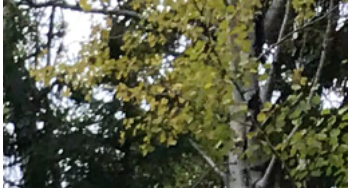
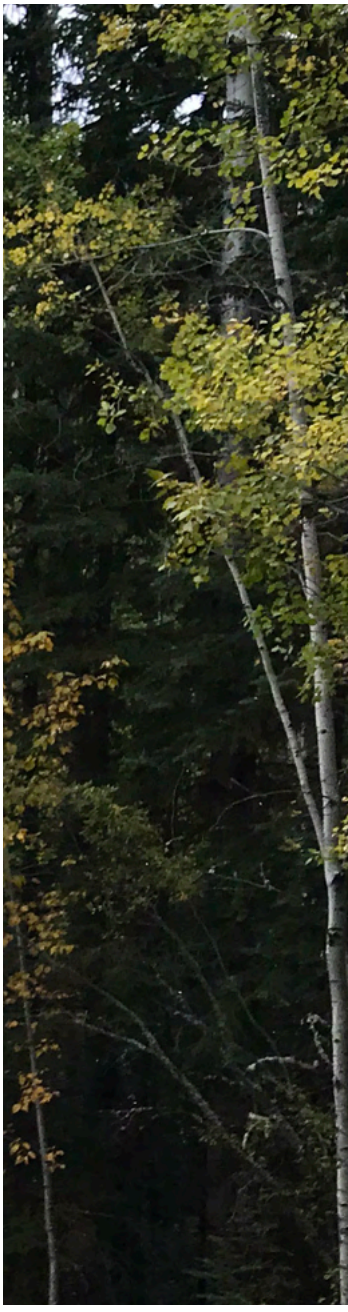




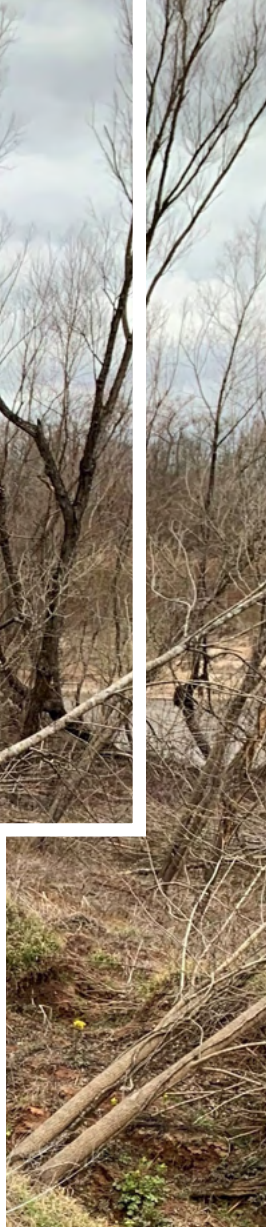
Pipelines

Statement of Qualifications

BGC Engineering Inc.

Vancouver | Victoria | Kelowna | Kamloops | Calgary | Edmonton | Toronto | Kingston | Ottawa | Halifax | Fredericton | Golden | Santiago | Santo Domingo | Brisbane

bgcengineering.ca



Services

BGC partners with pipeline companies from around the world to manage geohazard risk throughout the pipeline lifecycle. This includes continual management of geohazard programs with office and field-based inspections, on-site geotechnical support during pipeline construction, and proactive decisions pertaining to geohazard threats. Primary ways BGC supports pipeline companies in their management and solution of geohazards are summarized below:

CAMBIO™: CUSTOM SOFTWARE TO SUPPORT GEOHAZARD MANAGEMENT PROGRAMS

Using a regional expertise built from managing over 250,000 geohazard sites across 440,000 km (273,400 mi) of pipelines internationally to see system-wide and industry trends

Reducing geohazard-related failure rates by 3 to 4 times relative to the industry average[1]

Supporting risk decisions with probability of failure (PoF) assessments for multiple types of geohazard mechanisms[2]

Integrating geohazard characterizations from Cambio into operator-specific risk assessments

BUILDING RESILIENCY TO CHANGING CONDITIONS

Monitoring and assisting in the evaluation and response to extreme flooding, precipitation, and seismic events using near real-time data and automated alerts from Cambio

Integrating remote observation datasets such as InSAR, lidar change detection (LCD), and automatically processed satellite optical images into one place to understand changing conditions

Utilizing site-specific instrumentation to reduce uncertainty when characterizing geohazards

SITE-SPECIFIC SUPPORT

Applying practical solutions to help our clients quickly respond to weather emergencies and other conditions that could trigger geohazards

Conducting forensic reviews of geohazard failures

Designing hydrotechnical and geotechnical mitigations with a focus on common sense and constructability

Overseeing stress relief projects and other geotechnical integrity digs

UNDERSTANDING GEOHAZARD INDUCED PIPELINE STRAINS

Reviewing existing inertial measurement unit (IMU) bending strain data to identify where a geohazard may already have impacted a pipeline[3]

Estimating strain demand using reality-based finite element analysis (FEA) by incorporating geology and existing IMU signatures

Using IMU data to understand complex landslide mechanics before designing a mitigation

ROUTING, GEOHAZARD CHARACTERIZATION AND DESIGN

Providing early support to ensure the best opportunity to reduce pipeline geohazard risk

Committing to "getting the geology right" with geohazard characterization to support route selection, including routes through extreme environments

Designing engineering solutions to keep infrastructure safe

Developing geotechnical soil spring constants to support later pipeline stress analyses and FEA

SUPPORTING PIPELINE CONSTRUCTION

Providing BGC expertise across a range of complex geological environments

Providing timely and efficient recommendations on areas including trenchless crossings, foundations, access road construction, slope restoration, geohazard mitigation measures, slope drainage, and erosion control

Conducting organic soil delineation and construction soil verification to compare field observations to design parameters

COLLABORATION WITH CLIENTS

Pursuing research and development in partnership with clients and universities and efficiently leveraging joint interests

Facilitating inter- and intra-company discussions on geohazard related pipeline failures, successful mitigative measures, and the latest tools in geohazard management

Supporting conversations with regulators, the industry and the public through published papers, short-courses, presentations, and as invited panel participants

Cambio: Custom Software to Support Geohazard Management Programs

BGC developed the Cambio Geohazard Management System over 20 years ago to support pipeline operators with their integrity management programs. Cambio supports a systematic and proactive approach to tracking and evaluating geohazards. This is achieved by building a comprehensive geohazard inventory and using a consistent methodology to assign a probability of failure (PoF). With Cambio, pipeline operators can proactively manage their geohazard management programs, plan for inspections or mitigations, and allocate resources at the appropriate interval based on the hazard significance. All of this in a secure, cloud-hosted system that can be accessed from the office or in the field, and in a defensible and documented framework that is auditable and easily communicable to regulators and senior management. Statistical review shows that clients who use Cambio have a 3 to 4 times lower geohazard failure rate than the industry average.

Features of the Cambio Geohazard Management System include:

- Filterable and exportable geohazard inventories
- A single location to store all relevant data for geotechnical, hydrotechnical, and seismic hazards
- The integration of multiple data sources including the River Network Tools™ (RNT), lidar and lidar change detection, IMU bending strain features, and landslide susceptibility mapping to create a comprehensive view of potential threats
- Real-time flood, rainfall & earthquake monitoring with an integrated alert system
- A modern user interface with tabular and map formats that can be exported to other platforms
- A companion mobile application for geohazard field inspections
- Algorithms to calculate site-specific annual probabilities of exposure, impact, and failure, that go through continual review and enhancement based on real-world statistics and advances in knowledge

SELECTED EXPERIENCE

INVENTORY AND PRIORITIZATION OF GEOTECHNICAL AND HYDROTECHNICAL HAZARDS

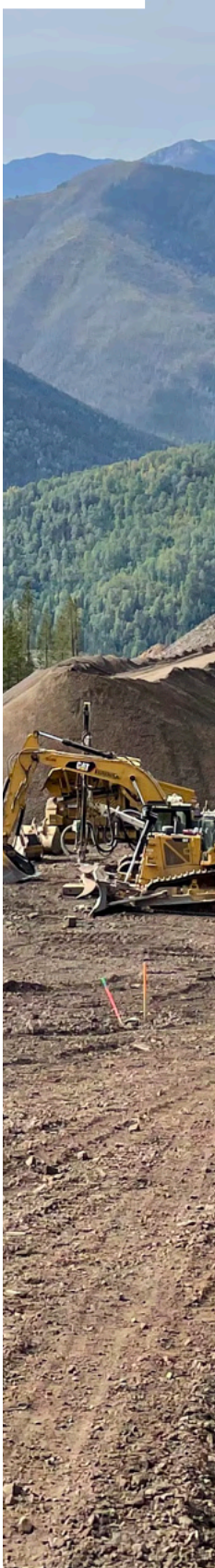
BGC personnel leverage the Cambio platform to compile an extensive inventory of geohazards. This is done by assembling multiple data sets together, including public data, proprietary client data, and BGC's in-house RNT system, and uses them to perform desktop hazard assessments along the pipeline alignment. The development of an extensive geohazard inventory allows operators to understand their overall geohazard risk along their system and prioritize the next actions required in their management program.

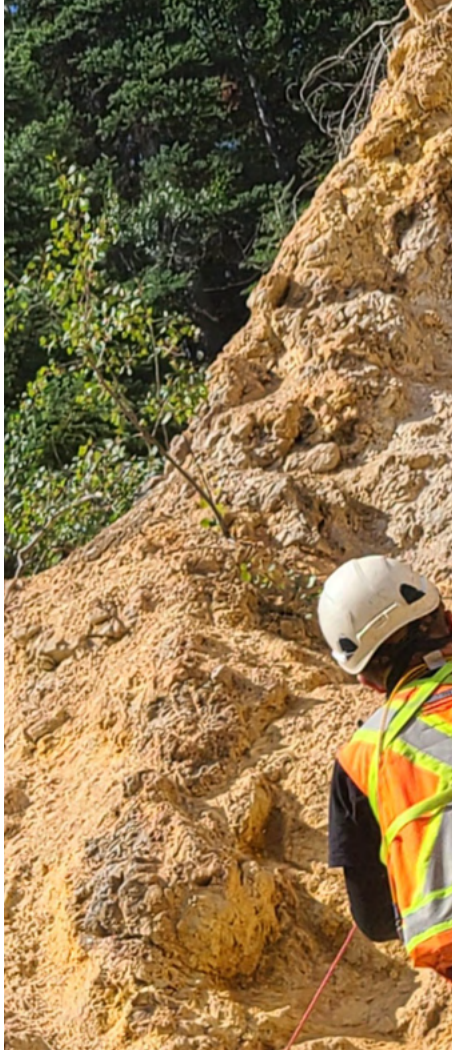
GEOHAZARD ASSESSMENTS DESIGNED AROUND CLIENT GEOHAZARD MANAGEMENT GOALS

Over the past 20 years, BGC has completed over 113,000 ground inspections, with 11,000 inspections completed in 2021 alone. Ground inspections consist of recording site-specific geomorphological characteristics, the activity of geohazards and their potential mechanisms, and measuring the pipeline's depth of cover. The Cambio algorithms use field data to assign vulnerability, probability of exposure, probability of impact, and probability of failure. The field-level assessments serve to differentiate the high category geohazard sites that need detailed investigations from the remainder of the sites in the client's geohazard inventory, and allows the client to target their resources to the highest hazard sites.

IDENTIFYING IMMINENT GEOHAZARD FAILURE SITES

Cambio management processes are able to identify sites that require further detailed investigation methods (IMU bending strain, instrumentation, detailed site characterization, etc.) to reduce uncertainties. In 2021 alone, over 15 sites affecting various Cambio clients were identified as near-failures and benefited from proactive risk reduction measures. Identifying critical geohazard sites to our clients brings BGC closer to our 2025 goal of efficiently reducing the global risk of pipeline incidents and failures caused by geohazards by more than 10%.





Building Resiliency to Changing Conditions

BGC's core business revolves around establishing practical solutions to critical earth science challenges. Unrecognized changing conditions present a challenge to pipeline integrity management, but limited resources mean that close monitoring for changing conditions is typically reserved for known, high-priority sites. To address the data gap over the remaining system, BGC has integrated remote observation data into the Cambio platform so that desktop monitoring can be efficiently applied to an operator's entire system complete with automatic alerts when thresholds are exceeded. This integration also promotes the visualization of all datasets in one place which enables better decision making. Some of our tools to monitor for changing conditions include:

AUTOMATED ALERTS CONFIGURED FOR SYSTEM-WIDE MONITORING

Flood and precipitation monitoring

Receive proactive alerts about anticipated high-flood and precipitation events, calibrated to characteristics of each pipeline crossing

Seismic monitoring

Identify whether a seismic event occurs close enough to an asset to be of concern (scaled by magnitude and distance or peak particle velocity) and guide post-event field assessments to areas prone to liquefaction or seismically-induced landslides

REMOTE SENSING, CONFIGURED FOR SYSTEM-WIDE OR SITE-SPECIFIC MONITORING

Lidar change detection

Identify and measure landslide activity, subsidence, erosion, or encroaching anthropogenic activities that occurs between two lidar datasets

InSAR

Large area coverage to assess centimeter-scale ground movement occurring between satellite passes

SITE-SPECIFIC INSTRUMENTATION

Integrating near real-time or manual instruments into Cambio, setting alert thresholds for subsequent management decision

SELECTED EXPERIENCE

PROACTIVE RISK REDUCTION DECISION TRIGGERED BY FLOOD MONITORING

Confidential Client | Central United States | 2018

In 2018, the BGC flood monitoring program proactively alerted a large pipeline operator to a forecasted extreme flood event on a large river that was expected to be capable of exposing the pipeline and causing a vortex-induced vibration (VIV) failure. The flood action thresholds had been determined in advance through a detailed hydrotechnical investigation completed by BGC and subsequently the river flow was monitored in near real-time through Cambio. With this information, the pipeline operator decided to proactively shut-in the pipeline during the flood event. As flooding receded, a survey was conducted and found that large sections of the pipeline were exposed and spanning. The proactive shut-in reduced the possible consequences of a VIV failure during the flood event.

ASSESSMENT AND MONITORING OF SEISMICALLY INDUCED HAZARDS ALONG THE TRANS MOUNTAIN EXPANSION PROJECT (TMEP)

Trans Mountain | Alberta and British Columbia, Canada | 2011 - ongoing

The TMEP pipeline intersects areas in the Lower Mainland region of British Columbia that can be prone to seismic liquefaction. BGC performed detailed assessments of liquefaction and seismically induced ground displacement along the route at sites screened as the highest hazard, incorporating subsurface information from more than 70 SPT drill hole and cone penetration tests along with hundred of terrain mapped polygons. BGC completed pipe-soil structural analyses to characterize the interaction of the pipeline with permanent ground displacements from liquefaction or seismic-induced slope failures. Leveraging these results, TMEP uses the Cambio seismic module to monitor for seismic events of concern at more than 40 locations throughout the region.

CORRIDOR-SCALE LANDSLIDE MONITORING WITH LIDAR AND INSAR

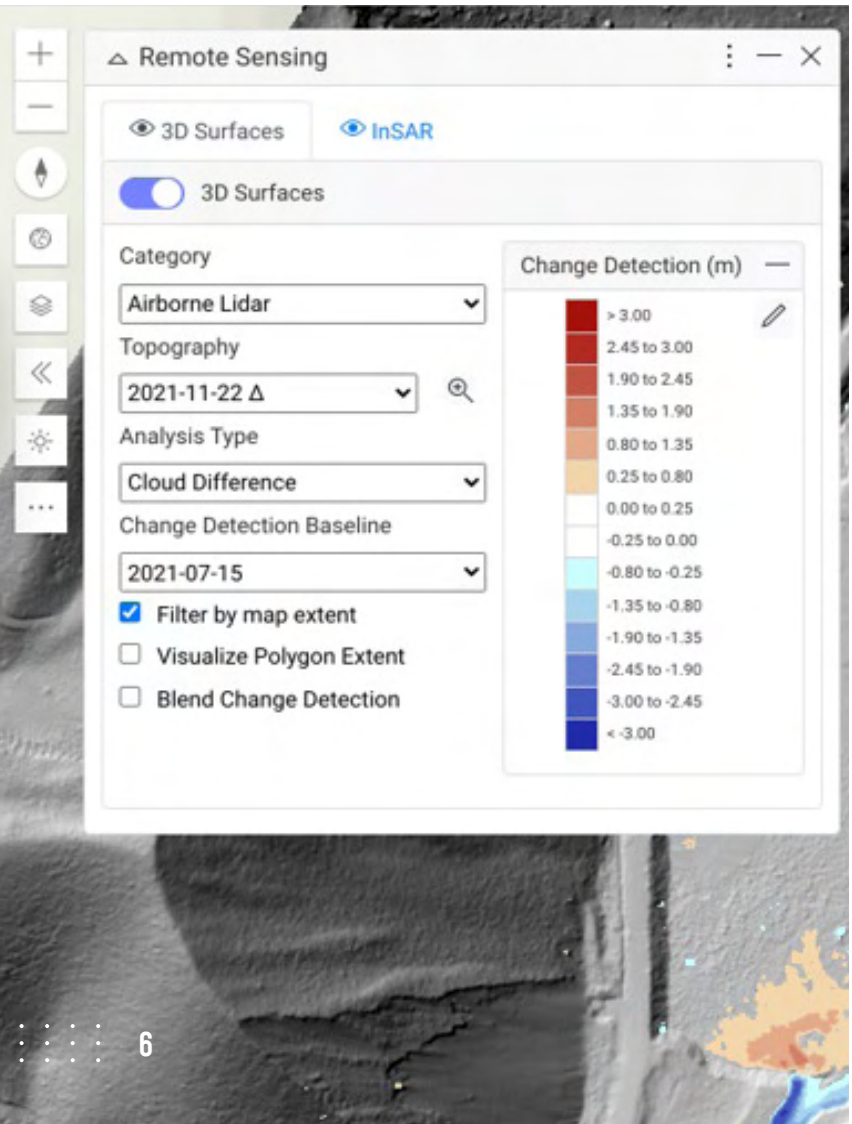
Enbridge Gas | Eastern United States | 2020 - ongoing

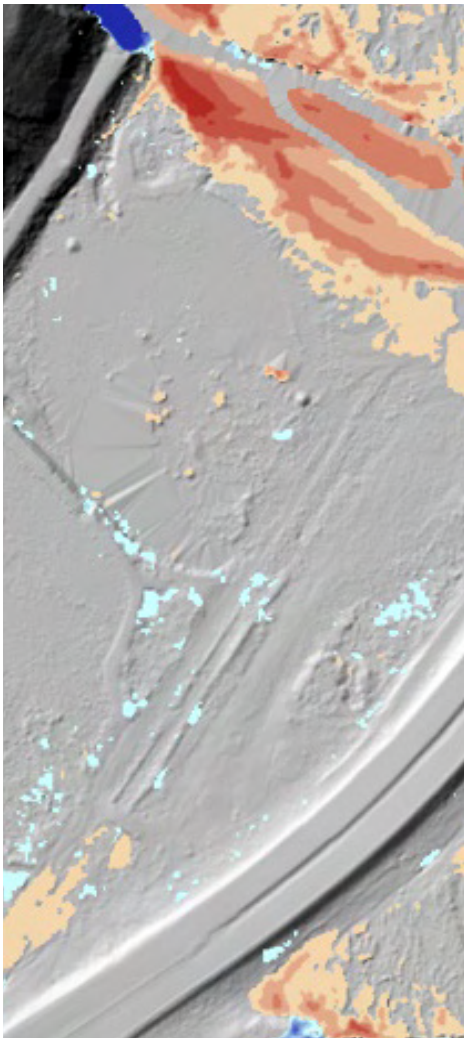
BGC performs corridor-scale lidar change detection over more than 16,000 km (10,000 mi) of right-of-way through areas of dense landslide terrain as part of a routine monitoring program. These broad reviews improve the understanding of hazard activity across thousands of sites and alert the geohazard team to accelerations, encroachments, and other changing conditions. InSAR analysis through these same corridors monitor for potential reactivation of sites of concern. Combined, these remote sensing tools enable site-specific monitoring while remaining selective about installing site-specific instrumentation.

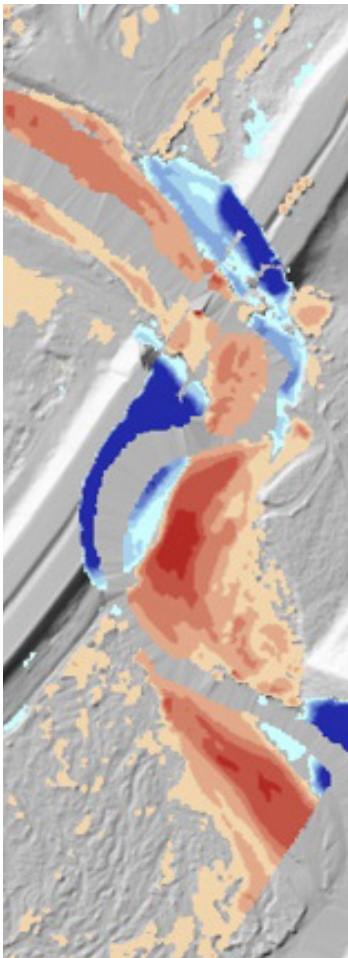
MEASURING MOVEMENT ALONG ARTESIAN SANDS WITH NEAR-REAL TIME INSTRUMENTATION

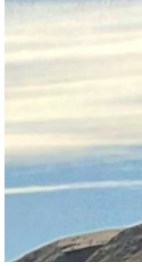
Confidential Client | Alberta, Canada | 2018 - ongoing

BGC was brought into a site where multiple operators crossed a broad, valley-scale landslide complex. IMU at the site confirmed that each operator's pipeline was deformed by landslide movement. Multiple pieces of instrumentation, including shape accel arrays (SAAs), slope inclinometers (SIs) and vibrating wire piezometers (VWPs), were installed to characterize the landslide behavior. The instrumentation revealed that the landslide was sliding along an artesian sand layer located below the valley bottom, a particularly unusual geometry because the landslide toe remained below the surface of the glacially infilled valley. Notifications from the near-real time instruments about landslide accelerations play a key roll in future operational decisions for these clients.









Site-Specific Support

BGC is a global leader in geohazard management and provides detailed site support both from the office and in the field utilizing the diverse expertise of our international team. As climate change continues to impact flood frequencies and other climate statistics, BGC has helped our clients by providing timely, practical solutions in response to unforeseen weather emergencies. BGC provides year-round hydrotechnical and geotechnical mitigation design support both for routine mitigations and in response to emergent conditions.

HYDROTECHNICAL ANALYSIS AND MITIGATION DESIGN

Where riverbed scour or lateral channel migration has resulted or could result in pipeline exposures, instream measures such as riverbed and bank armouring or river training structures may be effective solutions for mitigating the geohazard and bringing the pipeline back into regulatory compliance. BGC can help to assess the feasibility of instream mitigation measures compared to alternative measures such as HDD or open-cut replacement, as well as lead these projects from concept development to detailed design and construction. BGC has contributed to numerous hydrotechnical mitigation design projects by conducting:

- Depth of cover surveys with scour potential analysis
- Channel migration, bank erosion, and encroachment assessments
- Hydrologic and hydraulic analysis and modelling
- Flow failure displacement assessments of riverbanks related to seismic events
- Debris flow and debris flood hazard assessments
- Support during acquirement of regulatory approvals
- Channel stabilization and mitigation designs, from conceptual options to detailed designs
- Technical support during construction

GEOTECHNICAL ANALYSIS AND MITIGATION DESIGN

Ground movement or surface water erosion can expose and/or impact a pipeline. BGC analyses the site-specific conditions and then in partnership with our clients comes up with practical solutions including issued for construction (IFC) designs allowing operators to mitigate or reroute pipelines exposed to landslides, rockfalls and other geotechnical hazards. BGC can provide support for our pipeline clients by providing:

- Geotechnical drilling supervision, including soil logging, potential slip plane identification and instrumentation installation
- Forensic review of geohazard failures, including landslide and deformation assessments
- Slope stability modeling and slope support designs: shear keys, toe berms and soil anchors
- Trenchless and trenched crossing design and support
- Rock fall and debris flow barrier design
- Pipeline stress reliefs and corrosion/anomaly digs
- On-site supervision and support during construction

SELECTED EXPERIENCE

EMERGENCY RESPONSE TO A GEOTECHNICAL INCIDENT

Enbridge Gas | Eastern United States | 2019

Following a ground movement-induced pipeline failure in Appalachia, BGC reviewed approximately 400 km (225 mi) of IMU for indications of previous landslide strain, performed more than 70 immediate site visits, and supported 9 emergency mitigations over the course of three months. BGC supported conversations with regulators demonstrating that the system was safe and that lessons learned were being applied.

LANDSLIDE RESPONSE IN THE RAIN FOREST

COGA | South America | 2018 - 2019

BGC conducted a detailed field assessment at a landslide site in South America which had damaged a natural gas liquids pipeline. Field evidence demonstrated that the landslide was deeper than originally assumed and involved displacement within weak mudstone bedrock. The creation of a geologic model enabled the development of safe, practical, and cost-effective mitigation strategies and risk-informed selection of a preferred mitigation option.

EMERGENCY RESPONSE SUPPORT TO A WEATHER EMERGENCY

Multiple Clients | British Columbia, Canada | 2021

An atmospheric river made landfall in southwestern British Columbia in November 2021 and triggered flooding, bank erosion, and debris flows. The event effectively cut off Vancouver and other communities from the BC mainland for several weeks. BGC leveraged its relationships with pipeline, railways, transportation owners, communities, and First Nations, to facilitate a coordinated emergency response and collect high resolution lidar and orthophotos in the days and weeks after the event. The emergency response considered the hazards' impact to different pieces of infrastructure along shared corridors. Response efforts included rapid field and aerial assessment of impacted sites, lidar analysis and LCD, weather analysis, and mitigation support to rapidly return assets to service.

POUCE COUPE RIVER MITIGATION

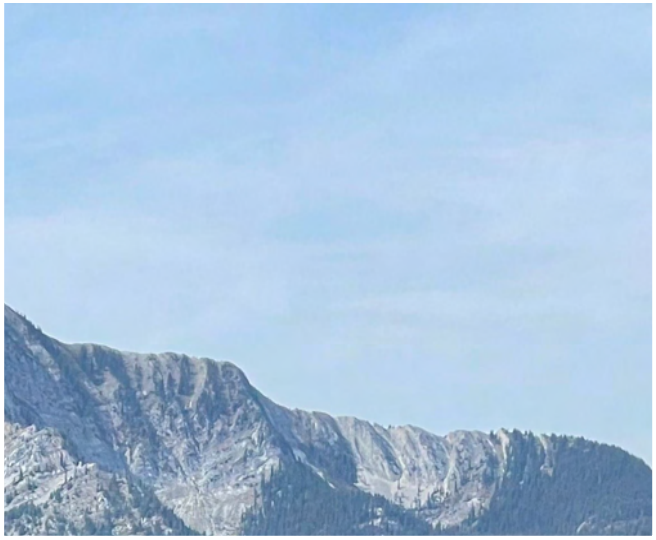
Westcoast | Alberta, Canada | 2017

Following exposure of the pipeline during high flows, a temporary riprap revetment was constructed to re-establish cover over the pipeline until long-term mitigation of the crossing could be designed and implemented. BGC supported temporary mitigation of the crossing through detailed design, acquisition of regulatory permits, and construction. BGC also completed a detailed feasibility assessment of potential long-term mitigation options including instream armouring, HDD, and open-cut replacement.

SLOPE STABILIZATION DESIGN

Pembina | Alberta, Canada | 2020 - 2022

Multiple pipelines and operators traverse an active landslide on an approach slope of a major river valley. Relatively large magnitudes of ground movement were observed in 2020 and confirmed to have impacted the pipelines from inertial bending strain surveys. BGC provided an assessment of various long-term mitigation options for Pembina and the adjacent operator. From this assessment, maintaining the current pipeline installations and stabilizing the slope was selected for being the most cost-effective option while meeting the risk reduction requirements. BGC prepared construction drawings and provided on site engineering support for earthworks and the installation of 53 horizontal drains and 134 post-tensioned soil anchors.



Understanding Geohazard Pipeline Strains

BGC is an industry leader in integrating IMU bending strains and other in-line inspection (ILI) data into geohazard assessments, recently reviewing more than 20,000 km (12,000 mi) of IMU data for geohazard signatures. An informed understanding of geohazard movement mechanisms and expected pipeline responses allows BGC to confirm when a pipeline is being impacted by a geohazard; this serves to focus resources to affected sites and allows for informed site monitoring using data that operators are already collecting.

Depending on the severity of hazard impact (measured strain) or an operator's sensitivity at a particular site, a subsequent finite element analysis (FEA) may be warranted. FEAs are used to assess the interaction between the ground and the pipeline, allowing for an estimation of the strain state of a pipeline and the magnitude of ground displacement that would produce a critical strain. It is therefore critical that the FEA be calibrated to realistic site conditions before it is used to drive key decisions. These site conditions include defining soil spring constants and their extents, defining a reasonable ground displacement profile, and if applicable, recreating the existing IMU bending strains. BGC collaborates with FEA service providers to provide these critical geotechnical inputs and assess whether the interim results are appropriate.

SELECTED EXPERIENCE

GEOHAZARD SCREENING THROUGH IMU REVIEW

Enbridge Gas | United States | 2019 - 2021

BGC used IMU data provided by Enbridge to screen approximately 19,000 km (12,000 mi) of pipeline for evidence of geohazard impact to several transmission pipelines. Integrated analysis of geomorphology and IMU allowed each strain feature to be binned into "tiers" indicating whether the strain was likely induced by geohazards, likely not, or uncertain. In dense Appalachian landslide terrain, the screening process narrowed the subset of priority sites (those impacted by geohazards) to <10% of those inventoried by traditional desktop assessments[3].

HDD "NO-DRILL ZONE" DESIGN INFORMED BY IMU SIGNATURES

Confidential Client | British Columbia, Canada | 2021 - 2022

BGC reviewed available IMU data and found that IMU signatures were indicative of landslide impact, and that these signatures helped explain the landslide's movement mechanism. Upon review of the IMU data, BGC's client planned a replacement HDD. BGC used the existing pipeline's landslide-induced IMU signature to assess the depth and mechanism of sliding and interpret the depth at which the new pipeline could be safely routed below the movement zones. The IMU was foundational to the development of the geohazard "no drill zone" to develop the replacement alignment.

CHARACTERIZE ACCEPTABLE LANDSLIDE DISPLACEMENTS WITH FINITE ELEMENT ANALYSIS

Westcoast Energy | British Columbia, Canada | 2022

Landslide compression at the toe of a slope, combined with a low depth of cover, produced unintentional pipeline overbending and uplift. BGC characterized the geotechnical parameters and collaborated with an FEA contractor to produce a model that realistically recreated the existing IMU bending strain pattern. The resulting model identified that small magnitude landslide displacements could induce critical total strains in the pipeline. The FEA was used to assess what level of ground displacement was acceptable, and thereby informed the timing and robustness of the slope mitigation. The results of the analysis determined that a temporary mitigation would provide limited value and a permanent mitigation was required.

Routing, Geohazard Characterization, and Design

BGC's experts assist clients with pipeline routing and geohazard characterization to avoid geohazards where practical, and if unavoidable, we provide engineering solutions to keep infrastructure safe. BGC has experience providing geohazard support for new pipeline projects in varied environments, including prairies/plains, mountainous, sub-arctic, high precipitation, and arid environments. Our geotechnical services provided to pipeline clients starts with early routing through detailed design and includes:

Terrain mapping & geohazard identification

Soil delineation, including organics for buoyancy control and soil spring constants

Bedrock characterization for excavatability and potential of acid rock drainage (ARD) and metal leaching (ML)

Permafrost delineation and characterization

Onshore and offshore geotechnical investigations

Geohazard risk assessment and erosion control

Detailed geotechnical feasibility assessments for HDDs and other trenchless crossings

Seismic liquefaction/lateral spreading assessments, fault crossing evaluations, and seismic slope stability assessments

Watercourse crossing evaluation and design

Slope and cut/fill stability design

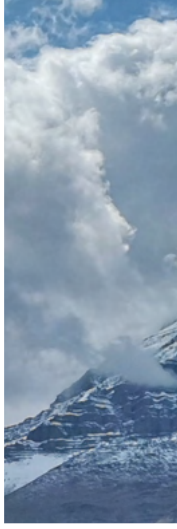
Shallow, deep, and anchored foundation designs

SELECTED EXPERIENCE

SUPPORT FOR CANADA'S TRANS MOUNTAIN EXPANSION PROJECT (TMEP)

Trans Mountain | Alberta and British Columbia, Canada | 2011 - ongoing

Terrain mapping with field verification of 1100 km (680 mi) of pipeline, with ground conditions ranging from competent bedrock to extremely low strength marine clays. BGC's support included route-wide geohazard assessment including landslides, rockfall and debris flow potential; seismic hazard assessments including liquefaction/lateral spreading; provision of a route-wide quantitative geohazard failure frequency assessment[4]; ARD/ML route assessments; and shallow water characterization for buoyancy control. In addition, hydrotechnical hazard characterization for over 800 trenched water crossings, detailed geotechnical investigations for 50 major trenchless crossings, investigations at over 200 road and rail bore crossings, and a feasibility investigation of a 4 km (2.5 mi) tunnel were conducted. All designs considered changing conditions due to climate change with the overall project following a risk-based design.



GEOTECHNICAL DESIGN OF THE NORLITE DILUENT PIPELINE (NDP) PROJECT

Enbridge Pipelines | Alberta, Canada | 2014 - 2019

Geotechnical design for NDP included terrain mapping and muskeg delineation along the proposed pipeline alignment, a slope assessment of the pipeline alignment to identify and characterize slope hazards requiring additional monitoring/pipeline design, several geotechnical drilling investigations at slopes and trenchless crossings, support with pipeline routing in locations with geotechnical hazards and providing designs for high-risk slopes. BGC also provided geotechnical support during pipeline construction.

ROUTE SELECTION AND DESIGN SUPPORT FOR PRINCE RUPERT GAS TRANSMISSION (PRGT)

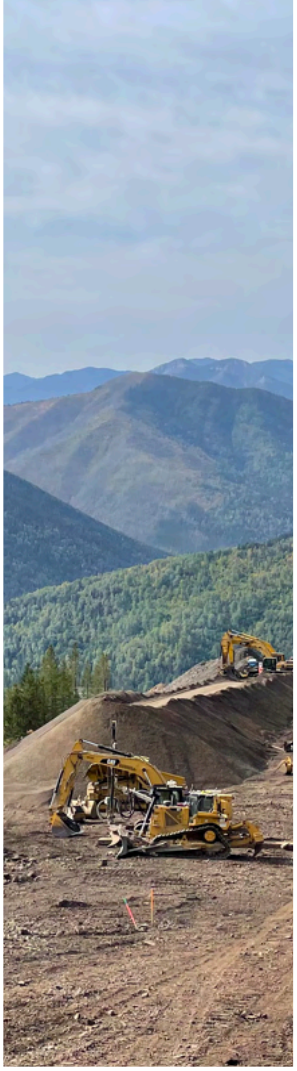
TC Energy | British Columbia, Canada | 2012 - 2015

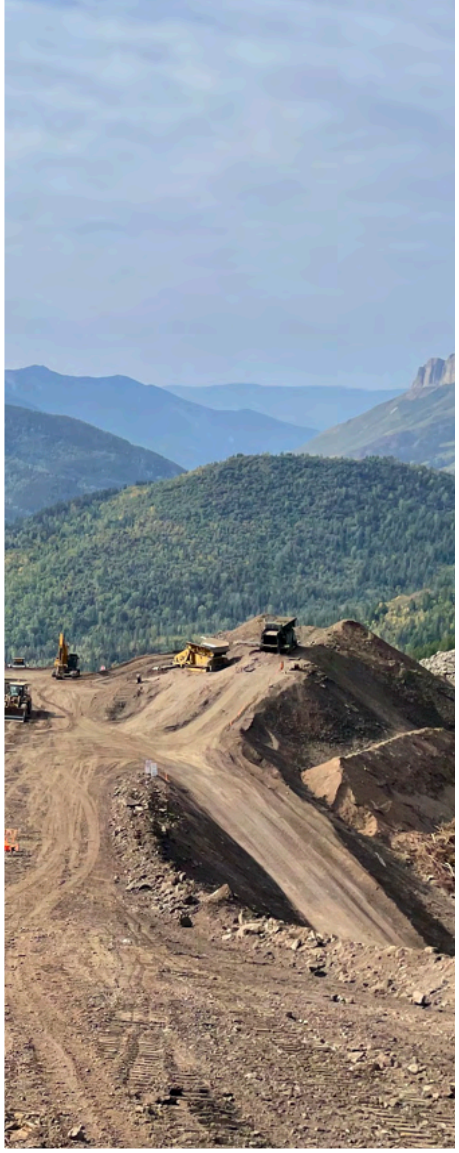
BGC completed terrain stability mapping for 1500 km (930 mi) of pipeline routes. BGC also completed an assessment of terrestrial and nearshore geohazards, mapping of shallow bedrock, erosion control, muskeg delineation for buoyancy control, and foundation design for aerial crossings, valves, compressor stations, and construction camp sites. Hydrotechnical hazard characterization for over 1000 trenched water crossings and nearshore geotechnical drilling and geophysical surveys were completed for six shore transition areas. A seismic fault assessment was conducted including analyzing lidar, aerial photographs, and geological maps to identify landforms indicative of possible Holocene surface rupture along geological faults. BGC completed detailed geomorphic and geologic mapping around landform targets to determine their genesis and earthquake hazard potential. In addition, BGC estimated displacements for pipeline crossings of potentially active faults and provided geotechnical parameters for fault crossing design.

DESIGN AND CONSTRUCTION SUPPORT FOR TC WEST PATH DELIVERY (WPD) 2022 AND 2023 PROGRAMS NATURAL GAS PIPELINE NPS 48

TC Energy | Alberta and British Columbia, Canada | 2019 - ongoing

The WPD program includes eight new 48-inch (1219 mm) sections of the TC Energy natural gas midstream western system, operated by NOVA Gas and Foothills Pipe Lines. BGC is providing applied earth science services for the Front-End-Engineering-and-Design phase for four of these eight proposed sections. BGC leveraged its multi-disciplinary, one-team approach to provide support to the WPD including: terrain mapping, assessments, recommendations and designs for geohazards (hydrotechnical, steep creeks, seismic, landslides and geotechnical), civil investigations and recommendations for once considered cable crane system and valve site foundations, culvert designs, soil properties for pipe stress design, crossing assessments, site specific assessments, bedrock excavatability assessments, and ARD/ML management. BGC is providing geotechnical and geochemical support through the ongoing construction of three of the four sections. The ARD/ML sampling and testing program involves the commissioning and operating of an on-site laboratory of which purpose is to optimize turn-around-time for test results and associated provision of guidance for spoil handling.





Supporting Pipeline Construction

Construction of new pipelines often occurs in complex geologic environments with challenging soil conditions, in the presence of geohazards, and in unforgiving terrain. BGC has experience providing construction support services to owners and prime contractors to keep projects moving forward.

Some of BGC's construction support services include:

Trenchless crossing support (HD-Bore, Auger Bore, Direct Pipe, HDD)

Cut-slope assistance and fill placement assessment

Acid rock drainage (ARD) and metal leaching (ML) management

On-site geohazard design and support as site conditions during construction evolve

Slope drainage and erosion control

Implementation of geohazard mitigation measures and slope restoration

Organic soil delineation and construction soil verification

Access road construction monitoring and materials sourcing

Facility foundation construction assessment and monitoring

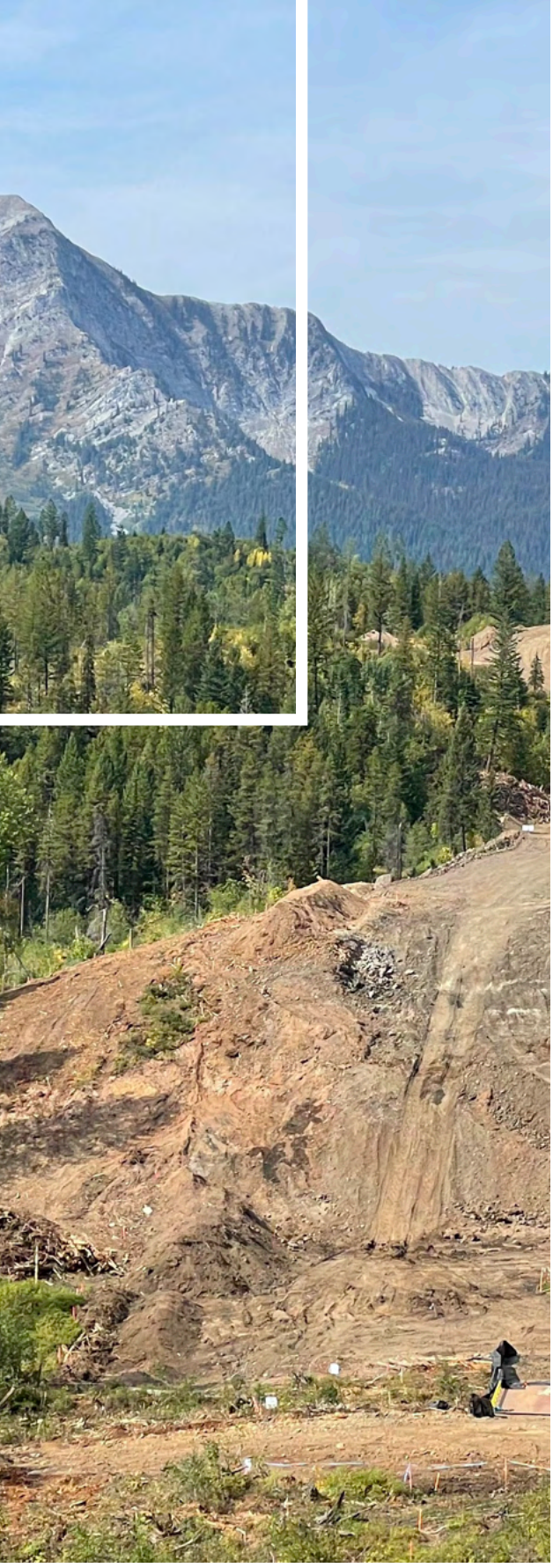
Post-construction geohazard inventory development

SELECTED EXPERIENCE

VARIED CONSTRUCTION SUPPORT FOR THE LINE 3 REPLACEMENT (L3R) PROJECT

Enbridge Pipelines | AB, SK, and MB, Canada | 2017 - 2020

The L3R project is the replacement of the existing Line 3 pipeline with a new 36-inch pipeline spanning over 1100 km (680 mi) from Hardisty, AB to Gretna, MB. BGC provided geotechnical support during construction including monitoring of geohazard slopes, soil classification of the alignment for overbend mitigation, monitoring of trenchless crossings, and reviewing the post-construction right-of-way for potential geotechnical issues.



ON-SITE GEOTECHNICAL SUPPORT FOR THE NORTH MONTNEY MAINLINE (NMML)

NOVA Gas Transmissions Ltd. And TC Energy | British Columbia, Canada | 2019 - 2021

NMML is a new 206 km (128 mi) 42-inch natural gas line connecting producers of the Peace River Regional District, BC, to an existing NOVA Gas line at the Saturn Metering station. BGC provided geotechnical support including monitoring of grading activities and soil verification for buoyancy control. In addition, BGC completed on-site design and support for inventoried geohazard slopes, including active landslides.

CONSTRUCTION SUPPORT FOR THE NORLITE DILUENT PIPELINE PROJECT (NDP)

Enbridge Pipelines | Alberta, Canada | 2014 - 2019

Enbridge constructed the NDP, a new 24-inch diluent line spanning over 445km (275 mi) between Fort Saskatchewan, AB and Ft McMurray, AB. BGC provided geotechnical support for construction on slopes including site specific landslide mitigation designs and implementation, slope restoration designs, field fits of drainage measures, and post-construction mitigation support.

CONSTRUCTION SUPPORT FOR THE TRANS MOUNTAIN EXPANSION PROJECT (TMEP)

Trans Mountain | Alberta and British Columbia, Canada | 2011 - ongoing

BGC had been involved in detailed engineering support for TMEP since 2011, and in 2019 transitioned into a construction support role. BGC acts as the Geotechnical Engineers of Record for our designs and as Owner's Engineer providing oversite on geotechnical and hydrotechnical challenges encountered during construction. Over the 1100 km of construction, BGC has had a team providing continual field presence across the project including at rivers for hydrotechnical site support, at road and rail crossings for support for monitoring for unplanned settlement, and at steep slopes or within high-risk geohazard areas with on-site geotechnical observations and mitigation support for unforeseen conditions or where rapid field-based adjustments and decisions are required.

Key Team Members

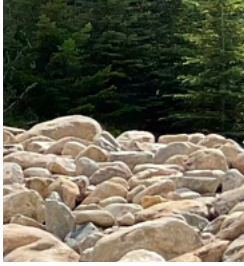
BGC offers a team of professional engineers and geoscientists with extensive experience in the pipeline industry. BGC's experts lead the industry in research and papers in a wide variety of journal and conferences, including PHMSA and PRCI.

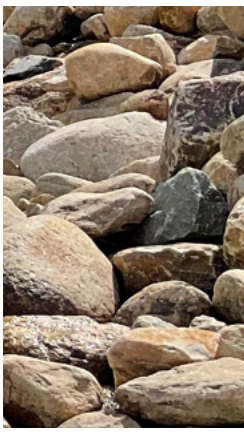
J. PETER BARLOW, M.Sc., P.Eng.

Pete is a Director and Principal Geotechnical Engineer with over 30 years' experience in his field and sits on BGC's Pipeline Leadership Team. He is a world-renowned expert in the application of engineering geology and geotechnical engineering to the pipeline industry, with a key focus on the assessment and mitigation of a wide range of geohazards. He has extensive experience in the areas of route selection, horizontal directional drilling, slope stability, geohazards, muskeg terrain, pipeline river crossings in general, soil-pipe interaction, IMU bending strain analysis, foundation design and site development related to tanks, pump stations and pipeline facilities. He has been involved in numerous new pipeline projects from initial planning stages through to construction; as well as many existing systems in relation to risk assessments and dealing with a range of geotechnical issues. This has included slope stability remediation; re-routes; settlement and ground movement mitigation; groundwater problems; erosion repair; reclamation; line exposures, stress analyses, emergency response with landslide related ruptures and numerous other issues.

ALEX BAUMGARD, Ph.D., P.Eng., P.Geo.

Alex is a Principal Geotechnical Engineer with over 25 years' experience providing consulting to both private industry as well as governments throughout North and South America, Europe, and Africa. His experience extends to both onshore and offshore pipelines, seismic soil analysis, as well as traditional geotechnical and geo-environmental areas. Alex has participated in the geohazard assessment of more than a dozen major pipelines, in such environments as steep mountains and regions subject to earthquakes and evaluated and mitigated sites subject to landslides. Since 2001, Alex has participated in the risk assessment/management of more than 10,000 km (6,000 mi) of pipeline and has led the geotechnical evaluation and design of pipeline projects from feasibility studies through preliminary engineering and into detailed engineering and design. He is the coauthor of over 10 technical papers. Alex is part of BGC's Management Team as the lead of the ERT and sits on BGC's Pipeline Leadership Team.





MICHAEL PORTER, M.Eng., P.Eng., LEG

Mike is a Director and Principal Geological Engineer with a broad background in engineering geology and geotechnical engineering, with over 25 years' experience. His technical work focuses on the development and implementation of geohazard risk management programs for the oil and gas, hydropower, transportation, and mining industries. He led one of Canada's first applications of quantitative landslide risk assessment for the management of urban landslides in North Vancouver, directed the reservoir shoreline studies and participated in the public consultation process for the Site C Clean Energy Project, and acted as an expert witness following the 2014 Oso Landslide in Washington State. He is a coauthor of the Canadian Technical Guidelines on Landslides, and author of over 40 technical papers on topics ranging from the numerical modeling of mine pit slope deformations to the investigation, risk assessment and remediation of landslides and other natural hazards. Mike is also a part of BGC's Pipeline Leadership Team.

CHRIS CAMPBELL, P.Eng.

Chris is a Geotechnical Engineer with BGC and has eleven year's experience working on technical projects and as a project manager. He is currently one of the members of BGC's Pipeline Leadership Team and is the Office Manager of BGC's westernmost office in Victoria, BC. Chris's project management experience includes managing teams of 5 to 15 people and working with some of Canada's largest pipeline companies to implement and maintain successful geohazard management programs. His technical project experience includes geotechnical site investigations, geohazard mapping and assessment for new pipeline routing projects and risk-based geohazard management. He has extensive experience working in challenging terrain along pipeline corridors in Western Canada. His experience also includes coordination of multi-disciplinary field programs, geohazard identification and inspection, landslide and erosion mitigation design and construction supervision, subsurface drilling investigations, landslide and pipeline monitoring, and scour assessments for pipeline river crossings.

HAMID KARIMIAN, Ph.D., P.Eng.

Hamid is a Principal Geotechnical/Earthquake Engineer and has over 20 years of experience in the fields of civil and geotechnical projects with a special focus on the design of buried pipelines, geotechnical earthquake engineering, geohazard characterization, and advanced laboratory testing. He has valuable international experience working on projects in Iran, Canada, Dominican Republic, and Chile. Hamid's expertise in pipelines also involves soil-pipe interaction problems, IMU interpretation, assessment of geohazard impact on pipelines, and pipe-stress and strain evaluation, including numerical modelling and finite element analyses of the pipeline and surrounding soil. He has close connections with academia and has been teaching soil mechanics and pipeline design courses as a seasonal instructor at both the British Columbia Institute of Technology and the University of British Columbia. Hamid has published several papers on the topics of soil and pipeline interaction problems in refereed journals and conference proceedings.

SARAH DAVIDSON, Ph.D., P.Geo.

Sarah is a Senior Geoscientist with BGC and has over 10 years of experience. She is currently a member of BGC's Pipeline Leadership Team. Sarah has diverse research and industry experience in fluvial geomorphology. In her project work Sarah often completes flood frequency analyses, historical assessments of geomorphic changes, and two-dimensional hydraulic modelling. Her experience also includes predicting riverbed scour and lateral change to support hazard assessments at pipeline crossings throughout Canada. In addition, she has developed numerical models to predict bank erosion during flood events in mountain streams. This modeling has been applied in hazard assessments in a range of stream types and settings across North America and Sarah is now overseeing the implementation of a bank erosion algorithm in Cambio. Sarah is also currently the project manager for hydrotechnical mitigation projects for a large pipeline operator and is the hydrotechnical lead for the pipeline team.

CASEY DOWLING, M.Sc., P.E.

Casey is a Senior Geological Engineer with BGC and has over ten years experience, working on a wide variety of geotechnical projects ranging from pipeline routing studies, detailed landslide investigations and system-wide geohazard management for pipeline operators. He is also one of the members of BGC's Pipeline Leadership Team. In recent years, Casey has focused on landslide characterization, mitigation design, and IMU bending strain analysis across a broad swath of North America, specializing in the Appalachian geology. The diversity of locations and landslide processes have given him a strong understanding of the complex mechanics of landslides, as well as the best and most practical methods to investigate and mitigate unstable slopes in a variety of geological and physiographical settings. Casey has been involved for several years with courses that BGC offers to pipelines operators including the pipeline geohazard management course and the IMU bending strain analysis course; in addition to internal BGC training initiatives.

KATHERINE JOHNSTON, M.Sc., P.Eng., P.Geo.

As a Senior Geological Engineer with BGC, Katherine has nearly 20 years of technical and project management experience working on a broad range of geotechnical and hydrogeological projects throughout western and northern Canada. She is a core manager at BGC leading the HR and Strategy teams and is also one of the members of BGC's Pipeline Leadership Team. She has led multi-disciplinary teams providing geohazard assessment, as well as geotechnical and hydrotechnical design support for new pipeline projects. Technical components of these projects have included assessment of terrestrial and nearshore geohazards, subsurface investigations to support horizontal directionally drilled stream and lake crossings, offshore geotechnical investigations for shore transition areas and terrain analysis to assess shallow rock excavatability, acid rock drainage and organic soils.

SARAH NEWTON, P.Eng.

Sarah is a Senior Geological Engineer with BGC. Sarah specializes in geohazard identification, assessment, and risk management. Sarah is currently the Product Lead for BGC's geohazard risk management software, Cambio. She has been a project manager for engineering and software projects and has field experience in diverse environments. Sarah has contributed to the advancement of geohazard risk assessment algorithms and data collection methodologies, including the development of screening level algorithms to assess pipeline vulnerability to hydrotechnical forces at watercourses and ground movement forces at landslides. She has supported the implementation of geohazard integrity management programs, the methods of which have been applied to 450,000 km (280,000 mi) of pipelines in North and South America.

JOEL VAN HOVE, M. Eng., P.Eng.

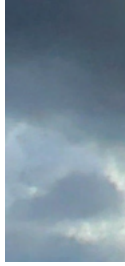
Joel has more than 15 years' experience specializing in pipeline related geohazards. His work as a Geological Engineer has focused on landslide hazards, including geohazard inventory development, probabilistic hazard assessment, landslide investigation and characterization, pipeline stress assessment and landslide stabilization. Although he primarily specializes in the large-scale deep-seated landslides of the western Canadian Sedimentary Basin, he has also worked on technical projects in landslide terrain in Peruvian Amazon and the Appalachians. Joel's project experience includes managing multimillion dollar geohazard management programs. His core skills and experiences include development of geological and slope stability models, integration, and assessment of geotechnical instrument data, and IMU bending and axial strain data assessment. Joel is currently serving on BGC's Pipeline Leadership Team and on the extended Management Team as lead of the Pipelines team.

BETH WIDMANN, M.Sc., P.G.

Beth is a Senior Geologist and has nearly 30 years of experience in applied geology and earth sciences. She has an extensive background in field geology and is an author on numerous geological hazard maps and investigations. Her work has focused on delineating, mitigating, and managing geological hazard risk associated with linear infrastructure including oil and gas pipelines, transportation and rail corridors, and water and wastewater conveyance systems. She has been the project manager for several geological and geotechnical projects from small, public utility projects to large complex energy sector pipeline projects across North America and Canada. Beth's experience also includes developing risk-based asset management plans to assist in the prioritization and implementation of preventative and mitigative measures to manage threats posed by geological hazards.

MARK ZELLMAN, M.Sc., P.G., CPG, GISP

Mark is a Senior Geologist with over 20 years experience in a broad range of geological and geotechnical related projects. His primary field of practice is geological and geotechnical site analysis and geohazard assessments with a specialization in seismic hazards. His work includes active fault studies and scale site-specific probabilistic seismic hazard assessments for pipeline infrastructure. For these studies his contributions have included geologic and geomorphic mapping, paleoseismic investigations, geophysical investigations, and seismic source characterizations for sites distributed globally. His experience also includes design, support, and management of complex, and often multidisciplinary studies for a wide variety of projects including energy facilities, dams, pipelines, canals, and other infrastructure for municipal and private entities. Mark has co-authored several technical papers related to seismic hazard assessments.



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