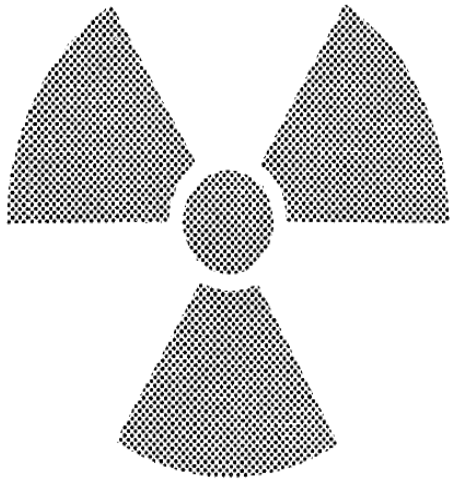
RADIATION
RADIOACTIVE
IRRADIATED

A GLOSSARY FOR THE *interested* LAY READER



compiled by:

The League of Women Voters
of Benton and Franklin Counties

PART I

RADIATION BASICS

activation — the process of making a material radioactive by bombarding it with neutrons.

activity — a measure of the rate at which radioactive material is emitting radiation usually given in terms of the number of nuclear disintegrations occurring in a given quantity of material over a unit of time. The standard unit of activity is the curie (Ci) which is equal to 37 billion disintegrations per second. Activity decreases with time as the material decays to a stable form.

alpha particle — a positively charged particle ejected spontaneously from the nuclei of some radioactive elements during radioactive decay. It consists of two protons and two neutrons and is identical to the nucleus of the helium atom. Alpha particles are the least penetrating of the three common types of radiation (alpha, beta, gamma) emitted by radioactive materials; being unable to penetrate clothing or the outer layer of skin. They are the most densely ionizing type of radiation and may cause more concentrated damage than other types of radiation if an alpha—emitting material enters the body.

atom — the smallest particle of an element that still exhibits all the chemical properties of the element. It is the basic component of the chemical elements and is indivisible by chemical means. An atom consists of a dense inner core (nucleus) composed of protons and neutrons and an outer layer of electrons orbiting in one or more levels around the nucleus. There are about six sextillion (6 x 1O) atoms in an ordinary drop of water.

atomic number — the number of protons within the nucleus of an atom. Each chemical element has a unique atomic number, referred to as the "Z" of the element and written as a left subscript. The element carbon having six protons in its nucleus is atomic number 6 and is written C.

atomic weight (atomic mass) — the mass of an atom relative to other atoms - approximately equal to the total number of protons and neutrons in its nucleus. Atomic weight is written as a left superscript or to the right following a hyphen. The element carbon having an atomic weight of 12 is written ^{12}C or C—12.

beta particle — a charged particle ejected spontaneously from the nuclei of some radioactive elements during radioactive decay. A negatively charged beta particle is called an electron a positively charged beta particle is called a positron. Some beta particles can penetrate the outer layer of skin, but are easily stopped by aluminum foil. Beta radiation may cause skin burns and beta emitters may cause serious damage if they enter the body in sufficiently large quantities.

chain reaction — a series of events whereby a -fissionable (split— table) nucleus absorbs a neutron and then fissions (splits), releasing additional neutrons. Released neutrons are in turn absorbed by other fissionable nuclei which fission, releasing still more neutrons. A generation is completed when the neutrons produced by one fission in turn produce fissions. A self—sustaining chain reaction is described as "critical" when the number of fissions produced per generation remains constant.

critical mass — the minimum mass of -fissionable material that will support a self—sustaining chain reaction.

criticality — a set of physical conditions within which a nuclear chain reaction is self—sustaining. The variables influencing criticality include the amount (critical mass) of fissionable material, its arrangement or spacing, and the presence, or absence, of neutron absorbers and of moderators (materials which slow down fast neutrons).

A criticality occurring outside a controlled experiment or reactor is considered an accident. Preventing a criticality is a necessary consideration in the handling and transportation of radioactive waste.

curie (Ci) — the basic unit describing the intensity of radioactivity in a sample of material. The curie is equal to 37 billion nuclear disintegrations (transformations) per second - or approximately the rate of decay of one gram of radium. Thus, the amount of any material which is disintegrating at that rate is defined as one curie regardless of the types of radiations it emits. Common fractions of a curie are the millicurie (37,000,000 d/s) • microcurie (37,000 d/s , nanocurie (37 d/s) and picocurie (0.037 d/s).

daughter — the nuclide resulting from the decay of a radioactive element. A daughter may be either stable or radioactive. The term "progeny" is also used to describe the nuclides resulting from radioactive decay.

decay, radioactive — the spontaneous radioactive transformation of one nuclide into a different nuclide or into a different energy state of the same nuclide. During this transformation, energy is emitted from the nucleus in the form of alpha particles, beta particles and/or gamma rays.

decay chain — the sequence of radioactive disintegrations in succession from one nuclide (parent) to another (daughter) to another (daughter) until a stable end product is reached..

electromagnetic radiation — radiation consisting of associated and interacting electric and magnetic waves that travel at the speed of light. Electromagnetic radiations range from high energy gamma and xrays having short wavelengths, through ultraviolet, visible and infrared waves, to low—energy radar and radio waves having relatively long wavelengths..

electron — a stable, negatively charged particle of matter with a mass 1/137 that of the proton. Electrons orbit the positively charged nucleus in one or more levels and determine the chemical properties of the atom..

element — a substance whose atoms all have the same atomic number. A n element is one of the approximately 106 known substances that cannot be divided into simpler substances by chemical means.

energy — a measure of the ability to do work, usually expressed in electron volts. The energy of particles or rays emitted from nuclei during radioactive decay determines, in part, their ability to penetrate matter and to cause tissue damage. These energies may be in the range of thousands to millions of electron volts. In Einstein's theory, energy (E) and mass (m) are two forms of the same thing. $E = mc^2$ (c being the speed cf light).

fission — the splitting of a heavy nucleus into two lighter nuclei (fission fragments) accompanied by the release of a relatively large amount of energy and generally one or more neutrons. Fission can occur spontaneously in a few isotopes, but it is usually induced by nuclear absorption of neutrons.

fission products — elements or compounds resulting from fission. This term is commonly used to refer to the complex mixture of nuclides produced by the fission of heavy elements and the subsequent daughters resulting from the radioactive decay of the fission fragments. Most, but not all, of the fission products produced from heavy elements are radioactive.

fusion — the joining of two light nuclei to form a heavier nucleus accompanied by the release of energy.

gamma radiation — energy in the form of short wavelength electromagnetic radiation emitted by the nuclei of some radioactive substances during radioactive decay. High—energy gamma radiation is very penetrating, being able to pass through the human body, but it does not concentrate its damage as alpha and beta particles do. It is best shielded against by dense materials such as concrete and lead.

Half-life (physical) - the time required for half the atoms of a particular radioactive substance to decay to another nuclear form. After a period of time equal to it's half—lives, the activity of a radionuclide has decreased to about one one—thousandth its original level. Half-lives range from millionths of a second to billions of years. Radon—222 has a half—life of 3.82 days, cobalt 60 a half-life of 5.2 years, strontium—90 ; 28 years, plutonium—239 has a half-life of 24,000 years and uranium—238 has a half-life of 4,470.000,000 years.

ion — an atom or molecule that has gained or lost one or more electrons resulting in a negative (additional electrons) or positive (fewer electrons) electrical charge. An ion is more chemically reactive than a neutrally charged atom or molecule. The process of creating ions, called ionization, is accompanied by the release or absorption of energy and can be caused by chemical reactions, high temperatures, electrical discharges or ionizing radiation.

ionizing radiation — any radiation capable of ionizing an atom or molecule by adding or displacing an electron. High doses of ionizing radiation may damage or destroy cells. Alpha and beta particles, gamma and x-rays, neutrons and short wavelength ultraviolet light are examples of ionizing radiation. Visible light, infrared light, microwaves and radio waves are examples of non-ionizing radiation.

irradiated — exposed to radiation. Irradiated material may or may not became radioactive, depending on the material and type of radiation. Normally, only neutrons can induce radioactivity in a material.

isotope — atoms of the same chemical element (that is, having the same atomic number) with differing numbers of neutrons in their nuclei. The isotopes of a given element usually have very nearly the same chemical properties but may differ greatly in radioactive behavior. A single element may have many isotopes, some of which may be radioactive. For example, there are three isotopes of hydrogen: ordinary hydrogen H, having one proton in its nucleus; deuterium H, a rare natural isotope, having one proton and one neutron in its nucleus; and tritium H, a radioactive isotope that is both naturally occurring and man-made, having one proton and two neutrons in its nucleus.

kinetic energy — energy due to motion.

molecule — a group of atoms held together by chemical forces. The atoms in a molecule may be of the same or of different elements.

neutron — an uncharged particle found in the nucleus of an atom having slightly greater mass than a proton. A free neutron is unstable and decays with a half-life of 13 minutes into an electron and a proton. Neutrons sustain the fission chain reaction in a nuclear reactor.

nuclear — referring to processes involving the core, or nucleus, of atoms.

nucleus — the dense, positively charged core of the atom, consisting primarily of neutrons and protons. The nucleus makes up almost the entire mass of the atom but only a minute part of its total volume.

nuclide — a general term referring to all known isotopes of the chemical elements, both stable and unstable.

penetrating radiation — photons or elementary particles which are capable of passing into or through solid material; these include gamma rays, x rays, neutrons and high energy beta particles.

photon — a quantity of pure energy having no mass nor electrical charge. As radiant energy, a photon behaves as a packet of electromagnetic waves, while in its interactions with matter, it behaves as a minute particle. Gamma rays, x-rays, visible light and radio waves are examples of photons.

positron — a positively charged beta particle with the same mass as an electron. A positron is the result of the transformation of a proton into a neutron and a positron during radioactive decay.

proton — a positively charged particle found in the nucleus of an atom which weighs about 1.67 x 1O grams. The atomic number of an atom equals the number of protons in its nucleus.

radiation — the emission and transmission of energy through matter or space by electromagnetic waves or streams of fast moving particles. Nuclear radiation is the emission of subatomic particles or electromagnetic energy from nuclear transformations.

radioactive — capable of spontaneously emitting radiation.

radioactivity — the spontaneous emission of radiation, such as alpha particles, beta particles, and/or gamma rays, from the decay or disintegration of an unstable nucleus.

radioisotope an unstable isotope of an element. Radioisotopes decay or disintegrate, spontaneously giving off radiation.

radionuclide — a radioactive nuclide.

transuranic elements — all elements above uranium on the periodic table thus those with atomic numbers greater than 92. Neptunium, plutonium, americium and curium are transuranic elements. Transuranics are radioactive and almost entirely man—made. The only known naturally occurring transuranics have been found at the site of a uranium mine near 0klo, Gabon in West Africa.

X ray — A penetrating electromagnetic radiation having a wavelength that is much shorter than that of visible light. These rays are usually produced by excitation of the electron field around certain nuclei. In nuclear reactions, it is customary to refer to photons originating in the nucleus as gamma rays, and to those originating in the electron field of the atom as x rays. These rays were sometimes called roentgen rays after Wilhelm Roentgen who discovered them in 1895.

PART II

RADIATI0N EXPOSURE

absorbed dose — the energy imparted to matter as ionizing radiation passes through it. The amount of energy absorbed per unit mass of irradiated material is called the absorbed dose and is measured in rads.

absorption — the process by which radiation imparts some or all of its energy to any material through which it passes.

acute exposure — exposure to radiation received over a very short time, as in medical therapy or an accident situation.

ALARA — acronym -for "As Low As Reasonably Achievable"; a basic concept of radiation protection which specifies that discharges of radioactivity from nuclear facilities and radiation exposure to personnel be kept as far below regulatory limits as reasonable.

background radiation — the level of radioactivity in man's environment. Cosmic radiation, naturally occurring radioactive elements in the earth, air, water, food and within the human body are natural sources of background radiation. Fallout from weapons testing, x rays., radiopharmaceuticals and products such as smoke alarms and televisions are man-made sources adding to background radiation. The average annual background dose for U.S. citizens is approximately 110 to 140 mrem.

bequerel (Bq) — in the International System of Units, a unit of measurement of radioactivity equal to one nuclear disintegration (transformation) per second. One bequerel equals 2.7 x 10 curies, or 37 billion bequerel equals one curie.

biosphere — the part of the earth in which life can exist; living beings together with the environment.

body burden — the amount of radioactive material present in the body of a person or animal. The permissible body burden of a particular radionuclide depends on the half-life of the nuclide the type and energy of the radiation emitted by the nuclide, and the size and sensitivity of the target organ.

carcinogenic — capable of causing cancer.

cathode ray — a stream of electrons emitted by the cathode (negative electrode) of a gas-discharge tube or by a hot filament in a vacuum tube. Televisions, computer monitors and x ray machines employ cathode ray tubes.

chelating agent — a chemical compound which will combine with a heavy metal to form a very large molecule. Chelating agents can be administered to personnel who have been internally contaminated by transuranic elements. The chelating agent binds the radioactive elements, speeding their elimination from the body and reducing their chance of settling in bone or tissue.

chronic exposure — exposure to radiation over an extended period of time.

contamination — the presence of radioactive material where it is not wanted.

cosmic radiation — penetrating ionizing radiation originating in space and striking the earth with nearly the speed of light. Cosmic radiation can include electrons, neutrons, protons and photons. Cosmic rays can account for one quarter of the background radiation the average individual receives in a year. Since cosmic rays are absorbed in interactions with the atmosphere, persons living at high altitude are exposed to a greater dose from cosmic radiation than those living at sea level.

critical organ — the organ which receives the highest dose from an exposure whether the exposure is internal or external. For internal exposure, it is normally the organ in which that particular radioisotope concentrates. For example, iodine tends to concentrate in the thyroid, strontium tends to concentrate in the bones. Each organ has a different dose limit depending on its size and sensitivity to radiation.

cumulative dose — the total dose to an organ or tissues resulting from all exposures to radiation.

curie (Ci) — the basic unit describing the intensity of radioactivity in a sample of material. The curie is equal to 37 billion (3.7×10^{10}) nuclear transformations (disintegrations) per second or approximately the rate of decay of one gram of radium. Thus the amount of any material which is decaying at that rate is defined as one curie regardless of the types of radiation it emits. Common fractions of a curie are the millicurie (37,000,000 d/s, microcurie (37,000 d/s), nanocurie (37 d/s) and picocurie (0.037 d/s).

decontamination — the removal of radioactive contaminants. Surfaces, clothing or equipment may be decontaminated by washing or cleaning with chemicals; air by filtering; personnel by washing or, for internal contamination, by administering chelating agents.

dose — the quantity of ionizing radiation received. The absorbed dose, expressed in rads, represents the energy absorbed from the radiation in a gram of any material. The dose equivalent, expressed in rem, is a measure of the relative biological damage to living tissue. The term "dose" is sometimes confused with the term "exposure".

dose commitment — the total radiation dose that will result from retention of radioactive material within the body. In estimating the dose commitment, it is assumed that from the time of intake, the period of exposure to the retained material will not exceed 50 years.

dose equivalent — a term used to express the relative effect of different kinds of radiation on biologic systems by considering modifying factors. It is defined as the product of absorbed dose in rads and the quality factor. It is expressed numerically in rem.

dose rate — the radiation dose delivered per unit of time measured, for example, in rad per hour.

dosimeter — a portable instrument for measuring and registering the total accumulated dose of ionizing radiation. Film badges, thermoluminescent dosimeters and pocket chambers are examples of dosimeters used for monitoring personnel.

emergency classifications — pre-established classifications for emergency events at industrial or government nuclear facilities determined by the Nuclear Regulatory Commission or the U. S. Department of Energy. The classifications are based on the anticipated severity of an event and specify required emergency responses. The four classifications for industrial facilities regulated by the NRC, from least severe to most severe, are:

1. ***Unusual event*** — an event which could jeopardize safety at the facility, but not serious enough to release activity outside the site. Appropriate state and local officials must be notified.
2. ***Alert*** — safety has been breached and very small amounts of radioactivity may be released. Monitoring teams are dispatched and appropriate federal, state and local officials must be notified and kept updated.
3. ***Site emergency*** — safety systems have failed and radiation releases exceed NRC guidelines near the site boundary, but not farther away. Offsite monitoring and emergency centers begin operation, authorities notified and updated regularly.
4. ***General emergency*** — safety systems have failed and radiation releases exceed NRC guidelines for more than the immediate site area. All previous actions are required plus regular press briefings and site evacuations.

(Similar classifications are used for government facilities regulated by the U.S.D.O.E.)

exposure — the condition of being exposed or made subject to the action of radiation.

fallout — air-borne particles containing radioactive material from a nuclear explosion; most particles eventually fall to the ground.

food chain — the pathway by which any material moves through the environment to edible plants, to animals and to man.

genetic effects — effects that can be transferred from parent to offspring; changes in the genetic material of tissues in the reproductive system.

gray (Gy) — in the International System of Units, a unit of absorbed dose which equals the energy of one watt-second (1 joule) per kilogram. One gray equals 100 rads.

Half-life, biological — the time required for the body to eliminate, by natural processes, half the amount of a substance that has entered it.

Half-life, effective — the time required for a radionuclide contained in a biological system, such as a man or an animal, to reduce its activity by half as a combined result of radioactive decay and biological elimination. For example, the physical half-life of tritium (an isotope of hydrogen) is 12.3 years; its biological half-life is 12 days, and its effective half-life is 11.97 days.

Half-life, physical — the time required for half the atoms of a particular radioactive substance to decay to another nuclear form. Half-lives range from millionths of a second to billions of years.

health physics — the science concerned with the recognition, evaluation and control of health hazards from ionizing radiation.

ionizing radiation — any radiation capable of ionizing an atom or molecule by adding or displacing an electron. High doses of ionizing radiation may damage or destroy living cells. Alpha and beta particles, gamma and x rays, neutrons and short wavelength ultraviolet light are examples of ionizing radiation. Visible light, microwaves and radio waves are examples of non-ionizing radiation.

latent period — the time of apparent inactivity between exposure of tissue to ionizing radiation and the onset of symptoms indicating radiation-caused damage.

lethal dose (LD)— a dose of ionizing radiation large enough to cause death. To be immediately lethal, radiation exposure to the whole body must exceed 1, 000 rem over a brief period (minutes or hours). The median lethal dose is the radiation dose at which 50 percent of the people exposed will die within a specified time, usually 30 days. For humans, the LD 50/30 is about 400 rem (400,000 mrem) assuming there is no specialized medical intervention.

linear hypothesis (linear model) — a mathematical method of predicting the effects of low-level radiation which assumes that any ionizing radiation causes damage, that there is no threshold dose below which damage does not occur. Using this hypothesis, the known dose-response -for high levels of radiation is plotted on a graph and the dose-response for low levels is extrapolated by drawing a straight line from the known data to zero (no dose, no response). The linear model yields a prediction of one additional cancer death for each 5000 man-rem.

linear quadratic theory — a mathematical method of predicting the effects of low-level radiation which presumes that cancer incidences will be proportionately lower at low doses than at high doses, in part because body cells repair themselves more easily at low doses. It thus predicts fewer cancer deaths at low doses than does the linear hypothesis.

man-rem (person-rem) — the total radiation dose to a given population group; obtained by multiplying the average dose by the number of people affected.

maximum individual dose — the maximum calculated dose that could possibly be incurred from exposure to radiation or radioactive materials resulting from the operation of a nuclear facility. It is generally estimated for a hypothetical person located at or just beyond the facility boundary.

maximum permissible concentration (MPC) — the quantity of a given radioactive material in air or water per unit volume or weight from which a person, consuming them at a standard rate of intake, should not exceed the permissible limits. MPCs are set by the Nuclear Regulatory Commission (NRC) and published in the Code of Federal Regulations. Similar limits, called concentration guides, are used by the U.S. Department of Energy.

millirem (mrem) — one one-thousandth rem (0.001 rem). Most commonly used fraction of the unit for dose equivalent. According to the standards set by the Nuclear Regulatory Commission (NRC), the average exposure limit for the general public is 170 mrem a year with no individual receiving more than 500 mrem from the operation of a nuclear facility. The limit does not include radiation received from medical treatment or from background radiation.

mutagenic — capable of producing cell mutations.

numerical prefixes — prefixes used to form names of the decimal multiples and fractions:

giga multiply by one billion (10^9)

mega multiply by one million (10^6)

kilo multiply by one thousand (10^3)

deci divide by ten (10)

centi divide by one hundred (10^2)

milli divide by one thousand ($1O^3$)

micro divide by one million (10^6)

nanc divide by one billion (10^9)

pico divide by one trillion (10^{12})

atto divide by one quintillion (10^{18})

occupational dose — the maximum allowed dose that a worker may receive in the course of his work from exposure to both radioactive materials and radiation generating devices such as x ray machines. Occupational dose limits are set by several government agencies including the U.S. Department of Energy, the Nuclear Regulatory Commission., the Environmental Protection Agency and individual state agencies. For U.S.DOE and NRC- regulated facilities, the occupational dose limit for whole body dose is 5 rem per year (5,000 mrem/yr).

penetrating radiation — photons or elementary particles which are capable of passing into or through solid material; these include gamma rays, x rays, neutrons and high-energy beta particles.

quality factor (QF) — a mathematical factor by which the absorbed dose (in rads) is multiplied to obtain the dose equivalent (in rem). The quality factor takes into account the fact that once inside the body, each type of radiation causes different amounts of damage to the tissue for the same absorbed dose. The quality factor for alpha radiation is 20; for beta, x ray, and gamma radiation, it's 1; and for neutron radiation, 10.

rad — the basic unit of absorbed dose of ionizing radiation. A dose of 1 rad means the absorption of 100 ergs (a very small but measurable amount of energy) per gram of absorbing material.

radiation protection — systems employed to keep radiation exposure within recognized limits. Time, distance and shielding are the basic factors used to protect against undue radiation exposure. One can reduce exposure time, one can move farther away from a source (moving twice as far from a small source reduces exposure by four, moving three times as far reduces exposure by nine times); or one can increase the thickness of shielding material. Radioactive material can also be contained and isolated until it decays to a permissible level; or it can be mixed with large volumes of air, water or soil to dilute the activity to well below maximum permissible concentrations.

radiation sickness — the effect of exposure to relatively large doses of ionizing radiation (100 to 400 rem or greater to the whole body). It is characterized by blood cell changes, nausea, vomiting, and diarrhea and in later stages by hemorrhage and loss of hair.

radiation warning symbol — an officially prescribed symbol consisting of a magenta trefoil (a Y constructed from triangles) on a yellow background, which is displayed when radiation or radioactive material is present in quantities specified by government regulations.

radiology — the science which deals with the use of all forms of ionizing radiation in the diagnosis and treatment of disease.

rem — the unit of measure for the dose equivalent. A rem is the amount of ionizing radiation which gives the same biological effect as one roentgen of 250 kilovolt x rays. Numerically it is the absorbed dose (in rads) multiplied by the quality factor. One rem equals approximately one rad for x, gamma or beta radiation. The most common fraction of a rem is the millirem (0,001 rem).

roentgen (R) — a unit of measure for the amount of radiation energy imparted to a specified volume of dry air. The roentgen can be used only in measuring x rays and gamma rays.

shielding — material placed around a source of radiation for protection against exposure to radiation. Common shielding materials are concrete, water, steel and lead.

sievert (Sv) — in the International System of Units, a unit of dose equivalent which is equal to 1 Joule per kilogram. One sievert equals 100 rem (100,000 mrem)

smear (swipe) — to wipe a surface with cloth or paper to determine if any loose (smear-able) contamination is present.

somatic effects — effects limited to the exposed individual, as distinguished from genetic effects which may also affect subsequent generations.

survey meter — any portable radiation detection instrument for surveying or inspecting an area to identify and measure any radioactive material present. The Geiger-Mueller counter, which detects beta and gamma radiation, and the PAM (Portable Alpha Monitor) are examples of survey meters.

threshold hypothesis — a method of predicting the effects of low- level radiation which presumes that radiation effects will only occur above some minimum (threshold) dose.

toxic — poisonous; chemically producing an injurious or lethal effect.

whole- body counter — a device to identify and measure radiation in the bodies of humans and animals. It uses ultrasensitive detectors and is heavily shielded to reduce background radiation.

whole-body exposure — an exposure of the body to radiation in which the entire body rather than an isolated part is irradiated. Where a radioisotope is uniformly distributed throughout the body tissues rather than being concentrated in certain parts, the irradiation can be considered as a whole—body exposure.

PART III

RADIOACTIVE WASTE

agreement state — any state which has concluded an agreement with the Nuclear Regulatory Commission by which that state assumes regulatory responsibility over byproduct and source material and small quantities of special nuclear material. Agreement states in the Pacific Northwest include Washington, Oregon and Idaho (but not Montana or Alaska).

barrier — a material or structure that slows or prevents the movement of radioisotopes. Engineered barriers are man-made safeguards, such as those used in packaging, which prevent contact with the enclosed waste. Natural barriers are those provided by the geologic materials that separate the waste from the biosphere. A multiple barrier approach to waste storage or disposal employs both engineered and natural barriers in several layers.

burial site — an area specifically designated for the shallow subsurface disposal of low-level radioactive wastes.

byproduct material — any radioactive materials, except special nuclear material, generated during the production or use of enriched uranium, uranium-233, uranium-235 or plutonium; and the tailings or wastes produced in extracting uranium or thorium from its ore.

calcine — a powder derived from spray-drying acidic reprocessing liquids at high temperatures. The dry powder can be stored in stainless steel bins or added to the ingredients for glass or ceramic to form a stable solid.

canister — a metal container into which solidified high-level waste or spent fuel rod assemblies can be placed to contain them for storage. Additional containers or packaging materials may be added prior to shipment or disposal.

cask — a massive container providing shielding, containment and heat dissipation during the storage and transportation of spent fuel or solidified high-level waste. Casks must be designed to prevent criticality, to include special sealing and handling features and to minimize exposure of personnel. Transportation casks must survive consecutive damage tests -first a 30 foot fall to a flat unyielding surface, second a fall of at least 40 inches onto a six inch vertical steel post, then a minimum of 30 minutes in a 1475° F fire followed finally by eight hours immersed in at least 30 inches of water -with no loss of containment.

cladding — the corrosion resistant outer covering of a nuclear fuel rod usually a zirconium alloy or stainless steel. The cladding serves as a barrier preventing the release of radioactivity into the coolant.

commercial waste — those radioactive wastes generated by private industry, primarily nuclear power plants, manufacturers, hospitals and research facilities.

compacts — agreements between two or more states to cooperate in storing and disposing of low-level wastes generated within their borders; authorized by the Low-Level Radioactive Waste Policy act.

containment — the secure retention of radioactive material within a designated boundary or container in a manner that prevents its release into or contact with the environment. Along with isolation, containment is one of the strategies for preventing the migration of radionuclides into the biosphere.

crib — a site used for the disposal of low activity liquid wastes. Perforated pipe is laid in a deep trench, up to several hundred meters long. The trench is back-filled with gravel, covered with an impermeable layer and topped with a blanket of soil. Liquid wastes are fed into the crib via the pipe at the bottom, and radioactive particles are trapped by absorption in the soil as the liquid percolates through it.

decay heat — heat generated by radioactive decay.

decommissioning — the process of closing down a nuclear facility at the end of its useful life. After any radioactive material is removed and surfaces decontaminated, options for decommissioning include:

1. Dismantling, or removing all structures and any radioactive material and razing the site.

2. Mothballing, or sealing the structure securely and restricting access until radiation has dropped to fairly safe levels; then dismantling it.

3. Entombment, or sealing the structure permanently, covering it with concrete or steel and soil and guarding it against intrusion.

defense wastes — those radioactive wastes which are generated during the production of nuclear materials for the national defense and during naval reactor operations.

Department of Energy (U.S.DOE) — a cabinet level department of the U.S. government which conducts research and development of commercial nuclear energy applications and other energy technologies, manufactures nuclear materials for defense programs and is responsible for implementing the federal government's high-level waste management policies. It is in charge of inactive uranium mill tailing sites and of transuranic and low- level nuclear wastes generated by defense programs. The U.S.DOE is generally responsible for regulating its own activities.

Department of Transportation (DOT) — a cabinet-level department of the U.S. government which governs the shipment of radioactive materials (including nuclear waste) by all modes of transport. It also administers the labeling, classification and marking of all radioactive waste packages.

disposal — the permanent isolation of potentially harmful nuclear wastes from humans and the accessible environment with no provision to recover or retrieve them. Disposal requires that there be no need for human control or maintenance.

drum — a cylindrical metal container used for the transportation, storage, and disposal of low-level waste materials, usually standard 59-gallon size.

dry storage — storage of spent fuel or solidified high-level waste surrounded by one or more gases (air, argon, helium) with no use of cooling liquids.

effluent — gaseous and liquid materials discharged into the environment as industrial waste.

encapsulation — the placement of radioactive material into a sealed metal capsule for containment prior to use, shipment, storage or disposal. For example, solidified cesium and strontium recovered from reprocessing wastes can be encapsulated. - A filled capsule might then be used as a radiation source for sterilizing such things as sewage or medical supplies or it might be stored under water prior to disposal.

Environmental Protection Agency (EPA) — a cabinet level agency of the U.S. government which issues and enforces environmental radiation regulations and standards effective outside the boundaries of sites that possess radioactive materials - including future geologic waste repositories.

extraction — a chemical process for selectively removing materials from solutions. Extraction is one of the steps in reprocessing irradiated fuel.

fractionization — the process of separating specific constituents, or fractions, such as plutonium and uranium, from irradiated fuel or from liquid wastes during reprocessing.

fuel assembly (fuel element) — a bundle of fuel rods fastened together prior to placement within the core of a nuclear reactor. The rods in an assembly are usually arranged in a square configuration, 6 to 9 inches across, with spacers between them. Assemblies can vary in the number of rods they contain, from 8 on a side to 17 on a side, depending upon the reactor for which they are intended. They can weigh from one quarter to three quarters of a ton.

fuel cycle — the complete series of steps involved in the production, utilization and disposal of fuel for a nuclear reactor. It begins with the mining and milling of uranium, refining and enrichment of the uranium, fabrication into fuel elements, irradiation in a reactor (usually three years in a power reactor and two to eight months in a production reactor), followed by removal to a storage basin. A once-through fuel cycle would then store the irradiated fuel prior to disposing of it intact. A closed fuel cycle would include the chemical reprocessing of the spent fuel to recover plutonium and uranium for recycling as fuel. Each step in the fuel cycle generates radioactive waste to be treated and disposed of.

immobilization — the process of converting wastes to a solid, stable form which prevents or slows the migration of radionuclides into the biosphere.

fuel rod — a sealed zirconium alloy or stainless steel tube, about 1/2 inch in diameter and 12 to 14 feet long, containing a stack of fissionable uranium oxide pellets.

geologic disposal — the permanent isolation of high-level radioactive waste in a repository constructed in a very deep geological medium (salt, balsalt, tuff, granite).

grout — a cement-like material mixed with low activity liquid wastes to form a stable solid.

High-efficiency particulate air filter (HEPA filter) — an air filter capable of removing at least 99.97 per cent of the particulate material in a flowing air stream.

High-level radioactive wastes (HLW) — irradiated reactor fuel. Liquid wastes resulting from the solvent extraction systems used in a reprocessing facility to extract uranium and plutonium from irradiated fuel as well as the concentrated wastes from subsequent extraction cycles and the solids into which such liquid wastes have been converted. Since there has been very little reprocessing of commercial reactor fuel in the U.S., most high-level liquid wastes are defense wastes. They are currently stored at three U.S.DOE-administered sites— Hanford, WA, Idaho National Engineering Laboratory (INEL) , ID, and Savannah River, SC. The only high-level wastes from commercial reprocessing are stored at West Valley, NY.

interim storage — storage operations for which monitoring and human control are provided after which treatment, transportation or disposal is expected.

isolation — removing radioactive waste far enough from human environments that any movement back into air or water would take longer than the time it takes for those materials to decay to safe levels. Along with containment, isolation is one of the strategies for protecting the biosphere from radiation hazards.

Low-Level Radioactive Waste Policy Act — passed by Congress in 1980, this act makes each state responsible for assuring adequate disposal of commercial low-level waste generated within its borders. It allows states to form regional groupings to build a single disposal facility but requires the agreements -called compacts- to be approved by Congress. To date, six compacts have been approved but no new low-level disposal sites have yet been developed. After the 1992 deadline, any operating low-level disposal site may refuse to accept waste from any state not in its compact.

low—level radioactive wastes (LLW) — those wastes which are not irradiated fuel, high-level, transuranic, uranium mill tailings or byproduct material. Low-level wastes are generated in almost any activity involving radioactive materials and can include protective clothing, animal carcasses, cleaning rags, rubber gloves, hand tools and test tubes. The Nuclear Regulatory Commission classifies low-level waste by its potential hazard into three categories:

A (least potential hazard), ***B*** and ***C***, and specifies packaging for each type. These wastes are generally disposed of by burying them at a suitable site at depths dependent upon waste category. Disposal of commercial low-level waste is currently handled by private companies at three sites—Barnwell, SC, Richland, WA, and Beatty, NV.

mill tailings — residues from the process of extracting uranium from its ore. These residues are usually a liquid slurry which is pumped into settling ponds and allowed to dry. The tailings contain some uranium and its decay products, such as thorium, radium and radon, and are about 15% less radioactive than the original ore. The dried tailings can be collected and covered with a layer of earth and vegetation to prevent their dispersion into water or air, to limit the release of radon gas and to prevent their use as a construction material or fill.

monitored retrievable storage (MRS) — a facility to receive, process, package and store spent fuel and other wastes prior to shipment to a repository for permanent disposal.

Nuclear Regulatory Commission (NRC) — an independent regulatory agency headed by five members appointed by the President to serve five-year terms. The NRC develops and enforces regulations to protect the public health and safety from all domestic commercial nuclear activities. It is responsible for licensing the construction and operation of nuclear power plants and any -future geologic waste repositories. The NRC does not have authority to regulate naturally occurring radioactive materials such as radium or polonium which are not source material nor to regulate accelerator-produced radioactive materials.

Nuclear Waste Policy Act — passed by Congress in 19B2, this act provides a framework for managing the disposal of commercial spent fuel and high-level radioactive wastes and assigns responsibility for implementation to the Department of Energy. The Act establishes federal responsibility for high-level waste management, sets a schedule for siting, construction, operation and closure of two repositories defines decision-making relationships between the federal governments, state governments and Indian tribes; provides for a host-state veto of a repository site which can only be overridden by a majority vote of both houses of Congress, and requires a fund to be established - supported by user fees, to cover disposal costs.

overpack — a secondary container applied over a primary container. It can be applied if the primary container is found to be defective or it can be part of the package design for long-term containment of nuclear waste.

partitioning — the separation of transuranic or other elements from waste solutions as a step toward disposal.

passive cooling — removal of heat through a means that requires no active mechanical systems or energy from outside sources.

pond — an artificial body of surface water formed by discharge of very low activity liquid waste. The liquids in the ponds evaporate or percolate into the soil. When ponds are retired from service, the radionuclide-bearing sediments can be either removed or buried in place.

pool — water-filled storage basin for spent fuel.

Price-Anderson Act — passed by Congress in 1957, extended in 1965 and 1975. The Price-Anderson Act sets up a system of combined government guarantees and private insurance to pay claims from personal injury and property damage caused by accidents at nuclear generating plants and U.S. DOE facilities or during transportation of nuclear material. Liability is limited at present (for any single accident) to $605 million. The act is due to expire in 1987.

production reactor — a nuclear reactor used primarily for production of plutonium from natural uranium, rather than for generation of electricity. One production reactor in the U.S. at Hanford, WA is a dual purpose reactor in that it also produces steam used for generation of electricity.

repository — a facility or designated site for storage or disposal of wastes. A geologic repository is an underground mined facility and its structures and equipment where high-level radioactive wastes are placed for disposal.

reprocessing — a chemical process for recovering useful materials from irradiated fuel. The fuel assemblies are cut into pieces and then the contents are dissolved in nitric acid. A solvent extraction process is used to separate the uranium, plutonium and fission products. The extracted uranium and plutonium can be treated for reuse as fuel or the plutonium can be processed for use in fabricating weapons. Reprocessing leaves highly radioactive liquids as waste. These can be further separated to remove highly active isotopes such as strontium and cesium, prior to being stored and solidified.

reracking — the process of moving stored spent fuel assemblies closer together as space in a storage basin nears capacity.

retrievability — the ability to find and safely remove wastes from a storage location.

salt cake — damp, crystalline solids formed by evaporation of alkaline liquid reprocessing waste in an evaporator-crystalizer.

shielding — material placed around a source of radiation for protection against exposure to radiation. Common shielding materials are concrete, water, steel and lead.

sludge — wet solids which settle and accumulate in the bottom of a vessel such as a storage tank; also solids formed by precipitation or self-concentration.

slurry — a mixture of solids and liquids requiring agitation to prevent separation.

solidification — transformation of liquid wastes into solids. Solidification refers generally to concentration of liquid wastes in an evaporator-crystallizer to produce salt cake and to procedures which dry the wastes in air to form calcine; and to vitrification of calcined waste.

sorption — the retention of one substance by another by close-range chemical or physical forces. Absorption takes place within the pores of a granular or fibrous material. Absorption takes place largely at the surface of a material or its particles. Inorganic ions in waste materials may be retained in soils and sediments by either absorption or adsorption.

source material — uranium and thorium in any physical or chemical form or the ores which contain them.
special nuclear material — plutonium, uranium-233, uranium-235 or uranium enriched to a higher than normal percentage of the 233 or 235 isotopes.

spent fuel — nuclear fuel which has reached the end of its useful life - about three to four years for commercial fuel in a power reactor. The spent fuel is a self-contained form of waste that is thermally hot and highly radioactive having a potential dose at the surface of millions of rem per hour. It is cooled and shielded in deep pools at the reactor site. After one year, the radiation and heat from the spent fuel are about 90 per cent less intense than at removal, but radiation levels drop much more slowly after that. Pools at reactor sites are filling with spent fuel while awaiting the construction of a repository. As a pool nears capacity, the fuel can be reracked or moved to an approved storage site away from the reactor.

stabilization — the removal or immobilization of liquid from old or leaking storage tanks as completely as possible. Current technology and equipment are limited to pumping, adding an absorbent material, or in situ drying in certain tanks.

storage — temporary placement of radioactive waste so as to permit retrieval.

storage basin — a pool of water located at a power reactor or other designated location for storage of spent fuel. The basin has concrete walls about six feet thick lined with stainless steel. Water, 30 to 40 feet deep, provides cooling and shielding as the radioactive materials in the fuel decay. The fuel assemblies are stored in racks made of neutron absorbing metal and spaced so as to prevent criticality.

tank — a large metal and concrete container located underground for storage of liquid high-level wastes. Modern tanks are metal-lined concrete with an inner steel tank and are equipped with sensors to detect leaks. A tank farm is an installation of interconnected underground tanks.

transuranic wastes (TRW) — solid wastes containing concentrations of transuranic elements greater than 100 nanocuries per gram of waste material. They are primarily the byproducts of fuel assembly, weapons fabrication and reprocessing. The activity level of these wastes is generally not high, but the isotopes they contain have long half-lives. Transuranic waste is currently being stored at six U.S.DOE sites pending the completion of a repository near Carlsbad, NM.

trench — a wide, deep ditch up to several hundred feet long used for the disposal of low-level wastes. Packaged wastes are placed in the trench and covered with earth. A filled trench is topped with a layer of gravel and mounded soil to aid drainage and to prevent intrusion by animals and plants.

Uranium Mill Tailings Radiation Control Act — passed by Congress in 1978, this act authorizes the Nuclear Regulatory Commission to insist on proper management of tailings by the uranium mills it licenses. It makes the Department of Energy responsible for managing 24 inactive tailings piles. The federal government is to pay 90 per cent of any clean-up costs and the state in which the tailings are located is to pay the remaining 10 per cent.

vitrification — a process of immobilization by which liquid wastes are solidified, added to the ingredients for glass, melted, then cooled to a solid. The glass used for vitrification is much like that used for cooking utensils because of its strength and temperature resistance.

waste volume reduction — reduction of waste volume. For example, volume reduction can be achieved for high-level liquids, by use of an evaporator-crystallizer, or by in-tank solidification for worn out or obsolete contaminated metallic equipment, by cutting it into pieces, melting it, and casting it into ingots - and for some solids, by incineration or compaction.