

Anne Gunn Ph.D. Curriculum Vitae

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EDUCATION

Ph.D. 1973 Imperial College, University of London, UK

B.A. Natural Sciences 1969 Trinity College, Dublin, Eire

EXPERIENCE AND SKILLS

As a field biologist, I have designed and managed programs for territorial government and co-management boards in wildlife management and environmental assessment. While with the Government of the NWT (1979-2006), I was the regional biologist in the central Arctic and then Caribou Biologist based in Yellowknife. Since becoming an independent consultant in 2006, I have provided technical advice on caribou conservation and management for the Wek'èezhii Renewable Resource Board, Mackenzie Valley Environmental Impact Review Board, Beverly Qamanirjuaq Caribou Management Board, Deline Renewable Resource Council, Qikiqtani Inuit Association, Kivalliq Inuit Association, Kitikmeot Inuit Association and World Wildlife Fund Canada. At the international scale, I help organize Arctic Council's Circum-Arctic Rangifer Monitoring and Assessment (CARMA) Network and am a member in the International Union for the Conservation of Nature's Deer Specialist and Caprinae Groups.

While I have designed and implemented caribou assessment and conservation programs, I have also formed university and government interdisciplinary partnerships to undertake studies. I have taken lead roles in data analyses and writing reports and journal publications and have presented seminars to university research groups and the public. I have worked with graduate students for their thesis research in the field and was the external examiner for Ph.D. thesis defenses in 2019 and 2006 (University of British Columbia and University of Alberta).

POSITIONS HELD

<i>Independent consultant</i>	2006 – present	Salt Spring Island, BC
<i>Government of the Northwest Territories</i>		
Caribou Biologist	1993 – 2006	Yellowknife
Kitikmeot Regional Biologist	1984 - 1993	Cambridge Bay; Kugluktuk
Wildlife Biologist	1979- 1984	Yellowknife
<i>Canadian Wildlife Service</i>		
Various biologist positions	1973-79	Ottawa, Edmonton

HONORS/AWARDS

Fellow, Arctic Institute of North America 1996

Premier's Award for Excellence, Northwest Territories, 2004

AUTHORSHIP: BOOK AND BOOK CHAPTERS

Caughley, G. and A. Gunn. 1996. Conservation biology in theory and practice. Blackwell Science, Cambridge, Mass. USA.

Gunn, A., C.J. Johnson, J. S. Nishi, C. J. Daniel, M. Carlson, D. E. Russell, and, J. Z. Adamczewski. 2011. Addressing Cumulative Effects in the Canadian Central Arctic – Understanding the Impacts of Human Activities on Barren-ground Caribou. Chapter 8. In eds. P. R. Krausman and L. K. Harris. Cumulative Effects in Wildlife Management: A Critical Aspect of Impact Mitigation. Taylor and Francis. 274pp.

Gunn, A. and J. Adamczewski. 2003. Muskox. Ch. 50 In: wild mammals of North America. Eds. G. Feldhamer, B. A. Chapman, and J. A. Chapman. The Johns Hopkins University Press, Baltimore. 1216 pp.

Gunn, A. 2001. Conservation and resource use in Arctic ecosystems. Pages 424-439. In Conservation of Exploited species. Eds. R. D. Reynolds, G. M. Mace, K. H. Redford and J. G. Robinson. Cambridge University Press, Cambridge, U.K.

- Gunn, A. 1998. Caribou and muskox harvesting in the Northwest Territories. Chapter 12. *In Conservation of biological resources*. Eds. E.J. Milner-Gulland and R. Mace. Blackwell Science, Cambridge, Mass, USA.
- Gunn, A. and T. Skogland. 1997. Responses of caribou and reindeer to global warming. Pages 189-200. *In Global change and arctic terrestrial ecosystems*. Eds. W. C. Oechel, T. Callaghan, J. I. Holten, B. Maxwell, U. Molau and B. Sveinbjornsson. Springer-Verlag, New York.
- Gunn, A. 1995. Responses of arctic ungulates to climate change. Pages 90-104. *In Human ecology and climate change*. Eds. D. L. Peterson and D. R. Johnson. Taylor and Francis, Washington, DC, USA.

AUTHORSHIPS: JOURNAL PUBLICATIONS SINCE 2000

- Kauffman, M. J., Cagnacci, F., Chamailé-Jammes, S., Hebblewhite, M., Hopcraft, J. G. C., Merkle, J. A., Mueller, T., Mysterud, A., Peters, W., Roettger, C., Steingisser, A., Meacham, J. E., Abera, K., Adamczewski, J., Aikens, E. O., Bartlam-Brooks, H., Bennitt, E., Berger, J., Boyd, C., Zuther, S. (2021). Mapping out a future for ungulate migrations. *Science*, 372, 566–569.
<https://doi.org/10.1126/science.abf0998>
- Russell, D., A. Gunn and R. White. 2021. A decision support tool for assessing cumulative effects on an Arctic migratory tundra caribou population. *Ecology and Society* 26 (1):4. [online] URL: <https://www.ecologyandsociety.org/vol26/iss1/art4/>
- Boulanger, J., K. G. Poole, A. Gunn, J. Adamczewski, and J. Wierzchowski. 2021. Estimation of trends in zone of influence of mine sites on barren-ground caribou populations in the Northwest Territories, Canada, using new methods. *Wildlife Biology* 2021: 1-16
- Gurarie, E., Hebblewhite, M., Joly, K., Kelly, A.P., Adamczewski, J., Davidson, S.C., Davison, T., Gunn, A., Sutor, M.J., Fagan, W.F., Boelman, N., 2019, Tactical departures and strategic arrivals: Divergent effects of climate and weather on caribou spring migrations, *Ecosphere*, 10 (12), e02971.
- Chen, W., S. G. Leblanc, H. P. White, C. Prevost, B. Milakovic, C. Rock, G. Sharam, H. O'Keefe, L. Corey, B. Croft, A. Gunn, S. van der Wielen, A. Football, B. Tracz, J. Snortland Pellissey, J. Boulanger. 2017. Does Dust from Arctic Mines Affect Caribou Forage? *Journal of Environmental Protection* 8: 258-276.
- McFarlane, K., A. Gunn, M. Campbell, M. Dumond, J. Adamczewski & G. A. Wilson. 2016. Genetic diversity, structure and gene flow of migratory barren-ground caribou (*Rangifer tarandus groenlandicus*) in Canada. *Rangifer*, 36: 1-24.
- Poole, K. P., A. Gunn, J. Wierzchowski and M. Anderson. 2015. Peary caribou distribution within the Bathurst Island Complex relative to the boundary proposed for Qausuittuq National Park, Nunavut. *Rangifer Special Issue No. 23*: 81-98.
- Adamczewski, J., A. Gunn, J. Nishi, K. Poole, and J. Boulanger. 2015. What happened to the Beverly caribou herd after 1994? *Arctic* 68:407-421.
- Gunn, A., D. Russell and L. Greig. 2014. Insights into integrating cumulative effects and collaborative co-management for migratory tundra caribou herds in the Northwest Territories, Canada. *Ecology and Society* 19 (4): 4. [online] URL: <http://www.ecologyandsociety.org/vol19/iss4/art4/>
- Gunn, A. and D. E. Russell. 2013. Changing abundances in migratory tundra caribou and wild reindeer and the role for a circumpolar collaborative network. *IUCN Deer Specialist Group Newsletter* 25: 3-10.
- Gunn, A., Russell, D.E., Daniel, C.J., White, R.G., & Kofinas, G. 2013. CARMA's approach for collaborative and inter-disciplinary assessment of cumulative effects. – *Rangifer Special Issue* 21:161-166.
- Russell, D.E., P.H. Whitfield, J. Cai, A. Gunn, R.G. White and K. Poole. 2013. CARMA's MERRA-based caribou climate database. *Rangifer*, 33, Special Issue No. 21:145-152.
- Russell, D.E., G. Kofinas, A. Gunn, R.G. White and S. Kutz. 2013. CircumArctic *Rangifer* monitoring and assessment (CARMA) network – origins, goals, accomplishments and future. *Rangifer*, 33, Special Issue No. 21:141-144.
- Gunn, A., K. G. Poole, J. Wierzchowski, J. S. Nishi, J. Adamczewski, D. Russell and A. D'Hont. 2013. Have geographical influences and changing abundance led to sub-population structure in the Ahlak caribou herd, Nunavut, Canada? *Rangifer Special Issue No.21*:35-58.
- Gunn, A., Poole, K.G. and Nishi, J.S. 2012. A conceptual model for migratory tundra caribou to explain and predict why shifts in spatial fidelity of breeding cows to their calving grounds are infrequent. *Rangifer Special Issue No. 20*: 259–267.
- Gunn, A., Russell, D.R. and J. Eamer. 2011. Northern caribou population trends. *Canadian Biodiversity: Ecosystem Status and Trends 2010 Technical Thematic Report Series No. 10*. Canadian Councils of Resource Ministers. Ottawa, ON. 55 p.
- Chen, W., D.E. Russell, A. Gunn, B. Croft, W.R. Chen, R. Fernandes, H. Zhao, J. Li, Y. Zhang, K. Koehler, I. Olthof, R.H. Fraser, S.G. Leblanc, G.R. Henry, R.G. White & G.L. Finstad. 2012. Monitoring habitat condition changes during winter and pre-calving migration for Bathurst Caribou in northern Canada, *Biodiversity* 10:1-9. DOI:10.1080/14888386.2012.705110
- Witter, L. A. C. J. Johnson B. Croft, A. Gunn, and L. M. Poirier. 2012. Gauging climate change effects at local scales: weather-based indices to monitor insect harassment in caribou. *Ecological Applications* 22: 1838–1851.

- Witter, L. A., C. J. Johnson, B. Croft, A. Gunn and M. P. Gillingham. 2012. Behavioural trade-offs in response to external stimuli: time allocation of an Arctic ungulate during varying intensities of harassment by parasitic flies. *Journal of Animal Ecology* 81: 284–295.
- Boulanger, J., K. G. Poole and A. Gunn. 2012. Estimating the Zone Of Influence of Industrial Developments on Wildlife: A Migratory Caribou and Diamond Mine Case Study. *Wildlife Biology* 18: 164-179.
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- Gunn A., Russell, D., White, R. & Kofinas, G. 2009. Facing a Future of Change: Migratory caribou and reindeer. *Arctic*. 62(3):3-4.
- Zalatan, R., A. Gunn and G. H. R. Henry. 2006. Long-term Abundance Patterns of Barren-ground Caribou Using Trampling Scars on Roots of *Picea mariana* in the Northwest Territories, Canada. *Arctic, Antarctic, and Alpine Research* 38: 624–630.
- Gunn, A., F. L. Miller, S. J. Barry and A. Buchan. 2006. A near- total decline in caribou on Prince of Wales, Somerset and Russell Islands, Canadian Arctic. *Arctic* 59:1-13
- McNeil, P. , D.E. Russell, B. Griffith, A. Gunn, and G.P. Kofinas. 2005. Where the Wild Things are: Seasonal Variation in Caribou Distribution in Relation to Climate Change. *Rangifer*, Special Issue No. 16: 51-63
- Lyver P.O'B. and A. Gunn. 2004. Calibration of Hunters' Impressions with Female Caribou Body Condition Indices to Predict Probability of pregnancy. *Arctic* 57:233-241.
- Gunn, A. 2003. Voles, lemmings and caribou - population cycles revisited? *Rangifer* Special Issue 14: 105-112.
- Gunn, A., F.L. Miller, and S.J. Barry. 2003. Conservation of erupting ungulate populations on islands -a comment. *Rangifer* 23: 57-65
- Miller FL and Gunn A. 2003. Status, population fluctuations and ecological relationships of caribou on the Queen Elizabeth Islands: Implications for survival. *Rangifer* Special Issue 14: 213-226.
- Miller, F. L. and A. Gunn. 2003. Catastrophic Die-off of Peary Caribou on the Western Queen Elizabeth Islands, Canadian High Arctic. *Arctic* 56:381-390.
- Gunn, A. and R. J. Irvine. 2003. Subclinical parasitism and ruminant foraging strategies- a review. *Wildlife Society Bulletin* 31:117-126.
- Gunn, A., F.L. Miller, and J. Nishi. 2000. Status of endangered and threatened caribou on Canada's Arctic Islands. *Rangifer* Special Issue No. 12:39–50.

List of other 50+ journal papers (prior to 2000) and 80 + unpublished reports and government reports available on request.



LORAX
ENVIRONMENTAL

BRUCE MATTSON (P.GEO. M.SC.)
SENIOR ENVIRONMENTAL GEOSCIENTIST

EDUCATION:

M.Sc. Hydrogeology
University of Idaho

B.Sc. Geology
University of Alberta

PROFESSIONAL AFFILIATION

Engineers and Geoscientists British Columbia (EGBC)

Northwest Territories Association of Professional Engineers and Geoscientists (NAPEG)

EXPERIENCE

Bruce has a strong mining, geological, hydrogeological and geochemical background with over 25 years of experience working as a consultant and working directly for the mining industry. This background has proven to be invaluable for evaluating environmental risk associated with metal leaching / acid rock drainage (ML/ARD) and developing effective science-based remedial measures. Bruce has been responsible for evaluating the geochemical reactivity of tailings and waste rock at numerous mine sites in North America, South America, Europe, Africa, and Southeast Asia. Direct observation and analysis of mine waste and drainage chemistry from operating and abandoned mines combined with the knowledge regarding geochemical testing protocols and their limitations is critical for conducting geochemical characterization studies and independent technical reviews. The cumulative breadth of knowledge and experience gained during the past 25 years has been directly applied in the development of mine waste management and mine decommissioning plans. Most recently, these skills have been applied to assess biogeochemistry and metal attenuation in mine waters for the development and design of passive water treatment systems and pit lake models.

AREAS OF EXPERTISE

- ML/ARD Prediction and Assessment
- Mine Waste Management
- Surface and Groundwater Hydrology
- Passive Water Treatment & Metal Attenuation

REPRESENTATIVE METAL LEACHING / ACID ROCK DRAINAGE PROJECTS

Site C Clean Energy Project – ML/ARD Qualified Professional Peace River Hydro Partners – Fort St. John, B.C.

- Develop operational ML/ARD Management and Monitoring Plan to ensure compliance with regulatory requirements.
- Evaluate potential risks of contamination to groundwater through development of groundwater Action Response Plan, development and review quarterly groundwater monitoring reports, and groundwater loading study.
- Environmental reporting to BC Hydro and Provincial Water Comptroller regarding management of ML/ARD and site water discharges to the Peace River.
- Evaluate and recommend options on site requirements for water treatment.

Line Creek Operations - Dry Creek Water Quality Assessment Teck Corporation – Sparwood, B.C.

- Review and compile existing laboratory and field geochemical kinetic tests to assess the observed water quality downstream of the mine spoils that was not originally predicted.
- Develop geochemical source terms to predict future water quality from the waste rock spoil piles.

ML/ARD Specialist Services BC Ministry of Energy Mines and Petroleum Resources - British Columbia

Technical reviewer over a 15-year period for mine project applications and mine closure plans with focusing on geochemical, water quality, groundwater, water management and closure planning.

- Conduct adequacy screening and detailed review of the New Afton Mine B3 Permit Amendment Application.
- Review Mine Certificate Applications and conduct mine site audits on behalf of the British Columbia Ministry of Energy, Mines and Petroleum Resources (EMPR).
- Review geochemical characterization studies and remedial measures proposed for the Prosperity Cu-Au Project to support permit requirements and closure bond costs.
- Review geochemical characterization studies and water quality effects models for the KSM Cu-Au Project to support permit requirements and closure bond costs.
- Review geochemical characterization studies, water quality effects models and closure plans for the Murray River Coal Project to support permit requirements and closure bond costs.
- Review development of geochemical assessment model for the Mount Polley Mine return to full operations application to support closure bond costs.
- Review Raven Coal geochemical characterization, hydrogeologic characterization and groundwater modelling studies.
- Conduct Boss Mountain Mine site inspection to evaluate effectiveness of closure measures.

**Boss Mountain Mine Water Quality Assessment
Glencore – 100 Mile House, B.C.**

- Evaluate hydrologic and biogeochemical processes responsible for metal attenuation and acid neutralization within a tailings storage facility containing acid generating tailings.
- Develop geochemical source terms to predict how tailings seepage chemistry may change in response to the implementation physical stabilization measures.

**Mount Nansen Remediation Plan Review
Yukon Government – Assessment and Abandoned Mines – Carmacks, Yukon Territory**

- Review the Remediation Plan and water quality predictions for Preliminary Design stage of the project.

**Elk Valley Operations - Harmer and Dry Creek Water Quality Assessment
Teck Corporation – Sparwood, B.C.**

- Evaluate hydrologic and geochemical processes responsible for sulphate, selenium and nitrate signature in Harmer and Dry creeks located downstream of mine spoil piles.

**Questa Mine – Senior Review
Norwest Engineering / Chevron EMC – Questa, New Mexico**

- Evaluate geochemical and hydrogeological constraints to prevent the formation of secondary mineral accumulation and maintain long-term free draining conditions within waste rockpiles.

**Technical Guidelines for the Management and Mitigation of ML/ARD in the Yukon
Yukon Government, Yukon Territory**

- Explain the geochemical and physical processes associated with the development and mitigation of ML/ARD.
- Define the required components of an ML/ARD program in the Yukon including: prediction, characterization, mitigation, monitoring and management planning.
- Present opportunities to mitigate ML/ARD through project design optimization, flooding, construction of dry covers, segregation of PAG and NPAG materials, blending PAG and NPAG materials, addition of alkaline amendments, co-disposal of mine rock and tailings, and freezing, with case studies, monitoring and design considerations.

**Faro Mine Urgent Works – Senior Review
BGC Engineering (Indigenous and Northern Affairs Canada) – Faro, Yukon**

- Develop the geochemical characterization study approach for the North Fork Rose Creek Realignment Project to limit the risk of degrading water quality.
- Provide study outline and senior review of predictive water quality model, management plans and draft study reports.

**Tujuh Bukit Project: Geochemical Assessment of Waste Rock and Ore
PT Bumi Suksesindo - Southeast Java, Indonesia**

- Senior review and design for comprehensive geochemical test program including static and kinetic testing

**Quinsam Coal Mine Permit Amendment
Quinsam Coal Corporation - Campbell River, British Columbia**

- Evaluate the effectiveness of passive water treatment system on reducing sulphate concentrations in Long Lake.
- Develop groundwater characterization and monitoring programs.
- Geochemical characterization of strata disturbed by mine operations.

**Portage Quarry ML/ARD Characterization and Management
PlanB Technical Services – Hudson Hope, B.C.**

- Conduct geochemical characterization of a hydro dam aggregate quarry and develop a ML/ARD Material Management Plan for BC Hydro.

**Ajax Mine Geochemical Characterization Study
KGHM Ajax, Kamloops - British Columbia**

- Manage a geochemical characterization study for waste rock and tailings from a large copper-porphyry deposit.
- Conduct program designed to evaluate the risk of future metal loading from waste rock and pit wall exposures to regional groundwater and surface water resources.
- Assess secondary mineral controls on closed basin lake waters.
- Report the results of pit lake model PitMod regarding the physical and geochemical evolution of the lake that will form in the open pit.

**Certej Geochemical Characterization Study
Eldorado Gold Corp. – Romania**

- Evaluate geochemical characteristics of ore and waste rock from deposit.
- Manage a Phase II geochemical characterization study to estimate quantity of potentially acid generating waste rock within the proposed pit limits for a block model.
- Prepare an initial set of geochemical source terms estimating drainage chemistry from proposed mine facilities.

**Narrows Inlet Project
BluEarth Renewables Inc. - Sechelt, British Columbia**

- Prepare a Metal Leaching / Acid Rock Drainage management plan for hydro-electric project.

Casino Project Geochemical Characterization Study Western Copper & Gold Corp. – Yukon

- Conduct and manage a geochemical characterization of waste rock and tailings from a large copper-porphyry deposit to direct waste management planning.
- Design a series of subaqueous column tests to evaluate best waste placement options to limit copper leaching.
- Estimate geochemical mass loading rates from waste rock, tailings, pit wall and heap leach.
- Conduct a risk-based evaluation of ML/ARD potential along access corridor.

Kışladağ Geochemical Characterization Eldorado Gold Corp., - Ankara, Turkey

- Review geochemical characterization work completed to assist in the design of waste rock dumps that will limit the amount of metal leaching to seepage water.
- Conduct a laboratory and field kinetic test program to evaluate the evolution of waste rock seepage chemistry.

Batu Hijau Closure Plan Newmont Mining Corporation, Sumbawa, Indonesia Evaluate waste rock closure management options

- Review geochemical database
- Assess geochemical risk associated with waste rock

Galore Creek Water Quality Effects Model Galore Creek Mining Company - Stewart, British Columbia

- Manage program to assess water quality effects from proposed mine project.
- Develop geochemical source terms for mine waste storage facilities.
- Construct a mass loading model to assess downstream water quality effects.

Izok Lake Road ML/ARD Assessment Mining Minerals Group Canada – Nunavut

- Conduct a gap analysis of historic geochemical reports.
- Initiate a supplementary geochemical characterization program to support waste management plans and direct water quality impact assessments.
- Design program linear road development ARD risk assessment program.

Emba Derho, Asmara, Debarwa - Acid Rock Drainage Characterization Sunridge Gold Corp. - Eritrea, Africa

- Undertake the geochemical characterization of a series of volcanic massive sulphide deposits.
- Conduct program designed to evaluate the risk of future metal loading from waste rock and pit wall exposures to regional groundwater and surface water resources.

Huguenot Coal Project ML/ARD Assessment
Colonial Coal International Corporation - Tumbler Ridge, British Columbia

- Geochemical characterization of coal, rock strata and coarse reject.
- Design field and laboratory geochemical characterization programs to assess metal leaching potential.

Cape Scott Wind Farm ML/ARD Assessment
GDF Suez - Port Hardy, British Columbia

- Prepare a pre-construction ML/ARD risk assessment.
- Conduct an operational monitoring program and risk assessment.
- Design program and provide senior review of linear road development ARD risk assessment.

Central South Coal Geochemical Characterization Study
First Coal Corporation - Chetwyn, British Columbia

- Evaluate the risk of ML/ARD from proposed bulk sample pit to support applications for Mine Permit and Water License.
- Assess relative risk and impact from proposed mining operation to water quality.

Silver Standard Mine Closure Plan
Silver Standard Resources Inc., Hazelton, British Columbia

- Detailed ARD assessment and geochemical characterization program for submission to Ministry of Energy and Mines, BC
- Evaluate mine hydrology and geochemical characteristics of waste rock, and tailings
- Develop mitigation strategies in support of closure
- Assess the chemical and physical groundwater conditions in tailings that effect metal loading rates to the aquatic system.

Thompson Creek Mine Tailings Assessment
Thompson Creek Mining - Challis, Idaho

- Evaluate geologic controls on neutralization depletion.
- Assess options for the management of low sulphur tailings sands and conduct evaluation of tailings pore water.

Izok Lake Geochemical Characterization
OZ Minerals, Nunavut

- Conduct a gap analysis of historic geochemical reports
- Initiate a supplementary geochemical characterization program to support waste management plans and direct water quality impact assessments.

Wolverine Coal Project EIA and Geochemical Characterization Western Canadian Coal Ltd., Tumbler Ridge, British Columbia

- Project manager for the writing and compilation of the Wolverine Application Report in accordance with the British Columbia Environmental Assessment Act
- Manage field program for subconsultants including wildlife and fisheries biology, archaeology, terrain/ecosystem mapping, water management
- Preparation of regulatory permitting strategies
- Evaluate lithologic variation within stratigraphic sections
- Characterize geochemical variation within mined strata
- Evaluate risk of metal leaching and ARD from future mined waste using mineralogy, static and kinetic test results
- Conduct geochemical source loading model
- Project manager for the writing and compilation of the Tulsequah Chief Project Report in accordance with the British Columbia Environmental Assessment Act
- Manage field program for subconsultants including wildlife and fisheries biology, archaeology, terrain/ecosystem mapping, water management
- Conduct metal loading and water quality impact analysis
- Participation in Project Committee meetings and presentations to stakeholders

Bonanza Ledge ML/ARD Study International Wayside, Wells, British Columbia

- Manage a geochemical characterization study to support reclamation planning for historic mine workings and permit applications for new mine workings.
- Evaluate the risk of ML/ARD from existing and future waste rock.
- Assess relative risk and impact from proposed mining operation to water quality in an area that has hosted numerous large mining projects for 1.5 centuries.
- Conduct finite element model simulation to evaluate groundwater inflow to proposed open pit.

High Lake ARD Management Program Wolfden Resources - Nunavut, Canada

- Evaluate the acid generating potential of the waste rock units and mine construction materials for the Environmental Impact Study.
- Develop waste rock management plans to address metal leaching issues from high risk materials.

Tundra Mine Remediation Plan

Indian and Northern Affairs Canada, Northwest Territories

- Conduct a professional peer review of work previously conducted by another geochemical practitioner.
- Investigate current and future metal loading sources from an abandoned mine on behalf of Indian and Northern Affairs Canada.
- Evaluate extent and thickness of tailings deposit from on-ice winter drill program.

Alamo Dorado ARD Characterization

Pan American Silver Corp., Hermosillo, Mexico

- Conduct kinetic testing for dry-stacked tailings to evaluate metal leaching potential.
- Select and analyses representative core samples to evaluate metal leaching risk from future waste rock materials.
- Develop a waste rock management plan to address findings of the characterization study.

Silver Bear Mines Remediation Plan

Indian and Northern Affairs Canada, Northwest Territories

- Design and implement a field investigation to identify potential sources of current and future metal loading to local watercourses on behalf of Indian and Northern Affairs Canada.
- Recommend conceptual remedial measures to be implemented at the abandoned mine sites.

Silvertip ARD and Water Quality Evaluation

Silver Standard Resources Ltd., British Columbia

- Compile water quality and geochemical loading data to evaluate geochemical loading from natural and anthropogenic sources.

Nanisivik Mines ARD Management

Breakwater Resources, Baffin Island, Canada

- Evaluate the acid generating potential of various waste rock units and mine construction materials.
- Produce report on kinetic test work conducted to evaluate the acid generating potential of tailings and cover material in arid arctic conditions.

La Granja Copper Project Project II ARD Evaluation

BHP Billiton, Peru, South America

- Conduct a Phase II acid rock drainage study to supplement a reevaluation of the property by BHP Billiton.
- Assess a full suite of static tests and kinetic tests and conducted a site assessment and field program.

Maqui Maqui Closure Study
Minera Yanacocha S.R.L., Cajamarca, Peru

- Review geochemical leaching data from site.
- Conduct critical assessment of conceptual closure options from a geochemical loading perspective.
- Review groundwater seepage pathways from mine components.
- Review climatic data to assess soil cover and pit water balance.
- Responsible for ARD assessment and hydrological characterization of WRSF.
- Responsible for confirming hydrogeologic model for Maqui Maqui area.

Farley Lake Mine Waste Rock Cover Design Study
Lynn Lake, Manitoba

- Acid rock drainage assessment of waste rock dump.
- Conduct a 2-D unsaturated flow model to evaluate waste rock cover design parameters.

Kori Kollo Mine Closure Plan
Battle Mountain Gold, Bolivia, South America

- Acid rock drainage assessment and recommendations for closure options and mitigation.
- Conduct field study for waste rock cover infiltration evaluation.
- Water quality assessment.

Tambo Grande Waste Management
Manhattan Minerals Corporation, Piura, Peru

- Preliminary acid rock drainage assessment and recommendations for subsequent full scale environmental impact evaluation.
- Design and conduct field and laboratory kinetic test program to establish site specific ARD segregation criteria.
- Evaluating the amount and timing of acid generating waste release by integrating ARD data with geology and mine plans.

Kemess Waste Dump Management Program
Kemess Mines Inc. Smithers, BC

- Interpretation of static and kinetic tests results for Cu-Au operation and report writing and preparation.
- Recommendations for waste rock segregation program based on site-specific Net Potential Ratio.
- Recommendations for handling waste rock with neutral drainage and elevated metals.
- Develop waste rock management program for potentially acid generating waste.

Soil Cover Design Study

Black Hawk Mining Inc., Lynn Lake, Manitoba

- Manage study of an appropriate cover system to prevent infiltration into a potentially acid-generating waste rock dump.
- Conduct field evaluation to determine physical parameters of suitable materials for the cover system.
- Conduct 2-D finite element flow modeling (SEEPW) to establish saturation levels in the cover.

Bald Mountain Mine Waste Management Program

Black Hawk Mining Inc., Maine, U.S.A.

- Evaluated humidity cell tests to determine the potential of unacceptable metal release from mine waste.
- Identified the most effective management method for the various types of waste.
- Established a predictive method to determine pit water chemistry through scaling humidity cell release rates by fracture density in the pit wall.

Restigouche/Caribou Mine Waste Rock Segregation

Black Hawk Mining Inc., New Brunswick, Canada

- Mine waste acid rock drainage assessment report using static test program and kinetic test result evaluation.
- Establish segregation criteria for waste rock management plan in final report.

Sithe Energy ARD Risk Assessment

Seward Power Plant, Pennsylvania, USA

- Review ARD prediction testwork and assess the geochemical risk associated with the purchase of a coal burning power generation station.

Cerro Crucitas Project

Vengold Inc., Costa Rica, Central America

- Review acid rock drainage assessment report compiled by previous project owner.
- Evaluate various acid rock drainage mitigation strategies and provided cost estimates on water treatment facilities and cover options.

Subaqueous Waste Rock Mineral Stability

MEND Project, NRCan, Canada

- Determine possible secondary mineral precipitates that may form in a subaerial waste rock dump.
- Identify solubility constraints on secondary minerals in a subaqueous environment.
- Propose a sequential extraction procedure to assess the subaqueous geochemical stability of oxidized waste rock.

REPRESENTATIVE PASSIVE WATER TREATMENT & PIT LAKE PROJECTS

Berkeley Pit Lake Study

BP Remediation / ARCO - Butte, Montana

- Constrain the physical and biochemical controls on pit lake development and report the predicted physical and chemical evolution of the lake.
- Determine the limnologic controls and biotic effects that control deep water redox conditions and water quality.
- Evaluate the effect of RO Brine deposition to physical stratification of the water column and water chemistry.
- Assess the effect lime neutralization sludge deposition has on buffering pH in the water column.

Certej Passive Water Treatment Evaluation

Eldorado Gold Corp. – Romania

- Evaluate passive treatment opportunities on existing mine site.
- Evaluate water management structures, flow rates, acid loading rates and appropriate treatment options.
- Design pilot treatment to assess best option for implementation at a full scale. System of six reactors constructed in parallel and series to evaluate efficiency of organic substrate composition and influent chemistry for metal attenuation and acid neutralization.
- Operational oversight of pilot treatment system.

San Martin Mine Water Passive Treatment Evaluation

Goldcorp Inc. - San Martin, Honduras

- Assess passive mine water treatment options for waste rock seepage. Develop conceptual design components suitable for the observed seepage flow rates and chemistry.
- Conduct laboratory tests to select most effective reactor substrates from available local materials.
- Finalize design components with geotechnical engineer and client including defining reactor size, materials and flow rates.

Kışladağ Waste Rock Seepage Characterization & Pit Lake Study

Tuprag Mining - Ulubey, Turkey

- Project Manager for a program to evaluate water quality effects during operation and closure phases of a mining project.
- Assess geochemical attenuation mechanisms in aquifer matrix.
- Constrain the physical-biochemical controls on pit lake development and report the predicted physical and chemical evolution of the lake that will form in the pit at closure.

Kışladağ Passive Water Treatment Design
Eldorado Gold Corp. - Ankara, Turkey

- Constrain site conditions that affect treatment efficiency including: local construction materials, water balance, site topography and mine effluent.
- Conduct a series of laboratory experiments to evaluate the key design constraints for a series of passive treatment systems for highly acidic and mildly acidic mine water.
- Design and construct pilot scale reactors at site to evaluate the efficacy, biogeochemical controls and longevity of organic substrate materials.
- Provide key design requirements for reducing-alkalinity producing passive treatment system (RAPS) to the civil construction group.

Duthie Passive Water Treatment Design
Silver Standard Resources Inc. - Smithers, British Columbia

- Evaluate tailings stack seepage rates, seepage chemistry and water collection system.
- Design and size the RAPS treatment facility.

SELECTED ENVIRONMENTAL RISK EVALUATION PROJECTS

Los Bronces Operational Risk Assurance Audit

BGC Engineering / Anglo American - Santiago, Chile

- Conduct an Operational Risk Assurance Audit at the Los Bronces Mine with a multidisciplinary team as technical leader for geochemistry.
- Review operating, monitoring and closure plans and prepare a process risk and controls register for the hydrogeochemistry of the Donoso Norte and San Francisco waste rock dumps.

Cozamin Due Diligence Review

Capstone Mining Corp. - Zacatecus, Mexico

- Conduct an environmental audit of active mine site in support of corporate merger.
- Review closure plans and assess environmental risk and associated cost.

Cantung Tungsten Mine Water License Review

Indian and Northern Affairs Canada - Northwest Territories

- Review geochemical characterization studies, remedial measures and closure plans of an operating tungsten mine completed in support of Water License Application.
- Participate in community meetings and as an intervenor at water review panel on behalf of INAC.

Mackenzie Valley Pipeline Review

Indian and Northern Affairs Canada - Norman Wells, Northwest Territories

- Review geochemical and water quality components of Environment Assessment for the proposed pipeline.
- Prepare outline of geochemical risks posed by pipeline construction and potential management procedures.
- Expert witness at review panel hearings for the project.

SELECTED PUBLICATIONS & PRESENTATIONS

- Mattson B.** and Sahami A. (1999) Assessing the subaqueous stability of oxidized waste rock. *Mine Environment Neutral Drainage (MEND) Project 2.36.3.*
- Mattson B.** and Holtby, M. (1999) Geochemical assessment of the Silver Standard Mine (*Invited Speaker*). *6th Annual British Columbia MEND Metal Leaching and Acid Rock Drainage Workshop. December 1 & 2, 1999, Vancouver, British Columbia.*
- Mattson, B.** and Carreau B. (2003) ARD prediction and waste rock segregation plan for ankerite-containing mine waste: Restigouche Mine case study. *6th International Conference on Acid Rock Drainage Proceedings, Cairns, Australia, July 2003.*
- Mattson, B.** (2005) Evaluating Depletion of Carbonate Neutralization Potential from Laboratory Kinetic Tests. *Securing the Future 2005, International Conference on Mining and the Environment and Metals and Energy Recovery. June 27 - July 1, 2005, Skellefteå, Sweden.*
- Mattson B.** (2005) ML/ARD Prediction – FeCO₃ and low-sulphide materials. (*Invited Speaker*). *12th Annual British Columbia - MEND Metal Leaching and Acid Rock Drainage Workshop., November 2000, Vancouver, British Columbia.*
- Mattson B.,** Salvador S, McNee J. (2007) Predicting pit lake evolution using numerical groundwater simulations to develop effective mine decommissioning plans. *Mining and the Environment IV Conference Proceedings October 2007, Sudbury, Ontario.*
- Mattson B.,** (2009) Assessing the availability and source of non-carbonate neutralization potential by pre-treatment of kinetic test samples. *8th International Conference on Acid Rock Drainage Proceedings, Skelleftea, Sweden, June 2009.*
- Mattson B.,** (2014) Sulphate Treatment in Mine Effluents. (*Invited Speaker*). *International Network of Acid Producers (INAP) Sulphate Treatment Workshop, February 2014, Salt Lake City, Utah.*
- De Baere B., R. Francois, U. Mayer and B. **Mattson** (2014) *Introducing a flow-through technique to aid predict drainage quality from mine waste: a case study. (Poster Presentation) Goldshmidt Conference June 8 – 13, 2014, Sacramento California.*
- Cowan D., and B. **Mattson.** (2014) Coarse Coal Reject ML/ARD Management - Quinsam Coal Mine (*Invited Speaker*). *21th Annual British Columbia MEND Metal Leaching and Acid Rock Drainage Workshop. December 3 & 4, 2014, Vancouver, British Columbia.*
- Mallen N., K. Malowany and B. **Mattson.** (2014) A Phased, Risk-based Approach for ML/ARD Assessment for Linear Projects (*Presentation*). *21th Annual British Columbia MEND Metal Leaching and Acid Rock Drainage Workshop. December 3 & 4, 2014, Vancouver, British Columbia.*
- Jeen, S-W., B. **Mattson** (2014) Evaluation of Reactive Mixtures for Passive Treatment of Mine Drainage from a Waste Rock Storage Area. – (*Poster Presentation*) - *American Geophysical Union Fall Meeting, December 15-19 San Francisco.*
- Kirchner T. and B. **Mattson.** (2015) Scaling Geochemical Loads in Mine Drainage Chemistry Modelling: An Empirical Derivation of Bulk Scaling Factors *10th International Conference on Acid Rock Drainage & IMWA annual Conference. April 21 - 24, 2015, Santiago, Chile.*
- Kirchner, T, N. Marsh, and B. **Mattson.** (2016) Geochemical trends in evaporative tailings ponds – an experimental study. *International Mine Water Association Annual Conference July 11-15, 2016, Leipzig, Germany.*

- Dockrey, J. and B. **Mattson** (2016) Effects of pH on the Arrhenius Paradigm. *International Mine Water Association Annual Conference July 11-15, 2016, Leipzig, Germany.*
- Jeen, Sung-Wook, and Bruce **Mattson**. (2016) Evaluation of layered and mixed passive treatment systems for acid mine drainage. *Environmental Technology: 37:22, 2835-2851*



STEPHANIE SIMPSON (M.Sc.)
ENVIRONMENTAL SCIENTIST

EDUCATION:

Master of Science Geochemistry and Mineralogy
University of Manitoba

Bachelor of Science Geology (Honors Program)
University of Manitoba

EXPERIENCE

Stephanie is an environmental geoscientist specialized in mine site characterization, sediment and water geochemistry, tailings-water interactions, environmental mineralogy, and acid rock drainage and metal leaching prediction. She has over 15-years of experience in mine-related environmental studies in Canada and abroad.

Stephanie has extensive experience and expertise in the compilation, analysis, interpretation, and delineation of trends and conclusions for large sets of monitoring and experimental data. She has organized and completed numerous field investigations and sampling programs in support of mine rock geochemical characterization and contaminant transport. Her M.Sc. project and on-going involvement with research and development projects at Lorax have enabled her to become proficient at field studies involving the collection of water, sediment, soil, tailings, sludge and vegetation samples as well as the application of analytical techniques such as petrography and high-resolution microscopy. In particular, her research studies have focused on the source, attenuation, and mobility of metal(loid)s at closed and operating mine sites in Canada.

AREAS OF EXPERTISE

- Metal Leaching and Acid Rock Drainage (ML/ARD) Prediction
- Mine Waste Geochemistry and Mineralogy
- Water, Sediment, and Soil Quality
- Inorganic Contaminant Fate and Transport
- Chemical Hydrogeology
- Operational Monitoring

REPRESENTATIVE PROJECTS

Red Lake Operation – *multiple studies and project management* **Evolution Mining Inc. – Red Lake, Ontario**

Closure Plan Amendment

- Project management.
- Development of report.

Environmental Characterization of Wetland System

- Field studies, including development of program and collection of water, sediment, and plant samples along potential contaminant flow paths.
- Evaluation of water quality and metal inventories in sediment and plant tissues.

Tailings Co-Disposal Assessment

- Desktop study to evaluate potential for water quality changes associated with the discharge of multiple mill tailings streams to one tailings management facility.
- Evaluation and comparison of different treatment systems and capacities.
- Documentation of data gaps and recommendation for future sampling and assessments.

Operational Waste Monitoring

- Assessment of static test results to track the geochemistry of operational waste rock and tailings samples.
- On-going assessment of field kinetic tests.
- On-going support and guidance for ML/ARD programs and liaison with analytical laboratories.

Groundwater Quality Monitoring

- Project Management.
- Update of surface and groundwater quality data in support of annual groundwater monitoring reports for the Red Lake, Campbell and Cochenour-Wilanour complexes.

Balmer Lake Mass Balance Assessment

- Project management.
- Review of model and report development.

Geochemical Assessment of Existing Waste Rock

- Development and implementation of field work, including collection of mine rock samples from stockpiles and site pads, and development of field kinetic tests.
- ML/ARD assessment of mine rock and preliminary risk assessment.

Geochemical Assessments for Advanced Exploration Programs

- ML/ARD assessment of waste rock in support of advanced exploration programs.

Red Lake Mine – *multiple studies in support of permit applications and operational monitoring*
Pure Gold Mining Inc. – Red Lake, Ontario

Metal Leaching and Acid Rock Drainage Assessment

- Development and execution of field sampling program.
- Assessment of ML/ARD potential of mine rock lithologies that will be brought to surface during construction and development of access routes.
- Characterization of existing mine rock and tailings solids and seepage/drainage quality from the existing mine waste.
- ARD assessment of mine rock in support of proposed bulk sampling program.

Surface Water Quality Baseline Characterization

- Development of water quality database.
- Development of baseline/current conditions of the mine site and the downstream receiving environment.
- Proposal of site-specific water quality objectives.

Water Quality Predictions

- Development of contact and non-contact source terms for water quality model.
- Interpretation and reporting.

Effluent Limits and Objectives

- Development of effluent limits and effluent objectives in support of permitting
- Liaison with regulatory agents.

Operational Monitoring Programs and On-going Support

- Development of surface water quality monitoring plan and sampling protocols.
- Development of metal leaching and acid rock drainage management plan and sampling protocols.
- On-going support and guidance for water quality sampling programs and liaison with the analytical laboratory.

Brucejack Gold Mines - *multiple studies in support of permit applications*
Pretivm Resources - Stewart, British Columbia

ML/ARD Characterization and Monitoring

- ML/ARD assessment of waste rock, tailings, and overburden.
- Development of 2015, 2016 and 2017 Annual Monitoring Reports.
- ML/ARD assessment of bedrock and alluvial source materials along the access road.
- Development of Standard Operating Procedures for waste rock, tailings, and drainage quality monitoring in support of the ML/ARD Management Plan.
- Development of source terms for water quality predictions amendment.

Evaluation of Tailings Disposal Options

- Development of kinetic test program to evaluate long-term stability of tailings submerged under water cover, as cemented paste backfill, and co-disposed with water treatment plant sludge.
- Development of testwork for mitigation of hexavalent chromium produced by cement of cemented paste backfill in support of Chromium Management Plan.

Coffee Gold Project - Geochemical Characterization **Kaminak Gold Corp. - Yukon**

- Characterization of waste rock, ore, tailings and overburden, including static and kinetic testwork, for mine site.
- Characterization of waste rock and overburden lithologies along access road.
- Development of ML/ARD Management Plan.
- Assessment of water quality predictions in receiving environment and contaminant sources.

Ajax Project - Geochemical Characterization **KGHM Ajax Mining Inc., - Kamloops, British Columbia**

- Phase 1 and II geochemical characterization of waste material through interpretation of static and kinetic test geochemistry and mineralogical investigations.
- Construction of kinetic field weathering bins and collection, analysis, and interpretation of leachate from different wastes.
- Development of loading model for nitrogen species produced by blasting activities.

Casino Project - Geochemical Characterization of Waste in Support of Environmental Assessment Application **Western Copper Corporation - Whitehorse, Yukon**

- Geochemical analysis of ML/ARD potential of waste material through interpretation of static geochemistry and metal leaching data.
- Assessment of field and laboratory based kinetic studies, including field weathering bins, humidity cells and saturated and unsaturated column tests for waste rock and tailings.
- Remediation options for degradation of cyanide from proposed heap leach.

Emba Derho Project - Geochemical Characterization of Waste in Support of Environmental Assessment Application **Sunridge Gold Corp. - Asmara, Eritrea**

- Phase II assessment of ML/ARD potential for waste material through interpretation of static geochemistry and metal leaching data.
- Assessment of kinetic studies, including field weathering bins humidity cells for waste rock and flotation tailings.

Yellowjacket Gold Mine Project - Geochemical Characterization of Waste Rock in support of Small Mine Permits

Yellowjacket Joint Venture - Atlin, British Columbia

- Geochemical analysis of ML/ARD potential of waste material through interpretation of static geochemistry and metal leaching data.
- Construction of kinetic field weathering bins and collection, analysis, and interpretation of leachate from different wastes.

Johnny Mountain – ML/ARD Risk Assessment

Skyline Gold Corporation - Smithers, British Columbia

- Water quality assessment with special focus on ML/ARD risk to the receiving environment.

Selenium Behaviour in Lentic Environments (Research & Development Project)

Elk Valley Coal Corporation and Lorax Environmental - Fernie, British Columbia

- Development and implementation of field program to collect surface and pore water samples, sediment cores, and plants from a wetland downstream of mining activities.

Quinsam Coal Project – ML/ARD Characterization

Quinsam Coal Corporation - Campbell River, British Columbia

- Review of existing static test and kinetic test data for target and adjacent coal seams and development of ML/ARD assessment program in support of permitting.

Wolverine Coal Project – Operational ARD Monitoring

Western Canadian Coal Corp. - Tumbler Ridge, British Columbia

- Development of Standard Operating Procedures for on-site laboratory in support of identification of potentially acid generating waste material for proper disposal.

Trend Mine Expansion – revised Technical Assessment Report

Peace River Coal - Tumbler Ridge, British Columbia

- Update of water quality baseline conditions in support of revised Effluent Permit Application Technical Assessment Report.
- Development of site specific water quality objectives for the expansion of the Trend Small Mine.

Roman Mine – Water and Sediment Quality Baseline and Monitoring Program

Peace River Coal - Tumbler Ridge, British Columbia

- Development of water quality baseline and monitoring programs in support of a Mine Permit Application.
- Acting Manager – water quality working group meetings.

New Britannia Mine, Snow Lake, Manitoba – site characterization

Manitoba Government and University of Manitoba

- Objectives of M.Sc. Thesis were to: 1) determine the source of the elevated arsenic in the local groundwater; 2) delineate the surface and groundwater flow paths from the mine site; and 3) define the geochemical and mineralogical processes controlling the mobility and attenuation of arsenic.
- Development and implementation of field and analytical programs for surface, ground and pore water, tailings, sediment, and aquatic plant samples.
- Analysis of solid samples by Optical and Scanning Electron Microscopy (SEM), Electron Microprobe Analyses (EMPA), micro-X-Ray Diffraction, and sequential extraction.
- Incorporation of geochemical modeling tools such as WATEQ4f and Geochemists Workbench.
- Interpretation, reporting and presentation of data.

PUBLICATIONS

Alan J. Martin, Colin Fraser, Stephanie **Simpson**, Nelson Belzile, Y.-W. Chen, Jacqueline London and Dirk Wallschläger, 2017. Hydrological and Biogeochemical Controls Governing the Speciation and Accumulation of Selenium in a Wetland Influenced by Mine Drainage. *Environmental Toxicology and Chemistry*. 999:1–15, February 2018.

Martin, A.J., Loomer, D., Fawcett, S., Rollo, A., Gault, A., Jamieson, H., **Simpson**, S., and Al, T. 2013. Characterization and Prediction of Trace Metal Bearing Phases in ARD Neutralization Sludges. Prepared for The Mine Environment Neutral Drainage Program (MEND), May 22, 2013.

Martin, A. J., **Simpson**, S., Fawcett, S., Wiramanaden, C. I. E., Pickering, I. J., Belzile, N., Chen, Y.-W., London, J., and Wallschläger, D. 2011. Biogeochemical mechanisms of selenium exchange between water and sediments in two contrasting lentic environments. *Environ. Sci. Technol.* 45: 2605-2612.

Sherriff, B.L., Salzsauler, K.A., **Simpson**, S., Sidenko, N.V., and VanGulck, J., 2006. Arsenic mobility from arsenopyrite-rich gold mine waste in Snow Lake, Manitoba, Canada *Chin. J. Geochem.* 25(1): 29-30.

Simpson, S., Sherriff, B.L., Van Gulck, J., Khozhina, E., Londry, K., and Sidenko, N., 2011. Source, attenuation and potential mobility of arsenic at New Britannia Mine, Snow Lake, Manitoba. *Appl. Geochem.* 26(11): 1843-1854.