HENRI SANGAM

Dr. Henri Sangam is a senior engineer with more than 22 years of experience in geo-environmental engineering spanning the fields of geotechnical design and assessments, rock mechanics, physical and contaminant hydrogeology, landfill design, and contaminated site assessment and remediation. He has acted as the project manager and lead geomechanical, geotechnical and/or hydrogeological engineer for multiple studies and engineering designs related to mine waste management including tailings and waste rock. In recent years, he was the senior rock mechanics engineer and/or senior reviewer for various cold climate projects in northern Canada, Greenland and Finland, as well as for projects in tropical regions. Dr. Sangam possesses valuable experience in developing field investigation programs in soil and bedrock, data collection and analysis and defining design parameters for mine site surface infrastructure such as portals, foundations and roads as well as for open pit and underground mines. He is conversant with many software programs in the fields of geotechnical engineering, rock mechanics and hydrogeology / contaminant transport. Dr. Sangam is also a member of the Canadian Dam Association and Canadian Geotechnical Society.

SECTORS OF EXPERTISE

Environment	› Environmental Impact Study; Contaminated Sites; Mining Sites; Groundwater / Hydrogeology; Groundwater Supply; Environmental Geotechnics ; Landfills
Mining & Metallurgy	› Mine rehabilitation; Rock mechanics

EDUCATION

2001	Ph.D. Geotechnical Engineering, University of Western Ontario, London, Ontario, Canada
1996	M.A.Sc. Geotechnical Engineering, Université de Moncton, Moncton, New Brunswick, Canada
1994	B.A.Sc. Civil Engineering, Université de Moncton, Moncton, New Brunswick, Canada
1988	B.Eng. Civil Engineering–Construction, École Nationale Supérieure d'Ingénieurs (ENSI), Lomé, Togo

EXPERIENCE

SINCE 2002 — SNC-LAVALIN, TORONTO, QUEBEC, CANADA

Mining & Metallurgy - Ontario

Since 2011 — Senior Engineer / Reviewer

Amaruq Water Management Infrastructure Prefeasibility Study, Agnico Eagle Mines Ltd. – Meadowbank Division, Nunavut, Canada (2016 - present)

› Senior Reviewer/Advisor for the geotechnical investigation for the open pit's diversion dyke.

Tailings Storage Facility Expansion Project – Portage in Pit Deposition, Agnico Eagle Mines Ltd. – Meadowbank Division, Nunavut, Canada (2016 - present)

› Senior Reviewer for overall project for the prefeasibility and feasibility studies

Years of Experience

› 24 years

Years with SNC-Lavalin

› 16 years

Key Positions

› Director-Geotechnical/Material Engineering
› Project Manager
› Hydrogeologist

Languages

› English
› Spanish
› French

phases, as well as the current detailed engineering phase.

Long Lake Gold Mine Rehabilitation Project, Ministry of Northern Development and Mines of Ontario, Canada (2014 - present)

› Senior Reviewer for the detailed design and construction management of site reclamation and construction.

Securing of openings at Mine Clark, Ministère de l'Énergie et des Ressources naturelles du Québec, Quebec, Canada (2017)

› Senior Geomechanical Reviewer.

Reviews of Sudbury Nickel Operations, Vale, Ontario, Canada (2017)

› Dam Safety Review and OMS Manual Review of Sudbury Nickel Operations.

Review of Kidd Creek Mine, Glencore, Ontario, Canada (2016)

› Dam Safety Review of Kidd Creek Mine.

Ak-Sug Copper-Molybdenum Project, Intergeo MMC Ltd., Russia (2012 - 2013)

› Geotechnical reviewer for the geotechnical investigation, the tailings management facility design and the open pit design
› Foundation recommendations for the process plant and mine infrastructure.

Basic and Detailed Engineering for the Mina de Cobre Panama Project, Minera Panama S.A, Panama (2011 - 2013)

› Senior reviewer for the tailings management facility, waste dumps, water management infrastructure and associated ponds
› Responsible for the geotechnical, hydrogeological and geochemical aspects of the project.

Expansion of the Aurizona Gold Mine, Luna Gold Corp., Brazil (2012)

› Senior reviewer for all the geotechnical and hydrogeological aspects related to the expansion of the tailings treatment plant, surface infrastructure and waste/tailings management.

Blue Marlin Project Third Party Review, Yamana Gold Inc., Ontario, Canada (2011)

› Geotechnical advisor for the third party review of the slope design for the open pit.

Since 2010

Mining & Metallurgy - Ontario

Director, Sustainable Mine Development - Toronto

› Set the group's vision, direction, budget preparation, staff assignments and recruitment
› Responsible for strategic development of the group
› Responsible for the day-to-day operations of the geo-environmental group, including review of technical aspects for tailings facilities, foundations for onshore and marine structures
› Oversees preparation and responsible for quality of reports and proposals

Site Experience

› Argentina
› Brazil
› Canada
› Finland
› Greenland
› Guyana
› Ivory Coast
› New Caledonia
› Paraguay
› Tanzania
› Togo
› Uruguay
› Venezuela

Computer Applications

› AutoCAD
› SLIDE
› Dips
› Swedge
› SLOPE/W
› SEEP/W
› SIGMA/W
› SoilCover
› gINT
› HELP
› POLLUTE
› MIGRATE
› Visual MODFLOW
› GMS
› CTRAN/W
› FEFLOW
› Surfer
› AquiferTest
› AquaChem
› UnWedge
› RockLab

› Oversees the project management and the coordination/logistics of projects.

Since 2009

Mining & Metallurgy - Ontario
Project Manager

Geochemical Gap Analysis and Geochemical Testwork at Essakane Gold Mine, Essakane S.A. (IAMGOLD), Burkina Faso (2017 - present)

› Project manager responsible for conducting site-wide geochemical testing of waste rock and tailings.

Soto Norte Gold Project Prefeasibility Study, Sociedad Minera de Santander, Colombia, CA $3 000 000 (2016 - 2017)

Engineering manager for the prefeasibility study. The project consists of a large undergroung mine and concentrator plant, and associated utilities and infrastructure.
› Site selection and trade-off studies for tailings dry stack facility, waste rock storage facility and water storage facility
› Design of the tailings dry stack facility, waste rock storage facility and water storage facility
› Prepared design drawings and design reports and inputs to the PFS report.

Broken Hammer Mine Closure, Wallbridge Mining Company Limited, Ontario, Canada (2015)

› Conducted the site inspection of the open pit and waste rock stockpile
› Assessed the slope stability of the open pit and the waste rock stockpile
› Prepared the assessment report.

Ambatovy Tailings Management Facility FEL 2 Phase 3 Stage 1 Dam Raising Design, Dynatec Madagascar S.A., Madagascar (2014)

› SNC-Lavalin has performed the detailed design for the Phase 1 TMF and a conceptual arrangement for Phase 2 and 3 of the TMF. The TMF Phase 3 is the subsequent dam raising to provide a further 3.3 years of storage for a total of about 8.5 years of operation.

Geotechnical Audit for SNIM Open Pits, SNIM, Mauritania (2013)

› Provided comments and recommendation for existing pit walls based on site inspection results
› Conducted compliance check
› Participated in the preparation of the audit reports.

South Pit Slope Stabilization Study for the Kapuskasing Phosphate Operations, Agrium, Ontario, Canada (2013)

Project manager for the slope stabilization study and the assessment of pit at closure study.
› Evaluated as-built slope pit slope performance
› Conducted pit wall stability analyses for different water level scenarios at closure
› Conducted field investigation
› Evaluated potential failure development area
› Provided remediation recommendations and pit slope monitoring guidelines
› Developed the slope monitoring program.

Qakimajurq Project at Raglan Mine, Xstrata Nickel, Nunavik, Quebec, Canada (2010 - 2011)

› Project manager for the geotechnical and geomechanical investigation as part of the combined Prefeasibility - Feasibility study for the design of the underground mine, ventilation system, surface and underground infrastructure, power generation infrastructure, and surface ore and waste rock handling system. Project involved the design and supervision of the drilling program, geotechnical and geomechanical logging, assessment of the rock mass quality, and factual report preparation.

Kikialik Project at Raglan Mine, Xstrata Nickel, Nunavik, Quebec, Canada (2009)

› Project manager for the geotechnical and geomechanical investigation as part of the Feasibility study for the underground mine design. Project involved the design and drilling supervision of oriented boreholes, rock core logging, data compilation and factual report preparation.

North Dyke Design Project for the Kapuskasing Phosphate Operations, Agrium, Ontario, Canada (2009)

› Project involved the review of existing design of flowing clay containment dyke, slope stability analysis, revision of dyke design and construction recommendations.

Since 2007

Mining & Metallurgy - Ontario

Senior Hydrogeologist / Geotechnical Engineer / Rock Mechanics Engineer

Environmental Assessment of the Icon Sullivan Legacy Mine Site, Ministère de l'Énergie et des Ressources naturelles du Québec, Quebec, Canada (2016)

› Lead geomechanical engineer for the crown pillar stability assessment for the legacy mine workings.

Environmental Site Investigation of Two Legacy Uranium Sites, Saskatchewan Research Council, Saskatchewan, Canada (2015 - 2016)

Lead rock mechanics engineer for the historical data review and crown pillar stability assessment at the Lorado Mine and Uranium Ridge legacy sites.

› Review and interpretation of historical data
› Conducted a data gap analysis
› Reconstructed the conditions of the abandoned mine workings and their crown pillars
› Assessed the stability of the crown pillars
› Developed the investigation plan for the next phase
› Prepared the assessment report.

Prefeasibility Study and Detailed Feasibility Study for a Carbon-in-Leach Gold Project, Société des mines d'Ity, Ivory Coast, CA $1 200 000 (2014 - 2015)

› Responsible for the geotechnical and hydrogeological field investigations
› Design of the investigation programs and supervision
› Data compilation and reporting
› Geotechnical assessment of the open pit.

El Halassa Phosphate Wash Plant, EPCM, Office chérifien des phosphates (OCP), Morocco (2012 - 2015)

› Lead geotechnical engineer responsible for the design and construction of the tailings storage facility and geotechnical engineering for surface infrastructure.

Lac Otelnuk Iron Ore Feasibility Study, Lac Otelnuk Mining Ltee, Quebec, Canada (2013 - 2014)

› Geotechnical Lead for tailings facility, water management, and surface infrastructure.

Site Closure for the Montauban Abandoned Mine Site, Ministère des Ressources naturelles du Québec, Quebec, Canada (2013)

Lead Geomechanics engineer for the surface pillar stability assessment at the Tétrault 2 site.

› Supervision and review of the geotechnical and geomechanics investigation program
› Review of the stability assessment of the underground workings and surface pillar.

Basic Engineering for the Veduga Gold Project, Polygon Gold, Russia (2012 - 2013)

- Senior geotechnical reviewer for the tailings storage facility design, hydrogeology, pit dewatering study and water management
- Involved in the preperation for open pit design recommendations
- Planned the investigation work for the next stage
- Reviewed previous data and commented on existing open pit design.

Crown Land Opportunities and Restoration Branch, Ministry of Forests, Lands, and Natural Resource Operations, British Columbia, Canada (2012)

- Geomechanical Lead for the securing of openings and surface pillars
- Developed the closure plans for the shafts
- Assessed the stability of surface pillars and of various sinkholes observed on the sites.

Prefeasibility Study and Bankable Feasibility Study for the ISUA Iron Ore Project, London Mining Plc, Greenland, Denmark (2010 - 2012)

Iron ore project located 150km from the capital city of Nuuk, on the edge of the ice cap, to consist of an open pit, processing plant, shipping facilities and other surface infrastructure, with a targeted capacity of 15 Mtpa.

- Lead Hydrogeologist, Geotechnical and Rock Mechanics engineer for the PFS and BFS
- Analysis of geotechnical field data
- Recommendations for soil and rock design parameters
- Design of the open pit slopes
- Assessment of dewatering requirements for open pit development.

Kittila Gold Mine, Agnico Eagles Mines Ltd., Finland (2010)

- Senior geomechanical engineer for the development and implementation of remedial actions to stabilize the movement of the eastern wall of the Suuri pit.

Vision in Motion Project, Cameco, Ontario, Canada (2010)

- Performed groundwater modelling associated with the planned remediation work
- Reviewed design of proposed storage facility for the excavated waste.

Goro Nickel Project, Vale, New Caledonia (2009 - 2010)

- Designed the interceptor wells for the Kwé West tailings storage facility
- Led a hydrogeological study related to the tailings storage facility including tracer tests, pumping tests, etc.

Ambatovy Mine Project, EPCM, Sherritt Corporation, Madagascar (2008)

The project consists of an open-pit mining operation and an ore preparation plant. The key project components include annual design capacity of 60,000 tonnes of LME Class 1 nickel metal and 5,600 tonnes of cobalt and 190,000 tonnes of ammonium sulphate.

- Responsible for hydrogeological investigations
- Responsible for the 3D regional groundwater modelling with Feflow
- Developed contaminant mitigation measures.

Las Cristinas Gold Project, EPCM, Crystallex International Corporation, Venezuela (2008)

- Responsible for site-wide hydrogeological studies including open pit dewatering.

Prefeasibility Study and Feasibility Study for the Reko Diq Copper-Gold Project, Tethyan Copper Company, Pakistan (2008)

› Geotechnical Area Manager for geotechnical investigations and reporting.

Preliminary Engineering of the Donalson and 5-8 Open Pit Projects at Raglan Mine, Xstrata Nickel, Nunavik, Quebec, Canada, CA $500 000 (2008)

› Geotechnical Lead
› Reviewed the geotechnical drilling program for open pit development
› Design of the open pit and of the Mine 7 and Area 5-8 portals.

Scoping Study and Prefeasibility Study for the Kabanga Nickel Project, Kabanga Nickel Company, Tanzania, CA $8 000 000 (2008)

› Geotechnical assessment for the underground mine design
› Design of the geotechnical and hydrogeological field investigation programs for the second phase of the scoping study and prefeasibility study
› Geotechnical lead during the investigations and for reporting.

Hydrogeological Study of the Guarani Aquifer System, Organization of American States, Secreteria General – Sistema Acuifero Guarani, Argentina, CA $5 300 000 (2007)

Consulting services to carry out the inventory, sampling, geology, geophysics, hydrogeochemistry, isotopy and local hydrogeology of the Guarani Aquifer System
(SAG).

› Principal technical resource for compiling and reporting on the hydrogeological aspects which included: well inventory and sampling, geology and geophysics, hydro-geochemistry, general isotopes, topographic base map, hydrogeological maps, GIS, monitoring wells and local hydrogeology modeling of four pilot areas: Ribeirao Preto (Brazil); Rivera (Uruguay)/Santana (Brazil); Salt (Uruguay)/Concordia (Argentina) and Itapúa (Paraguay).

2002 - 2008 | Geo-environmental Engineer

Detailed Engineering for the Las Brisas Copper-Gold Project, Gold reserve Inc., Venezuela (2005):
› Reviewed existing open pit design and provided recommendation for further pit optimization
› Evaluated soil and rock properties and carried out slope stability analyses for the open pit.

Feasibility Study for the Gatsuurt Gold Project, Centerra Gold Inc., Mongolia, $500,000 (2005):
› Design of the geotechnical and hydrogeological field investigation programs
› Analysis of geotechnical field data
› Recommendations for soil and rock design parameters
› Design of the open pit slopes.

Las Cristinas Gold Project Feasibility Study, Crystallex International Corporation, Venezuela, $2,000,000 (2003):
› Prepared the geotechnical investigation program
› Field supervision of hydrogeological and geotechnical investigations
› Data compilation and assessment
› Groundwater modelling
› Recommendations for soil and rock design parameters
› Responsible for the design of the open pit slopes.

Royal Canin Project, Guelph, Ontario, Canada:

› Responsible for the investigation and foundation recommendation.

Remediation of leachate seeps at Glanbrook and closed Stoney Creek Landfills, Hamilton, Ontario, Canada

Caledon Landfill Redevelopment, Caledon, Ontario, Canada:
› Assessed subsurface conditions for the redevelopment of the landfill as community recycling centre
› Coordinated field investigation program, analyzed data and provided recommendations site development including foundation design, excavations and retaining walls.

Tennis Canada Centre, York University, Toronto, Ontario, Canada:
› Responsible for investigation and foundation recommendation.

Portland Energy Centre, Toronto, Canada:
› Lead geotechnical engineer responsible for investigation and foundation recommendation.

Riverstown Landfill Expansion, County of Wellington, Ontario, Canada:
› Improved cover system to reduce infiltration and hence leachate production.

Brimley Road South Landfill, City of Toronto, Ontario, Canada:
› Geotechnical engineer responsible for the landfill slope monitoring.

Closed Ancaster Landfill Remediation, City of Hamilton, Ontario, Canada:
› Design and construction of improved low permeability cover incorporating end use soccer fields.

Peer review of 2005 Annual Monitoring Report for Rennie-Brampton Landfills, City of Hamilton, Ontario, Canada.
Landfill gas system at 474 Attwell Drive, Toronto, Ontario, Canada.
Gas odour control at Glanbrook Landfill, City of Hamilton, Ontario, Canada.

Remediation of PCB-Contaminated Soil at Saglek, Labrador, Canada:
› Oversaw remediation activities including excavation of contaminated soil, screening process and containerization
› Conducted due diligence soil sampling
› Oversaw compliance of remedial activities to environmental protection plant
› Oversaw contractor activities.

Farmhouse Court Site Project, Brampton, Ontario:
› Conducted Phase II site investigation to assess the level of site contamination
› Conducted geotechnical investigations to evaluate the quality of the material to be used as fill and to establish conditions existing on site for re-development.

West Demerara to Ruimveldt Road Improvement, Georgetown, Guyana:
› Verified that the construction activities were in compliance with environmental requirements and prohibitions of government legislation, particularly with respect to environmental management plan
› Provided training to environmental inspector, contractor and client.

2001 - 2002 | GEOENGINEERING CENTRE AT QUEEN'S – RMC, KINGSTON, ONTARIO, CANADA
Research Associate / Geo-environmental Engineer

Remediation of Arctic Diesel contamination at DEW Line Site (BAF3):
› Coordinated and supervised the laboratory team
› Designed laboratory experiment and developed laboratory test procedures and protocols for evaluating the

performance of the geocomposite containment system
› Supervised and coordinated the laboratory team and managed the geoenvironmental laboratory.

Evaluation of the performance of composite liner systems used as landfill barrier:
› Designed laboratory experiment for the evaluation of liner systems
› Developed laboratory test procedures and protocols
› Conducted laboratory testing.

1996 - 2001 | GEOTECHNICAL RESEARCH CENTRE, LONDON, ONTARIO, CANADA
Research Engineer - Research Assistant

Study of the durability of PipeSak Geotextiles:
› Designed laboratory experimental setups
› Conducted the laboratory investigation, analyzed laboratory data and prepared reports.

Review of the state-of-the-art of landfill site design:
› Prepared sections related to geosynthetic barrier systems including design, construction and long term performance, as member of the review team.

Durability and long-term performance of liners systems in landfill and other containment applications:
› Conducted field and laboratory investigationsAnalyzed data and prepared reports.

1993 - 1996 | UNIVERSITÉ DE MONCTON, MONCTON, NEW BRUNSWICK, CANADA
Research Associate

Evaluation of Northern Quebec glacial tills used in earth dams:
› Field sampling at different sites and laboratory testing
› Developed a code for analyzing laboratory data
› Analyzed data and prepared reports
› Performed modelling of various earth structures
› Wrote and presented papers at various conferences.

1988 - 1991 | SOCIÉTÉ ANONYME DES TRAVAUX D'OUTRE-MER (SATOM), LOMÉ, TOGO
Site Engineer

Construction and Rehabilitation of Highway RN1 – Lomé-Sokodé (300 km):
› Responsible for construction quality control
› Conducted daily and/or routine sampling and testing including compaction, aggregates and pavements
› Prepared quality control reports
› Prepared weekly site reports.

Construction of BCEAO Headquarters in Lomé, Togo:
› Conducted daily and/or routine site concrete sampling and testing
› Coordinated the construction of a retaining wall for the access road
› Prepared weekly site reports.

1987 | SOCIÉTÉ TOGOLAISE DE MARBRE (SATOMA), LOMÉ, TOGO
Junior Site Engineer

Marble Quarry, Pagala, Togo:
› Assisted the chief mining engineer in the identification of extraction zones
› Responsible for identifying drainage needs for access road and dewatering requirements for the quarry
› Prepared daily production datasheet

› Responsible for quality control during production
› Prepared monthly reports.

1986 | SOCIÉTÉ ANONYME DES TRAVAUX D'OUTRE-MER (SATOM), LOMÉ, TOGO
Junior Site Engineer

Construction of “Nouveau Grand Marché ” in Lomé, Togo:
› Assisted the chief engineer in preparing the weekly meeting
› Conducted daily and/or routine site concrete sampling and testing
› Prepared weekly site reports.

PROFESSIONAL ASSOCIATIONS

SINCE 2008	Engineers & Geoscientists British Columbia
SINCE 2002	Professional Engineers Ontario (PEO), Membership no. 100053196
SINCE 1996	Canadian Society for Civil Engineering (CSCE)

ANH-LONG NGUYEN

Mr. Anh-Long Nguyen, Eng., M.Sc. is a process engineer with 19 years of experience, specializing in the water management and treatment industry for the mining, industrial, and municipal sectors. Mr. Nguyen is presently the Discipline lead for water management and treatment at the Sustainable Mine Development group. He has acquired a solid background in the design and development of water treatment processes, including clarification, filtration and membrane systems. He has participated in all engineering phases of a project, including pre-feasibility studies, basic and detail engineering, and start-up and commissioning. He has also acted as proposal manager where he was responsible for a team of specialists (engineers, designers and estimators) for the process design, technical and commercial risk evaluation, and cost estimates and proposal preparation. With SNC-Lavalin, he has participated in the development of a mine site water management plan where he identified water sources, looked at water quality, identified streams requiring treatment and designed pump stations and water treatment processes to deal with these streams. Mr. Nguyen speaks English and French.

SECTORS OF EXPERTISE

Infrastructure & Buildings	› Wastewater collection and treatment; Industrial Planning (drainage, drinking water); Sludge Treatment and Management; Municipal & Sanitary Infrastructure; Water Treatment Plants; Pumping Stations (untreated and treated water)
Environment	› Effluent Treatment; Mining Waste Management

EDUCATION

1998	M. Sc. in Agricultural and Biosystems Engineering, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada
1996	B. Eng. in Chemical Engineering with minor in Biotechnology, McGill University, Montreal, Quebec, Canada

EXPERIENCE

SINCE 2006

SNC-LAVALIN INC., MONTREAL, QUEBEC, CANADA

Sustaining Capital / Mining & Metallurgy - QC

Lead Process Engineer - Water Treatment

Lead Process Engineer, Chuquicamata - Replacement of Weak Acid Treatment Plant EPC Project, Codelco, Calama, Chile (2016 - present)

- Provided process engineering support to SNC-Lavalin Chile office.
- Developed design criteria for the new weak acid treatment plant.
- Responsible for the development of process flow diagrams, water and mass balance and sizing of main process equipment.
- Participated in the technical evaluation of key process equipment for the weak acid treatment plant, included the thickener and flocculent preparation systems, the filter press systems, agitators and pumps.
- Multi-disciplinary coordination for detailed engineering of the plant.
- Participated in the production of the Operating and Maintenance manual for the new weak acid treatment plant.
- Participated in the planning of the commissioning of the plant.

Years of Experience

› 20 years

Years with SNC-Lavalin

› 12 years

Key Positions

› Engineering Specialist - Process

Languages

› English
› French

- Participated in the production of commissioning procedures of the plant.

Sr. Process Engineer, Feasibility Study Phase 2 for Mine Expansion, Glencore, Raglan Mines, Quebec, Canada (2017)

- Developed the feasibility level engineering of the new pumping systems and water treatment plant required for the Phase 2 expansion project.
- Evaluated the flow and head required for the new pumping systems.
- Developed the PFD and P&ID for the new pumping systems and water treatment plant.
- Developed the plot plan and the general arrangement drawings for the new water treatment system.
- Planned and Participated in a preliminary HAZOP session.

Alternative Study to Optimize the Water Management Infrastructures at Site, Niobec Inc., Quebec, Canada (2017)

- Identified new infrastructures and possible options required to optimize the water management at site based on expected future volumes and flows.
- Performed hydraulic calculations to evaluate if the existing pumping station capacity can meet the future water management requirements.
- Provided high level cost estimate for the new infrastructures.
- Evaluated advantages/disadvantages of the different options identified in the study.

Process Engineer, Scoping and Pre-Feasibility Study for the Development of Alternative Tailings Management Approach, Agnico-Eagle Mines (AEM), Meadowbank Site, Nunavut, Canada (2016 - 2017)

- Developed at a scoping level two alternative tailings management approach as part of the expansion project at site, which included preliminary equipment sizing, layouts and costing.
- Participated in a multiple account analysis to select with AEM the best option to move forward.
- Developed a water/mass balance and water quality forecast model based on the selected tailings deposition approach.
- Developed at a pre-feasibility study level the selected tailings management approach, which includes update of the water/mass balance and water quality forecast model, evaluate pump capacities required for the selected option , develop the site layout and MTO.

Yearly Water Quality Forecasting Update Study, Agnico-Eagle Mines (AEM), Meadowbank Site, Nunavut, Canada (2012 - 2017)

- Developed a water quality forecasting model for the reclaim water collected in the tailings storage facility in 2012/2013 based on the site water balance developed by AEM
- Updated on a yearly basis the water quality forecasting model based on the revised site water balance
- Reviewed yearly water quality data, compared the forecasted data with the actual measured values and update/calibrate the water quality forecast model
- Updated observations, conclusions and recommendations and produced an updated report

Site Experience

- Australia
- Bermuda
- Canada
- Chile
- Spain
- United States

Computer Applications

- Excel
- Powerpoint
- Word

- Assessed ammonia loading at site
- Project manager for the 2013 to 2015 and 2017 studies.

Process Engineer, Modification to IWTP Plant with the Addition of an MBBR System, Opinaca Mines Ltd, Opinaca, Quebec, Canada (2016)

- Developed the design basis for the modifications to the IWTP plant to add an MBBR system for BOD removal and ammonia nitrification in the process effluent.
- Updated the PFD and P&IDs to implement these modifications.
- Acted as package engineer with the MBBR Technology Provider.
- Multi-disciplinary coordination for the detail engineering of the modifications.
- Technical support during construction.

Pre-Feasibility Study Phase 2 for Mine Expansion, Glencore, Raglan Mines, Quebec, Canada (2015)

- Reviewed scoping study and provided recommendations on the path forward with regard to the management and treatment of surface water at the site based on Phase 2 expansion
- Reviewed current and future site water balance
- Developed treatment strategy based on specific site constraints (arctic location, limited number of operating days during summer, batch operation, etc.).

MSAN Pond System Review, Teck Coal LCO, British Columbia, Canada (2015)

- Conducted site visit to assess existing sedimentation pond and chemical dosing systems
- Provided recommendations to improve treatment performance of surface water runoff at the MSAN pond system
- Provided technical assistance to respond to questions from British Columbia's Ministry of Environment on Teck's proposed TSS correlation methodology.

Water Treatment Technical Assistance to Existing Operation, Bralorne Golds Mines, British Columbia, Canada (2015)

- Reviewed existing arsenic adsorption based water treatment plant of underground mine water and provided recommendations to improve system reliability and treatment performance
- Evaluated conceptually different treatment alternatives for long term operations
- Provided technical assistance to respond to questions from British Columbia's Ministry of Environment on the water treatment system at the site.

Study on Water Treatment Options for Mine Closure, Agnico-Eagle Mines, Meadowbank Site, Nunavut, Canada (2015)

- Project manager for the conceptual evaluation of water treatment options for closure
- Reviewed existing water treatment infrastructure on site
- Defined design criteria for treatment at closure
- Obtained and evaluated budgetary water treatment solutions from Vendors
- Provided order of magnitude CAPEX and OPEX cost.

Subject Matter Expert (SME) Consultant, Subject Matter Expert (SME) Consultant for Wastewater Recycle & Reduction EPICC Project for QG2 and QG3&4, Qatargas Operating Company Ltd, Doha, Qatar (2015)

- Reviewed key engineering documents from the retained Water Treatment Technology Provider to ensure quality and compliance with project requirements
- Reviewed overall treatment process, water/mass balance and proposed design and sizing of treatment equipment. Technologies reviewed include emulsified oil removal system, membrane biological reactors, nut shell and activated carbon filters and reverse osmosis system
- Challenged Technology Provider on key design parameters

› Provided process technical assistance with project team (Qatar Kentz).

Subject Matter Expert (SME) Consultant for Zero Liquid Discharge Project for LR2 Refinery, Qatargas Operating Company Ltd, Doha, Qatar (2015)

› Reviewed and assessed the water treatment process proposed in basic engineering to confirm that it can meet treatment objectives and identify any missing information required for detail engineering
› Identified possible areas of process optimization
› Reviewed the process flow sheets and P&IDs
› Assisted in the development of the water/mass balance
› Technology reviewed: Ultrafiltration membrane system, reverse osmosis system, activated carbon filters.

Lead Process Engineer, Bell Mine, Detail Engineering and Commissioning, HDS Water Treatment Plant, Glencore, Granisle, British Columbia, Canada (2013 - 2015)

› Responsible for the development of process flow diagrams, piping and instrument diagrams, and sizing of all process equipment
› Developed design criteria for the water treatment plant
› Developed technical specifications for the purchasing of equipment for the water treatment plant
› Multi-disciplinary coordination for detailed engineering of the plant.
› Lead the commissioning effort for the HDS water treatment plant following construction and mechanical completion.
› Planned and coordinated with Vendors and other disciplines for the realization of the WTP start-up and operation.
› Operated and optimized treatment performance of the HDS water treatment plant.

Feasibility Study - Iron Ore Mine, Lac Otelnuk Mining Ltd., Nunavik, Quebec, Canada (2014)

› Developed design basis for the water treatment systems required at the mine site for this study; this includes the treatment systems for fresh water, potable water and sewage water
› Reviewed potential sources of effluent that may cause a water quality issue
› Developed treatment solutions and/or water management solutions where required.

Goldcorp Eleonore Gold Mine Project, Opinaca Mines Ltd., Opinaca, Quebec, Canada (2011 - 2014)

› Process engineer for the industrial water treatment plant (IWTP) for the treatment of industrial effluent produced at the new mine site facility and processing plant
› Developed design criteria for the water treatment plant
› Developed of the scope of work and specifications for the industrial water treatment plant
› Provided technical support on the technical document required to obtain the Certificate of Authorization for the water treatment plant
› Multi-disciplinary coordination for the detail engineering of the plant
› Technical support during construction
› Developed operating manual for the IWTP.

Guelb II Iron Enrichment Plant Project, Société Nationale Industrielle et Minière (SNIM), Zouerate, Mauritania, CA $664 643 910 (2010 - 2014)

› Package engineer involved in the EPCM contract to increase the iron ore concentrate production at SNIM's facilities in Mauritania
› Responsible for the following packages: the wet concentration plant, the brackish water treatment plant, the deep well pumps, water storage tanks, fire water pumps, and incinerator
› Reviewed Vendor submittals deliverables
› Multi-disciplinary coordination for the detail engineering of the plant
› Participated in the review of the water consumption at the plant in order to define the needs for brackish and

dessalinated water; technical support during construction.

Feasibility Study for the Niobium Mine Niobec Expansion, Niobec, St-Honore, Quebec, Canada (2013)

- Conceptually reviewed the water treatment systems required for treatment of the mine effluent in the context of the mine expansion project
- Reviewed technologies that could be implemented for the project
- Evaluated order-of-magnitude capital and operating costs.

Conceptual Study of Water Treatment Needs for the Expansion of the Tailings Impoundment at Matagami Mine, Glencore , Matagami, Quebec, Canada (2011)

- Reviewed possible water treatment options based on the different concepts under review for the expansion of the existing tailings impoundments
- Evaluated treatment needs for each concept, and evaluation of an order-of-magnitude cost estimate for each option.

Cobre Las Cruces - Copper Mine, Inmet, Spain (2010)

- Reviewed and updated the water balance of the entire process plant based on its present state.

Potash One Legacy Project Feasibility Study, K+S Potash Canada General Partnership, Regina, Canada (2010)

- Developed the conceptual design for the water treatment processes to produce potable water, process water and boiler feed water from lake water for the new potash processing plant
- Developed the conceptual design for the sewage treatment plant
- Participated in the preparation of technical specifications for preliminary budgetary tenders and the technical evaluation of the budgetary proposal.

Qatalum Project - Service Areas and Potroom Building (SAPB), Qatalum - 50/50-Joint Ownership - Qatar Petroleum (QP) & Hydro Aluminium A.G., Messaieed Industrial City, Qatar, CA $2 000 000 000, 585 000 tpa (2007 - 2009)

- Participated in the conceptual design of the seawater effluent treatment process to treat seawater contaminated with non-oxided SO_2 coming from the aluminum plant's sulfur dioxide scrubbers
- Participated in the detail engineering of the seawater effluent treatment plant. Task included, coordination with other disciplines and with Vendors
- Updated PFD, P&ID, process description, HAZOP report and design reviews
- Participated in the conceptual design of the wastewater treatment plant used to treat effluent from the casthouse, vehichle wash, and other areas in the plant in order to re-use the treated effluent back in the process or for irrigation
- Participated in the detail engineering of the potable water disinfection system, the disinfection and corrosion control of the closed cooling medium, and the electrochlorination system to produce a dilute solution of hypochlorite solution from seawater.

Diavik Diamonds Project - NIWTP Expansion and Water Management Studies, Diavik Diamond Mines Inc, Lac de Gras, Canada (2006 - 2009)

- Coordinated and executed the start-up, commissioning and performance tests of the new water treatment plant expansion (NIWTP) in 2008/2009
- Produced all of the relevant documentation (procedures, operation manual, training material) for the start-up (2008)
- Process engineer during the detail engineering for the North Inlet Water Treatment Plant (NIWTP) expansion project (2007 to 2008)
- Evaluated water treatment technologies to allow for the re-use of effluent process water within the process plant (2007)
- Participated in the commissioning of the existing water treatment plant which was modified in order to double its hydraulic capacity (2007)

› Conducted an in-depth technology review and evaluated cost of treatment processes for the removal of ammonia in water. Evaluated the benefits and drawbacks of each technology relative to the specific application at Lac de Gras (arctic condition) (2006).

Corrective Work After Tailings Dam Failure, Opémiska Mine, Ministry of Natural Resources & Wildlife, Chapais, Canada, CA $2 700 000 (2008)

Corrective work after tailings dam failure, Opémiska Mine in the James Bay territory, Ungava County. Work included water diversion upstream of the polishing pond, Repair of the gullies and channels, plant cover, etc.

› Project Manager for the development of an emergency response plan following the rupture of a tailings dam at the closed Opémiska mine
› Coordinated with different disciplines for the conceptual engineering for the emergency work required.

Gaspé Mines Closure Project, Xstrata Copper Canada - Mines Gaspé, Murdochville, Canada (2006 - 2008)

› Participated in the design of a new water treatment process to treat a neutral mine drainage using sodium hydroxide neutralization
› Evaluated deliverables, budgets and schedule for this project
› Coordinated with other disciplines and technical reviewers
› Provided technical support in the development of a technical document to support the Client's request for a new Certificate of Authorization for the new water treatment plant
› Managed a water sampling campaign at the mine site to qualify the water sources that have not been investigated in the past; developed and provided order of magnitude cost estimates of treatment options for treatment of effluent generated during the demolition work.

Las Cruces Mining Project, Cobre Las Cruces, Spain (2006 - 2007)

› Developed the water treatment process for the production of process water from secondary municipal wastewater
› Responsible for the preparation of specifications and technical documents for a turn-key tender for the supply and installation of a process water treatment plant and reverse osmosis plant; participated in the technical evaluation of the proposals and provided recommendations
› Participated in the evaluation of the water balance and water quality at the plant, as well as in the development of the water management model of the plant.

1998 - 2006 | DEGRÉMONT LTÉE., MONTREAL, QUEBEC, CANADA

Commercial Department
Application Engineer

› 2.2 MLD Drinking Water Treatment Plant Expansion, Lac Etchemin, Quebec, Canada (2005 - 2006)
› 44.5 MLD Drinking Water Treatment Plant Expansion, Gatineau (Aylmer), Quebec, Canada (2004 - 2006):
  – Responsible for the design, equipment selection, cost estimate, coordination with other departments to produce technical proposals
› Treatment of Oily Wastewater Effluent, Montreal, Quebec, Canada (1998 - 2006):
  – Involved in the preliminary design for treatment of oily wasterwater effluent from a casthouse for a new aluminum smelter in Iceland
› Start-up and commissioning of a prototype high-rate DAF, Contrecoeur, Quebec, Canada (2005):
  – Participated in the start-up and commissioning of a prototype high-rate DAF unit for temporary production of clarified water during the renovation work at water treatment plant in Contrecoeur
› Headed the development and standardization of packaged high-rate dissolved air flotation units and dual media gravity filters, Montreal, Quebec, Canada (2005):
  – Produced all of the standard commercial documents (proposal, drawings, estimation)
› New 418 MLD Potable Water Plant for the city of Winnipeg, Winnipeg, Manitoba, Canada (2003 - 2005):

  - Responsible for the design, equipment selection, cost estimate, coordination with others department to produce technical proposals
- Water treatment plant at INCO, Sudbury, Ontario, Canada (2004):
  - Conducted a preliminary study to evaluate options to increase the capacity of the existing process water treatment plant at INCO in Sudbury
- 65.4 MLD municipal wastewater treatment plant, Sydney, Nova Scotia, Canada (2003):
  - Responsible for the design, equipment selection, cost estimate, coordination with others department to produce technical proposals
- Preliminary study, Hydro-Quebec, Quebec, Quebec, Canada (2002):
  - Conducted a preliminary study to replace the existing demineralisation plant with a reverse osmosis system
- Waste water treatment plant, Municipalities of Laval, Beloeil, St-Jean-sur-Richelieur et Gaspé, Quebec, Quebec, Canada (1998 - 1999):
  - Participated in the start-up, commissioning, process optimisation and perform test of municipal wastewater treatment plant.

2000 | IONICS INC., WATERTOWN, MASSACHUSETTS, UNITED STATES

R&D department

Process Engineer

- Participated in the maintenance and operation of an electrodialysis reverse (EDR) unit in Bermuda
- Involved in the site commissioning of a process water treatment plant taking tertiary treated sewage water and making boiler grade feed water in Luggage Point, Brisbane, Australia
- Conducted several pilot studies (Harding Dam, Pilbara, Australia, Stonington, Maine, USA) applying ultrafiltration membrane in the treatment of lake or reservoir water for the production of drinking water.

PROFESSIONAL ASSOCIATIONS

SINCE 2013 | Association of Professional Engineers & Geoscientists, Northwest Territories and Nunavut (NAPEG), Membership no. L2716

SINCE 1999 | Ordre des ingénieurs du Québec (OIQ), Membership no. 122858

PUBLICATIONS AND PRESENTATIONS

Nguyen A.L / Dissolved Air Floatation at High Rise Rates: Results of Pilot Studies in North America, WCWWA 55th Annual Conference and Trade Show, United States, 2003

Nguyen A.L., Duff S.J.B., Sheppard, J.D., « Application of Feedback Control Based on Dissolved Oxygen to a Fixed-Film Sequencing Batch Reactor for the Treatment of Brewery Wastewater », Water Environment Research, Vol. 72, No. 1, 75-83, United States, 2000

GUILLAUME COMEAU, Eng., M.Sc.

Mr. Comeau is an active member of l'Ordre des ingenieurs du Quebec since 2012. He has a bachelor degree in Geological Engineering since 2006 and a Master Degree in Earth Sciences with specialization in Hydrogeology since 2009. He has more than 10 years of experience in various fields of hydrogeology related to water supply, environmental and mining projects. He was involved in the design and implementation of a hydraulic containment system with pumping and injection wells and an in-situ remediation by chemical oxidation of a sandy aquifer. In the mining sector, he has participated to major projects aiming to evaluate groundwater conditions and the pumping requirements for open mines dewatering purpose, and was also involved in the prediction of contaminant migration and potential impacts on receptors in a complex permafrost setting. Those projects were realized in challenging conditions of northern Canada (Nunavut), as well as internationally (Ivory Coast). Lately, he has lead few projects on geothermal applications and was involved in the prefeasibility study for hazardous waste freezing with thermosiphons.

Before joining SNC-Lavalin, Mr. Comeau has lead major regional groundwater resources cartography projects for the Outaouais and Quebec areas. He was involved in multiple hydrogeological and environmental characterization projects of military bases, environmental monitoring of a landfill site and in the supervision of excavation, transport and disposal of contaminated soils.

Having a vast understanding of various hydrogeological contexts, his expertise includes: project management, fieldwork supervision and data interpretation (drilling and well installation, air-soil-water sampling, in-situ hydraulic and pumping tests), database management, spatial and geostatistical analysis with ArcGIS.

SECTORS OF EXPERTISE

Environment	› Environmental Impact Study; Groundwater / Hydrogeology; Water Quality; Site Rehabilitation; Environmental Monitoring; Mining Waste Management
Mining & Metallurgy	› Open pit planning and design; Underground planning and design
Additional Expertise	› Bedrock & Permafrost Hydrogeology; Geothermal and Heat transfert

EDUCATION

2009	M.Sc., Earth Sciences, specialized in Hydrogeology, Université du Quebec, INRS-ETE, Quebec, Canada
2006	B.Eng., Geological Engineering, Universite Laval, Quebec, Canada

EXPERIENCE

SINCE 2013

SNC-LAVALIN INC., QUEBEC CITY, QUEBEC, CANADA

Environment & Geoscience

Hydrogeologist, Project Manager

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Hydrogeological and Geotechnical Investigation for Crown Pillar MR-2017-010KA Design, Glencore Canada, Quebec, Canada, CA $136 000 (11/2017 - present)

Existing underground mine workings are extending down below an inferred ore deposit that would be mined out from the base and up to the surface, close to a lake. The

Years of Experience

› 10 years

Years with SNC-Lavalin

› 5 years

Key Positions

› Engineer - Environment
› Project Manager
› Hydrogeologist

Languages

› English
› French

geotechnical and hydrogeological field investigation would help defining if the lake is connected to the ore body in a talik zone and which pumping rate is expected for mine dewatering. Moreover, geotechnical analysis aim defining at which elevation it is still safe to mine out without bedrock collapsing.

Regional Geothermal Potential mapping of St.Lawrence Lowlands, Natural Sciences and Engineering Research Council of Canada (NSERC), Quebec, Canada, CA $10 000 (06/2017 - present)

In kind collaboration with the University of Quebec (INRS-ETE), the R&D project aims to map the thermal conductivity of St.Lawrence Lowlands with available Thermal Response Test (TRT) data, deep borehole logging and geological maps. SNC-Lavalin was in charge of TRT data gathering and participation to project orientations.

Detailed Engineering Study for in-pit tailings deposition at Meadowbank Mine, Agnico Eagle Mines Ltd, Nunavut, Canada (06/2017 - present)

Following the development of the Whale Tail Pit Project (Amaruq), 28 to 32 Mt of dry-solid tailings could be stored in 3 existing open pits at Meadowbank Mine. The project is located in a complex faulted geological setting with permafrost and talik areas. The objective of the hydrogeological part of this study is to evaluate the potential contaminant transport from in-pit tailings deposits towards nearby lakes, after mine closure. Groundwater Monitoring Network and Plan will be developed.

Hydrogeological study to assess groundwater pumping requirements associated with the excavation and replacement of a municipal sewer, Tonw of Neuville, Quebec, Canada, 24500 (01/2018 - 02/2018)

Long term pumping test using 40 new well points at 7 m depth and observation wells. Groundwater level monitoring in observation wells and points during pumping and recovery, interpretation of test to determine transmissivity and storage, estimation of probable pumping flowrate and drawdown related to drainage of soils to required depth, and recommendations for pumping setup.

Prefeasibility study for the implementation of a cryogenic barrier for hydraulic containment of a hazardous waste materials, Ministry of the Environment of Quebec, Quebec, Canada, CA $34 500 (07/2017 - 03/2018)

R&D project with objective to look at the technical and economic feasibility to freeze hazardous waste material with thermosiphon technology. A field investigation aims to determine in-situ thermal properties of the main material (waste, overburden and bedrock) with a novel Thermal Response Test (TRT). 2D-numerical modeling with SEEP/W and TEMP/W was carrying out to develop a preliminary design and costs estimate for Engineering&Construction and Operation&Maintenance.

Hydrogeological and Hydrological Study for the implementation of snow deposit site, Town of Nicolet, Quebec, Canada, CA $21 000 (11/2017 - 03/2018)

The description and evaluation of groundwater and surface water conditions at this proposed snow deposit site was required to obtain a Certificate of Authorization. Geological setting, aquifer characteristics, groundwater quality, flow direction and velocity, aquifer classification and vulnerability and monitoring program came out of this project.

Site Experience

- Canada
- Ivory Coast

Computer Applications

- Cartography and drawing: ArcGIS, CorelDRAW
- Data analysis: Grapher, Surfer, Strater, Isatis, Aqtesolv, Sswin
- Numerical Modeling: SEEP/W, HELP
- Office: Microsoft Office (incl. Microsoft Access), Endnote

Prefeasibility Study for in-pit tailings deposition at Meadowbank Mine, Agnico Eagle Mines Ltd, Nunavut, Canada, CA $350 000 (06/2017 - 11/2017)

Following the development of the Whale Tail Pit Project (Amaruq), 30 Mt of dry-solid tailings could be stored in 3 existing open pits. This project aims to determine if the storage volume available is sufficient for anticipated and possible future tailings production volumes. A 3D hydrogeological model was developed in a complex geological setting, and was used to identify potential contaminant migration paths seeping out of the pits at mine closure.

Impact Assessment study for the Quebec-Levis Rapid Bus Transit System, Bureau d'etude SRB, Quebec, Canada, CA $4 800 000 (06/2016 - 04/2017)

As part of this linear infrastructure prefeasibility study, the hydrogeologist role in this project was to evaluate the environmental impacts of construction and long term operations of this rapid bus transit system, linking Quebec City and Levis over 43 km, and crossing rivers and creeks.

Groundwater Monitoring Program and Report, Agnico Eagle Mines Ltd, Nunavut, Canada, CA $80 000 (12/2016 - 12/2017)

This project included a review of groundwater sampling practices by field technicians, the review of existing groundwater quality data, the selection of new sampling stations relevant for the understanding of mining operations on groundwater quality. As the main hydrogeologist on this project, my role was to review, at a high level, the results and monitoring program proposed by my colleague.

Trade-off study for the tailings facility extension projet, Agnico Eagle, Meadowbank Division, Nunavut, Canada, CA $135 000 (03/2016 - 08/2016)

A Multi-Account Assessment (MAA) session was conducted to select the best of 3 options to store additional tailings waste from Amaruq (in-pit tailings deposition, internal structures tailings deposition and filtered tailings deposition). Specifically, an hydrogeological conceptual model in a permafrost/talik area was built to outline the environmental risks, consequences, probability and mitigation related to the option of in-pit deposition.

Hydraulic conductivity evaluation at the water retention basin, rue des Tournesols, Ste-Brigitte-de-Laval, City of Becancour, Quebec, Canada, CA $7 000 (07/2016 - 08/2016)

For the design of a municipal water retention, a soil classification and evaluation of its hydraulic conductivity were carry out.

Hydrogeological characterization for the installation of a pump and treat system for the hydraulic containment of a former industrial site contaminated with chlorinated solvents, Confidential client, Canada, CA $1 300 000 (04/2015 - 09/2016)

This project aims to design a pump and treat system with pumping wells for the hydraulic containment of a bedrock and sandy aquifers, contaminated with chlorinated solvents. It also includes the feasibility assessment of water disposal after treatment either by deep injection wells, by infiltration through the near-surface soils, or by discharge to a creek. Field tests (geophysical surveys, pumping tests) and 3D
numerical modeling have been done to support the design.

Feasibility study for deep well water injection in a semi confined aquifer, Hydrological studies, Confidential client, Canada, CA $150 000 (08/2015 - 03/2016)

Due to water discharge restriction to the nearby creek, the feasibility to discharge treated water in 35 meters deep wells have been assess. This project includes design and installation of an injection well in a semi confined aquifer, with the injection test itself.

Technical evaluation of the infiltration rate and solutes leaching beneath the infiltration ponds, Societe des etablissements de plein air du Quebec (SEPAQ), Quebec, Canada, CA $7 000 (10/2015 - 12/2015)

As per the Environment Ministry requirement, an evaluation of the sewage water infiltration rate beneath two infiltration ponds was assessed. Groundwater flow and quality were evaluated for ammonia nitrogen, total phosphorus and ortho-phosphates. Mass flux of those components toward a nearby creek was also estimated.

Feasibility study for the dewatering of three proposed open pits, Ity Mine, La Mancha, Dix-Huit Montagnes, Ivory Coast, CA $294 000 000 (12/2014 - 12/2015)

This project includes a site-wide hydrogeological field investigation for a gold mine and the design of containment dikes, infrastructure and open pits. It included the supervision and interpretation of borehole drilling, well installation, packer test, in-situ permeability and pumping tests. Groundwater flowrate into the proposed pits was estimated and a dewatering strategy was developed for the entire mining period.

Design and implement an in-situ chemical oxidation (ISCO) pilot test for the remediation of a shallow sandy aquifer contaminated with chlorinated solvents, Confidential client, Canada, CA $8 000 000 (10/2013 - 12/2014)

An in-situ remediation pilot test using potassium permanganate has been carry out in a near-surface sandy aquifer, contaminated with chlorinated solvents. Prior remediation, a tracer test with sodium chloride was also performed to evaluate aquifer properties.

2010 - 2013

UNIVERSITE LAVAL – GEOLOGY AND GEOLOGICAL ENGINEERING DEPARTMENT, QUEBEC CITY, QUEBEC, CANADA

Hydrogeologist, Project manager

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Regional groundwater knowledge acquisition and mapping in Outaouais and Quebec regions, Ministry of the Environment of Quebec, Quebec, Canada, CA $2 300 000 (07/2010 - 09/2013)

This mandate includes hydrogeological data collection, database development and management, hydrogeological field tests and regional thematic mapping (e.g.: depth to bedrock, potential aquifer identification, vulnerability, water balance, geothermal potential, etc.). Final hydrogeological maps are now widely use for regional, urban and territorial planning purpose and as a starting tool for small scale hydrogeological studies.

2009 - 2010

AECOM INC., MONTREAL, QUEBEC, CANADA

Junior Hydrogeologist

Groundwater, surface water and air quality monitoring of the landfill site Depot Rive-Nord inc., Groupe EBI, Quebec, Canada (07/2009 - 06/2010)

- Hydrogeological database extractions;
- Environmental monitoring, participation in water and air sampling campaigns, perfoming data interpretation of groundwater and surface water sampling network of 350 stations;
- Supervision of a landfill cell capping along with drilling and well installations;
- Numerical modeling using Seep/W to evaluate the hydraulic conductivity of an existing bentonite slurry containment wall.

Contaminated site rehabilitation prior to LaSalle Ecocenter construction, City of Montreal, Quebec, Canada (08/2009 - 02/2010)

- Database development to manage excavated and disposed contaminated soil;
- Supervision, during winter conditions, of excavation, transport and disposal of more than 50 000 m^3 of petroleum

hydrocarbon, PAH and metal contaminated soil. Sampling control during construction. On-site reuse of thousands of cubic meters of non-contaminated (A-B) soils;
› Co-writing the site remediation report.

Complementary environmental characterization at the Jarry Complex, Hydro-Quebec, Quebec, Canada (10/2009 - 10/2009)

› Drilling inside a garage, soil sampling and monitoring well installation to characterize the soil under the concrete slab.

Geotechnical and environmental characterization for the expansion of the Batshaw Youth Center, Centres of Batshaw Youth and Family, Quebec, Canada (07/2009 - 10/2009)

› Geotechnical drilling supervision and soil sampling with Shelby tube.

Environmental monitoring at the Montreal Trudeau Airport and leakage testing of firefighter's training water reserve at the Mirabel Airport, Montreal Airports, Quebec, Canada (09/2009 - 10/2009)

› Sampling of monitoring wells;
› Conduct variable load permeability tests and piezometric measurements and water balance calculation to determine the water reserve impermeability.

Geotechnical and hydrogeological assessment for the confining wall feasibility study at the TechnoParc, The Jacques-Cartier and Champlain Bridges Inc., Montreal, Quebec, Canada (08/2009 - 10/2009)

› Supervision of drilling and well installations, stratigraphic description of soil and heterogeneous fill material and completion and interpretation of constant head permeability tests.

Environmental characterization of soil and groundwater in the vicinity of underground heating oil tanks for the environmental inventory plan of Lester-B.-Pearson School Board schools, Lester-B.-Pearson School Board schools, Quebec, Canada (08/2009 - 10/2009)

› Supervision of drilling, well installations and groundwater sampling.

Construction of Turcot overpass, Ministry of Transport of Quebec, Quebec, Canada (05/2010)

› Interpretation of 15 hydraulic tests interpretation having engineering implications for the overpass foundations.

Characterization of soil contamination following a fire, City of Montreal, Quebec, Canada (04/2010)

› Review of the spread of fire to develop a characterization plan, to carry out sampling of surface soil and to assess the PAH, metals and dioxins & furans contamination.

Geotechnical investigation after instability of the Cats Stairway, Parliament Hill, Public Works and Government Services Canada (PWGSC), Ontario, Canada (09/2009)

› Supervision of 20 geotechnical drilling in challenging location due to a very steep site. Rock Quality Designation (RQD).

2004 - 2009 | INSTITUT NATIONAL DE LA RECHERCHE SCIENTIFIQUE - EAU, TERRE ET ENVIRONNEMENT (INRS-ETE), QUEBEC CITY, QUEBEC, CANADA
Research Assistant – Hydrogeology (part-time)

Environmental and hydrogeological characterization of five Canadian Forces Bases, National Defence Canada, Alberta, Saskatchewan, Ontario, New-Brunswick, Canada (2004 - 2009)

- Participation to fieldworks, data analysis and technical report writing in order to assess soil, groundwater and surface water contamination related to military training and ammunitions compounds (TNT, RDX, HMX, heavy metals), propellants (perchlorate and nitroglycerin) and defoliants (dioxins and furans);
- Drilling work supervision and installation of piezometers, soil and groundwater sampling, piezometric surveys, slug test;
- Piezometric surface interpolation with advanced geostatistical analysis (cokriging) using ISATIS software. Developing data validation and workflow procedures for statistical data treatment before kriging.

Carbon monoxide production and propagation assessment following urban blasting operations, Institut de recherche Robert-Sauve en sante et en securite du travail (IRSST), Quebec, Canada (09/2008 - 12/2008)

- Evaluation of hydraulic properties in the unsaturated fracturated bedrock with pumping tests and mini-piezometer monitoring network, using pressure transducers and CR10X acquisition system. Monitored carbon monoxide and air pressure through blast-induced and natural bedrock fractures, within the adjacent building. Analysis of CO migration pathways;
- Participation to the report writing including eleven recommendations to prevent carbon monoxide poisoning cases of surrounding residents and workers during urban blasting operations.

Characterization of groundwater and soil potential contamination and its health implications by ammunition compounds (TNT, RDX, HMX, heavy metals), propellants (perchlorate and nitroglycerin) and defoliants (dioxins and furans) for a post-war zone in Quang Tri province, Vietnam, Ministry of International Relations of Quebec, Quang Tri, Viet Nam (09/2006 - 09/2007)

- Research plan elaboration including literature review of bombing areas and defoliants spreading during Vietnam War to identify the worst case contamination area. Preparation of the project description for funding.

PROFESSIONAL ASSOCIATIONS

SINCE 2016	International Association of Hydrogeologists (IAH), Membership no. 137290
SINCE 2012	Ordre des ingénieurs du Québec (OIQ), Membership no. 5007597

PROFESSIONAL DEVELOPMENT

2017	Heat transfer processes applied to Earth Sciences, University of Quebec (INRS-ETE), Quebec, Canada
2017	Northern Quebec: Issues, Spaces and Cultures, Institut nordique du Quebec (INQ), Quebec, Canada
2016	Workplace Hazardous Materials Information System (WHMIS), SNC-Lavalin inc., Quebec, Canada
2015	Characterization and Remediation in Fractured Rock Environments, ERSDP & ESTCP, United States
2015	Introduction to chemical reduction and bioremediation of chlorinated and recalcitrant compounds, EOS Remediation, United States
2014	Groundwater statistics for environmental project managers, United Stated Environmental Protection Agency (U.S. EPA), United States
2014	In situ chemical oxidation of contaminated soil and groundwater, United States Environmental Protection Agency (U.S. EPA), United States

2014	Frequently-asked questions about monitored natural attenuation in groundwater, United States Environmental Protection Agency (U.S. EPA), United States
2014	Groundwater statistics and monitoring compliance, statistical tools for the project life cycle, United States Environmental Protection Agency (U.S. EPA), United States
2014	Integrated DNAPL site strategy, United States Environmental Protection Agency (U.S. EPA), United States
2014	Transportation of dangerous goods (TDG), Santinel inc., Quebec, Canada
2014	Cardiopulmonary resuscitation (CPR) and Automated external defibrillator (AED), St. John Ambulance, Quebec, Canada
2012	Team Management, Humana Conseil, Quebec, Canada
2009	Health and Safety on construction sites, Ecole des metiers de la construction de Montreal, Quebec, Canada

PUBLICATIONS AND PRESENTATIONS

Tremblay Y., Lemieux J.-M., Fortier R., Molson J., Therrien R., Therrien P., Comeau G., Talbot Poulin M.C. Semi-automated filtering of data outliers to improve spatial analysis of piezometric data. Hydrogeology Journal, 23(5): 851-868. DOI: 10.1007/s10040-015-1257-y., United States, 2015

Talbot Poulin, M.C., Comeau, G., Tremblay, Y., Therrien, R., Nadeau, M.M., Lemieux, J.M., Molson, J., Fortier, R., Therrien, P., Lamarche, L., Donati-Daoust, F., Bérubé, S. Projet d'acquisition de connaissances sur les eaux souterraines sur le territoire de la Communauté métropolitaine de Québec (PACES-CMQ) - Rapport final, Canada, 2013

Comeau, G., Talbot Poulin, M.C., Tremblay, Y., Ayotte, S., Molson, J., Lemieux, J.M., Montcoudiol, N., Therrien, R., Fortier, R., Therrien, P., Fabien-Ouellet, G. (2013). Projet d'acquisition de connaissances sur les eaux souterraines en Outaouais, Rapport final. Département de géologie et de génie géologique, Université Laval, décembre 2013, 148 p., Quebec, Canada, 2013

Martel, R., Comeau, G., Trépanier, L., Parent, G., Lévesque, B. Évaluation de la production et de la propagation du monoxyde de carbone suite à des travaux de dynamitage en milieu urbain. Rapport R-551, 50 p., Québec, Canada, 2008

Comeau, G., Martel, R., Brochu, S., Hewitt, A.D. Chapter 9: Propellant residues in surface soils and groundwater at firing positions, Canadian Force Base Petawawa, Ontario. In Jenkins et al (eds) Characterization and Fate of Gun and Rocket Propellant Residues on Testing and Training Ranges Final Report, U.S. Army Engineer Research and Development Center (ERDC)., United States, 2008

COMMITTEES

SINCE 2010	Réseau québécois sur les eaux souterraines (RQES), Quebec, Canada
2013 - 2014	Engineer Without Borders Quebec (EWB-Quebec), Volonteer, Quebec, Canada