



**GEOLOGICAL SURVEY OF CANADA
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**Landslide Terminology
National Technical Guidelines and Best Practices on
Landslides**

R. Couture

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1. INTRODUCTION

The purpose of this glossary of landslide terms is two-fold:

- to provide a useful compendium of terms used by the landslide community in Canada and elsewhere, and
- to encourage a common language by all authors who are contributing to the national technical guidelines and best practices on landslides that are currently under development at Natural Resources Canada.

Several publications that include landslide terminology exist. For example, more recent publications include Cruden and Varnes (1996), Wise et al. (2004) and Fell et al. (2008). Cruden and Varnes (1996) is consistent with the terminology suggested by UNESCO's Working Party on the World Landslide Inventory (WP/WLI, 1993) and provides a historical perspective of landslide terminology. Wise et al. (2004) is consistent with the hazard and risk terminology recommended by the Canadian Standards Association (1997) and is used by most landslide professionals in western Canada. Fell et al. (2008) suggests landslide susceptibility, hazard and risk terminology for use throughout the world.

2. ABBREVIATIONS

C: Consequence (due to a hazardous landslide)

$P_{(H)}$: Annual probability of a landslide or probability of occurrence of a landslide.

$P_{(HA)}$: Partial risk (annual probability of occurrence of landslide impacting an element at risk at the site when the landslide affects this site)

$P_{(S:H)}$: Probability of spatial impact by the landslide on the property, taking into account the travel distance and travel direction.

$P_{(T:S)}$: Temporal spatial probability. For houses and other buildings $P_{(T:S)}$ is 1.0. For vehicles and other moving elements at risk $1.0 < P_{(T:S)} > 0$.

$R_{(S)}$: Risk (annual probability of loss)

$V_{(L:T)}$: Vulnerability of the individual or the element at risk; probability of loss or damage given the impact.

3. GLOSSARY

Abandoned: Inactive landslide no longer affected by its original causes.

Acceptable Risk: Risk that, for the purposes of life or work, society is prepared to accept as is, with no risk management; society does not typically consider expenditure to further reduce such risk as justifiable.

Accumulated Mass; Accumulation: Volume of displaced material that lies above the original ground surface of a landslide (see Fig. 1).

Active:

- a) Landslide that is currently moving; first-time movement or reactivated; or
- b) Form of mitigation that requires some engineering to prevent, reduce or eliminate the hazard, or to design protection to the elements at risk.

Activity: Stage of development of a landslide, including the state of activity, distribution of activity, and style of activity.

Advancing: Activity where the rupture surface extends in the direction of movement.

ALARP: As Low As Reasonably Practicable; with reference to risk.

Analysis: Process to determine the nature and level of hazard and risk; typically includes scope definition, identification and estimation.

Annual Exceedance Probability (AEP): Estimated probability that an event of specified magnitude will be exceeded in a year.

Assessment: Overall process of hazard or risk identification, analysis and evaluation.

Cause(s): see Preparatory Causes

Complex: Activity where a landslide exhibits at least two types of movement (fall, topple, slide, spread, or flow) in sequence.

Composite: Activity where a landslide exhibits at least two types of movement (fall, topple, slide, spread, or flow) in different parts of the displaced mass at the same time.

Confining: Activity where there is a scarp but no rupture surface visible at the foot of the displaced mass.

Consequence:

- a) Outcome or potential outcome arising from a landslide, expressed qualitatively or quantitatively in terms of loss, disadvantage (or gain), damage, injury or loss of life; the effect on human well-being, property, the environment, other things of value, or a combination of these; or
- b) Probability of total loss or damage, or a proportion of loss or damage, to an element at risk; combination of spatial probability, temporal probability and vulnerability; $C = P_{(S:H)} \times P_{(T:S)} \times V_{(L:T)}$.

Control: Process of decision making for managing hazard or risk, and implementation or enforcement of hazard or risk mitigation measures and re-evaluation of the effectiveness from time to time, using the results of hazard or risk assessment as one input.

Creep:

- a) Deformation that continues under constant stress.
- b) A very slow to extremely slow rate of movement; not a recommended term, use very slow or extremely slow instead.

Criteria: Terms of reference against which the significance of a hazard or risk are evaluated.

Crown: Non-displaced ground adjacent to the highest portion of the main scarp of a landslide (see Fig. 1).

Danger (Threat): Natural phenomenon that could lead to loss, disadvantage, damage, injury or loss of life; does not include any forecasting; also see Hazard.

Debris: Soil that contains a significant proportion of coarse material; 20% to 80% inorganic particles >2 mm (the upper limit of sand-size particles), and the remainder <2 mm.

Debris Avalanche: Type of landslide characterized by the very rapid movement of debris downhill.

Debris Flow: Type of landslide characterized by fast moving, unconsolidated, typically saturated debris; open-slope debris flows occur unconfined on a hillslope; confined debris flows occur in a pre-existing channel.

Debris Torrent: Former term for debris flow; not a recommended term.

Depleted Mass; Depletion: Volume of displaced material that overlies the rupture surface but underlies the original ground surface of a landslide (see Fig. 1).

Depth of Displaced Mass (D_d): Maximum depth of the displaced mass, measured perpendicular to the plane containing the width and length of the displaced mass (W_d and L_d) (see Fig. 2).

Depth of Rupture Surface (D_r): Maximum depth of the rupture surface below the original ground surface, measured perpendicular to the plane containing the width and length of the displaced mass (W_r and L_r) (see Fig. 2).

Diminishing: Activity where the volume of displaced material is decreasing.

Disaster: Serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses that exceed the ability of the affected community or society to cope using its own resources.

Displaced Material: Material moved from its original position by a landslide; includes both the depleted and accumulated masses (depletion and accumulation) (see Fig. 1).

Distribution of Activity: Terms that describe where a landslide is moving (advancing, retrogressing, widening, enlarging, confining, diminishing, or moving).

Dormant: Inactive landslide that can be reactivated by its original or other causes.

Dry: Material that has no visible moisture.

Early Warning: Provision of timely and effective information, through identified institutions, that allows individuals exposed to a hazard to take action to avoid or reduce their risk and prepare for effective response.

Earth: Soil that contains >80% inorganic particles <2 mm (the upper limit of sand-size particles).

Earth Flow: Type of landslide characterized by slow to rapid movement of saturated earth in a liquefied state.

Earth Slide: Type of landslide characterized by earth that has moved as a relatively coherent mass along a relatively shallow failure plane.

Elements at Risk: Population, buildings and engineering works, economic activities, public utilities, other infrastructure, and environmental values in an area affected, or potentially affected, by a landslide.

Enlarging: Activity where the rupture surface of a landslide is extending in two or more directions.

Erosion: Processes of weathering and transport of soil and rock from their natural environment or source. Agents of erosion include wind, water, ice, gravity and living organisms (bioerosion).

Estimation: The determination of hazard or risk.

Evaluation: Using values and judgments in the decision process, either explicitly or implicitly, to determine the importance of the estimated hazards or risks, and thereby identify alternatives to manage the hazards or risks.

Event: Occurrence or change of a particular set of circumstances; a landslide is an example of an event.

Fall: Detached movement of soil or rock from a steep slope along a surface on which little or no shear displacement occurs; material then typically descends by falling, bouncing or rolling.

Flank: Non-displaced material adjacent to the sides of the rupture surface of a landslide; compass directions are preferable in describing the flanks, but 'left' and 'right' can be used looking downslope (see Fig. 1); also see Side scarp.

Flow: Spatially continuous movement of soil or rock, in which surfaces of shear are short-lived, closely spaced and typically not preserved; distribution of velocities in the displaced mass resembles a viscous fluid.

Foot: Portion of a landslide that has moved beyond the toe of the surface of rupture and overlies the original ground surface (see Fig. 1).

Frequency: Probability or likelihood of occurrence of a repeating event, such as a landslide, expressed as the number of occurrences per unit time; also a measure of past occurrences per unit time; also see Probability and Likelihood.

Frozen: Thermal condition defining soils, sediments, or rock at or below 0°C. Newly proposed descriptor for materials (water content) within the Working Classification of Landslides to encompass landslides in permafrost terrain.

Hazard:

a) Condition with the potential for causing an undesirable consequence; source of potential harm; also see Danger; or

b) Probability that a particular danger (threat) occurs within a given period of time

Head: Upper part of a landslide along the contact between the displaced material and the main scarp (see Fig. 1).

Headscarp: Abrupt scarp at the head of a landslide; also see Main scarp.

Identification: Process of finding, recognizing and fully describing hazard or risk.

Inactive: Landslide that has not moved within the last 12 months; can be sub-divided into dormant, abandoned, stabilized, relict, and repaired.

Individual Risk: Risk of fatality or injury to an identifiable individual who lives or otherwise occupies an area affected, or potentially affected, by a landslide.

Intensity: Set of spatially distributed parameters related to the destructive power of a landslide; can be described quantitatively or qualitatively; can include maximum velocity, total displacement, differential displacement, depth of moving mass, peak discharge per unit width, kinetic energy per unit area.

Inventory: Study of the location, classification, volume, activity, date of occurrence and other characteristics of landslides within an area.

Involuntary Risk: Risk that typically is imposed on an individual or society.

Jökulhlaup: Glacial outburst flood, often the result of the breach of a glacial lake.

Lahar: Debris flow related in some way to volcanic activity, either directly as a result of an eruption, or indirectly by the collapse of loose material from the flanks of a recent volcano.

Landslide: Movement of a mass of soil (earth or debris) or rock down a slope.

Landslip: Former term for landslide; not a recommended term.

Lateral Spread: see Spread.

Length of Centre Line (L_{cl}): Distance from the crown to the tip of landslide through points on original ground surface equidistant from lateral margins of surface of rupture and displaced material (see Fig. 2).

Length of Displaced Mass (L_d): Minimum distance from the top to the tip of a landslide (see Fig. 2).

Length of Rupture Surface (L_r): Minimum distance from the crown to the toe of the surface of rupture of a landslide (see Fig. 2).

Level of Hazard or Risk: Magnitude of a hazard or risk, expressed in terms of probability or likelihood (for hazard) and in terms of probability or likelihood and consequences (for risk).

Likelihood: Chance of an event occurring; a qualitative description of probability of a landslide; also see Frequency and Probability.

Main Body: Part of the displaced material of a landslide that overlies the surface of rupture between the main scarp and the toe of the surface of rupture (see Fig. 1).

Main Scarp: Steep surface of undisturbed material at the upslope extent of a landslide; caused by movement of the displaced material away from the undisturbed ground; the visible part of the surface of rupture (see Fig. 1); also see Headscarp.

Management: Process of hazard or risk assessment and control or treatment.

Marginal: Inactive landslide, between preparatory and active, where a trigger can initiate movement.

Minor Scarp: Steep surface on the displaced material of a landslide produced by differential movements within the displaced material (see Fig. 1).

Mitigation: Strategy to reduce the effect of a landslide.

Moderate: Slope movement with velocity less than 1.8m/hour (0.5mm/sec) and greater than 13m/month (5×10^3 mm/sec).

Moist: Material that contains some water but no free water, and may behave as a plastic solid but does not flow.

Monitoring: Continual or frequent checking, critically observing or determining the status of activity of a landslide to identify change.

Moving: Activity where the displaced material continues to move without any visible change in the rupture surface and the volume of the displaced material.

Multiple: Activity where a landslide shows repeated development of the same type of movement.

Original Ground Surface: Surface of slope that existed before a landslide occurred (see Fig. 1).

Partial Risk: Combination of the probability of a (hazardous) landslide and probability of the landslide affecting the site of an element at risk at the site when the landslide occurs; does not consider vulnerability; $P_{(HA)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)}$.

Passive: Form of mitigation that requires no design engineering; includes avoidance, land use regulations, education and warning systems.

Permafrost: Ground condition of soil or rock that remains at or below 0°C for more than two years.

Preparatory: Inactive land area where destabilizing processes are insufficient to cause a landslide.

Preparatory Causes: Reason(s) that a landslide occurred at a particular location and time; mechanism(s) that put a landslide into a preparatory state of activity; can include geological factors (e.g. sensitive materials, joints and fissures), geomorphological factors (e.g. slope angle, erosion), physical factors (e.g. rainfall, earthquake) and factors associated with human activity (e.g. addition of a load or excavation).

Probability:

- a) Estimate of the degree of certainty between 0 (impossible) and 1 (certain) of an event occurring; also see Likelihood and Frequency; can be statistical or subjective; or
- b) Probability of occurrence of a (hazardous) landslide; can be statistical or subjective; $P_{(H)}$.

Qualitative Risk Analysis: Analysis that uses descriptive words or numeric rating scales to describe likelihood, vulnerability and consequences.

Quantitative Risk Analysis: Analysis based on numerical values of probability, vulnerability and consequences.

Reactivated: Landslide that is again active after being inactive.

Rapid: Slope movement with velocity greater than 1.8m/hour (0.5mm/sec).

Relict: Inactive landslide that developed under climatic or geomorphological conditions considerably different from those at present.

Remediation: Strategy by which the effects of a landslide are reduced.

Repaired: Inactive landslide that has been temporarily protected from its original cause(s) by artificial remedial measures.

Retreating: Activity where the surface of rupture extends in the direction opposite to the movement of the displaced material.

Residual: Hazard or risk remaining after mitigation.

Risk:

- a) Combination of the likelihood or probability of occurrence of a landslide and the consequences of a landslide occurring;
- b) Specific risk is the risk of loss or damage to a specific element at risk resulting from a specific hazardous affecting landslide; partial risk that also considers vulnerability; $R_{(S)} = P_{(HA)} \times V_{(L:T)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(L:T)} = P_{(H)} \times C$; or
- c) Total risk is the risk of loss or damage to all specific elements at risk from all specific hazardous affecting landslides.

Rock: Hard or firm mass of inorganic material that was intact and in situ before the initiation of a landslide.

Rotational Slide: Landslide in which the surface of rupture is curved concavely upward and movement is roughly rotational about an axis parallel to the ground surface and transverse across the landslide.

Run-out: Maximum travel distance of a landslide.

Run-up: Maximum height reached by a landslide mass.

Side Scarp: also see Flank

Single: Activity where a landslide exhibits only one type of movement (fall, topple, slide, spread, or flow).

Slide: Downslope movement of a soil or rock mass occurring dominantly on surfaces of rupture or relatively thin zones of intense shear strain; use as a diminutive of 'Landslide' not recommended.

Slope Instability: Landslide; not a recommended term.

Slope Stability Analysis: Analysis of static and dynamic stability of engineered and natural slopes of soil and rock.

Slow: Slope movement with velocity less than 13m/month (5×10^{-3} mm/sec).

Slump: A short, downslope movement of a coherent mass of loosely consolidated soil or rock; not a recommended term.

Societal Risk: Risk of multiple injuries or fatalities, financial, environmental, and other losses from a landslide, the burden of which society has to carry.

Soil: Aggregate of solid, typically inorganic particles, that either was transported or was formed in situ by weathering of rock; subdivided into earth and debris.

Spatial Probability: The potential of a landslide affecting the site of an element at risk; $P_{(S:H)}$.

Specific Risk: see Risk (b)

Spread: Extensional movement of a cohesive soil or rock mass combined with a general subsidence of the fractured mass of material into a softer underlying material; surface of rupture is not a surface of intense shear; spreads can result from liquefaction or flow (and extrusion) of the softer material.

Stabilized: Inactive landslide that has been permanently protected from its original causes by artificial remedial measures.

State of Activity: Terms that describe the timing of landslide movements (active, reactivated, suspended, inactive, dormant, abandoned, stabilized, relict, preparatory, marginal, and repaired).

Style of Activity: Terms that describe the manner in which different movements contribute to a landslide (complex, composite, multiple, successive, single).

Subsidence: Vertical downward movement of the ground surface; frequently occurs in karst terrains or can be related to mining activities.

Successive: Activity where a landslide exhibits the same type of movement as a nearby, earlier landslide but does not share displaced material or a surface of rupture.

Surface of Rupture: Surface that forms, or has formed, the lower boundary of the displaced material of a landslide below the original ground surface (see Fig. 1).

Surface of Separation: Part of the original ground surface overlain by the foot of a landslide (see Fig. 1).

Susceptibility: Qualitative or quantitative analysis of the classification, volume (or area), and spatial distribution of landslides that exist or potentially can occur in an area; can also include a description of the velocity and intensity of the existing or potential landslide; a time frame is explicitly not taken into account.

Suspended: Landslide that has moved within the last 12 months but is not active at present.

Temporal Probability: Probability that an element at risk is at the site when the site is affected by a landslide; $P_{(T:S)}$.

Tip: Point of the toe farthest from the top of a landslide (see Fig. 1).

Toe: Lower, usually curved, margin of the displaced material of a landslide, the most distant from the top of a landslide (see Fig. 1).

Toe of Surface of Rupture: Intersection (usually buried) between the lower part of the surface of rupture of a landslide and the original ground surface (see Fig. 1).

Tolerable Risk: Risk within a range within which society can live in order to have and secure certain benefits; a range of risk regarded as non-negligible but needing to be kept under review and reduced further if possible.

Top: Highest point of contact between the displaced material and the main scarp of a landslide (see Fig. 1).

Topple: Forward rotation, out of the slope of a mass of soil or rock, about a point or axis below the centre of gravity of the displaced mass.

Total Length (L): Minimum distance from the tip of a landslide to its crown (see Fig. 2).

Total Risk: see Risk (c)

Translational: Type of landslide that moves along a roughly planar surface with little rotation or backward tilting.

Trigger: Cause that puts a slope into a marginal state of activity leading to a landslide.

Velocity: Rate of movement of a landslide that can range from extremely slow (<16 mm/year or 0.5×10^{-6} mm/second) to extremely rapid (>5 m/second).

Very Wet: Material that contains enough water to flow as a liquid under low gradients.

Voluntary Risk: Risk that an individual or society typically takes willingly.

Vulnerability:

- a) Measure of the robustness (or alternatively, the fragility) of an element at risk, and its exposure to (or alternatively, protection from) a landslide; or
- b) Probability or degree of potential loss to a given element at risk or a set of elements at risk within an area affected by a landslide; $V_{(L:T)}$ expressed on a scale of 0 (impossible or no loss) to 1 (total loss).

Wet: Material that contains enough water to behave in part as a liquid, has water flowing from it, or supports significant bodies of standing water.

Widening: Activity where the rupture surface extends into one or both flanks of a landslide.

Width of the Displaced Mass (W_d): Maximum breadth of the displaced mass perpendicular to the length (L_d) (see Fig. 2).

Width of the Rupture Surface (W_r): Maximum width between the flanks of a landslide, perpendicular to the length (L_r) (see Fig. 2).

Zone of Accumulation: Portion of a landslide within which the displaced material lies above the original ground surface (see Fig. 1).

Zone of Depletion: Portion of a landslide within which the displaced material lies below the original ground surface (see Fig. 1).

Zoning: Division of land into somewhat homogeneous areas or domains, and their ranking according to degrees of actual or potential landslide susceptibility, hazard or risk or applicability of certain landslide-related regulations.

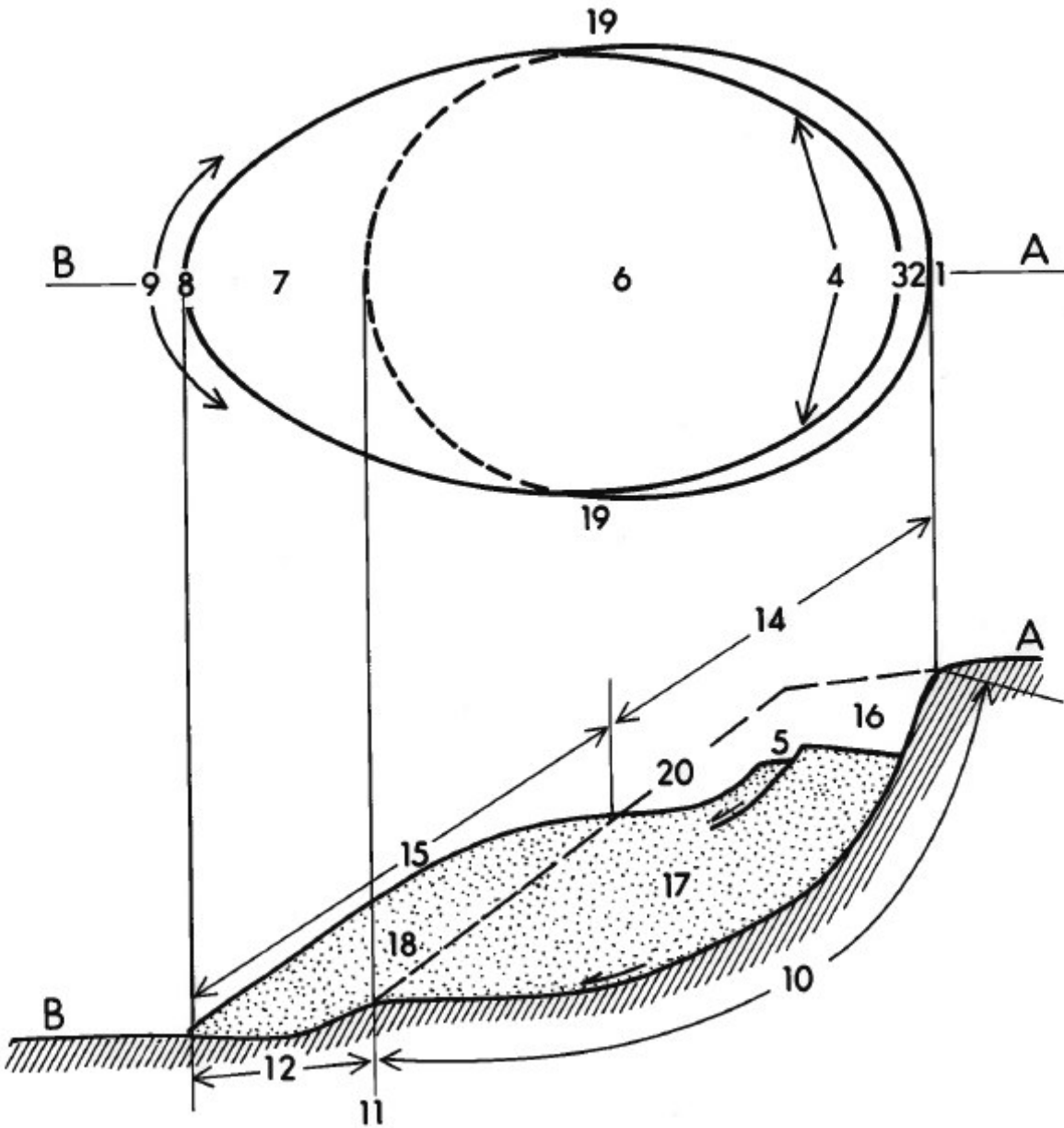


Figure 1. Landslide features (Cruden and Varnes, 1996). 1. Crown. 2. Main scarp. 3. Top. 4. Head. 5. Minor scarp. 6. Main body. 7. Foot. 8. Tip. 9. Toe. 10. Surface of rupture. 11. Toe of surface of rupture. 12. Surface of separation. 13. Displaced material. 14. Zone of depletion. 15. Zone of accumulation. 16. Depletion. 17. Depleted mass. 18. Accumulation. 19. Flank. 20. Original ground surface. See above pages for definitions of features.

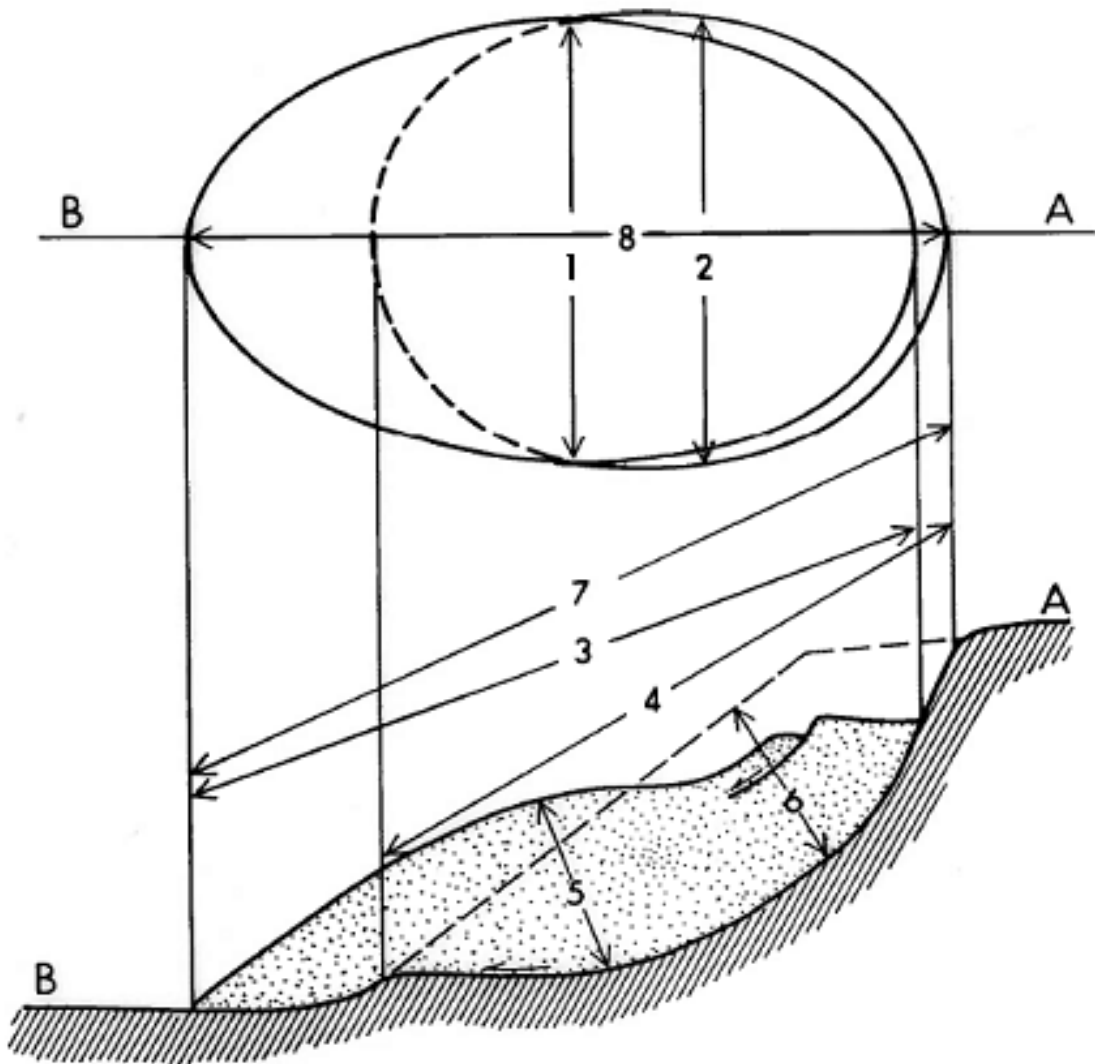


Figure 2. Landslide dimensions (Cruden and Varnes, 1996). 1. Width of displaced mass, W_d . 2. Width of surface of rupture, W_r . 3. Length of displaced mass, L_d . 4. Length of surface of rupture, L_r . 5. Depth of displaced mass, D_d . 6. Depth of surface of rupture, D_r . 7. Total length, L . 8. Length of centre line, L_{cl} . See above pages for definitions of landslide dimensions.

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