Federal Guidelines for Dam Safety

Glossary of Terms

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FEDERAL GUIDELINES FOR DAM SAFETY: GLOSSARY OF TERMS

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Interagency Committee on Dam Safety

U.S. Department of Homeland Security
Federal Emergency Management Agency

Glossary of Terms for Dam Safety

The Interagency Committee on Dam Safety (ICODS) was established to provide the Federal agencies involved in dam safety with the opportunity to coordinate their dam safety activities. One of the goals of ICODS is to provide a common forum for the Federal agencies and State officials to exchange ideas and procedures that are used for dam safety and to provide an efficient mechanism for technology transfer.

The purpose of this document is to establish a common Glossary of Terms for Dam Safety for use within and among Federal agencies. The objective was to select terms that would be generic and applicable to all dams, regardless of size, owner, or location.

The initial document was published in February 1988. The group that prepared the initial glossary consisted of:

Joseph S. Haugh	Department of Agriculture	Chair
Jack Thompson	U.S. Army Corps of Engineers	
James Price	Tennessee Valley Authority	
Jack Brynda	Department of the Interior	
Brian Holtham	Department of the Interior	
Edward C. Pritchett	U.S. Army Corps of Engineers	

The document was updated between 1995-1999 by an ICODS task group consisting of:

Arthur H. Walz, Jr.	U.S. Army Corps of Engineers	Chair
Jeng I. Chang	U.S Army Corps of Engineers	
Larry Babich	Department of Agriculture	
Sam Shipman	Tennessee Valley Authority	
Daniel Mahoney	Federal Energy Regulatory Commission	
Michelle Barry	Department of Interior	

This document was further updated and finalized by a NDSRB task group consisting of:

Meg Galloway	Wisconsin Department of Natural Resources
Charles Pearre	U. S. Army Corps of Engineers
Bill Irwin	Department of Agriculture

It is recognized that the contents of this document are dynamic and there will be a need for future changes. Users are invited to send suggestions for consideration in future changes to:

National Dam Safety Program
U.S. Department of Homeland Security
Federal Emergency Management Agency
500 C Street, S.W.
Washington, D.C. 20472

GLOSSARY OF TERMS
FOR DAM SAFETY

Abutment. That part of the valley side against which the dam is constructed. An artificial abutment is sometimes constructed, as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment. The left and right abutments of dams are defined with the observer viewing the dam looking in the downstream direction, unless otherwise indicated.

Acre-foot. A unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet.

Adit. A nearly horizontal underground excavation in an abutment having an opening in only one end. An opening in the face of a dam for access to galleries or operating chambers.

Adverse consequences. Negative impacts that may result from the failure of a dam. The primary concerns are loss of human life, economic loss (including property damage), lifeline disruption, and environmental impact.

Appurtenant structure. Ancillary features of a dam such as outlets, spillways, powerplants, tunnels, etc.

Attenuation. A decrease in amplitude of the seismic waves with distance due to geometric spreading, energy absorption, and scattering, or decrease in the amplitude of a flood wave due to channel geometry and energy loss.

Axis of dam. The vertical plane or curved surface, chosen by a designer, appearing as a line, in plan or in cross-section, to which the horizontal dimensions of the dam are referenced.

Backwater curve. The longitudinal profile of the water surface in an open channel where the depth of flow has been increased by an obstruction, an increase in channel roughness, a decrease in channel width, or a flattening of the bed slope.

Baffle block. A block, usually of concrete, constructed in a channel or stilling basin to dissipate the energy of water flowing at high velocity.

Base thickness. Also referred to as base width. The maximum thickness or width of the dam measured horizontally between upstream and downstream faces and normal to the axis of the dam, but excluding projections for outlets or other appurtenant structures.

Bedrock. Any sedimentary, igneous, or metamorphic material represented as a unit in geology; being a sound and solid mass, layer, or ledge of mineral matter; and with shear wave threshold velocities greater than 2500 feet/second.

Bedrock motion parameters. Numerical values representing vibratory ground motion, such as particle acceleration, velocity, and displacement, frequency content, predominant period, spectral intensity, and a duration that define a design earthquake. (These may also be used in a more general sense for ground motion.)

Berm. A nearly horizontal step in the sloping profile of an embankment dam. Also a step in a rock or earth cut.

Body wave. Waves propagated in the interior of the earth, i.e., the compression (P) and shear (S) waves of an earthquake.

Borrow area. The area from which natural materials, such as rock, gravel or soil, used for construction purposes is excavated.

Breach. An opening through a dam that allows the uncontrolled draining of a reservoir. A controlled breach is a constructed opening. An uncontrolled breach is an unintentional opening caused by discharge from the reservoir. A breach is generally associated with the partial or total failure of the dam.

Bulkhead. A partition or structure separating compartments or to hold back water.

Caisson. A watertight chamber or hallow floating box used in construction work under water.

Channel. A general term for any natural or artificial facility for conveying water.

Cofferdam. A temporary structure enclosing all or part of the construction area that construction can proceed in the dry. A diversion cofferdam diverts a stream into a pipe, channel, tunnel, or other watercourse.

Compaction. Mechanical action that increases the density by reducing the voids in a material.

Comprehensive EAP exercise. An in-depth exercise of an EAP that involves the interaction of the dam owner with the state and local emergency management agencies in a stressful environment with time constraints. Functional and full-scale EAP exercises are considered comprehensive EAP exercises.

Concrete lift. The vertical distance between successive horizontal construction joints.

Concurrent floods. Flood flows expected at a point on the river system below a dam at the same time a flood inflow occurs above the dam.

Conduit. A closed channel to convey water through, around, or under a dam.

Consequences. Potential loss of life or property damage downstream of a dam caused by floodwaters released at the dam or by waters released by partial or complete failure of dam. Also effects of landslides upstream of the dam on property located around the reservoir.

Construction joint. The interface between two successive placements or pours of concrete where bond, and not permanent separation, is intended.

Contact grouting. Filling, with cement grout, any voids existing at the contact of two zones of different materials, i.e., between a concrete tunnel lining and the surrounding rock.

Core. A zone of low permeability material in an embankment dam. The core is sometimes referred to as central core, inclined core, puddle clay core, rolled clay core, or impervious zone.

Core wall. A wall built of relatively impervious material, usually of concrete or asphaltic concrete in the body of an embankment dam to prevent seepage.

Crest length. The measured length of the dam along the crest or top of dam.

Crest of dam. See top of dam.

Critical damping. The minimum amount of damping that prevents free oscillatory vibration.

Cross section. An elevation view of a dam formed by passing a plane through the dam perpendicular to the axis.

Cutoff trench. A foundation excavation later to be filled with impervious material so as to limit seepage beneath a dam.

Cutoff wall. A wall of impervious material usually of concrete, asphaltic concrete, or steel sheet piling constructed in the foundation and abutments to reduce seepage beneath and adjacent to the dam.

Cyclic mobility. A phenomenon in which a cohesionless soil loses shear strength during earthquake ground vibrations and acquires a degree of mobility sufficient to permit intermittent movement up to several feet, as contrasted to liquefaction where continuous movements of several hundred feet are possible.

Dam. An artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water.

> **Afterbay dam.** See regulating dam.
>
> **Ambursen dam.** A buttress dam in which the upstream part is a relatively thin flat slab usually made of reinforced concrete.
>
> **Arch dam.** A concrete, masonry, or timber dam with the alignment curved upstream so as to transmit the major part of the water load to the abutments.

Buttress dam. A dam consisting of a watertight part supported at intervals on the downstream side by a series of buttresses. Buttress dam can take many forms, such as a flat slab or massive head buttress.

Crib dam. A gravity dam built up of boxes, crossed timbers or gabions, filled with earth or rock.

Diversion dam. A dam built to divert water from a waterway or stream into a different watercourse.

Double curvature arch dam. An arch dam that is curved both vertically and horizontally.

Earth dam. An embankment dam in which more than 50% of the total volume is formed of compacted earth layers are generally smaller than 3-inch size.

Embankment dam. Any dam constructed of excavated natural materials, such as both earthfill and rockfill dams, or of industrial waste materials, such as a tailings dam.

Gravity dam. A dam constructed of concrete and/or masonry, which relies on its weight and internal strength for stability.

Hollow gravity dam. A dam constructed of concrete and/or masonry on the outside but having a hollow interior and relying on its weight for stability.

Hydraulic fill dam. An earth dam constructed of materials, often dredged, which are conveyed and placed by suspension in flowing water.

Industrial waste dam. An embankment dam, usually built in stages, to create storage for the disposal of waste products from an industrial process. The waste products are conveyed as fine material suspended in water to the reservoir impounded by the embankment. The embankment may be built of conventional materials but sometimes incorporates suitable waste products.

Masonry dam. Any dam constructed mainly of stone, brick, or concrete blocks pointed with mortar. A dam having only a masonry facing should not be referred to as a masonry dam.

Mine tailings dam. An industrial waste dam in which the waste materials come from mining operations or mineral processing.

Multiple arch dam. A buttress dam comprised of a series of arches for the upstream face.

Overflow dam. A dam designed to be overtopped.

Regulating dam. A dam impounding a reservoir from which water is released to regulate the flow downstream.

Rock-fill dam. An embankment dam in which more than 50% of the total volume is comprised of compacted or dumped cobbles, boulders, rock fragments, or quarried rock generally larger than 3-inch size.

Roller compacted concrete dam. A concrete gravity dam constructed by the use of a dry mix concrete transported by conventional construction equipment and compacted by rolling, usually with vibratory rollers.

Rubble dam. A stone masonry dam in which the stones are unshaped or uncoursed.

Saddle dam (or dike). A subsidiary dam of any type constructed across a saddle or low point on the perimeter of a reservoir.

Tailings dam. See mine tailings dam.

Dam failure. Catastrophic type of failure characterized by the sudden, rapid, and uncontrolled release of impounded water or the likelihood of such an uncontrolled release It is recognized that there are lesser degrees of failure and that any malfunction or abnormality outside the design assumptions and parameters that adversely affect a dam's primary function of impounding water is properly considered a failure. These lesser degrees of failure can progressively lead to or heighten the risk of a catastrophic failure. They are, however, normally amenable to corrective action.

Dam safety. Dam safety is the art and science of ensuring the integrity and viability of dams such that they do not present unacceptable risks to the public, property, and the environment. It requires the collective application of engineering principles and experience, and a philosophy of risk management that recognizes that a dam is a structure whose safe function is not explicitly determined by its original design and construction. It also includes all actions taken to identify or predict deficiencies and consequences related to failure, and to document, publicize, and reduce, eliminate, or remediate to the extent reasonably possible, any unacceptable risks.

Dam safety program purposes. The purposes of a dam safety program are to protect life, property, and the environment by ensuring that all dams are designed, constructed, operated, and maintained as safely and as effectively as is reasonably possible. Accomplishing these purposes requires commitments to continually inspect, evaluate, and document the design, construction, operation, maintenance, rehabilitation, and emergency preparedness of each dam and the associated public. It also requires the archiving of documents on the inspections and histories of dams and the training of personnel who inspect, evaluate, operate, and maintain them. Programs must instill an awareness of dams and the hazards that they may present in the owners, the users, the public, and the local and national decision-makers. On both local and national scales, program purposes also include periodic reporting on the degree of program implementation. Key to accomplishing these purposes is to attract, train, and retain a staff proficient in the art and science of dam design.

Damping. Resistance that reduces vibrations by energy absorption. There are different types of damping such as viscous, Coulomb, and geometric damping.

Damping ratio. The ratio of the actual damping to the critical damping.

Design water level. The maximum water elevation, including the flood surcharge, that a dam is designed to withstand.

Design wind. The most severe wind that is reasonably possible at a particular reservoir for generating wind setup and run-up. The determination will generally include the results of meteorologic studies that combine wind velocity, duration, direction and seasonal distribution characteristics in realistic manner.

Deterministic methodology. A method in which the chance of occurrence of the variable involved is ignored and the method or model used is considered to follow a definite law of certainty, and not probability.

Dewpoint temperature. The temperature at which dew begins to form or vapor begins to condense into a liquid.

Diaphragm wall (membrane). A sheet, thin zone, or facing made of an impervious material such as concrete, steel, wood, plastic, etc. Also see core wall.

Dike. See saddle dam.

Diversion channel, canal, or tunnel. A waterway used to divert water from its natural course. The term is generally applied to a temporary arrangement, e.g., to bypass water around a dam site during construction. "Channel" is normally used instead of "canal" when the waterway is short.

Drain, blanket. A layer of pervious material placed to facilitate drainage of the foundation and/or embankment.

Drain, chimney. A vertical or inclined layer of pervious material in an embankment to facilitate and control drainage of the embankment fill.

Drain, toe. A system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet.

Drainage area. The area that drains to a particular point on a river or stream.

Drainage curtain. A line of vertical wells or boreholes to facilitate drainage of the foundation and abutments and to reduce water pressure.

Drainage wells or relief wells. Vertical wells downstream of or in the downstream shell of an embankment dam to collect and control seepage through and under the dam. A line of such wells forms a drainage curtain.

Drawdown. The difference between a water level and a lower water level in a reservoir within a particular time. Used as a verb, it is the lowering of the water surface.

Duration of strong ground motion. The "bracketed duration" or the time interval between the first and last acceleration peaks that are equal to or greater than 0.05g.

Dynamic routing. Hydraulic flow routing based on the solution of the St.-Venant Equation(s) to compute the changes of discharge and stage with respect to time at various locations along a stream.

Emergency Action Plan (EAP) exercise. An activity designed to promote emergency preparedness; test or evaluate EAPs, procedures, or facilities; train personnel in emergency management duties; and demonstrate operational capability. Exercises consist of the performance of duties, tasks, or operations very similar to the way they would be performed in a real emergency. However, the exercise performance is in response to a simulated event.

Earthquake. A sudden motion or trembling in the earth caused by the abrupt release of accumulated stress along a fault.

Earthquake, Maximum Credible (MCE). The earthquake(s) associated with specific seismotectonic structures, source areas, or provinces that would cause the most severe vibratory ground motion or foundation dislocation capable of being produced at the site under the currently known tectonic framework. It is determined by judgment based on all known regional and local geological and seismological data.

Earthquake, Maximum Design (MDE). A postulated seismic event, specified in terms of specific bedrock motion parameters at a given site, which is used to evaluate the seismic resistance of manmade structures or other features at the site.

Earthquake, Operating Basis (OBE). The earthquakes for which the structure is designed to resist and remain operational. It reflects the level of earthquake protection desired for operational or economic reasons and may be determined on a probabilistic basis considering the regional and local geology and seismology.

Earthquake, Safety Evaluation (SEE). The earthquake, expressed in terms of magnitude and closest distance from the dam site or in terms of the characteristics of the time history of free-field ground motions, for which the safety of the dam and critical structures associated with the dam are to be evaluated. In many cases, this earthquake will be the maximum credible earthquake to which the dam will be exposed. However, in other cases where the possible sources of ground motion are not easily apparent, it may be a motion with prescribed characteristics selected on the basis of a probabilistic assessment of the ground motions that may occur in the vicinity of the dam. To be considered safe, it should be demonstrated that the dam can withstand this level of earthquake shaking without release of water from the reservoir.

Earthquake, synthetic. Earthquake time history records developed from mathematical models that use white noise, filtered white noise, and stationary and non-stationary filtered white noise, or theoretical seismic source models of failure in the fault zone. (White noise is random energy containing all frequency components in equal proportions. Stationary white noise is random energy with statistical characteristics that do not vary with time.)

Emergency. A condition that develops unexpectedly, which endangers the structural integrity of a dam and/or downstream human life or property, and requires immediate action.

Emergency Action Plan (EAP). A plan of action to be taken to reduce the potential for property damage and loss of life in an area affected by a dam failure or large flood.

Emergency Alert System. A federally established network of commercial radio stations that voluntarily provide official emergency instructions or directions to the public during an emergency.

Emergency gate. A standby or reserve gate used only when the normal means of water control is not available for use.

Emergency Management Agency. The state and local agencies responsible for emergency operations, planning, mitigation, preparedness, response, and recovery for all hazards. Names of emergency management agencies may vary such as: Division of Emergency Management, Comprehensive Emergency Management, Disaster Emergency Services, Civil Defense Agency, Emergency and Disaster Services.

Emergency Operations Center (EOC). The location or facility where responsible officials gather during an emergency to direct and coordinate emergency operations, to communicate with other jurisdictions and with field emergency forces, and to formulate protective action decisions and recommendations during an emergency.

Energy dissipater. A device constructed in a waterway to reduce the kinetic energy of fast flowing water.

Epicenter. The point on the earth's surface located vertically above the point where the first rupture and the first earthquake motion occur.

Erosion. The wearing away of a surface (bank, streambed, embankment, or other surface) by floods, waves, wind, or any other natural process.

Failure. See Dam, Failure.

Failure mode. A potential failure mode is a physically plausible process for dam failure resulting from an existing inadequacy or defect related to a natural foundation condition, the dam or appurtenant structures design, the construction, the materials incorporated, the operations and maintenance, or aging process, which can lead to an uncontrolled release of the reservoir.

Fault. A fracture or fracture zone in the earth along which there has been displacement of the two sides relative to one another and which is parallel to the fracture.

Fault, active. A fault which, because of its present tectonic setting, can undergo movement from time to time in the immediate geologic future.

Fault, capable. An active fault that is judged capable of producing macroearthquakes and exhibits one or more of the following characteristics:

Movement at or near the ground surface at least once within the past 35,000 years.

Macroseismicity (3.5 magnitude or greater) instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault.

A structural relationship to a capable fault such that movement on one fault could be reasonably expected to cause movement on the other.

Established patterns of microseismicity that define a fault, with historic macroseismicity that can reasonably be associated with the fault.

Fetch. The-straight-line distance across a body of water subject to wind forces. The fetch is one of the factors used in calculating wave heights in a reservoir.

Filter (filter zone). One or more layers of granular material graded (either naturally or by selection) so as to allow seepage through or within the layers while preventing the migration of material from adjacent zones.

Flashboards. Structural members of timber, concrete, or steel placed in channels or on the crest of a spillway to raise the reservoir water level but intended to be quickly removed, tripped, or fail in the event of a flood.

Flip bucket. An energy dissipater located at the downstream end of a spillway and shaped so that water flowing at a high velocity is deflected upwards in a trajectory away from the foundation of the spillway.

Flood. A temporary rise in water surface elevation resulting in inundation of areas not normally covered by water. Hypothetical floods may be expressed in terms of average probability of exceedance per year such as one-percent-chance-flood, or expressed as a fraction of the probable maximum flood or other reference flood.

Flood, Safety Evaluation (SEP). The largest flood for which the safety of a dam and appurtenant structure is to be evaluated.

Flood, Inflow Design (IDF). The flood flow above which the incremental increase in downstream water surface elevation due to failure of a dam or other water impounding structure is no longer considered to present an unacceptable threat to downstream life or property. The flood hydrograph used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works and for determining maximum storage, height of dam, and freeboard requirements.

Flood, Probable Maximum (PMF). The flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the drainage basin under study.

Flood plain. An area adjoining a body of water or natural stream that may be covered by floodwater. Also, the downstream area that would be inundated or otherwise affected by the failure of a dam or by large flood flows. The area of the flood plain is generally delineated by a frequency (or size) of flood.

Flood routing. A process of determining progressively over time the amplitude of a flood wave as it moves past a dam or downstream to successive points along a river or stream.

Flood storage. The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel.

Fluctuation. The variation in water level, up or down, as a result of project operation.

Flume. An open channel constructed with masonry, concrete or steel of rectangular or U shaped cross section and designed for medium or high velocity flow. Also, a channel in which water is accelerated for purposes of measurement.

Flyash. The finely divided residue resulting from the combustion of ground or powdered coal and which is transported from the firebox through the boiler by flue gases; known in the United Kingdom as pulverized fuel ash (pfa).

Foundation. The portion of the valley floor that underlies and supports the dam structure.

Freeboard. Vertical distance between a specified stillwater (or other) reservoir surface elevation and the top of the dam, without camber.

Gallery. A passageway in the body of a dam used for inspection, foundation grouting, and/or drainage.

Gantry crane. A fixed or traveling bent-supported crane for handling heavy equipment.

Gate. A movable water barrier for the control of water.

Bascule gate. See flap gate.

Bulkhead gate. A gate used either for temporary closure of a channel or conduit before dewatering it for inspection or maintenance or for closure against flowing water when the head difference is small, e.g., for diversion tunnel closure.

Crest gate (spillway gate). A gate on the crest of a spillway to control the discharge or reservoir water level.

Drum gate. A type of spillway gate consisting of a long hollow drum. The drum may be held in its raised position by the water pressure in a flotation chamber beneath the drum.

Emergency gate. A standby or auxiliary gate used when the normal means of water control is not available. Sometimes referred to as guard gate.

Fixed wheel gate (fixed roller gate) (fixed axle gate). A gate having wheels or rollers mounted on the end posts of the gate. The wheels bear against rails fixed in side grooves or gate guides.

Flap gate. A gate hinged along one edge, usually either the top or bottom edge. Examples of bottom-hinged flap gates are tilting gates and fish belly gates so called from their shape in cross section.

Flood gate. A gate to control flood release from a reservoir.

Outlet gate. A gate controlling the flow of water through a reservoir outlet.

Radial gate (Tainter gate). A gate with a curved upstream plate and radial arms hinged to piers or other supporting structure.

Regulating gate (regulating valve). A gate or valve that operates under full pressure flow conditions to regulate the rate of discharge.

Roller drum gate. See drum gate.

Roller gate (stoney gate). A gate for large openings that bears on a train of rollers in each gate guide.

Skimmer gate. A gate at the spillway crest whose prime purpose is to control the release of debris and logs with a limited amount of water. It is usually a bottom hinged flap or Bascule gate.

Slide gate (sluice gate). A gate that can be opened or closed by sliding in supporting guides.

Gate chamber (valve chamber). A room from which a gate or valve can be operated, or sometimes in which the gate is located.

Geotextiles. Any fabric or textile (natural or synthetic) when used as an engineering material in conjunction with soil, foundations, or rock. Geotextiles have the following uses: drainage, filtration, separation of materials, reinforcement, moisture barriers, and erosion protection.

Groin. The area along the contact (or intersection) of the face of a dam with the abutments.

Grout. A fluidized material that is injected into soil, rock, concrete, or other construction material to seal openings and to lower the permeability and/or provide additional structural strength. There are four major types of grouting materials: chemical; cement; clay; and bitumen.

Grout blanket. An area of the foundation systematically grouted to a uniform shallow depth.

Grout cap. A concrete filled trench or pad encompassing all grout lines constructed to impede surface leakage and to provide anchorage for grout connections.

Grout curtain. One or more zones, usually thin, in the foundation into which grout is injected to reduce seepage under or around a dam.

Hazard. A situation that creates the potential for adverse consequences such as loss of life, property damage, or other adverse impacts.

> **Hazard potential.** The possible adverse incremental consequences that result from the release of water or stored contents due to failure of the dam or misoperation of the dam or appurtenances. Impacts may be for a defined area downstream of a dam from flood waters released through spillways and outlet works of the dam or waters released by partial or complete failure of the dam. There may also be impacts for an area upstream of the dam from effects of backwater flooding or landslides around the reservoir perimeter.
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> **Hazard potential classification.** A system that categorizes dams according to the degree of adverse incremental consequences of a failure or misoperation of a dam. The hazard potential classification does not reflect in any way on the current condition of the dam (i.e., safety, structural integrity, flood routing capacity).

Head, static. The vertical distance between two points in a fluid.

Head, velocity. The vertical distance that would statically result from the velocity of a moving fluid.

Headwater: The water immediately upstream from a dam. The water surface elevation varies due to fluctuations in inflow and the amount of water passed through the dam.

Heel. The junction of the upstream face of a gravity or arch dam with the ground surface. For an embankment dam, the junction is referred to as the upstream toe of the dam.

Height, above ground. The maximum height from natural ground surface to the top of a dam.

Height, hydraulic. The vertical difference between the maximum design water level and the lowest point in the original streambed.

Height, structural. The vertical distance between the lowest point of the excavated foundation to the top of the dam.

Hydrograph, breach or dam failure. A flood hydrograph resulting from a dam breach.

Hydrograph, flood. A graph showing, for a given point on a stream, the discharge, height, or other characteristic of a flood with respect to time.

Hydrograph, unit. A hydrograph with a volume of one inch of runoff resulting from a storm of a specified duration and areal distribution. Hydrographs from other storms of the same duration and distribution are assumed to have the same time base but with ordinates of flow in proportion to the runoff volumes.

Hydrology. One of the earth sciences that encompasses the natural occurrence, distribution, movement, and properties of the waters of the earth and their environmental relationships.

Hydrometeorology. The study of the atmospheric and land-surface phases of the hydrologic cycle with emphasis on the interrelationships involved.

Hypocenter. The location where the slip responsible for an earthquake originates; the focus of an earthquake.

Inflow Design Flood (IDF). See Flood.

Instrumentation. An arrangement of devices installed into or near dams that provide for measurements that can be used to evaluate the structural behavior and performance parameters of the structure.

a. **Borehole extensometers.** (single-point or multi-point). An instrument designed to measure axial displacement of a fixed point or points along its length. Extensometers can be a rod-type, or a wire-type and are usually grouted into an uncased borehole. They can be installed horizontally, vertically, or at any angle.

b. **Crack monitors. (Whittemore gauges, dial gauges, depth micrometers, and Avongard crack monitors).** Measure movements transverse and along a joint or crack.

c. **Flow measurement devices.** (flowmeters, weirs, and calibrated bucket and stopwatch). Instruments that measure leakage quantities.

d. **Inclinometer.** An instrument, usually consisting of a metal or plastic casing inserted in a drill hole and a sensitive monitor either lowered into the casing or fixed within the casing. This measures at different points the casing's inclination to the vertical. The system may be used to measure settlement.

e. **Joint meters. (Carlson type and vibrating-wire).** An embedded instrument that uses electrical principles to measure movement across a joint or crack.

f. **Observation well.** A hole used to observe the groundwater surface at atmospheric pressure within soil or rock.

g. **Piezometers.** An instrument designed to measure water levels or pore water pressures in embankments, foundations, abutments, soil, rock, or concrete. Open system porus-tube, and slotted-pipe piezmoters, or observation wells. Closed,system - Hydraulic twin-tube, pneumatic or vibrating-wire piezometers.

h**. Plumblines.** Measures the movement of a concrete dam due to applied reservoir water pressures and temperature changes. Installations consist of a formed shaft, suspension assembly, wire, plumb bob, dash pot and reading stations.

i. **Pressure cell. (Gloetzl cell. Carlson Load cell, vibrating-wire gauges, flat jacks and total pressure cell).** An instrument for measuring pressure within a mass of soil, rock, or concrete or at an interface between one and the other.

j. **Pressure relief pipes.** Pipes used to relieve uplift or pore water pressure in a dam foundation or in the dam structure.

k. **Settlement sensors. (pneumatic and vibrating-wire).** Monitors the difference in elevation between the sensor unit and its reservoir.

l. **Strain meters. (Carlson type and vibrating-wire).** An instrument that uses electrical principles to measure the strain at the location of the strain meter.

m. **Surveys. (Triangulation, trilateration, Global Positioning System (GPS), photogrammetric, and collimation).** Measure external vertical and horizontal movement on the surface.

n. **Thermometers. (resistance temperature devices, thermistors, and thermocouples).** Measures temperature using electrical principles of changing resistance in a copper wire as temperature changes, a semiconductor material that changes its resistance very markedly with temperature, or when two dissimilar metal wires are joined together, a change in temperature produces a change in voltage.

o. **Tiltmeters.** An instrument that monitors the horizontal or vertical tilt of structures and rock masses.

Intake. Placed at the beginning of an outlet-works waterway (power conduit, water supply conduit), the intake establishes the ultimate drawdown level of the reservoir by the position and size of its opening(s) to the outlet works. The intake may be vertical or inclined towers, drop inlets, or submerged, box-shaped structures. Intake elevations are determined by the head needed for discharge capacity, storage reservation to allow for siltation, the required amount and rate of withdrawal, and the desired extreme drawdown level.

Intensity, seismic. A numerical index describing the effects of an earthquake on man, manmade structures, or other features of the earth's surface.

Inundation map. A map showing areas that would be affected by flooding from releases from a dam's reservoir. The flooding may be from either controlled or uncontrolled releases or as a result of a dam failure. A series of maps for a dam could show the incremental areas flooded by larger flood releases.

Landslide. The unplanned descent (movement) of a mass of earth or rock down a slope.

Leakage. Uncontrolled loss of water by flow through a hole or crack.

Length of dam. The length along the top of the dam. This also includes the spillway, powerplant, navigation lock, fish pass, etc., where these form part of the length of the dam. If detached from the dam, these structures should not be included.

Lining. With reference to a canal, tunnel, shaft, or reservoir, a coating of asphaltic concrete, reinforced or unreinforced concrete, shotcrete, rubber or plastic to provide watertightness, prevent erosion, reduce friction, or support the periphery of the outlet pipe conduit.

Liquefaction. A condition whereby soil undergoes continued deformation at a constant low residual stress or with low residual resistance, due to the buildup and maintenance of high pore water pressures, which reduces the effective confining pressure to a very low value. Pore pressure buildup leading to liquefaction may be due either to static or cyclic stress applications and the possibility of its occurrence will depend on the void ratio or relative density of a cohesionless soil and the confining pressure.

Logboom. A chain of logs, drums, or pontoons secured end-to-end and floating on the surface of a reservoir so as to divert floating debris, trash, and logs.

Low level outlet (bottom outlet). An opening at a low level from a reservoir generally used for emptying or for scouring sediment and sometimes for irrigation releases.

Magnitude, Body Wave (m_b). The magnitude of an earthquake measured as the common logarithm of the maximum displacement amplitude (microns) and period (seconds) of the body waves.

Magnitude, Richter or Local (M_L). The magnitude of an earthquake measured as a common logarithm of the displacement amplitude, in microns, of a standard Wood-Anderson seismograph located on firm ground 100 km from the epicenter and having a magnification of 2800, a natural period 0.8 second, and a damping coefficient of 80 percent.

Magnitude, Surface Wave (Ms). The magnitude of an earthquake measured as the common logarithm of the resultant of the maximum mutually perpendicular horizontal displacement amplitudes, in microns, of the 20-second period surface waves.

Maximum flood control level. The highest elevation of the flood control storage.

Maximum wind. The most severe wind for generating waves that is reasonably possible at a particular reservoir. The determination will generally include results of meteorologic studies that combine wind velocity, duration, direction, fetch, and seasonal distribution characteristics in a realistic manner.

Meteorological homogeneity. Climates and orographic influences that are alike or similar.

Meteorology. The science that deals with the atmosphere and atmospheric phenomena, the study of weather, particularly storms and the rainfall they produce.

Minimum operating level. The lowest level to which the reservoir is drawn down under normal operating conditions. The lower limit of active storage.

Multipurpose project. A project designed for irrigation, power, flood control, municipal and industrial, recreation, and fish and wildlife benefits, in any combinations of two or more. Contrasted to single-purpose projects serving only one need.

Non-overflow dam (section). A dam or section of dam that is not designed to be overtopped.

Normal reservoir level. For a reservoir with a fixed overflow sill the lowest crest level of that sill. For a reservoir whose outflow is controlled wholly or partly by moveable gates, siphons or other means, it is the maximum level to which water may rise under normal operating conditions, exclusive of any provision for flood surcharge.

Notification. To inform appropriate individuals about an emergency condition so they can take appropriate action.

One-Percent-Chance Flood. A flood that has 1 chance in 100 of being equaled or exceeded during any year.

Orographic. Physical geography that pertains to mountains and to features directly connected with mountains and their general effect on storm path and generation of rainfall.

Outlet. An opening through which water can be freely discharged from a reservoir to the river for a particular purpose.

Outlet works. A dam appurtenance that provides release of water (generally controlled) from a reservoir.

Overflow dam (section). A section or portion of a dam designed to be overtopped.

Parapet wall. A solid wall built along the top of a dam (upstream or downstream edge) used for ornamentation, for safety of vehicles and pedestrians, or to prevent overtopping caused by wave runup.

Peak flow. The maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

Penstock. A pressurized pipeline or shaft between the reservoir and hydraulic machinery.

Pervious zone. A part of the cross section of an embankment dam comprising material of high permeability.

Phreatic surface. The free surface of water seeping at atmospheric pressure through soil or rock.

Piezometer. An instrument used for measure water levels or pore water pressures in embankments, foundations, abutments, soil, rock, or concrete. (See instrumentation.)

Piping. The progressive development of internal erosion by seepage.

Plunge pool. A natural or artificially created pool that dissipates the energy of free falling water.

Predominant period. The period(s) at which maximum spectral amplitudes are shown on response spectra. Normally, acceleration response spectra are used to determine the predominant period(s) of the earthquake ground motion.

Probability. The likelihood of an event occurring.

Probable. Likely to occur; reasonably expected; realistic.

Probable Maximum Flood (PMF). See Flood.

Probable Maximum Precipitation (PMP). Theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location during a certain time of the year.

Reservoir. A body of water impounded by a dam and in which water can be stored.

Reservoir regulation procedure (Rule Curve): The compilation of operating criteria, guidelines, and specifications that govern the storage and release function of a reservoir. It may also be referred to as operating rules, flood control diagram, or water control schedule. These are usually expressed in the form of graphs and tabulations, supplemented by concise specifications and are often incorporated in computer programs. In general, they indicate limiting rates of reservoir releases required or allowed during various seasons of the year to meet all functional objectives of the project.

Reservoir rim. The boundary of the reservoir including all areas along the valley sides above and below the water surface elevation associated with the routing of the IDF.

Reservoir surface area. The area covered by a reservoir when filled to a specified level.

Response spectrum. A plot of the maximum values of acceleration, velocity, and/or displacement response of an infinite series of single-degree-of-freedom systems subjected to a time-history of earthquake ground motion. The maximum response values are expressed as a function of natural period for a given damping.

Riprap. A layer of large uncoursed stone, precast blocks, bags of cement, or other suitable material, generally placed on the slope of an embankment or along a watercourse as protection against wave action, erosion, or scour. Riprap is usually placed by dumping or other mechanical methods, and in some cases is hand placed. It consists of pieces of relatively large size, as distinguished from a gravel blanket.

Risk. A measure of the likelihood and severity of adverse consequences (National Research Council 1983). Risk is estimated by the mathematical expectation of the consequences of an adverse event occurring, i.e., the product of the probability of occurrence and the consequence, or alternatively, by the triplet of scenario, probability of occurrence, and the consequence.

Risk analysis. A procedure to identify and quantify risks by establishing potential failure modes, providing numerical estimates of the likelihood of an event in a specified time period, and estimating the magnitude of the consequences. The risk analysis should include all potential events that would cause unintentional release of stored water from the reservoir.

Risk assessment. The process of deciding whether existing risks are tolerable and present risk control measures are adequate and, if not, whether alternative risk control measures are justified. Risk assessment incorporates the risk analysis and risk evaluation phases.

River basin. The drainage area for a river above a particular point.

Rock anchor. A steel rod or cable placed in a hole drilled in rock, held in position by grout, mechanical means, or both. In principle, the same as a rock bolt, but usually the rock anchor is more than 4 meters long.

Rock bolt. A tensioned reinforcement element consisting of a steel rod, a mechanical or grouted anchorage, and a plate and nut for tensioning or for retaining tension applied by direct pull or by torquing.

Rock reinforcement. The placement of rock bolts, untensioned rock dowels, prestressed rock anchors, or wire tendons in a rock mass to reinforce and mobilize the rock's natural competency to support itself.

Scaling. An adjustment to an earthquake time-history or response spectrum where the amplitude of acceleration, velocity, and/or displacement is increased or decreased, usually without change to the frequency content of the ground motion.

Seepage. The internal movement of water that may take place through the dam, the foundation or the abutments.

Seiche. An oscillating wave in a reservoir caused by a landslide into the reservoir or earthquake-induced ground accelerations or fault offset or meteorological event.

Seismic Moment (Mo). A measure of the earthquake size containing information on the rigidity of the elastic medium in the source region, average dislocation, and area of faulting. It determines the amplitude of the long-period level of the spectrum of ground motion. It is calculated as:

> Mo = Shear Modulus of Faulted Rock (Dynes/cm2) x Length of Fault Rupture Zone (cm) x Width of Fault (cm) x Displacement of Fault (cm)

Seismotectonic province. A geologic area characterized by similarity of geologic structure and tectonic and seismic history.

Seismotectonic source area(s). An area or areas of known or potential seismic activity that may lack a specific identifiable seismotectonic structure.

Seismotectonic structure. An identifiable dislocation or distortion within the earth's crust resulting from recent tectonic activity or revealed by seismologic or geologic evidence.

Sensitivity analysis. An analysis in which the relative importance of one or more of the variables thought to have an influence on the phenomenon under consideration is determined.

Settlement. The vertical downward movement of a structure or its foundation.

Significant wave height. Average height of the one-third highest individual waves. May be estimated from wind speed, fetch length, and wind duration

Slope. Inclination from the horizontal. Sometimes referred to as batter when measured from vertical.

Slope protection. The protection of a slope against wave action or erosion. See Riprap.

Sluice. An opening for releasing water from below the static head elevation.

Smooth response spectrum. A response spectrum devoid of sharp peaks and valleys that specifies the amplitude of the spectral acceleration, velocity, and/or displacement to be used in the analyses of the structure.

Spectrum intensity. The integral of the pseudovelocity response spectrum taken over the range of structural vibration periods from 0.1 to 2.5 seconds.

Spillway. A structure over or through which flow is discharged from a reservoir. If the rate of flow is controlled by mechanical means, such as gates, it is considered a controlled spillway. If the geometry of the spillway is the only control, it is considered an uncontrolled spillway.

Spillway, auxiliary. Any secondary spillway that is designed to be operated infrequently, possibly in anticipation of some degree of structural damage or erosion to the spillway that would occur during operation.

Spillway, emergency. See Spillway, auxiliary.

Spillway, service. A spillway that is designed to provide continuous or frequent regulated or unregulated releases from a reservoir, without significant damage to either the dam or its appurtenant structures. This is also referred to as principal spillway.

Spillway capacity: The maximum spillway outflow that a dam can safely pass with the reservoir at its maximum level.

Spillway channel. An open channel or closed conduit conveying water from the spillway inlet downstream.

Spillway chute. A steeply sloping spillway channel that conveys discharges at super-critical velocities.

Spillway crest. The lowest level at which water can flow over or through the spillway.

Spillway Design Flood (SDP). See Flood, Inflow Design.

Spillway, fuse plug. A form of auxiliary spillway consisting of a low embankment designed to be overtopped and washed away during an exceptionally large flood.

Spillway, shaft. A vertical or inclined shaft into which water spills and then is conveyed through, under, or around a dam by means of a conduit or tunnel. If the upper part of the shaft is splayed out and terminates in a circular horizontal weir, it is termed a bellmouth or morning glory spillway.

Stability. The condition of a structure or a mass of material when it is able to support the applied stress for a long time without suffering any significant deformation or movement that is not reversed by the release of the stress.

Stilling basin. A basin constructed to dissipate the energy of rapidly flowing water, e.g., from a spillway or outlet, and to protect the riverbed from erosion.

Stillwater level. The elevation that a water surface would assume if all wave actions were absent.

Stoplogs. Large logs, timbers, or steel beams placed on top of each other with their ends held in guides on each side of a channel or conduit so as to provide a cheaper or more easily handled means of temporary closure than a bulkhead gate.

Storage. The retention of water or delay of runoff either by planned operation, as in a reservoir, or by temporary filling of overflow areas, as in the progression of a flood wave through a natural stream channel. Definitions of specific types of storage in reservoirs are:

Active storage. The volume of the reservoir that is available for some use such as power generation, irrigation, flood control, water supply, etc. The bottom elevation is the minimum operating level.

Dead storage. The storage that lies below the invert of the lowest outlet and that, therefore, cannot readily be withdrawn from the reservoir.

Flood surcharge. The storage volume between the top of the active storage and the design water level.

Inactive storage. The storage volume of a reservoir between the crest of the invert of the lowest outlet and the minimum operating level.

Live storage. The sum of the active-and the inactive storage.

Reservoir capacity. The sum of the dead and live storage of the reservoir.

Surcharge. The volume or space in a reservoir between the controlled retention water level and the maximum water level. Flood surcharge cannot be retained in the reservoir but will flow out of the reservoir until the controlled retention water level is reached.

Surface waves. Waves that travel along or near the surface and include Rayleigh (Sv) and Love (SH) Waves of an earthquake.

Tailwater. The water immediately downstream from a dam. The water surface elevation varies due to fluctuations in the outflow from the structures of a dam and due to downstream influences of other dams or structures. Tailwater monitoring is an important consideration because a failure of a dam will cause a rapid rise in the level of the tailwater.

Thrust block. A massive block of concrete built to withstand a thrust or pull.

Toe of the dam. The junction of the downstream slope or face of a dam with the ground surface; also referred to as the downstream toe. The junction of the upstream slope with ground surface is called the heel or the upstream toe.

Topographic map. A detailed graphic delineation (representation) of natural and man-made features of a region with particular emphasis on relative position and elevation.

Top thickness (top width). The thickness or width of a dam at the level of the top of dam (excluding corbels or parapets). In general, the term thickness is used for gravity and arch dams, and width is used for other dams.

Trashrack. A device located at an intake to prevent floating or submerged debris from entering the intake.

Tributary. A stream that flows into a larger stream or body of water

Tunnel. A long underground excavation with two or more openings to the surface, usually having a uniform cross section used for access, conveying flows, etc.

Upstream blanket. An impervious blanket placed on the reservoir floor and abutments upstream of a dam. For an embankment dam, the blanket may be connected to the core.

Unit Hydrograph. See Hydrograph, unit.

Valve. A device fitted to a pipeline or orifice in which the closure member is either rotated or moved transversely or longitudinally in the waterway so as to control or stop the flow.

> **Hollow jet valve.** A device for regulating high-pressure outlets. Essentially, it is half a needle valve in which the needle closure member moves upstream toward the inlet end of the valve to shut off flow. As there is no convergence at the outlet end, the flow emerges in the form of an annular cylinder, segmented by several splitter ribs for admitting air into the jet interior to prevent jet instability.
>
> **Regulating sleeve valve.** A valve for regulating high pressure outlets and ensuring energy dissipation. Inside the valve there is a fixed-cone, pointed upstream, which ensures dispersion of the jet. Outside the valve, a cylindrical sleeve moves downstream to shut off flow by sealing on the periphery of the cone.

Volume of dam. The total space occupied by the materials forming the dam structure computed between abutments and from top to bottom of dam. No deduction is made for small openings such as galleries, adits, tunnels, and operating chambers within the dam structure. Portions of powerplants, locks, spillway, etc., should be included only if they are necessary for the structural stability of the dam.

Watershed. The area drained by a river or river system or portion thereof. The watershed for a dam is the drainage area upstream of the dam.

Watershed divide. The divide or boundary between catchment areas (or drainage areas).

Wave protection. Riprap, concrete, or other armoring on the upstream face of an embankment dam to protect against scouring or erosion due to wave action.

Wave runup. Vertical height above the stillwater level to which water from a specific wave will run up the face of a structure or embankment.

Weir. A notch of regular form through which water flows.

> **Weir, broad-crested.** An overflow structure on which the nappe is supported for an appreciable length in the direction of flow.

Weir, measuring. A device for measuring the rate of flow of water. It generally consists of a rectangular, trapezoidal, triangular, or other shaped notch, located in a vertical, thin plate over which water flows. The height of water above the weir crest is used to determine the rate of flow.

Weir, ogee. A reverse curve, shaped like an elongated letter "S." The downstream faces of overflow spillways are often made to this shape.

Wind setup. The vertical rise in the stillwater level at the face of a structure or embankment caused by wind stresses on the surface of the water.

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