

Education

Ph.D. Biology, University of Saskatchewan, Saskatchewan, 2009

B.A. Communication, University of Toledo, Ohio, 1992

Certifications

RPBio, July, 2018

Languages

English – Fluent

Golder Associates Ltd. – Victoria

Wildlife Biologist (2009 to present)

Dr. Dan Coulton is a wildlife biologist with more than 10 years of consulting experience in northern Canada. He is a population ecology specialist in Arctic and boreal ecosystems with experience covering a broad array of wildlife fauna. As a practitioner, he leads terrestrial wildlife and wildlife habitat assessments, baseline studies and permitting applications and represents clients during regulatory proceedings and meetings. Dan’s has authored numerous environmental assessments, wildlife effects mitigation and management plans, monitoring study designs, data collection and analyses and communicated results. He has completed these on barren-ground and boreal caribou, grizzly bear, wolverine, moose, waterfowl, shorebirds, upland birds and polar bear.

Employment History

University of Saskatchewan – Saskatoon, Saskatchewan

Graduate Research Assistant (2002 to 2008)

PROJECT EXPERIENCE (PERMITTING, ENVIRONMENTAL ASSESSMENT, MONITORING)

**Big River Project
Caribou Mitigation and
Offset Plan**
Saskatchewan, Canada

Development of boreal caribou offset plan and engagement with the Saskatchewan Ministry of Environment. The plan is designed to support Federal and Provincial Recovery Strategies and range planning in Saskatchewan. November 2018 to May 2019.

Mary River Project
Nunavut, Canada

Marine wildlife team member and lead Technical Support for the Phase 2 Proposal regulatory phase and Icebreaking Assessment of polar bear. March 2018 to present.

**Pine Point Project,
Pine Point Mining Ltd.**
Northwest Territories,
Canada

Wildlife technical lead for baseline monitoring and habitat characterization of wildlife species at risk, including boreal caribou, bison, wolverine and birds and amphibians through autonomous recording and camera monitoring. May 2018 to present.

**Lynx/Jay Projects and
Ekati Diamond Mine,
Dominion Diamond
Mines**
Northwest Territories,
Canada

Component lead for environmental effects on wildlife for the Jay Project Developer’s Assessment Report. Species assessed included barren-ground caribou, grizzly bear, wolverine and migratory bird species at risk. Planned, managed and reported on baseline wildlife monitoring activities caribou, raptors and waterfowl. Developed Caribou Road Mitigation Plan, Caribou Mitigation Plan. Community and regulator engagement. July 2012 to present.

**Tlichó All Season Road
Project, Government of
the Northwest
Territories**
Northwest Territories,
Canada

Wildlife technical lead for the Adequacy Statement Response for the Tlichó All Season Road Project Description Report. Species assessed included boreal caribou, barren-ground caribou, bison, moose, wolverine and migratory bird species at risk. Study design for monitoring birds using autonomous recording units. December 2016 to present.

**East-West Tie Project,
NextBridge**
Ontario, Canada

Wildlife team member (moose) for environmental effects on wildlife for the East-West Tie Project Environmental Assessment Report. August 2016 to December 2016.

**Whale Tail Expansion
Project, Agnico Eagle
Mines**
Nunavut, Canada

Wildlife technical lead on the permitting amendment for expansion of the approved Whale Tail Project. Assessed barren-ground caribou and upland birds. August 2018 to September 2018.

**Diavik Diamond Mine,
Diavik Diamond Mines
(2012) Inc.**
Northwest Territories,
Canada

Wildlife technical lead on for the Diavik Diamond Mine's Wildlife Monitoring Program including study design, data analysis and reporting and regulatory engagement. Species monitored and analysed included caribou, grizzly bear, wolverine, falcons, and waterbirds. Assessed barren-ground caribou and upland birds. January 2009 to present.

**Gahcho Kué Mine, De
Beers Canada Inc.**
Northwest Territories,
Canada

Wildlife technical lead on for the Gahcho Kué Mine's Wildlife Effects Monitoring Program including study design, data analysis and reporting and regulatory engagement. Species monitored and analysed included caribou, grizzly bear, wolverine, falcons, and waterbirds. Assessed barren-ground caribou and upland birds. January 2009 to present.

**Snap Lake Mine, Diavik
De Beers Canada Inc.**
Northwest Territories,
Canada

Wildlife technical lead on for the Snap Lake Mine's Wildlife Monitoring Program including study design, data analysis and reporting and regulatory engagement. Species monitored and analysed included caribou, grizzly bear, wolverine, falcons, and waterbirds. Assessed barren-ground caribou and upland birds. January 2009 to 2015.

**Lutsel K'e Mini Hydro
Northwest Territories
Power Corp.**
Northwest Territories,
Canada

Terrestrial environmental setting survey and assessment for Northwest Territories Energy Corporation's mini hydro project on the Snowdrift River near Lutsel K'e, NWT. December, 2009.

Supplemental Skills

Analytical software

SAS, version 9.1, JMP version 7.0, SPSS, Statistica, R, Programs MARK, PRESENCE and DISTANCE

Publications

Refereed Journal Articles

Virgl, John A., Jim Rettie, and Daniel W. Coulton. 2017. Spatial and temporal changes in seasonal ranges of a declining barren-ground caribou herd. Rangifer, in press. Accepted April 24, 2017.

Coulton, Daniel W., John A. Virgl, and Colleen English. Falcon Nest Occupancy and Hatch Success Near Two Diamond Mines in the Southern Arctic, Northwest Territories. Avian Conservation and Ecology 8 (2013), 14.

Coulton, Daniel W., Robert G. Clark, David W. Howerter, Leonard I. Wassenaar and Michael G. Anderson. Costs and benefits of natal dispersal in yearling mallards *Anas platyrhynchos*. Journal of Avian Biology, 42 (2011), 123-133.

Coulton, Daniel W., Robert G. Clark, Leonard I. Wassenaar, David W. Howerter and Michael G Anderson. Social and habitat correlates of immigrant recruitment of yearling female Mallards to breeding locations. *Journal of Ornithology*, 152 (2011), 781-791.

Coulton, Daniel W., Robert G. Clark and Craig E. Hebert. Determining natal origins of birds using stable isotopes ($\delta^{34}\text{S}$, δD , $\delta^{15}\text{N}$, $\delta^{13}\text{C}$): Model validation and spatial resolution for mid-continent mallards. *Waterbirds*, 33 (2010), 10-21.

Coulton, D. W., R. G. Clark, K. A. Hobson, L. I. Wassenaar and C. E. Hebert. Temporal sources of deuterium (δD) variability in waterfowl feathers across a boreal-to-prairie gradient. *Condor*, 111 (2009), 255-265.

Coulton, Daniel W. and Robert G. Clark. An integrated stable isotope mark-recapture approach to modeling sources of population rescue. *Auk*, 125 (2008), 923-931.

Ali Naghibi Ph.D., P.Eng.

Senior Water Resources Engineer

Dr. Ali Naghibi is a water resources engineer with 15 years of professional and research experience in a wide range of environments, in Canada and internationally. His role includes contribution to building effective relationships with our clients, expanding strong reputation for technical excellence in the natural resource sector. Ali actively collaborates with project teams to deliver integrated water models that address our clients' most challenging water management issues. The studies he has conducted and supervised include hydrologic monitoring and analysis, water balance modelling (GoldSim), optimization and simulation models for water management, hydraulic and hydrologic modelling, instream/environmental flow analysis, and environmental impact assessment.

EDUCATION

B.Sc. Civil Engineering, Sharif University of Technology, Tehran, Tehran, 1998

M.Sc. Civil Engineering (Hydraulic Structures), Sharif University of Technology, Tehran, Tehran, 2000

Ph.D. Water Resources Engineering, University of British Columbia, Vancouver, British Columbia, 2011

REGISTRATIONS

Professional Engineer #L3873, Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists

Professional Engineer #38106, Engineers and Geoscientists British Columbia

PROJECT EXPERIENCE

Environmental Assessments – Mining

Kemess Underground Mine*, British Columbia (Senior Surface Water Hydrologist)

Reviewed the hydrology report, and developed a water balance model with GoldSim for the mine site and receiving environment in northern British Columbia. The model was used to optimize the water management plan, and supported the EA/EIS application, as well as the MA/EMA permit applications, for the project.

Murray River Coal Project*, British Columbia (Senior Hydrologist)

Developed a water balance model with GoldSim for the mine site and the receiving environment. The model was built upon hydrologic analyses and supported the effects assessment application of the project and informed engineering alternatives assessment including closure planning.

Hope Bay Mining Project*, Nunavut (Senior Hydrologist)

Managed the baseline hydrology monitoring program, performed surface water quantity effects assessment, and authored the hydrology chapter of the Environmental Impact Statement. Provided a third party senior technical review for hydrology analysis and water balance model.

KSM Mining Project*, British Columbia (Senior Hydrologist)

Managed the baseline hydrology monitoring program and performed a hydrologic assessment for the project area in British Columbia. Data were collected from 20+ on-site hydrometric stations as well as the Water Survey of Canada stations. Authored the hydrology chapter of the Environmental Impact Statement. Contributed to the monitoring program and desktop modelling for fish habitat effects assessment. Improved the site-wide water balance model (GoldSim) to support the water and waste management decisions.

* denotes projects completed with other firms

Ali Naghibi Ph.D., P.Eng.

Senior Water Resources Engineer

Back River Mine Project*, Nunavut (Senior Hydrologist)

Managed a baseline hydrometric monitoring program with up to 18 hydrometric stations in Arctic watersheds over a period of four years. Developed a water balance model with GoldSim for a pit lake closure. Provided peer review for the water management plan and operational water balance model. Authored the hydrology chapter of the Environmental Impact Statement. Conducted hydrologic and hydraulic analysis to support assessment of the potential effects of the proposed project on fish and aquatic habitat.

Brucejack Mining Project*, British Columbia (Hydrologist)

Performed a hydrologic assessment for the project area in glaciated watersheds in northern British Columbia. Authored the hydrology chapter of the Environmental Impact Statement, as well as the Mines Act Permit Application.

PUBLICATIONS

Naghibi, A. and B. Lence. Assessing impacts of high flow events on fish population: evaluation of risk-based performance measures. *Ecological Modelling*, , 2012, pp. Vol 240, pp 16-28.

Naghibi, A. Comparative review of mine water balance modelling approaches in BC, Canada. *Proceedings of the Second International Conference on Mine Water Solutions in Extreme Environments*, Vancouver, Canada,, 2015.

Naghibi, A. Hydrologic Data Uncertainty – Evident and Ignored. *Proceedings of the World Environmental and Water Resources Congress*, West Palm Beach, Florida,, 2016.

** denotes projects completed with other firms*

Erica Bonhomme has over 22 years of experience in Northern Canada as an environmental assessment and regulatory specialist, as an environmental geoscientist, and project manager. Her expertise includes regulatory planning, permitting, and environmental assessment coordination for major developments, stakeholder engagement, and technical writing. Erica excels at managing large, complex projects with multi-disciplinary teams and places particular emphasis on effective coordination and communication. Erica has a current and practical knowledge of environmental legislation, Board processes, government programs and policies and regional challenges and opportunities unique to the Territories. Through her ongoing leadership and involvement in a broad range of northern projects, Erica has established very good relations with northern stakeholders, including industry, regulators, Aboriginal organizations and government. Erica leads a team of environmental professionals based out of the Yellowknife, Northwest Territories office.

EDUCATION

B.Sc. Physical Geography/Geology, Carleton University, Ottawa, Ontario, 1996

M.Sc. Earth Sciences, Carleton University, Ottawa, Ontario, 1998

REGISTRATIONS

Professional Geoscientist, Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists

PROJECT EXPERIENCE

Environmental Assessment and Permitting Hamlet of Kimmirut Sewage Lagoon Relocation Project (Regulatory Advisor)

Reviewed regulatory approach, supporting documents and permit applications associated with the proposed construction of a new sewage lagoon in Kimmirut, Nunavut, located within the airport exclusion zone.

Grays Bay Road and Port Project, NIRB Screening (Project Director)

Led the development of a Project Proposal for a 230 km highway and deep water port in Nunavut to the Nunavut Planning Commission and Nunavut Impact Review Board; engaged with regulators on pre-permit applications; coordinated limited field studies used to supplement existing information for the project area; provided engagement support to project proponents.

Inuvik Tuktoyaktuk Highway Construction Regulatory Support, Tuktoyaktuk, Northwest Territories (Senior Advisor)

Provided regulatory (compliance) support to contractor building 140 km all-season road between Tuktoyaktuk and Inuvik, Northwest Territories; provided technical support during the closure phase for borrow sources, including input on closure objectives and criteria.

Erica Bonhomme M.Sc., P.Geo.

Principal, Team Lead Environmental Services Northern Canada

Iqaluit Emergency Supplementary Pumping Program, Iqaluit, Nunavut (Permitting Lead)

Acquired DFO Authorization and amendment to type A water licence on emergency basis to permit supplementary pumping of water to augment the City of Iqaluit's drinking water supply. Obtained NUPPAA exemptions; coordinated meetings with regulators and led development of applications and associated monitoring and management plans.

NICO Project Environmental Assessment*, Yellowknife, Northwest Territories (Federal Environmental Scientist)

As representative of the federal Responsible Minister, coordinated federal departmental input during environmental assessment scoping phase and subsequent judicial review of the proposed project.

Chinook EL470 Exploration Drilling Program Permitting, Tulita, Northwest Territories (Technical Director / Project Manager)

Provided regulatory and permitting advice during preparation of permit applications to Sahtu Land and Water Board; coordinated regulatory consultations; led preparation of a regional cumulative effects assessment.

Paramount Resources Cameron Hills Development Field Responsible Minister Review (Federal Environmental Scientist)

As representative of the federal Responsible Minister, coordinated departmental technical review of land use permit and type A and type B water license applications for medium-sized oil and gas development field in Northwest Territories.

Mackenzie Gas Project, Responsible Minister Review, Yellowknife, Northwest Territories (Federal Environmental Scientist)

As representative of the federal Responsible Minister, Led Federal technical review of cumulative effects assessment and environmental management plans and program components of Environmental Impact Statement; led preparation of technical and hearing submissions in Joint Review Panel process.

Taltson Hydroelectric Expansion Project Environmental Assessment Responsible Minister* (Federal Environmental Scientist)

As representative of the federal Responsible Minister, coordinated technical review of DAR, prepared departmental submissions, and led Federal and Responsible Ministers' input during EA and subsequent decision phase.

Western Alberta Transmission Line 500 kV Project, Calgary, Alberta (Technical Director)

Provided strategic planning environmental technical input during AUC regulatory review of 350 km, high-voltage DC transmission line; oversaw environmental program study design and hearing preparation.

Inuvik-Tuktoyaktuk Highway Baseline Studies, Tuktoyaktuk, Northwest Territories (Technical Director)

Coordinated design and completion of vegetation, terrain, archaeology, waterbird, species at risk and TK/TLU studies to support the environmental impact review of the project and to support mitigation planning

* denotes projects completed with other firms

Erica Bonhomme M.Sc, P.Geo.

Principal, Team Lead Environmental Services Northern Canada

Inuvik to Tuktoyaktuk Highway Permitting, Tuktoyaktuk (Project Manager / Technical Director)

Coordinated field and desktop studies to support development of application and supporting documentation for type A water licence for highway construction; developed environmental management plans and quarry pit development plans.

Mackenzie Valley Highway Project Planning, Yellowknife, Northwest Territories (Regulatory Advisor)

Provided strategic regulatory advice and conducted regulatory consultations during pre-application stage designed to initiate regulatory review of project; contributed to development of project scoping document to consolidate information from four independently-prepared project description reports.

Inuvik to Tuktoyaktuk Highway Borrow Sources Investigations Program, Tuktoyaktuk, Northwest Territories (Project Manager / Permitting Lead)

Coordinated permitting and planning of geotechnical investigations program to investigate type and quantity of granular resources along proposed highway; led development of borrow pit management plans required in support of Quarry Permit applications.

Grays Bay Road and Port Project Planning (Project Director)

Provided environmental planning advisory services during the pre-assessment stage of the project (ongoing)

Hamlet of Tulita Municipal Water Licence Renewal, Tulita, Northwest Territories (Regulatory Advisor)

Project Value: CAD 70,000

Developed workplan and coordinated development and update of various management plans and reports required for renewal of municipal water licence, including additional studies.

Snap Lake Mine Environmental Permitting Manager*, Yellowknife, Northwest Territories (Manager)

Developed strategy and plan and led multidisciplinary technical team to support two major amendments to Type A water license using innovative approach, BATEA, and ground-breaking toxicology research.

Snap Lake Mine Environmental Compliance Programs Manager*, Yellowknife, Northwest Territories (Manager)

Planned and managed all aspects of compliance monitoring and reporting at an operational diamond mine in Northwest Territories.

Environmental Management

Best Management Practices Plan for Placer Operations in Yukon*, Whitehorse, Yukon (Project Manager / Technical Lead)

Prepared technical report characterizing permafrost and ice-rich ground surrounding placer operations in Yukon. The recommended management practices were used to develop the permafrost component of the plan. The plan has now been supplemented by other guides, including the Guidebook of Mitigation Measures for Placer Mining in the Yukon (Yukon Placer Secretariat, 2008).

** denotes projects completed with other firms*

Education

M.Sc., Hydrogeology,
University of Waterloo,
Waterloo, Ontario, 1976

B.Sc. (Honours), Geology,
University of Alberta,
Edmonton, Alberta, 1974

Golder Associates Ltd. – Vancouver**Employment History****Golder Associates Ltd. – Vancouver, BC**

Principal (2003), Senior Hydrogeology Specialist (1986 to Present)

Engaged in hydrogeological investigations throughout North America, Europe, Asia, and South America. Provides senior technical review for hydrogeological aspects of mining and dewatering, water resource management, computer modelling of groundwater flow, design and assessment of groundwater dewatering/depressurization systems.

Independent Consulting Hydrogeologist – Vancouver, BC

Principal (1985 to 1986)

Emphasis on groundwater resource evaluation, groundwater remedial studies, evaluation of proposed mining scenarios, computer modelling of groundwater regimes, and contaminant hydrogeology.

SIMCO Ground Water Research Ltd. – Vancouver, BC

Principal (1980 to 1985)

Emphasis on resource evaluation, environmental assessment, and computer modelling of groundwater flow and mass transport. Responsibilities included management and technical supervision of hydrogeological projects, client representation at environmental hearings, and business development.

Golder Associates Ltd. – Vancouver, BC

Hydrogeologist (1979 to 1980)

Engaged in hydrogeological investigations in mining, geotechnical, and nuclear energy industries.

Alberta Research Council and University of Alberta – Edmonton, AB

Research Hydrogeologist (1973 to 1979)

Provided technical assistance in research projects at the Alberta Research Council and at the University of Alberta. Duties included characterisation of hydrogeological regimes, conducting and analysing pumping tests to assess aquifer properties, numerical modelling of groundwater flow in deep sedimentary basins and coal aquifers and analyses of drill stem tests.

PROJECT EXPERIENCE – GROUNDWATER DEWATERING AND SEEPAGE ANALYSIS**Greenhills**
SE British Columbia

Developed a numerical model of an open pit coal mine to predict pore pressures in the pit slopes and to assess dewatering options. Assisted in the design of deep dewatering wells to lower the pressures in the pit walls to acceptable levels for slope stability.

La Colorada
Mexico

Undertook hydrogeological investigations in an underground silver mine. Testing included pumping tests and measurement of hydraulic heads in probe holes. A numerical hydrogeological model was developed to predict future mine inflows and to assess dewatering options.

TransLink
Lower Mainland, BC

Acted as senior technical review of the hydrogeological aspects of the Evergreen rapid transit line. Project consisted of characterization of groundwater regime in the tunnel portion of the rapid transit line. Instrumental in developing the hydrogeological aspects of the Geotechnical Baseline Report and Project Specifications.

BC Hydro John Hart Project
Campbell River, BC

Acted as senior technical review of the hydrogeological aspects of the John Hart penstock replacement project. Project consisted of replacing on ground penstock with a 1.2 kilometre tunnel. It consisted of an assessment of groundwater inflows during construction and outflow during operations and potential effects to nearby slopes and dam. Assisted with the development of Specifications and Geotechnical Baseline Report.

TransCanada Highway
Revelstoke, BC

Groundwater investigations to assess the design of drainage galleries for slope stability purposed on TransCanada Highway. Investigations included installation of piezometers, groundwater modelling to assess optimum location of drainage tunnels and assistance in the design of the tunnels and drains.

Metro Vancouver
Coquitlam, BC

Senior technical review of hydrogeological aspects of an excavation for the Coquitlam UV facility on the Coquitlam River. Included instrumentation, hydrogeological testing and numerical modelling to assess excavation slope stability and dewatering requirements. Provided preliminary design of dewatering system for technical specifications.

Endako Mines
Prince George, BC

Hydrogeological testing and instrumentation to evaluate current water pressures in the walls of an open pit mine and to predict future water pressures. Developed remedial measures consisting of horizontal drainholes to improve slope stability conditions.

Huckleberry Mines
Smithers, BC

Involved in the hydrogeological assessment of a proposed open pit expansion that would intersect a historical tailings disposal areas. Involved in the design of dewatering/depressurization systems to assist in the stabilization of the pit slopes. Included hydrogeological testing and the development of a numerical model.

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- Ivanhoe Mines**
Mongolia
Senior technical review of hydrogeological aspects of the Oyu Tolgoi Project. Developed numerical hydrogeological model to predict seepage into a proposed open pit and to predict hydraulic heads to assess future slope stability conditions in the pit walls. Assisted in the preliminary design of dewatering/depressurization systems to improve slope stability.
- Diavik Diamond Mine**
Lac De Gras, NT
Senior technical review of the hydrogeological aspects of an open pit mine. Included the instrumentation and hydrogeological testing of pit slopes to evaluate the current slope stability and groundwater seepage conditions and to predict future conditions. Where required, developed dewatering/depressurization methods to improve stability of the slopes. Providing on-going support to dewatering design for the underground mine.
- Metro Vancouver**
North Vancouver, BC
Senior technical review of the hydrogeological aspects of the Seymour Capilano Filtration Project (SCFP). Project consisted of the installation of twin tunnels, 7 km in length, in bedrock between the Capilano Dam and the Seymour River drainage for the conveyance of raw and treated water. Estimated groundwater inflow quantities during excavation of the tunnels and groundwater outflow and cross-flow between tunnels when at full operating pressures. Assessed the potential effects to seepage and slope stability to the East Abutment of the Cleveland Dam and the west slope of Lynn Creek during construction and operations of the twin tunnels.
- GVRD**
North Vancouver, BC
Designed dewatering measures required to prevent uplift in the floor of a Digester during cleaning and to prevent ground settlement at a GVRD water treatment plant.
- BC Hydro**
Castlegar, BC
Designed and provided specifications for a drain collection system for slope stability of dam abutments at the Kootenay Canal Power Plant. Specified pre-packed screens to drain a silt slope.
- Highland Valley
Copper**
Kamloops, BC
Provided on-going monitoring and evaluation of dewatering program at an open pit mine. There are two components to the dewatering program - deep high capacity wells to dewater highly permeable alluvial fans and vacuum assisted low capacity wells to depressurize silt and clays for slope stability purposes.
- Newmont Gold
Company**
Indonesia
Assessed the dewatering requirements and the effects of dewatering, pit lake formation, and waste rock on groundwater and surface waters.
- GVRD**
Annacis Island, BC
Developed contractor specifications and reviewed the dewatering plans for installation of permanent flow monitoring stations.
- Cominco Ltd.**
Smithers, BC
Conducted computer modelling of the groundwater regime. Assessed dewatering schedule and procedures. Included training of mine staff in model utilisation.
- PetroCanada Ltd.**
Chetwynd, BC
Modelled the groundwater flow regime at a proposed open pit mine to assess groundwater inflow and dewatering requirements.
- Polygon Development**
Coquitlam, BC
Assessed excavation inflows at a condominium development, designed the underdrain and the dewatering plan for excavation.

**Mine
Decommissioning**
Whitehorse, YT

Developed computer models to assess groundwater flow following decommissioning of an underground mine. Included evaluation of changes in groundwater discharge volumes as a result of decommissioning of mine tailings and rock waste dump.

**Tar Sands
Development**
Fort McMurray, AB

Assessed the groundwater regime at a proposed tar sands development in Northern Alberta. Included computer model to estimate mine inflow and to develop mine dewatering strategies.

Uranium Mine
Northern Saskatchewan

Developed computer model of groundwater regime at a proposed underground uranium mine. Analyses included assessment of mine inflows to various mine works scenarios and the effect of grouting on mine inflow and water pressures.

Open Pit Coal Mine
Wabamum Lake, AB

Modelled the groundwater regime at an open pit coal mine to evaluate the impact of the mine on the regional groundwater system and supply.

**Coal Washing
Reservoir**
Gravelbourg, SK

Characterised the groundwater regime beneath a proposed coal washing reservoir. Included computer model analysis to determine the effect of high water levels in lagoon on the regional groundwater flow system and on groundwater supply.

Potash Mine
Esterhazy, SK

Carried out model analysis of groundwater regime to determine approximate location and chronology of leaks at a potash mine. Included analysis of several hundred drill stem tests to determine formation transmissivities.

Coal Aquifers
Alberta

Conducted a study to characterise the hydraulic parameters of coal aquifers in Alberta. Included analyses of hundreds of pumping tests to determine effect of fracturing on transmissivity and storativity of coal seams.

PROJECT EXPERIENCE – HYDROLOGICAL ASPECTS OF ENVIRONMENTAL ASSESSMENTS AND PERMITTING

Snap Lake
Northwest Territories

Provided technical assistance on hydrogeology components of an environmental assessment and in hearings relate to project approvals and permitting. Included characterization of the regional groundwater flow regime and the prediction of the direction, travel time and contaminant transport of dissolved metals originating from the mine following closure of the mine. The environmental assessment was approved in late 2003.

Jay Pit Project
Northwest Territories

Senior technical review of hydrogeological baseline and the groundwater section of the Environmental Assessment. Field investigations included hydraulic conductivity measurements in deep boreholes and installation of a multi-level groundwater well to assess the salinity/depth profile. Single well pumping tests were undertaken in two of the ports in the multi-level well. The Environmental Assessment included prediction of groundwater inflow quantity and quality to the proposed Jay pit; predicted effects to groundwater quality and flow; and predicted effects to surface water bodies.

**BC Hydro John Hart
Project**
Campbell River, BC

Acted as senior technical review of the hydrogeological aspects of the John Hart penstock replacement project. Project consisted of replacing an above ground penstock with a 1.2 kilometre tunnel. Included an assessment of groundwater inflows during construction and outflow during operations and potential effects to nearby slopes and dam. Assisted with the development of Specifications and Geotechnical Baseline Report and Groundwater Section of an Environmental Assessment.

**Diavik Diamond
Project**
Northwest Territories

Providing on-going hydrogeological investigations to determine groundwater inflows to a mine located near Yellowknife. Duties have included conducting permeability tests in deep exploratory boreholes and conducting pumping tests in the underground mine. Numerical hydrogeological modelling was undertaken to assess mine inflows, dewatering systems, dewatering strategies and remedial measures. Drainage galleries consisting of 4 to 6 drainholes were designed and installed at approximately 75 m depth intervals in the underground mine. Acted as expert witness during project approval process and water licence renewal.

Meliadine
Nunavut

Hydrogeological Lead in the Environmental Assessment for several open pits and one underground mine for mining of gold deposits near Baker Lake. Included characterization of groundwater for baseline environmental conditions and development of effects assessment.

Turnbull
Elkford, BC

Hydrogeological Assessment for permitting of groundwater flow and quality from proposed tailings storage within an open pit coal mine. Included prediction of groundwater flow paths and groundwater quantity and quality.

McNab Cr.
British Columbia

Hydrogeological Lead in an Environmental Assessment for an aggregate extraction project in Howe Sound. Included characterization of the groundwater regime and effects assessment of the project and assessment of measures to mitigate effects to freshwater aquatic habitat.

Gahcho Kue
Northwest Territories

Hydrogeological Lead in an Environmental Assessment for a diamond mine. Included the development of characterization of groundwater regime for baseline conditions and numerical modelling to assess environmental effects. Options were examined to mitigate effects to the environment. Acted as Expert Witness at MacKenzie Valley Environmental Impact Review Board hearings.

Meadowbank
Nunavut

Hydrogeological Lead in the Environmental Assessment for open pit mines installed in a former lake bottom. Included characterization of the baseline groundwater quality and quantity and numerical hydrogeological model to assess potential effects to groundwater and other values ecosystem components.

PROJECT EXPERIENCE – HYDROGEOLOGICAL ASPECTS OF OPEN PIT MINE DEVELOPMENT

<p>Snap Lake Northwest Territories</p>	<p>Provided technical assistance on hydrogeology components of an environmental assessment and in hearings relate to project approvals and permitting. Included characterization of the regional groundwater flow regime and the prediction of the direction, travel time and contaminant transport of dissolved metals originating from the mine following closure of the mine. The environmental assessment was approved in late 2003.</p>
<p>Jay Pit Project Northwest Territories</p>	<p>Senior technical review of hydrogeological baseline and the groundwater section of the Environmental Assessment. Field investigations included hydraulic conductivity measurements in deep boreholes and installation of a multi-level groundwater well to assess the salinity/depth profile. Single well pumping tests were undertaken in two of the ports in the multi-level well. The Environmental Assessment included prediction of groundwater inflow quantity and quality to the proposed Jay pit; predicted effects to groundwater quality and flow; and predicted effects to surface water bodies.</p>
<p>Rea Gold Company Uruguay</p>	<p>Characterised the groundwater regime prior to mine development. Numerical modelling was conducted to assess mine inflows and depressurisation for slope stability purposes and the potential impacts of mine development of nearby surface water and groundwater supply.</p>
<p>Highland Valley Copper Kamloops, BC</p>	<p>Provided on-going monitoring, evaluation, and design of dewatering program for slope stability purposes at an open pit mine in south-central British Columbia. Presently, the dewatering system pumps a total of over 28,000 m³/day from overburden materials. Modelling conducted to assess future dewatering requirements.</p>
<p>Newmont Gold Company Batu Hijau Project, Indonesia</p>	<p>Assessed dewatering requirements and the effects of dewatering, pit lake formation; and waste rock, on groundwater and surface waters. Conducted numerical modelling of groundwater regime to evaluate mine inflows over life of mine.</p>
<p>Diavik Diamond Project Northwest Territories</p>	<p>Providing on-going hydrogeological investigations to determine groundwater inflows to a mine located near Yellowknife. Duties included conducting permeability tests in deep exploratory boreholes, design of deep groundwater sampling device, conducting a pumping test in an exploratory decline, and modelling to assess mine inflows, dewatering systems and strategies, and remedial measures. Acted as expert witness during project approval process.</p>
<p>Cominco Northwest Territories</p>	<p>Conducted feasibility level investigations to determine hydrogeological regime and to estimate flows to proposed open pit mine. Conducted modelling investigations to estimate inflows to proposed open pit and design preliminary dewatering process.</p>
<p>Newmont Gold Company Mesel Project, Indonesia</p>	<p>Provided recommendations on well installations and testing, to be conducted by the owner to characterise the hydrogeology at a mine site. Conducted numerical modelling to assess mine depressurisation for slope stabilisation.</p>

Cominco Ltd. Smithers, BC	Evaluated the groundwater inflows and groundwater pressures following installation of proposed remedial measures at a closure of an open pit mine. Included numerical modelling to assess proposed closure measures.
Meadowbank Nunavut	Hydrogeological Lead in the Environmental assessment for gold deposit in Nunavut. Included development of Baseline studies, numerical modelling to assess effects of project on groundwater regime and pathways to other receptors.
Royal Oak Mines NWT	Modelling to assess pit lake formation and groundwater flow conditions under long term equilibrium conditions.
Armenonic Ecuador	Assessed the existing tailings pond dam and proposed additions. Included recommendations for monitoring and slope stability improvements.
Teck Corporation Chile	Modelling to predict pit lake formation and long-term groundwater flow conditions.
Cominco Ltd. Pine Point, NWT	Computer modelling of groundwater regime. Assessment of dewatering schedule and procedures. Included training of mine staff in model utilisation.
PetroCanada Ltd. Chetwynd, BC	Modelling of groundwater flow regime at a proposed open pit mine to assess groundwater inflow.
Fording Coal Elkford, BC	Assessed tailings dam leakage and designed leakage retrieval system.
Effects of Open Pit Mine on Groundwater Supply Fife Lake, SK	Evaluated the impacts of an open pit coal mine in Southern Saskatchewan on the quality and quantity of groundwater at a nearby town. Conducted domestic water well survey and collected water samples over two years to assess impacts.
Tar Sands Development Fort McMurray, AB	Assessed the groundwater regime at a proposed tar sands development in Northern Alberta. Included computer model to estimate mine inflow and to develop mine dewatering strategies.
Open Pit Coal Mine Wabamum, AB	Conducted modelling of the groundwater regime at an open pit coal mine, to evaluate the impact of the mine on the regional groundwater system and resource.
Coal Washing Reservoir Gravelbourg, SK	Characterised the groundwater regime beneath a proposed coal washing reservoir. Included computer model analysis to determine the effect of high water levels in lagoon on the regional groundwater flow system and on groundwater supply.
Coal Aquifers Alberta	A study to characterise the hydraulic parameters of coal aquifers in Alberta. Included analyses of hundreds of pumping tests to determine effect of fracturing on transmissivity and storativity of coal seams.

PROJECT EXPERIENCE – HYDROGEOLOGICAL ASPECTS OF UNDERGROUND MINE DEVELOPMENT**Teck Corporation**
Alaska

Conducted studies to estimate mine inflow and to assess dewatering and grouting strategies at a proposed underground mine. Included packer testing, installation of monitoring wells, water sampling, pumping tests and numerical modelling. Designed wells for the injection of treated mine water during the development of exploration decline. Providing on-going hydrogeological assessment for full mine development.

Giant Mine
Northwest Territories

Conducted hydrogeological investigations related to an existing and a recently excavated arsenic stope. Conducted permeability testing and hydraulic head measurements in the pillar between stopes. Recommended the installation of a drainage galley beneath the two stopes to promote dewatering of the stopes. Drainage galley was nearing completion when the mine was shut-down.

Winspear
Northwest Territories

Provide hydrogeological services to the EIS and Feasibility mine plan. Investigations have included the installation of piezometers, permeability testing and water sampling. Computer modelling was undertaken to estimate mine inflows during the exploration decline and at the planned full mine development.

Pend Oreille
Washington

Hydrogeological investigations related to mine expansion. Investigations included permeability testing and hydraulic head measurement of proposed shaft development. Computer modelling was undertaken to estimate inflows to shaft development. Provide recommendations on mine dewatering strategies and grouting procedures.

Turquoise Ridge
Nevada

Hydrogeological investigations to develop dewatering strategies to improve trafficability in production areas. Included 3-D visualization of underground development, geology, structure and measurements of groundwater inflow during drilling of long exploration holes. The structure and geology were correlated to high inflows in order to identify major groundwater pathways that can be intercepted and drained prior to mining.

Asia Pacific
Thailand

Conducted pre-feasibility and feasibility hydrogeological investigations of a proposed underground potash mine. Including pumping tests, installation of monitoring wells, water sampling and numerical modelling. Estimated mine inflows and water supply potential and provided conceptual dewatering strategies.

Polaris Mine
Cornwallis, NWT

Provided testing procedures to determine hydrogeological properties at a proposed underground mine expansion. Numerical modelling was conducted to assess mine inflow at a planned expansion.

Raglan
Northern Quebec

Undertook and groundwater benchmark study that examined potential groundwater issues that could result if underground mining progressed below the permafrost zone. The quantity of inflow to this mine was of a particular concern as the ventilation in the underground is not heated. All previous mining was within the permafrost. Studies included review of thermal regime data, groundwater inflows to boreholes drilled below the permafrost, regional water level elevations of large lakes in area, geology and hydrogeologic projects with similar hydrogeologic and thermal regimes.

Red Mountain Smithers, BC	Conducted hydrogeological investigations to assess hydrogeological conditions and to estimate mine inflows to proposed underground mine.
Westmin Resources Myra Creek, BC	Characterised the groundwater regime and determined the source of acid rock drainage. Investigation included installation of wells, permeability testing and water sampling. Assisted in the design of remedial measures.
Uranium Mine Northern Saskatchewan	Developed a computer model of the groundwater regime at a proposed underground uranium mine. Analyses included assessment of mine inflows to various proposed mine plans and the effect of grouting and/or dewatering on mine inflow and water pressures.
Potash Mine Esterhazy, SK	Model analysis of groundwater regime to determine approximate location and chronology of leaks at an underground potash mine. Included analyses of several hundred drill stem tests to determine formation transmissivities and numerical modelling.
Hudson Bay Mining and Smelting Manitoba	A study to estimate groundwater inflow and recommend dewatering strategies in underground mines at Photo Lake and Kunoto Lake.
Eldorado Gold Corporation Turkey	A study to estimate groundwater inflow to a proposed underground mine and to assess the effects of mining on the groundwater and surface water regime.
Homestake British Columbia	Hydrogeological study including pumping tests, inflow mapping, structural modelling and packer testing. Groundwater inflow was estimated for the life of the mine. Dewatering wells were designed and installed. Dewatering strategies were determined.
Snap Lake Northwest Territories	Provided technical assistance on hydrogeology components of an environmental assessment and in hearings relate to project approvals and permitting. Included characterization of the regional groundwater flow regime and the prediction of the direction, travel time and contaminant transport of dissolved metals originating from the mine following closure of the mine. The environmental assessment was approved in late 2003.
TVX Gold Eastern Europe	Assessment of groundwater inflow to a proposed underground mine. Included the development of a computer model that was calibrated to measured inflows to preliminary mine development.
Diavik Diamond Project Northwest Territories	Providing ongoing hydrogeological investigations to determine groundwater inflows to a mine located near Yellowknife. Duties have included conducting permeability tests in deep exploratory boreholes and conducting pumping tests in the underground mine. Numerical hydrogeological modelling was undertaken to assess mine inflows, dewatering systems, dewatering strategies and remedial measures. Drainage galleries consisting of 4 to 6 drainholes were designed and installed at approximately 75 m depth intervals in the underground mine. Acted as expert witness during project approval process.
Jullietta Former U.S.S.R	Groundwater investigations at a proposed underground mine to assess groundwater inflows. Groundwater model was developed and calibrated to inflows to advanced exploration program.

T'Sable River
BC

Groundwater investigations to assess groundwater inflows to an exploration decline. Investigations included flow meter testing, permeability testing, piezometer installation and computer modelling. The potential for saline water intrusion will be assessed.

PROFESSIONAL AFFILIATIONS

Member, Association of Professional Engineers and Geoscientists of the Province of British Columbia

Member, Association of Professional Engineers, Geologists & Geophysicists of the Northwest Territories

Member, International Association of Hydrogeologists

Demonstrated Expertise in Pit Lake Management, Environmental Chemistry and Modeling – Curriculum Vitae for Jerry Vandenberg

Jerry A. Vandenberg

Vandenberg Water Science Ltd., 7441 Hawk Road, Kelowna, BC, V1P 1H9, Canada



ABSTRACT

Developing large-scale industrial projects poses risks to surface water bodies and their connected ecological systems. At all stages of project development, from initial site investigations to approvals to operations and closure, environmental models can be employed to predict the risk to the environment. More importantly, models can be used to derive and test mitigation strategies to avoid or minimize the risk. However, models are often mis-applied during this process – not through nefarious means but through lack of understanding and communication of the model's limitations, uncertainty and range or reliability.

A special case where models are often mis-applied is mine pit lakes. Mine pit lakes are formed at the cessation of open-pit mining, when the void is filled either passively or actively with water and other materials. In the past decade, many case studies have been published from which lessons can be derived about how to avoid the failures of the past and create beneficial uses in existing and future pit lakes. In some cases, this may require the use of numerical models, whereas in other cases, especially where applicable analog pit lakes have been created, best practices and lessons learned can guide the development of the pit lake toward beneficial end uses.

This document describes case studies of relevant projects undertaken by Jerry Vandenberg over the past two decades and serves as his curriculum vitae.

Keywords: *water quality modelling; mine pit lakes; fate and transport models; expert witness services; best practices; maximizing environmental performance*

Introduction

Vandenberg Water Science, Ltd. was formed as a consulting firm that specializes in three core areas of environmental science:

1. Pit Lake Management
2. Review of Environmental Models
3. Expert Witness Services

Jerry Vandenberg is the sole proprietor of VWS, and his demonstrated expertise over the past two decades is highlighted below.

Background

Jerry Vandenberg is registered as a Professional Chemist in Alberta and B.C. He holds an M.Sc. (Environmental Chemistry) and B.Sc. (Environmental Science, Chemistry Major) from the University of Calgary and a Water Quality Technology diploma from Okanagan University College.

Jerry retired as a Principal Environmental Chemist after 15 years at Golder Associates in 2019. Between 1998 and 2004, he held positions as a water treatment and environmental technologist.

He is now active in part-time careers such as Vandenberg Water Science, Ltd; as a paid-on-call fire fighter; and as a sessional instructor of Limnology at UBC (Okanagan).

Methods

Jerry has developed and applied methods for water quality monitoring and modelling that have become part of university course material (Vandenberg et al. 2005) and industry best practices (Vandenberg et al. 2016). A list of his notable projects related to model development, model application, water quality monitoring, pit lake management and expert witness services is provided in Table 1.

Jerry has taught these methods to staff at Golder Associates, as well as external courses for Indigenous Communities, Environment Canada model reviewers and at pre-conference workshops (Vandenberg 2011). Courses and workshops developed and delivered include:

- Aquatics Monitoring Protocols and Interpretation
- Best Practices for Mine Water Modelling
- Water Quality, Hydrodynamic & Dispersion Modelling
- Visual Basic for Applications
- Mental Health and Wellness in the Workplace

Table 1. Summary of Experience

Expertise	Services	Projects applied to
Model developer	Sediment diagenesis model (<i>Vandenberg et al. 2015; Prakash et al. 2015</i>)	Alberta oil sands pit lakes
	Oil sands pit lake model (<i>Mackenzie 2006; Lauzon et al. 2009</i>)	Alberta oil sands pit lakes
	Oil sands reclamation wetlands model (<i>Vandenberg and MacKenzie 2006</i>)	Regional oil sands reclamation research
	Cooling pond mass balance and geochemical model	Capital Power Genesee
Modeller or Reviewer	Pit lake hydrodynamic and water quality models	All Alberta oil sands mines; all NWT diamond mines; Burnco McNab; Greater Phoenix; Eagle Mine
	Multiple linked models including site-wide water quality, receiving environment dispersion and far-field (<i>Lauzon et al. 2011; Vandenberg et al. 2015; Zawadzki et al. 2017</i>)	Mines: Mount Polley; Amaruq; Wolverine; Constancia; Gahcho Kué; Jackpine; Frontier; Kearl; Muskeg River
	Aerial deposition model (<i>Dayyani et al. 2016</i>)	Alberta oil sands mines
	Sediment-water partitioning model	Alberta oil sands mines
	Tailings storage facility spill model	Nickel Plate Mine; Alberta oil sands mines
	Lake hydrodynamic and water quality model (<i>Snow et al. 2014</i>)	Snap Lake, NWT; Lac de Gras, NWT; Bootjack Lake, BC
	Cooling pond thermal model	TransAlta Sundance
	Hydroelectric reservoir and river model	Site C Dam
	CORMIX dispersion modelling	Meadowbank Mine
	Water Quality Monitoring	Automated instrumentation (<i>Vandenberg 2008</i>)
Forensic monitoring		Calgary Zoo; Shorncliffe Lake; Abbotsford; Lussier Hot Springs
Routine monitoring		Teck Beaverdell Mine; Okanagan Lake; Kearl Lake
Spill monitoring		Nickel Plate Mine
Pit Lake Management	Beneficial use of pit lake for water treatment (<i>Moger et al. 2017; Vandenberg and Litke 2017</i>)	Mount Polley Mine
	Third-party review of internal model	Rio Tinto, Australia
	Determine optimal use of pit lakes for mine waste disposal	NWT diamond mines; Alberta oil sands mines
	Develop industry guidance documents, roadmaps, global reviews and expert workshops for pit lake development (<i>McCullough et al. 2018; Vandenberg et al. 2014; Vandenberg 2016</i>)	Alberta oil sands mines
	Physical limnology of pit lakes used for passive selenium treatment	BC coal mines
Expert Witness	Reservoir model	BC Hydro Site C Dam
	Water quality and aquatic health components and pit lakes	Teck Frontier Oil Sands Mine
	Water quality component and pit lakes	Total Joslyn North Mine
	Water quality component and pit lakes	Shell Jackpine Mine Expansion
	Hydrodynamic and water quality model	De Beers Snap Lake Mine
	Water quality component and pit lakes	De Beers Gahcho Kué Mine
	Pit lake and water quality expert	Lafarge Phelan Pit
	Provide expert opinion (not testimony) on evidence	Multiple cases, under privilege, for law firms

Results

Jerry has applied the best available scientific information to approximately 40 large-scale industrial projects to minimize environmental disturbance, balance cost with environmental performance, obtain the necessary permits and approvals, safely operate and close facilities. Many of these projects were multi-year endeavors with rounds of review by government, stakeholders and third-party experts.

Acknowledgements

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References

Books and Chapters

Vandenberg, J.A. and C.D. McCullough. 2017. Key Issues in Mine Closure Planning for Pit Lakes. In: Spoil to Soil: Mine Site Rehabilitation and Revegetation. Boca Raton, FL, USA, Eds. Bolan, N.S., M.B. Kirkham and Y.S. Ok. CRC Press.

Vandenberg, J.A. 2012. In-lake Processes. In: Wylynyko, D. and J. Hrynshyn, End Pit Lakes Guidance Manual. Fort McMurray, AB, Document prepared for Cumulative Environmental Management Association pp. 175-212.

Vandenberg, J.A., N. Lauzon, S. Prakash and K. Salzsauler. 2011. Use of water quality models for design and evaluation of pit lakes. In: McCullough, C.D. Mine Pit Lakes: Closure and Management., Australian Centre for Geomechanics. pp. 63-82.

Sawatsky, L.F., M.A. Fitch, A.K. Beersing and J.A. **Vandenberg.** 2011. Hydrologic and geometric design of pit lakes for long-term sustainability. In: McCullough, C.D. Mine Pit Lakes: Closure and Management., Australian Centre for Geomechanics. pp.53-62.

Vandenberg, J.A. 2008. Remote, Real-time Water Quality Monitoring on the Bow River, Alberta, Canada. Establishing the Necessary Instrumentation and Communication Equipment in the Absence of Infrastructure. Saarbrücken, Germany, VDM Verlag Dr. Müller Aktiengesellschaft & Co.

Refereed Journal Articles

McNaughton, C.S, J.A. **Vandenberg** and P. Thiede. 2019. Reanalysis of Aerial Deposition of Metals and Polycyclic Aromatic Compounds to Snow in the Athabasca Oil Sands Region of Alberta Canada. Science of the Total Environment. Published online 26 May 2019. /DOI: 10.1016/j.scitotenv.2019.05.097

Vandenberg, J.A. and S. Litke. 2018. Beneficial use of Springer Pit Lake at Mount Polley Mine, Canada. Mine Water and the Environment. 37(4), 663-672. DOI: 10.1007/s10230-017-0504-y

Vandenberg, J.A. and A. Snow. 2016. A simple but effective model calibration for nitrite in northern lakes. Integrated Environmental Assessment and Management, 12(4): 821–829. DOI: 10.1002/ieam.1807.

Dayyani, S., G. Daly and J.A. **Vandenberg.** 2016. Approach to Assessing the Effects of Aerial Deposition on Water Quality in Alberta Oil Sands Region. Water Environment Research. 88(2), pp.175-189.

Vandenberg, J.A., M. Herrell, J.W. Faithful, A.M. Snow, J. Lacrampe, C. Bieber, S. Dayyani and V. Chisholm. 2015. Multiple Modeling Approach for the Aquatic Effects Assessment of a Proposed Northern Diamond Mine Development. Mine Water and Environment, <http://dx.doi.org/10.1007/s10230-015-0337-5>, 1-9.

Jiang, J., J. **Vandenberg,** I. Halket, K. Clipperton, K. Kavanagh and J. Hogg. 2015. Modelling Water Quality in an Oil Sands Compensation Lake. Canadian Journal of Civil Engineering, 10.1139/cjce-2014-0292

Vandenberg, J.A., S. Prakash and E. Buchak. Sediment Diagenesis Module for CE-QUAL-W2. Part 1: Conceptual Formulation. Environmental Monitoring and Assessment, 20(3) DOI: 10.1007/s10666-014-9428-0 (2015), 239-247.

Prakash, S., J.A. **Vandenberg** and E. Buchak. Sediment Diagenesis Module for CE-QUAL-W2. Part 2: Numerical Formulation. Environmental Monitoring and Assessment, 20(3) DOI:10.1007/s10666-015-9459-1 (2015), 249-258.

Vandenberg, J.A., M.C. Ryan, D.D. Nuell and A. Chu. 2005. Field evaluation of mixing length and nutrient attenuation of a wastewater effluent plume. Environmental Monitoring and Assessment, 107:45-57.

Conference Talks and Papers

Skeries, K. Herrell, M., **Vandenberg, J.A.,** Faithful, J., Hayward, A., Novy, L. 2018. Influence of Probability Distribution Function Sampling Frequency on Stochastic Water Quality Model Predictions. 11th ICARD/IMWA/MWD 10-14 September 2018. Pretoria, South Africa.

Herrell, M., **Vandenberg, J.A.,** Faithful, J., Hayward, A., Novy, L. 2018. Long-term Water Management of Saline Groundwater at the Ekati Diamond Mine. 11th ICARD/IMWA/MWD 10-14 September 2018. Pretoria, South Africa.

McCullough, C, Schultze, M. and **Vandenberg, J.** 2018 Realising Successful Beneficial End Uses for Pit Lakes. Mine Closure. September 4-7, 2018. Leipzig, Germany.

Vandenberg, J. and McCullough, C. 2018. Global review of pit lake case studies. COSIA Innovation Summit. June 7-8, 2018. Calgary, Canada.

McNaughton, C., Thiel, P., **Vandenberg, J.** 2018. Re-analysis of snowpack and lake sediment data in the Athabasca Oil Sands Region. COSIA Innovation Summit. June 7-8, 2018. Calgary, Canada.

Fawcett, S., Bechtold, J.P., **Vandenberg, J.** 2018. Water quality-based strategies for successful oil sands mine closure and the importance of model validation. COSIA Innovation Summit. June 7-8, 2018. Calgary, Canada.

- Fawcett, S., Bechtold, J.P., **Vandenberg**, J. 2017. Operational water quality-based strategies for successful oil sands mine closure. Tailings and Mine Waste 2017. November 5-8, 2017. Banff, Canada.
- Moger, L., McMahan, K., Weeks, B., da Silva Sympovsky, T., **Vandenberg**, J. 2017. Passive Treatment Concepts for Mine Closure at Mount Polley Mine. Tailings and Mine Waste 2017. November 5-8, 2017. Banff, Canada.
- Zawadzki, W., Millar, R., **Vandenberg**, J.A., Moger, L. and Hughes, C. 2017. Real-time Analyses Supporting Temporary Mine Water and Tailings Storage in the Springer Pit, Mount Polley, BC. IAH-CNC - UBC Spring 2017 Hydrogeology Symposium. May 12, 2017. Vancouver, Canada.
- Vandenberg**, J.A. and P. Beddoes. 2016. Beneficial use of Springer Pit Lake at Mount Polley Mine. Mine Environment Neutral Drainage (MEND) BC Conference, December. Vancouver, Canada.
- Vandenberg**, J.A., L. Nikl, J. Wernick, J. Van Geest, C. Hughes, K. McMahan and L. Anglin. 2016. Mount Polley Mine embankment breach: overview of aquatic impacts and rehabilitation. Saskatchewan Mining Association Annual Conference, October. Saskatoon, Canada.
- Beddoes, P., M. Herrell, J.A. **Vandenberg**, J. Richards, R. Millar and K. McMahan. 2016. Validation of Springer Pit Lake Water Balance and Water Quality Model, Mount Polley Mine, British Columbia, Canada. International Mine Water Association, July 2016. Leipzig, Germany.
- Vandenberg**, J.A., K. Salzsauler and S. Donald. 2016. Best Practices Checklist for Modelling Mine Waters. International Mine Water Association, July 2016. Leipzig, Germany.
- McNaughton, C., T. White and J.A. **Vandenberg**. 2016. Understanding Aerial Deposition of Metals and PAHs in the Athabasca Oil Sands Region. 2016 COSIA AI-EES Water Conference, March. Calgary, Canada.
- Vandenberg**, J.A.. 2016. Current perspectives in pit lake water management and passive treatment. 2016 COSIA AI-EES Water Conference Workshop, March. Calgary, Canada.
- Vandenberg**, J.A., C.D. McCullough and D. Castendyk. 2015. Key issues in mine closure planning related to pit lakes. 10th International Conference on Acid Rock Drainage and IMWA Annual Conference, April 25. Santiago, Chile.
- Herrell, M., J.A. **Vandenberg** and J. Faithful. 2015. Designing meromictic pit lakes as a mine closure mitigation strategy in northern Canada. 10th International Conference on Acid Rock Drainage and IMWA Annual Conference, April 25. Santiago, Chile.
- Vandenberg**, J.A., E. Buchak, D. Castendyk, A. James, M. Lund, C.M. McCullough, M.D. Mackinnon and J. Rogers. 2014. Planning for Canada's Future in Oil Sands Pit Lakes: The Demonstration Pit Lake Project. Geological Society of America Annual Conference, October 19-22. Vancouver, BC, Canada.
- Beddoes, P., J.A. **Vandenberg**, M. Rogers and I. Mackenzie. 2014. Oil Sands Mine Water Salt Loading Model. Canada's Oil Sands Innovation Alliance (COSIA) Water Summit, March 11-13. Edmonton, AB, Canada.
- Vandenberg**, J.A., E. Buchak, D. Castendyk, A. James, M. Lund, C.M. McCullough, M.D. Mackinnon and J. Rogers. 2014. The Demonstration Pit Lake Project. Canada's Oil Sands Innovation Alliance (COSIA) Water Summit, March 11-13. Edmonton, AB, Canada.
- Snow, A., J.A. **Vandenberg**, S. Prakash, V. Chisholm and A. Hood. 2014. Water quality modelling in Northern Canada. Canadian Conference for Fisheries Research, January 3-5. Yellowknife, NT, Canada.
- Beddoes, P., M. Herrell and J.A. **Vandenberg**. 2013. Role of Professional Judgement and Scaling in Interpretation of Water Quality Model Results. International Mine Water Association Annual Conference, August 5-9. Golden, CO, USA.
- Prakash, S., J.A. **Vandenberg** and E. Buchak. 2012. CEMA Oil Sands Pit Lake Model. CONRAD 2012 Water Conference, April. Edmonton, AB, Canada.
- Prakash, S., J.A. **Vandenberg** and E. Buchak. 2011. The Oil Sands Pit Lake Model - Sediment Diagenesis Module. MODSIM 2011. Modelling and Simulation Society of Australia and New Zealand, December 12-16. Perth, Australia.
- Lauzon, N., J.A. **Vandenberg** and J.P. Bechtold. 2011. Probabilistic Modelling Applied to the Mining Industry to Address Water Quality Uncertainty. MODSIM 2011. Modelling and Simulation Society of Australia and New Zealand, December 12-16. Perth, Australia.
- Lauzon, N., J.A. **Vandenberg** and I.B. Mackenzie. 2009. Pit Lake Modelling for the Athabasca Oil Sands Region, Alberta, Canada. Enviromine 2009, September. Santiago, Chile.
- Vandenberg**, J.A., I.B. Mackenzie, N. Lauzon and A. Takyi. 2008. Water Quality Modelling of Oil Sands Pit Lakes. North American Lake Management Society Symposium on Lake Management in a Changing Environment, November 12. Lake Louise, AB, Canada.
- Mackenzie, I.B., N.L. Lauzon, A. Takyi and J.A. **Vandenberg**. 2006. Pit Lake Modelling for the Oil Sands Region: Comparison of Water Quality Models. Canadian Society of Petrol. Geol., Canadian Soc. of Geoph. & Canadian Well Logging Soc. 2006 Conf., May 15-18. Calgary, AB, Canada.
- Vandenberg**, J.A. and I.B. Mackenzie. 2006. Natural Wetland Analysis Tools to Determine Treatment Efficiencies in the Oil Sands Area of Alberta. Alberta Soc. of Prof. Bio. Annual Conference on Water: Science and Politics, March 25-28. Calgary, AB, Canada.
- Vandenberg**, J.A., M.C. Ryan, D.D. Nuell and A. Chu. 2004. Mixing and Attenuation of Nutrients in a Wastewater Plume, Bow River, Alberta. 56th Annual Western Can. Water and Wastewater Conference, October 17-20. Calgary, AB, Canada.
- Nuell, D.D., J.A. **Vandenberg** and M.C. Ryan. 2004. Using GIS to Model Transverse Mixing of Effluent Downstream of Bonnybrook Wastewater Treatment Plant, Calgary, Alberta, Canada. ESRI International User Conference, Aug. 9-13. San Diego, CA, USA.
- Ryan, M.C., J.A. **Vandenberg** and A. Chu. 2004. Real Time Water Quality Monitoring - Trails and Tribulations. International Watershed Symposium, June 22-25. Edmonton, AB, Canada.
- Ryan, M.C., J.A. **Vandenberg**, A. Chu and M. Iwanyszyn. 2004. Real Time River Monitoring in the Total Maximum Daily Load Context. Monitoring in a Changing Climate: Recent Advances in Automatic Electronic Water Quality Monitoring and Assessment. Canadian Water Res. Assoc. BC Branch Workshop, October 13-14. Vancouver, BC, Canada.
- Guillemaud, J., I.R. Hunt, V.J. Mozol, J.D. Tunuguntla and J.A. **Vandenberg**. 2004. Undergraduate Chemistry Online. 31st Annual C3 Conference, June 10-12. Kelowna, BC, Canada.
- Vandenberg**, J.A., B.R. Manwell and M.C. Ryan. 2003. Basin Scale Groundwater - Surface Water Interaction in a Mountain River. Ground Water Assoc. Annual Conference, December 8-11. Las Vegas, NV, USA.

Education

B.Sc. Zoology, University of Western Ontario, London, ON Canada, 1998

M.Sc. Zoology, University of Western Ontario, London, ON Canada, 2000

Ph.D. Biology, University of New Brunswick, Saint John, NB Canada, 2006

Certifications

SCUBA Certified Open Water Diver, November 2002

Standard First Aid - Level A CPR, October 2016

Transportation of Dangerous Goods, September 2016

Construction Safety Training System, September 2016

WHMIS, September 2016

Languages

English – Fluent

Golder Associates Ltd. – Edmonton**Senior Ecotoxicologist, Fish Biologist**

Dr. Rainie Sharpe is an ecotoxicologist and fish biologist with over 18 years experience in the design and implementation of physiology, toxicology, and environmental effects monitoring studies, including aquatic effects monitoring programs. Her expertise relates to fish health and tissue chemistry assessments associated with metal and organic pollutants, endocrine disruptors, and perfluorinated substances.

Rainie currently acts as senior technical reviewer and advisor for various fisheries components on several aquatic effects monitoring programs in the Canadian Northwest Territories and Nunavut, as well as provincially-based regional aquatic biomonitoring programs. Rainie has led environmental risk assessments and served as a technical advisor for contaminated site remediation efforts involving aquatic habitats.

Employment History**Golder Associates – Edmonton, Alberta**
Ecotoxicologist, Fish Biologist (2008 to Present)

Senior reviewer and technical advisor for various fish health and fish tissue chemistry components of Environmental Effects Monitoring programs and Aquatic Effects Monitoring Programs. Project manager for AEMP, EEM, and other environmental services/monitoring and assessment projects. Involved with the Water Quality and Biophysical division leadership through staff mentoring and training, business development, and marketing at various environmental toxicology conferences.

University of Alberta – Edmonton, Alberta
Adjunct Professor (2017 to Present)

Appointed in November 2017 to the department of Biology as an Adjunct Professor. Responsibilities include graduate student mentoring, supervision, and acting as an internal/external reviewer for graduate student theses and oral exams, as well as delivering lectures for undergraduate student courses.

University of Alberta – Edmonton, Alberta
Post-Doctoral Fellow (2006 to 2008)

Cross-appointed to the Biology and Chemistry departments; primary research involved chemical bioassays using two model fish species, Lake Trout and Zebrafish. Designed study and implemented experiments investigating isomer-specific PFOS bioaccumulation in various organs and multiple life stages of Rainbow Trout, and demonstrated maternal transfer and developmental toxicity of PFOS in Zebrafish. Served as advisor for two honours student thesis projects. Responsible for management of animals, permits, training, experiments, data synthesis & analysis, writing of final reports, and publication in primary literature.

University of New Brunswick – Saint John, New Brunswick

Instructor (2004 to 2006)

Responsible for developing and delivering course material for first year Human Anatomy and Physiology (Nursing curriculum). Coordinated classes, exams, assignments, and supervised graduate student teaching assistants. Responsible for final submission of marks to the University and accountable to department Chair.

University of New Brunswick – Saint John, New Brunswick

Graduate Student (2000 to 2006)

Responsible for completing Ph.D. thesis research in phytosterol-induced endocrine disruption and alteration of lipid dynamics in Goldfish. Participated in academic service to various committees. Fulfilled teaching commitments in the form of research and teaching assistantships.

University of Western Ontario – London, Ontario

Graduate Student (1998 to 2000)

Responsible for completing M.Sc. thesis research in muscle physiology and ion transport in Rainbow Trout. Participated in academic service through various committees, including Zoology Grad Student President (1999-2000). Fulfilled teaching commitments in the form of research and teaching assistantships.

University of Western Ontario – London, Ontario

Laboratory Instructor (1997 to 1998)

Responsible for delivering laboratory course material (Animal Reproduction) and co-ordinating labs, exams, and assignments. Responsible for grading of laboratory reports and activities, accountable to course Professor.

PROJECT EXPERIENCE – ENVIRONMENTAL MONITORING

- Snap Lake**
Snap Lake, NT, Canada
- Previous technical Lead for the fish health and fish tissue chemistry component of the Aquatic Effects Monitoring Program (AEMP) for the De Beers Snap Lake diamond mine (operations). Responsible for ongoing component management, study design, data synthesis, interpretation, reporting and fisheries team cohesion, as well as subsequent response planning activities as a result of monitoring conclusions. Current role as senior reviewer for fish health and fish tissue chemistry components.
- Gahcho Kue**
Kennady Lake, NT,
Canada
- Previous technical Lead for development of Adaptive Management Response Framework, Surveillance Network Program development, and fish health and fish tissue chemistry component lead for the detailed Aquatic Effects Monitoring Program (AEMP) for the De Beers Gahcho Kue diamond mine (construction). Responsible for presentation of response framework materials at AEMP workshop and technical sessions; coordinating design and integration of aquatic environmental monitoring approaches with emerging adaptive management approaches, as well as provincial and federal guidance. Current role as senior reviewer for fish health and fish tissue chemistry components.
- Dominion Diamonds**
Lac du Sauvage, NT,
Canada
- Previous technical Lead for development of fish health and fish tissue chemistry component for the detailed Aquatic Effects Monitoring Program (AEMP) for the Jay Project diamond mine. Responsible for coordinating design and integration of aquatic environmental monitoring approaches with emerging adaptive management approaches, as well as provincial and federal guidance. Current role as senior reviewer for fish health and fish tissue chemistry components.
- Fortune Minerals**
Burke Lake, NT, Canada
- Technical lead for the Aquatic Effects Monitoring Program (AEMP) for Fortune Minerals gold-cobalt-bismuth-copper mine through project permitting, including expert witness at Water License Hearings, technical sessions and AEMP working group sessions towards AEMP finalization in the design phase; previously technical lead for fish health and fish tissue component of the AEMP (pre-production). Responsible for team coordination towards finalizing AEMP design, technical development of fisheries components study design and the effective integration of environmental baseline data with proponent and regulatory requirements towards an effective aquatics monitoring program.
- TransAlta-Capital
Power Regional
Biomonitoring**
Wabamun, AB, Canada
- Project Manager and Technical Lead for fisheries component for Regional Biomonitoring Program (Aquatic Receptors) at the TAU-EPCOR Wabamun coal-fired power generation Facility and the Capital Power Genesee coal-fired power generation Facility from 2008 until present. Responsibilities include client and regulator communications, field program co-ordination and completion, including fishing efforts and associated analyses and subsequent data analysis, interpretation, reporting, and presentation of findings to provincial regulators. Current role is senior technical reviewer for fisheries component.

- Meliadine**
Kivalliq Region, NU,
Canada
- Lead for development of Aquatic Effects Monitoring Program for Agnico Eagle Mines gold mine (pre-production). Responsible for AEMP program design and the effective integration of environmental baseline and ongoing environmental impact statement (EIS) details towards an effective monitoring program. Current role as senior reviewer for fish health and fish tissue chemistry components.
- Giant Mine**
Yellowknife, NT, Canada
- Previous Fish Health Technical Lead for Phase 3 EEM program at Giant Mine (closure; 2009-2011) and Fish Health technical advisor for contaminated site remediation investigations (2011-present) at Baker Creek. Responsible for integration of baseline and newly collected fisheries data towards making informed decisions regarding remediation of Baker Creek.
- Con Mine**
Yellowknife, NT, Canada
- Previous Technical Lead for Phase 3 EEM program (Investigation of Cause, 2010) and Phase 4 EEM (2011-2012) at Con Mine, presently senior technical reviewer for fish health component. Responsible for acquiring subcontractors, study design review, supervising and completing field program, data synthesis, interpretation and reporting.
- Whitefish Lake First Nation**
Goodfish Lake, AB,
Canada
- Senior Technical Advisor for marsh sampling during remediation of lagoon associated with a former dry-cleaning facility, followed by a screening level environmental risk assessment of a proposed portable wastewater treatment system installation. Assisted, advised and reported on issues relating to chemical, environmental and toxicological analyses and interpretation during project activities. Included extensive liaising with Indian and Northern Affairs Canada (INAC) and band administration.
- Kipohakaow Tourism Div. Inc.**
Sandy Lake, AB,
Canada
- Project manager and fisheries lead for a screening level environmental risk assessment for the KTDI tourism development (including a golf course and cottage lots) at Sandy Lake, AB. Included financial management and liaising with KTDI staff and band administration.

PROJECT EXPERIENCE – PROJECT MANAGEMENT

- Diavik Environmental**
Lac de Gras, NT,
Canada
- Project Manager for the Diavik Environmental Project, specifically coordination and technical oversight of the Aquatic Effects Monitoring Program and other environmental programs, from November 2016 to present.
- Fortune Minerals Limited**
Northwest Territories,
Canada
- Project Manager for the Fortune Minerals Limited NICO Project baseline monitoring program and other environmental programs, from November 2016 to present.
- TransAlta Capital Power Regional Biomonitoring Program**
Edmonton, AB, Canada
- Project Manager for Regional Biomonitoring Program (Aquatic Receptors) at the TAU-EPCOR Wabamun coal-fired power generation Facility and the Capital Power Genesee coal-fired power generation Facility, from 2015 until present.

Husky Oil Emergency Response
Maidstone, AB, Canada

Project Manager for emergency response effort in support of Husky Oil following pipeline breach on the North Saskatchewan River in July 2016. Responsible for staffing and field coordination, equipment tracking, and client communications.

PROJECT EXPERIENCE – EMERGENCY RESPONSE

Husky Oil
Maidstone, SK, Canada

Project Manager and technical advisor for emergency response water quality and wildlife support teams to Husky Oil following pipeline breach on the North Saskatchewan River in July 2016. Responsible for staff and field coordination and client communications

Mount Polley Mining Corporation
Mount Polley Mine, BC, Canada

Fisheries lead for assessment of changes in fish tissue chemistry as a result of a tailings breach and release of tailings to downstream environment. Received data collected by MPMC and other stakeholders; responsibilities included assessment and interpretation of risk to fish and consumers of fish in the downstream environment as a result of the tailings breach.

Canadian National Railway Company
Wainwright, Alberta, Canada

Lead for interpretation of chemical exposure risk for environmental impact of a train derailment where phenol formaldehyde resin, petroleum coke and cement products were released on railway embankment in proximity to a wetland. Chemical testing and assessment of soil, groundwater and surface water conditions was completed.

Enbridge
Athabasca, Alberta, Canada

Lead for interpretation of environmental impact of drilling mud release investigation. Chemical testing and interpretation of risk from bentonite mud slurry that was accidentally released to the environment and downstream environment was performed, in consideration of aquatic life, habitat and human water consumption.

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSMENT

Trans Alta-Epcor
Wabamun, AB, Canada

Project Manager and Fisheries lead for Gas Bubble Trauma (GBT) study in the North Saskatchewan River and outlet canal of TAU-EPCOR Keephills facility. Investigated occurrence of GBT in waters downstream of cooling pond blowdown in the North Saskatchewan River, and within cooling pond in 2010 and 2011. Responsibilities included client service, study planning and design, as well as field efforts, data analyses, interpretation and reporting and overall project coordination.

Whitefish Lake First NationGoodfish Lake, AB,
Canada

Project manager for a marsh media assessment adjacent to contaminated site associated with a former dry-cleaning facility. Responsibilities included field program co-ordination and completion, including water and sediment sampling in and around the marsh, as well as fishing efforts to determine the presence/absence of fish species within the marsh ecosystem. Included extensive liaising with INAC, band administration and the analytical laboratory.

PROJECT EXPERIENCE – EMERGENCY RESPONSE TRAINING**Kinder Morgan**

Edmonton, AB, Canada

Environmental Team (Aquatic Lead) participant in Emergency Incident Response Drill in Edmonton, AB in June 2015. Responsible for developing surface water sampling program during the drill and adjusting as necessary in real time to escalating emergency situations as part of the drill.

PROJECT EXPERIENCE – NEW SUBSTANCES NOTIFICATION**Department of
Research and Defence
(DRDC)**CFB Suffield, AB,
Canada

Project manager for a New Substances Notification (NSN) process for bioaerosol simulant testing at the Colin Watson Aerosol Layout (CWAL) grid and CFB Suffield. Included extensive liaising with DRDC staff, a field site and risk assessment, and ongoing dialogue with Environment Canada staff with regards to specific NSN filing process details.

PROJECT EXPERIENCE – TRANSPORTATION**Highway 16**

Hinton, AB, Canada

Responsible for the aquatics assessment on a project which proposed to twin Highway 16 from the Jasper National Park boundary west to the Hinton city limit. Involved a thorough review of existing literature, Alberta Environment data base information searches and synthesis of the aquatics portion of the report.

Sheep River

Okotoks, AB, Canada

Responsible for the aquatics assessment on a project which proposed to cross the Sheep River and construct a significant diversion of the river bed. Involved a thorough review of existing literature and data bases, liaising with personnel who had performed extensive field surveys at the site, and synthesis of the aquatics portion of the report.

PROJECT EXPERIENCE – PRIMARY RESEARCH**Primary Research -
University of Alberta**

Edmonton, AB, Canada

Examined maternal transfer and developmental toxicity of perfluorinated chemicals in fish species; studied organ specific distribution of PFOS isomers following single or repeated exposure at various life stages; developed extraction and detection methods for organic pollutants (e.g., pesticides, pharmaceuticals, industrial chemicals) in water and biological samples by liquid chromatography and mass spectrometry; investigated heat shock protein (HSP) induction in rainbow trout as a non-specific stress response.

- Primary Research -
University of New
Brunswick**
Saint John, NB, Canada
- Investigated effects & mechanisms of endocrine disruption associated with pulp & paper mill effluent and its associated contaminants in fish species. Research focused on naturally occurring phytoestrogens as constituents of pulp and paper mill effluent and their effects on lipid dynamics, reproductive hormones and reproductive capacity in fish. Cholesterol synthesis and metabolism were investigated, along with endocrine and reproductive health indicators in reproductively developing fish.
- Primary Research -
University of Western
Ontario**
London, ON, Canada
- Investigated metabolite-specific membrane transport in Rainbow Trout white muscle.
- Primary Research -
University of Western
Ontario**
London, ON, Canada
- Examining spermatogenic integrity in rat testis following disruption by glycerol injection as a contraceptive method.

TRAINING

- Microsoft ACCESS Database Training Part 2**
Northern Alberta Institute of Technology, November 2014
- Microsoft ACCESS Database Introductory**
Grant McEwan University, November 2013
- The Experimental Fish Online Animal Care Training Program**
Canadian Aquaculture Institute, September 2002

SUPPLEMENTAL SKILLS

Workshop Planning and Organization

Invited and organized for BGen (ret'd) Joe Sharpe and team to deliver a two-day "Leadership and Command" training workshop to the multiple Golder offices and Project teams in 2013.

Aquatics Techniques Workshop Contributor

Synthesized and delivered Fish Health session at internal Golder Aquatic Techniques Workshop 2013 in Kananaskis, AB.

Training Course Creation

Designed and delivered two-day internal workshop for junior and intermediate field staff on fish health and tissue chemistry sampling protocols and subsequent data analyses in 2015, Edmonton AB.

Conference Organization

Member of the 2016 Canadian Ecotoxicity Workshop (CEW) Organizing Committee, wherein prepared audio-visual marketing material in advance of the meeting for presentation at CEW 2015, and served on numerous organizing for the 2016 CEW conference in September 2016 at Edmonton AB.

SCUBA

Certified and experienced open water SCUBA diver

PROFESSIONAL AFFILIATIONS

Canadian Ecotoxicology Workshop

Society of Environmental Toxicology and Chemistry

Canadian Water Network

Canadian Rivers Institute

PUBLICATIONS

Conference Proceedings

MacLatchy, D.L., M.G. Dube, M.L. Hewitt, S.C. Courtenay, R.L. Sharpe and G. J. Van Der Kraak. 2003. *Development of a fish bioassay to test for hormonally-active contaminants in pulp mill effluents*. 5th International Conference on Fate and Effects of Pulp Mill Effluents. Seattle, Washington, USA.

Chapters

MacLatchy, D. L. M., Gormley, K. L., Ibey, R. E. M., Sharpe, R. L., Shaughnessey, K. S., Courtenay, S. C., Dubé, M. G. & Van Der Kraak, G. J. 2005. A short-term mummichog (*Fundulus heteroclitus*) bioassay to assess endocrine responses to hormone-active compounds and mixtures. In *Techniques in Aquatic Toxicology* (Ostrander, G., ed.), Vol. 2, pp. 55-91.

Journal Articles

Barrett, Timothy J, Kelly A Hille, Rainie L Sharpe, Katherine M Harris, Hilary M Machtans and Peter M Chapman. Quantifying natural variability as a method to

detect environmental change: definitions of the normal range for a single observation and the mean of m observations. *Environmental Toxicology and Chemistry*, 34(5) (2015), 1185-1195.

Barrett, Timothy J, Rainie L Sharpe and M Ekram Azim. A novel approach for graphing censored environmental data. *Integrated Environmental Assessment and Management*, 10(4) (2014), 5.

Sharpe, R.L., J.P. Benskin, A.H. Laarman, S.L. MacLeod, J.W. Martin, C.S. Wong and G.G. Goss. Perfluorooctane sulfonate toxicity, isomer-specific accumulation, and maternal transfer in Zebrafish (*Danio rerio*) and Rainbow Trout (*Oncorhynchus mykiss*). *Environmental Toxicology and Chemistry*, 29(9) (2010), 1957-1966.

Sharpe, R.L., A. Woodhouse, T.W. Moon, V.L. Trudeau and D.L. MacLatchy. β -Sitosterol and 17β -estradiol alter gonadal steroidogenic acute regulatory protein (StAR) expression in goldfish, *Carassius auratus*. *Gen. Comp. Endocrinol.*, 151 (2007), 34-41.

Sharpe, R.L. and MacLatchy D.L.. Cholesterol dynamics in goldfish (*Carassius auratus*) exposed to β -sitosterol and 17β -estradiol during a period of recrudescence. *Comp. Biochem. Physiol.*, 145 (2007), 507-517.

Sharpe, R.L., M. Drolet and D.L. MacLatchy. Investigation of de novo cholesterol synthetic capacity in the gonads of goldfish (*Carassius auratus*) exposed to β -sitosterol and 17β -estradiol. *Repro. Biol. Endocrinol.*, 4 (2006), 60.

Sharpe, R.L. and C.L. Milligan. Lactate efflux from sarcolemmal vesicles isolated from rainbow trout *Oncorhynchus mykiss* white muscle is via simple diffusion. *J. Exp. Biol.*, 206 (2002), 543-549.

Other

Canadian Water Network. 2004-2005. The Canadian Water Network Student Newsletter, Volume 1 (Issue 1 and 2). Brasfield, S. and Sharpe R.L.

Canadian Rivers Institute. 2004. Progress Report to the University of New Brunswick Board of Governors. Blonar, C., Brasfield, S., Doherty, C., Keeler, R., Reid, J., Sharpe, R., Munkittrick, K. and MacLatchy, D.

Canadian Ecotoxicology Workshop. 2014. Adaptive Management in Canada's Northwest Territories: Using Prediction Intervals as Benchmarks to Quantify Natural Variability in Environmental Monitoring Studies. Rainie L Sharpe (PRESENTER), Timothy J Barrett, Hilary M Machtans, Peter M Chapman, Alexandra Hood.

Canadian Ecotoxicology Workshop. 2015. Adaptive Management in Canada's Northwest Territories: A Case Study of the Application of Prediction Intervals to Quantify Natural Variability. Rainie L Sharpe (PRESENTER), Timothy J Barrett, Hilary M Machtans, Peter M Chapman, Alexandra Hood.

Canadian Ecotoxicology Workshop. 2016. Assessing Natural Variability: Dare to

be (Quantifiably) Different. Rainie L Sharpe (SESSION CHAIR).

Canadian Ecotoxicology Workshop. 2016. Adaptive Management in Canada's Northwest Territories: A Case Study of cesium and thallium in fish tissue at a diamond mine. Rainie L Sharpe (PRESENTER), Melanie D Campbell, Clayton James, Hilary M Machtans, Peter M Chapman, Alexandra Hood.

Canadian Ecotoxicology Workshop. 2017. Assessing Natural Variability: How Different is Too Different? Rainie L Sharpe (SESSION CO-CHAIR), Gerald Tetreault (SESSION CO-CHAIR).

Bill is a Registered Professional Biologist with over 35 years of experience in the wildlife field, specializing in wildlife management planning, environmental impact assessment, habitat compensation, endangered species management, habitat classification and modeling, and wildlife legislation. Recent work has focused on wildlife inventory, habitat assessment, and mitigation measures for infrastructure projects, particularly major linear developments and mines. Having had the opportunity to work in the field in most of the terrestrial ecosystems in British Columbia, Bill has extensive knowledge of the birds, mammals, reptiles, and amphibians in northwestern North America.

EDUCATION

Master of Science, University of British Columbia – Animal Science, Vancouver, BC, 1984

Bachelor of Science, University of British Columbia – Zoology, Vancouver, BC, 1979

REGISTRATIONS and MEMBERSHIPS

Registered Professional Biologist #316, College of Applied Biology, British Columbia

Member, Association of Professional Biology of British Columbia

PROJECT EXPERIENCE

Environmental Assessments

Sukunka Mine, Tumbler Ridge, British Columbia (Wildlife Discipline Lead)

Prepared an Offset Measures Plan to address residual direct and indirect impacts of the Sukunka Coal Mine Project on woodland caribou habitat.

Schaft Creek Mine, Telegraph Creek, British Columbia (Wildlife Discipline Lead)

Coordinated and prepared an environmental assessment of the effects on wildlife of a proposed open pit metals mine in northwestern British Columbia for Copper Fox Metals.

Hermann Mine, Tumbler Ridge, British Columbia (Wildlife Biologist)

Prepared Caribou Mitigation and Monitoring Plans (CMMPs) to mitigate potential project effects on woodland caribou, including development an Offset Measures Plan.

Diavik Diamond Mines, Lac de Gras, Northwest Territories (Wildlife Biologist)

Prepared an environmental assessment of the effects on wildlife of a proposed processed kimberlite to mine workings project for an open pit diamond mine in the Northwest Territories. The focus of the assessment was a potential change in wildlife health associated with water quality.

Northeast British Columbia Expansion Project, Fort St John, British Columbia (Wildlife Discipline Lead)

Coordinated and prepared the wildlife technical data report and environmental assessment (wildlife) for a 147-km gas pipeline near Fort St. John for Pembina Pipeline Corporation (Plateau Pipelines Ltd).

Northern Gateway Pipelines, Edmonton, Alberta (Lead - Linear Features Removal and Management Planning)

Assisted Enbridge Northern Gateway Pipelines with development of wildlife offset and compensation plans to address residual environmental impacts of their proposed 1,177 km pipeline from Edmonton, AB to Kitimat, BC. Developed priority area sub-plans designed to be the operational tools for removing and managing linear disturbance outside the pipeline right-of-way to offset project effects on caribou and grizzly bear.

* denotes projects completed with other firms

Bill Harper M.Sc., R.P. Bio.

Senior Wildlife Biologist – Environmental Services

LNG Canada, Kitimat, British Columbia (Wildlife Discipline Lead)

Developed the first Conservation Allowances Plan for Marbled Murrelet under provisions of the federal Species at Risk Act. This plan describes how project-related loss of nesting habitat associated with constructing and operating a liquefied natural gas (LNG) facility and marine terminal near Kitimat will be offset through off-site acquisition of old-growth coniferous forest areas.

New Prosperity Mine, Williams Lake, British Columbia (Wildlife Advisor)

Assisted Taseko Mines Ltd. with the environmental assessment under CEAA of the effects on wildlife of its proposed open pit gold-copper mine in Cariboo-Chilcotin, British Columbia. Presented wildlife information at the Public Hearing in Williams Lake, BC.

Kicking Horse Canyon Project*, Golden, British Columbia (Wildlife Discipline Lead)

The Kicking Horse Canyon Project involves upgrading 26 km of Trans-Canada Highway from two to four lanes between Golden, BC, and Yoho National Park. Coordinated and conducted various wildlife studies including; bighorn sheep surveys, winter track counts, aerial ungulate surveys, vegetation and habitat inventory, rare plant surveys, and breeding bird surveys. Assessed wildlife effects and proposed appropriate mitigation measures at the preliminary design, functional design, detailed design, and construction phases of the project. Developed a wildlife-exclusion fencing system that included both underpass and overpass wildlife crossing structures, ungulate guards, and one-way escape structures (including the first deployment of wildlife jumpouts in BC).

Environmental Management

Endangered Species Conservation*, Victoria, British Columbia (Senior Government Advisor)

Senior government advisor responsible for endangered species management in the province of BC. Produced and presented cabinet submissions and Ministerial briefings, developed policies and procedures, and wrote high-level government correspondence on species at risk issues. Responsible for development and release of the Red and Blue Lists of wildlife at risk, and amending provisions in provincial legislation and regulations, as well as providing provincial input to federal legislation and national strategies for endangered species conservation. Government of British Columbia representative on COSEWIC and member of national recovery teams for Vancouver Island Marmot, Spotted Owl, and South Okanagan Ecosystems. Provincial committee work included the Mountain Caribou Team, Interagency Endangered Species Committee, Northern Goshawk Working Group, and the Spotted Owl Community Advisory Group.

Habitat Inventory and Enhancement*, Victoria, British Columbia (Habitat Enhancement Specialist)

Provided specialized habitat management advice to government agencies and industry. Coordinated production of the interagency Procedures for Habitat Monitoring.

Management plan for wood bison in British Columbia*, Victoria, British Columbia (Lead)

In consultation with various agencies, organizations, and individuals, developed the Management Plan for Wood Bison in British Columbia. This plan defined the conservation actions necessary to protect, recover, and manage wood bison populations, including re-establishing herds through translocation, maintaining their separation from Plains Bison.

* denotes projects completed with other firms

Recovery plan for California bighorn sheep in the South Okanagan Valley*, Penticton, British Columbia (Project Lead)

Assessed metapopulation status and options for recovery after the first recorded all-age die-off in bighorn sheep in the South Okanagan. Contact with domestic sheep in 1999 had resulted in an epizootic outbreak of bronchopneumonia associated with *Manheimia* [*Pasteurella*] *multocida*, resulting in a 63% population decline (from 430 to 159). Developed a Recovery Plan using information from a workshop attended by local, national, and international representatives.

Wildlife Surveys and Field Studies

Foraging ecology of the American White Pelican in British Columbia*, Williams Lake, British Columbia (Project Lead)

Coordinated and conducted surveys and research into the foraging ecology of an endangered species, the American White Pelican. Prepared project reports and public presentations to support provincial conservation efforts through the BC Forest and Range Practices Act.

Marbled Murrelet Inventory and Conservation in TFL 37*, Woss, British Columbia (Project Lead)

Coordinated and conducted surveys of a threatened species, the Marbled Murrelet. Techniques included audio-visual detections, radar surveys, and nesting habitat sampling designed to monitor population trends and identify areas suitable for WHAs within TFL 37 (Nimpkish Valley, Vancouver Island).

Wildlife Habitat Evaluation and Mapping

Northeast British Columbia Expansion Project, Fort St John, British Columbia (Wildlife Discipline Lead)

Conducted field assessments of wildlife habitat suitability assessment for 13 wildlife species (including species at risk) for the ecosystem mapping program associated with this gas pipeline project near Fort St. John, British Columbia for the Pembina Pipeline Corporation (Plateau Pipelines Ltd).

Habitat Inventory and Enhancement*, Victoria, British Columbia (Habitat Inventory Specialist)

Planned and implemented biophysical habitat mapping projects for various wildlife species (caribou, moose, deer, grizzly bear, threatened and endangered species) throughout British Columbia. Interpreted and modeled species-habitat relationships to produce wildlife thematic maps from terrestrial ecosystem and forest cover mapping.

REPORTS AND PUBLICATIONS

Harper, W.L. 2014. Caribou and grizzly bear habitat compensation plans. PowerPoint Presentation at the 4th Annual Community Advisory Boards Conference, June 26, 2014, Prince George, BC. Available at: <http://www.communityadvisoryboards.com/wp-content/uploads/2014/07/Harper-Habitat-presentation.pdf>

* denotes projects completed with other firms

Harper, B., C.A. Bryden and V.M. Stevens. 2014. Resource road removal as an option for conservation offsets: Opportunities and challenges. *In* Resource Roads in British Columbia: Environmental challenges at a landscape level, Columbia Mountains Institute for Applied Ecology, May 14–15, 2014, Nelson, BC. Available at: <http://cmiae.org/event/resource-roads-in-british-columbia-environmental-challenges-at-a-landscape-level/>

Morley, C.F. and W.L. Harper. 2008. National Environmental Achievement Award for 2007 to the Kicking Horse Canyon Project. Transportation Association of Canada, Toronto, ON. 12 pp. Available at: <http://www.tac-atc.ca/english/resourcecentre/readingroom/conference/conf2008/docs/aw3/britishcolumbia.pdf>

Harper W.L., B.K. Schroeder, I.A. Manley and J.A. Deal. 2004. Radar monitoring of Marbled Murrelet populations at Inland Sites on northern Vancouver Island. Proceedings of the Species at Risk 2004 Pathways to Recovery Conference (T.D. Hooper, ed). March 2–6, 2004, Victoria, B.C. 18 pp. Available at: http://www.llbc.leg.bc.ca/public/PubDocs/bcdocs/400484/harper_edited_final_june_13.pdf

Harper W.L., B.K. Schroeder, I.A. Manley and J.A. Deal. 2004. Direct comparison of tilted and untilted radar for monitoring Marbled Murrelet *Brachyramphus marmoratus* populations. *Marine Ornithology* 32: 35-41. Available at: http://www.marineornithology.org/PDF/32_1/32_1_35-41.pdf

Harper, W.L., H.M. Schwantje, T.J. Ethier and I. Hatter. 2002. Recovery plan for California bighorn sheep in the South Okanagan Valley, British Columbia. Report by Osiris Wildlife Consulting for BC Ministry of Water, Land and Air Protection, Penticton, BC.

Harper, W.L., J.M. Cooper, K. Simpson, J. Hamilton, K.A. Dunham, and D.S. Eastman. 2001. Guidelines for evaluating, avoiding and mitigating impacts of major development projects on wildlife in British Columbia. Report by Osiris Wildlife Consulting for the Environmental Assessment Branch, Ministry of Envir., Lands and Parks, Victoria, BC.

Harper, W.L., J.P. Elliott, I. Hatter, and H. Schwantje. 2000. Management plan for wood bison in British Columbia. Wildlife Bulletin No. B-102, B.C. Minist. Environ., Lands and Parks, Victoria, BC. 43pp. Available at: <http://wlapwww.gov.bc.ca/wld/documents/statusrpt/b102.pdf>

Harper, B., G. Court, S. Brechtel, A. Harcombe, B. Hall, R. Halladay, and B. Andrews. 1996. Proposal for ranking species under the National Framework for Endangered Species Conservation. Report to "Making Endangered Species Conservation Work: A National Workshop", Toronto, Ontario. Min. of Environ., Lands and Parks, Victoria, BC and Depart. of Environ. Prot., Edmonton, AB.

Meidinger, D. and J. Pojar. 1991. Ecosystems of British Columbia. Co-author (wildlife) of chapters 4 (resource values), 8 (bunchgrass zone), 9 (Ponderosa pine zone), 10 (interior Douglas-fir zone), 12 (montane spruce zone), and 14 (sub-boreal spruce zone). Special Report Series 6, BC Ministry of Forests, Victoria, BC. 330pp. Available: <http://www.for.gov.bc.ca/hfd/pubs/Docs/Srs/SRseries.htm>

Harper, W.L., and R.D.H. Cohen. 1985. Accuracy of Doppler ultrasound in diagnosing pregnancy in bighorn sheep. *Journal of Wildlife Management* 49: 793-796. Available at: <http://www.jstor.org/stable/3801713>

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Brad is a Fish Biologist with over 25 years' experience working for industry, non-governmental organizations, and regional, provincial, and federal governments in western and northern Canada. In the last 18 years, Brad has been an environmental assessment practitioner developing mitigation measures, offsetting plans, and effectiveness monitoring plans for hydro-electric developments, transmission lines, pipelines, mines, oil sands, and transportation infrastructure projects. In this capacity, Brad has been responsible for developing and coordinating fish and aquatic community baseline sampling programs, developing mitigation measures compatible with engineering designs, assessing project-specific and cumulative effects consistent, and providing strategic advice to clients during the regulatory review and permitting phases of their projects. He is fluent in all provincial and federal policies, guidelines, and laws affecting fish and fish habitat. Brad has developed and negotiated 12 fisheries offsetting plans (formerly "no-net-loss" plans) on behalf of clients requiring a Fisheries Act Authorization for the unavoidable loss of fish habitat and "serious harm to fish". These plans have offset project impacts ranging in size from 100 square metres of stream crossings to 1,000 hectare open-pit mines.

Brad has expertise in fish passage design, stream and lake restoration, radio and acoustic telemetry studies, water temperature modeling, and instream flow studies and assessment. He has extensive knowledge of the fish species of western and northern Canada, their unique life history and habitat requirements, and the gear and techniques necessary to effectively sample them.

EDUCATION

Master of Science, Resource Ecology and Management, University of Michigan, Ann Arbor, Michigan, 2001

Bachelor of Science, Ecology (Honours), University of Manitoba, Winnipeg, Manitoba, 1991

REGISTRATIONS

Registered Professional Biologist #1468, College of Applied Biology, British Columbia, Member in good standing since June 19, 2003

MEMBERSHIPS

Member, Association of Professional Biologists of British Columbia, Member in good standing since October 18, 2002

Member, American Fisheries Society, Member in good standing since 2001

PROJECT EXPERIENCE

Fisheries Management

Aquatic Biodiversity and Water Quality Pilot Study*

Conducted a pilot study for the Saskatchewan Ministry of Environment to identify appropriate study design, methods, and habitats necessary to use benthic macro-invertebrates as a biological indicator of potential future effects of oil sand developments in northwest Saskatchewan.

Lake Trout Stock Assessment*, Fort St. John, British Columbia

Conducted stock and habitat assessments and winter creel surveys for the BC Ministry of Water, Land, and Air Protection to assess status of lake trout populations in Moberly, Gwillim, and Carbon lakes in northern British Columbia. Developed recommendations for recovery of the Moberly Lake trout population using potential brood stock from Gwillim and Carbon lakes.

* denotes projects completed with other firms

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Lower Mainland Steelhead Stock Assessment*

Analyzed and reported on a pilot study for the BC Ministry of Water, Land, and Air Protection with recommendations for monitoring steelhead populations in the Chilliwack, Squamish, and Alouette rivers in BC's lower Mainland

Debris monitoring in Playgreen Lake*, Manitoba

Designed and conducted a multi-year study assessing the spatial distribution, duration, and magnitude of debris-fouling in commercial fishing nets in Playgreen Lake, Manitoba caused by Manitoba Hydro's Lake Winnipeg Diversion Channel. Study results were used in the negotiation of compensation between Manitoba Hydro and the Playgreen Lake Fisherman's Cooperative.

Ecological Risk Assessment

Fisheries Impact Management Framework for Linear Developments in the NWT*, Yellowknife, NWT

Developed a risk-based framework for Fisheries and Oceans Canada to identify fish stocks susceptible to over-fishing due to increased access created by new linear developments in the Northwest Territories. Framework included statistical methods to identify lakes of likely to contain susceptible fish stocks, methods to identify lakes most likely of interest to recreational anglers, and recommendations for baseline data, mitigations, and monitoring requirements.

Hydroelectric

Site C Dam Project*, Fort St. John, British Columbia

Designed, coordinated, and reported a multi-year radio-telemetry program and tributary fish utilization study as part of on-going Water Use Planning and baseline data collection for the proposed Site C dam on the Peace River.

Site C Dam Project*, Fort St. John, British Columbia

Identified data gaps, prioritized baseline studies, and developed budgets and Terms of Reference for studies necessary to create a defensible baseline for assessing potential effects to fish from BC Hydro's proposed Site C dam on the Peace River. Potential impacts, mitigation measures, and required baseline studies were placed in a risk-management framework to highlight linkages to other disciplines, needs for multi-year studies, and to identify critical issues.

Aishihik Lake Dam Study*, Yukon Territory

Conducted a multi-year study supporting the re-licensing application of Yukon Energy's Aishihik Lake dam in the Yukon Territory. Studies focused on identifying lake levels necessary to ensure successful spawning of lake whitefish and identifying release discharges necessary to ensure the viability of re-introduced rainbow trout in the East Aishihik River.

Conawapa Hydroelectric Project*, Manitoba

Conducted multi-year studies of fish and lower trophic communities, water quality, and instream habitat for the environmental impact assessment of Manitoba Hydro's proposed Conawapa hydroelectric project and for post-construction monitoring of the Limestone Dam on the lower Nelson River.

* denotes projects completed with other firms

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Limestone Hydroelectric Project*, Manitoba

Conducted multi-year studies of fish and lower trophic communities upstream and downstream of Manitoba Hydro's Limestone Generating Station. Studies included enumeration of spawning runs in Nelson River tributaries, gillnetting survey of the changing reservoir fish community, and monitoring of benthic invertebrate communities in the reservoir, forebay, and tail-race.

Grand Rapids Generating Station, Grand Rapids, Manitoba

Conducted multi-year study assessing potential ramping rates to minimize stranding of spawning walleye below the Manitoba Hydro's Grand Rapids GS. Responsibilities included field work, data management, and technical report preparation.

Nelson River Flow Regulation Project*, Cross Lake, Manitoba

Conducted a multi-year study assessing effects of hydro-related water level manipulations on commercially and culturally valuable fish populations in Cross Lake, Manitoba. Responsibilities included field work and analyzing population statistics over time to determine relationships between lake level fluctuations and lake whitefish and walleye recruitment success.

Selkirk and Brandon Thermal Electric Generating Stations*

Conducted a multi-year study assessing the impacts of Manitoba Hydro's Selkirk and Brandon thermal electric generating stations on fish communities in the Red and Assiniboine Rivers. Studies focused on determining the seasonal impact of downstream thermal plumes and level of impingement and entrainment of fish in plant cooling systems.

Mining

Sukunka Coal Project, Tumbler Ridge, British Columbia (Freshwater Fish Discipline Lead)

Freshwater Fish Discipline Lead responsible for preparing technical responses to Fisheries and Oceans Canada (DFO) regarding Glencore's proposed offset plan, and to the BC Environmental Assessment Office (EAO), Canadian Environmental Assessment Agency (CEAA), and intervening First Nations on outstanding issues on the environmental assessment. Responsible for preparing and negotiating a conceptual Fisheries Offset Plan for Glencore's Fisheries Act authorization application.

Highland Valley Copper Project, Logan Lake, British Columbia (Aquatics Team Lead)

Aquatics Team Lead responsible for conducting a gap analysis comparing existing data to potential Project effects and current regulatory requirements, for developing water quality, benthos and sediment, and fish and fish habitat baseline studies, for developing Environmental Impact Statement guidelines, and for developing a fish habitat offsetting strategy for the Project.

Lynn Lake Gold Project, Lynn Lake, Manitoba

Aquatics Team Lead responsible for fish and fish habitat, fish tissue, benthos and sediments, plankton and algae, and water quality disciplines during preparation of baselines and the environmental impact assessment for Alamos's proposed Lynn Lake mine. Also responsible for providing mitigation and permitting advice regarding Fisheries Act authorizations, Navigable Waters Act approvals, and Schedule 2 amendments of the Metal Mine Effluent Regulation.

* denotes projects completed with other firms

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Blackwater Gold/Copper Project*, Vanderhoof, British Columbia (Regulatory Lead)

Senior reviewer and regulatory lead for the freshwater fisheries discipline for the 60,000 tonnes/day open-pit gold/copper mine proposed by NewGold approximately 100 km south of Vanderhoof, BC. Responsible for ensuring that field studies and analysis were appropriate for preparing a defensible baseline upon which to assess potential project and cumulative effects, mitigation measures were technically feasible and appropriate for the fish species effected, and that the project-specific and cumulative effects assessments used appropriate methods and were scientifically defensible and consistent with provincial and federal guidelines. Developed and negotiated a conceptual fisheries offsetting plan that was consistent with provincial, federal, and local First Nations fisheries management objectives and with DFO's Fisheries Protection Policy Statement.

Kitsault Molybdenum Mine Project*, Kitsault, British Columbia

Responsible for the baseline, impact assessment, and fish habitat compensation plan for Avanti's proposed Kitsault Molybdenum Mine near Kitsault, BC. Mine is currently under construction.

Mt. Milligan Copper/Gold Project*, Fort St. John, British Columbia (Fish Discipline Lead)

Fish Discipline Lead responsible for the design and successful completion of periphyton, benthic invertebrates, and fish and fish habitat baseline studies, assessment of potential project-specific and cumulative effects to fish and fish habitat, and development and negotiation of two Fish Habitat Mitigation and Compensation Plans: one for a paragraph 35(2)(b) Fisheries Act authorization for the unavoidable loss of fish habitat and one for the Schedule 2 amendment of the Metal Mine Effluent Regulation to allow the deposit of deleterious mine tailings in fish-bearing streams. Part of multi-disciplinary team that successfully acquired provincial and federal permits for the Mt. Milligan Copper/Gold Project, the first new metal mine in BC in 20 years.

Fish Discipline Lead responsible for preparing environmental assessment amendment applications and Water Sustainability Act water use approvals for immediate and medium-term water withdrawals from previously unauthorized lakes and streams for continued operation of the Mt. Milligan Project in 2017, 2018, and 2019. Currently responsible for the identification and screening of potential long-term water supply sources for the mine.

Raven Coal Project*, Vancouver Island, British Columbia

Freshwater fisheries discipline lead responsible for the baseline, impact assessment, and conceptual fisheries offset plan for the Raven Coal Project on eastern Vancouver Island. Worked with local stream keepers to prioritize and offset projects in the local area and greater region to benefit endangered cutthroat trout, steelhead, and salmon populations.

* denotes projects completed with other firms

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Gahcho Kue Diamond Mine Project*, Northwest Territories

Freshwater fisheries discipline lead responsible for baseline, impact assessment and development and negotiation of a fish habitat compensation plan for the proposed Gahcho Kue diamond mine in the Northwest Territories. Mine opened in 2016.

Muskeg Valley Quarry Project, Fort McMurray, Alberta

Fisheries Discipline Lead for responsible for baseline, project and cumulative effects assessment for Birch Mountain's proposed Muskeg Valley Quarry in the heart of the Alberta oil sands region. Worked with a multi-disciplinary team and provincial regulators at all phases of the assessment process.

Hermann Coal Project, Tumbler Ridge, British Columbia (Aquatics Team Lead)

Aquatic Team Lead responsible for development of detailed, multi-disciplinary gap analysis comparing existing baseline data and effects assessment to updated Project Description and current provincial and federal regulations, policies, and expectations. Brad acted as the engineering-environmental liaison responsible for communication of information between the engineering team and the environmental team and for identifying fatal flaws, critical paths, and regulatory risks during preparation of an environmental assessment of a proposed bulk sample application to the BC Ministry of Mines, Energy, and Petroleum Resources.

Oil & Gas

LNG Canada Export Terminal Project, Kitimat, British Columbia (Senior Fish Biologist)

Provided strategic advice to LNG Canada's core permitting team during preparation and negotiation of applications for Fisheries Act Authorizations from Fisheries and Oceans Canada. Senior reviewer of authorization application for work-force accommodation centre, co-author of authorization application for the Liquid Natural Gas Facility, and principle author of authorization application for associated transportation infrastructure. Authorizations were for freshwater, estuarine, and marine impacts to fisheries production.

Northern Gateway Pipelines Project, British Columbia (Senior Fish Biologist)

Senior reviewer responsible for ensuring the accuracy, thoroughness, and clarity of baseline information at over 1,200 stream crossings in British Columbia and Alberta, for ensuring the defensibility and clarity of a novel risk-based approach for identifying high risk stream crossings, and for developing a conceptual framework for a future fish habitat compensation plan.

Aurora South Oil Sands Project*, Fort McMurray, Alberta

Fisheries Discipline Lead for responsible for baseline inventory of historic and current fisheries studies in the local and regional study areas, identifying potential project impacts and mitigation options, assessing residual and cumulative effects of Syncrude's proposed Aurora South open pit mine. Worked with a multi-disciplinary team and provincial regulators at all phases of the assessment process.

* denotes projects completed with other firms

Bradley D. Horne B.Sc., M.Sc., P.Biol.

National Technical Leader, Freshwater Ecosystems

Husky Sunrise Oil Sands Project*, Fort McMurray, Alberta

Fisheries Discipline Lead for responsible for baseline inventory of historic and current fisheries studies in the local and regional study areas, identifying potential project impacts and mitigation options, assessing residual and cumulative effects of Husky Oil's proposed Sunrise Steam-Assisted Gravity Drainage (SAGD) oil sands project. Worked with a multi-disciplinary team and provincial regulators at all phases of the assessment process.

Linear Infrastructure

Port Mann Bridge Project*, Surrey, BC (Fish Discipline Lead)

Conducted an environmental impact assessment of the construction phase of the new Port Mann Bridge and demolition phase of the old Port Mann Bridge connecting Surrey and Coquitlam, BC across the Fraser River. Assessment included identification of potential risks to federally and provincially listed white sturgeon, green sturgeon and eulachon from bridge construction and demolition activities. Designed and coordinated a multi-year monitoring program to assess potential changes to sturgeon and eulachon habitat downstream of the new and old bridge.

Terrace to Kitimat Transmission Line Project*

Senior reviewer of freshwater fisheries baseline and environmental effects assessment for BC Hydro's proposed Terrace-to-Kitimat (TKT) transmission line project along the western Kitimat River valley.

Peace River Electric Supply Project*

Senior reviewer of freshwater fisheries baseline and environmental effects assessment for BC Hydro's proposed Peace River Electric Supply (PRES) transmission line project between Chetwynd and Dawson Creek, BC.

PUBLICATIONS

Mann, D., P. Cott, B. Horne. Under-ice noise generated from diamond exploration in a Canadian sub-Arctic lake and potential impacts on fishes. *Journal of the Acoustical Society of America* Volume 126:2,215–2,220, 2009.

Horne, B., E. Rutherford, K. Wehrly. Simulating effects of hydro-dam alteration on thermal regime and wild steelhead recruitment in a stable-flow Lake Michigan tributary. *Regulated Rivers and Applications* Volume 20(2):185–203, 2004.

** denotes projects completed with other firms*

Colin Buchanan Ph.D.

Senior Facilitator, Traditional Knowledge and Land Use

Colin Buchanan holds a Ph.D. in Anthropology from the University of Calgary and has over 20 years professional and academic experience in ethnographic and historical research pertaining to Aboriginal peoples in Canada, Aboriginal culture and history, Canadian Indian policy, Land Claims, and Aboriginal Rights. Currently, Colin provides oversight and direction for all projects within the Traditional Knowledge discipline in Calgary, advising on the scoping, planning and execution of Traditional Knowledge and Traditional Land Use studies.

Colin has worked as a Senior Researcher responsible for major research projects on outstanding treaty obligations, expropriation of reserve lands, Aboriginal timber rights, taxation of off-reserve band members, creation of new bands, Aboriginal rights of non-status Indians, treaty land entitlements, oil and gas leases on reserve lands, and mismanagement of band funds. Recently, Colin appeared as an expert witness on Traditional Knowledge/Traditional Land Use studies before the National Energy Board Joint Review Panel for the Northern Gateway Pipeline Project.

Colin has worked with the following First Nations as a senior facilitator, traditional knowledge: Chipewyan Prairie Dene First Nation, Fort McMurray #468 First Nation, Mikisew Cree First Nation, Kapawe'no First Nation, Driftpile First Nation, Sucker Creek First Nation, Burns Lake Band, Lheidli T'enneh Nation, Fort McMurray Métis Local #1935, Willow Lake Métis Local #780, Chard Métis Local #214, East Prairie Métis Settlement, Woodland Cree First Nation, Duncan's First Nation, and Samson Cree Nation.

EDUCATION

Ph.D., University of Calgary, Anthropology, Calgary, Alberta, 2008

M.A., Carleton University, Anthropology, Ottawa, Ontario, 1995

B.A., University of Winnipeg, Winnipeg, Manitoba, 1987

MEMBERSHIPS

Member, Canadian Anthropology Society / Société canadienne d'anthropologie

PROJECT EXPERIENCE

Academic

Department of Anthropology, University of Calgary*, Calgary, Alberta (Instructor)

Taught courses on Aboriginal history, ethnography, Canadian Indian policy, and contemporary Aboriginal issues.

Oil & Gas Upstream, Oil Sands In Situ

JACOS Hangingstone Expansion, Environmental Impact Assessment (Senior Advisor; Traditional Knowledge Lead)

Senior Advisor, Traditional Knowledge and Project Manager for the TK/TLU study component of a regulatory Environmental Impact Assessment.

Devon Pike Project, Environmental Impact Assessment (Senior Advisor; Traditional Knowledge Lead)

Senior Advisor, Traditional Knowledge and Project Manager for the TK/TLU study component of a regulatory Environmental Impact Assessment.

* denotes projects completed with other firms

Colin Buchanan Ph.D.

Senior Facilitator, Traditional Knowledge and Land Use

Oil & Gas Midstream, Facilities

Swan Hills Synfuels In-situ Coal Gasification Project, Environmental Assessment, Whitecourt, Alberta (Senior Advisor; Traditional Knowledge Lead)

Senior Advisor, Traditional Knowledge and Project Manager for the TK/TLU study component of an EPEA regulatory Assessment.

Oil & Gas Midstream, Pipelines

Enbridge Northern Gateway Pipeline Project (Traditional Knowledge Discipline Lead)

Discipline Lead, coordinating the conduct of Aboriginal Traditional Knowledge Studies for this NEB regulated pipeline between Bruderheim Alberta and Kitimat British Columbia.

TransCanada PipeLines Ltd., Prince Rupert Gas Transmission Project, British Columbia (Senior Advisor)

Stantec expects to engage up to 20 Aboriginal communities in northern British Columbia in TEK fieldwork as well as individual TLU studies. Stantec is currently overseeing the logistics for the TEK fieldwork, scoping TLU studies and coordinating third-party consultants in other aspects of the TK programme. For this large and challenging project, Stantec provides oversight on all aspects of the TEK/TLU component, including, tracking TEK and TLU study progress, coordinating with other disciplines, working with client Aboriginal Relations team to consult on the Aboriginal engagement strategy, providing updates reports other management tasks.

TransCanada PipeLines Ltd., Energy East Pipeline Project, Alberta, Saskatchewan, Manitoba, Ontario, Québec, and New Brunswick (Senior Advisor)

The Energy East Pipeline Project aims to engage over 100 Aboriginal communities across Canada. Stantec is leading the TK component on this project, scoping and executing TK studies with Aboriginal communities along the entire route of the Project in Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and New Brunswick. This work requires thorough working knowledge of regulatory requirements, Aboriginal consultation policies, and use of TK in regulatory applications across provincial governments.

Transmission & Distribution

Milner Power Inc. Ash Management Facility, Grande Cache, Alberta (Senior Advisor; Traditional Knowledge Lead)

Senior Advisor, Traditional Knowledge and Project Manager for the TK/TLU study component for a project.

Colin Buchanan Ph.D.

Senior Facilitator, Traditional Knowledge and Land Use

Community-based Traditional Knowledge and Land Use Studies

Community-specific Engagement Guidelines (Senior Advisor)

The intent of this project was to learn how each of the ten existing Aboriginal CEMA-member organizations want to work within CEMA and be meaningfully engaged in CEMA's work. This work involved developing a workshop approach compatible with each member community's varying interests and needs, as well as establishing a good working relationship with CEMA's team and the community focus-group participants. This project reported on the issues and concerns regarding cumulative effects facing each community, each community's desires for enhancing their working relationship with CEMA, as well as each community's suggested best practices for working with TK Holders and improving the meaningful and cohesive treatment of traditional knowledge in the larger context of land and resource management practices and policies.

Traditional Knowledge and Land Use GIS Mapping

Government of Alberta GeoData Mapping Project (Senior Advisor)

Stantec is assisting the Ministry of Aboriginal Relations in the collection and review of spatial traditional knowledge data from participating First Nations throughout Alberta. The objective of the project is to create more accurate and relevant areas of consultation interest for each First Nation by dialoguing with First Nation leaders about the data that communities are willing to share to augment or revise what the government currently holds. Various government ministries will use these updated areas of interest with the aim of improving consultation efforts. Stantec is working closely with ministry representatives to create a standardized geospatial template, meet with interested First Nations, analyze and standardize submitted spatial data, and verify the data assessment with each participating First Nation.

Expert Testimony / Witness

Total E&P Energy Canada Joslyn North Mine Project (Regulatory Support)

Appeared as an Expert Witness before the National Energy Board Joint Review Panel Hearings for this pipeline this mine application.

Enbridge Northern Gateway Pipeline Project (Regulatory Support)

Appeared as an Expert Witness before the National Energy Board Joint Review Panel Hearings for this pipeline this mine application.

Research

Blood Cattle Claim: Additional Research*

Report prepared for the Blood Tribe providing supplemental research for a Specific Claim.

** denotes projects completed with other firms*

Historical Report on the Doncaster Reserve No. 17*

Report prepared for the Wahta Mohawk First Nation, regarding the establishment and proportional interest in the Doncaster Reserve.

Report on the Establishment and Use of the Timber Limit Reserve 148A*

Report prepared for the Blood Tribe regarding mismanagement of Reserve land.

Report on the Operation of the Canadian Pacific Railway on the Blood Reserve*

Report prepared for the Blood Tribe regarding expropriation of Reserve land by the C.P.R.

Report on the Establishment and Enduring Interest in the Doncaster Reserve No. 17

Report prepared for the Mohawk Council of Kahnawake regarding the Band's rights in the Doncaster Reserve.

Report on the Provision of Cattle under Treaty Seven*

Report prepared for the Blood Tribe regarding claim of failure to provide Treaty obligations with respect to cattle.

Report on the Status of Public Roads on Kahnawake*

Report prepared for the Mohawk Council of Kahnawake.

Report on the Expropriation for the St. Lawrence Seaway Canal*

Report prepared for the Mohawk Council of Kahnawake regarding compensation received for Reserve land expropriated by the St. Lawrence Seaway Authority.

PUBLICATIONS

Buchanan, C. Review of 'Enough to Keep them Alive': Indian Welfare in Canada, 1873-1965 by Hugh Shewell. The Canadian Review of Sociology and Anthropology On-Line Book Reviews. Posted at <http://www.csaa.ca/CRSA/BookReview/Reviews/200503SHEWELL.htm>, 2005.

Buchanan, C. Canada's Indian Problem: Canadian Anthropology and Ideas of Aboriginal Emendation. Historicizing Traditions in Canadian Anthropology. J. Harrison and R. Darnell, eds. Vancouver: UBC Press. Pp. 93-106, 2006.

Presentation. Buchanan, C. 'All the etceteras of a whiteman's election': Band Government and the Regulation of Aboriginal Political Culture in Canada. Canadian Anthropology Society/société canadienne d'anthropologie (CASCA) Meetings, Calgary Alberta, 2000.

Presentation. Smart, A. and C. Buchanan. Illegality and the Constitution of Space in Colonial and Post-Colonial Hong Kong. Law, Knowledge and Power in Post-Colonial and Post-Socialist Anthropology Conference, RGGU—Russian State University for the Humanities, Moscow, Russia, 2000.

Presentation. Buchanan, C. Band Government Legislation, 1869-1895: Establishing the Elective System on Canadian Indian Reserves. Annual meeting of the American Society for Ethnohistory, London Ontario, 2000.

* denotes projects completed with other firms

Colin Buchanan Ph.D.

Senior Facilitator, Traditional Knowledge and Land Use

Presentation. Buchanan, C. Canadian Indian Policy and Images of Aboriginal Incapacity. Canadian Anthropology Society/société canadienne d'anthropologie (CASCA) Meetings, Montreal Quebec, 2001.

Presentation. Buchanan, C. Canada's Indian Problem: Canadian Anthropology and Ideas of Aboriginal Emendation. Historicizing Canadian Anthropology Conference, Peterborough Ontario, 2003.

Karen Ann Munro

B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Ms. Karen Munro has over 35 years of experience in aquatic ecology, ecotoxicology, water quality, and watershed planning. Much of her current practice area is in cross-discipline planning, through environmental assessment of major projects (e.g., in mining, port development, and pipelines) under federal and provincial legislation, and through watershed planning at the municipal level. She enjoys working with proponents in designing suitable mitigation measures to minimize potential project effects on the aquatic environment. Karen has designed and implemented studies to distinguish effects of industrial activities in complex environments, employing ecological and statistical tools to provide scientifically defensible conclusions. She has assessed effects of mining, pulp and paper and transportation industries, municipal discharges and regulated rivers, and is well acquainted with concerns associated with contaminants in water, sediment and fish tissue; nutrient cycling; habitat alteration, community (fish, benthos and algae) responses; and cumulative effects. Karen's familiarity with environmental legislation, compliance monitoring, performance measures and indicators provides clients and regulatory agencies with environmentally relevant results.

Karen is an experienced writer, problem-solver, and project manager, and is particularly interested in making scientific information easily understood by decision-makers and the public. She has authored or edited several plain-language reports on aquatic and other environmental topics.

EDUCATION

Master of Science in Biology, Queens University, Kingston, Ontario, 1978

Bachelor of Science (Hons.) in Botany, University of British Columbia, Vancouver, British Columbia, 1974

REGISTRATIONS

Registered Biologist #1712, College of Applied Biology, British Columbia

PROJECT EXPERIENCE

Environmental Assessments

Sukunka Coal Project, Northeastern British Columbia (Senior Advisor)

Provided senior review and guidance for the environmental assessment for the integrated aquatic team (hydrology, hydrogeology, geochemistry, water quality and aquatic biota, and fish and fish habitat). Worked on mitigation measures to protect streams and wetlands. Addressed information requests from regulators, First Nations, and the public.

Canpotex Terminal, Prince Rupert, British Columbia (Senior Aquatic Scientist)

Assessed sediment in dredge area for proposed terminal using a sampling plan compliant with Environment Canada and the Disposal at Sea Regulation. Developed and conducted a study to assess effects of disposal at alternative disposal site options. Assessed ambient dioxin and furan levels in relation to sediment disposal options and aquatic effects.

Fairview Terminal Environmental Assessment, Prince Rupert, British Columbia (Senior Aquatic Scientist)

Comprehensive Study under Canadian Environmental Assessment Act. Assessed sediment in dredge area for proposed terminal using a sampling plan compliant with Disposal at Sea Regulation. Assessed effects of disposal at the existing designated site and alternative disposal options. Presented at technical working group meetings.

* denotes projects completed with other firms

Karen Ann Munro B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Greenstone Gold Mine Project, Northwestern Ontario (Senior Advisor)

Provided direction and senior review for an environmental assessment of effects of a brown-field mine development on the aquatic environment (a lake) near Thunder Bay, ON. Included an assessment of arsenic bioavailability related to historical mining activities. Reports and conference presentations.

Wolverine Project, Southeast Yukon, Yukon (Senior Aquatic Scientist and Project Manager)

Conducted baseline studies and environmental assessment of water, sediment, periphyton, benthos under Yukon Environmental Act for proposed zinc mine, developed rationale for development of site specific water quality objectives.

Prince Rupert Gas Transmission Project, Multiple Sites, British Columbia (Senior Aquatic Scientist) Project Value: CAD 6B

Assessed the potential project effects of construction of a natural gas pipeline from near Hudson's Hope to Prince Rupert on freshwater and marine water quality, including potential contaminant sources in sediment. Evaluated sediment dispersion potential from burial of pipeline in the marine environment. Developed and implemented a wetland water quality monitoring program to meet BC Oil and Gas Commission permit conditions.

Prosperity Project, British Columbia (Project Manager and Senior Scientist)

Aquatic Disciplines Coordinator and aquatic science lead for proposed gold-copper mine in central British Columbia. Conducted baseline aquatic studies (water, sediment, biota) and integrated hydrology, ARD_ML, and hydrogeology into the assessment. Participated in the 2009 Panel Review of the original environmental assessment.

Pacific NorthWest LNG Marine Terminal, Prince Rupert, British Columbia (Senior Aquatic Scientist)

Assessed potential effects of terminal development on aquatic biota related to release of existing contaminants in sediment, during dredging and disposal, and treated stormwater during operations; evaluated potential effects of sediment movement during vessel berthing activities. Included design of baseline field programs, preparation of technical data report and environmental assessment and negotiations with Environment Canada for preparation of permit application. Addressed concerns about dioxins and furans in sediment related to historical pulp mill effluent discharges in the area. Developed permit application for disposal at sea of dredged sediment.

Vancouver Island Transmission Reinforcement Project, Vancouver to Vancouver Island, British Columbia (Senior Aquatic Scientist)

Assessed potential effects on marine sediment of installation of a 65 km long submarine electrical cable between Vancouver and Vancouver Island; considered fate and effects of release of cable insulating fluid on the marine environment.

* denotes projects completed with other firms

Karen Ann Munro B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Lynn Lake Gold Project, Manitoba (Senior Advisor)

Providing senior guidance for water quality and aquatic resources chapters of an environmental assessment under Canadian and Manitoba legislation. The project will be built on two brown-field sites and includes a cyanide extraction process for gold.

Aurora LNG Project, Northern British Columbia (Senior Scientist)

Directed development of the assessment of project effects on water quality for freshwater (acidification and eutrophication) and marine (dredging, sediment disposal, effluent discharges) environments for a proposed LNG facility in Prince Rupert. Provided independent review for many sections of the overall assessment report.

Eagle Gold Project, Yukon (Senior Aquatic Scientist)

Prepared assessment under the Yukon Environmental and Socio-economic Assessment Act for the proposed Eagle Gold project. Included predicting water quality at all project phases based on surface water, groundwater, waste rock storage and treatment plant source terms, and mitigations to protect the aquatic environment.

Mining

Environmental Effects Monitoring Thompson Mines, Thompson, Manitoba (Project Manager and Senior Scientist)

Prepared study designs and conducted Periodic and Focused Monitoring studies and Investigation of Cause for two mines at Thompson, Manitoba over five monitoring cycles (since 2006), pursuant to Metal Mining Effluent Regulations for active mines.

Baseline Studies for Proposed Areva Mine, Nunavut (Senior Scientist)

The proposed Areva uranium mine north of Baker Lake includes a transportation route through Baker Lake and Chesterfield Inlet. Designed freshwater sampling programs for Baker Lake to assess conditions at a proposed dock, developed a rationale for assessment of the marine transportation route, and provided senior review of the reports.

Baseline Studies, Thor Lake Rare Earth Elements Project, Northwest Territories (Discipline Lead and Senior Scientist)

Directed baseline aquatic studies (water quality, lake biota) in an area north of Great Slave Lake. Provided input to decisions on locations of mine infrastructure based on ecological features and regulatory requirements for protection of aquatic habitat.

Baseline Studies for Arctos Anthracite Coal Project, Northern British Columbia (Senior Scientist and Aquatic Team Lead)

Directed the updating of baseline water quality and aquatic biota conditions, participated in working group meetings and First Nations consultations in planning for an environmental assessment (for the integrated aquatic team consisting of hydrology, hydrogeology, geochemistry, water quality and aquatic biota, and fish and fish habitat disciplines).

* denotes projects completed with other firms

Karen Ann Munro

B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Copper Fox Project, Northern British Columbia (Senior Scientist and Aquatic Team Lead)

Directed the update of baseline water quality and aquatic data and reviewed water quality predictions for mine operations in preparation of and environmental assessment (for the integrated aquatic team consisting of hydrology, hydrogeology, geochemistry, water quality and aquatic biota, and fish and fish habitat disciplines).

Central South Project, Chetwynd, British Columbia (Discipline Lead and Senior Scientist)

Discipline lead for aquatic science (water, sediment, periphyton, benthos) for a proposed coal mine in northeast British Columbia. Conducted baseline studies and integrated historic data.

Baseline Studies for Gething Coal Project, Northeastern British Columbia (Senior Scientist and Aquatic Team Lead)

Provided senior review and guidance for study of baseline water quality and aquatic conditions.

Dublin Gulch Mine Project, Mayo, Yukon Territory (Discipline Lead and Senior Scientist)

Discipline lead for aquatic science (water, sediment, periphyton, benthos) for a proposed gold mine in Yukon; conducted baseline studies, integrated historic data.

Conuma Coal Resources, Integrated Selenium Management Plan, Northwest British Columbia (Senior Scientist)

Developed an integrated selenium management plan for three mines (Brule, Willow Creek, Wolverine), updating plans developed for previous owners, addressing amended permit requirements, and reviewing recent biological monitoring programs.

Lucky Ship Mine Project, Houston, British Columbia (Discipline Lead and Senior Scientist)

Managed a multidisciplinary team (aquatics, fisheries, wildlife, vegetation, air) preparing baseline assessments for a proposed molybdenum mine in central British Columbia. Was the lead for aquatic ecology on this project.

Quinsam Coal Mine Biological Studies, British Columbia (Project Manager, Senior Scientist)

Qualified Environmental Professional for the aquatic environment studies required under the Environmental Management Act effluent permit. Reviewed study design for benthic invertebrate and sediment studies of five lakes and a river system. Assessed the effects of mine effluent discharges on phytoplankton, zooplankton, benthic invertebrates, and sediment. Reviewed the annual report submitted by Quinsam Coal. Provided support at regulatory and public meetings.

Britannia Mine Project*, Howe Sound, British Columbia (Aquatic Scientist)

With G3 Consulting Ltd. assessed sediment chemistry, toxicity, metal bioavailability and benthic data for shallow subtidal sediments of Howe Sound related to Britannia Mine tailings. Used weight-of-evidence, Sediment Quality Triad, statistical and ecological tools to describe impacts to and recovery of the marine environment.

* denotes projects completed with other firms

Toxicology for Environmental Effects

Monitoring (EEM)

Abitibi Mackenzie Pulp Mill Environmental Effects Monitoring Programs*, Mackenzie, British Columbia (Senior Aquatic Scientist)

For G3 Consulting, analyzed data and wrote reports for Cycle 3 of federally-required EEM programs for marine and freshwater discharges. Benthic invertebrate, sediment chemistry, effluent and toxicology data were integrated in a weight-of-evidence approach to create concise reports.

Pope and Talbot Mackenzie Pulp Mill*, Mackenzie, British Columbia (Senior Aquatic Scientist)

For G3 Consulting, analyzed data and wrote reports for Cycle 3 of federally-required EEM programs for marine and freshwater discharges. Benthic invertebrate, sediment chemistry, effluent and toxicology data were integrated in a weight-of-evidence approach to create concise reports.

Harmac Pulp Mill Environmental Effects Monitoring Programs*, Nanaimo, British Columbia (Senior Aquatic Scientist)

For G3 Consulting, analyzed data and wrote reports for Cycle 3 of federally-required EEM programs for marine and freshwater discharges. Benthic invertebrate, sediment chemistry, effluent and toxicology data were integrated in a weight-of-evidence approach to create concise report.

Environmental Mitigation and Monitoring

Design and Long-Term Monitoring of Habitat Offsetting–Nelson Creek Tributary, Coquitlam, British Columbia (Project Manager, Senior Aquatic Scientist)

Design, implementation, and long term (five year) monitoring of instream and riparian habitat compensation in the Nelson Creek Tributary (Mackin Park), City of Coquitlam.

Response to Oil Release to an Abbotsford Stream, Abbotsford, British Columbia (Project Manager)

Prepared the environmental impact statement for submission to the National Energy Board following remediation of an accidental oil release to a stream-wetland area, covering impacts on aquatic and terrestrial habitat, long term monitoring, and habitat restoration. Supervised the long-term monitoring program.

Columbia River Environmental Response to Smelter Upgrades*, Trail, British Columbia (Senior Aquatic Scientist)

With G3 Consulting, assessed Columbia River water, sediment, and biota (periphyton, benthic invertebrates) before and after major smelter upgrade. Considered confounding influences of dams, pulp mill, and municipal discharges. Performed presentations at international conferences.

Burrard Inlet Monitoring in Response to an Oil Release, Burnaby, British Columbia (Senior Aquatic Scientist)

Prepared the Environmental Impact Statement for submission to National Energy Board. Designed a marine and shoreline monitoring program to assess effects of oil release from a damaged pipeline, and cleanup. Examined water, sediment, mussels, and crabs in a confounded environment (historic and current sources of hydrocarbons). Led the long-term monitoring program, 2007 through 2013 and responded to stakeholder and NEB concerns.

* denotes projects completed with other firms

Water Resources Management

City of White Rock with Urban Systems - Integrated Stormwater Management Plan, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)

Managed environmental studies for an ISMP with multiple stormwater outfall discharges to the marine environment (high recreational and wildlife values in a sandy bay).

City of Coquitlam with Kerr Wood Leidal - Como Creek Integrated Stormwater Management Plan, Coquitlam, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
Urban creek with upland and floodplain concerns.

Integrated Stormwater Management Plans (ISMP), Multiple Sites, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
The ISMPs integrate hydrological, engineering, environmental, land use and stakeholder concerns into a watershed plan.

Municipal WWTP Effluent in the Fraser River Receiving Environment*, New Westminster, British Columbia (Senior Aquatic Scientist)
For G3 Consulting, organized and conducted sampling at the Initial Dilution Zone boundary of the Annacis Island Wastewater Treatment Plant.

Fraser River Ambient Water Quality within the Lower Mainland*, Burnaby, British Columbia (Senior Aquatic Scientist)
For G3 Consulting, assessed water quality in the lower Fraser River (bacteriological, metal, nutrient, and general water quality data) as part of Metro Vancouver's long-term monitoring program.

City of Coquitlam with CH2M Hill - Nelson Creek Integrated Stormwater Management Plan, Coquitlam, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
Urban creek with upland and floodplain concerns.

City of Surrey with Urban Systems - Hyland Creek Integrated Stormwater Management Plan, Surrey, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
Mix of Urban and undeveloped areas.

City of Surrey with Associated Engineering - Erickson Creek Integrated Stormwater Management Plan, Surrey, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
Mix of rural, agricultural and urban land uses.

District of West Vancouver with Associate Engineering - Rodgers and Marr Creeks Integrated Stormwater Management Plan, West Vancouver, British Columbia (Project Manager, Senior Aquatic Scientist and Facilitator)
Two steep mountain creeks in residential areas.

Environmental Planning

Hay River Basin State of Aquatic Knowledge, Yellowknife, Northwest Territories (Technical Review, Contaminant Specialist)
Provided technical direction and quality review of the State of Aquatic Knowledge report for the Northwest Territories-Alberta Bilateral Water Management Agreement. Compiled and reviewed contaminant data (PAHs, PCBs, pesticides, etc.) in water and suspended sediment datasets for the Hay and Slave Rivers. The final report was a plain language document to be used by the Northwest Territories—Alberta transboundary waters committee.

* denotes projects completed with other firms

Karen Ann Munro B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Haida Gwaii Waste Discharge Assessment, Haida Gwaii, British Columbia (Senior Advisor)

The project involved review of sewage and offal sources and applicable regulatory structure on Haida Gwaii, for the Marine Plan Partnership. Potential influences of discharges from sanitary waste treatment plants, vessels, fishing lodges, and other activities were reviewed and links with marine resource use (including shellfish harvesting) discussed. Recommendations for next steps were made.

The Streamkeepers Handbook*, Vancouver, British Columbia (Co-author)

Edited, co-authored and designed The Streamkeepers Handbook, A Guide to Stream and Wetland Care, widely used by thousands of stewards in BC; worked with steering committee, 20 contributing authors, and 40 reviewers.

Pilot Salmon Recovery Program Evaluation, Vancouver, British Columbia (Senior Biologist)

Reviewed Community Salmon Program and Strategic Salmon Recovery Programs. Implemented and developed evaluation framework with indicators of conservation and recovery, financial and operational status, people and relationships, leadership, awareness, and innovation. This project consisted of a workshop, project review, interviews, a report, and a presentation.

Governance Review for Water Licence Monitoring Programs, Burnaby, British Columbia (Senior Biologist)

Designed and conducted a review of BC Hydro's delivery model for Water Licence monitoring plans, for its ability to deliver projects on time, on budget, on scope. Program review, interviews with managers, regulatory agencies, First Nations and report preparation.

Evaluation of the British Columbia Conservation Land Forum, Surrey, British Columbia (Project Manager and Senior Author)

Designed and conducted an evaluation of multi-partner BCCLF, created to streamline funding and improve coordination of land securement and management of conservation projects. Assessed functioning of management board and committees.

Environmental Strategic Plan, City of White Rock, British Columbia (Project Manager, Senior Scientist and Facilitation)

Worked with municipal Environment Committee to develop an environmental strategic plan that reflects the City's values and priorities. Identified key issues and strategies for marine, freshwater and terrestrial environments, solid waste management, energy efficiency and greenhouse gas reductions. Report, presentations, community surveys.

* denotes projects completed with other firms

Karen Ann Munro B.Sc., M.Sc., R.P.Bio.

Water Quality Practice Lead

Columbia River Integrated Environmental Monitoring Program*, Castlegar, British Columbia (Senior Scientist)

For G3 Consulting, conducted a data gap analysis and developed a study design to assess river health and cumulative impacts in a complex environment. Issues included regulation of mainstem and tributary flows (dissolved gas generation, reservoir oligotrophication, fish and fish habitat effects related to three dams), pulp mill, smelter and municipal effluent discharges, decline of white sturgeon populations, and non-point sources. Wrote the reports and made presentations.

Burrard Inlet Environmental Indicators Report, Burnaby, British Columbia (Project Manager, Senior Scientist and Facilitation)

Prepared public consultation document describing seven key indicators of ecosystem health (land use, air, and water quality). Consulted a multi-agency committee to summarize trends over time and the relevance of the indicator and future actions. Also consulted them on public meetings to present the information.

Littoral and Riparian Assessment of Anderson and Seton Lakes*, Lillooet, British Columbia (Senior Aquatic Scientist)

For G3 Consulting, developed littoral and riparian habitat classification for lakes, focusing on rock and debris disposal activities that would affect fish, fish habitat and compliance with the Fisheries Act. Developed an innovative periphyton and invertebrate sampling program for steep habitat. Contributed to development of an Environmental Management Plan for BC Rail.

Log Handling Activities – BMP Guidebook*, Vancouver, British Columbia (Co-author)

For G3 Consulting, co-authored the Guidebook: Environmentally Sustainable Log Handling Facilities in British Columbia, directed by a government-industry steering committee.

Alta Lake Limnology, Whistler, British Columbia (Project Manager and Senior Aquatic Scientist)

Designed and implemented a program to monitor water quality and aquatic life in Alta Lake and other area lakes on a five-year cycle, developed a decision framework to guide development of monitoring programs and to link results to environmental management.

Environmental Indicators Report, Burnaby, British Columbia (Project Manager, Senior Scientist and Facilitation)

Prepared public consultation document describing seven key indicators of ecosystem health (land use, air and water quality). Consulted a multi-agency committee to summarize trends over time and relevance of the indicator and future actions. Also consulted them on public meetings to present the information.

Evaluation of Adaptive Management Plans for NWT Diamond Mines, Yellowknife, Northwest Territories (Researcher and Facilitator)

Reviewed adaptive management plans for environmental monitoring of Diavik and Ekati mines in the Northwest Territories. Also facilitated a two-day multi-stakeholder workshop on adaptive management and the diamond mines, with four presenters.

* denotes projects completed with other firms

Education

Ph.D. Bioresource Engineering, McGill University, Canada, 2010

M.Sc. Irrigation and Drainage Engineering, TMU University of Tehran, Iran, 2003

B.Sc. Irrigation Engineering, Isfahan University of Technology, Iran, 2000

Certifications

Standard First Aid/CPR AED, July 2019

Languages

English – Fluent

Golder Associates Ltd. – Calgary***Water Quality Modeller, P.Eng.***

Shadi Dayyani is a water quality modeller with over 8 years of consulting experience in Alberta, Northwest Territories and British Columbia. She is a registered professional engineer with the Association of Professional Engineers and Geoscientists of Alberta (APEGA).

Shadi has been involved in numerous mining projects with focuses on assessing quality of water in watersheds, rivers, lakes and pit lakes as part of environmental impact assessments or approval applications. Recently, she has served as water quality lead for several projects for Suncor, Teck, Canadian Natural, Shell, Dominion Diamond, Diavik Diamond Mine and Mount Polley. Shadi has direct modelling experience with a number of models including HSPF, Athabasca River Model, CORMIX, CE-QUAL-W2, MIKE3, GEMSS, GoldSim, Golder Pit Lake Model, WASP, WARMF, SWAT, ArcGIS, DRAINMOD and Mike-SHE. Shadi has led the development of multi-phase Aerial Deposition Model, which includes compartments for atmospheric loadings, snow, soil water and instream water.

Employment History***Golder Associates Ltd. – Calgary, Canada***

Water Quality Modeller (2010 to Present)

- Project management (Hydropower projects)
- Water quality Lead (Environmental Assessments and Baseline Studies)
- Environmental Impact Assessments (Oil Sands)
- Hydrodynamic Modelling of the Pit Lakes and Lakes (Diamond and Metal Mines and Hydropower Projects)

School of Engineering, University of Guelph – Guelph, Canada

Research Scientist (part time) (2010 to 2012)

Pesticide Concentration in Streams and Rivers in Ontario

Bioresource Engineering Dept., McGill University – Montreal, Canada

Research Assistant (2004 to 2009)

Hydrological and Water Quality Modelling:

Surface water and non-point source (NPS) pollution modelling

Subsurface water and NPS pollution modelling

Developing a new linked surface and subsurface flow and NPS modelling

Evaluation of the effectiveness of watershed and field management practices using computer modelling

Evaluated the impacts of climate change on surface and subsurface flows and NPS pollution in watersheds.

Jamab Consulting Engineers Company – Tehran, Iran*Surface Water Specialist and GIS analyst (2001 to 2004)*

Involved in several water resources projects including:
 GIS development of Atlas of Water Resources / Watershed analysis;
 Snow covers analysis using NOAA images;
 Feasibility study of small hydropower potentials;
 GIS development for Kowsar Irrigation and Drainage Network; and
 GIS development for Moghan Irrigation and Drainage Network.

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSMENT

**Suncor Energy Inc.
 Froth Treatment
 Tailings Amendment
 Application for Base
 Plant**

Fort McMurray, Alberta,
 Canada

Water quality modelling lead.

**Canadian Natural
 Horizon Mine North Pit
 Extension**

Fort McMurray, Alberta,
 Canada

Water quality component lead for Environmental Impact Assessment. Responsible for assessing potential surface water quality effects resulting from the development of North Pit Extension of Horizon Mine Project. Role focused on working with other members of the interdisciplinary team to ensure an efficient flow of information between components; overseeing and reviewing model set-up and calibration; overseeing and reviewing simulation of water quality in pit lakes, local and regional watercourses; reviewing all model results; preparing modelling reports and presentations; preparing responses for supplemental information requests.

**Suncor Millennium
 Operational
 Amendment**

Fort McMurray, Alberta,
 Canada

Water quality component lead, responsible for water quality assessment/modelling of the pit lakes based on the revised mine plan.

**Teck Resources
 Frontier Project**

Fort McMurray, Alberta,
 Canada

Water quality component lead for updated EIA modelling, SIRs and SOCs. Responsible for assessing potential surface water quality effects resulting from the development of Teck Resources Ltd.'s Frontier Project. Role focused on working with other members of the interdisciplinary team to ensure an efficient flow of information between components; overseeing and reviewing model set-up and calibration; overseeing and reviewing simulation of water quality in pit lakes, local and regional watercourses; modelling snowmelt concentrations as a results of aerially deposited metals and PAHs; reviewing all model results; preparing modelling reports and presentations; preparing responses for supplemental information requests and public hearings.

**TOTAL Joslyn North
 Mine**

Fort McMurray, Alberta,
 Canada

Water quality modelling of treated effluent discharge from the wastewater treatment facility of Joslyn north mine project using WASP model and preparing modelling report.

Shell Pierre River Mine
Fort McMurray, Alberta,
Canada

Water quality component lead for updated EIA modelling. Responsible for assessing potential surface water quality effects resulting from the development of Shell Pierre River Mine Project. Role focused on working with other members of the interdisciplinary team to ensure an efficient flow of information between components; summarizing large datasets containing water quality information for input into selected water quality models; completing the surface water quality modelling of pit lakes, local and regional watercourses, including model set-up, calibration and simulation; modelling snowmelt concentrations as a results of aerially deposited metals and PAHs; processing model results; and preparing modelling reports and presentations.

**Shell Jackpine Mine
Expansion**
Fort McMurray, Alberta,
Canada

Water quality component lead for updated EIA modelling, SIRs and SOCs. Responsible for assessing potential surface water quality effects resulting from the development of Shell Jackpine Mine Project. Role focused on working with other members of the interdisciplinary team to ensure an efficient flow of information between components; overseeing and reviewing model set-up and calibration; overseeing and reviewing simulation of water quality in pit lakes, local and regional watercourses; modelling snowmelt concentrations as a results of aerially deposited metals and PAHs; reviewing all model results; preparing modelling reports and presentations; preparing responses for supplemental information requests and public hearings.

PROJECT EXPERIENCE – HYDRODYNAMIC AND WATER QUALITY MODELLING

**Falco Resources Ltd.
Horne 5 Gold Mine
Project**
Rouyn-Noranda,
Quebec, Canada

Hydrodynamic and water quality modelling lead. Assessing the effects of potential tailing pipeline failure on the Lake Dufault. Role focused on overseeing and reviewing model set-up, reviewing model results, preparing model reports and presentations.

**Diavik Diamond Mines
- A418, A154 and A21
Pit Lakes**
Yellowknife NT, Canada

Hydrodynamic water quality modelling lead. Modelling hydrodynamics and water quality of A418, A154 and A21 Pit Lakes using CEQUAL-W2 model to assess stratification and predict quality of water in the pit lakes. Role focused on overseeing and reviewing model set-up, reviewing model results, preparing model reports and presentations, presenting results to client and in technical sessions and preparing response to information requests.

**Dominion Diamond
Ekati ULC - Panda,
Koala, and Koala North
Pit Lakes**
Yellowknife NT, Canada

Hydrodynamic water quality modelling lead. Modelling hydrodynamics and water quality of Panda, Koala and Koala-North Pit Lakes using CEQUAL-W2 and GoldSim models to assess stratification and predict quality of water in the mined-out pits. Role focused on overseeing and reviewing model set-up, reviewing model results, preparing model reports and presentations, presenting results to client, and preparing response to information requests.

**Dominion Diamond
Ekati Corporation
Misery Underground
Project**
Yellowknife NT, Canada

Hydrodynamic modelling lead. Modelled hydrodynamics of Misery Pit Underground and Jay Pit using CEQUAL-W2 model to assess stratification of the pits and predict quality of water in the pits as a results of future mine developments.

<p>Mount Polley Mine – Boott Jack Lake Likely, BC, Canada</p>	<p>Hydrodynamic modelling lead. Modelled hydrodynamics of the Boot Jack Lake using GEMSS to assess the effects of seepage from the Springer Pit on the lake. Modelling report was prepared.</p>
<p>Shell Pearl Hill Hydro Battery Washington, US</p>	<p>Responsible for near-field water quality modelling of Shell's proposed Pearl Hill Hydro Battery Project. The near-field modelling was completed using CORMIX mixing zone model, to assess the effects on currents within the immediate area of the discharge under the expected conditions in Rufus Woods Lake. The Model was used to estimate the near-field mixing of the discharge plume for few assessment scenarios.</p>
<p>The Jay Project NWT, Canada</p>	<p>Hydrodynamic water quality modelling lead; modelled hydrodynamics of the Lac du Sauvage, Jay and Misery Pits using CEQUAL-W2 model; and preparing the modelling reports and presentations.</p>
<p>COSIA Aerial Deposition Calgary, Alberta, Canada</p>	<p>Technical lead for assessing the effects of aerial deposition to snowpack on water quality in the Alberta Oil Sands Region.</p>
<p>De Beers Canada Inc. Gahcho Kué diamond mine project NWT, Canada</p>	<p>Modelling Analysis of Diffuser Discharge in Lake N11, using CORMIX mixing zone model; and preparing modelling reports and presentations.</p>
<p>Capital Power Genesee Station Wabamun, Alberta, Canada</p>	<p>Project manager and water quality component lead for thermal (hydrodynamic) and chemical modelling of the cooling pond using GEMSS and mass balance models.</p>

PROJECT EXPERIENCE – VARIOUS

<p>Alaska Pipeline Project- Water Quality GAP analysis Yukon & BC, Canada</p>	<p>Responsible for reporting the available water quality data (gathered from different sources) along the proposed Alaska pipeline in Yukon and BC for gap analysis.</p>
<p>City of Calgary Bow River Impact Study; TSS Objectives Calgary, Alberta, Canada</p>	<p>Involved in development of total suspended solids (TSS) objectives for the City of Calgary, Bow River. Compared the monitored and predicted TSS data (generated using the Bow River Water Quality Model, BRWQM) to the in-stream TSS threshold described in the Bow River Impact Study and the TSS objective defined by the Bow River Basin Council (BRBC) for the Central Reach of the Bow River. Presenting the methods, calculations and discussion of results to the City of Calgary.</p>
<p>Battle River - Water Quality Objectives Alberta, Canada</p>	<p>Responsible for developing water quality objectives for different uses for reaches of Battle River, based on several guidelines.</p>
<p>North Saskatchewan River Monitoring Program City of Edmonton Edmonton, Alberta</p>	<p>Data preparation and analysis to run the developed tool for water quality index for interpretation of the annual monitoring program results of municipal loading to the North Saskatchewan River.</p>

TRAINING**WASP Model (V 7.0)**

EPA, August 2012

CORMIX Model

Portland State University, June 2011

GEMSS Model

ERM Inc., March 2014

GoldSim Workshop: Water Resource Applications

GoldSim Technology Group, February 2012

CE-QUAL-W2 Model Version 3.7

Portland State University Professional Development Center, June 2013

SWAT Model

Texas A&M University, May 2010

Application of Remote Sensing (RS) and Geographic Information Systems (GIS) in Irrigation and Drainage Projects [World Bank Irrigation Improvement Project through the cooperation of FAO

FAO, 2001

SUPPLEMENTAL SKILLS**GIS/RS**

ArcGIS, IDRISI, ILWIS, ERDAS

Hydrodynamic, Hydrological and Water Quality Modelling

MIKE3, HSPF, CE-QUAL-W2, GEMSS, WASP, SWAT, CORMIX, DRAINMOD, WARMF, MIKE-SHE.

PROFESSIONAL AFFILIATIONS

Professional Engineer (P.Eng.), Association of Professional Engineers and Geoscientists of Alberta (APEGA)

PUBLICATIONS**Books**Dayyani, S. 2007. *GIS and its application in water and soil management (In Persian)*. Tehran, Iran, Bahman-Borna /publications Co.**Refereed Journal Articles**Dayyani, S., G. Daly and J.A. Vandenberg. Approach to Assessing the Effects of Aerial Deposition on Water Quality in Alberta Oil Sands Region. *Water Environment Research*. 88(2), pp.175-189.

Vandenberg, J.A., M. Herrell, J.W. Faithful, A.M. Snow, J. Lacrampe, C. Bieber, S. Dayyani and V. Chisholm. Multiple Modelling Approach for the Aquatic Effects

Assessment of a Proposed Northern Diamond Mine Development. *Mine Water and Environment*, <http://dx.doi.org/10.1007/s10230-015-0337-5>, (2015), 1-9.

Dayyani, S. et al. Development of DRAIN-WARMF Model to Simulate Flow and Nitrogen Transport from an Agricultural Watershed. *Agricultural Water Management*, 98 (1). 2010, 55-68.

Dayyani, S. et al. Impact of Climate Change on the Hydrology and Nitrogen Pollution in a Tile-Drained Agricultural Watershed in Eastern Canada. *Transactions of ASABE*, 55(1) (2012)

Dayyani, S. et al. Field Evaluation of Drainmod 5.1 under a Cold Climate: Simulation of Daily Midspan Water Table Heights and Drain Outflows. *American Water Resource Association*, 45 (3), 2009, 779-792.

Dayyani, S. et al. Water Quantity and Quality Modelling in Cold Conditions using DRAINMOD 5.1. *Transactions of ASABE (American Society of Agricultural and Bioresource Engineers)*, 53 (2). 2010, 385-395.

Dayyani, S. et al. Evaluation of Watershed Analysis Risk Management Framework (WARMF) for Flow and Nitrogen Transport in an Agricultural Watershed under a Cold climate. *Water Quality Research Journal of Canada* (2013)

Dayyani, S. Modeling Hydrology and Nitrogen Fate and Transport in a Tile-Drained Agricultural Watershed in a Cold Region. *Ph.D. Thesis, Bioresource Engineering Department, McGill University* (2010), 226.

Dayyani, S. Development of a Geographic Information System (GIS) for Optimal Management of an Irrigation and Drainage Network. *M.Sc. Thesis, Department of Irrigation and Drainage Engineering, TMU University of Tehran* (2003)

Dayyani, S. et al. Simulation rainfall-runoff and estimating river flow in un-gaged places using ANN and GIS. *Journal of Agricultural Science, Tabriz University, Iran*, 15 (4), (2004), 157-170.

Refereed Conference Proceedings

Ahmed, S., R. Rudra, S. Dayyani, P. Goel and B. Gharabaghi. 2012. *Analysis of Pesticide Application and Stream Water Quality Using Long-Term Data at County Level for Southern Ontario*. 21st Century Watershed Technology Conf. and Workshop by ASABE and IRSA/CNR, May. Bari, Italy.

Dayyani, S. et al. 2010. *Impact of Climate Change on Drainage Outflow and Water Quality in Eastern Canada*. International Drainage Symposium (IDS), June. Quebec City, Canada.

Dayyani, S. et al. 2009. *Impact of Climate Change on Nitrogen Pollution in an Agricultural Watershed in a Cold Region*. The 60th IEC of ICID (International Commission on Irrigation and Drainage), December. New Delhi, India.

Dayyani, S. et al. 2003. *Application of GIS in Optimum Water Use Efficiency in Irrigation and Drainage Networks*. 11th Seminar of Iranian National Committee

on Irrigation and Drainage, Improving Water Productivity in Agriculture and Food Security (IRNCID), June. Tehran, Iran.

Dayyani, S. et al. 2003. *Using Geographic Information System in River Engineering for Estimation of River Flow*. International Conference of GIS and Remote Sensing in Hydrology, Water Resources and Environment (ICGRHWE), April., China.

Conference Proceedings

Dayyani, S. et al. 2009. *Development of DRAIN-WARMF Model to Simulate Flow & Nitrogen Transport and Evaluate the Impact of Climate Change on Water Pollution on Watershed Scale*. CSBE/ SCGAB annual meeting (Canadian Society of biological Eng.), July. Charlottetown, Canada.

Dayyani, S. et al. 2009. *Development of DRAIN-WARMF Model to Simulate Flow & Nitrogen Transport on Watershed Scale*. ASAE Meeting, June. Reno, USA.

Dayyani, S. et al. 2007. *Modelling Surface and Subsurface Nitrogen Transport in an Agricultural Watershed: Linking DRIANMOD 5.1 and WAMRF model*. ASAE Meeting, June. Minneapolis, USA.

Dayyani, S. et al. 2004. *GIS Based Decision Support System for On-Farm Sprinkler Irrigation Management Using Soil-Water Content Balance*. Iranian National Committee on Irrigation and Drainage, July. Tehran, Iran.