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RADIOACTIVE WASTE MANAGEMENT GLOSSARY

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FOREWORD

Terminology used in documents published by the IAEA is frequently defined in glossaries in the separate documents so that understanding is enhanced, particularly for terms having unique meanings in the field of radioactive waste management. This has been found to be a good practice but frequently a burdensome one, too. In addition, terms in various documents occasionally were used differently. Thus, a common glossary of terms for radioactive waste management documents is believed to have merit.

This glossary has been developed for use in IAEA documentation on radioactive waste management topics. The individual items have been compiled by selecting terms and definitions from thirty sources, listed on the next page, and numerous people. An effort has been made to use the definitions in internationally-accepted glossaries (e.g. ICRP, ICRU, ISO), with minimum modification; similarly, definitions in recently published IAEA documents have been respected. Nevertheless, when modifications were believed appropriate, they have been made.

The glossary, stored on magnetic tape, is intended to be used as a standard for terminology for IAEA use; it is hoped that some benefits of common international terminology may result from its use in IAEA documentation. It is acknowledged that some modifications to the definitions may be desirable when they are transferred from the master tape to a glossary for a specific document. Also, additional terms will be added as the glossary is used. Thus, this document is considered as a working document. Hopefully, its availability in this form may be beneficial and convenient for our Consultants, Technical Committees and Advisory Groups, as well as the Secretariat Staff.

Suggested modifications or additions should be addressed to Mr. E.R. Irish, Scientific Secretary, Waste Management Section of the Agency.

SOURCES OF VARIOUS DEFINITIONS

Source

ISO-921 Nuclear Energy Glossary (1975)

ICRP Publication No. 26, Recommendations of the International Commission on Radiological Protection (1977)

ICRP Publication No. 30, Limits for Intakes of Radionuclides by Workers (1979)

ICRU Report 33 - Radiation Quantities and Units (1980)

INFCE/PC/2/7 - Waste Management and Disposal - Report of Working Group 7, Appendix A - Glossary (January 1980)

INFCE Working Group 7 - Draft Glossary (1979)

NUSS (Nuclear Safety Standards) Programme Glossaries

IAEA Safety Series 9, Basic Safety Standards for Radiation Protection (27 July 1981 draft)

IAEA Safety Series No. 15, Radioactive Waste Disposal into the Ground (1965)

IAEA Safety Series No. 44, Management of Wastes from the Mining and Milling of Uranium and Thorium Ores (1976)

IAEA Safety Series No. 45, Principles for Establishing Limits for the Release of Radioactive Materials into the Environment (1978)

IAEA Safety Series No. 50-C-S, Safety in Nuclear Power Plant Siting (1978)

IAEA Safety Series No. 51, Development of Regulatory Procedures for the Disposal of Solid Radioactive Waste in Deep, Continental Formations (1980)

IAEA Safety Series 52, Factors Relevant to the Decommissioning of Land-based Nuclear Reactor Plants (1980)

IAEA Safety Series No. 53, Shallow Ground Disposal of Radioactive Waste: A Guidebook (1981)

IAEA Safety Series No. 54, Underground Disposal of Radioactive Waste: Basic Guidance (1981)

IAEA Safety Series No. 56, Safety Assessment for the Underground Disposal of Radioactive Wastes (1981)

IAEA Technical Reports Series No. 78, Operation and Control of Ion-Exchange Processes for Treatment of Radioactive Wastes (1967)

IAEA Technical Reports Series No. 82, Treatment of Low- and Intermediate-Level Radioactive Waste Concentrates (1968)

IAEA Technical Reports Series No. 176, Techniques for the Solidification of High-Level Wastes (1977)

IAEA Technical Reports Series No. 177, Site Selection Factors for Repositories of Solid High-Level and Alpha-Bearing Wastes in Geological Formations (1977)

IAEA Technical Reports Series, Site Investigations for Repositories for Solid Radioactive Wastes in Deep, Continental Geological Formations (In press)

ERDA 76-53-Alternatives for Managing Wastes from Reactors and Post-Fission Operations in the LWR Fuel Cycle (May 1976)

DOE/NE - 0007 - Statement of Position of the U.S. Department of Energy in the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (April 1980)

Dictionary of Ecology (Herbert C. Hanson) (1962)

Penguin Dictionary of Geology (D.G.A. Whitten) (1972)

Dictionary of the Environmental Sciences (1973)

International Glossary of Hydrology (WHO- No. 385) (1974)

Dictionary of Environmental Terms (1976)

Chemical Engineers' Handbook (John H. Perry)

RADIOACTIVE WASTE MANAGEMENT GLOSSARY

A

absorbed dose: The quotient of $d\epsilon$ by dm, where $d\epsilon$ is the mean energy imparted by ionizing radiation to matter of mass dm. The special name for the SI unit of absorbed dose is gray (Gy); the rad may be used temporarily. (See ICRU Report 33.)

absorbed dose rate: The increment of absorbed dose in a particular medium during a given time interval.

absorption: Incorporation within the physical or molecular structure. (See sorption.)

acceptable limit: Limit acceptable to the regulatory body. (See authorized limit and prescribed limit.)

accessible environment: Those portions of the environment directly in contact with or readily available for use by human beings. Includes the Earth's atmosphere, the land surface, aquifers, surface waters, and the oceans. (See human environment.)

accident condition: A substantial deviation from a normal operating condition of a nuclear facility which could lead to release of unacceptable quantities of radioactive materials if the relevant engineered safety features did not function as per design intent.

actinide: An element with an atomic number from 89 to 103, inclusive. All are radioactive.

action level: Environmental level specified in advance that has been determined to justify remedial action on the basis of knowledge that resulting exposures of people would otherwise be greater than is necessary or desirable.

activation product, neutron: An element made radioactive by bombardment with neutrons.

activity: For an amount of a radioactive nuclide in a particular energy state at a given time, the quotient of dN by dt is the expectation value of the number of spontaneous nuclear transitions from that energy state in the time interval dt. The special name for the SI unit of activity is becquerel (Bq); the curie (Ci) may be used temporarily. (See ICRU Report 33.)

adsorption: Adhesion of ions or molecules or particles to the surface of solid bodies with which they come in contact. (See sorption.)

age of waste:

(i) In terms of spent fuel or reprocessing waste, the time after the end of irradiation.

(ii) For waste whose activity arises from contact with radioactive materials, the time after separation from those materials.

AGR: Advanced gas-cooled reactor.

ALARA: "As low as reasonably achievable, economic and social factors being taken into account." A basic principle of radiation protection taken from the Recommendations of the ICRP, ICRP Publication No. 26 (p.3).

alpha-bearing waste: Waste containing one or more alpha-emitting radionuclides, usually actinides, in quantities above acceptable limits. The limits are established by the national regulatory body.

anhydrite: A mineral, anhydrous calcium sulphate, $CaSO_4$.

anisotropic: Having physical properties that vary in different directions.

annual dose limit: Any of the annual dose equivalent limits for individual members of the public or workers recommended by the ICRP as part of its system of dose limitation in ICRP Publication 26.

annual limit on intake (ALI): The activity of a radionuclide which taken alone would irradiate a person, represented by Reference Man, to the limit set by the ICRP for each year of occupational exposure. (See ICRP Publication 30.)

anticline: A fold of stratified rock from the crest of which the strata slope downwards in opposite directions; antonym of syncline.

applicant: The organization that applies for formal granting of a licence to perform specified activities connected with the nuclear fuel cycle. In waste management, these activities are related to the treatment, storage and disposal of waste.

aquiclude: A geological formation which is capable of absorbing water slowly but will not transmit it fast enough to furnish an appreciable supply for a well or spring.

aquifer: A water-bearing formation below the surface of the earth that can furnish an appreciable supply of water for a well or spring.

arenaceous: Applied to rocks that have been derived from sand or that contain sand; sandstones.

argillaceous: Applied to all rocks and substances composed of clay or having a notable proportion of clay in their composition.

argillaceous rocks: A group of detrital sedimentary rocks, commonly clays, shales, mudstones, siltstones and marls. Two ranges of particle size are recognized: silt grade 60-4 μm; clay grade < 4 μm.

arisings, waste: See waste arisings.

arrival, waste: Quantity of radioactive waste arriving at a nuclear facility for treatment, storage, or disposal.

audit: A documented activity undertaken to determine by investigation, examination and evaluation of objective evidence the adequacy of or the adherence to established procedures, instructions, specifications, codes, standards, administrative or operational programmes and other applicable documents, and the effectiveness of implementation.

authorization: The granting of written permission to perform specified activities.

authorized limit: Limit set for a given radionuclide or source or for a given environment by a national or international authority. (See acceptable limit and prescribed limit.)

B

back end of the fuel cycle: Includes spent fuel storage, fuel reprocessing, mixed-oxide fuel fabrication, and waste management; reactors are not usually included.

backfill: The material used to refill the excavated portions of a repository or of a borehole after waste has been emplaced.

barren solution: Acid or alkaline leach liquor from which the recoverable uranium (and/or thorium, where applicable) has been recovered. This solution often contains reusable reagents.

barrier (natural or engineered): A feature which delays or prevents radionuclide migration from the waste and/or repository into its surroundings. An engineered barrier is a feature made by or altered by man; it may be part of the waste package and/or part of the repository. (See multibarrier.)

becquerel (Bq): The SI unit of radioactivity, equivalent to 1 disintegration per second (approx. 2.7×10^{-11} Ci).

bedded salt: A salt formation in which the salt is roughly horizontal, laterally extensive and relatively thin in the vertical direction (approx. 200 metres).

benthic organisms: Organisms which live on the bottom or in the sediments of the ocean, seas or bodies of freshwater, from the water's edge down to the greatest depths. (See pelagic organisms.)

bioaccumulation: The accumulation of a chemical element or compound by living organisms.

biocoenosis: The aggregate of interacting organisms living together in a particular habitat, e.g. an oyster-bed community.

biological shield: Physical barriers to reduce radiation exposure to living organisms.

biosphere: That portion of the Earth's environment inhabited by any living organisms. It comprises parts of the atmosphere, the hydrosphere (ocean, seas, inland waters and subterranean waters) and the lithosphere. The biosphere includes the human habitat or environment in the widest sense of these terms. (See accessible environment and human environment.)

biotope: The smallest geographic unit of a habitat, characterized by a high degree of uniformity in the environment and in its plant and animal life, e.g. a sandy beach.

bituminization: The process of incorporating wastes into a bitumen matrix as a means of immobilization.

borosilicate glass:

(i) A supercooled liquid based on a random lattice of silica tetrahedra, modified with boron and other cations.

(ii) A glass composition used as an immobilization matrix for a radioactive waste.

buffer zone: A controlled area surrounding a nuclear installation (e.g. a waste repository) established to ensure an adequate distance between the installation and places used by or accessible to the public.

BWR: Boiling water reactor.

C

calcareous: Containing calcium carbonate.

calcine: To heat a substance to a temperature below its melting point, in air, to bring about a loss of moisture and volatile products and to transform the constituents of interest into stable oxides. Such oxides or mixture of oxides are termed 'calcine'.

calciner: High-temperature process equipment used to convert waste solutions into a solid mixture of oxides (calcine).

can: A sealed container for nuclear fuel or other material that provides protection from a chemically reactive environment and containment of radioactive materials produced during the irradiation of the composite. It may also provide structural support. (See cladding.)

CANDU: A type of pressurized heavy water reactor, developed by AECL, Canada, which is moderated and cooled by D_2O and uses natural uranium fuel.

canister: A container (usually cylindrical) for solid radioactive waste. A canister affords physical containment; shielding is provided by a cask, but extra shielding may be required. (See cask.)

cap rock: A disc-like plate covering all or part of the top of most salt domes. It is mainly composed of anhydrite and gypsum, and sometimes dolomite and sulphur.

carnallite: A salt mineral, $KCl.MgCl_2.6H_2O$.

cask (or flask): A massive transport container providing shielding for radioactive materials and holding one or more canisters.

cementation: The process of incorporating wastes into a concrete matrix as a means of immobilization.

chemical digestion: A chemical process for softening or solubilizing a material with heat and moisture.

chop and leach (fuel reprocessing): A method for preparing irradiated fuel elements for reprocessing by cutting the fuel assemblies into pieces and subsequently dissolving selectively the fuel material by leaching with acid.

cladding (material): An external layer of material directly surrounding nuclear fuel or other material that provides protection from a chemically reactive environment and provides containment of radioactive materials produced during the irradiation of the composite. It may also provide structural support. (See can.)

cladding waste: Radioactive waste comprised of cladding hulls and assembly grid spacers for nuclear fuel elements.

Generated during reprocessing when spent fuel assemblies are disassembled and the fuel is dissolved. (See hulls and spacers.)

clastic: Consisting of fragments of rocks or of organic structures that have been moved individually from their places of origin.

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 a composition of fine to very fine clay particles. Clays differ greatly mineralogically and chemically and consequently in their physical properties; especially because of their large surface areas, most of them have good sorption characteristics.

clay loam: Soil material that contains 27 to 40 percent of clay particles and 20 to 45 percent of sand, the rest being silt.

code: As used by the IAEA, a body of advisory or regulatory statements 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 radiological safety.

cold testing: Testing of method, process, apparatus or instrumentation with the highly radioactive materials replaced by non-radioactive materials or materials which may contain radioactive tracers. (See hot testing.)

collective dose equivalent: The collective dose equivalent to a population, expressed in units of man-sievert (man-Sv) or man-rem, that is, the sum of the products of the individual or per caput dose equivalents and the number of individuals in each exposed group in a population.

collective dose equivalent commitment (or collective effective dose equivalent commitment): The (effective) dose equivalent commitment multiplied by the number of individuals in the specified population. It is commonly expressed in units of man-sievert (man-Sv) or man-rem. (Note that the modifiers 'incomplete' and 'truncated' are sometimes used for specific purposes of radiation protection, the details of which must be clearly stated.)

commissioning: The process during which a plant and its components and systems, having been constructed, are made operational and verified to be in accordance with design assumptions and to have met the performance criteria; it includes both non-nuclear and nuclear tests.

compartment: Any part of the environment which may conveniently be considered as a single entity. (Used for environmental modelling.)

competent authority: A national authority designated or otherwise recognized as competent authority by the

Government of a Member State for a specific purpose. (See also regulatory authority.)

competent rock: A bed or stratum which, during folding, is able to lift not only its own weight but also that of overlying beds or strata without appreciable internal flow.

compressive strength: The load per unit of area under which a solid block fails by shear or splitting.

concept, waste management: A basic idea from which a waste management practice may be developed. An example of a waste treatment concept is immobilization of liquid high-level waste.

concession: An area for which a single person or a company has been granted the right to undertake prospecting for mineral deposits.

conditioning of waste: Those operations that transform waste into a form suitable for transport and/or storage and/or disposal. The operations may include converting the waste to another form, enclosing the waste in containers, and providing additional packaging.

conductivity, hydraulic: See hydraulic conductivity.

confinement (or isolation) of waste: The segregation of radionuclides from the human environment and the restriction of their release into that environment in unacceptable quantities or concentrations.

consequence analysis, biosphere: A safety analysis that estimates potential individual and collective radiation doses to humans, based on radionuclide releases and transport from a nuclear facility (e.g. a waste storage or disposal site) to the human environment as defined by hypothetical release and transport scenarios.

containment: The retention of radioactive material in such a way that it is effectively prevented from becoming dispersed into the environment or only released at an acceptable rate.

contamination, radioactive: A radioactive substance in a material or place where it is undesirable.

continental formation: A geological formation which occurs either beneath a present-day land mass and adjoining large islands or beneath the surrounding shallow sea.

controlled area: An area to which access is limited and in which individual exposure of personnel to radiation is controlled through the supervision of a person who has knowledge of the appropriate radiation protection regulations and responsibility for applying them.

control rod waste: A radioactive waste consisting of used reactor control rods and reactor internals. (See reactor internals.)

cost-benefit analysis: A systematic examination of the positive effects (benefits) and negative effects (costs) of undertaking an action. For example, cost-benefit analysis may be used for optimization studies in radiation protection practice.

creep: The deformation of a material at a very slow rate due to external forces and/or its own mass.

criteria: Principles or standards on which a decision or judgement can be based. They may be qualitative or quantitative. Acceptability criteria are set by a regulatory authority. (Some Member States use terms such as 'protection goals' instead of 'acceptability criteria'.)

critical arrangement: A geometrical arrangement of a sufficient mass of fissile material to achieve criticality, that is, a sustained chain reaction.

critical group: For a given radiation exposure, the group of people whose exposure is considered acceptably homogeneous and typical of the persons receiving the highest dose.

critical pathway: For a given group of people, usually the critical group, the environmental pathway(s) for radioactive materials through which the highest potential exposures may occur. The critical pathway(s) is used to evaluate critical group doses.

curie (Ci): A unit of activity equal to 3.7×10^{10} bequerels.

D

darcy: A measure of the permeability of a rock. One darcy equals a permeability such that one millilitre of fluid, having a viscosity of one centipoise, flows in one second under a pressure differential of one atmosphere through a porous material having a cross-sectional area of one square centimetre and a length of one centimetre.

decant solution: Solution which is removed from the surface of a waste retention system after the solids have settled out. Some solids are always removed in the decant solution.

decay, radioactive: A spontaneous nuclear transformation in which particles or gamma radiation are emitted, or X radiation is emitted following orbital electron capture, or the nucleus undergoes spontaneous fission.

decommissioning: The work required for the planned permanent retirement of a nuclear facility from active service. Different regulations will apply thereafter. (In some Member States a facility is not regarded as decommissioned until it is suitable for unrestricted use.) (See stage of decommissioning.)

decontamination: Removal or reduction of radioactive contamination.

decontamination factor: The ratio of initial content of contaminating radioactive material to the final content as a consequence of a decontamination process. (The term may refer to a specified radionuclide or to gross radioactivity.)

deep-well injection: The discharge of liquid wastes via deep wells into permeable but confined geological formations deep underground as a means of isolating the wastes from the human environment.

delay tank: A tank or reservoir for the temporary holdup of radioactive fluids. One of the purposes of the tank is to permit sampling prior to discharge and/or time for radioactivity to decay.

de minimis: An expression derived from the Latin expression "de-minimis non jurat lex", i.e. the law is not concerned with trivialities.

A de-minimis level is one which is so low as to be trivial. There is no unique number which may be attributed to the expression; the value depends on a wide range of scientific factors and upon the legislative framework of the appropriate Member States.

derived air concentration (DAC): A derived limit which is the Annual Limit on Intake (of a radionuclide) divided by the volume of air inhaled by Reference Man in a working year (i.e. 2.4×10^3 m^3). The unit of DAC is Bq/m^3. (See ICRP Publication 30.)

design life: The period during which a facility is expected to perform as designed.

deterministic analysis: A classical technique for studying a system behaviour mathematically using the laws of science and engineering provided that all system parameters, events and features are deterministically (as opposed to probabilistically) defined.

detriment: The mathematical expectation of harm to a population incurred from a radiation exposure, taking into account not only the probabilities of each type of deleterious effect but the severity of the effect as well. Detriment, in general, also includes deleterious effects not associated with health, such as the need to restrict the use of some areas or products. If a linear dose response relationship is assumed, the detriment associated with health may be directly related to the collective dose equivalent commitment.

diapir: A piercement through geological strata in which a mobile core, such as rock salt, has injected into the more brittle overlying rock, generally forming geological folds or anticlines.

dip: The angle at which a stratum or any planar feature is inclined from the horizontal.

direct maintenance: Maintenance by manual means with the worker in direct contact with the item, as opposed to maintenance by the use of remote controlled devices.

dispersion: The summed effect of those processes of transport, diffusion and mixing which tend to distribute materials from wastes or effluents through an increasing volume of water or air. The ultimate effect appears as a dilution of the materials.

disposal: The emplacement of waste materials in a repository, or at a given location, without the intention of retrieval. Disposal also covers direct discharge of both gaseous and liquid effluents into the environment. (See storage.)

disruptive event: An event (e.g. earthquake, meteorite impact) that disrupts a waste repository.

diversion: The removal of significant quantities of nuclear materials from a nuclear fuel cycle, if they are under safeguards, without the knowledge and approval of the parties co-operating in the safeguards agreement, unless removed as provided in the agreement.

documentation: Written, recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures or results.

dolomite: A mineral, $CaMg(CO_3)_2$. Also applied to those rocks which approximate the mineral dolomite in composition.

domal (or dome) salt: A local geologic formation of salt in which the salt thickness is greater vertically than laterally. The top of the formation may bear resemblance to a dome or to a mushroom.

dose: A general term denoting the quantity of radiation or the radiation energy absorbed by a medium. Dose should be qualified as absorbed dose, dose equivalent, effective dose equivalent, effective dose equivalent commitment, committed dose, or collective dose. Dose alone may be used when it does not matter if reference is made to absorbed dose or dose equivalent.

dose, absorbed: See absorbed dose.

dose commitment: See dose equivalent commitment.

dose equivalent: The product of absorbed dose and quality factor and all other modifying factors necessary to obtain an evaluation of the effects of irradiation received by exposed persons, so that the different characteristics of the exposure are taken into account. The special name for the SI unit of dose equivalent is the sievert (Sv); the rem may be used temporarily. (See ICRU Report 33.)

dose equivalent commitment (or effective dose equivalent commitment): For any specified decision, practice or operation, the infinite time integral of the per caput dose-equivalent rate for a specified population. The exposed population is not necessarily constant in numbers. It is commonly expressed in units of sieverts (Sv) or rems. (Note that this can apply over very long (geological) times and care must be taken to maintain perspective. The concept can be useful in making comparisons among alternatives but in a given case may have little meaning in an absolute sense.)

dose equivalent, effective: See effective dose equivalent.

dose rate: See absorbed dose rate.

drum: A type of waste container similar in appearance to an oil drum which may be sealed by a fitted lid. Can be encased in concrete for intermediate-level wastes requiring some shielding.

E

ecosphere: That portion of the Earth which includes the biosphere and all the ecological factors which operate on the living organisms it contains.

ecosystem: A natural complex of plant and animal populations and the particular sets of physical conditions under which they exist; the organisms of a locality, together with the functionally-related aspects of environment considered as a single entity.

effective dose equivalent: The weighted sum of the dose equivalents received by several organs from an intake of radionuclides and/or non-uniform external irradiation. The weighting is carried out in such a way that the effective dose equivalent would give rise to the same risk of induction of fatal cancer or serious genetic defects in the first two generations as a whole body dose equivalent resulting from uniform external irradiation which is numerically equal to the effective dose equivalent; (e.g. an effective dose equivalent of 5 mSv would give rise to the same risk as a dose equivalent of 5 mSv to the whole body from uniform external irradiation).

effluent: A fluid (liquid or gas) which is discharged into the environment.

electrodialysis: A process in which an electrical potential difference applied between two solutions causes a migration of ions through a membrane or diaphragm separating the solutions.

emanation: Radioactive gas formed by decay of a radioactive solid. The emanation may or may not be retained within the pore space of the solid phase.

embankment: A raised structure usually constructed as an earth dam to retain liquid and solid wastes. The embankment may be built using tailings, other materials, or a combination of both.

embedding: A process of putting solid or liquid waste into a matrix to form a heterogeneous waste form.

emplacement: Placing the waste in its location for storage or disposal.

emplacement density: Amount of waste emplaced per unit area or volume of a storage or disposal site (e.g. canisters per hectare).

endogenous: Originating or produced within. (See exogenous.)

engineered barrier: See barrier.

engineered storage: The storage of radioactive wastes, usually in suitably sealed containers, in any of a variety of structures especially designed to protect them and to help keep them from leakage to the biosphere by accident or sabotage. They may also provide for extracting heat of radioactive decay from the waste.

entombment decommissioning: Placement of radioactive wastes and structural materials within an entombment structure (often comprising a portion of the existing production structure) for permanent disposal. Only those materials with hazardous lifetimes, as determined by radiological assessments, less than or equal to the expected lifetime of the entombment structure are intended to be so placed. Other radioactive materials are removed from the site for disposal.

environment:

(i) The surroundings of an installation. (The immediate surroundings are termed the environs.)

(ii) The sum total of all the conditions and influences that surround an organism, human or otherwise, that affect its life, survival and development.

environmental compartment: Any part of an environment which it is convenient to consider as a single entity in modelling studies.

evaporite: A sediment which is deposited from aqueous solution as a result of extensive or total evaporation of the solvent.

evapotranspiration: The sum total of water lost from the land by evaporation and plant transpiration.

event-tree analysis: An inductive probabilistic technique that starts with hypothesizing the occurrence of basic initiating events and proceeds through their logical propagation (considering binary decisions at each branch

point) to system failure events. The event tree is the diagrammatic illustration of the alternative consequences or outcomes of specified initiating events. (See fault-tree analysis.)

exchange capacity: The total number of equivalents of exchangeable ions contained in a unit weight of soil or minerals or other materials. The quantity found will sometimes vary with the methods of analysis employed. The equilibrium constant is the mass action constant for the equilibrium achieved when a material is contacted by waste solution. The equilibrium distribution coefficient (K_d) is the amount of the subject ion sorbed per gram of material divided by the amount of ion in solution per unit volume of liquid after equilibrium is achieved. The equilibrium surface distribution coefficient (K_a) is the amount of the subject ion sorbed per unit surface area of material divided by the amount of ion per unit volume of liquid after equilibrium is achieved.

exclusion area: A term used in some countries to designate a zone which may be established around a nuclear facility or other radiation source, to which access is permitted under controlled conditions and in which residence is normally prohibited.

exhalation: Escape of gases from the bulk solid phase into the atmosphere.

exogenous: Originating from without. (See endogenous.)

exposure:

(i) A general term relating to the incidence of ionizing radiation on living or inanimate material, by accident or intent.

(ii) The quotient of dQ by dm where the value of dQ is the absolute value of the total charge of the ions of one sign produced in air when all the electrons (negatrons and positrons) liberated by photons in air of mass dm are completely stopped in air. The special unit of exposure, roentgen (R), may be used temporarily. (See ICRU Report 33.)

exposure rate: The quotient of dX by dt, where dX is the increment of exposure in the time interval dt. (See ICRU Report 33.)

external zone: An area in the neighborhood of an installation in which population distribution and density, and land and water uses, are considered with respect to the possibility of implementing emergency measures.

extraction ratio: The ratio of the mine level area in which excavation has occurred to the total mine level area.

extrusive: Applied to those igneous rocks derived from magmas or magmatic materials pushed up through the Earth or poured out or ejected at or near the earth's surface. (See intrusive.)

F

fail-safe: Refers to a principle of design by which, in the event of any failure in a system, the system assumes a safe condition.

far-field: Rock formations outside of the repository, including the surrounding strata, at a distance from the waste disposal site such that, for modelling purposes, the site may be considered as a single entity, and the effects of individual waste packages are indistinguishable in the effects of the whole.

fault-tree analysis: A deductive probabilistic analysis technique that starts with hypothesizing and defining failure events and systematically deduces the events or combinations of events that could cause the failure events to occur. The fault tree is the diagrammatic illustration of the events in a tree-like structure. (See event-tree analysis.)

FBR: Fast breeder reactor.

fertile material: One of several nuclides (principally ^{238}U and ^{232}Th) capable of being transformed, directly or indirectly, into a fissile nuclide by neutron capture.

filtration: The process of separating solids from liquids or gases moving through the interstices of a solid medium.

final effluent: A solid, liquid or gaseous emission which is discharged from the controlled site.

fissile material: A (radioactive) material containing one or more fissile nuclides.

fissile nuclide: A nuclide capable of undergoing fission by interaction with neutrons. For reactors, nuclides of major interest are ^{235}U and ^{239}Pu.

fission, spontaneous: Nuclear fission which occurs without the addition of particles or energy to the nucleus, and is required in a reactor to initiate the fission chain reaction. (See fissile nuclide.)

fission gas: A fission product in gaseous form.

fission product: A nuclide produced either by fission or by the subsequent radioactive decay of a radioactive nuclide thus formed.

fissure: An extensive crack, break or fracture in the rock.

fixation (in soil): The conversion of a soluble substance, such as phosphorus, from a soluble or exchangeable form to a relatively insoluble or non-exchangeable form, thus retarding its movement through soil.

flocculation: A process of removing finely divided solid particles, frequently colloids, from a waste slurry by neutralizing their electrical charges and allowing the neutralized particles to agglomerate and settle out. The neutralization is usually effected by chemical means through introducing charges of an opposite sign by the addition of either an electrolyte or another colloid. (See precipitation scavenging.)

fluidized bed technology: Technology to suspend solid particles in a loose bed of material by a rapidly moving upward stream of gas for enhancing chemical or physical reaction.

food-chain (or web): A figure of speech for the dependence for food of organisms upon others in a series, beginning with plants or scavenging organisms and ending with the largest carnivores. A web is a network or series of food-chains.

front end of the fuel cycle: Mining, milling, enrichment, and fabrication of UO_2 fuel; sometimes reactors are included.

fuel, nuclear reactor: Fissile and fertile material used as the source of energy when placed in a critical arrangement in a nuclear reactor.

fuel assembly: A grouping of fuel elements and supporting structures which is normally treated as a unit for handling and accountability purposes.

fuel-cooling installation: A large container or cell, usually filled with water, in which spent nuclear fuel is set aside until its activity has decreased to a desired level. Sometimes called a cooling basin or cooling pond.

fuel cycle: All of the steps involved in supplying and using fuel materials for nuclear power reactors, including related waste management operations.

fuel element (or fuel pin): The smallest structurally discrete part of a nuclear reactor fuel assembly which has fuel as its principal constituent.

fuel reprocessing plant (FRP): Plant where spent fuel elements are dissolved, waste materials removed, and reusable materials are segregated.

G

gabbro: A plutonic coarse-grained dark igneous rock.

GCFBR: Gas-cooled fast breeder reactor.

generic analysis: A generalized analysis for a nuclear facility; for a waste repository it is for a type of host rock, as opposed to an analysis for a site-specific host rock.

geohydrology (or groundwater hydrology): A science that is concerned with the properties, distribution and movement of water below the surface of the land (i.e. in the soil and underlying rocks).

geological disposal: See underground disposal.

geosphere: See lithosphere.

geothermal gradient: The change in temperature of the Earth with depth, expressed either in degrees per unit depth, or in units of depth per degree.

gneiss: A coarse-grained metamorphic rock in which bands rich in granular minerals alternate with bands in which schistose minerals predominate.

gradient: Slope, particularly of a stream or land surface. In mathematical terms, a change in value of one variable with respect to another variable.

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

grid spacers: Metallic components used to separate fuel elements in a fuel assembly.

groundwater: Water which permeates the (rock) strata of the Earth, filling their pores, fissures and cavities. (It excludes water of hydration.)

guide: As used by the IAEA, a document providing general guidance on a procedure or procedures that might be followed in implementing a code.

gypsum: A mineral, $CaSO_4.2H_2O$.

H

half-life, biological: The time required for the amount of a particular substance in a biological system to be reduced to one half of its value by biological processes when the rate of removal is approximately exponential.

half-life, effective: The time required for the amount of a particular radionuclide in a system to be reduced to half its value as a consequence of radioactive decay and all other processes.

half-life, radioactive: For a single radioactive decay process, the time required for the activity to decrease to half its value by that process. (After a period equal to ten half-lives, the activity has decreased to about 0.1% of its original value.)

hazard: A natural or man-made cause of a potential deleterious effect, as differentiated from an expected deleterious effect. (To avoid confusion and reduce the number of terms in usage, use of the terms 'risk' or 'detriment', as appropriate, is recommended in place of 'hazard' or 'harm' when potential effects are being considered.)

heap leaching: The process whereby leach liquor percolates through a pile of previously mined ore placed on an impervious base in such a way that the leachate can be collected for recovery of the metal values.

heavy metal fuel (HM): Thorium, uranium or plutonium component of reactor fuel.

HEPA (High-Efficiency Particulate Air) filter: Filter used for removing sub-micrometre and larger particles from a gaseous stream.

high-level waste:

(i) The highly radioactive liquid, containing mainly fission products, as well as some actinides, which is separated during chemical reprocessing of irradiated fuel (aqueous waste from the first solvent extraction cycle and those waste streams combined with it).

(ii) Spent reactor fuel, if it is declared a waste.

(iii) Any other waste with a radioactivity level comparable to (i) or (ii).

(Note that these definitions are not related to "high-level radioactive waste unsuitable for dumping in the ocean", as used in the London Dumping Convention. See IAEA/INFCIRC/205/Add.1/Rev.1.)

homogeneous medium: A porous medium in which the permeability is the same at every point. Formations having unequal permeabilities at different points are termed heterogeneous. A formation which, in addition to being homogeneous, has permeabilities of the same magnitude along all axes is termed an isotropic medium.

horizon: A horizontal plane on which an activity is taking place (e.g. a waste horizon is the horizontal plane of the repository in which waste is emplaced).

host rock (or host medium): A geological formation in which a repository is located.

hot testing: Testing of method, process, apparatus or instrumentation under normal working conditions at expected radioactivity levels. (See cold testing.)

HTGR: High temperature gas-cooled reactor.

hulls and spacers: Radioactive waste, comprised of cladding hulls and assembly grid spacers, generated during reprocessing when spent fuel assemblies are disassembled and the fuel is dissolved.

human environment: Those portions of the Earth that are inhabited by humans or are readily accessible to them. (See accessible environment.)

hydration: The chemical combination of water with another substance.

hydraulic conductivity: Ratio of flow velocity to driving force for viscous flow under saturated conditions of a specified liquid in a porous medium.

hydraulic equilibrium: The dynamic equilibrium achieved in an aquifer supporting a flow of water in which the piezometric gradient and pressure head at every point are constant with time.

hydraulic fracturing (hydrofracturing): A process in which fluid is injected into a geological stratum near a well under pressure to induce artificial fracturing, thus increasing the permeability of that stratum.

hydrogeology: The study of the geological factors relating to the Earth's water.

hydrology: The study of all waters in and upon the Earth. It includes underground water, surface water and rainfall, and embraces the concept of the hydrological cycle.

hydrosphere: The total body of water of the Earth, i.e. the oceans, rivers, lakes, underground and atmospheric water.

I

ICRP limit: A primary dose equivalent limit recommended by the ICRP. Dosimetric models may be used to derive the annual limit on intake (ALI) and derived air concentration (DAC).

igneous rock: Rock formed by solidification of hot mobile material formed within the upper mantle of the Earth, termed magma.

immobilization of waste: Conversion of a waste to a solid form that reduces the potential for migration or dispersion of radionuclides by natural processes during storage, transport and disposal.

implementing organization: The organization (and its contractors) that performs activities in order to select and investigate the suitability of a site for a nuclear facility, and that undertakes to design, construct, commission, operate and shut down such a facility.

incineration: The process of burning a combustible material to reduce its volume and yield an ash residue.

ingest: Take into the body by way of the digestive tract.

in-situ leaching: The process whereby leach liquor percolates through or is injected into an ore body in the place where it was originally deposited so that the leachate can be collected for recovery of the metal values.

inspection: Quality control actions which, by means of examination, observation or measurement, determine whether materials, parts, components, systems, structures as well as processes and procedures, conform to predetermined quality requirements.

interim storage (storage): A storage operation for which (a) monitoring and human control are provided and (b) subsequent action involving treatment, transportation, and final disposition is expected.

intermediate-level waste (or medium-level waste): Waste of a lower activity level and heat output than high-level waste, but which still requires shielding during handling and transportation. The term is used generally to refer to all wastes not defined as either high-level or low-level. (See alpha-bearing waste and long-lived waste for other possible limitations.)

intrusive rock: A body of igneous rock which has forced itself into an existing rock formation.

ion exchange: A usually reversible exchange of one ion with another, either in a liquid, or on a solid surface, or within a crystalline lattice.

ion-exchange resin: A natural or synthetic mineral or an organic polymer that exhibits technically useful ion-exchange characteristics.

irradiated fuel: Nuclear fuel that has been exposed to irradiation in a nuclear reactor. Irradiated fuel contains considerable amounts of radioactive fission products. (Also called spent fuel.)

isolation of waste: See confinement of waste.

isostatic: Equal pressure from all sides.

isotopes: Nuclides having the same atomic number but different mass numbers.

J

joint: A fracture in rock, generally transverse to bedding, along which no appreciable relative movement of the rocks on either side has occurred.

justification, radiological: The basis upon which a specified decision, practice or operation that is expected to result

in human exposures to radiation is judged to have a positive net benefit.

Note: The production of radioactive wastes is an unavoidable consequence of the generation of nuclear power and can therefore only be justified within the scope of an overall cost-benefit justification of the complete nuclear fuel cycle.

L

leachability: The susceptibility of a solid material to having its soluble, sorbed and/or suspendable constituents removed by the dissolving or erosive action of water or other fluids.

leaching:
(i) Extraction of a soluble substance from a solid by a solvent with which the solid is in contact.
(ii) The term is often used in waste management to describe the gradual dissolution/erosion of emplaced solid waste or chemicals therefrom, or the removal of sorbed material from the surface of a solid or porous bed.

leach rate: The rate of dissolution or erosion of material from a solid. The term may be used to describe the rate of gradual dissolution/erosion of emplaced solid waste or the removal of sorbed material from the surface of a solid or porous bed.

license: Formal document, issued by the regulatory body for major stages in the development of a nuclear facility, defined by regulations permitting the holder (the implementing organization) to perform specified activities.

limestone: A bedded sedimentary deposit consisting chiefly of $CaCO_3$; a general term for that class of rocks which contain at least 80% of the carbonates of calcium or magnesium.

lithology:
(i) The general characteristics of sediments, i.e. unconsolidated material forming sedimentary rocks.
(ii) The physical and mineralogical characteristics of rocks present in a stratigraphic sub-division, based on macroscopic features.

lithosphere: A broad, general term which refers to the upper, rigid part of the Earth's crust. In a waste management context it is used more loosely in describing storage and disposal practices which apply to the land as opposed to wastes discharged into the hydrosphere or atmosphere. The material composing upper parts of the lithosphere may be referred to as subsoil underlying a layer of soil as used

in an agricultural sense. Occasionally the term soil is found in reference to all forms of unconsolidated or semi-consolidated earth materials. An identifiable unit or stratum of material may be termed a rock.

lithostatic pressure: Pressure underground due to the weight of overlying rock and/or soil and/or water.

LMFBR: Liquid metal-cooled fast breeder reactor.

long-lived nuclide: For waste management purposes, a radioactive isotope with a half-life greater than about 30 years.

long-lived waste: Waste that will not decay to an acceptable activity level in a period of time during which administrative controls can be expected to last. (See short-lived waste.)

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

low-level waste: 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.)

LWR (light water reactor): Nuclear reactor that employs H_2O as a coolant and moderator.

M

macroreticular resin: A highly porous resin. (From 'macro' meaning 'large-scale' and 'reticular' meaning 'net-like' or 'sieve-like')

magma: Molten rock beneath the Earth's crust.

Magnox: A magnesium alloy fuel cladding used in Magnox reactors.

Markov chain analysis: A stochastic method of simulation analysis for analysing and solving a problem by specifying the possible states of a system, determining the probabilities for transition between those states, and using extensive mathematical formalism to derive analytical functional forms for solution.

matrix: In waste management, a non-radioactive material used to immobilize radioactive waste in a monolithic structure. Examples of matrices are bitumen, cement, various polymers, etc.

metamorphic rock: A rock which has formed in the solid state in response to pronounced changes of temperature, pressure, and chemical environment that take place, in general, at depths below the shells of weathering and cementation.

migration: The movement of materials through a rock medium or some other solid substance, e.g. radionuclide migration.

migration retardant: A material or a natural mineral (e.g. bentonite) that retards the movement of radionuclides and other chemicals away from the waste and/or repository into the geosphere and, hence, to the human environment.

milling: Operation of processing ore to obtain uranium or thorium for conversion into reactor fuel.

mill tailings: Finely ground residues resulting from processing of ore for recovery of uranium or thorium.

mine closure: In waste management, closing of the repository rooms by either natural, planned or accidental means.

mine drainage: Water pumped or flowing from a mine.

model: In applied mathematics, an analytical or mathematical representation or quantification of a real system and the ways that phenomena occur within that system. Individual or sub-system models can be combined to give system models. Deterministic and probabilistic models are two types of mathematical models.

molecular sieve: A material with a rigid, uniform pore structure which completely excludes molecules larger than the structure pore openings and can sorb certain classes of small molecules from a fluid in contact with the material.

Monte Carlo analysis: A stochastic method of simulation analysis that involves statistical sampling techniques in obtaining a probabilistic approximation to the solution of a problem. The method requires continued sampling of values of a large number of elementary events by the application of the mathematical theory of random variables.

MPC: The maximum permissible concentration. This refers to maximum levels of radioactivity in drinking water or in air for the occupational worker, as established by national authorities, usually based on the then-current ICRP recommendations; levels an order-of-magnitude lower were 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.

multibarrier: A system using two or more independent barriers to isolate the waste from the human environment. These can include the waste form, the container (canister), other engineered barriers and the emplacement medium and its environment. (See barrier.)

N

natural background radiation: The various natural radiation sources include:

(a) External sources of extra-terrestrial origin (cosmic-rays) and external sources of terrestrial origin, i.e. the radioactive isotopes naturally present in the crust of the Earth, the waters and the air;

(b) Internal sources, i.e. the radioisotopes ^{40}K and ^{14}C, which make up a small percentage of these elements and are normal constituents of the body, and other isotopes, such as ^{226}Ra and ^{232}Th and their decay products, which are taken up from the natural environment and are retained in the body.

near-field region: The excavated repository including the waste package, filling or sealing materials, and those parts of the host medium whose characteristics have been or could be altered by the repository or its content.

non-conformance: A deficiency in characteristics, documentation or procedure which renders the quality of an item unacceptable or indeterminate.

non-high-level waste: Intermediate- or low-level waste.

nuclear fuel: Fissionable and/or fertile material for use as fuel in a nuclear reactor.

nuclear installation (or nuclear facility): Any installation in which radioactive or fissile materials are produced, processed or handled on such a scale that considerations of nuclear safety are necessary.

nuclear power plant: A nuclear reactor or reactors together with all structures, systems and components necessary for safety and for the production of power, i.e. heat or electricity.

nuclear safety: A general term pertaining to the protection of people and property from the deleterious effects of radioactive contamination, exposure to ionizing radiation, and a criticality excursion. (In this context, the term ionizing radiation may or may not include X-radiation produced by an X-ray machine, depending upon national usage.) (Also known as radiological safety.)

nuclide: A species of atom characterized by its mass number, atomic number, and nuclear energy state. (See radionuclide.)

O

off-gas treatment: The removal of radioactive components or chemical pollutants from gases prior to their release under controlled conditions into the atmosphere.

olivines: An important rock-forming mineral series. Mainly solid solutions of Mg_2SiO_4 with Fe_2SiO_4. Other minerals with olivine structure are Mn_2SiO_4 and $CaMgSiO_4$.

operating organization: The organization authorized by the regulatory authority to operate the nuclear facility.

operation: All activities performed to achieve, in a safe manner, the purpose for which the facility was constructed, including maintenance, in-service inspection and other associated activities.

operational limits and conditions: A set of rules, approved by the regulatory authority for safe operation of the nuclear facility, which set forth parameter limits, the functional capability and the performance levels of equipment and personnel.

operational period: The period during which a nuclear facility is being used for its intended purpose until it is shut down and decommissioned.

operating records: A set of documents, such as instrument charts, certificates, log books, computer print-outs and magnetic tapes, kept at each nuclear facility and organized in such a way that they provide a complete and objective history of the operation of the facility.

operations, waste management: Broad classification of waste management activities in terms of their basic function (e.g. waste storage, treatment, transportation or disposal).

operator: Any person, government or other entity that conducts or carries on operations at a nuclear facility.

optimization: As used in radiation protection practice, the process of reducing the expected detriment deriving from radiation exposure of a population, through the use of protective measures, to as low as reasonably achievable, economic and social factors being taken into account. (See ALARA, detriment.)

osmosis: The passage of solvent through a semi-permeable membrane from a dilute solution into a more concentrated one. (A semi-permeable membrane allows passage to the molecules of the solvent but not to the molecules of the solute.)

overpack: Secondary (or additional) external containment for packaged radioactive waste.

owner: Any person, government or other entity that holds title to or owns the land upon which a mine, plant or other facility is located.

P

package, waste: See waste package.

PCM: Plutonium contaminated material.

pelagic organisms: Marine organisms which either float or swim in the water mass. (See benthic organisms.)

permeability (of rock): The capacity of a porous or pervious rock for transmitting a fluid. (See darcy.)

physical separation:
(i) Separation by geometry (distance, orientation, etc.).
(ii) Separation by appropriate barriers.
(iii) Separation by a combination of both concepts (i) and (ii).

pile: An above-ground deposit of self-supporting material not intended to retain water.

pillar: Solid unexcavated rock between rooms and corridors in underground mines.

plasticity: The property of a material, e.g. rock salt, that enables it to undergo permanent deformation without appreciable volume change or elastic rebound, and without rupture.

plutonic:
(i) Describes a body of igneous material of presumed deep-seated origin.
(ii) Describes a body of igneous rock (solidified magma) implying a large intrusion formed at depth.

polyhalite: A salt mineral, $K_2SO_4 \cdot 2CaSO_4 \cdot MgSO_4 \cdot 2H_2O$.

porosity: The ratio of the aggregate volume of interstices in a rock or soil to its total volume.

post-sealing period: The period after a waste repository has been shut down and sealed.

precipitation scavenging: A chemical treatment whereby trace concentrations of radioactive ions may be partially removed by a co-precipitation process. The precipitate is chosen to have a high affinity for incorporating the ions of interest. The actual removal may in some cases be described as an adsorption process on freshly formed precipitates. Occasionally a very flocculent precipitate proves to be useful for such treatment, probably by trapping colloidal species; here the treatment is sometimes referred to as flocculation.

prescribed limit: Limit established or accepted by the regulatory authority. (See acceptable limit.)

Note: The term 'authorized limit' is sometimes used for this term in other IAEA documents.

primary waste: As-generated form and quantity of a waste.

probabilistic analysis: A statistical analysis technique for studying the expected behaviour of a system with parameters whose values are uncertain, with events whose occurrences are random, and with features which may or may not be present.

proliferation, nuclear: A commonly used term for the acquisition of a nuclear weapons or nuclear-explosives capability by a nation or subnational group.

PWR: Pressurized water reactor.

pyroclastic: A general term for the class of rocks comprising fragmental volcanic material that has been blown into the atmosphere by explosive volcanic activity.

pyrolysis: A chemical decomposition of a substance by heat.

pyroxene: A group of rock-forming silicates of general formula $(A)_{1-p}(B,C)_{1+p}Si_2O_6$, where p ranges from zero to one.

A may be Ca, Na; B may Mg, Fe^{++}, Li; C may Al, Fe^{+++}, Cr, Ti; Si may in part be replaced by Al. The group includes some of the commonest rock-forming minerals.

Q

qualified person: A person who, having complied with specific requirements and met certain conditions, has been officially designated to discharge specified duties and responsibilities.

quality assurance: Planned and systematic actions necessary to provide adequate confidence that an item, facility or person will perform satisfactorily in service.

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

quartz: A mineral, silica, i.e. SiO_2.

R

rad: A unit of absorbed dose of ionizing radiation equal to one hundredth of a gray (1 cGy).

radiation damage: Deleterious changes in the physical or chemical properties of a material resulting from exposure to ionizing radiation. This term does not apply to biological systems.

radiation protection or radiological protection:
(i) All measures associated with the limitation of the harmful effects of ionizing radiation on people, such as limitation of external exposure to such radiation, limitation of bodily incorporation of radionuclides as well as the prophylactic limitation of bodily injury resulting from either of these.

(ii) All measures designed to limit radiation-induced chemical and physical damage in materials.

radiation stability: Capability of a material to withstand the action of ionizing radiation without changing its essential characteristics.

radioactive material: A material of which one or more constituents exhibit radioactivity.

Note: For special purposes such as regulation, this term may be restricted to radioactive material with a radioactivity level or specific activity greater than a specified value.

radioactive source term: The activities per unit time of radionuclides either leaving a nuclear installation, or entering the environment or an environmental compartment.

radioactive waste: Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the 'exempt quantities' established by the competent authorities and for which no use is foreseen.

radioactivity: The property of certain nuclides of spontaneously emitting particles or gamma radiation, or of emitting x-radiation following orbital electron capture, or of undergoing spontaneous fission.

radiochemistry: That part of chemistry which deals with radioactive materials. It includes the production of radionuclides and their compounds by processing irradiated or naturally occurring radioactive materials, the application of chemical techniques to nuclear studies, and the application of radioactivity to the investigation of chemical problems.

radiodecay heat: Heat generated by the absorption of radiation energy emitted by the decay of radionuclides.

radiolysis: Chemical decomposition by the action of ionizing radiation.

radiolytic effect: An effect caused by radiolysis, e.g. radiation-induced degradation of chemical compounds.

radionuclide: A radioactive nuclide.

radionuclide migration: The movement of radionuclides through various media due to fluid flow and/or by diffusion.

radwaste: See radioactive waste.

reactor internals: Internal reactor components. These frequently require periodic renewal and subsequent disposal.

Reference Man: A hypothetical person with the anatomical and physiological characteristics defined in the report of the ICRP Task Group on Reference Man (ICRP Publication 23).

regeneration: With reference to ion-exchange materials, regeneration is defined as the process of removing those ions from the exchanger which had been absorbed during treatment of a solution and replacing them with appropriate other ions. The exchanger can then continue to be used for treatment of solution.

regulatory authority or regulatory body: An authority or system of authorities designated by the Government of a Member State as having the legal authority for conducting the licensing process, for issuing of licenses and thereby for regulating the siting, design, construction, commissioning, operation, shut-down, decommissioning and subsequent control of nuclear facilities (e.g. waste repositories) or specific aspects thereof. This authority could be a body (existing or to be established) in the field of nuclear-related health and safety or mining safety or environmental protection, vested with such legal authority, or it could be the Government or a department of the Government, or it could be an international agency.

regulatory inspection: An examination, observation, measurement or test undertaken by or for the regulatory authority during any stage of the licensing process to ensure conformance of materials, components, systems and structures, as well as operational activities, processes, procedures and personnel competence, with predetermined requirements.

release scenario: See scenario analysis.

reliability, expected or probable: In a technical sense, the probability that a device, system or facility will perform its intended function satisfactorily for a specified time under stated operating conditions.

rem: A unit of dose equivalent equal to one hundredth of a sievert (1 cSv).

repository: An underground facility in which waste may be emplaced for disposal.

Note: Some Member States use the term 'vault' as a synonym.

repository system: A repository and all its supporting facilities.

reprocessing, fuel: The processing of nuclear fuel, after its use in a reactor, to remove fission products and recover fissile and fertile material.

responsible organization: The organization having overall responsibility for a nuclear installation or facility.

retrievability: The capability to remove waste from where it has been stored.

reverse osmosis: Movement of a solvent out of a solution under pressure through a semi-permeable membrane into pure solvent or a less concentrated solution at lower pressure. (See osmosis.) This process can be used to extract essentially pure (fresh) water from polluted or salt water.

rheological character: The tendency to flow or deform.

risk: A measure of the deleterious effects that may be expected as a result of a technology, traditionally quantified as the product of the probability and the consequence of the occurrence of an event or series of events. (In radiation protection, the term is normally used to indicate the sum of the probabilities of the deleterious effects that a given individual or population will incur as a result of a radiation dose.) However, the definition and quantification of the concept of 'risk' are being re-evaluated with regard to safety considerations.

risk analysis: An analysis of the risks associated with a technology wherein the possible events and their probabilities of occurrence are considered together with their potential consequences, the distribution of these consequences within the affected population(s), the time factor and the uncertainties of these estimates.

rock: To the geologist any mass of mineral matter, whether consolidated or not, which forms part of the Earth's crust is a rock. Rocks may consist of only one mineral species, in which case they are called monomineralic, but they more usually consist of an aggregate of mineral species.

rock burst: A sudden and often violent failure of masses of rock in mines, quarries and tunnels. Types of failure vary from splitting off of small slabs of rocks of a mine wall to the collapse of large pillars, roofs or other massive portions of the mine structure.

rock salt (or halite): An evaporite mineral, sodium chloride, (NaCl), i.e. common salt.

rock structure: The sum total of the geological and structural features of and under a land area or of a mineral deposit.

S

safeguards, IAEA: A system of technical measures within the framework of international non-proliferation policy entrusted to the IAEA in its Statute and by the Non-Proliferation Treaty (NPT).

Note: The term 'safeguards' or 'international (IAEA) safeguards' should not be confused with similar terms used in the context of national legislations; these sometimes cover measures for physical protection. The term 'domestic safeguards' is recommended for these activities.

safeguards, objectives of IAEA: To provide timely detection of diversion of significant quantities of nuclear material from peaceful nuclear activities to the manufacture of nuclear weapons or other nuclear explosive devices or for purposes unknown, and deterrence of such diversion by the risk of early detection.

safety: Protection of persons and property from undue hazard (risk).

safety analysis: The analysis and calculation of the hazards (risks) associated with the implementation of a proposed activity.

safety assessment: A comparison of the results of safety analyses with acceptability criteria, its evaluation, and the resultant judgements made on the acceptability of the system assessed.

safety limit: Limit upon a process variable within which the operation of the nuclear facility has been shown to be safe.

safety report: A document, required of the implementing organization by the regulatory authority, containing information concerning a nuclear installation (e.g. a waste repository), the site characteristics, design, operational procedures, etc., together with a safety analysis and details of provisions aimed at reducing the risk to the site personnel and to the public. (See ALARA.).

salinity: A measure of the total dissolved salts in salt or saline water.

salt dome: A dome-like salt structure resulting from the upward movement of a salt mass, generally due to diapirism.

scenario analysis: Part of a safety analysis that identifies and quantitatively defines phenomena, their probabilities and their interactions, which could initiate and/or influence the release and transport of radionuclides from a source to humans. A release scenario defines the phenomena relevant to release of radionuclides from a radioactive (e.g. waste) source; a transport scenario defines the

phenomena relevant to transport of the released radionuclides through the geosphere and biosphere to humans.

schist: A metamorphic banded rock with a predominance of bedded mica minerals.

secondary waste: A form and quantity of a waste that result from applying a waste treatment technology to a primary waste.

security area: An area within the site of a nuclear installation established for the purpose of physical protection of a facility and/or the materials contained therein, and secured in a manner designed to prevent or delay unlawful access.

sedimentary rock: A layered formation of rock fragments laid down under water or land and usually subsequently cemented.

seismicity: Relating to vibrations of the earth caused by earthquakes.

selectivity (for ions): Describes the ability of solvents or a porous bed of solids to remove preferentially certain ions from waste solutions in the presence of other competing ions. It is often expressed as a comparison between the chemical behaviour of two different ions, e.g. the selectivity for the caesium ion in the presence of the sodium ion. (Another expression sometimes used as a synonym is specificity, though the quantities referred to by these expressions differ. Specificity is sometimes defined as the ratio of distribution coefficients or equilibrium constants for the ion of interest relative to that of the competing ion.)

sensitivity analysis: An analysis of the variation of the solution of a problem with changes in the values of the variables involved. Two types of sensitivity analysis can be recognised. In simple parameter variation, the sensitivity of the solution is investigated for changes in one or more input parameters within a reasonable range about selected reference or mean values. In perturbation analysis, the sensitivities of the solution with respect to changes in all input parameters can be obtained by applying differential and/or integral analysis.

SGHWR: Steam generating heavy water reactor.

shaft: An access passage from the surface to the subsurface facilities for men and materials, ventilation, or nuclear waste.

shale: A laminated densely packed argillaceous sediment in which the constituent clay mineral particles are oriented parallel to the bedding planes.

shallow-ground disposal (e.g. shallow-ground burial): Disposal of radioactive waste, with or without engineered barriers, above or below the ground surface, where the final

protective covering is of the order of a few metres thick. Some Member States consider 'shallow-ground disposal' to be a mode of storage rather than a mode of disposal.

shielding: A material interposed between a source of radiation and personnel or equipment, etc. for protection from radiation. Common shielding materials are concrete, water and lead.

shipping cask: A shielding container used for transporting and handling high-level and medium-level nuclear materials.

short-lived nuclide: For waste management purposes, a radioactive isotope with a half-life shorter than about 30 years, e.g. ^{137}Cs, ^{90}Sr, ^{85}Kr, ^{3}H.

short-lived waste: Waste which will decay to a level which is considered to be insignificant from a radiological viewpoint, in a time period during which administrative controls can be expected to last. Such waste can be determined by radiological assessment of the storage or disposal system chosen. (See long-lived waste.)

shut-down and sealing: Action taken, after disposal operations have ceased, to prepare an installation for abandonment or minimum surveillance.

sievert (Sv): The SI unit of dose equivalent. (1 Sv = 100 rem)

siltstone: One of the group of argillaceous rocks, a very fine-grained consolidated clastic rock composed predominantly of particles of silt grade (60-4 /um size).

simulation analysis: A general method of studying the behaviour of a real system or phenomenon. The method usually involves devising a model representing the essential features of the system and carrying out the solution of the mathematical and logical relations of the model. The simulation can be either deterministic or stochastic depending on the model selected. Markov chain analysis and Monte Carlo analysis are two well known examples of stochastic simulation techniques.

site: The area containing a nuclear installation, (e.g. a waste repository) that is defined by a boundary and which is under effective control of the implementing organization.

siting: The process of selecting a suitable site for an installation, including appropriate assessment and definition of the related design bases.

solidification: Conversion of liquid or liquid-like materials into a solid.

sorption: A broad term referring to reactions taking place within pores or on the surfaces of a solid. Its use avoids the problem of technical distinction between absorption and adsorption reactions. Absorption is generally used to

refer to reactions taking place largely within the pores of solids, in which case the capacity of the solid to absorb is proportional to its volume. Adsorption refers to reactions taking place on solid surfaces, so that the capacity of a solid is proportional to its effective surface area. An example of the latter process is ion exchange, whereby ions occupying charged sites on the surface of the solid are displaced by ions from solution.

source term: In analysis of 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.

specific activity:
(i) The activity per unit mass of a pure radionuclide.
(ii) The activity of a radioisotope per unit mass of that element present in the material.
(iii) The activity per unit mass or volume of any sample of radioactive material.

Note: Specific activity is commonly expressed in a wide variety of units, and care must be exercised in defining units.

specification: A written statement of requirements to be satisfied by a product, a material or a process, indicating the procedure by which compliance with the specified requirements may be verified.

spent fuel: Nuclear reactor fuel elements that have been irradiated in a reactor and have been utilized to an extent such that their further use is no longer efficient.

stage of decommissioning: The term 'stage', in IAEA usage, implies a state or condition of a facility after decommissioning activities:
Stage 1 - storage with surveillance;
Stage 2 - restricted site release;
Stage 3 - unrestricted site release.

These stages are discussed in IAEA Safety Series No. 52, pp.3-5. The term does not necessarily imply a step-wise procedure through various 'stages', as indicated by normal usage of the word. Thus, decommissioning to 'stage' 2 does not necessarily have to be preceded by going through 'stage' 1, and 'stage' 3 does not have to be preceded by 'stages' 1 and 2. Many Member States prefer and/or use other terms such as 'alternative', 'level', 'option', 'mode', etc. in place of 'stage'. (See decommissioning.)

stochastic analysis: Decomposition of a time series into components which are of a deterministic nature (e.g. seasonal effects) and of a probabilistic nature.

stochastic event: A random event which can be predicted only by the probability of its occurrence. The term applies to data on phenomena that occur in time and/or space which are

basically of a probabilistic nature, but whose values depend partially on their respective time and/or space co-ordinates. In a stochastic time series a term in the series is significantly related to the next one and this is considered in the time series analysis and synthesis.

storage (or interim storage): The emplacement of waste in a facility with the intent that it will be retrieved at a later time.

stratigraphic section: Usually vertical section through rock strata, demonstrating the layers of different rock types deposited at various geological times.

stratigraphy: That branch of geology which treats stratified rocks and considers their formation, character, composition, deposition sequence in time, and correlation of different beds in the Earth's crust.

stratum (or bed): A layer of a geological formation that consists of approximately the same kind of rock material.

subsidence: Sinking or caving in of the ground surface. This results from the inability of the upper layers of the Earth's crust to support their own mass, or that mass with additional surface load, over an area containing poorly compacted material and/or voids. Such voids can be man-made, as in the case of mines.

surface water: Water which fails to penetrate into the sub-soil and flows along the surface of the ground, eventually entering a lake, a river or the sea.

surge storage: Temporary nuclear materials storage to accept a temporary excess of materials to be stored, due to either handling equipment outages or a limited handling capability.

surveillance:

(i) Includes 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 and the degradation of structures, systems and components which could at a later time result in an unsafe condition. These activities can be classified as:

- (a) monitoring of individual parameters and system status;
- (b) checks and calibrations of instrumentation;
- (c) testing and inspection of structures, systems and components;
- (d) evaluation of the results of items (a) and (c).

(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 related to locations and quantities of nuclear material, and tampering with IAEA safeguards devices.

T

tailings: These may be:

(i) mill tailings, which are the residues resulting from processing of ore in a mill to extract the metal values;

(ii) heap leach residues, which result from treatment of ore by heap leaching.

tailings seepage: Seepage of liquid from a tailings retention system.

tectonic: Pertaining to the structural features of rock, i.e. the external forms resulting from the deformation of the Earth's crust during the periods of mountain formation (orogenesis).

testing: Determination or verification of the capability of a component or assembly of components to meet specified requirements by subjecting the component or assembly to a set of physical, chemical, environmental or operational conditions.

thermal loading; The quantity of heat-generating materials placed in a given area or volume; units are power per area or per volume, respectively.

toe: Lower portion of the slope of a rock pile.

topography:

(i) The configuration of (a portion of) the Earth's surface, including its relief and relative positions of its natural and man-made features.

(ii) The practice of graphical representation of the same.

transmissivity, hydraulic: Rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient. It is expressed as the product of the hydraulic conductivity and the thickness of the saturated portion of the aquifer.

transmutation: Nuclear conversion transforming one element into another, naturally or artificially, (i) as a result of bombardment with ionizing radiation or nuclear particles or (ii) by radioactive decay if the original element is radioactive.

transport scenario: See scenario analysis.

transuranic (TRU) waste: Waste containing quantities of nuclides having atomic numbers above 92 above agreed limits. The limits are established by national regulatory bodies. (See alpha-bearing waste.)

transuranium nuclide: A nuclide having an atomic number greater than that of uranium (i.e. greater than 92). The

principal transuranic radionuclides of concern in radioactive waste management are tabulated below with their half-lives and decay modes.

nuclide	half-life (years)	principal decay modes
neptunium-237	2 140 000	alpha
plutonium-238	86	alpha, spontaneous fission
plutonium-239	24 390	alpha, spontaneous fission
plutonium-240	6 580	alpha, spontaneous fission
plutonium-242	379 000	alpha
americium-241	458	alpha
americium-243	7 950	alpha
curium-245	9 300	alpha
curium-246	5 500	alpha, spontaneous fission

treatment of waste: Operations intended to benefit safety or economy by changing the characteristics of the waste. Three basic treatment concepts are:

(a) volume reduction;
(b) removal of radionuclides from the waste;
(c) change of composition. (See conditioning)

tuff: One of a series of pyroclastic rocks, i.e. comprising fragmental volcanic material blown into the atmosphere by volcanic activity. Tuff is consolidated ash, and comprises
(a) crystals,
(b) small fragments of lava or rock (< 4 mm dia),
(c) larger rock fragments (4-32 mm dia)
(d) fragments of a glassy nature.

U

uncertainty analysis: An analysis to estimate the uncertainties and error bounds of quantities involved in and/or results from the solution of a problem. This requires the application of statistical techniques and definition of the input data in probabilistic form.

underground disposal: Disposal of waste at an appropriate depth below the ground surface.

uplift: Rising up of the Earth's surface. In the vicinity of a waste repository this uplift could be due to thermal effects deriving from heat in the waste.

V

validation: A conceptual model and the computer code derived from it are 'validated' when it is confirmed that the conceptual model and the derived computer code provide a good representation of the actual processes occurring in the real system. Validation is thus carried out by comparison of calculations with field observations and experimental measurements.

vault: A term used by some Member States as a synonym for repository. (See repository.)

verification: A computer code is 'verified' when it is confirmed that the conceptual model of the real system is adequately represented by the mathematical solution. Verification can thus be carried out, for example, by intercomparison of codes and by comparison of numerical codes with analytical solutions.

very-near-field: Refers to the rock within about one metre of a buried waste canister. (See near-field.)

vitrification: Any process of converting materials into a glass or glass-like form.

vitrified:
(i) Transformed into a glass or glass-like material.
(ii) Of waste, immobilized in a glass or glass-like matrix.

volume reduction factor (VRF): The ratio of the volumes of radioactive waste prior to and following treatment. In concentration processes the VRF is greater than one; in dilution systems, the VRF is less than one.

W

waste arisings: Radioactive wastes generated by any stage in the nuclear fuel cycle.

waste disposal: See disposal.

waste form: The physical and chemical form of the waste (e.g. liquid, in concrete, in glass, etc.) without its packaging.

waste management: All activities, administrative and operational, that are involved in the handling, treatment, conditioning, transportation, storage and disposal of waste.

waste package: The waste form and any container(s) as prepared for handling, transportation, storage and/or disposal. A cask or overpack may be a permanent part of the waste package or it may be re-usable for any waste management step. The waste package may vary for the different steps in waste management.

waste retention system: Storage system for liquid and/or solid wastes. This includes systems for wastes generated by the uranium or thorium mining and milling process.

waste rock: Material removed from a mine to allow extraction of the ore. This may be:

(a) barren rock containing essentially no metal values;
(b) low-grade material containing concentrations of uranium, thorium or other metals at which it is uneconomic to recover the metal values.

waste rock seepage: Liquid seepage from a waste-rock storage area which may or may not contain environmentally significant materials.

water table:
(i) The upper surface of the groundwater;
(ii) The upper surface of a zone of groundwater saturation.

'worst-case' scenario: The scenario for release and transport of radionuclides from a nuclear installation or facility (e.g. a waste storage or disposal site) to the biosphere that represents the most severe accident situation conceivable on the basis of pessimistic assumptions. Agreement on a 'worst-case' scenario may be difficult. Thus, the terminology "'conservative, but realistic' scenarios" is frequently used to define a set of scenarios that can be used in sensitivity and uncertainty analyses for safety assessment purposes.

Z

zeolite: A generic term for a group of hydrated alumino-silicates of Na, Ca, Ba, Sr, and K, characterized by their easy and reversible loss of water of hydration. Many are also characterized by a significant capacity for ion exchange.

Zircaloy: A zirconium alloy used as fuel cladding in some types of nuclear reactor.

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