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Regional landslide mapping in a permafrost environment: landslide inventory database and case studies in the Mackenzie Valley, Northwest Territories, Canada

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Natural Resources Canada initiated a regional landslide mapping project along the proposed gas pipeline between Inuvik and Norman Wells to provide baseline knowledge on types, regional distribution, and control of landslides in the Mackenzie Valley. The preliminary Mackenzie Valley Landslide Spatial Database will be presented as well as a detailed description of three case studies. The study area covers a corridor extending 20 km to either side of the proposed gas pipeline, for a length of 540 km from Inuvik (68.35˚N, 133.72˚W) to Norman Wells (65.28˚N, 126.83˚W). The study area is covered by unconsolidated sediments (99%), which are dominated by morainal deposits (60%), and encompasses three zones of permafrost: continuous, extensive discontinuous, and intermediate discontinuous. The study area is characterized by cold winters with low precipitation and relatively warm summers with moderate precipitation.

Using classical photo-interpretation techniques, a preliminary inventory of over 1800 landslides and other natural terrain hazard features (e.g. karstic sink holes, rock glaciers) has been created for the study area. Currently, about 40% of the study area has been mapped using 665 coloured air photos (scale of 1:30,000) acquired in 2004. For all of the 1800 landslide entries in the landslide database, the following attributes are recorded: unique identifier, landslide type and size, location, morphological parameters, surface tone and texture, vegetation re-growth in landslide scar, relative age, activity, material type, flight line, air photo number, and topographic map sheet

number. A collection of several hundreds of photographs of landslides, taken while carrying out field surveys, completes the database. The compilation of the landslide database and existing physical and environmental information have been integrated into a GIS-based multi-theme database, which includes data on permafrost, bedrock and surficial geology, soil, hydrology, elevation, climate, vegetation and forest fires, digital air photos (temporal sequences), and satellite images.

Spatial analyses from desktop landslide mapping and a statistical analysis derived from the landslide database attributes were performed to characterise the landslide distribution. Preliminary results indicate an average density of one landslide per 5 km^2 and show that the dominant landslide types are retrogressive thaw flows (28%) and active layer detachments (26%). Rock falls (11%), debris flows (10%), earth slides (9%), and retrogressive thaw slides (5%) are second in order of importance. About 47% of all landslides took place in morainal deposits, 19% in lacustrine sediments, 13% in glaciofluvial sediments, and 12% in bedrock. The relative age of landslides was estimated based on tone, texture, and vegetation re-growth parameters in the landslide scar, where 38% were classified old ($>$50 years old), 40% intermediate in age (10-50 years old), and 22% recent ($<$10 years old).

Detailed investigations at eight landslide sites throughout the valley were carried out during the 2005 field survey including three areas of great interest: 1) east of Travaillant Lake (67.66˚N, 131.54˚W), 2) Thunder River (67.48˚N, 130.91˚W), and 3) northwest of Norman Wells (65.5˚N, 127.5˚W). The area east of Travaillant Lake is characterised by continuous permafrost with low to moderate ice content, low relief, low slopes, silty clay morainal deposits, and wetland/shrub land vegetation cover where mainly retrogressive thaw flows were mapped. Thunder River area is defined by extensive discontinuous permafrost with nil to moderate ice content, low relief, moderate slopes, glaciofluvial, morainal, and colluvial deposits, overlain by a coniferous forest where retrogressive thaw flows and active layer detachments were observed. The area northwest of Norman Wells is distinguished by extensive discontinuous permafrost with nil to moderate ice content, moderate relief, high slopes, and a coniferous forest cover. This area is covered by Quaternary deposits which include morainal and lacustrine units. An anticline formed by Devonian shale and limestone units cut by thrust faults was mapped in the area where exposed bedrock outcrops were observed. Multiple massive rock falls and rock slides were identified.