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IPL Project (IPL - 202) Annual Report Form 2023-2024

January 2023 to 31 March 2024

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

Form completed and submitted on 10 July 2024 to ICL Network <icl-network@iclhq.org>

1. Project Number and Title:

IPL-202: SLOW-MOVING LANDSLIDE MONITORING PROJECT (ASHCROFT, BRITISH COLUMBIA, AND VIRDEN, MANITOBA, CANADA)

2. Main Project Fields

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

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

Capacity Building – Technology transfer and capacity building to government and private sector; 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 risk 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 (Basque Slide, Nepa Slide, South Slide) situated along the Thompson River, south of Ashcroft, BC, Canada; and in the Assiniboine River valley, near Virden, MN, Canada. 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 2023-2024 encompassed work in the Thompson River valley, BC, the Assiniboine River valley, MN, and the Frenchman River valley, SK.

Thompson River valley railway corridor. Field activities included short site visits in March 2023 (decommissioning instruments), September 2023 (epochal and RTK-GNSS surveys), and March 2024 (installation of GNSS network). Desktop activities included the processing of UAV imagery using experimental and commercially available software, and processing of fine and ultra-fine resolution RADARSAT Constellation Mission (RCM) synthetic aperture radar (SAR) imagery. At Ripley Landslide, InSAR corner reflectors, Geocube and PRIME networks were decommissioned ahead of slope remediation. Geoengineering of the landslide will continue until 2025, after which time, long-term monitoring will resume. The North Slide continues to be most active landslide intersecting railway infrastructure and remains the focus of attention by the GSC and stakeholders. High-resolution photogrammetric change detection results using RTK-GNSS, and UAVs are successfully benchmarking RCM SAR interferometry datasets (see publications and presentations for 2023-2024). To improve interferometric analyses, 6 InSAR corner reflectors were installed over the active toe slope to act as persistent scatterers on the landslide. Replacing the Geocube installation, we are testing high-precision SparkFUN positioning modules track GPS, GLONASS, Galileo, and BeiDou satellite systems. These units operate on dual frequency bands, with receiver accuracies of 15 mm Horizontal and 10-20 mm Vertical, collect measurements every 60s of Longitude, Latitude, and Height above Ellipsoid, and store data on

32GB microSD cards.

Assiniboine River valley railway corridor. Field activities were restricted to brief site visits in October 2023 (UAV surveys, reconnaissance). At the CN Rivers and CPKC Bredenbury sites, UAV overflights captured the ground conditions at the transition from summer to fall. Oblique aerial photographs are aiding in the characterization of surficial geological at these sites. Rail tracks traversing the flanks of the Assiniboine valley encounter glaciolacustrine sediments, hummocky tills, shales and sandstones, colluvium, and alluvial deposits that are moderately to highly susceptible to shallow, slow-moving planar-rotational slides and gullying. University partners installed SparkFUN units across the CN Rivers slide. Both landslides appear to have undergone little deformation in 2023, suggesting continuing drought conditions across central Canada are influencing near-surface groundwater and slope stability. A reconnaissance field excursion to southwestern SK provided preliminary baseline observations of climate change impacts on landslides, other geohazards, and regional railway operations in the Frenchman River valley. River meandering and cutbank erosion appear to trigger localized landslides, with tension cracks and shallow slumping impact both ballast and tracks.

Geoscience Outreach. Project 202 results were presented at two prestigious international conferences in 2023 (see publications and presentations for 2023-2024). In July, a 15-minute presentation was given at the International Geoscience and Remote Sensing Symposium in Pasadena, California, USA. A second 15-minute talk was given at the 6th World Landslide Forum in Florence, Italy in November 2023. At the national level, a 40-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 March 2024.

Planned future activities or Statement of completion of the Project: Plans for 2024-2028 include upgrades and repairs to the SparkFUN-GNSS and weather station networks, maintenance and addition of soil moisture probes, and internet connections to Ripley, Nepa, 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 and Frenchman River valley, SK in collaboration with industry and academic stakeholders. Change detection monitoring will employ advanced UAV photogrammetric and LiDAR data for all slides that are hazards to railway infrastructure. Collaboration with the Canada Centre for Mapping and Earth Observation (CCMEO) will be extended to enhance RCM InSAR data analysis. Partnership with the railway industry is ongoing and information on rail infrastructure maintenance will potentially allow developing a quantitative correlation between landslide deformations in the area (satellite InSAR) and railway track serviceability and risk. Ongoing InSAR, borehole inclinometer, piezometric, and weather information will be compiled to develop models for geohazard management and landslide risk assessment. Transport Canada funding for 2024-2028

on landslide research and development will amount to $500,000.

Beneficiaries of Project for Science, Education and/or Society: Beneficiaries of the project include local resource-based communities, the two primary rail companies in Canada (CN and CPKC), short line rail operators (Great Western Railway, Fife Lake Railway), in addition to professional geoscientists and landslide specialists. Project 202 publications released in 2023-2024 (see below) and in the coming years will greatly benefit regional, national, and global landslide 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

The following presentations were given, and publications released in **2023-2024.**

Conferences

Huntley, D., Rotheram-Clarke, D., LeSueur, P., Cocking, R., Joseph, J. and MacLeod, R. 2023. Direct comparison of RADARSAT Constellation Mission InSAR, UAV & RTK deformation methods at North Slide, Thompson River Valley, British Columbia. *International Geophysical and Remote Sensing Symposium*, Presentation, 12 Slides. Pasadena, California, USA

Huntley, D., Rotheram-Clarke, D., LeSueur, P., Cocking, R., and Joseph, J. 2023. IPL PROJECT 202 – Landslide disaster-risk reduction along Canada's primary national railway corridor: comparing geospatial measurement methods of deformation at North Slide, Thompson River Valley, British Columbia, Canada. *6th World Landslide Forum*, Presentation, 10 Slides. Florence, Italy

Huntley, D. 2024. 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, 50 slides. Montreal, Quebec, Canada

Peer-reviewed publications

Sharifi, S., Macciotta, R., Hendry, M., Rotheram-Clarke, D., and Huntley, D. 2023. Evaluating topography-based methods in 3D decomposition of InSAR 1D velocities obtained for translational landslides: Thompson River Valley in Canada. Landslides, https://doi.org/10.1007/s10346-023-02153-0

Book chapters

Huntley, D., Rotheram-Clarke, D., LeSueur, P., Cocking, R., Joseph, J. and MacLeod, R. 2023. Direct comparison of RADARSAT Constellation Mission InSAR, UAV & RTK deformation methods at North Slide, Thompson River Valley, British Columbia. *International Geophysical and Remote Sensing Symposium*, Abstracts and Papers Volume, 8 pages

Huntley, D., Rotheram-Clarke, D., MacLeod, R., Cocking, R., Joseph, J. and LeSueur, P. 2023. Landslide monitoring with RADARSAT Constellation Mission InSAR, RPAS-derived point-clouds and RTK-GNSS time-series in the Thompson River Valley, British Columbia, Canada. *Progress in Landslide Research and Technology*, Vol. 2 (1), 8 pages

Huntley, D., Rotheram-Clarke, D., Sattler, K., and Elwood, D. 2023. Surficial geology and geomorphology of the North Slide, Thompson River valley, British Columbia: application of fundamental geoscience information to interpretations of geospatial monitoring results. *Progress in Landslide Research and Technology*, Vol. 2 (2), 16 pages