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IPL Project (IPL - 202) Annual Report Form 2025-2026

January 2025 to 30 April 2026

Changes to items 1-7 in the proposal: revised content in Red.

Form completed and submitted on 30 April, 2026 to ICL Network <icl-network@iclhq.org>

1. Project Number and Title:

IPL-202: SLOW-MOVING LANDSLIDE MONITORING PROJECT (THOMPSON VALLEY, BRITISH COLUMBIA, AND ASSINIBOINE VALLEY, MANITOBA, CANADA)

2. Main Project Fields

Fundamental Geoscience – Quaternary and Bedrock Geology, Geomorphology and Landform Evolution, Hydrogeology and Geophysics, Remote Sensing and Photogrammetry

Technology Development – Geohazard Mapping, Monitoring and Early Warning, Vulnerability and Risk Assessment

Capacity Building – Technology transfer and capacity building to government, academia, private sector, and communities; enhancing human and institutional capacities; collating and disseminating information/ knowledge

Mitigation, Preparedness and Recovery – Preparedness, mitigation and recovery related to socioeconomic infrastructure, monitoring and early warning, hazard mapping, vulnerability, and disaster-risk reduction assessment at targeted landslides

Name of Project leader: **David Huntley**

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Core members of the Project: Dr. David Huntley (Geological Survey of Canada); Prof. Michael Hendry and Prof. Renato Macciotta (University of Alberta); Prof. David Elwood (University of Saskatchewan)

3. Objectives: The Geological Survey of Canada (GSC), universities of Alberta and Saskatchewan, Canadian Pacific - Kansas City Railway (CPKC) and Canadian National Railway (CN) are coordinating a multi-partner effort to apply and test a suite of technologies and methods used in the characterization, assessment, and monitoring of slow-moving landslides in the Thompson River valley, British Columbia (BC), and Assiniboine River valley, Manitoba (MN). This work is funded by Transport Canada and National Science and Engineering Research Council (NSERC). Results are being shared with the professional community to improve global landslide monitoring.

4. Study Areas: Primary focus on the Ripley Landslide and North Slide but includes several others (Nepa Cross-Over Slide, Nepa Slide, South Slide) situated along the Thompson River, south of Ashcroft, BC; the Chilcotin River landslide, near Williams Lake, BC; and in the Assiniboine River valley, near Virden, MN. Secondary focus on remote landslide test sites with at-risk railway infrastructure, e.g., the Frenchman River valley, Saskatchewan (SK).

5. Project Duration: Project will continue indefinitely, depending on Federal funding (minimum to 2028)

6. Report

Progress in the project: Field-based research and conventional geoscience outreach activities in 2024-2025 encompassed work in the Thompson and Chilcotin river valleys, BC, and the Assiniboine River valley, MN.

Thompson River valley railway corridor. Field activities in 2024 included site visits in March and June 2024 (to begin installation of SparkFUN GNSS network), September 2024 (epochal and RTK-GNSS surveys), and March 2025 (inspect GNSS network after winter, and install). Desktop activities included the processing of UAV imagery using experimental and commercially available software, processing of fine and ultra-fine resolution RADARSAT Constellation Mission (RCM) synthetic aperture radar (SAR) imagery, and interrogation of climate data from the Thompson and Assiniboine weather stations.

Climate datasets for the Thompson River valley were compiled from a digital archive of data from the original station (2016-2019) and data from new weather station (2022 to 2024) accessed from the Hydromet Cloud (https://www.hydrometcloud.com). Air temperatures are highest in summer months (May to August) and lowest in winter months (December to February) (Figure 16a). Lower temperatures are also associated with higher precipitation rates, and the opposite applies for higher temperatures with lower precipitation. Over the years of observation (from 2016 to 2024), more extreme temperatures are recorded closer to 2024. For example, one of the coldest days was December 22, 2022, at -29.8°C. One of the hottest days was recorded on August

15, 2023, at 40.3°C. Conversely, precipitation rates have decreased over time, with highest precipitation recorded on January 5, 2018, with 2.40 mm of precipitation, either as rain or snowmelt.

When comparing daily temperature data with daily river discharge, a consistent relationship is observed: as discharge increases, so does temperature. Periods of high precipitation correspond with low discharge rates, while a decrease in precipitation is followed by a sharp increase in river discharge. Additionally, high precipitation in one year tends to result in high discharge in the subsequent year, and vice versa. This pattern suggests a delayed response of river discharge to changes in precipitation. The observed lag effects and cumulative impacts of precipitation on river discharge states the complexity of predicting hydrological responses to climate variables. Understanding these dynamics will enable more accurate predictive models and effective mitigation strategies.

At **Ripley Landslide**, geoengineered slopes continue to be monitored with RCM, revealing a reduction in a mean displacement rate from 4.4 cm/yr to 0.2 cm/yr across most of the slide body. Fresh tension cracks along the headscarp indicate the south flank of the slide is still active. The **North Slide** continues to be most active landslide intersecting railway infrastructure and remains the focus of attention by the GSC and stakeholders. Differences in RTK-GNSS measurements of ground control points (GCPs) across the North Slide between March 14, 2023, and June 27, 2024, are mostly <2 cm, so movement cannot be resolved within the accuracy and precision limits of the Spectra SP80 RTK system. GCP displacements >2 cm and <14 cm to the NW on the toe slope are consistent with displacement vectors derived from UAV DSMs and RCM InSAR. Snow sheds installed on 7 InSAR corner reflectors will extend InSAR time-series sets, allowing acquisition and processing of winter scenes. SparkFUN positioning modules installed in 2024 failed to record data over the winter months, prompting a redesign of installations to weather-proof electronics and improve solar power supplies to batteries. Following a ground inspection visit of the **Nepa Cross-Over Slide**, three sites for SparkFUN installations were identified to monitor the expansion of a tension crack developing on the north flank of the slide mass.

Chilcotin River landslide. Around midnight on July 30 and into the early hours of July 31, 2024, a 0.06 km^3 mass of unconsolidated fine-grained glacial sediments, 30-60 m thick and 600 m wide, and with an enclosed area of 1.22 km^2, failed on the north-facing valley slope, blocking drainage of Chilcotin River, British Columbia. Over the next six days, the landslide impounded a 0.8 km^3 lake that extended approximately 20 km upstream of the debris dam, nearly reaching the community of Hanceville. This ephemeral lake had an enclosed area of 7.4 km^2 at its maximum extent when the water level reached 585 m elevation, topping and breaching the dam on August 5, 2024. Out-flowing waters with high sediment load and woody debris incised the landslide dam, almost draining the lake over the next seven days. High-resolution epochal orthophotography captured with UAVs, oblique air photos captured with a single-lens reflex camera in a helicopter, and synthetic aperture radar satellite imagery of the Chilcotin Landslide are benchmarked with field observations and descriptions of earth materials and landforms. This foundational geoscience information on the form and function of the landslide and other geohazards in the Chilcotin River valley can be acted upon to quantify landslide risks and reduce the potential of downstream geohazard damage to, or destruction of vulnerable communities and critical infrastructure (e.g., settlement structures, highways, bridges, rail tracks), the environment and fragile ecosystems, and natural resources (e.g., forests, riparian zones, potable water supplies, salmon populations).

Assiniboine River valley railway corridor. Field activities were restricted to brief site visits in August 2024 (UAV surveys, reconnaissance), an opportunity afforded by short-lived industrial action. At the **CN Rivers** and **CPKC Bredenbury** sites, UAV overflights captured the ground conditions during summer. Both shallow, slow-moving planar-rotational slides appear to have undergone little deformation in 2024, suggesting continuing drought conditions across central Canada are influencing near-surface groundwater and slope stability. SparkFUN units installed across the CN Rivers slide by university partners will begin yielding measurements in the summer of 2025.

Assiniboine Valley weather station data was collected over two years, from May 23, 2022, to June 10, 2024. Only temperature, total precipitation, and relative humidity were assessed for time series analysis. Temperature data, averaged over daily means, fluctuates daily, and observable increases in from June-August, and decreases from December-February. Highest daily mean temperatures were found on July 17, 2022, with values averaging 26.6℃ and lowest daily mean temperatures on December 20, 2024, and January 14, 2024, at -28.8℃. Minimum and maximum temperatures were plotted to determine overall changes in daily temperatures. Daily maximum and minimum temperatures differ by 12.5 ± 5.2 ℃. Daily differences in maximum and minimum temperatures differ by 36.9 ± 18.4 %. Seasonal temperatures, calculated to obtain mean seasonal values, were found to be highest during the summer of 2022, averaging 18.1 ℃, and lowest during winter 2023, averaging -17.8℃. Comparing seasons, the fall and winter 2023 season had higher averages compared to fall and winter 2022. Relative humidity, averaged from 15-minute intervals to daily means fluctuated daily, but generally had higher values in winter and decreased values in summer. Minimum and maximum relative humidity were plotted to determine overall daily changes. Total precipitation was averaged over daily means and shows an increase in overall precipitation from 0 mm on May 23, 2022, to a cumulative value of 670 mm by June 2024 (the end of the time-series analysis). Increases in The change in total precipitation increased the most from June 2022 to the end of September 2022. From October 26, 2022, to April 19, 2024, the total precipitation did not significantly change, increasing by only 23.5 mm over a 6-month period.

The relationship between climate, precipitation and river stage is complex and has played an important role in initiating flooding events along the Assiniboine River. River stage (and discharge) is typically controlled by the spring freshet. The river stage time-series indicates that the timing of the spring freshet and the resulting rise in river stage varies from year to year. The variance in annual river stage during the freshet may be attributed to stream flow regulation by the upstream Shellmouth Reservoir / Lake of the Prairies (50° 57′ 49″ N 101° 25′ 07″ W), along with changes in snowpack accumulation from the previous winter or increased, and continued precipitation over the spring and summer seasons. Notable historical flooding events of the Assiniboine River occurred in 1826, 1950, 1979, 2009, 2011, and 2014. Some flooding events were caused by heavy snowfall in the winter followed by heavy and prolonged precipitation in the spring. Cold snaps in the winter result in deeper frost penetration and leads to less absorption of water and increased overland flow, while colder spring temperatures delay and concentrate the spring freshet.

Geoscience Outreach. Project 202 results were presented at one national conference (August 2024) and one technical workshop (February 2025). In August 2024, a poster was presented at the Canadian Quaternary Association biennial meeting in Regina, Saskatchewan, Canada. A 20-minute presentation was prepared for the annual Railway Ground Hazard Research Program (RGHRP) technical workshop. Over 80 professionals and students participated in a hybrid blend of live talks and pre-recorded presentations, with breakout sessions over two days in February 2025.

Planned future activities or Statement of completion of the Project: Plans for 2025-2028 include upgrades and repairs to the SparkFUN-GNSS and weather station networks, and internet connections to Ripley, Nepa Cross-Over, South and North slides in the Thompson River valley, BC. In addition, efforts will be focused on developing comparative landslide test sites along the Assiniboine River valley, MN. Collaboration with the Canada Centre for Mapping and Earth Observation (CCMEO) will be extended to enhance RCM InSAR data analysis. Ongoing InSAR, RTK-GNSS, UAV-DSM, and weather acquisitions will be compiled to develop models for geohazard management and landslide risk assessment. Transport Canada funding for 2025-2028 on landslide research and development will amount to $200,000.

Beneficiaries of Project for Science, Education and/or Society: Stakeholders benefitting from the project goals include the two primary rail companies in Canada (CN and CPKC), short line rail operators (e.g., Great Western Railway, Fife Lake Railway), professional geoscientists and landslide specialists, in addition to local resource-based communities. Research and development are also contributing to knowledge-transfer through the mentoring and training of highly qualified personnel (M.Sc. and Ph.D. students, and post-doctoral fellows).

7. Results

Project 202 publications released in 2023-2024 (see below) and in the coming years will greatly benefit regional, national, and global landslide communities. The following presentations were given, and publications released in **2024-2025.**

Conferences

Huntley, D., Rotheram-Clarke, D., Joseph, J., and Cocking, C. 2024. Railways, Geological Hazards, and Climate Change in the Assiniboine River valley, Manitoba-Saskatchewan, and Frenchman River valley, Saskatchewan. Canadian Quaternary Association, Conference Session 11, Towards Improving the Understanding of Natural Hazards and Risk, Poster. Regina, Saskatchewan

Huntley, D. 2025. Landslide Disaster Risk Reduction and National Railway Corridors: Enhanced Landslide and Climate Monitoring and Assessment Tools & Technologies. *Railway Ground Hazard Research Program, Technical Workshop*, Presentation, 20 slides. University of Alberta, Edmonton, Canada

Government publications (peer-reviewed)

Huntley, D.H. 2025. Surficial geology and geomorphology of the North Slide, Thompson River Valley, British Columbia: application of fundamental geoscience information to interpretations of geospatial monitoring results. Geological Survey of Canada, Open File Report, 22 pages (*in review*)

Huntley. D., Rotheram-Clarke, D., Joseph, J. and Cocking, R. 2025. Understanding Cordilleran and Prairie Landslides: railways, landslides and climate change research in the Thompson River valley, British Columbia, Assiniboine River valley, Manitoba-Saskatchewan, and Frenchman River valley, Saskatchewan. Geological Survey of Canada, Open File Report, 60 pages (*in review*)

Book chapter (peer-reviewed)

Huntley, D., Lakeland, B., Menounos, B., Geertsema, M., Hawkins, A. and Rotheram-Clarke, D. 2025. The July 30-31, 2024, Chilcotin Landslide, British Columbia, Canada: Enhancing Landslide Disaster Risk Reduction with AI-Powered UAV and Satellite Imagery Analysis, Benchmarked with Field Observations. Progress in Landslide Research and Technology, Vol. 4 (2), 31 p.