shall use or operate in or within 300 metres of a forest or woodland any burner, chimney, engine, incinerator or other spark-emitting outlet that is not provided with an adequate device for arresting sparks. |

REFERENCE FOR APPENDIX F

Government of Ontario 1990. Forest Fires Prevention Act. RSO 1990, Vol. 4, F.24.

## APPENDIX G

<u>EXAMPLES OF INDICATORS OF CHANGES IN THE NATURAL AND HUMAN ENVIRONMENT</u>

# APPENDIX G

## Examples of Indicators of Changes in the Natural and Human Environment

In the environmental assessment field, the term "indicator" is generally used to denote an environmental aspect or variable which is monitored to detect change in that aspect or variable (Beanlands and Duinker, 1983). Indicators are not necessarily related directly to valued ecosystem components (e.g. species diversity may be an indicator of change in an important wildlife population although it is not directly related). Indicators which are directly related to a valued ecosystem component may be referred to as "surrogates" (e.g. preferred habitat may be used as a surrogate of an important wildlife population). Typically, several indicators (or surrogates) are used to identify whether changes are occurring in a particular compartment of the natural or human environment.

TABLE G-1
Examples of Potential Indicators of Natural Environment Effects

| ENVIRONMENTAL FACTOR | INDICATORS |
|---|---|
| **ATMOSPHERIC ENVIRONMENT CHANGES** | |
| Air Quality | Diffusion factor<br>Radionuclide concentration<br>Particulates concentration<br>Sulfur oxides concentration<br>Hydrocarbon concentration<br>Nitrogen oxide concentration<br>Photochemical oxidants concentration<br>Hazardous toxics concentration<br>Odour |
| Noise | Ambient level<br>Noise sensitive zones<br>Effectiveness of natural barriers |
| **TERRESTRIAL ENVIRONMENT CHANGES** | |
| Flora and Fauna | Large animals population<br>Small animals population<br>Predatory birds population<br>Small game population<br>Waterfowl population<br>Endangered species<br>Species Diversity<br>Natural vegetation<br>Species Habitat<br>Radionuclide concentration in vegetation<br>Radionuclide concentration in fish |
| **AQUATIC ENVIRONMENT CHANGES** | |
| Groundwater | Aquifer safe yield<br>Flow variations<br>Suspended solids<br>Dissolved solids<br>Contaminant levels |
| Surface Water | Aquatic life population<br>Water levels<br>Water temperature<br>Radionuclide concentration<br>Contaminant levels<br>Sediment contamination |
| **NON-RENEWABLE RESOURCE CHANGES** | |
| Wildlife resource | Trapping catches<br>Hunting catches |
| Other natural resources | Minerals<br>Forestry |

Table G-2 presents a set of factors and indicators which could be used in a site-specific assessment and monitoring program to identify changes in the socio-economic environment. This set of indicators was derived from past practice and from the review of the social science literature. Because no specific site or community could be assumed in this disposal concept assessment, a comprehensive approach was used for describing the broad range of socio-economic changes in potentially affected communities. The three general community characteristics described in Section 6.5.2 of the main text (Social & Cultural Vitality, Economic Viability and Political Efficacy) provide a conceptual framework for assessing the ability of communities to evaluate and cope with changes in their environment. The factors and indicators listed in Table G-2 could be used in a community-based, site-specific socio-economic assessment to describe the changes that may occur within the scope of these three general community characteristics. However, the range of factors and indicators applicable at the site-specific stage may not be as comprehensive, depending on local conditions and needs.

TABLE G-2
A Suggested Approach for Developing Indicators of Changes in the Socio-Economic Environment for Site-Specific SEIA

| **SOCIO-ECONOMIC FACTOR** | **INDICATORS** |
|---|---|
| **CHANGES IN THE ECONOMY** | |
| Business Activity | - number of businesses<br>- level of sales<br>- bankruptcies<br>- project spending<br>- project workers<br>- project worker expenditures<br>- number of employees |
| Business Development Plans and Potential | - number of businesses<br>- number of employees<br>- available labour force<br>- local wage rates<br>- level of sales<br>- bankruptcies<br>- employee turnover rates<br>- planned private/public investment |
| Local Income and Price Structure | - per capita income/family income<br>- project wage rates<br>- income distribution<br>- average commodity prices |
| Project Employment Opportunities | - project workforce requirements<br>- labour force<br>- wage rates and union restrictions<br>- employment/unemployment levels |
| Secondary Employment Opportunities | - population<br>- project workforce<br>- project worker expenditures<br>- project spending<br>- labour force<br>- employment/unemployment levels<br>- participation rates<br>- community and region specific employment multipliers |

| SOCIO-ECONOMIC FACTOR | INDICATORS |
|---|---|
| Tourism-Related Activities | tourism-related operations<br>- tourism service employment<br>- historical and prevailing accommodation occupancy rates<br>- historical and prevailing visitation rates<br>- tourist characteristics<br>- visitor perceptions |
| Tourism Development Plans and Potential | - planned public/private sector investments<br>- historical and prevailing visitation rats<br>- number and quality of access roads/routes<br>- tourist operator satisfaction<br>- visitor perception |
| **CHANGES IN COMMUNITY INFRASTRUCTURE** | |
| Availability of Housing | - housing stock<br>- number of temporary accommodation<br>- number of building permits<br>- lots available<br>- historical and prevailing turn-over rates<br>- population (supply/demand)<br>- project workforce<br>- housing supply<br>- perception of the community |
| Adequacy of Housing | - housing stock<br>- temporary accommodation<br>- unit condition<br>- per capita income/family income<br>- special needs |
| Property Values | - appraised value of properties<br>- sale and resale values of properties project workforce<br>- population<br>- planned infrastructure developments |
| Existing Environmental Facilities, Services and Utilities<br><br>Waste Management Services<br><br>• solid<br>• sewage<br><br>Air Emission Control System | - capacity of existing services and facilities<br>- condition of existing facilities, distribution or collection networks<br>- current service and facility use<br>- current service and facility use<br>- current and historic levels of service<br>- quality of service and supply<br>- cost of services<br>- user perception of services and facilities |

| SOCIO-ECONOMIC FACTOR | INDICATORS |
|---|---|
| Existing Transportation Infrastructure and Services | - transportation features<br>- use of feature<br>- planned and proposed changes<br>- population<br>- resident perception of transportation infrastructure |
| **CHANGES IN COMMUNITY SERVICES - NORMAL OPERATIONS** | |
| Existing Recreational and Community Features | - community and recreational facilities<br>- characteristics of features<br>- users<br>- current and planned investment<br>- sensitivity of users<br>- perceived disruptive effects |
| Existing Educational Facilities and Services | - existing and planned facility capacities<br>- project workers<br>- curriculum/programs<br>- historical, current and project enrolment<br>- in-migrant expectations<br>- teaching staff<br>- class size<br>- professional/administrative staff |
| New Curriculum and Programs | - distribution of curricula<br>- enrolment<br>- local employment opportunities and skill requirements<br>- in-migrant expectation/community perceptions |
| School Board's Financial Resources | - existing funding sources<br>- existing cost structure<br>- capital expansion plans<br>- population |
| Student Drop Out Rate | - current drop-out rate<br>- project workforce requirements<br>- employment/unemployment rates<br>- student statistics |
| Fire-Fighting Services | - existing facilities and equipment<br>- services/programs offered<br>- characteristics of users<br>- applicable provincial standards<br>- existing and planned facility, agency/organization capacities<br>- project workers<br>- population |
| New Forms of Health and Safety Facilities and Services | - existing facilities and services<br>- in-migrant expectations/community perceptions<br>- facilities and services required for the project |

| SOCIO-ECONOMIC FACTOR | INDICATORS |
|---|---|
| Existing and New Forms of Social Services | - available services<br>- social service agency, organization capacity<br>- expenditures/budgets<br>- users<br>- project workers<br>- population<br>- in-migrant expectations/community perceptions |
| **FISCAL AND ADMINISTRATIVE CHANGES** | |
| Local Planning and Administrative Services | - population<br>- development applications<br>- existing municipal structure<br>- inquiries, complaints and requests |
| Land Use | - existing land use designations<br>- approved and proposed developments<br>- local and regional official plan, policies and by-laws<br>- federal and provincial land use policies<br>- absence of land ownership |
| Municipal Capital and Operating Costs | - capital spending<br>- long-term liabilities incurred<br>- current revenues, funds and expenditures |
| Other Revenues | - changes in taxable assessment<br>- payments-in-lieu of taxes<br>- Ontario unconditional grants<br>- Ontario specific grants<br>- sewer and water charges<br>- developer contributions<br>- licenses and permit revenues |
| Property Taxes and Service Charges | - local tax requirement<br>- school board requirement<br>- upper tier requirement<br>- shared costs<br>- sewer and water charges |
| **SOCIAL AND CULTURAL CHANGES** | |
| Resident Displacement | - residents displaced<br>- attachment to place of those displaced |
| Resident Activities, Use and Enjoyment of Property | - residents potentially affected<br>- activities/uses of property<br>- resident's perceptions of compatibility of facility with their daily lives<br>- risk and radiological assessment results |

| SOCIO-ECONOMIC FACTOR | INDICATORS |
|---|---|
| Health and Safety | - population<br>- resident's perceptions of the potential effect of the facility<br>- social service agency caseloads<br>- risk and radiological assessment results<br>- alcoholic beverage consumption rates<br>- police and hospital statistics |
| Satisfaction with Community and Voluntary Out-Migration | - perceived changes in community attributes which contribute to satisfaction with place<br>- extent of social interaction<br>- existing and proposed levels of investment in the community |
| Labour Organisations | - union membership<br>- history of labour relations<br>- distribution of programs and services<br>- expenditures/budgets<br>- union/labour organization facilities<br>- worker and union perceptions/attitudes |
| Family Stability and Organisation | - social service caseload<br>- divorce rate<br>- family-related offenses<br>- mutual aid groups |
| Native Rights and Governance | - financial assistance<br>- membership levels<br>- ownership of land and territorial boundaries<br>- existing land claims<br>- community organization<br>- leadership characteristics<br>- community programs<br>- community attitudes and perceptions |
| Land Use and Resource Management | - access roads/routes<br>- traditional activities<br>- income sources |
| Traditional Life-Style and Culture | - population<br>- native burial grounds<br>- native employment<br>- unemployment levels<br>- community development orientation<br>- traditional activities<br>- income sources<br>- native language |

| SOCIO-ECONOMIC FACTOR | INDICATORS |
|---|---|
| Community and Region | - population<br>- historic trends in demographic character<br>- project workers<br>- federal and provincial grants/programs<br>- non-local business and government agency presence<br>- absentee land ownership<br>- membership in non-local organizations<br>- resident perceptions |
| Community Cohesion | - extent of neighbouring and social interaction<br>- number and characteristics of existing and new residents<br>- community features that may contribute to cohesion<br>- commitment and satisfaction with community<br>- extent of polarity of residents views regarding the project<br>- number and characteristics of residents displaced |
| Community Stability | - population<br>- employment/unemployment rates<br>- rate of population change<br>- seasonal population fluctuations<br>- existing levels of service<br>- community features that may contribute to stability<br>- community aspirations and desired social change |

**APPENDIX H**

EXAMPLE OF AN OCCUPATIONAL HEALTH AND SAFETY POLICY AND IMPLEMENTATION PROGRAM FOR UFDC OPERATION

# Appendix H

## Example of an Occupational Health & Safety Policy and Implementation Program For UFDC Operation

The following example of an occupational health & safety policy and implementation program that could be adapted for operation of the disposal facility is contained in a guide published by the Ontario Ministry of Labour (1991). The occupational safety analysis assumes that such a policy and program would be in place during operation of the facility.

**Health & Safety Policy**

Management of the implementing organization must be vitally interested in the health and safety of its employees. Protection of employees from injury or occupational disease is a major continuing objective. The "implementing organization" will make every effort to provide a safe, healthy work environment. All supervisors and workers must be dedicated to the continuing objective of reducing risk of injury.

The "implementing organization" as an employer, is ultimately responsible for worker health and safety and for ensuring that every reasonable precaution will be taken for the protection of workers.

Supervisors will be held accountable for the health and safety of workers under their supervision. Supervisors are responsible to ensure that machinery and equipment are safe and that workers work in compliance with established safe work practices and procedures. Workers must receive adequate training in their specific work tasks to protect their health and safety.

Every worker must protect his or her own health and safety by working in compliance with the law and with safe work practices and procedures established by the company.

It is in the best interest of all parties to consider health and safety in every activity. Commitment to health and safety must form an integral part of this organization from the president to the workers.

**Health and Safety Policy Implementation Program**

In addition to preparing a health and safety policy like the one above, the implementing organization would have a program in place to implement that policy. This program would depend on the hazards encountered in a particular workplace. Program elements may include:

1) Joint health and safety committees (management and workers)

2) Worker training (e.g. new employees, WHMIS, new job procedures)

3) Workplace inspections and hazard analysis

4) Investigation of analysis of accidents and illnesses occurring at the workplace

5) A health and safety budget

6) A formal means of communication to address promptly the concerns of workers

7) Confined space entry procedure

8) Lock-out procedure

9) Machine guarding

10) Material-handling practices and procedures

11) Maintenance and repairs

12) Housekeeping

13) Protective equipment

14) Emergency procedures

15) First-aid and rescue procedures

16) Electrical safety

17) Fire prevention

18) Engineering controls (e.g. ventilation) and other elements as required.

REFERENCES TO APPENDIX H

Ontario Ministry of Labour, 1991, A Guide to the Occupational Health and Safety Act, Occupational Health & Safety Division, Report No. 10M/5/91 Rev., Publications Ontario, 880 Bay St. Toronto.

## APPENDIX I

## TYPE OF QUALITY ASSURANCE PROGRAM THAT COULD BE APPLIED TO THE DESIGN AND MANUFACTURING OF USED FUEL TRANSPORTATION SYSTEMS

APPENDIX I

Type of Quality Assurance Program
that Could be Applied to the Design
and Manufacturing of Used Fuel Transportation Systems

## I.1 Introduction

The following Quality Assurance procedures are based on the quality assurance program used by Ontario Hydro for the design and manufacturing of the demonstration used fuel transportation cask. It is used as an example of the type of quality assurance program that could be implemented for large scale used fuel transportation to a used fuel disposal centre. It is assumed that the utility that owns the fuel would be responsible for its transportation to the disposal centre.

## I.2 Quality Assurance During Design

The demonstration used fuel cask design was be done in accordance with Ontario Hydro Engineering & Construction Branch Quality Engineering Procedures and Standards (QEPS). It is assumed that design of future casks would be done under similar quality engineering procedures. The specific procedures used include:

| | |
|---|---|
| QEPS 2.2 | Preparation of Design Requirements |
| QEPS 2.3 | Preparation of System Design Descriptions and Manuals |
| QEPS 2.4 | Formal Design Reviews |
| QEPS 2.8 | Preparation of Quality Engineering Plans in Design |
| QEPS 2.14 | Occupational Radiation Safety Review |
| QEPS 2.24 | Design Change Control |

The Quality Engineering Program and Quality Engineering Plan for the design, construction and operation of the cask would define organizational controls, interfaces and major quality engineering tasks, and ensure that design function control was exercised over design changes at all phases.

The packaging design would be specified by:

- detailed design drawings defining the geometrical requirements, and
- technical specification of materials, fabrication methods, inspection and test requirements, and quality assurance standards.

The Quality Assurance level for manufacturing the demonstration cask was CSA Z299.2 which would be used as a minimum for any future cask (CSA 1985).

## I.3 Quality Assurance Program During Manufacturing

It is assumed that the transportation system (cask, trailer, barge etc.) would be manufactured by external contractors and not by the utility. This is because of the size, the material and the manufacturing requirements for the cask, as well as a lack of manufacturing experience for other components such as barges or rail cars.

The technical specification and the design drawings would be part of the cask supply contract. The complete contract conditions would be contained in a number of documents, as follows:

1) the Purchase Order and amendments to the contract in the form of Instruction Notices to the Purchase Order;

2) the tendering document, containing Special Commercial Conditions;
3) the Standard Commercial Conditions;
4) the Technical Specification;
5) the drawings and data;
6) the utility Invitation to Tender and Form of Tender; and
7) the manufacturer's Tender, drawings and data.

The contract with the manufacturer would contain statements that affirm this order of document precedence (for example, "In case of conflict between the specification and the drawing, the governing document shall be the specification").

In order to ensure specific quality standards during the manufacturing and supply of the casks, the manufacturer must strictly adhere to the Technical Specification. The Technical Specification is comprised of the requirements for the supply of materials, fabrication, assembly, inspection, shop testing, guarantee, and delivery of all the components listed on the drawings. As specified in the Technical Specification, the quality assurance program to be applied by the cask supplier would be CSA Z299.2 as a minimum.

The engineering drawings along with the Technical Specification, would contain all of the necessary data for cask manufacture. Any drawings or subsidiary specifications generated by the supplier would be within the limits set by these drawings and specifications. All requests for variance or non-conformance with the drawings and specifications would be subject to the approval by the utility. Any variances or non-conformances with the engineering drawings or with the specification provided as part of the Safety Analysis Report, which are judged by the utility to be of minor nature and not to affect safety, would be approved without the review of the Atomic Energy Control Board. Any significant items which are considered to affect safety but judged to be acceptable by the utility would be submitted to the Atomic Energy Control Board for approval prior to implementation.

## I.4 AECB Access during Cask Manufacturing

At the commencement of cask manufacturing, the utility would submit to the AECB, a manufacturing schedule itemizing all major manufacturing steps. The AECB would be given access to witness all stages of cask construction and associated tests as specified in the Technical Specification.

## I.5 Quality Assurance Records

On completion of construction, all quality assurance documentation relevant to the construction of the cask would be retained by the utility. This documentation would be updated throughout the lifetime of the casks regarding any subsequent modification which may be relevant to the in-service casks (QEPS 2.24).

## I.6 Quality Assurance during Cask Operation

The lifetime record of the casks would be maintained by the appropriate operation department. Any design changes or modifications to the equipment would be reviewed by the design function in the utility and the AECB (depending upon significance) before implementation.

## I.7 Transportation System Quality Assurance Program

The purpose of a transportation system quality program would be to establish the principles and practices to be used during the design, manufacture, and testing of the Transportation System, to ensure that the required quality is achieved, and that the system would perform as planned. The program described in this section is based on the program established by Ontario Hydro for the Roadrunner Transportation System (Dhalwal 1991).

The program applies to all the organizational units during the design, manufacturing, testing and procurement of the system starting from the initial design to the turnover stage.

The program also applies to external organizations engaged to carry out work on behalf of the utility responsible for used fuel transportation. External organizations may either follow the practices identified in the program, or follow their own practices and procedures provided that these are reviewed and approved by the utility to ensure that the intent of the program is met.

The program would meet the requirements of:

- the Corporate Bulk Electricity System (BES) Quality Program;
- the AECB Regulations: Transport Packaging of Radioactive Materials, SOR-83-740: dated 29 September 1983, with amendments for design and manufacture of the transportation system (except for the transport trailer);
- the Highway Traffic Act - Ontario, and the Motor Vehicle Safety Act - Canada, for design and manufacture of the transport trailer;
- the Canada Shipping Act requirements;
- the Railway Act requirements; and
- the Transportation of Dangerous Goods requirements.

The program would define the following elements:

- organization and responsibilities;
- management practices;
- design practices;
- procurement and manufacturing of items;
- transfer of the system to the user;
- documentation and records;
- assessment of performance.

## I.8 REFERENCES TO APPENDIX I

CSA (Canadian Standards Association). 1985. Quality Assurance Standards. CSA/CAN3-Z299 series. Canadian Standards Association, Rexdale, Ontario.

Dhalwal, R.. 1991. Roadrunner Transportation System Quality Program. Ontario Hydro. File #907-TRAN-03450.09P. April 15, 1991.

# APPENDIX J

## REFERENCE EMERGENCY RESPONSE PLANS FOR ROAD, RAIL AND WATER TRANSPORTATION OF USED FUEL TO THE DISPOSAL CENTRE

## APPENDIX J

## Reference Emergency Response Plans for Road, Rail and Water Transportation of Used Fuel to the Disposal Centre

## J.1 Introduction

During implementation, the actual emergency response plan would be developed in consultation with the local emergency response authorities along the route and would be reviewed by the public. This appendix focuses on a conceptual emergency response plan for used fuel transportation in Ontario by either road, rail, water, or a combination thereof. It is expected that similar emergency response plans would be in place in Quebec and New Brunswick prior to transportation of used fuel from these provinces. A Mutual Initial Response Assistance Agreement exists between all of the Canadian nuclear utilities (Ontario Hydro, Hydro Quebec, and New Brunswick Power) and AECL to assist each other during emergencies if called upon.

## J.2 Road Emergency Response

The road emergency response plan is based on the plan presently in place at Ontario Hydro for transportation of radioactive materials by road (Karmali 1991). This is a detailed plan involving local police, fire, ambulance, and an emergency response team from Ontario Hydro. The purpose of referring to the Ontario Hydro plan is to demonstrate the scope of radioactive material transportation management.

The following sections summarize the features of an emergency response plan for large scale used fuel transportation by road from the existing nuclear generating stations in Ontario to a disposal centre located in the Ontario portion of the Canadian Shield:

i) Response Areas

The province of Ontario is divided into three emergency response areas with emergency response centres (staffed with an emergency response team) at Bruce Nuclear Power Development, Pickering Nuclear Generating Station and Darlington Nuclear Generating Station responsible for their respective areas. These divisions are only used for guidance and are not binding. The future divisions would depend on the location of emergency response personnel with the capability to respond to a radiological emergency.

ii) Response Capability

Each emergency response centre would have in place the appropriate emergency response capability. This includes dedicated equipment, stored in a trailer, ready to be transported off-site in the event of an accident. Each centre would also have detailed response procedures, as well as personnel who are trained to respond to such accidents.

iii) Central Shipping Log

All shipments would be centrally logged at one of the emergency response centre (Pickering NGS in the current plan) and this information made available to the other centres. The information to be recorded includes type of container, contents, curie content or contact dose rates, shipper, destination and the like. This information would be used by the shift supervisor to provide advice to initial responders to an accident.

iv) Response Initiation

Response would be initiated by calling a toll-free phone number located at the central shipping log centre. The shift supervisor would answer the call, identify the shipment, and provide advice to the caller. The shift supervisor would also notify the Local Area Manager and the closest responding emergency response centre (Bruce, Pickering, Darlington in the current plan).

v) Emergency Information

The Local Area Manager from the responding emergency response centre provide the initial corporate (Ontario Hydro in the current plan) presence at the scene. The Local Area Manager would have a thorough understanding of the emergency response plan and would inform affected persons (public and drivers) of the details of the forthcoming assistance.

vi) Response Objectives

The objectives of the emergency response team would be to assist emergency workers to accomplish the following:

- Assist in emergency rescue and first aid procedures where required.
- Minimize radiation exposure to all personnel.
- Minimize the spread of contamination.
- In the event of a spill of radioactive material, attempt to contain the spill, stop the leak, prevent loss to drainage ports or water supplies, and repackage low-level radioactive material.
- Decontaminate people and equipment, and restore the accident scene.
- Have a spokesperson (from Ontario Hydro in the current plan) to provide emergency information to the public and media.

vii) Training

The Ontario Hydro emergency response communication program which started in 1979 to meet the needs of emergency response personnel on Ontario Hydro's radioactive materials transportation routes is an example of the type of emergency response training that would be required for large scale used fuel transportation by road. The program provides information on Ontario Hydro's shipping program, types of radiation, its uses and hazards, types of accidents, first on-the-scene response actions, Ontario Hydro's response capability and a video. To date, there have been more than 300 presentations which have been made to approximately 15 000 police, fire fighters, ambulance personnel and other groups.

In addition to seminars, emergency agencies are sent action cards, which assist first on-the-scene emergency workers in identifying shipments, in evaluating the hazards and in planning the response. Emergency agencies also receive a field guide, which describes containers, contents, documentation, shipping routes, resources and safety regulations. A video, is also included which depicts the roles of police, fire and ambulance personnel. It is assumed that a similar program would be established by the utility responsible for used fuel transportation.

The Ontario Fire College also administers a one-day radioactive materials training seminar. The course covers Ontario Hydro's Transportation Program, radiation theory, fire-fighting procedures, action cards, field guide, as well as written exercises.

As part of emergency preparedness, emergency drills with local emergency services would be held on a regular basis (as done currently at Ontario Hydro).

## J.3 Rail Emergency Response

If rail transportation was selected, the following type of emergency response procedures could be implemented:

i) Response

Standard rolling stock tracking methods allow the railway operating personnel to know the location of all equipment at any time. Proposed security requirements (Frost 1993) require that on-board communication equipment be used to provide the central tracking station with frequent reports on the train's location and status. The equipment and procedures allow for the notification of and response to most abnormal operating conditions.

Emergency response procedures would be able to function independently of the above systems if necessary.

In the event of a rail accident involving Used Fuel Casks, the response would involve the following stages (CHI 1990): Initial Notification, Emergency Response, Sustained Field Recovery, Inspection of Site and Declaration of End of Recovery Work.

As in the road mode, a spokesperson (responsibilities to be determined during development of detailed emergency response plan) would provide emergency information to the public and media.

ii) Responsibility

The major divisions of responsibility, currently in effect, for carrying out the emergency response are:

Rolling stock and track: CN/CP
Sealing of casks: utility
Reloading of displaced cargo: CN/CP
Restoration of site: CN/CP
Monitoring of personnel: Employer (utility, CN/CP, implementing organization etc.)
Monitoring of site: Ontario Ministry of Environment and Energy

Financial responsibilities are set out in the governing Acts and Regulations.

iii) Recovery

Possible rail accident scenarios have been classified into three groups. Table J-1 shows a list of those groups, as well as the necessary recovery procedures for each group (CHI 1990).

## Table J-1
## Recovery Procedures for Rail Transportation Accident

**Type 1 - no cargo problem**

Once there is confirmation that there is no radiation hazard, a typical recovery procedures would include:

1. Bring heavy equipment to the scene.

2. Start removing each piece of rolling stock from the tracks.

3. Make special provision for any rolling stock which is a substantial distance from the scene (on or off the tracks). These provisions could include making temporary road access, separating the cargo from the rolling stock etc.

4. When the track is cleared, repair the track if necessary. Normal use of the track is then restored.

5. Set derailed rolling stock back on the track. Bring substitute rolling stock to the scene to replace that which is no longer serviceable.

6. Reassemble the train and dispatch it to the UFDC.

7. Restore the area. Remove damaged equipment.

**Type 2 - potential loss of cargo integrity**

The recovery procedures would ultimately become similar to Type 1 if there was no loss of cargo integrity. In those cases where loss of integrity and the presence of a radiation hazard were confirmed, the recovery procedure would be modified to ensure that exposure to radiation is controlled. The recovery procedure would include the following:

1. Minimize personnel exposure and spread of radioactive contamination.
    - Establish exclusion area,
    - Set up entry/exit control point,
    - Provide protective equipment, and
    - Record names and other necessary information on exposed personnel

2. Contain released radioactive material.
    - Seal the container and
    - Contain surface water at the site

3. Decontaminate equipment, vehicles and land as necessary with the objective of restoring the site to its pre-accident state.

After the container(s) has been sealed and the train reassembled, it would complete the journey to the UFDC.

**Type 3 - cask damage**

Even in this "worst case scenario", the recovery procedures would be similar to a Type 1 situation except that the recovery effort would involve more time and resources. Cask recovery, inspection, minor repair and reattachment to a flat car may be required. Based on development of accident scenarios and because the cask is designed to survive severe accidents, it is not expected that the cask damage would be such that the modules would need to be removed from the cask.

If tie downs are damaged and cannot be repaired locally, replacements would be shipped to the accident scene. If the cask is damaged such that the standard tie down cannot be used, a modified tie down would be used to allow the cargo to be transported safely to its planned destination.

[1] Although the rail carrier has not been selected yet, to simplify this study CN was the assumed carrier.

iv) Recovery Equipment

The key elements in the recovery equipment inventory are the cranes. Two cranes are preferred at an accident site to allow work to start at each end of the scene (twice as fast) and to allow big lifts to be done in a highly controlled manner. As long as the planned cargo weight is kept below 130 Mg (HiRail crane capacity) then CN should be able to respond to an emergency with existing equipment. The following is a simplified list of CN's resources available for response and recovery (CHI 1990):

a) a 250 tonne railroad only crane;
b) HiRail cranes ranging in capacity from 60 to 130 Mg;
c) sleepers, kitchen, and tool cars in addition to the crane and crane idler car;
d) a road trailer with radios, telephones, telex, video and public address equipment, weather monitors and other facilities such as washroom, sleeping accommodation and the like.
e) a Suburban vehicle designed as an initial response vehicle for accidents involving dangerous goods (communication equipment, and monitor/detection equipment including toxic gas detection, etc.).

Lifting of cars and/or cargo is usually done by sling. Where there is no clearance under the load for slinging, a tunnel is dug under the load and the sling is fed through the tunnel. Therefore, no special lifting lugs should required for cask recovery.

v) Training

Railway Company

The minimum level of training for dangerous goods response personnel is detailed in the federal Transportation of Dangerous Goods Regulations Part IX. The training would need to be expanded to include procedures specific to radioactive materials and cargo knowledge.

Utility

The skills required by the emergency response personnel would essentially be the same as those required for response to a road transportation accident.

vi) Emergency Personnel

Local police or Ontario Provincial Police (OPP), local fire departments, ambulance services and hospitals, which may be called upon in the event of a rail accident, would need to be identified in the Emergency Response Plan. Identification would be based on proximity to the route or routes to be taken by the unit trains.

Each agency would require training in coping with the unique problems which may result from the possible accident situations.

## J.4 Water Emergency Response

As discussed in Ulster (1993), there are some hazardous occurrences such as fire, collision, grounding and sinking that could cause an emergency situation for the tug/barge and the cargo. The utility would have an Emergency Response

Plan to cope with these emergency situations. This plan would be well documented and cover both non-radiological and radiological conditions. This plan would be included in the shipping papers carried aboard the tug.

Much of the Emergency Response Plan would deal with normal emergency procedures which would be initiated by an experienced ship master in the event of circumstances such as collision, fire, grounding or sinking. However, some additional factors would be considered due to the nature of the cargo being carried. At all times, the main concern would be safety of life, both for the crew and for the general public.

i) Response

As a ship owner, and under the authority of the Canada Shipping Act, the St. Lawrence Seaway Authority Act and the United States Code of Federal Regulations #33, the utility would be responsible for the care and conduct of both vessel and cargo. It would, therefore, have a response organization in place capable of handling any accident. This response organization would include personnel from their own internal forces, and/or augmented as circumstances dictate by external contractors.

The emergency response organization for the marine transportation mode would be formed from three distinct groups within Ontario Hydro:

a) The Tug/Barge Crew;
b) The Marine Operations Office Staff; and
c) The Utility Radioactive Transportation Emergency Response Team.

Each group would have the following role in any marine emergency response situation:

a) <u>Tug/Barge Crew</u> - Stabilize the situation at the accident site with respect to safety of life, vessel and cargo, having due regard for the safety of navigation of other vessels.

b) <u>Marine Operations Office</u> - monitor communications with the response team, provide functional support to the vessel, helicopters, salvors and other necessary equipment. Serve as a communication centre throughout the crisis period.

c) <u>Response Team</u> - assessment of present or potential radiation hazards, continuous monitoring of cargo and technical resources to the tug/barge crew, salvaging company personnel, and other government agencies. The response team would provide a spokesperson to liaise with the public and media.

The overall responsibility for the conduct of the personnel within each individual group lies with:

a) Master;
b) Marine Manager; and
c) Response Team Leader.

The overall responsibility for emergency response would lie with the Marine Manager.

The responsibility for all activities at the accident site would remain with the Master until such time as the Marine Manager arrives on site and has been fully briefed.

In the event that the Response Team arrives on site before the Marine Manager, the Response Team Leader would report to the Master.

Once the Marine Manager has arrived on site and has been fully briefed, both Master and Response Team Leader would report to and take directions from the Marine Manager.

Once the Response Team Leader has arrived on site he/she would assume responsibility for all radiation-related activities, particularly the monitoring of the cargo throughout the response effort.

In the event that a grounding necessitates off-loading of casks to refloat the vessel, every effort would be made to reload and complete the voyage without bringing casks ashore.

Should damage to the barge prevent this, or should casks be recovered from a sinking vessel, it is assumed that they would only be landed in Ontario, and if practical, at one of the Ontario Hydro Nuclear Generating Stations or Transfer Facility Docks. Should it become necessary to land the casks at another commercial or government dock, the Emergency Response Plan for land transportation (Karmali 1991) would become effective at the point of landing.

The Canadian or United States Coast Guard, or the St. Lawrence Seaway Authority would be recognized as the lead agency in their respective jurisdictions. In the event of an accident, the lead agency would provide representatives to investigate the cause of the accident, to review and approve activities at the accident site, to notify other government agencies in accordance with their own response plans, and to control and possibly even stop navigation in the vicinity of the accident.

ii) Recovery

The recovery of a cask from a lake would be carried out by a salvaging company, fully trained to carry out this task. In order to provide a fast and full response, the utility would enter into a standing agreement with a salvaging company. The equipment normally used by a salvage company is able to handle depths of up to 200 metres (approximately 100 fathoms) and would be available within 24 hours. For recovery in depths greater than 200 metres (Lake Ontario, Lake Huron, Lake Superior), specialized equipment such as sophisticated diving suits and Remote Operating Vehicles, would be necessary to both locate and recover the casks. With the specialized equipment, divers have the capability to cut, burn, release securing devices, sling and attach hooks or shackles underwater. Remote Operating Vehicles have the same capability as the divers. However, they are equipped with specialized sensing devices for locating material on the sea bed. As with the salvaging company, the utility would enter into a standing agreement with a deep water specialist to take on such tasks.

iii) Recovery Equipment

As part of the salvaging operation, it would be necessary to have access to a crane. While mobile cranes capable of lifting a cask out of the water or out of the barge can be rented, due to the stability aspects, a specialized barge with a self-contained internal ballasting system would be required. Since commercial crane barges presently located in North America might be in use far away from the site, and they could not be moved to the accident site in a reasonable time frame, the utility would, construct two barges capable of loading a mobile crane for use in salvage activities. These barges would be stationed with an appropriate towing contractor in Sault Ste Marie or Sarnia, and in Hamilton, and ready for immediate use in the event of a salvage operation. Standing agreements would be entered into with the towing contractor, and with a crane rental contractor to ensure that a mobile crane capable of lifting at least 100 Mg at a radius of not less than 20 metres can be available to be loaded on to the barge within eight hours of notification.

iv) Training

Since the vessels would be of a specialized nature, the utility would establish emergency personnel training to ensure familiarity with:

a) the particular systems on these vessels and their function in an emergency;
b) the individual role of crew members in various emergency situations;
c) the characteristics of the cargo, particularly its packaging and ability to withstand damage, securing systems and operation;
d) the use of radiation monitoring equipment and specialized clothing;
e) the role of the Utility Radioactive Transportation Emergency Response Team; and
f) the role of other agencies.

Managers and officers would receive additional training to ensure familiarity with:

g) reporting procedures, both for normal transits, and in cases of emergency;
h) the location of specialized salvaging equipment, and contractual arrangements with salvaging companies; and
i) the location of Canadian and U.S. Search and Rescue Coast Guards detachments.

## J.5 REFERENCES TO APPENDIX J

CHI Process Associates. 1990. Operational Marine Head Office and Remote Transfer Station Cost Analysis, File No. 907-TRAN-03456.00P, Ontario Hydro, December 1990.

Frost, C.R. 1993. Analysis of the Security and Safeguards Requirements for Used Fuel Transportation - Support Document B-8 for the Used Fuel Transportation Assessment. Ontario Hydro, Toronto, Ontario.

Karmali, N. 1991. Radioactive Materials Transportation Emergency Response Plans, Revision 1. Ontario Hydro, Toronto, Ontario.

Ulster, C. 1993. Description of Road, Rail and Water Used Fuel Transportation Systems - Support Document B2a for the Used Fuel Transportation Assessment. Ontario Hydro, Toronto, Ontario.

**APPENDIX K**

CHARACTERIZATION OF THE REFERENCE DISPOSAL ENVIRONMENT
REGIONAL REFERENCE ENVIRONMENT PARAMETERS

# APPENDIX K

## Characterization of the Reference Disposal Environment
## Regional Reference Environment Parameters

### K.1 Use of a GIS in Environmental Characterization of the Reference Disposal Environment

Environmental data for each of the following environmental factor were collected and reviewed for appropriateness: Air, Water, Flora and Fauna, Non-Renewable Resources, Geology, and Land Use.

Where necessary, data was reduced to a compatible scale and in a form that could be digitized. The chosen scale of the maps is 1:7 000 000. This choice was made on the basis of the ability to:

1) present the information in sufficient detail for analysis or demonstration purposes;
2) allow the area over which each factor value range occurs to be estimated consistently; and
3) be incorporated into a report format.

A Geographic Information System (GIS) was used to aid the analysis of the spatially-represented material. This computer tool has the ability to convert visually-represented material to a numerical scale using x,y coordinates, through a process referred to as "digitizing". This enables the data to be spatially integrated with other digitally-represented material. Once converted to numerical values (digitized), the relational database in the GIS was used to estimate the area covered by each factor value range in each region of the study area. For some factors, area data were readily available (e.g., for population, the Census already provides population, density and area statistics by township and county) and, therefore, did not require the areas to be estimated. The area for each factor value range was summed over each of the regions to provide value range statistics for the total study area. These areas are then incorporated into environment summary Tables K-1, K-2 and K-3.

The proportions of each region and of the whole study area occupied by the different factor value ranges are calculated and expressed as a percentage. These figures are included in the environment summary tables. The percentage figures serve two purposes:

1) to illustrate differences between the regions; and
2) to indicate the probability of encountering certain environmental conditions (value ranges) within each region or across the study area as a whole.

The GIS was then used to produce maps of all the geographically referenced data collected. These maps are included in Grondin and Fearn-Duffy (1993).

<u>REFERENCE TO APPENDIX K</u>

Grondin, L. and Fearn-Duffy, M. 1993. Reference environment database for the Preclosure Assessment. Support document A-1 to the Preclosure Assessmental and Safety Assessment. Nuclear Waste and Environment Services Division Report No. N-03784-939999 (UFMED), Ontario Hydro Nuclear.

Table K-1
Summary Reference Environment Data for the Northern Shield Region
(Grondin and Fearn-Duffy 1993)

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| **AIR QUALITY[b] ($Mg \bullet a^{-1}$)[c]** | | | | | |
| Particulate matter | 50-1 999 | 74 | 0-49 | 14 | 12 |
| Hydrocarbon | 100-999 | 53 | 0-99 | 40 | 7 |
| Sulphur dioxide | 0-24 | 64 | 25-999 | 2 | 14 |
| Nitrogen oxide | 50-499 | 58 | 500-4 999 | 26 | 16 |
| Carbon Monoxide | 100-4 999 | 46 | 5 000-245 999 | 43 | 11 |
| **WATER QUALITY** | | | | | |
| Area covered by water ($km^2$) | 58 000 | 15 | Not Applicable | | |
| Total dissolved solids ($mg \bullet L^{-1}$) | 51-150 | 65 | 0-50 | 35 | 0 |
| Total Hardness ($mgCaCO_3 \bullet L^{-1}$) | 0-60 | 79 | 61-120 | 1 | 0 |
| Turbidity (Jackson Turbidity Unit) | 0-5 | 80 | 5.1-10 | 20 | 0 |
| Suspended sediment ($mg \bullet L^{-1}$) | 0-50 | 72 | 51-200 | 27 | 1 |
| Mean annual runoff (mm) | 250-349 | 55 | 150-249 | 41 | 4 |
| Munic. water supply ($m^3 \bullet d^{-1}$) | no supply | 58 | 10 000-25 000 | 23 | 19 |
| Mean lake size ($km^2$) | 7.8 | Non Applicable | | | |
| Lake size distribution ($km^2$) | <1 | 92 | 1-10 | 7 | 1 |
| Mean lake depth (m) | 6.2 | Non Applicable | | | |
| Lake coverage by size ($km^2$) | >10 | 52 | 1-10 | 26 | 22 |
| Mean river discharge ($m^3 \bullet s^{-1}$) | <1.5 | 49 | 1.5-15 | 27 | 25 |
| Drainage basins | Hudson Bay | 57 | Manitoba | 29 | 14 |
| Mean annual precipitation (mm) | 700-799 | 37 | 600-699 | 33 | 30 |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| Mean annual snowfall (cm) | 200-249 | 47 | 250-299 | 28 | 25 |
| Mean lake Evaporation (mm) | 400-499 | 37 | 300-399 | 31 | 32 |
| Mean evapotranspiration (mm) | 400-499 | 46 | 300-399 | 38 | 16 |
| Lake freezeup dates | December 1 | 74 | November 15 | 23 | 3 |
| River freezeup dates | December 1 | 94 | December 15 | 6 | 0 |
| Lake breakup dates | May 1 | 49 | April 15 | 36 | 15 |
| River breakup dates | April 15 | 49 | May 1 | 26 | 25 |
| Well yields from bedrock ($L \bullet s^{-1}$) | <1 | 99 | 1-4 | 1 | 0 |
| **FLORA AND FAUNA** | | | | | |
| Fish yield ($kg \bullet a^{-1}$ per lake) | 2 730 | Not Applicable | | | |
| Common wildlife species | 150 | | | | |
| Common fish species | 35 | | | | |
| Forest tree associations | 10 | | | | |
| Endangered species (total no.) | 44 | | | | |
| **NON-RENEWABLE RESOURCES** | | | | | |
| Mining division boundaries | Thunder Bay | 40 | Red Lake | 27 | 0 |
| Number & type of mines | 174 (gold) | 46 | 106 (silver) | 28 | 25 |
| **GEOLOGY** | | | | | |
| Area covered by land ($km^2$) | 327 461 | 85 | Not Applicable | | |
| Geology | Early Precam. | 96 | late-middle | 3 | 1 |
| Number of plutons | 861 | 63 | Not Applicable | | |
| Soil categories | sand/no lime | 51 | loam/l. lime | 32 | 17 |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| **LAND USE/CAPABILITIES** | | | | | |
| Forest types | forested | 80 | wetland/ O. lichen | 19 | 1 |
| Timber use capability | low | 68 | moderate | 15 | 17 |
| Intensive[d] recreation use | low | 97 | high | 2 | 1 |
| Extensive[e] recreation use | low | 43 | moderate | 42 | 15 |
| Parks | wilderness | 4 | waterway | 3 | 1 |
| Indian Reserves/communities | I. Reserve | 1 | uninhab. Reserve | <1 | <<1 |
| Population density (persons•$km^{-2}$)[f] | 38 | (i) | 19 | (i) | |
| Forest fires (anthropogenic) annual # per 1000 $km^2$ | <0.1 | 43 | 0.1-0.5 | 23 | 34 |
| Forest fires (lightening) annual # per 1000 $km^2$ | 0.1-0.5 | 39 | 0.5-2 | 35 | 26 |
| Forest fires (average # per year) | 484 | Not Applicable | | | |
| Forest fires (average ha per fire) | 102 | | | | |
| Agricultural lands ($km^2$) | 6 176 (total) | 2 | 1 164 (in use) | <<1 | 0 |
| Agriculture (products)[g] | livestock | <<1 | grain | <<1 | <<<1 |
| Natural/historical features[h] | in Grondin and Fearn-Duffy (1993) | | | | |
| Wetland regions | humid mid-boreal | 32 | Cont. High Boreal | 24 | 44 |
| Distribution of wetlands | 26-50% cover | 47 | 6-25% cover | 27 | 26 |

[a] The predominant condition in the region is to be used in the assessment.

[b] Average weather frequency data to be used in the assessment is tabulated with respect to 16 wind sectors based on data (hourly) from all existing Environment Canada meteorologial stations in the region and, therefore, cannot be expressed as a single number. See Grondin and Fearn-Duffy (1993) for data tables.

[c] Per grid size 120 km x 120 km

[d] Intensive recreational land use capability: lands capable of providing outdoor recreational opportunities for large numbers of people (e.g., bathing, camping, downhill skiing).

[e] Extensive recreational land use capability: lands capable of supporting dispersed, low density recreation use (e.g., hiking, canoeing, remote cottaging).

[f] The predominant and secondary conditions here are the highest and second highest population density encountered in the region. These population densities are assumed for the area closest to the UFDC in the 100 km reference environment considered in the radiological assessment. Since these high population densities are only found in a very small fraction of the region, this assumption is extremely conservative.

[g] The predominant and secondary conditions here are the largest and second largest (in terms of agricultural land area) production for the region.

[h] These are single features that cannot be summarized in that format (e.g., geological formation of special interest). See Grondin and Fearn-Duffy (1993) for full data set.

[i] Population density assumed for a radius of about 32 km around the site, based on the highest census division population density in the region.

[j] Population density assumed for a ring from about 32 km to 40 km around the site, based on the second highest census division population density in the region.

Table K-2
Summary Reference Environment Data for The Central Shield Region
(Grondin and Fearn-Duffy 1993)

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| AIR QUALITY[b] ($Mg \bullet a^{-1}$)[c] | | | | | |
| Particulate matter | 50-1 999 | 51 | 2 000-9 999 | 23 | 26 |
| Hydrocarbon | 100-999 | 52 | 1 000-4 999 | 34 | 14 |
| Sulphur dioxide | 25-999 | 42 | 1 000-99 9929 | 29 | 29 |
| Nitrogen oxide | 50-499 | 54 | 500-3399 | 33 | 13 |
| Carbon Monoxide | 5 000-24 999 | 65 | 25 000-99 999 | 25 | 10 |
| WATER QUALITY | | | | | |
| Land covered by water ($km^2$) | 14 500 | 7 | Non Applicable | | |
| Total dissolved solids ($mg \bullet L^{-1}$) | 51-150 | 53 | 0-50 | 47 | 0 |
| Total Hardness ($mgCaCO_3 \bullet L^{-1}$) | 0-60 | 55 | 61-120 | 45 | 0 |
| Turbidity (JTU) | 0-5 | 78 | 10.1-20 | 22 | 0 |
| Suspended sediment ($mg \bullet L^{-1}$) | 51-200 | 68 | 0-50 | 30 | 2 |
| Mean annual runoff (mm) | 350-449 | 69 | 250-349 | 31 | 0 |
| Munic. water supply ($m^3 \bullet d^{-1}$) | 50 000-150 000 | 34 | 25 000-50 000 | 33 | 33 |
| Mean lake size ($km^2$) | 2.0 | Non-Applicable | | | |
| Lake size distribution ($km^2$) | <1 | 98 | 1-10 | 2 | 0 |
| Mean lake depth (m) | 5.2 | Non-Applicable | | | |
| Lake coverage by size ($km^2$) | <1 | 39 | >10 | 37 | 24 |
| Mean river discharge ($m^3 \bullet s^{-1}$) | <1.5 | 54 | 1.5-15 | 28 | 18 |
| Drainage basins | Hudson Bay | 59 | Great Lakes | 41 | 0 |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| Mean annual precipitation (mm) | 800-899 | 70 | 700-799 | 18 | 12 |
| Mean annual snowfall (cm) | 250-299 | 41 | >300 | 35 | 24 |
| Mean lake Evaporation (mm) | 400-499 | 55 | 500-599 | 38 | 7 |
| Mean evapotranspiration (mm) | 400-499 | 80 | 300-399 | 12 | 8 |
| Lake freezeup dates | December 1 | 63 | December 15 | 28 | 9 |
| River freezeup dates | December 1 | 81 | December 15 | 18 | 1 |
| Lake breakup dates | April 15 | 59 | May 1 | 41 | 0 |
| River breakup dates | April 15 | 63 | April 1 | 34 | 3 |
| Well yields from bedrock ($L \bullet s^{-1}$) | <1 | 97 | 1-4 | 3 | 0 |
| **FLORA AND FAUNA** | | | | | |
| Fish yield ($kg \bullet a^{-1}$ per lake) | 600 | Non-Applicable | | | |
| Common wildlife species | 162 | | | | |
| Common fish species | 41 | | | | |
| Forest tree associations | 10 | | | | |
| Endangered species (total no.) | 44 | | | | |
| **NON-RENEWABLE RESOURCES** | | | | | |
| Mining division boundaries | Porcupine | 50 | Sault.SteMarie | 17 | 33 |
| Number & type of mines | 233 (gold) | 39 | 159 (silver) | 28 | 34 |
| **GEOLOGY** | | | | | |
| Area covered by land ($km^2$) | 193 291 | 93 | Non-Applicable | | |
| Geology | Early Precam. | 89 | middle | 4 | 7 |
| Number of plutons | 331 | 24 | Non-Applicable | | |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| Soil categories | sand/no lime | 55 | clay/high lime | 27 | 18 |
| **LAND USE/CAPABILITIES** | | | | | |
| Forest types | forested | 79 | wetland/ O. lichen | 16 | 5 |
| Timber use capability | low | 61 | moderate | 37 | 2 |
| Intensive[d] recreation use | low | 88 | high | 8 | 4 |
| Extensive[e] recreation use | low | 38 | high | 34 | 29 |
| Parks | waterway | 2 | natural wilder. | 2 | 2 |
| Indian Reserves/communities | I. Reserve | <1 | settle./ other | <<1 | 0 |
| Population density (persons•km$^{-2}$)[f] | 55 | (i) | 34 | (i) | |
| Forest fires (anthropogenic) annual # per 1000 km$^2$ | 0.5-2 | 39 | <0.5 | 29 | 32 |
| Forest fires (lightening) annual # per 1000 km$^2$ | 0.1-0.5 | 38 | 0.5-2 | 37 | 25 |
| Forest fires (average # per year) | 498 | Non-Applicable | | | |
| Forest fires (average ha per fire) | 4 | | | | |
| Agricultural lands (km$^2$) | 13 648 (total) | 7 | 2 071 (in use) | 1 | 0 |
| Agriculture (products)[g] | grains | <1 | livestock | <1 | <<1 |
| Natural/historical features[h] | in Reid and Grondin (1993a) | | | | |
| Wetland regions | humid mid-boreal | 58 | low boreal | 42 | 0 |
| Distribution of wetlands | 51-75% cover | 40 | 0-5% cover | 32 | 28 |

[a] The predominant condition in the region is to be used in the assessment.

[b] Average weather frequency data to be used in the assessment is tabulated with respect to 16 wind sectors based on data (hourly) from all existing Environment Canada meteorologial stations in the region and, therefore, cannot be expressed as a single number. See Grondin and Fearn-Duffy (1993) for data tables.

[c] Per grid size 120 km x 120 km

[d] Intensive recreational land use capability: lands capable of providing outdoor recreational opportunities for large numbers of people (e.g., bathing, camping, downhill skiing).

[e] Extensive recreational land use capability: lands capable of supporting dispersed, low density recreation use (e.g., hiking, canoeing, remote cottaging).

[f] The predominant and secondary conditions here are the highest and second highest population density encountered in the region. These population densities are assumed for the area closest to the UFDC in the 100 km reference environment considered in the radiological assessment. Since these high population densities are only found in a very small fraction of the region, this assumption is extremely conservative.

[g] The predominant and secondary conditions here are the largest and second largest (in terms of agriculture land area) production for the region.

[h] These are single features that cannot be summarized in that format (e.g., geological formation of special interest). See Grondin and Fearn-Duffy (1993) for full data set.

[i] Population density assumed for a radius of about 32 km around the site, based on the highest census division population density in the region.

[j] Population density assumed for a ring from about 32 km to 60 km around the site, based on the second highest census division population density in the region.

Table K-3
Summary Reference Environment Data for the Southern Shield Region
(Grondin and Fearn-Duffy 1993)

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| AIR QUALITY[b] ($Mg \bullet a^{-1}$)[c] | | | | | |
| Particulate matter | 2 000-9 999 | 72 | 10 000-19 999 | 12 | 16 |
| Hydrocarbon | 1 000-4 999 | 74 | 5 000-49 999 | 26 | 0 |
| Sulphur dioxide | 1 000-9 999 | 48 | 25-999 | 36 | 16 |
| Nitrogen oxide | 500-4 999 | 73 | 10 000-140 000 | 17 | 10 |
| Carbon Monoxide | 25 000-99 999 | 51 | 5 000-24 999 | 37 | 12 |
| WATER QUALITY | | | | | |
| Area covered by water ($km^2$) | 5 000 | 9 | Non Applicable | | |
| Total dissolved solids ($mg \bullet L^{-1}$) | 0-50 | 63 | 51-150 | 34 | 3 |
| Total Hardness ($mgCaCO_3 \bullet L^{-1}$) | 0-60 | 61 | 61-120 | 29 | 10 |
| Turbidity (JTU) | 0-50 | 100 | - | 0 | 0 |
| Suspended sediment ($mg \bullet L^{-1}$) | 0-50 | 56 | 51-200 | 42 | 2 |
| Mean annual runoff (mm) | 250-349 | 46 | 350-449 | 32 | 22 |
| Munic. water supply ($m^3 \bullet d^{-1}$) | 50 000-<br>150 000 | 76 | 350 000-500 000 | 16 | 8 |
| Mean lake size ($km^2$) | 1.5 | Non Applicable | | | |
| Lake size distribution ($km^2$) | <1 | 96 | 1-10 | 3 | 1 |
| Mean lake depth (m) | 4.6 | Non Applicable | | | |
| Lake coverage by size ($km^2$) | >10 | 47 | 1-10 | 28 | 25 |
| Mean river discharge ($m^3 \bullet s^{-1}$) | <1.5 | 58 | 1.5-15 | 28 | 14 |
| Drainage basins | Great Lakes | 100 | - | 0 | 0 |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| Mean annual precipitation (mm) | 800-899 | 53 | 900-999 | 39 | 8 |
| Mean annual snowfall (cm) | 200-299 | 54 | 150-199 | 36 | 10 |
| Mean lake Evaporation (mm) | 600-699 | 52 | 700-799 | 42 | 6 |
| Mean evapotranspiration (mm) | 500-459 | 73 | 400-499 | 27 | 0 |
| Lake freezeup dates | December 15 | 72 | January 1 | 28 | 0 |
| River freezeup dates | December 15 | 53 | January 1 | 47 | 0 |
| Lake breakup dates | April 1 | 65 | March 15 | 32 | 3 |
| River breakup dates | March 15 | 94 | March 1 | 6 | 0 |
| Well yields from bedrock ($L \bullet s^{-1}$) | <1 | 73 | 1-4 | 24 | 3 |
| **FLORA AND FAUNA** | | | | | |
| Fish yield ($kg \bullet a^{-1}$ per lake) | 500 | Non Applicable | | | |
| Common wildlife species | 187 | | | | |
| Common fish species | 49 | | | | |
| Forest tree associations | 10 | | | | |
| Endangered species (total no.) | 49 | | | | |
| **NON-RENEWABLE RESOURCES** | | | | | |
| Mining division boundaries | Eastern Ont. | 92 | Sudbury | 8 | 0 |
| Number & type of mines | 79 (limestone) | 27 | 26 (clay) | 9 | 64 |
| **GEOLOGY** | | | | | |
| Area covered by land ($km^2$) | 50 698 | 91 | Non-Applicable | | |
| Geology | Early Precam. | 63 | late | | 12 |
| Number of plutons | 235 | 17 | Non-Applicable | | |

| Descriptive Factor | Predominant Condition in the Region[a] | % of Region Covered | Secondary Condition in the Region | % of Region Covered | % of Region with Other Conditions |
|---|---|---|---|---|---|
| Soil categories | sand/no lime | 96 | loam or low lime | 3 | 1 |
| **LAND USE/CAPABILITIES** | | | | | |
| Forest types | forested | 85 | forest/ agricultural | 8 | 7 |
| Timber use capability | moderate | 73 | low | 20 | 7 |
| Intensive[d] recreation use | low | 72 | high | 23 | 5 |
| Extensive[e] recreation use | high | 70 | moderate | 23 | 7 |
| Parks | nat. env. | 16 | waterway | 2 | 2 |
| Indian Reserves/communities | I. Reserve | 1 | uninhabit/other | 1 | 0 |
| Population density (persons•km$^{-2}$)[f] | 240 | (i) | 31 | (i) | |
| Forest fires (anthropogonic) annual # per 1000 km$^2$ | 4-8 | 79 | 8-15 | 16 | 5 |
| Forest fires (lightening) annual # per 1000 km$^2$ | 0.5-2 | 99 | 0.1-0.5 | 1 | 0 |
| Forest fires (average # per year) | 253 | Non Applicable | | | |
| Forest fires (average ha per fire) | 2 | | | | |
| Agricultural lands (km$^2$) | 23 376 (total) | 42 | 7037 (in use) | 13 | 0 |
| Agriculture (products)[g] | livestock | 4 | grains | 4 | 5 |
| Natural/historical features[h] | in Reid and Grondin (1993a) | | | | |
| Wetland regions | low boreal | 88 | eastern temperate | 12 | 0 |
| Distribution of wetlands | 0-5% cover | 65 | 6-25% cover | 27 | 8 |

[a] The predominant condition in the region is to be used in the assessment.

[b] Average weather frequency data to be used in the assessment is tabulated with respect to 16 wind sectors based on data (hourly) from all existing Environment Canada meteorologial stations in the region and, therefore, cannot be expressed as a single number. See Grondin and Fearn-Duffy (1993) for data tables.

[c] Per grid size 120 km x 120 km

[d] Intensive recreational land use capability: lands capable of providing outdoor recreational opportunities for large numbers of people (e.g., bathing, camping, downhill skiing).

[e] Extensive recreational land use capability: lands capable of supporting dispersed, low density recreation use (e.g., hiking, canoeing, remote cottaging).

[f] The predominant and secondary conditions here are the highest and second highest population density encountered in the region. These population densities are assumed for the area closest to the UFDC in the 100 km reference environment considered in the radiological assessment. Since these high population densities are only found in a very small fraction of the region, this assumption is extremely conservative.

[g] The predominant and secondary conditions here are the largest and second largest (in terms of agriculture land area) production for the region.

[h] These are single features that cannot be summarized in that format (e.g., geological formation of special interest). See Grondin and Fearn-Duffy (1993) for full data set.

[i] Population density assumed for a radius of about 8 km around the site, based on the highest census division population density in the region.

[j] Population density assumed for a ring from about 8 km to 16 km around the site, based on the second highest census division population density in the region.

## APPENDIX L

Additional details on the Study Area

TABLE L-1: Description of the ecoregions in the Ontario Portion of the Canadian Shield

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| SOUTHERN REGION | NIPPISSING 79% | - warm summers, mean daily temp > 0°C from March to December<br>- cold snowy winters with snowfall varying across the region | - dominated by moderate to strongly broken sandy loam morainal plain | - on dry well drained sites, Humo-Ferric Podzols<br>- on fresh well drained sites, Gray Brown Luvisols & Melanic Brunisols<br>- Gleysols on imperfectly drained sites<br>- Organic soils on poorly drained depressions | - tolerant hardwoods, sugar maple, yellow birch, eastern hemlock & eastern white pine on fresh to well drained sites<br>- dry rapidly drained sites have red pine, eastern white pine & red oak<br>- wet, imperfectly drained sites have black ash, red maple, white spruce, tamarack & eastern white cedar | - forestry, hydroelectric power & tourism are the most important<br>- North Bay is the major urban centre<br>- mining is also present |
| | SAINT-LAURENT 33% | - warm summers and cold snowy winters | - north has weakly to very weakly broken, poorly drained clay and sand plains<br>- central has large, weakly to very weakly broken limestone plain with shallow soils<br>- south has an extensive weakly broken, very stony, morainal plain | - poorly drained clay soils are generally Gray Brown Luvisols or Luvic Gleysols<br>- Organic soils occur frequently and are associated with the poorly drained clay plains or depressions in the morainal deposits | - sugar maple, oak, beech, & eastern hemlock are on fresh, well drained sites<br>- white elm, ash, red maple, & eastern white cedar are on shallow imperfectly drained soils<br>- tamarack & black spruce on deep, poorly drained peat deposits<br>- eastern white pine, red pine, & red oak are on drier sites | - dairy farming and growing of crops like alfalfa, oats, mixed grains, & silage corn are major economic activities<br>- Ottawa is the largest urban centre |
| CENTRAL REGION | SUPERIOR HIGHLANDS 46% | - warm summers and long cold winters | - strongly to moderately broken topography covered by shallow, sandy to loamy moraine<br>- granitic bedrock outcrops are common as bedrock knobs & sheer cliffs<br>- along the shore the bedrock knobs are shaped by the waves<br>- deep, glacially-eroded valleys are frequently filled with sandy outwash deposits, varved lacustrine clay, or silt deposits | - Humo-Ferric Podzols & Dystric Brunisols are found under coniferous stands on dry to fresh, & rapidly to well drained sites<br>- Gray Luvisols occur where soils are finer textured<br>- Gleysols & Organic soils are present in poorly drained depressions or lower slope landscape positions | - fresh, well drained sites have boreal mixedwood stands of trembling aspen, white birch, white spruce, & balsam fir<br>- dry well drained sites have pure stands of jack pine, mixedwood stands of jack pine, black spruce, trembling aspen, & white birch<br>- wet imperfectly drained sites have black spruce, tamarack, & eastern white cedar<br>- thick mats of feathermoss cover the forest floor | - dominant economic activity is forestry<br>- mining of precious metals is also an important activity |
| | NIPPISSING 21% | - warm summers, mean daily temp > 0°C from March to December<br>- cold snowy winters with snowfall varying across the region | - dominated by moderate to strongly broken, shallow to bedrock sandy loam morainal plain | - on dry well drained sites, Humo-Ferric Podzols<br>- on fresh well drained sites, Gray Brown Luvisols & Melanic Brunisols<br>- Gleysols on imperfectly drained sites<br>- Organic soils on poorly drained depressions | - tolerant hardwoods, sugar maple, yellow birch eastern white pine on fresh to well drained sites<br>- dry rapidly drained sites have black ash, red maple, white spruce, tamarack & eastern white cedar | - forestry, hydroelectric power & tourism are the most important<br>- Sudbury, Sault St. Marie are the major urban centres<br>- mining is important in Sudbury |

continued...

SOURCE: Environment Canada. 1989. Ecoregions of Ontario. Edited by G.M. Wickware and C.D. A. Rubec. Ecological land Classification Series No. 26, Ottawa, Canada.

TABLE L-1 (continued)

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| CENTRAL REGION cont'd | CHAPLEAU PLAINS 97% | - warm summers and cold winters | - strongly to moderately broken, sandy to loamy in the shore sections<br>- moderately to weakly broken in the central & eastern sections, with central having sandy to loamy materials & eastern having broken lacustrine clay | - shore sections are Humo-Ferric Podzols with well developed Ah horizons<br>- Humo-Ferric Podzols are also in the central sections under a more typical boreal vegetation<br>- Brunisolic Gray Luvisols & Gray Luvisols dominate the eastern sections<br>- Greysolic & Organic soils occupy imperfectly & poorly drained sites throughout the region | - fresh well drained sites have white spruce, balsam fir, eastern white pine, red pine, white birch, & trembling aspen<br>- shore sections there are tolerant hardwoods like sugar maple, red maple, & yellow birch, these are in well drained sites. Imperfectly and poorly drained sites along the shore have black spruce, tamarack, red maple, & black ash<br>- jack pine & black spruce are found on dry, rapidly drained sites | - region is sparsely populated, with most centres having less than 5000 residents<br>- dominant economic activity is forestry & tourism |
| | LAC MATTAGAMI 91% | - warm summers and cold snowy winters | - imperfectly to poorly drained, very weakly to weakly broken, glaciolacustrine clay plain<br>- coarse sandy textured, glaciofluvial outwash deposits occur throughout the region, but are prominent in the south & west<br>- much is covered by a blanket of peat | - poorly drained organic soils or imperfectly drained peaty phase Gleysols<br>- Humo-Ferric Podzols on the well drained sandy sites<br>- Gray & Brunisolic Gray Luvisols on the better drained, fine loamy to clayey textured sites | - extensive stands of black spruce on the thick peat deposits that cover the region<br>- white spruce, balsam fir, black spruce, & eastern white cedar on fresh, well drained, fine loamy & clayey deposits<br>- jack pine & jack pine-black spruce are on the drier, rapidly drained, coarse textured sandy sites | - primary economic activities are forestry, mining, & tourism<br>- Timmins is the largest populated centre<br>- outside communities support the forest industry |
| | JAMES PLAINS 11% | - short warm summers and long cold winters | - flat & poorly drained, underlain by Tyrell Sea silts & clays<br>- well drained, gravelly beach ridges parallel the coast & extend inland<br>- peatland landforms such as domed bogs, patterned ferns & bog islands characterized the flat marine plain<br>- extensive tidal flats occur along most of the coast<br>- north from Akimiski Island the prominence of coastal ridges increases | - Orthic Regosols on well drained beach ridges near the coast<br>- Ferro-Humic Podzols or Dystric Brunisols inland from the coast<br>- poorly developed soils, Orthic & Humic Gleysols, occur in coastal salt marches<br>- poorly drained organic soils are found where peat depths are >40 cm<br>- peaty pase Gleysols, Humic Gleysols, & Organic soils occur on major river levees | - black spruce-tamarack dominated treed swamps, & tamarack dominated treed fens are the most extensive wetland types<br>- white & black spruce, & balsam fir occupy the well drained beach ridges & river levees<br>- treed bogs with black spruce, & open low shrub, graminoid & sphagnum moss bogs also occur widely | - tourism & recreation are the dominant economic activities<br>- Moosonee & Moose Factory are the most common destination for hunters & fishermen |

continued...

TABLE L-1 (continued)

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| CENTRAL REGION cont'd | LAKE ST. JOSEPH PLAINS 2% | - warm summers & long cold, snowy winters | - in the east it is undulating to rolling & covered by a shallow to moderately deep, sandy to coarse loamy textured moraine; frequent bedrock knobs occur; pockets of lacustrine silts & clays occur<br>- in the north it is covered by a weakly broken outwash sand plain, & a coarse loamy, drumlinized morainal plain<br>- in the west it is a weakly broken lacustrine clay plain | - predominantly Humo-Ferric Podzols<br>- Dystric Brunisols are on coarse textured sites & Gray Luvisols on fine loamy-clayey sites<br>- Gleysolic & Organic soils occur on imperfectly drained sites & in bedrock depressions<br>- peaty phase Gleysols are particularly predominant on the poorly drained clay sites of the Longlac-Geraldton area | - fresh well drained sites have black spruce, white spruce, balsam fir, jack pine, trembling aspen, & white birch are on fresh well drained sites<br>- on dry, rapidly drained coarse textured sands there is jack pine and jack pine-black spruce<br>- stunted low density jack pine are in the shallow soil bedrock sites<br>- black spruce, balsam poplar, & tamarack occur in bedrock depressions & poorly drained sites | - forestry for pulp & paper & hydroelectric generation are the major economic activities |
| NORTHERN REGION | JAMES PLAINS 4% | - short warm summers and long cold winters | - flat & poorly drained underlain by Tyrell Sea silts & clays<br>- well drained, gravelly beach ridges parallel the coast & extend in land<br>- peatland landforms such as domed bogs, patterned ferns & bogs, & bog islands characterize the flat marine plain<br>- extensive tidal flats occur along most of the coast<br>- north from Akimiski Island the prominence of coastal ridges increases | Orthic Regosis on well drained beach ridges near the coast<br>- Ferro-Humic Podzols or Dystric Brunisols inland from the coast<br>- poorly developed soils, Orthic & Humic Gleysols, occur in coastal salt marshes<br>- poorly drained organic soils are found where peat depths are >40 cm<br>- peaty phase Gleysols, Humic Gleysols, & Organic soils occur on major river levees | - black spruce-tamarack dominated treed swamps, & tamarack dominated treed fens are the most extensive wetland types<br>- white & black spruce, & balsam fir occupy the well drained beach ridges & river levees<br>- treed bogs with black spruce, & open low shrub, graminoid, & Sphagnum moss bogs also occur widely | - tourism & recreation are the dominant economic activities<br>- Moosonee & Moose Factory are the most common destinations for hunters & fishermen<br>- Moosonee, Fort Albany, & Attawapiskat are major settlements in the ecoregion but they are outside the Canadian Shield |
| | NIPIGON PLAINS 100% | - warm summers & cold winters | - weakly to moderately broken topography<br>- adjacent to Lake Nipigon is a weakly broken sandy plain with pockets of finer textured silty to clayey, lacustrine parent materials<br>- in the north & west is extensive plains of outwash plains of outwash sands & gravels<br>- central section has sandy to coarse loamy textured deposits which overlie a weakly to moderately broken substrate | - Humo-Ferric Podzols are in coarser textured, well drained sites<br>- Gray Luvisols are associated with finer textured silts & clays of the Lake Kipigon area<br>- Gleysolic & Organic soils are found on imperfectly & poorly drained bedrock depressions | - white spruce, balsam fir, jack pine, black spruce, trembling aspen, & white birch on fresh, well drained sites<br>- white spruce & balsam fir are suited to finer textured materials in the Lake Nipigon area<br>- jack pine with lichen mats occurs on bare bedrock knobs<br>- black spruce, tamarack, & balsam poplar occur on imperfectly & poorly drained sites | - forestry & tourism are the main economic activity in this sparsely populated region |

continued...

TABLE L-1

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| NORTHERN REGION cont'd | THUNDER BAY PLAINS 100% | - warm & somewhat dry summers and cold snowy winters | - shore areas have strongly to moderately broken topography with frequent bedrock exposures<br>- large geological structures (mesas) occur where soft underlying sedimentary rocks are protected by a resistant overlaying cap of basaltic rock<br>- topography is moderately to weakly broken with a shallow, sandy-loamy surface morainal parent material in the inland<br>- west of thunder bay deep silty-clayey lacustrine deposits occur | - Humo-Ferric Podzols & Dystric Brunisols occur on the coarser textured, dry to fresh, rapidly to well drained sites<br>- Gray Luvisols occur on the finer textured silts & clays of the region<br>- Gleysolic & Organic soils occur in poorly drained bedrock depressions & in imperfectly drained sites of finer textured materials | - red maple, silver maple, & yellow birch occur on slight warmer sites<br>- coniferous forests of white spruce, balsam fir, trembling aspen, white birch, & eastern white pine occur on fresh, well drained sites<br>- jack pine, & jack pine-black spruce are on dry, rapidly drained sites<br>- black spruce, tamarack, & balsam poplar are on imperfectly & poorly drained sites | - forestry & tourism are the main economic activities<br>- Thunder Bay is the regional centre, it acts as a major transhipment point for western Canadian grain and pulp & paper |
| | LAKE OF THE WOODS PLAINS 100% | - warm summers and cold winters | - northern section has moderately to weakly broken topography with bare, wave-washed bedrock ridges or shallow, loamy to silty textured sands<br>- shallow to deep silty clays occur in valleys and deep depressions the sandy morainal material is typically very bouldery & consists of a surface ablation moraine<br>- pockets of deep, well drained glaciofluvial or lacustrine sands occur throughout the region<br>- the Rainy River area has very weakly broken clay plains, frequently covered by peatlands<br>- scattered bedrock ridges occur in the eastern section but are most frequent in the north | - fresh, well drained, coarse textured sites have Humo-Ferric Podzols or Dystric Brunisols, with gleyed phases occurring on the moist & wet landscape positions<br>- fresh, well drained sites with finer textured silts & clays are typically Gray Luvisols & Brunisolic Gray Luvisols or Humic Gleysols are common<br>- peaty phase Gleysols & deep Fibrisols, Mesisols, & Humisols are associated with poorly drained depressions and organic sites | - jack pine & black spruce occur on well drained, coarser textured soils, & on very shallow soils<br>- mixed stands of trembling aspen, white birch, black spruce, & balsam fir occur over a range of site conditions<br>- black spruce & tamarack drained sites<br>- white elm, black ash, & balsam poplar occur on poorly drained sites but are most frequent in the southern sections | - forestry & tourism are the most important economic activities<br>- in the Rainy River area farming is locally important but generally declining<br>- most of the region is accessible by road<br>- Kenora & Fort Frances are the two major population centres of the region |
| | BIG TROUT PLAINS 96% | - cool summers & long cool winters | - weakly broken topography<br>- undulating rock ridges with pockets of calcareous lacustrine clays & non-calcareous sands in the west<br>- rock ridges & shallow to deep drumlinized & undrumlinized morainal plains make up the remaining parts of the region | - Humo-Ferric Podzols & Dystric Brunisols on the drier well drained sites<br>- Gleysols on imperfectly drained landscape<br>- in the clayey lacustrine deposits there are Orthic Gray and Gleyed Gray Luvisols<br>- peaty phase Gleysols & Terric/Typic Fibrisols & Mesisols are on poorly drained upland sites & wetlands | - fresh, well drained sites have black spruce, trembling aspen, & white birch<br>- drier, rapidly drained sites have open growth stands of jack pine, aspen, white birch, & black spruce<br>- on variably drained, wet silty & sandy sites there are black spruce, tamarack, white spruce, balsam fir, & trembling aspen<br>- black spruce-jack pine & black spruce-tamarack are on variably drained, wet to dry silty & sandy sites | - sparsely settled with one major settlement at Big Trout Lake<br>- Forest access roads are now only reaching the area & little economic activity occurs |

continued...

(Envirc  ıt Canada, 1989)

TABLE L-1

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| NORTHERN REGION cont'd | SUPERIOR HIGHLANDS 54% | - warm summers and long cold winters | - strongly to moderately broken covered by shallow, sandy to loamy moraine<br>- granite bedrock outcrops in the form of rounded rock knobs & sheer cliff faces are common<br>- deep, glacially-eroded valleys near Lake Superior are filled with sandy outwash deposits, varved lacustrine clay, or silt deposits | - Humo-Ferric Podzols & Dystric Brunisols are found under coniferous forest stands on dry to fresh, & rapidly to well drained sites<br>- Gray Luvisols occur where soils are finer textured, & gleysols & organic soils are in poorly drained depressions or lower slope landscape positions | - boreal mixed wood stands of trembling aspen, white birch, white spruce, & balsam fir are on fresh, well drained sites<br>- dry, well drained sites have jack pine, black spruce, trembling aspen & white birch<br>- wet, imperfectly drained sites have black spruce, tamarack, & eastern white cedar<br>- thick mats of feathermoss cover the forest floor under a coniferous forest<br>- bedrock knobs are covered by a stunted discontinuous forest of jack pine with understory lichen mats | - dominant land use of economic activity is forestry<br>- mining of precious metals has recently become important |
| | GODS PLAINS 100% | - cool summers and long cold winters | - gently undulating to hummocky veneer of shallow to deep, moderately calcareous lacustrine clay deposits<br>- occasional bedrock outcrops occur<br>- shorelines are generally irregular & rocky | - loamy to sandy textured morainal materials underlie surficial clay textured soils<br>- Orthic Gray Luvisols & Eutric Brunisols on wave washed sites<br>- Terric Mesisol & Terric Fibric Organic Cryosols occur in peatlands<br>- all mineral soils are generally weakly to strongly calcareous & well drained | - mainly closed coniferous forests<br>- on variably drained, wet silty & sandy sites, stands of black spruce & tamarack with white spruce, balsam fir, & trembling aspen are found | - sparsely settled with only a few small centres<br>- hunting & trapping are the main economic activities in this region |
| | SPECTOR PLAINS 8% | - long cold winters and short cool summers | - large flat-laying geological structure comprised of early Paleozoic carbonate rocks<br>- an extensive wet, flat plain with complex of poorly drained peatlands & a myriad of small lakes, ponds, & creeks | - Organic Cryosols & Typic/Terric Fibrisols or Mesisols are in this region<br>- entire area is wet & poorly drained except for a few bedrock outcrops | - "treed bogs" in the north consist of black spruce & lichen<br>- featureless black spruce-tamarack swamps with understories of swamp birch, sweet gale, & leatherleaf extend over large areas<br>- open bogs & fens dominated by Sphagnum species & shrubs also occur over extensive areas | - only a few scattered settlements<br>- little economic development<br>- hunting, trapping & fishing by residents are the primary activities |

continued...

TABLE L-1 (concluded)

| SHIELD REGION | ECOREGIONS (% of ecoregion) | CHARACTERISTICS | | | | |
|---|---|---|---|---|---|---|
| | | CLIMATE | TERRAIN | SOILS | VEGETATION | LAND USE |
| NORTHERN REGION cont'd | LAKE ST. JOSEPH PLAINS 98% | - warm summers & long cold, snowy winters | - in the east it is undulating to rolling & covered by a shallow to moderately deep, sandy to coarse loamy textured moraine; frequent bedrock knobs occur; pockets of lacustrine silts & clays occur<br>- in the north it is covered by a weakly broken outwash sand plain, & a coarse loamy, drumlinized morainal plain<br>- in the west it is a weakly broken lacustrine clay plain | - predominantly Humo-Ferric Podzols<br>- Dystric Brunisols are on coarse textured sites & Gray Luvisols on fine loamy-clayey sites<br>- Gleysolic & Organic soils occur on imperfectly drained sites & in bedrock depressions<br>- peaty phase Gleysols are particularly predominant on the poorly drained clay sites of the Longlac-Geraldton area | - fresh well drained sites have black spruce, white spruce, balsam fir, jack pine, trembling aspen, & white birch are on fresh well drained sites<br>- on dry, rapidly drained, coarse textured sands there is jack pine and jack pine-black spruce<br>- stunted low density jack pine are in the shallow soil bedrock sites<br>- black spruce, balsam poplar, & tamarack occur in bedrock depressions & poorly drained sites | - forestry for pulp & paper & hydroelectric generation are the major economic activities |
| | LAC MATTAGAMI 9% | - warm summers and cold snowy winters | - imperfectly to poorly drained, very weakly to weakly broken, glaciolacustrine clay plain<br>- coarse sandy textured, glaciofluvial outwash deposits occur throughout the region, but are prominent in the south & west<br>- much is covered by a blanket of peat | - poorly drained organic soils or imperfectly drained peaty phase Gleysols<br>- Humo-Ferric Podzols on the well drained sandy sites<br>- Gray & Brunisolic Gray Luvisols on the better drained, fine loamy to clayey textured sites | - extensive stands of black spruce on the thick peat deposits that cover the region<br>- white spruce, balsam fir, black spruce, & eastern white cedar on fresh, well drained, fine loamy & clayey deposits<br>- jack pine & jack pine-black spruce are on the drier, rapidly drained coarse textured sandy sites | - primary economic activities are forestry, mining & tourism<br>- outside communities support the forest industry |
| | BERENS PLAINS 100% | - warm summers and cold winters | - the west is weakly to moderately broken plains, with bare to shallow soils over bedrock; peat-covered thin clay deposits are found in most valleys & depressions; shallow sandy to silty sandy moraine covers many of the ridges<br>- a large, weakly broken, varved lacustrine clay plain surrounding Lac Seul dominates the central area; extensive peat deposits are found to the north of this clay plain<br>- the remaining areas have weakly to moderately broken shallow moraine over bedrock, & shallow moraine over bedrock with pockets of lacustrine clay sediments | - dry to fresh, well drained sandy sites have Ferro-Humic Podzols or Dystric Brunisols; Gleyed phases of these soils can also occur on similar parent materials in moist or wet landscape positions<br>- Brunisolic Luvisols & Gray Luvisols are found on fresh sites, along with clayey Gleyed Luvisolic soils on moist to wet clay sites<br>- bedrock sites are characterized by shallow Folisolic soils<br>- deep Organic soils are found in many bedrock depressions & range from Fibrisols to Humisols | - on well drained, fresh, loamy to silty & clayey sites there are white birch, & trembling aspen<br>- on dry, rapidly drained sites there is jack pine<br>- imperfectly drained, fine textured sites have balsam poplar, eastern white cedar, & tamarack<br>- Organic soils are dominated by black spruce, & tamarack<br>- eastern white pine & red pine occur on warmer site positions throughout the area | - forestry & tourism are the predominant economic activities in the region<br>- gold & iron ore mining are also important<br>- Red Lake, Dryden, & Sioux Lookout are the largest communities in this sparsely populated region |

(Environment Canada, 1989)

TABLE L-2
Active Labour Force by Sector of Activity in the Ontario Portion of the Canadian Shield

| SOUTHERN REGION | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Labour Force by Industry | Ottawa/ Carleton* | Leeds/ Grenville* | Lanarck* | Frontenac* | Lennox/ Addington* | Hastings* | Peterborough* | Victoria* | Simcoe* | Muskoka* | Haliburton | Renfrew | Nipissing* | Perry Sound | TOTALS | |
| Agriculture | 282 | 1 107 | 1 109 | 878 | 512 | 1 456 | 821 | 292 | 240 | 255 | 145 | 1 785 | 296 | 370 | 8 441 | 2.9% |
| Fishing & Trapping | 4 | 10 | 8 | 20 | 0 | 11 | 9 | 1 | 3 | 20 | 5 | 20 | 21 | 35 | 167 | 0.06% |
| Logging & Forestry | 31 | 171 | 113 | 98 | 67 | 359 | 60 | 9 | 12 | 145 | 115 | 975 | 283 | 205 | 2 643 | 0.9% |
| Mining, Quarrying & Oil | 27 | 48 | 97 | 70 | 31 | 124 | 115 | 15 | 25 | 70 | 25 | 185 | 229 | 70 | 1 131 | 0.4% |
| Manufacturing | 1 774 | 5 159 | 4 061 | 4 957 | 1 823 | 6 507 | 4 987 | 958 | 1 227 | 2 455 | 435 | 6 870 | 2 041 | 1 730 | 44 984 | 15.2% |
| Construction | 1 433 | 1 441 | 1 487 | 2 925 | 652 | 2 176 | 1 543 | 345 | 460 | 2 215 | 630 | 2 715 | 1 297 | 1 520 | 20 839 | 7.0% |
| Trans & Storage | 709 | 768 | 857 | 1 244 | 386 | 1 569 | 614 | 149 | 243 | 870 | 155 | 1 335 | 1 271 | 1 035 | 11 205 | 3.8% |
| Comm. & other Utilities | 1 106 | 551 | 563 | 1 084 | 286 | 1 207 | 823 | 139 | 176 | 700 | 155 | 1 230 | 801 | 435 | 9 256 | 3.1% |
| Wholesale Trade | 788 | 785 | 760 | 1 307 | 330 | 1 143 | 943 | 147 | 257 | 730 | 235 | 1 290 | 670 | 445 | 9 830 | 3.3% |
| Retail Trade | 2 988 | 2 690 | 2 524 | 5 745 | 1 313 | 4 984 | 3 609 | 563 | 885 | 2 790 | 655 | 5 615 | 2 761 | 2 175 | 39 297 | 13.2% |
| Finance & Insurance | 887 | 434 | 399 | 1 225 | 221 | 731 | 591 | 77 | 138 | 445 | 105 | 650 | 377 | 260 | 6 540 | 2.2% |
| Real Estate & Ins. Agents | 573 | 337 | 290 | 679 | 134 | 508 | 453 | 79 | 106 | 425 | 160 | 415 | 237 | 240 | 4 636 | 1.6% |
| Business Service | 2 252 | 640 | 790 | 1 576 | 236 | 1 058 | 741 | 92 | 185 | 570 | 85 | 2 810 | 468 | 310 | 11 813 | 4.0% |
| Government Service | 7 211 | 1 793 | 2 268 | 705 | 820 | 4 569 | 1 070 | 191 | 535 | 1 185 | 370 | 6 630 | 2 366 | 1 225 | 37 284 | 12.6% |
| Educational Service | 1 954 | 1 250 | 1 205 | 5 916 | 591 | 2 151 | 1 697 | 230 | 331 | 840 | 335 | 2 180 | 1 313 | 910 | 20 903 | 7.1% |
| Health & Soco. Service | 2 137 | 1 986 | 2 020 | 5 542 | 829 | 2 840 | 2 180 | 292 | 515 | 1 675 | 330 | 3 325 | 1 736 | 1 370 | 26 777 | 9.0% |
| Acc. Food & Bev. Service | 1 542 | 1 566 | 1 092 | 3 635 | 644 | 2 371 | 1 764 | 214 | 405 | 2 420 | 725 | 2 450 | 1 653 | 1 625 | 22 106 | 7.5% |
| Other Service Ind. | 1 858 | 1 232 | 1 100 | 3 093 | 462 | 2 041 | 1 645 | 251 | 311 | 1 270 | 275 | 2 700 | 1 175 | 995 | 18 408 | 6.2% |
| Total | | | | | | | | | | | | | | | 296 260 | |

continued...

* Figures correlate with fraction of county that is represented/present in the region.
Source: Statistics Canada: 1986 Census. Copyright (C) 1988;89 by Compusearch.

TABLE L-2 (continued)

| | CENTRAL REGION | | | | | | | | NORTHERN REGION | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nipissing * | Sudbury | Sudbury Town | Timiskimin | Cochrane* | Algoma* | **TOTALS** | | Thunder Bay | Rainy River | Kenora* | **TOTALS** | |
| Agriculture | 274 | 225 | 375 | 915 | 302 | 619 | 2 710 | 1.5% | 785 | 290 | 136 | 1 211 | 1.1% |
| Fishing & Trapping | 19 | 40 | 40 | 25 | 9 | 114 | 361 | 0.2% | 130 | 40 | 53 | 223 | 0.2% |
| Logging & Forestry | 262 | 750 | 490 | 755 | 1 198 | 1 356 | 4 811 | 2.7% | 3 520 | 835 | 1 012 | 5 367 | 5.1% |
| Mining, Quarrying & Oil | 212 | 675 | 7 910 | 1 945 | 1 476 | 4 544 | 16 762 | 9.4% | 1 600 | 55 | 802 | 2 457 | 2.3% |
| Manufacturing | 1 884 | 2 020 | 6 680 | 1 640 | 5 301 | 12 845 | 30 370 | 17.1% | 12 790 | 1 570 | 1 808 | 16 168 | 15.3% |
| Construction | 1 198 | 595 | 3 825 | 940 | 1 340 | 3 138 | 11 036 | 6.2% | 4 490 | 540 | 720 | 5 750 | 5.5% |
| Trans & Storage | 1 174 | 830 | 3 155 | 1 080 | 1 238 | 3 005 | 10 482 | 5.9% | 6 465 | 655 | 1 168 | 8 288 | 7.9% |
| Comm. & other Utilities | 739 | 285 | 2 375 | 650 | 615 | 1 450 | 6 114 | 3.4% | 2 355 | 355 | 407 | 3 117 | 2.9% |
| Wholesale Trade | 619 | 190 | 2 940 | 510 | 708 | 1 653 | 6 620 | 3.7% | 3 060 | 265 | 342 | 3 667 | 3.5% |
| Retail Trade | 2 549 | 1 375 | 9 610 | 2 315 | 3 303 | 8 336 | 19 152 | 10.8% | 9 790 | 1 360 | 1 823 | 12 973 | 12.3% |
| Finance & Insurance | 348 | 105 | 1 940 | 330 | 464 | 1 233 | 4 420 | 0.8% | 1 555 | 150 | 224 | 1 929 | 1.8% |
| Real Estate & Ins. Agents | 218 | 105 | 1 020 | 200 | 345 | 812 | 2 700 | 1.5% | 965 | 140 | 159 | 1 264 | 1.2% |
| Business Service | 432 | 105 | 1 840 | 405 | 502 | 1 475 | 4 759 | 2.7% | 2 175 | 180 | 289 | 2 644 | 2.5% |
| Government Service | 2 184 | 815 | 6 965 | 915 | 1 520 | 3 648 | 16 047 | 9.0% | 6 150 | 1 050 | 1 861 | 9 061 | 8.6% |
| Educational Service | 1 212 | 800 | 6 425 | 1 470 | 1 859 | 4 178 | 15 944 | 9.0% | 5 820 | 785 | 856 | 7 461 | 7.1% |
| Health & Soco. Service | 1 603 | 575 | 5 875 | 1 675 | 2 201 | 4 866 | 16 795 | 9.4% | 7 370 | 930 | 1 177 | 9 477 | 9.0% |
| Acc. Food & Bev. Service | 1 526 | 1 240 | 4 820 | 1 265 | 1 723 | 5 138 | 15 712 | 8.8% | 6 025 | 1 245 | 1 726 | 8 996 | 8.5% |
| Other Service Ind. | 1 085 | 410 | 4 555 | 950 | 1 041 | 3 232 | 11 273 | 6.3% | 4 230 | 505 | 690 | 5 425 | 5.1% |
| **Total** | | | | | | | **177 978** | | | | | **105 478** | |

*Figures correlate with fraction of county that is represented/present in the region - please see Table A-41.

## APPENDIX M

## BACKGROUND ON POSSIBLE CLIMATE CHANGE

# Appendix M

## Background on Possible Climate Change

### 1. Introduction

Recent measurements clearly indicate that the composition of the Earth's atmosphere is changing markedly (Environment Canada 1987). Human activities such as deforestation, the burning of fossil fuels, and even certain agricultural practices are significantly increasing the amount of gases in the atmosphere which contribute to the "greenhouse effect". The greenhouse effect is the warming of the Earth's atmosphere due to the reduction of the Earth's emission of infrared radiation to space, resulting from infrared absorption by radiatively active gases in the atmosphere.

### 2. Greenhouse Gases

The most abundant atmospheric constituent contributing to the "greenhouse effect" is carbon dioxide ($CO_2$). Over thirty years of accurate measurements of concentrations of this gas in the atmosphere indicate that an increase of 10% has taken place since the late 1950s, and a probable 25% since pre-industrial periods (Environment Canada 1986). Other greenhouse gases such as methane ($CH_4$), nitrous oxide ($N_2O$), low-level ozone ($O_3$) and industrial gases such as chlorofluorocarbons (e.g., freon) are increasing even more rapidly. These constituents effectively act as a barrier to infrared radiation originating from the Earth's surface, resulting in increased temperatures within the atmosphere.

Projections of future levels of $CO_2$ in the atmosphere indicate, at minimum, an eventual doubling of concentrations over pre-industrial levels. The timing of such a doubling, however, remains uncertain due to the difficulties of predicting long-term human behaviour with respect to energy consumption and other $CO_2$ producing activities. Concentrations of other greenhouse gases are also likely to increase in the future, compounding the climatic effects of rising $CO_2$ levels. A combined effect on climate equivalent to a doubling of $CO_2$ appears possible as early as 2030 AD, and highly probable by 2050 AD.

### 3. Global Climate Models and Their Predictions

The six most widely accepted Global Climate Models (GCMs) predict that future global mean temperatures will range from 1.5° to 4.5°C higher than current averages. This temperature rise could have implications on the natural and built environments of Ontario.

The following is a list of potential impacts for Ontario which have been identified as common to the various models currently in use (Environment Canada 1991):

- shift of climatic zones several hundred kilometers northward over the next 50 years;

- decrease in the amount of precipitation in Southern Ontario but an increase in Northern Ontario;

- potential for northward expansion of agricultural crops where the soils permit but increases in the frequency and severity of drought and pest occurrences in the south;

• shift northwards of forest ecosystems but with narrower boundaries for some species;

• significant degradation of permafrost within the next 40-50 years (northward movement of southern limit by about 200-600 km);

• net basin runoff decrease of 25-50% in the Great Lakes - St.Lawrence System (water level reduction of 30-80 cm);

• resident fish species may disappear from the Great Lakes but an estimated 30 new species will replace them;

• increased potential for forest fires with drier conditions;

• increase in the ice-free shipping season in the Great Lakes;

• positive effects on summer recreation and tourism but negative effects for winter activities.

REFERENCES TO APPENDIX M

Environment Canada 1986. Understanding $CO_2$ and Climate: Annual Report 1986.

Environment Canada 1987. Canadian Climate Impacts Program, In: Canadian Climate Change Digest.

Environment Canada 1991. Climate Change and Canadian Impacts: The Scientific Perspective", In: Canadian Climate Change Digest.

**APPENDIX N**

<u>REVIEW OF METHODS FOR CHARACTERIZATION OF THE NATURAL AND HUMAN ENVIRONMENT AT THE IMPLEMENTATION STAGE</u>

## Appendix N

## REVIEW OF METHODS FOR CHARACTERIZATION OF THE NATURAL AND HUMAN ENVIRONMENT AT THE IMPLEMENTATION STAGE

## N.1 INTRODUCTION

This appendix presents a review of methods that could be used during implementation of the concept to characterize and monitor the natural and human environment during UFDC siting, and as required during subsequent stages. Examples of the kind of data that would be collected are also given.

The data collection, which would begin with the preliminary characterization at the site screening sub-stage, would continue and be refined throughout the site evaluation sub-stage to include other site-specific components and pre-project baseline studies. Data collection would also continue with a monitoring program for the selected site during construction and operation, based primarily on the design of the baseline studies. Post-operational monitoring would take over once the facility's operations cease. This data collection threads throughout the life cycle of the disposal facility as illustrated in Figure N-1. For this reason, baseline studies and environment monitoring are also discussed here as part of the overall environment characterization.

Decisions on the scope of the natural and human environment characterization at the siting stage would be taken in consultation with all stakeholders. It is assumed that the siting process would have provisions for extensive input into the scope of the environmental characterization from the public, government agencies, scientific groups and other stakeholders. This participation may take place in the form of scoping workshops/symposia, steering committees(s), liaison committees or any other means that would promote cooperation. It is assumed that through this consultative process, the integration of the human and natural environment aspects is achieved and that important interactions are identified.

## N.2 REVIEW OF METHODS FOR CHARACTERIZATION OF THE NATURAL ENVIRONMENT

The environment characterization, during siting and subsequent stages of the disposal facility life-cycle, would be based on an ecological framework. Ecological characterization was defined by Hirsch (1980) as "a description of the important components and processes comprising an ecosystem and an understanding of their functional relationships".

A broad characterization of the natural environment of the three Ontario shield regions has been carried out for the present assessment (see Section 3.1) and use of a Geographical Information System (GIS) for region-wide characterization has been demonstrated in Grondin and Fearn-Duffy 1993). At the siting stage, characterization methods have to be refined and characterization performed at a more detailed level.

In general, ecological characterization implies the collection of information on both the key biotic resources, such as species and their habitats, and key abiotic processes, such as energy transfers and climatic conditions (Beanlands and Duinker 1983). A variety of approaches have been documented for collecting such information (Holling 1978; Beanlands and Duinker 1983; Everitt and Colnett 1987; Wolfe 1987). Portions of these approaches can be embodied into a natural environment characterization strategy for both the site screening and site evaluation sub-stages.

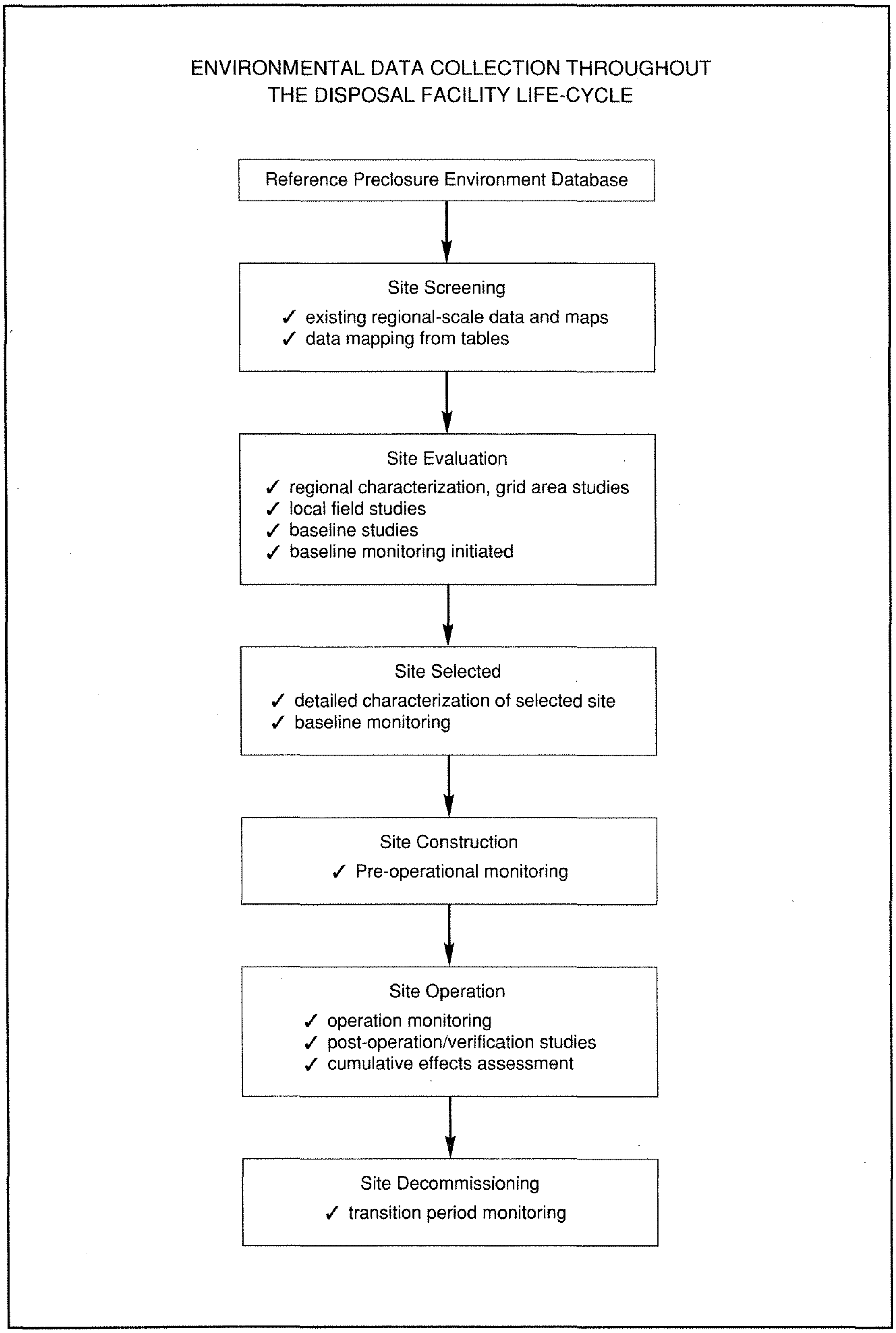


FIGURE N-1: Data Collection Thread

Not every natural environment characteristics may be applicable, nor may they be of interest to everyone. Therefore, it is important to identify the parameters of the natural environment that are of concern and/or interest to the public, government agencies and the scientific community. Based on this information, the scope of the natural environment characterization can be constructed such that it identifies and addresses each group's concerns.

It is assumed that the characterization strategy would include the following elements:

1) identification of valued ecosystem components (VECs) at the site-screening sub-stage; they are components of the environment for which there is public or scientific/technical concern, or both, and to which the assessment would be primarily directed (Everitt and Colnett 1987);
2) prioritization of these VECs;
3) refining the VECs in the preliminary site evaluation sub-stage when the process has reduced the alternatiaves to a small number of sites; and
4) performing a site-specific environment characterization in the second part of the site evaluation sub-stage, when the process has reduced the alternatives to 2 or 3 sites.

The identification of the VECs can be done through scoping workshops to seek and incorporate input from public and government agencies (Holling 1978), thus allowing for the participation of the various stakeholders.

Although the range of environmental factors that may be considered in ecological characterization is very broad, it is important to ensure that the intricacies of the receiving environment are appropriately identified and addressed. Table N-1 presents an example of the kind of data that could be collected at the site-screening sub-stage to characterize the receiving environment. As seen in section 3.1, the environmental data used in the present assessment is only a subset of the data types presented in Table N-1 because of the restrictions imposed by the non site-specific nature of the study.

### N.2.1 Data Acquisition for Site Screening Environment Characterization

Information on the existing environment would be collected to the same regional level of detail as the geological information that would be used to screen sites for geological suitability (Davison et al. 1994). This regional characterization would be used to screen out areas where sensitive natural environmental features (e.g., wintering areas for woodland caribou) should be protected. Without carrying out a full assessment of impacts, this information would help in establishing avoidance criteria for site screening (see Appendix J).

The preliminary environmental characterization would be based on data from existing sources. These may include various types of remote sensing data, governmental agency data bases, published scientific literature, regional/local expertise, as well as traditional knowledge (e.g., Aboriginal elders).

Table N-1
Examples of Environmental Factors Considered in the Preparation of an Existing Environment Inventory

| Air Resources | Water Resources | Land Resources |
|---|---|---|
| 1. Dispersion Conditions<br>- atmospheric stability<br>- wind direction<br>- topography<br>- surface roughness<br>- air temperature | 1. Dispersion Conditions<br>- river flow<br>- offshore topography<br>- river width and depth<br>- lake size and depth<br>- shoreline and offshore features<br>- water temperature<br>- precipitation<br>- ice conditions | 1. Topography, hydrogeology and surface drainage<br>- topography<br>- soils<br>- surface drainage<br>- geology and geomorphology<br>- groundwater |
| 2. Air Quality<br>- non-radiological<br>- radiological<br>- existing emission sources | 2. Water Quality<br>- non-radiological<br>- radiological<br>- local discharges | 2. Agriculture<br>- capability<br>- percent usage<br>- productivity |
| 3. Human Population<br>- distribution around site<br>- main population centres<br>- sensitive population groups | 3. Local Intakes<br>- municipal<br>- industrial | 3. Forestry and Vegetation<br>- capability<br>- forest management areas<br>- forest species<br>- un-managed forest areas<br>- forest productivity<br>- commercially valuable species |
| 4. Agriculture<br>- sensitive agricultural crops<br>- edible biota<br>- dairy areas | 4. Fishing and Spawning<br>- migratory routes<br>- spawning areas<br>- fishing areas<br>- angling activity<br>- commercial fishery | 4. Recreation<br>- capability<br>- parks, conservation areas<br>- cottage development |
| 5. Forestry<br>- sensitive forest species<br>- forest areas | 5. Other Aquatic Life<br>- river channel characteristics (littoral zone, substrate characteristics)<br>- lake characteristics<br>- benthos, plankton<br>- weeds<br>- density and diversity | 5. Wildlife Habitat<br>- capability (site area)<br>- terrestrial habitat (species)<br>- waterfowl<br>- commercial value<br>- migratory routes<br>- seasonal movements<br>- special areas |
| 6. Natural Areas<br>- wildlife areas<br>- recreational areas<br>- inland lakes<br>- geological areas (buffering capacity) | 6. Water-based Recreation<br>- shoreline usage<br>- yachting<br>- ice fishing, snow-mobiling | 6. Aesthetics<br>- visibility<br>- noise sources<br>- unique natural and historical areas<br>- residential and cottage areas |
| 7. Property and Industry<br>- sensitive industries<br>- property | 7. Wildlife<br>- waterfowl areas | 7. Secondary Environmental Stress<br>- proposed development (residential and industrial)<br>- potential stress |

Although it might not include all the pertinent VECs, several existing characterizations may provide a starting point upon which to build. For example, Environment Canada (1989b) has characterized the Canadian environment using a standardized approach to ecological land survey and classification. Their framework characterizes the natural environment based on 7 levels of generalization: ecozone, ecoprovince, ecoregion, ecodistrict, ecosection, ecosite, and ecoelement.

Examples of the types of data that could be used for natural environment characterization at the site screening sub-stage are presented in Appendix K.

N.2.2 Review of Methods for Site-specific Characterization

Following an approach outlined in Beanlands and Duinker (1983), the environment characterization at the site specific stage would be part of an assessment strategy designed with an ecological perspective (Figure N-2).

It is assumed that the Beanlands and Duinker four-stage approach would be used to characterize the natural environment throughout the life-cycle of the project:

1) ecological characterization;
2) baseline studies;
3) impact prediction; and
4) project monitoring.

Using this framework, environment characterization of a potentially suitable site would be done through ecological characterization and baseline studies (including baseline monitoring).

N.2.2.1 <u>Ecological Characterization</u>

The ecological characterization of one or more sites would be done by carrying out the same type of characterization studies undertaken for the site screening sub-stage but at a more detailed level, and with modifications to accommodate for the particular characteristics of the site(s) under study. This would be an iterative process with input from a variety of public and government agency stakeholders. Maintaining and adding to an ecological characterization at the site-specific stage would ensure that the description of the VECs would be more complete, as well as provide an opportunity to address effects on newly-identified VECs.

Because the ecological characterization could be used as part of a benchmark for impact validation, it is necessary before designing a characterization strategy, to decide what would constitute a statistically meaningful change in a component of the environment. In other words, it is necessary to know what result is expected, at least in general terms, and on what basis the significance of an impact would be determined.

The delineation of spatial and temporal boundaries is also very important. Some of these boundaries are: administrative, project, ecological, and technical boundaries (Beanlands and Duinker 1983) (Figure N-2). In establishing these boundaries, certain factors may work against each other: the limitations or constraints imposed by the political, social, and economic conditions (administrative boundaries) surrounding the project may dictate the overall temporal and spatial scope of the project (project boundaries). If either the temporal or spatial scopes are limited, the level of detail attainable may not be ideal to adequately characterize and monitor the natural systems operating

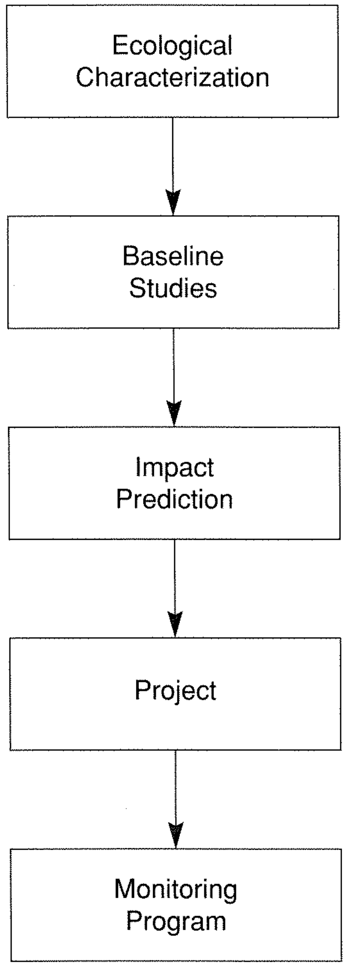


FIGURE N-2: Five Stages of Impact Assessment (ecological boundaries). Even with these limitations, adequate characterization may be restricted by the state-of-the-art technology in predicting and/or measuring the ecological changes (technical boundaries). Therefore, trade-offs may be necessary to provide for a meaningful scope of study, highlighting the need to ensure public involvement in decision making.

N.2.2.2 Baseline Environmental Studies

Baseline environmental studies would generally be undertaken after a site has been selected. The objective then is to describe environmental conditions existing prior to project development, including natural variations, against which potential changes may be detected through studies and monitoring following project development.

Since results of the baseline studies would be used for impact evaluation, it is necessary to distinguish project related changes from changes due to natural variation when designing the baseline studies. Several key questions must be taken into account: first, the terms and assumptions around impact predictions or hypotheses must be clearly indicated; secondly, the expected level of significance of the impact must be determined; a third key element is the level of confidence of impact prediction. In the assessment report, it should be clearly stated whether an impact prediction is: reasonably firm, based on experience and/or professional judgement, or an outright guess (Beanlands and Duinker 1983).

Eberhardt and Thomas (1991) published a guide to the choices available when designing environmental field studies. They suggest eight different types of field study designs (Figure N-4). The basic distinction among the eight methods is based upon whether or not the investigator can control the measured effect to occur at a particular time and place. Controlled methods include:

1) replicated experiments: strong inferences, this is the preferred approach when feasible;

2) un-replicated experiments: cost or circumstances prohibit replication;

3) sampling for modelling: efficient experimentation for parameter estimation in specified non-linear models;

Uncontrolled methods include:

4) intervention analysis: retrospective assessments of time-series data;

5) observational analysis: deliberate selection of contrasting groups, in lieu of experimentation;

6) analytical sampling: inferences from sampling over entire population of interest;

7) descriptive sampling: efficient estimation of means and totals; and

8) sampling for pattern: description of spatial pattern, interpolation to reduce bias from haphazard sampling;

The advantages and disadvantages of each of these methods are described in Eberhardt and Thomas (1991).

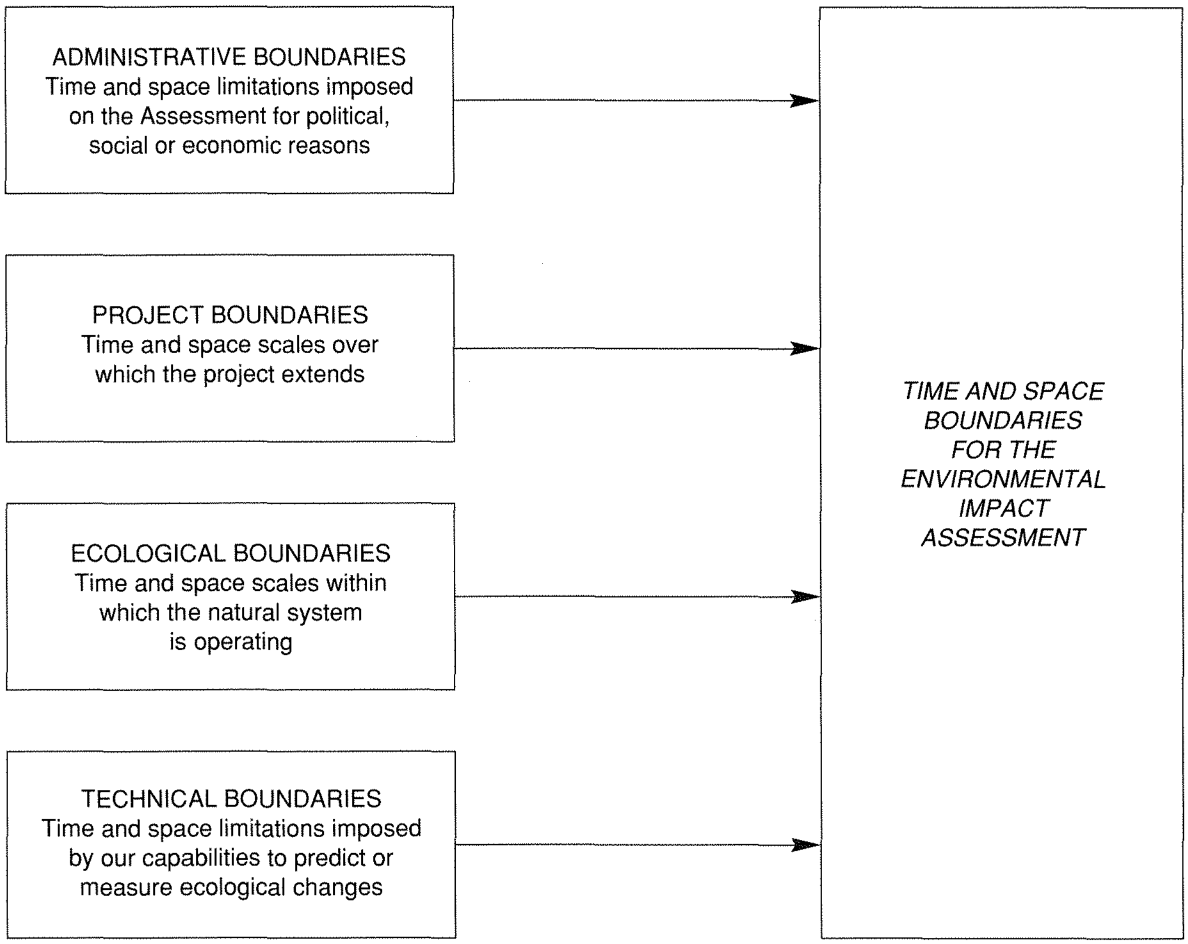


FIGURE N-3: Spatial and Temporal Boundaries

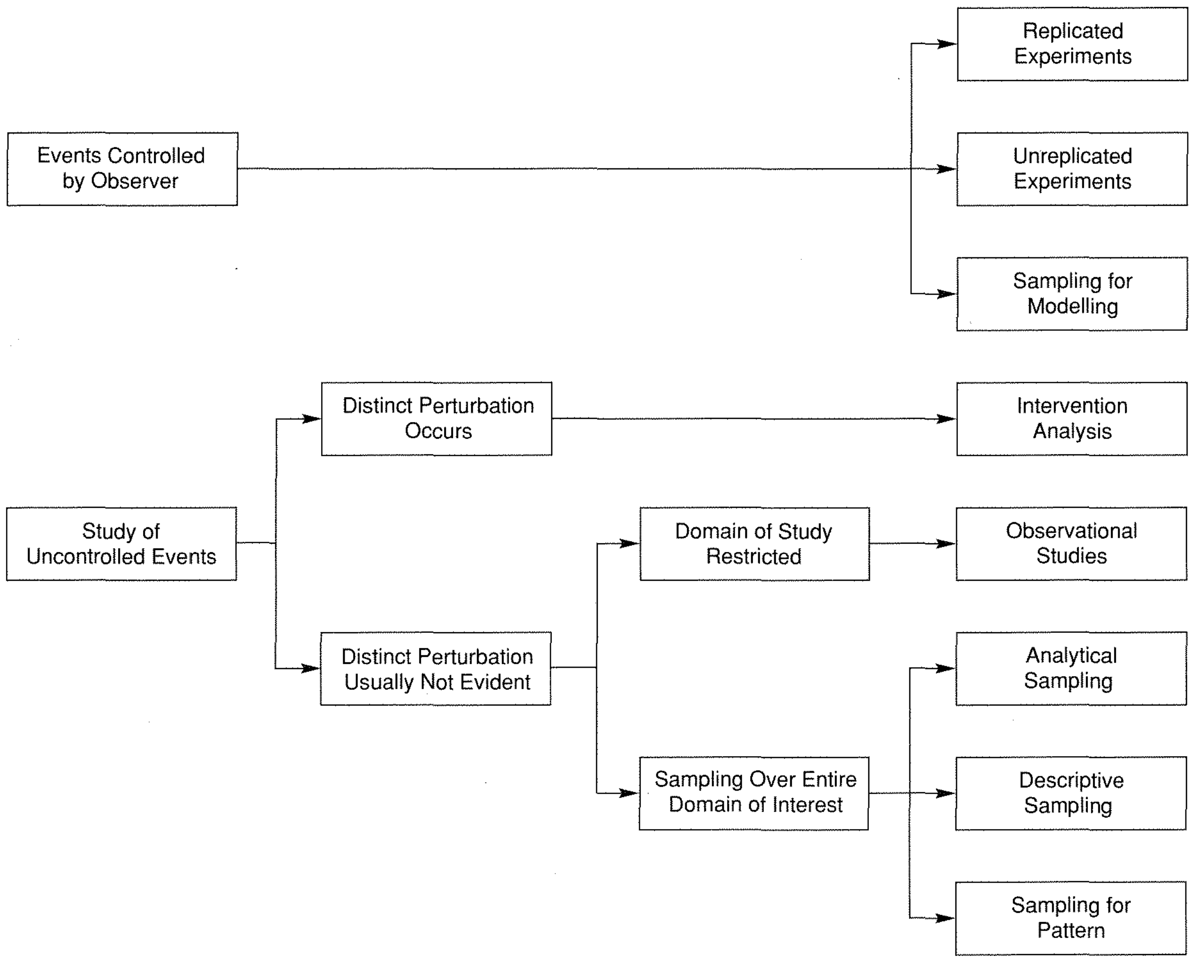


FIGURE N-4: Type of Field Studies

It is very rare that all suggested baseline studies for an environmental assessment can be undertaken. Therefore, they must be prioritized in terms of the importance of the information they would contribute. The ranking of environmental studies by priority should reflect the extent to which the science of ecology has developed a knowledge base for the VEC of interest (or how much is known about the system), and the prioritization of the VECs during the site screening and site specific scoping sessions.

N.2.2.3 Baseline Monitoring

In addition to the ecological characterization and the baseline studies, it is critical that a baseline monitoring program also be established to document change in a specific ecological phenomenon primarily for the purposes of (1) testing impact hypotheses and predictions as well as (2) testing mitigative measures (Beanlands and Duinker 1983).
It is important to distinguish between the baseline monitoring program discussed here for the pre-operational stages (environmental monitoring), and that which would be instituted after the project activities have been initiated (environmental effects monitoring). These two types of monitoring can be defined as follows (Conover 1985):

- environmental monitoring is repetitive data gathering, data analysis and interpretation, and data presentation to observe, record, or test the operation of an environmental factor for the purposes of determining its status or evidence of change;

- environmental effects monitoring measures changes in environmental factors to establish cause-and-effect relationships between a natural or human-generated environmental factor and affected environmental components.

The strategy for environmental monitoring should stem directly from the baseline studies. Before any development begins on the project, a baseline monitoring program should be implemented. With proper foresight during the conceptual and design stages of the ecological characterization and baseline studies stages, the data collected prior to development would be of adequate resolution, quality and duration, to provide a meaningful base upon which to confirm any impacts on the environment.

An effective monitoring program can only be established once successful ecological characterization and baseline studies have been undertaken.

Five basic objectives for monitoring programs can be identified (Krawetz et al. 1987):

1) compliance with expected performance (inspection, contractual agreements, and regulatory permits);
2) impact management - project control to ensure problems do not arise during the construction stage;
3) research and development - straight documentation, enhancing technical capacity for the future, evaluating predictions, and testing specific hypotheses;
4) credibility - public assurance; and,
5) evidence of change, including determination of status, trend monitoring, and early warning systems.

Several types of environmental monitoring can be used to achieve these objectives:

- monitoring against expected performance through environmental audits or status and trend monitoring;
- contaminant monitoring (looking at environmental concentration of pollutants);
- biological effects monitoring (measuring net response of biotic-abiotic interactions as a function of pollutant inputs).

Another method of evaluating changes in ecological components is to establish control and treatment areas in the pre-operational periods, and then later evaluate the impacts using the shift in the value of the ratio of control units (dependent upon what is being measured) to treatment (impacted) units in the post-operational period (Bernstein and Zalinski 1983; Beanlands and Duinker 1983; Stewart-Oaten et al. 1986). This is called the BACI method "Before, After, Control, Impact", an approach that uses replication in time, in order to compensate for the fact the effects cannot be replicated in space.

The methodology, or the combination of methodologies, chosen for monitoring of the baseline conditions would be guided by the long-term requirements for data, the data resolution, and the desired spatial and temporal scope.

### N.2.3 Data Management

Technologies, such as Geographic Information Systems (GISs), have been developed to efficiently and cost-effectively integrate large volumes of data. A GIS is a computer-based system including hardware and software and graphics for the input storage and retrieval, manipulation and analysis, and output of spatial data. Spatial data sources may include a variety of parameters such as economic, environmental, social and land/resource use.

It is foreseen that a GIS technology would be used for environment characterization both at the site screening and the site evaluation sub-stages. Use of a GIS would be beneficial for project planning and data manipulation purposes. Visual representations of the receiving human and natural environments before and after the concept could dramatically heighten the understanding of decision-makers, reviewers and the general public. At the outset of project planning, the GIS could be used to assist in the integration of existing spatial attributes and remote sensing data. This would enable the proponent to develop preliminary avoidance/constraint maps to determine those areas which are not acceptable, either environmentally or socially, for project implementation.

As the siting process continues, data collected for the ecological characterization and pre-operational baseline studies would also be added to the database. Because new layers would be added, more refined avoidance/constraints maps could be derived, enhancing the site selection processes.

After the site has been selected, monitoring data from the construction, operation, and decommissioning stages may also be incorporated. Although avoidance/constraint maps would no longer be needed, maps showing various parameters before and after project implementation may be useful in assessing project impacts

## N.3 REVIEW OF METHODS FOR CHARACTERIZATION OF THE HUMAN ENVIRONMENT

In conducting a socio-economic impact assessment and selecting appropriate methods and techniques, a distinction can be drawn between siting and site characterization/assessment activities. This reflects the different role socio-economic analysis has during site selection and its role in predicting and managing potential impacts at a particular site.

Impact studies for site selection involve the comparative evaluation of alternative sites to identify a preferred site where impacts might reasonably be expected to be minimized. There are a variety of approaches which can be adopted, ranging from highly technical or analytical processes to more political or community oriented ones. However, certain activities would be required regardless of the approach. At some stage in a siting and impact assessment process, it would be necessary to identify study areas, to screen areas or sites, and to compare alternatives.

### N.3.1 Study Area Identification

In the context of siting, study area identification is the process of deriving a long list of potentially suitable siting choices. The selection of this initial array of siting choices may, for example, be based upon such considerations as ability to meet basic facility requirements (e.g., granitic or plutonic rock), regulatory requirements, political jurisdiction, the ownership or use of the land, the physical characteristics of the area, proximity to generators or transportation facilities, and locations of population centres.

The methods of deriving and testing these siting criteria through technical review, and political and public involvement would be of critical importance. The use of focus groups, workshops, referenda, open houses and other procedures, to directly involve agencies, and interested and potentially affected publics, can help to establish conducive and constructive dialogue and debate, and also assist in providing a broad basis of understanding and support for the decisions on study area choices.

### N.3.2 Site Screening

The screening of areas and/or sites involves the progressive exclusion of siting choices. Screening criteria should be developed in consultation with interested and potentially affected publics. Examples of screening criteria include: basic land use conflicts, physical suitability limitations, highly vulnerable communities, a lack of community acceptance and areas where facility development would be inconsistent with regulatory requirements. Often the data employed for this activity are regional in scale and frequently derived from secondary sources with selective verification through field reconnaissance.

With the constraints identified, it is essential that the data can be documented or mapped and interpreted at the level of analysis or scale selected. Screening judgements would involve selecting a threshold of acceptability. The criteria used to differentiate between acceptable and unacceptable areas are, by definition, somewhat arbitrary. From a social impact perspective, thresholds may be simply the presence or absence of certain features. Broad consultation regarding screening criteria to derive a clear basis of site rejection is essential.

In applying screening criteria, it is important that a clear distinction is drawn between criteria suitable for screening alternatives (e.g., a failure to satisfy one or more criteria results in the rejection of alternatives) and factors suitable for comparing alternatives. Factors make it possible to understand the differences and trade off (e.g., advantages and disadvantages) of alternatives but are used collectively rather than individually (as is the case with criteria) to compare and rank alternatives.

### N.3.3 Comparative Evaluation

Another site selection activity involves the comparative evaluation of a smaller number of siting choices. This stage would involve a broad range of criteria, an extensive array of data sources, a substantial choice of methods, and a diversity of public and agency consultation methods. With the comparative evaluation of alternative sites, it would be necessary to identify and compare relative advantages and disadvantages across all areas of concern.

Distinctions, such as the magnitude of potential impacts (e.g., severity, duration, frequency and probability), the importance of the impacts (by stakeholder group), the extent to which potential impacts can be prevented or reduced, and the degree of uncertainty associated with the impact predictions, would need to be drawn.

It would be necessary to progressively focus the analysis towards the identification and evaluation of the critical trade off among the alternatives. The review of these key differences and trade off should be the focus of intensive public and agency consultation. Consultation during the evaluation sub-stage is essential for decision-makers to appreciate the positions and preferences of all interested and affected parties, and facilitates the building of a consensus across stakeholder groups.

Clearly, comparative evaluation is conducted at a greater level of detail than screening. However, with comparative evaluation, the emphasis is on obtaining a sense of the relative differences among alternatives to indicate that, for the major aspects of the environment, a given alternative is more suitable than another. Comparative evaluation is, therefore, undertaken at a broader level of detail than site characterization.

Site characterization involves the very detailed prediction and management of the impacts associated with a preferred alternative. With a very complex and controversial project such as the UFDC development, it may be necessary and desirable to conduct the comparison of a short list of sites at a site assessment level of detail. Regardless, of whether one or more sites are characterized, socio-economic impact studies would involve six activities: scoping, profiling, predicting, evaluating, assessing and recommending.

### N.3.4 Scoping

Socio-Economic Impact Assessment (SEIA) work begins with an explicit stage for formulating an overall approach which is fully integrated with a public and agency consultation program. Public and agency consultation is fundamental to all aspects of socio-economic impact assessment. The SEIA conducted at the concept stage can be considered as the basis for detailed program design. However, in implementing this approach, the siting or site assessment would also encompass scoping.

Scoping refers to the process of consultation with all relevant interests, particularly affected residents, to identify key concerns and issues, determine study areas, and design a detailed study program including the selection of appropriate impact assessment methods and techniques.

Thus, a detailed program design should only be established after a careful scrutiny of the circumstances within which it might be applied and after consultation with potentially affected agencies and publics. This is particularly important considering that the selection of socio-economic assessment methods and detailed program design are not purely technical activities. The program can then be progressively refined through the course of the siting and impact assessment process.

One of the main objectives of scoping activities is to build agreement regarding the key issues and concerns, study areas, and the nature and timing of the siting, impact assessment and impact management processes, including roles and responsibilities. This can be achieved through the development of appropriate institutional arrangements.

In most cases, the establishment of such arrangements would require building agreement among different levels of government, specific government agencies, the proponent, various community interests, and others (e.g., labour unions) who are interested in the undertaking.

Joint planning agreements to facilitate fact finding or to undertake detailed socio-economic studies may be necessary to initiate the site selection stage of the project. This is particularly important in Aboriginal communities where the success of socio-economic studies would be largely dependent upon the participation of community members and the degree to which the proponent's activities are culturally appropriate. Successful joint planning efforts, early in the project, would help to establish working relationships that would aid in further studies and impact management negotiations.

Such agreements provide the structure on which to base a long-term proponent-community partnership. They may be negotiated between the proponent and municipal governments, individual First Nations and in some cases, their respective Tribal Councils. Negotiated agreements with other levels of government and appropriate organizations may also be required.

Table N-2 provides a listing of a range of available scoping, public and agency consultation methods. These methods are largely derived from the Manual on Public Involvement in Environmental Assessment: Planning and Implementing Public Involvement Programs prepared by the Federal Environmental Assessment Review Office (FEARO 1988). It is noteworthy that the manual also describes the characteristics, strengths and limitations of the methods.

Table N-2 differentiates among public information, public information feedback, consultation, extended involvement and joint planning methods, and also identifies different publics that should be involved in the study. Taken together, these two columns point to the importance of selecting and adjusting the methods employed to suit the needs and preferences of different publics.

These methods can assume a valuable role in scoping both the siting activities and the site-specific assessments. Methods which facilitate small group dialogue among the major stakeholders are especially valuable

Table N-2 Examples of Scoping, Public and Agency Consultation Methods

| EXAMPLES OF PUBLICS | EXAMPLES OF METHODS |
|---|---|
| Concerned, interested and directly/indirectly affected individuals:<br>- Residents<br>- Business Owners/Operators<br>- Employees<br>- Facility Operators and User Groups<br>- Resource Users (eg: tourists, trappers) | **Public Information:**<br>- Advertising<br>- Brochures<br>- Citizen Training<br>- Contests/Events<br>- Direct Mail<br>- Exhibits/Displays<br>- News Conferences<br>- Newsletters<br>- New Releases<br>- Public Service Announcement<br>- Position Papers<br>- Political Review<br>- Publications<br>- Publicity<br>- Reports<br>- Newspaper inserts |
| Concerned, Interested and Directly/Indirectly Affected groups:<br>- Groups and Organizations<br>- Communities<br>- Segments of Communities based on variations in traditions, lifestyles, institutions, legal status | **Public Information Feedback:**<br>- Focus Groups<br>- Policy Profiling<br>- Questionnaires<br>- Interviews<br>- Polls<br>- Surveys<br>- Submissions and briefs<br>- Analysing public involvement data<br>- Community or social profiles<br>- Computer assisted participation<br>- Media/other content analysis |
| Province-wide interest groups<br>Local interest groups (eg: Ratepayers)<br>Community leaders<br>Key local informants<br>Provincial and federal elected representatives<br>Media<br>Aboriginal leaders, groups and organizations | **Consultation:**<br>- Brainstorming<br>- Conferences<br>- Dialogues<br>- Public/town meetings<br>- Open houses<br>- Phone lines<br>- Simulation games<br>- Trade-off games<br>- Coffee klatches<br>- Delphi processes<br>- Field offices/workers<br>- Nominal group processes<br>- Panels<br>- Participatory TV<br>- Technical assistance<br>- Workshops<br><br>**Extended Involvement:**<br>- Advisory or liaison committees<br>- Charettes and task forces<br><br>**Joint Planning:**<br>- Collaborative Problem Solving<br>- Arbitration, Conciliation<br>- Mediation, Negotiation<br>- Niagara Process |

Source: Wlodarczyk (1993)

in the scoping of alternatives and potential impacts. Examples of such methods include advisory committees, workshops, and small group meetings. Wolfe (1987) describes the characteristics, strengths and limitations of a number of these scoping and consultation methods.

In selecting the appropriate mix of scoping, and public and agency consultation methods it is important to recognize that scoping and consultation are necessities and not an optional extra in the environmental assessment process. These methods are only meaningful if they are directly related to decision making and suit the needs of those involved.

### N.3.5 Profiling

Profiling is the establishment of existing and likely future conditions without the proposed project. It represents the baseline against which individual and cumulative impacts are predicted, assessed, evaluated and managed. Typically, profiling occurs after the scoping of concerns and issues with interested and potentially affected stakeholders. Profiling can be a staged process, with progressive increases in the level of detail and depth to which baseline data are collected and analyzed.

The overall characterization of potentially affected communities and regions is necessary in order to address direct, indirect and cumulative impacts, undertake sensitivity analyses and ensure a comprehensive approach to impact management.

Table N-3 provides a list of profiling methods. The table distinguishes among methods involving the use of documentation or secondary source material; methods involving interactions with interested and potentially affected publics; and methods for integrating the individual items of data into an overall image or characterization of a community.

With respect to documentation, a wide array of potential source materials are identified. In socio-economic impact assessment, there has been a tendency to rely on readily available source materials (e.g., census, planning documents) and to concentrate on characterizing existing conditions. It is also important to make use of less directly accessible materials (e.g., historical records, population forecasts) to establish historical trends, patterns and likely future conditions. In this way a context for impact-related change is established and predictions of effects are more likely to be firmly grounded.

Table N-3: Examples of Profiling Methods

| COMPONENTS | METHODS |
|---|---|
| DOCUMENTATION | - Census & other demographic data analysis<br>- Media content analysis<br>- Archival research<br>- Historical records analysis<br>- Comparable project review<br>- Mapping & photographic analysis<br>- Municipal data analysis<br>- Analysis of records of public meetings and discussions<br>- Statistical analysis<br>- Literature review<br>- Analysis of briefs & submissions |
| COMMUNITY INTERACTION | - Scientific surveys<br>- Interviews (extended, intensive, detailed) - key informants, community - leaders & interest groups<br>- Public involvement methods<br>- Ethnographic studies<br>- Participant observation methods<br>- De-briefing of on-site workers<br>- Field investigations & observations |
| INTEGRATION | - Community structure analysis - key dimensions (Battelle 1980)<br>- Social indicator system |

Source: Wlodarczyk (1993)

Community interaction profiling methods can significantly expand upon, and supplement, the information available through existing documentation. Community interaction profiling methods make it possible to identify the unique social structural characteristics of communities and regions. These methods are especially important for determining attitudes, values, perceptions, and past and current behaviour patterns. The profiling methods can, for example, identify the nature and distribution of perceived risk among various segments of a community and region. Consultation programs and public education activities can then be refined to better respond to risk perception-related concerns and expectations.

Profiling and data collection should be conducted within the context of a social system model utilizing a system of indicators. Wlodarczyk (1993) lists a range of potential indicators according to a number of areas of concern. These indicators represent the specific data requirements that could be collected and used to develop specific measures of impact relevant to a particular community or region. By using such a system of indicators, it is also possible to systematically consider the major interrelationshipsamong elements of the social system. These indicators can also provide a base from which a socio-economic monitoring program can be derived in consultation with the public and government agencies. There is a tendency in environmental impact assessment to collect large quantities of baseline data without a clear sense of the purpose to which that data might ultimately be used. Conflicts can arise during later project stages where data is interpreted and potential impacts are evaluated and assessed. Therefore, agreement on the choice of indicators may need to be reached prior to the commencement of profiling activities in order to avoid potential conflicts.

### N.3.6 Predicting and Assessing

For the purpose of this discussion, the predicting and assessing steps outlined in the general SEIA process have been combined into a single stage.

Predicting involves determining the kinds of changes from the baseline condition that are likely to occur should the undertaking proceed. This step also involves identifying who would be affected, in what way and for how long. Assessing involves the analysis of potential impacts to determine their relative importance.

The available methods and techniques for predicting and assessing socio-economic impacts have been grouped according to their application to the following activities: the identification of individual effects; the identification of interactions among effects; the focusing of the analysis on key effects; the measurement of historical effects; the projection of future effects; the interpretation of the significance of potential effects; and the synthesis of individual effects into a characterization of overall or cumulative effects. Table N-4 provides a listing of the most commonly used analysis methods.

The identification of direct effects and the analysis of how they interact to cause indirect and cumulative effects requires, as a first step, a broad ranging effort to identify as full a range of potential effects as possible. When conducting an SEIA at the site-specific stage, the identification of potential effects and interactions can be conducted fairly informally without the explicit use of any particular methods or systematic process. The use of a series of methods would help ensure impacts are identified comprehensively. In any case, the identification of potential effects must be conducted jointly with the public and government, particularly with those potentially affected.

Focusing on critical effects tends to be an informal process. The methods shown in Table N-4 make it possible to identify in a more structured and comprehensive manner, potential impacts which are pivotal, as they may cause or contribute to the occurrence of other impacts, or are significant because of their importance to major stakeholders.

The measurement methods are directed towards making use of the results of the profiling stage to identify historical impacts. Documented data may be the best source of accurate and bias-free information. However, they tend to be problematic in an impact assessment because of intervening variables and units of analysis, which often do not coincide with a particular areas of interest. The community interaction methods are more direct and more interpretative.

Table N-4 lists time series and projection methods, models and simulations, and holistic qualitative techniques. All these methods can address future conditions as an extension of past conditions, and quantitative and qualitative interactions among potential impacts. They also have the capability to address impacts which can be predicted with some degree of precision, impacts which must be addressed in a more speculative manner, alternative future conditions, and both "worst case" and desired future conditions.

The choice of methods used would vary depending upon the subject matter, the data available and the level of confidence associated with the impact projections. For example, a host of quantitative models have been established for predictions of impacts on the economic base, employment, income, population migration, and municipal finance.

Table N-4: Examples of Analysis Methods

| COMPONENTS | METHODS |
|---|---|
| IDENTIFICATION - INDIVIDUAL EFFECTS | - Checklists<br>- Matrices<br>- Literature review<br>- Contextual analysis (Project/community overview)<br>- Analogous project analysis<br>- Community leader interviews<br>- Community forums<br>- Imagery analysis |
| IDENTIFICATION - EFFECT INTERACTIONS | - Matrices<br>- Networks<br>- Models<br>- Cross Impact analysis<br>- Relevance tree analysis |
| FOCUSING | - Expert opinion (e.g Delphi)<br>- Workshops with stakeholders<br>- Divergent mapping (Scope key issues, mini-scenarios)<br>- Relevance tree analysis<br>- Public & agency consultation (see Table N-2)<br>- Analysis of community and social profile |
| MEASUREMENT | - Information interviews<br>- Census & other data analysis<br>- Ethnographic studies<br>- Secondary source analysis<br>- Field investigations |
| PROJECTION | - Time and series projection<br>* Trend Extrapolation<br>* Pattern Identification<br>* Probabilistic Forecasting<br><br>- Models & Simulation<br>* Economic (eg: Basic/Non-basic, Income and Employment Multipliers)<br>* Cross Impact Analysis<br>* Gravity Models<br>* Municipal Financial Analysis Models<br><br>- Holistic qualitative techniques<br>* Scenarios (eg: Extrapolative, Normative, Speculative, Dialectic)<br>* Focus Groups<br>* Gaming Techniques<br>* Expert Opinion Methods (eg: Delphi)<br>* Alternative Futures<br>* Values Forecasting<br>* Social Systems Models<br>* Comparative Dichronic Studies |
| INTERPRETATION | - Interviews with potentially affected parties<br>- Focus groups<br>- Surveys<br>- Workshops & meetings (see Table N-2)<br>- Expert opinion |
| SYNTHESIS | - Social Theory<br>* Functional, Ecological, Systems Theory<br>* Conflict Theory<br>* Exchange Theory<br><br>- Double impact trees<br>- Network analysis<br>- Modelling<br>- Scenarios<br>- Operations research<br>- Group ecology methods<br>- Cross Impact Analysis<br>- Relevance tree analysis<br>- Systems analysis<br>- Input/output analysis |

Source: Wlodarczyk (1993)

Quantitative and more qualitative techniques are available for the interpretation of public attitude research to predict human behavioural patterns (Mushkatel et al. 1990; Easterling et al. 1990).

It is important to distinguish between the magnitude of a potential effect and its significance. In as much as impact interpretation is an important area of judgement, the methods cited reflect the need to draw upon expert, public and agency perspectives. It is also important to consistently apply a set of indicators to guide judgements regarding impact significance. Some of the more commonly used indicators are magnitude, duration, vulnerability, level of public concern, reversibility, uncertainty and public preference.

The synthesis or integration of individual impact projections and interpretations into a coherent picture of the network of potential impacts resulting from a proposed project is important. The application of the methods listed in Table N-4 make it possible to consider and interpret cumulative impacts. The synthesis or integration process is more than a question of addressing interrelationships among individual impacts and relies upon the social analysis framework (e.g., functional, ecological, systems theory versus conflict) through which impacts are being considered.

In synthesizing more complex sets of potential impacts it is advisable to use more than one framework, as well as more than one synthesis procedure. The framework employed in this concept assessment is a proposal and provides a means of structuring future socio-economic impact studies.

### N.3.7 Evaluating

Evaluating involves judging the overall significance of the impacts taking into account possible measures that could avoid, reduce the severity, redress adverse impacts and enhance positive effects. Evaluation is the stage which takes the products of impact analysis and places them in a form suitable for decision-making purposes. There can be evaluation of both alternatives (e.g., alternative sites) and the net effects of the proposed project.

The list of evaluation methods provided in Table N-5 is a broad grouping of a much wider array of evaluation methods and provides a general sense of the various approaches which can be used for comparing alternative sites, for addressing the basic question of whether the project should proceed given the overall net effects, and for identifying the conditions under which the project might proceed.

Table N-5 distinguishes among qualitative, quantitative, and social process methods. The distinction between the more technical and social process methods is an important one because it bears directly on the issue of the extent to which the evaluation is undertaken, or at least largely managed by a team of "experts" or a social process which focuses on procedures for directly involving key stakeholders. Technical evaluation procedures can, of course, incorporate the positions and perspectives of other stakeholders. However, the tendency is to limit stakeholder involvement to abstract trade off (e.g., the ranking of factors) rather than direct participation in the consideration of trade off among anticipated impacts.

Table N-5: Examples of Evaluation Methods

| TYPES | METHODS |
|---|---|
| QUALITATIVE - TECHNICAL | - Matrices & Networks<br>* Leopold<br>* Moore Interaction Matrix<br>* Sorensen Stepped Matrix<br>- Nominal Amalgamation Techniques<br>* Exclusionary, Conjuctive, Lexicographic Screening<br>- Ordinal Amalgamation Techniques<br>* Conjunctive ranking<br>* Holmes Ordinal Techniques<br>- Overlaps & Land Suitability Mapping<br>- Planning Balance Sheet<br>- Iterative methods (eg: Bishops Factor Profile) |
| QUANTITATIVE - TECHNICAL | - Economic<br>* Cost/Benefit Analysis<br>* Cost Effectiveness Analysis<br>* Cost Minimization Analysis<br>- Pairwise comparison (eg: Saaty's Analytical Hierarchy)<br>- Weighting summation<br>* Goals Achievement Matrix<br>* Linear Combination Land Suitability Methods<br>- Mathematical programming<br>* Linear Programming<br>* Dynamic Programming<br>* Goal Programming |
| SOCIAL PROCESS | - Committees & workshops (See Table N-2)<br>- Charettes<br>- Dialectical scanning<br>- Nominal group process<br>- Cross impact analysis<br>- Delphi<br>- Gaming |
| QUALITATIVE/QUANTITATIVE | - Adaptive Environmental Assessment<br>- Qualitative as cross check<br>- Quantitative as cross check<br>- Co-use of methods with qualitative &<br>Quantitative sensitivity analyses |

Source: (Wlodarczyk 1993)

Different evaluation methods can be used for different data sets (e.g., economic versus social impacts). In most cases, more than one method is desirable to minimize the potential for bias, to test conclusions and for sensitivity analysis purposes. However, it would still be necessary to integrate the products of these various procedures into an overall evaluation framework.

### N.3.8 Recommending

Recommending involves setting out a preferred way to proceed with the undertaking and suggesting appropriate impact management measures for potentially significant impacts.

Public and agency consultation is a fundamental aspect of socio-economic impact assessment. In any impact assessment process, regular feedback steps should be included to reflect and respond to its highly iterative nature. Frequently, various activities would be occurring in parallel. The results of any one stage or activity often have implications for, and lead to, the reconsideration of results from previous stages. Wlodarczyk (1993) presents a recommended process for impact management which includes mitigation, enhancement, compensation, monitoring and contingency measures, and community liaison measures.

Consideration of the extent to which potential impacts can be prevented or avoided is essential to each analysis and interpretation stage of the process. The consideration of mitigation and other impact management measures must also be incorporated into key decision points. contingency measures, and community liaison measures.

Future studies relating to the siting and site assessment of a UFDC would likely take place in a context characterized by a diverse array of conflicting attitudes, values and perceptions. Effective public and agency consultation would be a critical component of the environmental assessment process and an important input to its socio-economic impact assessment component. As a consequence, the choice and manner of application of socio-economic impact assessment methods should reflect the pluralistic, frequently controversial and necessarily open nature of the assessment process.

## N.4 INDICATORS OF CHANGE IN THE NATURAL AND HUMAN ENVIRONMENT

It is possible, based on a review of the effects of industrial projects to establish a typical list of natural and human environment indicators that would signal that the project has affected the environment. Such a list is included in Appendix G. The actual indicators for the disposal facility would be established based on site characteristics and a detailed design. They would be used in deciding what human and natural environmental parameters would be monitored in the short and long term.

## N.5 CONSIDERATIONS OF METHODS FOR CHARACTERIZATION OF THE TRANSPORTATION NATURAL AND HUMAN ENVIRONMENT DURING SITING

The strategy for characterizing the transportation natural environment would be similar to the strategy used for the disposal environment characterization in that the scope of the environmental characterization would be established in cooperation with all public and government agencies stakeholders. The difference lies in the fact that the characterization of transportation routes would be constrained by the existing transportation network and the destination of the shipment.

The type of information that would be gathered would include, but not be limited to, the data types contained in the Used Fuel Transportation Database (Grondin 1988) and other route planning studies such as the studies performed by the Ministry of Transportation of Ontario (MTC 1987).

The methods for characterizing the transportation human environment would again be similar to methods described in section N.3 for the disposal environment.

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