Jonathan Fennell, M.Sc., Ph.D., P.Geol.
Hydrogeology | Geochemistry | Water Resources

Resume

SUMMARY

Dr. Jon Fennell has been a practicing consultant in the natural resource sector for over 30 years. His expertise includes the analysis and development of local and regional-scale groundwater systems, mine assessments and dewatering strategies, water supply and disposal systems, groundwater-surface water interaction assessments, implementation of monitoring and management systems, and environmental forensics including: i) remote sensing, ii) application of geophysical methods, iii) geochemical assessment & modelling, and iv) the application of stable and radiogenic isotopes to support source water tracing, chemical fingerprinting, and age-dating. He has also been involved in a number pf projects requiring expertise in climate variability and climate change assessment, including the role major tele-connections and the development of sustainable adaptation strategies. The bulk of Jon's experience is associated with various oil & gas and mineral resource development projects in Canada and abroad. Over the last decade, Jon has worked closely the Alberta Government through various initiatives to support the Water for Life Strategy and cumulative effects management in the province. A primary area of focus is developing management processes to ensure water security, and communicating the importance of data, information and knowledge as it applies to responsible development.

POSITIONS HELD

2019 to Present	Program support, Expert-in-Residence – SAIT Integrated Water Management Program
2018 to Present	Technical Advisory Committee – Oil Sands Monitoring program (Joint Alberta Environment and Parks/Environment and Climate Change Canada)
2013 to 2017	Department of Renewable Resources, University of Alberta (Adjunct position) Department of Geography, University of Lethbridge (Adjunct position)
2012 to Present	Vice President, Advisory Services (Water Security and Climate Resiliency), Principal Hydrogeologist, Geochemist, and Technical Lead) – Integrated Sustainability, Calgary
2007 to 2012	Director, Water Resources (Canada) – WorleyParsons, Calgary
2005 to 2007	Vice President, Water Resources and Principal Hydrogeologist – WorleyParsons Komex, Calgary
2003 to 2006	Member of the Canadian Management Team – Komex International Ltd., Calgary
2003 to 2007	Group Leader – Komex International Ltd., Calgary
1990 to 2005	Senior Hydrogeologist – Komex International Ltd., Calgary
1985 to 1990	Petroleum Geologist – Industry Consultant, Calgary

EXPERIENCE

Mining

Alberta Environment and Parks

Preparation of oil sands tailings pond seepage review report. Responsibilities included:

- Review of background information pertaining to oil sands produced water (OSPW) seepage research and natural bedrock groundwater discharge studies
- Review of industry-submitted EPEA compliance reports to assess current "state of affairs" regarding monitoring and OSPW detections
- Assessment of seepage management systems
- Review of geological pathways for OSPW migration
- Development of seepage risk profiles for all active tailings ponds

Alberta Environment and Parks

Provision of external expert review for the Implementation Directive for the Surface Water Body Aggregate Policy (SWBAP) for gravel mining in floodplain areas. Responsibilities include:

- Review of relevant Government of Alberta documents relating to aggregate mining in or near surface water bodies and/or floodplain environments
- Use of information from relevant policies in other jurisdictions as well as studies and research (aquatic, terrestrial, river morphology, climate risk) regarding impacts of aggregate mining in floodplain areas
- Identification of gaps regarding goals and objectives of the approval and management process
- Review of risk assessment approach to approving aggregate mines near surface water bodies, and provision of recommendations for monitoring, evaluating and reporting
- Interaction with AEP project team members and presentation of results

Blackbird Mine, Idaho, USA

Completion of a hydrogeological baseline study and associated stable isotope investigation ($\delta^{34}S$, $\delta^{18}O$, and $\delta^{2}H$) to determine the source of acid mine drainage near active underground workings. Responsibilities included:

- Review of existing geochemical data and related mineral equilibria conditions (i.e. baseline and impacted)
- Assessment of geochemical reactions leading to acid mine drainage conditions, including biogeochemical aspects.

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of a tailing pond seepage risk assessment and preparation of a peer-review journal manuscript to place suspected oil sands impacts into perspective. Responsibilities included:

- Review of individual tailings ponds established at the various operating oil sands mines in the Athabasca Oil Sands region

- Application of source-pathway-receptor model in relation to calculated groundwater flow velocities, stand-off distances from receptors, and natural attenuation properties to assess risk associated with each structure
- Preparation of manuscript to place into context natural discharge of low-quality groundwater from bedrock formation versus oil sands seepage

Graymont Western US Inc.

Preliminary development of a mine dewatering and water management strategy for a large limestone quarry located in the eastern from ranges of the Rocky Mountains. Responsibilities included:

- Assessment of baseline hydrogeological and hydrogeochemical conditions in a mountain environment
- Source water fingerprinting and groundwater age-dating
- Fracture and lineament analysis using structural geology and geophysical analysis (GPR, borehole tele-viewer)
- GW-SW interaction assessment (i.e., Bow River)
- Conceptualization of dewatering strategy utilizing oriented and horizontal well technology
- Issues identification and risk analysis

Imperial Oil Ventures Ltd.

Conceptual model design for dewatering scheme in support of mine development. Responsibilities included:

- Assessment of geological conditions
- Boundary assessment
- Parameter selection and optimization
- Assessment of model results

JDS Energy & Mining

Review of mine dewatering and water treatment & disposal strategy for gold mine in Guatemala. Preparation of proposed strategy to assess mitigation strategies (e.g. back pressure system) for hot water up to 160°C entering mine and flashing upon dewatering and subsurface disposal of arsenic-laden mine waters (including transport, fate, and risk assessment).

Suncor Energy

Preparation of an AB Environment approved Groundwater Management Plan at a large oil sands mining operation. Activities included:

- The design of a cost-effective sampling schedule including rationalization of over 300 wells to establish a meaningful monitoring network of 150 wells

- Development of statistically established trigger values for response and mitigation
- Liaison with Government of Alberta during review and approval

Suncor Energy

Various projects:

- D51 disposal monitoring at the Firebag Thermal In Situ Project
- Thermal mobilization assessment
- Preparation of an oil sands mining closure strategy outlining goals, objectives, tasks, timelines, and consulting and research agencies to execute in support of Life of Mine Closure and Reclamation process
- Assistance with Fort Hills Operational Plan regarding preservation of McClelland Lake and wetland complex; review of physical hydrogeology and geochemical setting; assessment of numerical model design and output; review of cut-of wall design and mitigation system; review of adaptive management processes
- Review of Devonian – McMurray interactions at the North Steepbank mine expansion and assistance with investigation program design (including geochemical assessment)
- Completion of geophysical and porewater surveys on the Athabasca and Steepbank Rivers to determine contributions of natural discharge versus industry inputs

Syncrude Canada

Participation on expert hydrogeology panel to review Devonian investigation program for Aurora mine and assess mitigation strategies to control high risk areas (Les Gray - UBC, Carl Mendoza, - UofA, Ken Baxter - Golder, Jon Fennell - WP). Responsibilities included:

- Review of existing baseline data for active mining site
- Identification of high-risk areas to consider for future investigation and monitoring
- Participation in group workshop settings to communicate findings and accumulate input for recommendations refinement
- Participation in internal panel meetings to discuss concepts and develop final recommendation

Talisker Resources Ltd.

Review of mine water balance, dewatering strategy, impact analysis and Arsenic source-tracing (Bralorne Mine, BC) to develop mitigation system for cost-efficient water treatment (including upset conditions of higher flow rates).

Teck Resources Limited

Evaluation of stream response to groundwater interception in support of fisheries habitat offsetting at Line Creek Mine, BC. Responsibilities included:

- Baseline reconnaissance of Line Creek alluvial system and GW-SW water interactions with Line Creek

- Assessment of area springs, shallow groundwater, and creeks to determine geochemical quality and flow conditions (using drive point well technology and data logger systems)
- Completion of ground penetrating radar survey to map thickness and morphology of alluvial deposits
- Water quality fingerprinting using major ion, trace elements (in particular selenium) and stable isotopes to determine interaction of groundwater environment with Line Creek

Assessment of selenium mobilization conditions related to active mine workings and development of a conceptual (passive) mitigation strategy to offset impacts to fisheries habitat

Total E&P

Support for mine dewatering strategy. Responsibilities included:

- Development of baseline hydrogeology
- Liaison with project team and governing agencies
- Joint Panel hearing support
- Selection and phasing of depressurization wells and associated monitoring wells
- Review of deep well injection potential, including geochemical compatibilities of waters
- Development of a performance monitoring system
- Selection of pipeline route
- Preparation of a design-based memorandum with related costs of implementation and long-term operation

Geochemistry

Amoco Canada

Completion of a stable isotope study using $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$ to determine the source of anomalous groundwater sulphate concentrations (natural vs. anthropogenic)

Canadian Occidental

Completion of a stable isotope studies to determine the source of sulphate impact from two large sour gas processing facilities (Balzac and Okotoks). Responsibilities included:

- Drilling, installation, and testing of monitoring wells
- Development of a conceptual site model
- Review of site-wide geochemistry (soil and groundwater)
- Application of $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C$ isotopes to resolve natural versus anthropogenic influences

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of regional geochemical assessments in NE Alberta (35,000 km^2 area) supporting the Regional Water Management Initiative. Responsibilities included:

- Collation of regional geological, hydrogeological, and geochemical data using public domain and industry information
- Assessment and interpretation of hydrogeological setting and of conceptual models
- Assessment of traditional and isotope geochemistry to determine source water chemistry to define flow path phenomena areas of aquifer interactions
- Statistical analysis of data to determine groupings and associations (PCA analysis)
- Documentation and presentation of results at various public venues

Cumulative Environmental Management Association (CEMA) and Alberta Environment (AENV)

Assessment of baseline hydrological and hydrogeological conditions and development of a regional-scale groundwater quality monitoring network (18 000 km^2 study area) located in the Athabasca Oil Sands Region of northeast Alberta. Responsibilities included:

- Refinement of conceptual hydrogeological model
- Groundwater-surface water interaction assessment
- Assessment of quality conditions and trends (including statistical analysis)
- Knowledge and data gap analysis
- Pathway identification and vulnerability assessment for sensitive receptors
- Field reconnaissance and well selection
- Isotope interpretation ($\delta^{18}O$, $\delta^{2}H$, $\delta^{13}C$, Carbon-14)
- Groundwater hydrograph analysis
- Report preparation and presentation
- Liaison with government and industry representatives

Department of Environment and Resource Management, Queensland, Australia

Lead for a hydrogeochemical assessment and water fingerprinting exercise in Great Artesian Basin aquifers of the Surat and Bowen basins to support Coal Seam Gas development and cumulative effects analysis. Responsibilities included:

- A comprehensive data and information inventory to facilitate source water fingerprinting and collation of large public-domain data sets to provide a first-of-its-kind database of water quality information
- Review of major ions, metals and trace elements, stable and radiogenic isotopes and dissolved gases to identify recharge phenomenon, cross-formational flow characteristics and distinct water types
- Statistical analysis to assess data groupings and spatial trends

East Calgary, AB

Detailed assessment of hydrogeological and hydrochemical conditions in the vicinity of residential water wells to identify locally used aquifers, variation in water quality, groundwater availability and the potential of impact from nearby sour gas production wells.

Government of Yemen

Hydrogeological and geochemical support for a regional-scale study of water supply potential in the country. Responsibilities included:

- Hydrogeological and hydrogeochemical facies mapping,
- Geochemical assessment and flow path evolution modelling,
- Groundwater flow field assessment and modelling,
- Sustainable yield evaluation
- Groundwater tracing & age dating (trace elements; stable and radiogenic isotopes)

Imperial Oil

Completion of field and bench-scale tests to determine facilitated mobility of metals, trace elements, and dissolved organics resulting from artificial ground heating around thermal in situ wells. Responsibilities included:

- Tracer experiment to determine groundwater flow velocities in a deep (>80 m) confined aquifer. Responsibilities have included:
- Drilling, installation, testing, and sampling (soil and water) from 22 deep (up to 90 m) monitoring wells at a newly established thermal in situ pad to determine baseline geochemistry and groundwater flow directions
- Completion of a tracer test (deuterated water) to determine groundwater flow velocities
- Collection of sediment samples (under anoxic conditions) for bench-scale heating experiments to determine metals mobility and related kinetics
- Review of stable isotopes in groundwater and dissolved gases to determine effects of heating from in-situ thermal wells on local geochemical conditions (inorganic and organic constituents)
- Reaction path modelling to determine processes influencing changes metals concentrations and biological activity resulting from subsurface heating
- Determination of activation energies for metals release, and the role of biogeochemical reactions in facilitating metals release
- Transport and fate modelling to determine the long-term risk of thermal mobilization of metals (and other related constituents) to the surrounding environment
- Documentation of result and liaison with client and regulatory agencies

Imperial Oil Resources

Completion of numerous isotope studies using to determine groundwater flow rates in regional confined aquifers and the source of anomalous groundwater quality conditions and dissolved gas concentrations near a large heavy oil recovery operation using:

- Assessment of $\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ and $\delta^{13}C$
- Tritium and Carbon-14 for groundwater age-dating

Imperial Oil Resources

Tritium age dating of groundwater in Norman Wells, NWT to determine vertical groundwater flow characteristics in discontinuous permafrost environment

Mobil Oil Canada

Completion of a stable isotope study to determine the source of sulphate impact from a large sour gas processing facility. Responsibilities included:

- Drilling and installation of monitoring wells
- Development of a conceptual site model
- Review of site-wide geochemistry (soil and groundwater)
- Application of $\delta^{34}S$, $\delta^{18}O$, $\delta^{2}H$, and $\delta^{13}C$ isotopes to resolve natural versus anthropogenic influences

Nexen ULC

Design and completion of bench-scale testing to determine the mobilization of metals and trace elements under applied heating. Responsibilities included:

- Conceptual design of experimental process in collaboration with AGAT lab representatives
- Assessment of frozen core samples and selection of appropriate intervals for physical (grain size, mineralogy via XRD) and chemical testing (total metals, leachable metals)
- Assessment of results from sequential batch heating experiments extending from 5-100°C for metals species released to solution
- Geochemical modelling of kinetic experiment results to determine activation energies of metals release
- Completion of attenuation experiments to determine potential for mobilized metals to re-associated with sediments under cooled conditions
- Preparation of a summary report and presentations to the client in support of AER interactions

Suncor Energy

Development of an Athabasca River reconnaissance program to identify and sample natural groundwater-surface water interaction zones discharging waters from the Cretaceous and Devonian formations. Responsibilities included:

- Planning/execution and interpretation of a marine-based geophysical program using EM31 imaging and bathymetric readings

- Development of pore water sampling program including geochemical assessment of waters and source fingerprinting (major ion, trace element, dissolved organics and stable and radiogenic isotopes)
- Interpretation of results and presentation at various venues (government, industry)

Suncor Energy

Groundwater age-dating and source area identification in support of active tailings pond seepage investigations. Responsibilities included:

- Conceptual site model design
- Review of traditional geochemistry to determine end-point water types
- Application of Tritium, $\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ to resolve geochemical setting and potential areas of seepage

Climate change (International)

Canadian International Development Agency, Catamayo, Ecuador SA

Completion of a baseline soil and groundwater study (physical and chemical) to determine the feasibility of siting an engineered wastewater impoundment for the treatment of municipal sewage treatment (project funded by CIDA). Responsibilities included:

- General site reconnaissance
- Collection of soil and groundwater samples for baseline geochemical quality assessment
- Review of watershed conditions and processes relating to baseline hydrology and hydrogeology
- Assessment of climate aspects to regarding timing and magnitude of river flows, implications of changing conditions and influence of climate cycles
- Submission of recommendations on the suitability of the proposed location and possible approaches to rectify existing limitations

Department of Environment and Resource Management, Queensland, Australia

Lead for water security assessment to assess groundwater and groundwater-dependent ecosystem risks from Coal Seam Gas development in southeast Queensland. Responsibilities included:

- Development of a multi-criteria weighting and ranking system linked with GIS to display areas of highest risk to drawdown including areas users and groundwater dependent ecosystems
- Assessment of major climate modes influencing regional water balances (ENSO, SOI)
- Facilitation of industry and government workshops to present and vet results

Department of Environment and Resource Management, Queensland, Australia

Lead for an aquifer vulnerability assessment to assess groundwater and groundwater-dependent ecosystem risks from Coal Seam Gas development in southeast Queensland. Responsibilities included:

- Development of a multi-criteria weighting and ranking system linked with GIS to display areas of highest risk to drawdown including areas users and groundwater dependent ecosystems
- Facilitation of industry and government workshops to present and vet results

Mexican Soda and Water Company, Monterrey Mexico

Lead for a groundwater evaluation project to supplement beverage making operations a large manufacturing plant in the city of Monterrey. Responsibilities included:

- Review of background geological, hydrogeological and geochemical information across a large study area centered on the Monterrey Metropolitan Area
- Assessment of structural fabric of study area including presence of major folds, faults, and other features (e.g. karst)
- Amalgamation of background data with result from Quantum Geoelectrophysics reconnaissance program to identify prospective drilling targets
- Completion of a 4C report (compare, contrast, correlate, confirm) and selection of prime drilling target for testing and evaluation

Origin Energy, Queensland, Australia

Water resources technical lead for a large-scale coal seam gas project (up to 10,000 wells) located in the headwaters of the Murray-Darling Basin and recharge area for the Great Artesian Basin. Responsibilities included:

- Development of a regional-scale groundwater monitoring system using vulnerability and risk mapping
- Design of a hydrogeological model covering a 173 000 km^2 area (using FEFLOW) to assess groundwater -surface water impacts and cumulative effects from coal seam gas development
- Incorporation of climate variability and climate change aspects to the model conceptualization to forecast natural changes and implication for project effects
- Completion of supporting Technical Report (including risk mapping, injection feasibility, model development) and Environmental Impact Statement chapter
- Liaison with the Queensland Department of Environment and Natural Resources to address needs for the required Environmental Impact Assessment

United Nations, Joint Caribbean Climate Change Partnership

Technical lead for the development of UNFCCC-sanctioned National Adaptation Plans for the countries of Guyana and Belize, with the goal of addressing multi-sector impacts from future climate change. Responsibilities include:

- Review of existing policies and studies supporting climate change adaptation
- Assessment of current adaptation plans for major economic, social, and environmental sectors
- Incorporation of IPCC (Global Climate Models) and PRECIS (Regional Climate Models) output under various RCP scenarios
- Delivery of facilitated in-country workshops for various Ministries
- Provision of recommendations to address gaps identified in current plans
- Liaison with government officials and UNDP organizers
- Completion of climate change risk assessment and options analysis to identify high-value actions
- Preparation of capacity-building plan and 10-yr strategic plan
- Risk and vulnerability assessment (including spatial aspects under various climate change scenarios – SRES and RCP)

Climate change (domestic)

Alberta Environment and Parks (AEP)

Provision of external expert review for the Implementation Directive for the Surface Water Body Aggregate Policy (SWBAP). Responsibilities include:

- Review of relevant Government of Alberta documents relating to aggregate mining in or near surface water bodies and/or floodplain environments
- Use of information from relevant policies in other jurisdictions as well as studies and research (aquatic, terrestrial, river morphology, climate risk) regarding impacts of aggregate mining in floodplain areas
- Incorporation of climate variability (ENSO, PDO) and climate change aspects to define risk to river flow characteristics as a result of future changes to temperature and precipitation regimes
- Identification of gaps regarding goals and objectives of the approval and management process
- Review of risk assessment approach to approving aggregate mines near surface water bodies, and provision of recommendations for monitoring, evaluating and reporting
- Interaction with AEP project team members and presentation of results

Alberta Innovates (AI)

Provision of water resources services for the University of Alberta led study into:

- Resolving human versus Industrial Influences on the water quality of the Lower Athabasca River
    - data synthesis

  - geophysical and geochemical assessment
  - isotope geochemistry source water fingerprinting
  - GW-SW interaction – identification and flux
  - climate implications to river flows
- Predicting Alberta's Water Future (complete estimates of groundwater recharge to Alberta's 2200 sub-basins
  - determining groundwater use projections by major sector to 2050
  - assessing baseflow contributions and groundwater stress area based on analytic element model outputs
  - projected changes to provincial water supplies based on population growth, energy extraction, food production, and land use
  - assessment of climate variability and change on provincial water balance
  - coordinate results with climate change model outputs and SWAT model outputs to generate preliminary Water Risk map for the province.

Alberta Water Research Institute (AWRI)

Completion of an inventory of Alberta's water and its associated dynamics (natural and human-induced). Responsibilities included:

- The development of a partnership model including participants from Universities and Institutes in Beijing, Switzerland, Edmonton, Calgary and Lethbridge
- Completion of a complete inventory of surface water, groundwater and fossil water (glaciers and deep groundwater) to identify current and future risks to water supplies in the province
- Assessment of climate variability and change implications to provincial groundwater water resources

Apache Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Smoky Lake. Responsibilities included:

- Assessment of Smoke Lake watershed and water supply potential
- Water supply modelling to determine availability and reliability of lake water
- Review of historical flow data and determination of suitable IFN at outlet (i.e. Q80)
- Review of terrestrial, fisheries and water quality data to support water diversion strategy
- Assessment of climate variability and climate change as they apply to water availability and reliability
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representative

Apache Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Smoke Lake. Responsibilities included:

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- Assessment of climate variability and climate change as they apply to water availability and reliability
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representative

Bellatrix Exploration Ltd.

Completion of a Water Sourcing study for Rocky Mountain asset. Responsibilities included:

- Review of existing and potential water sourcing options
- Assessment of climate change considerations in ensuring water security
- Development MCA and of GIS tool to assess and map high-value water opportunities
- Completion of a water security plan

Butte Action Committee

Preparation for, and participation in, AEP-led Surface Water Body Aggregate Policy 2017 stakeholder review workshops. Responsibilities included:

- Consultation with stakeholder group
- Review of AEP materials in advance of Airdrie workshop (AEP policies, guides, codes, risk assessment framework)
- Review of other Canadian and International policies and guides to aggregate mining near water bodies
- Review of impact studies related to aggregate mine development near surface water bodies (erosion, pit capture, infrastructure risk, fisheries and riparian area impacts)
- Assessment of climate change implications for streamflow timing and magnitude, as well as intensity, duration, and frequency of storms and related runoff, on 1:100 levels
- Documentation of questions to AEP for clarification and response to AEP questions re: climate change implications

Devon Canada

Completion of detailed studies to define baseline hydrogeological and hydrological conditions in support of a coalbed methane project in the Crowsnest Region of the eastern Rocky Mountains. Responsibilities included:

- Completion of detailed field reconnaissance program
- Establishment of a spring and water well monitoring network
- Investigation of surface water/groundwater interactions

- Review of climate variability and climate change implications for water availability and reliability
- Development of a conceptual water balance model in a mountainous area using geological and geochemical data
- Groundwater age dating of regional confined aquifers using radioactive isotopes (i.e. Tritium and Chlorine-36)
- Public and regulatory liaison

Enerplus

Completion of a Water Security Plan for the Western Canadian assets. Responsibilities included:

- Review of asset operations and water management process
- Assessment of basin water risk conditions and current mitigations in place (including climate variability and climate change)
- Source water and disposal opportunity assessment
- Development of MCA process to rank water risk profile of each asset and provide recommendations for mitigation

Hammerhead Resources

Completion of watershed analysis, flood assessment and intake siting in support of a Water Act Application on the Smoky River. Responsibilities included:

- Assessment of Smoky River watershed and water supply potential
- Review of historical flow data and assessment of Q80 and Q95
- Review of climate variability implications for river flow characteristics
- Flood assessment to determine 1:10 and 1:25 year event levels
- Review of fisheries and bank stability assessment in support of intake siting
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representatives

Husky Oil Operations Ltd.

Completion of a water security plan for the Ansell asset, west-central Alberta. Responsibilities included:

- Review of project water profile and future requirements for hydraulic fracturing
- Assessment of water security in relation to changing climatic conditions
- Facilitation of risk review workshop
- Review of water source opportunities and development of MCA opportunity ranking process

Lakeland Industry and Community Association (LICA)

Assessment of the current health of two large watersheds (covering over 8500 km^2) in response to changing climatic conditions, land use practices, and increased pressure on

water resources (surface water and groundwater) by agricultural and industrial users. Responsibilities included:

- The assessment of historical multispectral satellite imagery
- Review of stream and groundwater hydrograph data
- Assessment of effects of climate tele-connections (ENSO, PDS) on basin hydrology
- Review of temporal groundwater and lake dynamics in response to changing conditions

Nexen ULC

Development of a water strategy to service the Aurora LNG project/Dilly Creek asset. Responsibilities included:

- Assessment of development trajectory with respect to water use
- Identification of feasible water supply source to accommodate up to 6.5 million m^3 per year of water
- Review of climate variability and climate change implications for water availability and reliability
- Conceptualization of water storage strategy to reduce pressure on local water sources and minimize physical footprint of development
- Development of a water conveyance strategy utilizing existing rights of way, including Class 5 cost estimation
- Liaison with Fort Nelson first Nations to facilitate development of baseline hydrology monitoring program and facilitation of a Section 10 water licence (following successful EAB appeal of previous licence)

Red Deer River Watershed Alliance (RDWA)

Assistance with development of an Integrated Watershed Management Plan to address future development in the basin. Responsibilities included:

- Groundwater inventory
- Water use patterns
- Effects of land use and climate variability and climate change on basin water balance and storage conditions
- Water quality conditions
- Risk and vulnerability assessment
- Development of beneficial management practices
- Development of a conceptual monitoring system to achieve plan goals and objectives

Shell Canada

Completion of watershed analysis and intake siting in support of a Water Act Application on Iosegun Lake. Responsibilities included:

- Assessment of Iosegun Lake watershed and water supply potential
- Water supply modelling to determine availability and reliability of supply

- Review of historical flow data and determination of suitable IFN at outlet (i.e. Q80)
- Assessment of climate variability and climate change as they apply to water availability and reliability
- Review of terrestrial, fisheries and water quality data to support water diversion strategy
- Development of proposed monitoring and response plan
- Liaison with AEP and AER representatives

Shell Canada

Support for Carmon Creek EIA and assessment of brackish water supply potential in support of heavy oil operations in the Peace River area. Responsibilities included:

- Assessment of baseline hydrogeological conditions and potential impacts from project development
- Preparation of climate change assessment for project development
- Support for SIR submissions and EIA team interactions
- Feasibility assessment of potential for deep formations to produce sustained supplies and conceptual well-field development
- Liaison with regulatory agencies
- Development of a DBM level review for a groundwater well-field development

South McDougall Flats Protection Society

Review of proposed re-zoning for aggregate mine development in historic floodplain of Little Red Deer River in Sundre, AB. Responsibilities included:

  - Review of proposed gravel pit re-zoning area
- Air photo assessment and delineation of paleo-floodplain
- Assessment of climate variability and climate changes aspects regarding river flow conditions (flood and low flow)
- Preparation of workshop materials
- Presentation at public forum re: pros and cons of gravel mining (including policy framework review)
- Support for Town Council hearing

Town of Okotoks, AB

Assistance with review of development applications and support for ensuring water security through conjunctive use strategies. Responsibilities included:

- Expert review of development applications assessing cumulative drawdown effects and provision of recommendations to manage effects
- Engagement with Town official on development of a sustainable water management strategy
- Assessment of climate variability and climate change considerations as they relate to water security

- Provision of support for AENV and Environmental Appeal Board process

Town of Okotoks

Completion of a pre-feasibility study to assess aquifer storage and recovery (ASR) and managed aquifer recharge (MAR) as a solution to water supply challenges. Responsibilities included:

- Review of regulatory setting and constraints for ASR and MAR (Canada and international jurisdictions).
- Review of ASR and MAR projects world-wide
- Assessment of local geological and hydrogeological conditions and identification of potential areas to facilitate ASR and MAR success
- Modelling to determine optimal placement of MAR system to enhance baseflow conditions
- GW-SW interaction assessment & climate impact assessment
- Preparation and presentation of pre-feasibility summary to Town Council and Mayor

Town of High River, AB

Lead for the development of a Water Sustainability Plan predicated on risk identification and alternative storage and management options for a large alluvial aquifer system. Responsibilities included:

- Concept and program design
- Execution of vulnerability mapping approach to assess risk to High River from groundwater impacts (e.g. underground storage tanks)
- Development of conceptual hydrogeological framework
- Review of groundwater–surface water interaction and climate variability effects
- Assistance with groundwater model development
- Liaison with town officials, MD Foothills official and other project stakeholders

Tsuut'ina First Nation

Completion of flood analysis (overland and groundwater) for the Redwood Meadow development on the Elbow River floodplain. Responsibilities included:

- Review of river hydrology, flood frequency, and related changes in river morphology
- Assistance with hydrological modelling to address groundwater flooding potential to existing and panned development areas
- Calculation of damage estimates associated with 5, 20,100, 200 and 500-year return periods
- Assessment of climate change aspects regarding river flow characteristics and flood risk
- Liaison with First Nations representatives, Government of AB, and Canadian Environmental Assessment Agency.

Other International

Origin Energy, Queensland, Australia

Groundwater lead for a large-scale coal seam gas project (up to 10,000 wells) located in the headwaters of the Murray-Darling Basin and recharge area for the Great Artesian Basin. Responsibilities included:

- Development of a regional-scale groundwater monitoring system using vulnerability and risk mapping
- Design of a hydrogeological model covering a 173 000 km^2 area (using FEFLOW) to assess cumulative effects from CSG development
- Completion of supporting Technical Report (including risk mapping, injection feasibility, model development) and Environmental Impact Statement chapter
- Liaison with the Queensland Department of Environment and Natural Resources to address needs for the required Environmental Impact Assessment

Texas Petroleum Company, Ecuador, SA

Completion of a baseline groundwater and surface water study in a remote and environmentally sensitive area of the Amazon basin (headwaters area) to support a helicopter-assisted drilling program for oil and gas exploration. Responsibilities included:

- Field reconnaissance to establish the suitability of proposed drilling targets
- Assessment of the suitability of local surface water and groundwater sources for drilling fluid provision (quality and quantity)
- Review of baseline soil quality, site hydrogeology, and geochemical conditions
- Development of recommendations for pit construction and site preparation.

Texas Petroleum Company, Magdalena Valley, Colombia, SA (1994)

Completion of an onsite environmental assessment of oilfield operations in support of the transfer of the Teca Nare, Cocorná, Velásques Oil Fields and the Velásquez-Galan Pipeline. Responsibilities included:

- Phase 1 site assessment of field operations
- Verification of site conditions at all well sites including soil and vegetation conditions prior to property transfer
- Assessment of baseline surface water and groundwater chemical conditions, as wells as environmental quality assessment to determine contamination from oilfield operations
- Provision of summary report including recommendations

Canadian International Development Agency, Catamayo, Ecuador SA

Completion of a baseline soil and groundwater study (physical and chemical) to determine the feasibility of siting an engineered wastewater impoundment for the treatment of municipal sewage treatment (project funded by CIDA). Responsibilities included:

- General site reconnaissance
- Collection of soil and groundwater samples for baseline geochemical quality assessment
- Review of hydrogeological conditions and processes relating to baseline conditions
- Submission of recommendations on the suitability of the proposed location and possible approaches to rectify existing limitations

Other Government

BC Ministry of Energy, Mines and Petroleum Resources

Provision of expert review support for hydraulic fracturing review process. Responsibilities included:

- Preparation of background information pertaining to water quality risks and source-pathway-receptor aspects of hydraulic fracturing operations
- Provision of recommendation regarding geochemical fingerprinting (ion ratios, isotopes, NORMs), risk assessment and mapping techniques, and monitoring
- Appearance at in-camera session to discuss water quality aspects with academic panel members including recommendations.

Alberta Utilities Commission

Provision of expert review support for a wind power application in the Provost AB area. Responsibilities included:

- Review of submitted application documents
- Research on wind vibration implications for shallow aquifer deliverability
- Submission of opinion report

Alberta Environment and Parks (AEP)

Participation on expert hydrogeology panel to development a template for groundwater management frameworks in Alberta. Responsibilities included:

- Assessment of background on Alberta groundwater resources and documents highlighting existing GMFs inside and outside of Canada
- Review of sustainability goals and challenges with groundwater management (quantity and quality)
- Review of prevailing concepts to groundwater management (i.e. surface water capture, risk and vulnerability assessment)
- Identification of data needs and required infrastructure to support cumulative effects management
- Identification of proposed indicators using DPSIR approach
- Participation in external panel and internal AEP team of hydrogeological experts to define aspects of a standardized GMF template

Alberta Environmental Monitoring Evaluation and Reporting Agency (AEMERA)

Assessment of Alberta's groundwater observation well network, including redundancy and gap analysis. Responsibilities included:

- Groundwater risk mapping
- Development of a numerical scoring scheme to prioritize monitoring wells
- Statistical and spatial analysis of provincial water chemistries using information from the Alberta water well information database
- Development of monitoring strategy including analytes and frequency to address key development activities (e.g. hydraulic fracturing, waste disposal, large-scale groundwater extractions)

Alberta Environment and Sustainable Resource Development (ESRD)

Development of a multi-attribute point-scoring system and ArcGIS tool to assist with optimal siting of provincial monitoring wells to address concerns regarding hydraulic fracturing (HF). Responsibilities included:

- Identification of key risks to groundwater resource from HF activities
- Conceptualization and construction of a subsurface risk assessment
- Identification of surface access opportunities in an ArcGIS platform to identify prime locations for monitoring in active and future development areas

Alberta Environment and Sustainable Resource Development (ESRD)

Various projects:

- Northern Athabasca Oil Sands Region groundwater monitoring program. Responsibilities included development of sampling methodology, data evaluation process and program logistics, communication to technical team comprising oil sands operators, ERCB and AEP representatives, development of an on-line visualization tool, and client liaison.
- Review of LARP management plan, supporting Groundwater Management Frameworks and supporting guidance documents re: Thermal Mobilization of Trace Elements during In Situ Developments and Groundwater Monitoring Directive.
- Preparation of summary document for Scientific Advisory Committee of the Oil sands GW working group, and Alberta Environment.

Alberta Land Use Secretariat (LUS)

Assistance with development of land planning scenarios in NE Alberta to guide future development in the Lower Athabasca Regional Plan area pursuant to the goals of the Alberta Land-use Framework. Responsibilities included:

- Presentations to the Land Use Secretariat, Regional Planning Team and Regional Advisory Council

- Development and assessment of modelled results from a cumulative effects simulator, completion of groundwater modelling over a 93 000 km^2 area (using MODFLOW)
- Development of an approach to deal with groundwater resources in the LARP area

Alberta Environment (AENV)

Technical assistance with development of a guidance framework to respond to the implications of thermal mobilization of constituents at in-situ bitumen recovery projects. Responsibilities included:

- Facilitation of team workshops to communicate the physical and chemical aspects of thermal mobilization and the risks posed by ion-situ operations
- Development of a risk-based, phased, approach to assessing thermal mobilization to address source-pathway-receptor aspects
- Development of a draft guidance document and interaction with the AEP communications team
- Support for industry and CAPP consultation meetings to review the draft guidance document

Alberta Environment (AENV)

Completion of vulnerability and risk mapping for the Lower Athabasca Regional Planning area and development of a groundwater management framework. Responsibilities included:

- Assessment of potential cumulative effects from large-scale thermal in-situ bitumen recovery operations and related activities (i.e. water withdrawal for steam generation and down-hole waste disposal
- Facilitation of technical and policy-related work sessions to engage stakeholders (operators, AENV and ERCB) directly affected by changes to provincial water management

Alberta Environment (AENV)

Development of a groundwater management framework within the South Athabasca Oil Sands area of the Lower Athabasca Planning Region. Responsibilities included:

- Completion of an inventory of existing quality and quantity issues, water supply conditions and related environmental policy
- Participation in technical and policy-related work sessions involving various stakeholder representatives

Alberta Environment (AENV)

Development of a groundwater water management framework within the mineable area of the Lower Athabasca Planning Region. Responsibilities included:

- Completion of an inventory of existing quality and quantity issues, water supply conditions and related environmental policy

- Participation in technical and policy-related work sessions involving various stakeholder representatives

Alberta Environment (AENV)

Completion of vulnerability mapping for the Lower Athabasca Regional Planning area and development of a groundwater management framework. Responsibilities included:

- Assessment of potential cumulative effects from thermal in-situ bitumen recovery operations and related activities (i.e. water withdrawal for steam generation; fluid waste injection)
- Facilitation of technical and policy-related work sessions to engage stakeholders (operators, AENV and ERCB) directly affected by changes to provincial water management

Alberta Utilities Commission (AUC)

External review of application to establish a wind farm in east-central Alberta. Responsibilities included:

- Review of project concept and environmental implications
- Assessment of completeness regarding baseline hydrogeological assessment
- Assessment of impact analysis and proposed mitigation
- Identification of gaps and provision supplemental information requests

Other Agencies

Alberta Innovates (AI)

Provision of hydrogeological services for the following University of Alberta led studies:

- Resolving human versus Industrial Influences on the water quality of the Lower Athabasca River (data synthesis; geophysical and geochemical assessment; isotope geochemistry source water fingerprinting, GW-SW interaction – identification and flux)
- Review of Arsenic in Alberta's groundwater (collation of multiple open source and private data bases, GIS platform design; correlation/cluster/factor analysis to determine source/cause/reasons(s), both physical and geochemical, for elevated concentrations, development of a risk mapping tool to identify existing and potential future high risk areas and aquifer intervals)
- Predicting Alberta's Water Future (complete estimates of groundwater recharge to Alberta's 2200 sub-basins; determining groundwater use projection by major sector to 2050; assessing baseflow contributions and groundwater stress area based analytic model outputs; project changes to provincial water supplies based on population growth, energy extraction, food production, land use, and climate variability/change; coordinate results with climate change model outputs and SWAT model outputs to generate preliminary Water Risk map for the province.

Alberta Water Research Institute (AWRI)

Preparation of a report assessing Alberta's inventory of water and its associated dynamics (natural and human-induced). Responsibilities included:

- The development of a partnership model including participants from Universities and Institutes in Beijing, Switzerland, Edmonton, Calgary and Lethbridge
- Completion of a complete inventory of surface water, groundwater and fossil water (glaciers and deep groundwater) to identify current and future risks to water supplies in the province
- Assessment of climate variability and change implications to provincial groundwater water resources

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of a water disposal assessment in NE Alberta (153,000 km^2 area) supporting the Regional Water Management Initiative. Responsibilities included:

- Collation of regional geological, hydrogeological, and water production data using public domain and industry information
- Development of a multi-criteria analysis approach to assessing Injection Potential and Theoretical Injection Rates based on a system of weighted and ranked physical and chemical attributes
- Development of an ArcGIS platform to identify high-value disposal formations in relation to existing and planned in situ developments and pipelines

Canada's Oil Sands Innovation Alliance (COSIA)

Completion of oil sands industry study assessing the risks and benefits of landfills, salt caverns and disposal wells in liquid waste management. Responsibilities included:

- Participation in industry workshops
- Assessment of liquid waste management options
- Documentation and presentation of the results to industry members

Cumulative Environmental Management Association (CEMA)

Preparation of a groundwater monitoring and management plan in support of the State of the Muskeg River Watershed report. Responsibilities included:

- Assessment of baseline groundwater quantity and quality conditions in the study area
- Identification of development stresses and potential short and long-term impacts
- Identification of proposed physical, chemical and state indicators for monitoring
- Interaction in multidisciplinary team

Cumulative Environmental Management Association (CEMA)

Overview of historical, current, and planned groundwater initiatives in the Regional Municipality of Wood Buffalo. Responsibilities included:

- Interviews with relevant industry, government, academia, aboriginal, and non-governmental organization groups
- Identifying and accessing relevant studies, reports, and investigations relating to groundwater and groundwater-surface water interaction
- Development of a useable database with relevant descriptors of content and results

Petroleum Technology Alliance of Canada (PTAC)

Completion of studies and industry workshops assessing:

- Environmental net benefit of saline versus non-saline water use in unconventional oil and gas development
- The role of collaboration in unconventional oil and gas development

Other Industry

Alberta Energy Company

Preparation of an Environmental Operations Manual for all aspects of petroleum exploration and development in Alberta. Contents of the manual included environmental procedures for seismic cutline provision and reclamation, siting and construction of drilling leases and processing facilities, siting and construction of pipeline right of ways, spill response and cleanup, and site reclamation.

Amoco Canada

Review of fresh groundwater usage for steam injection. Responsibilities included assessment of historical monitoring well and lake level readings to evaluate local effects resulting from groundwater withdrawal.

Amoco Canada

Sounding Lake area monitoring program to determine effects from nearby drilling activity. Responsibilities included:

- Interviews with well-owners
- Assessment of the water delivery system
- Short-term aquifer testing
- Sample collection using ultra-clean sampling methods
- Review of the data
- Communication of results to client and owner

Amoco Canada

Completion of environmental site assessments and landfill delineation programs for gas plant divestitures. Responsibilities included:

- Installation, testing and sampling of groundwater monitoring wells
- Completion of soil sampling programs
- Assessment of the results to determine the liability cost associated with property transfer

BP Canada

Resident well sampling program to determine effects from nearby drilling programs and existing gas wells. Responsibilities included:

- Well-owner interviews
- Assessment of the well conditions and water delivery system
- Sample collection using ultra-clean sampling methods
- Data review of communication of results.

Brooks, AB

Assessment of the construction and integrity of groundwater source wells, local hydrogeological and hydrochemical conditions, groundwater usage, assessment of potential impact to local water supply wells in the event of a well failure, and development of a risk management plan.

Delcan Corporation

Conceptual design of dewatering system in support of large sewage treatment facility upgrade. Responsibilities included:

- Review of site geological conditions
- Analytical model construction to determine stand-off distances for DW wells
- Predictive outcome assessment and DW plan development

Devon Canada

Completion of detailed studies to define baseline hydrogeological and hydrological conditions in support of a CBM project in the Crowsnest Region of the eastern Rocky Mountains. Responsibilities included:

- Completion of detailed field reconnaissance program
- Establishment of a spring and water well monitoring network
- Investigation of surface water/groundwater interactions
- Development of a conceptual hydrogeological framework in a mountainous area using geological and geochemical data
- Groundwater age dating of regional confined aquifers using radioactive isotopes (i.e. Tritium and Chlorine-36).

- Public and regulatory liaison

Devon Canada

Development of a thermal mobilization risk model to support development efforts in the Jackfish and Pike oil sands developments. Responsibilities included:

- Review and evaluation of existing geochemical data including metals and trace elements
- Development of conceptual site model using existing geological picks for various identified formations
- Design of Spatial MCA approach to map risk of thermal mobilization from artificial ground heating
- Preparation of summary document and presentation at various public venues

Husky Energy Ltd.

Completion of a Water Security Plan for a 200,000 barrel per day thermal in situ oil sands operation (Sunrise(. Responsibilities included:

- Review of water supply and disposal needs for the duration of the planned project
- Risk and opportunity analysis using multi-criteria analysis to ensure viability of supply and disposal strategies
- Identification of strategies to ensure project viability and project sustainability

Pembina Pipeline Corp.

Provision of expert legal support to review source and cause of industrial chemical contamination at an operating gas plant. Responsibilities included:

- Review of existing site investigations, procedures, and documentation
- Assessment of efficacy of investigations and protocols (field and laboratory)
- Development of conceptual model to explain presence and movement of sulfolane in bedrock deposits
- Review of risk assessment findings and provision of recommendations to close data and information gaps

Imperial Oil Resources

Support for re-licensing of supply wells for oilfield injection using Alberta Environment "Water Conservation and Allocation Guideline for Oilfield Injection" and "Groundwater Evaluation Guideline." Responsibilities included:

- Completion of field-verified surveys
- Review of site geological conditions
- Acquisition and interpretation of aquifer test data
- Assessment of groundwater/surface water interaction
- Determination of long-term sustainable yield using analytical solutions.

Imperial Oil Resources

Hydrogeological lead for a large oil sands mine EIA (Kearl Oil Sands Mine Project). Responsibilities included:

- Analysis and interpretation of water well information and chemical data
- Defining Quaternary stratigraphy
- Temporal water level assessment to determine potential impact to regional groundwater quality and quantity arising from mine development and dewatering
- Support at Joint Panel hearing

Imperial Oil Resources

Design and implementation of dewatering program for large process water ponds. Responsibilities included:

- Review of site geological conditions
- Installation of dewatering wells
- Acquisition and interpretation of aquifer test data
- Design of dewatering system using appropriate theoretical calculations and analytical modelling solution
- Development of dewatering plan and associated performance monitoring

Imperial Oil Resources

Completion of a regional groundwater investigation and development of a regional-scale ground water monitoring network (per EPO 95-07 requirements) in a multi-layer inter-till aquifer system in east-central Alberta. Responsibilities included:

- Assessment and interpretation of Quaternary stratigraphy
- Interpretation of seismic line data and geophysical borehole log analysis
- Regional groundwater flow mapping
- Geochemical facies mapping
- Assessment of regional arsenic concentrations, trends, and potential connection to thermal in situ development activities
- Groundwater age-dating and stable isotope analysis ($\delta^{18}O$, $\delta^{2}H$, $\delta^{34}S$, $\delta^{11}B$ and $\delta^{13}C$: dissolved constituents and gases)
- Preparation of investigation report to address EPO questions (i.e. source and cause of groundwater quality issues)
- Liaison with regulators during investigation and EPO closure process

Imperial Oil Resources

Completion of an environmental liability assessment to determine the cost of decommissioning, abandoning and restoring the area currently occupied by the Norman Wells field. Responsibilities included:

- Completion of a Phase 1 audit of production facilities and supporting infrastructure (i.e. wellheads, pipelines, satellites, batteries and former refinery)
- Design and implementation of a late Fall field program to sample a statistically sufficient number of locations to generate realistic liability costing for field shutdown and closure
- Generation of a summary report
- Assistance with design of liability costing model and summary reporting

Imperial Oil Resources

Development and implementation of a site characterization program at a former refinery and battery (circa 1930s) located approximately 160 km south of the Arctic Circle. Responsibilities included:

- The design and installation of a monitoring network in discontinuous permafrost
- Assistance in development of assessment programs to generate Tier II criteria in support of a human health and ecological risk assessment

Imperial Oil Resources

Cold Lake area monitoring program (Arsenic Investigation – 30 private residents). Responsibilities included:

- Interviews with well-owners
- Assessment of the water delivery system
- Sample collection using ultra-clean sampling methods
- Review of the data
- Communication of results to client, well owner and Alberta Environment

Imperial Oil Resources

Completion of an environmental liability assessment and costing exercise in support of the sale of the Judy Creek field to PenGrowth Corp. to statistically sample a sufficient number of facilities to generate realistic liability cost for property transfer. Responsibilities included:

- Completion of Phase 1 audits of production facilities and supporting infrastructure (i.e. wellheads, pipelines, satellites, and batteries), design and implementation of winter field program to sample facilities to generate realistic liability cost for property transfer

Imperial Oil Resources

Completion of a groundwater modelling study to determine the sustainable yield of a major deep freshwater aquifer in the Cold Lake area. Responsibilities included:

- The provision of hydrogeological support for model conceptualization and design
- Input parameter selection
- Evaluation and communication of results

Imperial Oil Resources

Development and implementation of a regional groundwater quality monitoring network covering an area of 1,200 km^2. Responsibilities included:

- Regular interaction with environmental regulatory agencies and the local landowners
- Installation, testing and sampling of deep (up to 230 m) monitoring wells to assess potential impact to confined aquifers due to production well casing failures
- Design, implementation and interpretation of aquifer tests in support of groundwater remediation programs
- Development of cost-effective approaches towards restoring water quality conditions in deep aquifers influenced by heavy hydrocarbons and associated production fluids

Imperial Oil Resources

Preparation of an AB environment approved Incident Response Plan to deal with groundwater quality issues identified during routine monitoring activities at a large heavy oil recovery scheme. Responsibilities included:

- Design of a cost-effective sampling schedule including rationalization of a 200 well monitoring network to provide a meaningful network of approx. 100 wells
- Development of statistical limits for response and mitigation actions

Japan Canada Oil Sands (JACOS)

Execution of hydrogeological section of an expansion EIA for the Hangingstone Thermal In Situ Oil Sands project. Responsibilities included:

- Development of baseline hydrogeology, EIA sections, and SIR responses
- Liaison with project team and governing agencies
- Stakeholder consultation with First Nations and 3PC

Japan Canada Oil Sands (JACOS)

Completion of a water supply project in support of a heavy oil recovery scheme using Alberta Environment "Water Conservation and Allocation Guideline for Oilfield Injection" and "Groundwater Evaluation Guideline." Responsibilities included:

- Assessment of geophysical logs and EM survey results
- Design and implementation of field programs
- Step test and constant rate test data acquisition and analysis
- Well screen selection and well design
- Well efficiency assessment

- Use of pertinent analytical equations to predict effect of long-term pumping

Petro-Canada

Completion of detailed regional and local baseline studies, and cumulative impact assessment, to establish regional and local hydrogeological and geochemical characteristics in support of a 30,000 bbl/d heavy oil recovery expansion (MacKay River Project). Responsibilities included:

- Defining Quaternary stratigraphy
- Temporal water level assessment to determine potential impact to regional groundwater quality and quantity arising from bitumen recovery operations
- Development of a numerical groundwater model to assess long-term effects of water withdrawal and waste disposal to support project activities
- Completion of climate change assessment formed part of the assessment for project design

Petro-Canada

Conceptualization and design of field program to assess water supply and water disposal for two major heavy oil projects (>30,000 bbl/d). Responsibilities included:

- Selection of drilling locations based on geophysical reconnaissance
- Implementation of field programs
- Step test and constant rate test data acquisition and analysis
- Well efficiency assessment
- Well screen selection and well design
- Use of pertinent analytical equations

Petro-Canada

Review of fresh groundwater use for a water flood project. Responsibilities included interpretation of historical monitoring well data to determine the effects of the groundwater withdrawal from the local aquifer.

Petro-Canada

Assessment of long-term effects of industrial water supply wells used for a water flood scheme. Responsibilities included a review groundwater chemistry and well hydraulic data to determination sustainable production rates.

Petro-Canada

Completion of an environmental operations audit and subsequent industrial landfill delineation to determine the source area of possible groundwater contamination. Responsibilities included completion of a comprehensive intrusive landfill delineation and soil sampling program to determine the extent and volume of landfill contamination.

Petro-Canada

Completion of an industrial landfill delineation project to determine possible sources of groundwater contamination. Responsibilities included completion of a magnetometer survey, follow-up excavation and soil sampling near a decommissioned landfill to determine the presence, extent and volume of residual landfill material.

Procor

Review of operational history of a salt cavern storage facility including an assessment of groundwater quality near the large brine storage ponds and the potential for impact to the Regina Aquifer.

Shell Canada

Development of Groundwater Management Plan and annual monitoring support at Shell's Muskeg River Mine. Responsibilities included:

- Review of site-wide groundwater monitoring network for applicability to EPEA Approval requirements (including gap analysis
- Routine monitoring and reporting per EPEA requirements
- Selection of indicator suites to facilitate routine monitoring, evaluation, and reporting
- Identification of locations with water quality concerns
- Development of approach to statically assessing and responding to data excursions and trends
- Preparation of the GMP for consideration and acceptance by AEP

Shell Canada

Support for Carmon Creek EIA and assessment of brackish water supply potential in support of heavy oil operations in the Peace River area. Responsibilities included:

- Assessment of baseline hydrogeological conditions and potential impacts from project development
- Preparation of climate change assessment for project development
- Support for SIR submissions and EIA team interactions
- Feasibility assessment of potential for deep formations to produce sustained supplies and conceptual well-field development
- Liaison with regulatory agencies
- Development of a DBM level review for a groundwater well-field development

Shell Canada

Development of a regional-scale ground water monitoring network in a multi-layer aquifer system in the Peace River region of Alberta. Responsibilities included:

- Assessment of Quaternary stratigraphy

- Interpretation of seismic line data
- Geophysical borehole log analysis
- Geochemical facies mapping and solution chemistry analysis

Shell Canada

Assistance with the development and construction of an induced infiltration groundwater supply system for the Shell Caroline Gas Plant industrial water supply project. Responsibilities included:

- Drilling and installation of large diameter water production wells
- Borehole geophysical logging and interpretation
- Sand quantification testing and analyses to determine sediment production volumes prior to pipeline construction
- Liaison with client and local landowners

Suncor Energy

Lead subsurface specialist for a multi-criteria decision analysis and life-cycle value analysis in support of a regional brine management strategy in the Athabasca Oil Sands area. Responsibilities included:

- Development of a holistic weighting and ranking approach to address triple-bottom-line assessment of treatment and disposal options for liquid and solid waste streams originating from oil sands mining and in situ assets located across a 30 000 km^2 area
- Facilitation of, and participation in, workshops to assess viable options for treatment and disposal including Class 4 costing
- Development of a constraints mapping approach (vulnerability, risks and opportunities) using ArcGIS to assist in management and disposal options for liquid and solids waste streams

Suncor Energy

Review of existing water supply for Steepbank and Millennium mine operations and development of contingency supply options. Responsibilities included:

- Review of past water resource evaluations
- Development of geophysical investigation program and interpretation of results
- Assessment of contingency water supply (groundwater and operations water)
- Client consultation and liaison with Alberta Environment
- Implementation of horizontal well technology to provide a secure supply of water for continued operations

Union Pacific

Supervision of supply well installation for the Ferrybank water flood scheme and completion of extensive aquifer test to determine the local effects of water withdrawal from the target aquifers.

Various Gas Plants, Batteries and Refineries (AB, SK, BC)

Completion of piezometer network design at numerous operating facilities to assess the potential impact to local groundwater quality resulting from industrial activities and extent of contaminant migration from known source areas (Imperial Oil, Amoco/BP, Shell, Mobil, Canadian Occidental); and, provision of hydrogeological services in support of a gas plant decommissioning (ongoing). Responsibilities include:

- Well installation, testing and sampling
- Involvement in a site-specific risk assessment (ecological and human health)
- Development of sampling protocols
- Assessment of cost-effective remediation techniques to address various contaminant situations in both soil and groundwater

Various Oil and Gas Facilities (AB, SK)

Completion of environmental operations audits and development of waste management plans at numerous oil and gas facilities (Amoco, Petro-Canada, Shell). Responsibilities included:

- Review of historical operations files (spill reports, waste handling procedures, EUB and AENV records)
- Completion of site inspections & historical air photo interpretation

HEARINGS / APPEALS / PANEL EXPERIENCE

McQuiston Gravel Pit, Butte AB (2019-present): Clearwater County re-zoning

Crouch Gravel Pit, Sundre AB (2019-2020): EAB appeal

Phelan Gravel Pit, Fort Assiniboine AB (2016-2019): EAB appeal hearing

BC Scientific Hydraulic Fracturing Review Panel (2018): assessment of water quality issues and presentation to panel members

South McDougall Flats Protection Society (2017): support for re-zoning hearing

Town of Black Diamond (2013): EAB appeal

Town of Okotoks vs. Sandstone Springs Development (2011): EAB appeal

Queensland Government, Dept. of Energy, Resources, and Mine (2010): hydrogeology panel for assessing implication of coal seam gas development

Total Joslyn North Mine – Joint Panel hearing

Imperial Oil Kearl Mine, Athabasca Oil Sands: Joint Panel hearing

Suncor Voyageur, Athabasca Oil Sands: Joint Panel hearing

BlackRock Ventures, Cold Lake: ERCB hearing

Imperial Oil Mahkeses Expansion, Cold Lake: ERCB hearing

EDUCATION

Ph.D. (Geochemistry) – University of Calgary, 2008

M.Sc. (Physical Hydrogeology and Isotope Geochemistry) – University of Calgary, 1994

B.Sc. (Geology: hard rock, sedimentology, mineralogy, structural, geochemical) – University of Saskatchewan, Saskatoon, 1985

REGISTRATIONS / AFFILIATIONS / BOARDS

APEGA (P.Geol. – Alberta)

EGBC (P.Geo. – British Columbia)

APEGS (P.Geo. P.Eng. – Saskatchewan)

NAPEG (P.Geol. – Northwest Territories and Nunavut)

National Ground Water Association (NGWA)

International Association of Hydrogeologists (CNC)

Canadian Water Resources Association (CWRA)

Sustainable Energy Development Program (Univ. of Calgary) – External Advisory Board

Bow River Basin Council (Calgary), Board of Directors (2008-2013), Chair of Monitoring and Modelling committee (2008 to 2012), Member of Legislation and Policy Committee (2006-2011), Member of Integrated Watershed Management Group (2007 to 2010)

SPECIFIC TECHNICAL EXPERTISE / SPECIALIST COURSES

Training Certificates

WHMIS

Petroleum Safety Training

Transportation of Dangerous Goods

ISO 9001:2000 (Management Responsibilities)

Analytical Experience

ICP-MS, GC-MS, Ion chromatography (LC-MS, HPLC, IC)

SEM, XRD (bulk and clays), XRF, EDS and Synchrotron Light (XANES, and EXAFS)

Isotope ratio mass spectrometry (IRMS)

Solid-phase extraction, Alumina fraction, and sequential soil extraction

Toxicity identification evaluation for metals and organics

Selection of appropriate inorganic or organic analytical techniques based on Standard Methods

Statistical analysis (e.g. population testing, trend analysis, control charting, PCA, HCA, spatial analysis)

Multi-criteria analysis (MCA) for decision support

Vulnerability and risk mapping

Climate change analysis (models, tele-connections, impacts to land, water, biodiversity)

Risk assessment (human and ecological)

PUBLICATIONS / PRESENTATIONS

Publications

Fennell J. and Aciszewski T (2019). Current knowledge of seepage from oil sands tailings ponds and its environmental influence in northeastern Alberta. Science of the Total Environment, 686, p. 968-985.

Birks S.J., **Fennell J.W.**, Gibson J.J., Yi. Y., Moncur M.C., and Brewster M. 2019. Using regional datasets of isotope geochemistry to resolve complex groundwater flow and formation connectivity in northeastern Alberta, Canada. Applied Geochemisty, 101 (2019), p. 140-159.

Hatala R., **Fennell J.,** and Gurba G. 2018. Advances in the realm of Hydrogeophysics: The emerging role of Quantum Geoelectrophysics in Aquifer Exploration. Can. Soc. of Expl. Geoph., RECORDER October Focus - Hydrogeophysics: the Past, Present, and Future. Vo. 43, No. 6, p. 32-36.

Birks S.J., Moncur M.C., Gibson J.J., Yi Y., **Fennell J.**, and Taylor E.B. 2018. Origin and hydrogeological setting of saline groundwater discharges to the Athabasca River: Characterization of the hyporheic zone. Applied Geochem., 98, p. 172-190.

Fennell J., 2018. Predictions, perceptions and the precautionary principle: responding to climate change in a realm of uncertainty. Canadian Water Resources Association, Water News, Fall/Winter 2018. Vo. 37, No. 2, p. 6-9.

Fennell J., 2018. Water, Peace, and Global Security: Canada's Place in the World We Want (Sandford and Smakhtin, eds.), Groundwater and Canada's Future – Moving data and information to knowledge and security. Prepared for the United Nations University, Institute for Environment, Water and Health, 17 pp.

Fennell J. 2018. Poison Well: Chasing arsenic in Alberta's groundwater. Water Canada, January/February 2018, p. 20-21.

Fennell J. 2017. Let's make a deal: Canada's vital role in the Columbia River Treaty. Water Canada, September/October 2017. p. 42-43.

Faramarzi M., K. Abbaspour, V. Adamowicz, W. Lu, **J. Fennell**, A. Zehnder and G. Goss 2017. Uncertainty based assessment of dynamic freshwater scarcity in semi-arid watershed of Alberta, Canada. *Journal of Hydrology: Regional Studies*, 9, p. 48-68.

Fennell J. 2015. Disposal in the unconventional oil and gas sector: Challenges and solutions. American Assoc. of Petroleum Geologists, *Environmental Geosciences*, Vol. 22, No. 04, December 2015, p. 127-138.

Fennell J. and O. Keilbasinki 2014. Water, food, and our climate: Is California a harbinger of things to come? *WaterCanada*, July/August 2015, p. 24-25.

Fennell J. and O. Keilbasinki 2014. Water without Borders: What is Canada's role in water security? *WaterCanada*, November/December 2014, p. 50-51.

Gibson J.J., **J. Fennell**, S.J. Birks, Y. Yi, M. Moncur, B. Hansen and S. Jasechko 2013. Evidence of discharging saline formation water to the Athabasca River in the northern Athabasca oil sands region. *Canadian Journal of Earth Sciences*, 50, p. 1244 - 1257.

M.S. Ross, A.S. Santos Pereira, **J. Fennell**, M. Davies, J. Johnson, L. Sliva, and J.W. Martin 2012. Quantitative and Qualitative Analysis of Naphthenic Acids in Natural Waters Surrounding the Canadian Oil Sands Industry. *Environmental Science and Technology*, 46, p. 12796 – 12805.

Fennell J. 2011. Total Water Management – a new and necessary paradigm. Environmental Science and Engineering Magazine, May/June edition.

Fennell J., Klebek M. and Forrest F. 2011. An approach to managing cumulative effects to groundwater resources in the Alberta Oil Sands. World Heavy Oil Congress proceedings, March 2011.

Fennell J. 2010. Protecting water supplies in CSG development. *Water Engineering Australia*, Vo. 4, No. 6, September 2010.

Fennell J. 2008. Effects of Aquifer Heating on Groundwater Chemistry with a Review of Arsenic and its Mobility. Ph.D. thesis, Department of Geoscience, University of Calgary.

Fennell J. Zawazki A. and Cadman C. 2006. Influence of natural vs. anthropogenic stresses on water resource sustainability: a case study. *Water Science and Technology*. Volume 53, No. 10, p 21-27.

William L.B., M.E. Wieser, **J. Fennell**, I. Hutcheon, and R.L. Hervig 2001. Application of boron isotopes to the understanding of fluid-rock interactions in a hydrothermally stimulated oil reservoir in the Alberta Basin, Canada. *Geofluids*, Vol. 1, p. 229-240.

Kellett R., **J. Fennell**, A. Glatiotis, W. MacLeod, and C. Watson 1999. An Integrated Approach to Site Investigations in Permafrost Regions: Geophysics, Soils, Groundwater, and Geographical In-formation Systems. ARCSACC Conference, Edmonton '99.

Gilson E.W., R. Kellett, **J. Fennell**, P. Bauman, and C. Sikstrom 1998. High Resolution Reflection Seismic and Resistivity Imaging of Deep Regional Aquifers for Stratigraphic Mapping. CSEG Conference.

Fennell J. and Bentley L. 1997. Distribution of Sulphate and Organic Carbon in a Prairie Till Setting: Natural versus Industrial Sources. *Water Resources Research*, Vol. 34, No. 7, p. 1781-1794.

Fennell J. and Sevigny J. 1997. Effects of Acid Conditions on Element Distribution Beneath a Sulphur Base Pad (Acid Mobilization Study). Publication submitted to the Canadian Association of Petroleum Producers (CAPP).

Fennell J. 1994. Source and Distribution of Sulphate and Associated Organics at a Sour Gas Plant in Southern Alberta. M.Sc. thesis, Department of Geology and Geophysics, University of Calgary.

Hayes B., J. Christopher, L. Rosenthal, G. Los, B. McKercher, D. Minken, Y. Tremblay, and **J. Fennell** 1994. *Atlas of the Western Canadian Sedimentary Basin – Chapter 19: Cretaceous Manville Group*. Canadian Society of Petroleum Geologists and Alberta Research Council, ISBN 0-920230-53-9.

Presentations / Lectures

COSIA Oil Sands Innovation Summit, June 2019 Calgary AB: Fact or fiction – the truth regarding tailings pond seepage in Canada's oil sands (response to a Free Trade Agreement Challenge)

CWRA Alberta Branch conference, April 2019 Red Deer: Flooding, climate change, and the need for a precautionary approach.

University of Calgary, Sustainable Energy Development Program. February 2019, Decision support processes and tools in sustainable energy development projects.

Mine Water Solutions, June 2018. Total Water Management: Canada's contribution to sustainable mine development.

Canadian Water Resources Association, April 2018, Red Deer, AB. Arsenic and Alberta's Groundwater: the where and why.

Southern Alberta Institute of Technology (water Initiative), February 2018, Calgary AB. Risky business: understanding Alberta water security

Canadian Society of Unconventional Resources (CSUR), January 2018, Calgary AB. Managing through nature's extremes: ensuring water security for successful UCOG operations.

SEAWA, Nov 2017, Medicine Hat AB. Hydrology of riparian areas: the need for protection and preservation.

CWRA National Conference, June 2017, Lethbridge AB. Climate change, the Columbia River Treaty, and considerations for a successful re-negotiation.

Thermal mobilizations and the regulatory response, May 2017, Calgary AB. CHOA forum.

National Ground Water Association, March 2017, Denver CO. Advances in the realm of hydrogeophysics: the role of Quantum Geoelectrophysics in groundwater exploration

Haskayne School of Business IRIS series, Feb 2017. Following the molecules: the importance of water to Canada's future.

BRBC-CEAC, Feb 2017, Cochrane AB, GW-SW interaction and the implication for development in riparian lands.

Watertech, April 2017, Banff AB. Arsenic in Alberta's Groundwater: the where and why; Isotopes and Geochemistry:

National Ground Water Association, Hydrogeophysics for deep groundwater exploration, March 2017, Denver CO. Advances in the realm of Hydrogeophysics: the role of Quantum Geoelectrophysics in Groundwater Exploration

Haskayne School of Business CPC IRIS seminar series, February 2017, Calgary AB. Following the molecules: the importance of water in Canada's future.

Bow River Basin Council/Cochrane Environmental Action Committee Collaborating for Healthy Riparian Lands Engagement Workshop, February 2017, Cochrane AB. Groundwater-Surface water interaction and the implications of human development in riparian lands.

Watertech, April 2016, Banff AB. Predicting Alberta's Groundwater Future & An Integrated Approach to Resolving Complex Hydrogeological Settings.

Canadian Water Resources Association (CWRA), April 2016, Edmonton AB. Natural discharge and its role in Athabasca River water quality.

Canada's Oil Sands Innovation Alliance (COSIA) Water Forum, March 2016, Calgary AB. Natural discharge and its role in Athabasca River water quality.

Canadian Association of Petroleum Geologists (CSPG), March 2016, Calgary AB. Climate, water availability, and the success of Western Canada's Energy Development & Natural discharge and its role in Athabasca River water quality.

Underground Injection Control (GWPC), February 2016, Denver CO. Disposal in the unconventional oil and gas sector: challenges and solutions.

AGAT Environmental Series, Jan/Feb 2016. Calgary and Edmonton, AB. Climate, water availability and the success of Western Canada's energy industry.

International Water Conference, November 2015, Orlando FL. Disposal in the unconventional oil and gas sector: challenges and solutions.

Chemistry Industry Association of Canada, October 2015, Edmonton AB. Water Sustainability: and its importance to successful industry.

EnviroAnalysis, July 2015, Banff AB. Thermal mobilization and Arsenic: implication for the oil sands.

WaterTech, April 2015, Kananaskis AB. Smart Monitoring to address challenges of Unconventional Gas development and an approach to mapping risk related to thermal mobilization of constituents.

Canadian Water Resources Association, April 2015, Red Deer AB. Water, Energy and Canada's Future (keynote address)

Underground Injection Council, February 2015, Austin TX. Monitoring to address challenges of Unconventional Gas development (invited speaker)

National Ground Water Association, Groundwater monitoring for Shale Gas developments workshop, November 2014, Pittsburgh PA. Smart monitoring to address the challenges of Unconventional Gas Development (invited speaker)

Canadian Water Resources Association, June 2014, Hamilton ON. Water disposal in the Oil Sands: challenges and solutions and What is Water Security and Why is it Important.

Water Management in Mining, May 2014, Vancouver BC. Total Water Management: a necessary paradigm for sustainable mining.

CSPG GeoConvention May 2014, Calgary AB. Water disposal in the Oil Sands: challenges and solutions; Placing the risk of thermal mobilization into perspective; What is Water Security and Why is it Important?

WaterTech, April 2014, Banff AB. Water disposal in the Oil Sands: challenges and solutions and Placing the risk of thermal mobilization into perspective.

Canada's Oil Sand Innovation Alliance (COSIA), March 2014, Edmonton AB. Water disposal in the Oil Sands: challenges and solutions and Placing the risk of thermal mobilization into perspective.

International Assoc. of Hydrogeologists, GeoMontreal 2013, October 2013, Montreal QC. The role of subsurface heating in trace element mobility.

Oil Sands Heavy Oil Technology 2013, July 2013, Calgary AB. The role of subsurface heating in trace element mobility.

Watertech, April 2013, Banff AB. The role of subsurface heating in trace element mobility.

International Assoc. of Hydrogeologists World Congress 2012, September 2012, Niagara ON. Session Chair for Hydrogeological Issues in the Oil Sands and presenter: i) Oil Sands overview – economic and environmental setting; ii) Framing groundwater vulnerability in the oil sands: an approach to identify and discern; and iii) Climate: a driving force affecting water security in the oil sands

Water in Mining 2012, June 2012, Santiago Chile. Total Water Management: a necessary paradigm for sustainability.

BCWWA 2012 Annual Conference, April 2012, Penticton BC. The role of inventory, dynamics, and risk analysis in water management: a case study.

WaterTech, April 2012, Banff AB. Plenary Session. Bringing context to the oil sands debate: understanding the role of nature and its environmental effects.

BCWWA Hydraulic Fracturing Workshop, Fort St. John BC, March 2012. Keynote address: Striking a Balance – water resource management versus economic development (keynote address).

CONRAD 2012, March 2011, Edmonton AB. Bringing context to the oil sands debate: understanding the role of nature and its environmental effects.

Alberta Irrigation Projects Assoc., November 2011, Lethbridge AB. Managing what we have: a review of Alberta's water sources, volumes and trends (invited speaker).

Alberta Innovates Technology Talks, November 2011, Calgary AB. Dynamics of Alberta's Water Supply: a review of supplies, trends and risks.

Red Deer River Watershed Alliance Annual General Meeting, October 2011, Red Deer AB. Water in the Red Deer: volumes, patterns, trends and threats.

Land and Water Summit, October 2011, Calgary AB. Total Water Management: a necessary paradigm for water security.

CEMA Groundwater Working Group, June 2011, Fort McMurray AB. Groundwater in the oil sands: facts, concepts and management processes.

CWRA Alberta / Alberta Low Impact Development Annual Conference, April 2011, Red Deer AB. A Review of Alberta's Water Supply and trends.

WaterTech, April 2011, Banff AB. Managing what we have: a review of Alberta's water supply.

World Heavy Oil Congress 2011, March 2011, Edmonton, AB. An approach to managing cumulative effects to groundwater resources in the Alberta Oil Sands.

Engineers Australia, August 2010, Brisbane Qld. CSG development in Australia: an approach to assessing cumulative effects on groundwater (invited speaker).

Joint IAH/AIG meeting, July 2010, Melbourne Vic. Assessing the effects of coal seam gas development on water resources of the Great Artesian Basin (invited speaker).

18th Queensland Water Symposium, June 2010, Brisbane Qld. A cumulative effects approach to assessing effects from coal seam gas development on groundwater resources (invited speaker).

WaterTech, April 2010, Lake Louise AB. Regional Groundwater Monitoring Network Implementation: Northern Athabasca Oil Sands Region.

University of Calgary, December 2009, Calgary AB. What's happening to our water? A review of issues and dynamics.

CSPG Gussow Conference, October 2009, Canmore AB. Water sustainability in the Alberta Oil Sands: managing what we have (invited speaker).

Bow River Basin Council, Legislation and Policy Committee Groundwater Licensing Workshop, March 2009, Calgary AB. Groundwater: the hidden resource

BlueWater Sustainability Initiative, January 2009, Sarnia ON. Planning approaches and forensic tools for large-scale regional monitoring initiatives.

CWRA Technical luncheon session, October 2008, Calgary, AB. Water sustainability in a growing Alberta.

Bow River Basin Council, September 2008, Calgary AB. Basin Monitoring and Management Approaches.

IAH/CGS GeoEdmonton08, Edmonton AB. Coordinator and Chair of Groundwater Development Session.

North American Lake Management Society (NALMS) 2008, Lake Louise AB, Coordinator and Chair of Climate Change Effects to Lakes, Reservoirs and Watersheds section.

EcoNomics™ Luncheon, May 2008, Calgary AB. Water Sustainability in the Hydrocarbon Industry.

WaterTech, April 2008, Lake Louise AB. Effects of climate and land cover changes on basin water balances.

CWRA Annual Conference, April 2008, Calgary AB. Role of climate change and land cover on water supply sustainability.

Bow River Basin Council, March 2007, Calgary AB. Forest Hydrology and the effects of Climate Change.

ALMS/CWRA, October 2006, Lethbridge AB. Reservoir Maintenance Workshop. Climate tele-connections and their effects on basin water supplies

Bow River Basin Council, June 2006, Calgary AB. Groundwater sustainability: the invisible resource (Climate change and basin sustainability)

Engineering Institute of Canada, May 2006, Ottawa ON. CCC2006 Land use and climate change effects at the basin scale.

International Water Association, Watershed and River Basin Management Specialists Group Conference, Calgary, AB, 2005. Basin Water Management Strategies.

Burgess Shale Geoscience Foundation, August 2004 and 2005, Field BC. Water in a Changing Climate: understanding and adapting.

C-CAIRNS, October 2005, Victoria BC, Climate and Fisheries Impacts, Uncertainty and Responses of Ecosystems and Communities, Effects of Climate and the PDO on Hydrology of a Major Alberta Watershed.

North American Lake Management Society, November 2004, Victoria BC. Climate Change and Effects on Water Resources.

Canadian Institute Conference, June 2004, Calgary AB. Water Management Strategies for the Oil and Gas Industry: The challenge and approach

Canadian Society of Petroleum Geologists, Gussow Conference, March 2004, Canmore AB. Understanding the Effects of Natural and Anthropogenic Forcings on Basin Water Resources.

Alberta Environment and EUB, April 2003, Elk Point AB. Climate and Land Use Change Effects on Basin Water Resources in the Lakeland Region - East-central Alberta.

Joint CGS/IAH Conference, June 2001, Calgary AB. A Multidisciplinary Approach to Resolving Complex Hydrogeologic Systems.

Aquatic Toxicity Workshop, October 1996, Calgary AB. Use of site characterization and contaminant situation ranking to focus a risk assessment evaluation at a decommissioned sour gas plant and associated landfill.

Joint GAC/MAC Conference, April 1995, Waterloo ON. Use of geochemical modelling and stable isotopes to determine the source of groundwater quality impacts near a sour gas processing facility.

Joint GAC/MAC Conference, Edmonton AB, 1994. Assessment of depression-focused recharge as a mechanism for variable groundwater and soil chemistry.

GasRep Conference, Calgary AB, 1994. Use of stable isotopes to determine the source of water quality impacts near a sour gas processing facility.