

GLOBAL FAILURE MODES	ELEMEN AND/OR ELEMENT FUNCTION	MOST BASIC FUNCTIONAL FAILURE CHARACTERISTICS	External Hazards				Internal Hazards (Design, Construction, Maintenance, Operation)					
			Meteorological	Seismic	Reservoir Environment	Human Attack	Water barrier	Hydraulic struct.	Mech/elec	Infrastructure & Plans		
DAM COLLAPSE BY OVERTOPPING (erosion or overturning)	Water elevation too high	Inadequate installed discharge capacity	Meteorological inflow > buffer + outflow capacity	Could a meteorological event cause the inflow to be greater than the outflow capacity and lead to dam overtopping / failure due to insufficient installed discharge capacity?	Could a seismic event cause a meteorological event and cause the dam to be overtopped/fail from a reduced discharge capacity (inlets, outlets)?	Could the reservoir environment (landslide, debris) cause a meteorological event leading to the dam to be overtopped/fail because of insufficient installed discharge capacity?	Could terrorist action cause a meteorological event that leads to the dam being overtopped/fail due to insufficient installed discharge capacity?	Could design or construction of the water barrier cause a meteorological event leading to dam overtopping / failure due to insufficient installed discharge capacity?	Could the design or construction of the hydraulic structure cause a meteorological inflow greater than the buffer + outflow capacity and cause the dam to be overtopped/fail?	Could the design or construction of the mech/elec systems cause a meteorological inflow greater than the buffer + outflow capacity and lead to the dam being overtopped/fail due to insufficient installed discharge capacity?	Could inadequate infrastructure and plans cause a meteorological inflow greater than the buffer + outflow capacity and lead to the dam being overtopped/fail due to insufficient installed discharge capacity?	
		Inadequate available discharge capacity	Inadequate reservoir operation (rules not followed)	Could the dam be overtopped/fail during a meteorological event if the operating rules are not followed?	Could a seismic event create a condition that prevents the operating rules from being followed, leading to the dam being overtopped/fail?	Could the reservoir environment cause the operating rules to not be followed leading to the dam being overtopped/fail?	Could terrorist action cause the operating rules to not be followed leading to the dam being overtopped/fail?	Could design or construction of the water barrier cause the operating rules to not be followed and cause the dam to be overtopped/fail?	Could the design or construction of the hydraulic structure cause the operating rules to not be followed and lead to dam collapse by overtopping?	Could the design or construction of the mech/elec systems cause the operating rules to not be followed leading to dam overtopping/failure?	Could inadequate infrastructure and plans cause inadequate reservoir operation leading to dam collapse by overtopping?	
		Inadequate available discharge capacity	Random functional failure on demand	Could the dam be overtopped/fail during a meteorological event if there is a random functional failure of spilling capability?	Could a seismic event cause a random functional failure of spilling capability leading to the dam be overtopped/failed?	Could the reservoir environment cause random functional failure on demand of discharge capability and lead to the dam being overtopped/fail?	Could terrorist action cause random functional failure of spilling capability causing the dam to be overtopped/fail?	Could design or construction of the water barrier cause a random functional failure of spilling capability and cause the dam to be overtopped/fail?	Could the design or construction of the hydraulic structure cause random functional failure of spilling capability and lead to the dam being overtopped/fail due to inadequate available discharge capacity?	Could the design or construction of the mech/elec systems cause a random functional failure on demand leading to dam collapse by overtopping?	Could inadequate infrastructure and plans cause random functional failure on demand leading to dam collapse by overtopping?	
		Inadequate available discharge capacity	Discharge capability not maintained or retained	Could the dam be overtopped/fail during a meteorological event if the discharge capacity is not maintained?	Could a seismic event cause the discharge capacity to be damaged causing the dam to be overtopped/fail?	Could the reservoir environment cause loss of the discharge capability leading to the dam being overtopped/fail?	Could terrorist action cause loss of discharge capability and cause the dam to be overtopped/fail?	Could design or construction of the water barrier cause the discharge capability to be not maintained/retained and cause the dam to be overtopped/fail?	Could the design or construction of the hydraulic structure cause loss of the discharge capability and lead to the dam being overtopped/fail due to inadequate available discharge capacity?	Could the design or construction of the mech/elec systems cause the discharge capability to be not maintained / retained leading to dam collapse by overtopping?	Could inadequate infrastructure and plans cause discharge capacity to not be maintained or retained leading to dam collapse by overtopping?	
		Inadequate freeboard	Excessive elevation due to landslide or U/S dam	Could the dam be overtopped/fail during a meteorological event due to a reservoir landslide or upstream dam failure?	Could a seismic event cause the dam to be overtopped/fail by a reservoir landslide or upstream dam failure?	Could the reservoir environment cause excessive elevation of the reservoir leading to the dam being overtopped/fail?	Could terrorist action cause a landslide or upstream dam failure leading to the dam being overtopped/fail?	Could design or construction of the water barrier cause a reservoir landslide or upstream dam failure and cause the dam to be overtopped/fail?	Could the design or construction of the hydraulic structure cause excessive elevation due to a landslide or upstream dam failure leading to the dam being overtopped/fail due to inadequate freeboard?	Could the design or construction of the mech/elec systems cause excessive elevation due to a landslide or upstream dam failure leading to dam collapse by overtopping?	Could inadequate infrastructure and/or plans cause the dam to fail due to a reservoir landslide or upstream dam failure?	
	Inadequate freeboard	Wind-wave dissipation inadequate	Is freeboard and wind wave dissipation adequate to prevent overtopping/failure during a meteorological event?	Could a seismic event cause the dam to be overtopped/fail due to inadequate freeboard and wind wave dissipation?	Is freeboard and wind wave dissipation adequate to prevent overtopping/failure from failure of features in the reservoir environment?	Could terrorist action cause inadequate freeboard and wind wave dissipation leading to dam overtopping/failure?	Could design or construction of the water barrier cause inadequate freeboard and wind wave dissipation and cause overtopping/failure?	Could the design or construction of the hydraulic structure cause inadequate wind wave dissipation leading to dam collapse by overtopping?	Could the design or construction of the mech/elec systems cause inadequate wind wave dissipation leading to dam collapse by overtopping?	Could inadequate infrastructure and plans cause inadequate wind-wave dissipation leading to dam collapse by overtopping?		
	Management System Failure	Safeguards fail to provide timely detection and correction	Operation, maintenance and surveillance fail to detect/prevent hydraulic adequacy	Could a meteorological event prevent the Dam Safety Engineers activities (based on OMS requirements, see column L) from detecting/prevent hydraulic inadequacy leading to dam overtopping/failure?	Could a seismic event prevent the Dam Safety Engineers activities (based on OMS requirements, see column L) from detecting/preventing hydraulic inadequacy leading to overtopping/failure of the dam?	Could the reservoir environment prevent Dam Safety activities (based on OMS requirements, see column L) from detecting/preventing hydraulic inadequacy leading to dam overtopping/failure?	Could terrorist action cause the OMS activities to not detect/prevent hydraulic inadequacy leading to dam overtopping/failure?	Could inadequate operation, maintenance and surveillance fail to detect / prevent hydraulic adequacy and lead to failure of the water barrier?	Could inadequate operation, maintenance and surveillance fail to detect / prevent hydraulic adequacy and lead to failure of the hydraulic structure?	Could inadequate operation, maintenance and surveillance fail to detect / prevent failure of the mech/elec system leading to dam collapse by overtopping?	Could inadequate operation, maintenance and surveillance of the infrastructure and plans cause the OMS activities to not detect /prevent hydraulic inadequacy before leading to overtopping/failure of dam?	
		Safeguards fail to provide timely detection and correction	Operation, maintenance and surveillance fail to detect poor dam performance	Could the meteorological event prevent the OMS rules from being implemented by the DS Engineer leading to dam collapse by loss of strength?	Could a seismic event cause the OMS rules to not be followed leading to collapse by loss of strength during a seismic event?	Could the reservoir environment cause the OMS rules to not be followed leading to dam collapse by loss of strength?	Could terrorist action cause OMS activities to not be followed leading to dam collapse by loss of strength?	Could inadequate operation, maintenance and surveillance fail to prevent poor dam performance and lead to dam collapse by loss of strength?	Could inadequate operation, maintenance and surveillance of the hydraulic structure fail to prevent poor dam performance and lead to dam collapse by loss of strength?	Could inadequate operation, maintenance and surveillance of the mech/elec systems fail to prevent poor dam performance and lead to dam collapse by loss of strength?	Could inadequate surveillance and management of the infrastructure and plans cause the OMS activities to not detect /prevent dam collapse by loss of strength?	
	DAM COLLAPSE BY LOSS OF STRENGTH (External or internal structural failure and weakening)	Crest elevation too low	Stability under applied loads	Mass movement (external stability- displacement, tilting, seismic resistance)	Could loss of strength and static instability occur during a meteorological event and cause dam collapse?	Could a seismic event cause mass external instability and cause dam collapse?	Could the reservoir environment cause external instability of the dam leading to dam collapse?	Could terrorist action cause external instability of the dam and cause dam collapse?	Could design or construction of the water barrier cause external instability and lead to dam collapse?	Could the design or construction of the hydraulic structure cause external instability leading to dam collapse by loss of strength?	Could the design or construction of the mech/elec systems cause external instability leading dam collapse by loss of strength?	Could inadequate infrastructure and plans cause external instability leading to dam collapse by loss of strength?
			Stability under applied loads	Loss of support (foundation or abutment failure)	Could reduction/lack of support in foundation or abutments during a meteorological event cause dam collapse?	Could a seismic event cause reduction/lack of support in foundation or abutments leading to dam collapse?	Could the reservoir environment (debris, ice, landslides) cause foundation or abutment failure leading to dam collapse?	Could terrorist action cause reduction/lack of support in foundation or abutments and cause dam collapse?	Could design or construction of the water barrier cause reduction/lack of support in foundation or abutments and cause dam collapse?	Could the design or construction of the hydraulic structure cause reduction/lack of support in foundation or abutments and lead to dam collapse by loss of strength?	Could the design or construction of the mech/elec systems cause a reduction/lack of support in foundation or abutments leading to dam collapse by loss of strength?	Could inadequate infrastructure and plans cause reduction/lack of support in foundation or abutments leading to dam collapse by loss of strength?
Watertightness		Seepage around interfaces (abutments, foundation, water stops)	Could seepage around interfaces/abutments/foundation during meteorological event reduce water tightness sufficient to cause dam collapse?	Could a seismic event cause seepage around interfaces / abutments / foundation reduce water tightness sufficient to cause dam collapse?	Could the reservoir environment (debris, ice, landslides) cause seepage around interfaces/abutments/foundation and reduce water tightness sufficient to cause dam collapse?	Could terrorist action cause seepage around interfaces / abutments / foundation and reduce water tightness sufficient to cause dam collapse?	Could design or construction of the water barrier cause seepage around interfaces / abutments / foundation and reduce water tightness sufficient to cause dam collapse?	Could the design or construction of the hydraulic structure cause seepage around interfaces/ abutments/ foundation leading to dam collapse by loss of strength?	Could the design or construction of the mech/elec systems cause seepage around interfaces/ abutments/ foundation leading to dam collapse by loss of strength?	Could inadequate infrastructure and plans cause seepage around interfaces/ abutments/ foundation and reduce water tightness sufficient to cause dam collapse by loss of strength?		
Watertightness		Through dam seepage control failure (filters, drains, pumps)	Could through -dam seepage (filters/drains/pumps, internal instability) during a meteorological event reduce watertightness and cause dam collapse?	Could a seismic event cause through dam seepage (filters/drains/pumps) to fail and reduce watertightness and cause dam collapse?	Could the reservoir environment (landslides, ice, debris) cause through dam seepage control be lost (filters/drains/pumps) and reduce watertightness and cause dam collapse?	Could terrorist action cause failure of through dam seepage (filters / drains / pumps) control and reduce watertightness and cause dam collapse?	Could design or construction of the water barrier cause through dam seepage (filters / drains / pumps) and reduce watertightness and cause dam collapse?	Could the design or construction of the hydraulic structure cause through dam seepage control failure (filters/ drains/ pumps) and lead to dam collapse by loss of strength?	Could the design or construction of the mech/elec systems cause through dam seepage (filters/ drains/ pumps) and reduce watertightness and cause dam collapse?	Could inadequate infrastructure and plans cause through dam seepage (filters/ drains/ pumps) and cause dam collapse by loss of strength?		
Durability/cracking		Structural weakening (internal erosion, AAR, crushing, gradual strength loss)	Could structural weakening (internal erosion, crushing, cracking, strength loss) caused by a meteorological event cause dam collapse?	Could a seismic event cause internal structural weakening (internal erosion, crushing, cracking, strength loss) and cause dam collapse?	Could the reservoir environment (landslides, ice, debris) cause internal structural weakening (internal erosion, crushing, cracking, strength loss) and lead to dam collapse?	Could terrorist action cause internal structural weakening (internal erosion, crushing, cracking, strength loss) and cause dam collapse?	Could design or construction of the water barrier cause internal structural weakening (internal erosion, crushing, cracking, strength loss) and cause dam collapse?	Could the design or construction of the hydraulic structure cause internal structural weakening (internal erosion, crushing, cracking, strength loss) leading to dam collapse?	Could the design or construction of the mech/elec systems cause internal structural weakening (internal erosion, crushing, cracking, strength loss) leading to dam collapse by loss of strength?	Could inadequate infrastructure and plans cause internal structural weakening (internal erosion, crushing, cracking, strength loss) and cause dam collapse by loss of strength?		
Durability/cracking	Instantaneous change of state (static liquefaction, hydraulic fracture, seismic cracking)	Could instantaneous change of state occur (Liquefaction, hydraulic fracture) caused by a meteorological event cause dam collapse?	Could a seismic event cause instantaneous change of state to occur (Liquefaction, hydraulic fracture) leading to dam collapse?	Could the reservoir environment (landslides, ice, debris) cause instantaneous change of state to occur (liquefaction, hydraulic fracture) and cause dam collapse?	Could terrorist action cause instantaneous change of state to occur (Liquefaction, hydraulic fracture) and cause dam collapse?	Could design or construction of the water barrier cause instantaneous change of state occur (Liquefaction, hydraulic fracture) and cause dam collapse?	Could the design or construction of the hydraulic structure cause instantaneous change of state to occur (Liquefaction, hydraulic fracture) leading to dam collapse?	Could the design or construction of the mech/elec systems cause instantaneous change of state to occur (Liquefaction, hydraulic fracture) leading to dam collapse by loss of strength?	Could inadequate infrastructure and plans cause instantaneous change of state occur (Liquefaction, hydraulic fracture) and cause dam collapse by loss of strength?			