Dynamic Risk

INDEPENDENT ALTERNATIVES ANALYSIS FOR THE STRAITS PIPELINE

20 YEARS OF REDUCING RISK

April 18, 2016

Michigan Departments of Environmental Quality and Natural Resources, the Michigan Agency for Energy, and the Michigan Office of Attorney General

ATTN: Holly Simons
The State of Michigan

Mailing Address:
P.O. Box 30458
Lansing, Michigan, USA 48909-7958

Physical Address:
Constitution Hall
3 North, 525 West Allegan Street
Lansing, Michigan, USA 48933

SUBJECT: Proposal for Independent Alternatives Analysis for the Straits Pipeline

Dear Holly,

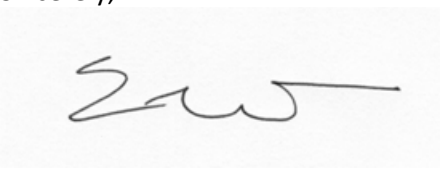
Dynamic Risk Assessment Systems, Inc. (Dynamic Risk) is pleased to offer its consulting, engineering and technical expertise to The State of Michigan (The State) to conduct an independent alternatives analysis for the Straits Pipeline.

James Mihell, Chief Engineer, is presented as the Technical Leader for this important project. Mr. Mihell brings substantial industry recognized experience with risk based pipeline design, quantitative risk analysis, pipeline operations, regulatory compliance and pipeline integrity. As Technical Lead, James will be managing a team of highly qualified Dynamic Risk engineers and subcontractors. Mr. Mihell's Curriculum Vitae, along with all technical resources presented for this project, are included in our submittal for your review.

We understand the significance of this project and accept the deep responsibility that comes with providing a technically sound and robust analysis of the alternatives to the Straits pipelines. We have committed the top technical minds in the industry to support the project. We sincerely appreciate your consideration of our firm and look forward to discussing our proposed approach with your offices.

Please do not hesitate to contact myself by phone at 403.245.5800 or by email at trevor_macfarlane@dynamicrisk.net to discuss any aspect of the technical or commercial terms of our proposal.

Sincerely,



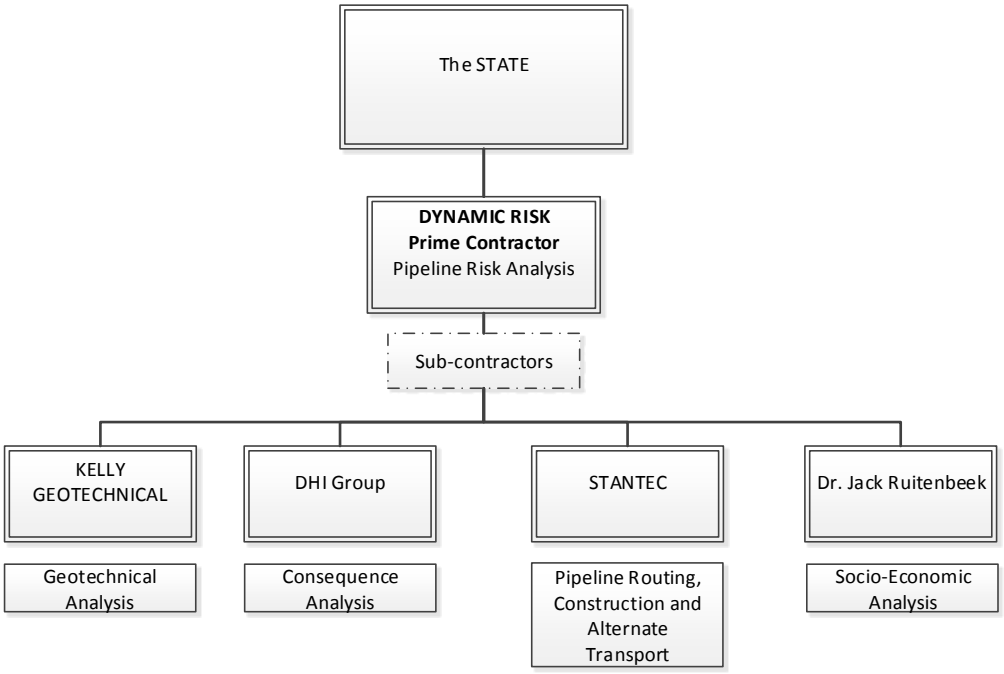
Trevor MacFarlane, M.Sc., P.Eng.
President
Dynamic Risk Assessment Systems, Inc.

1 Executive Summary

Dynamic Risk has assembled a multi-disciplinary team of world class expertise to complete the independent analysis of the alternatives to the Straits of Mackinac Enbridge Line 5 pipeline crossings. The team consists of the following key members:

1. Dynamic Risk – overall program management and quantitative pipeline risk analysis;
2. DHI Group – industry leaders in oil spill fates and effects analysis in marine environments;
3. Dr. Jack Ruitenbeek – recognized global expert in socio-economic financial impact analysis of oil spill events;
4. Stantec Engineering – pipeline engineering and design firm with global expertise on multi-billion dollar projects; and,
5. Kelly Geotechnical – an experienced and recognized authority in assessing geotechnical (ground movement) threats to existing and new pipeline designs.

Dynamic Risk would act as the Prime Contractor with the State of Michigan and be responsible for all reporting, communication and project deliverables from the project team.



Our proposal includes providing an independent review of the risks associated with the existing pipelines as well as a technical evaluation and risk analysis of each of the alternatives contemplated by the State of Michigan. In addition, we have presented additional alternatives for your consideration, including a tunnel option.

The team's qualifications and credentials are considered the very highest in the oil and gas industry. Our firms have been involved in the analysis and review of over 400,000 miles of pipelines in North America. We have worked extensively in the Great Lakes regions and have working knowledge of the local

geography, environment and sensitivities. Specifically, James Mihell, the Technical Lead for this project, resides less than 55 miles from the Straits of Mackinac pipeline crossing.

We can also confirm that no members of our project team have performed any work for Enbridge on its Line 5 system and feel we have no conflict in completing this analysis.

The project is expected to take 9 to 10 months to complete and will involve several interim deliverables through the course of that schedule. As specified, 1st and 2nd drafts report would be issued to the State and be open for public consultation as outlined in the Request for Proposal.

The total costs to deliver this project is $2,920,200 USD which is inclusive of all materials, expenses and time to complete the project as described in this proposal. A more detailed breakdown by alternative is presented in the costing section of this proposal.

2 Objective and Statement of Work (SOW)

The analysis will consist of a feasibility and impact analysis for six alternatives, described as follows:

Alternative 1: The construction of one or more new pipelines that do not cross open waters of the Great Lakes to transport the volume of petroleum products that are currently transported by Enbridge Line 5 from its terminal at Superior, Wisconsin to its terminus in Sarnia, Ontario, and the decommissioning of Line 5.

Alternative 2: The utilization of existing pipeline infrastructure located in Canada, other states, and elsewhere in Michigan that do not cross the open waters of the Great Lakes, to transport the volume of petroleum products that are currently transported by Enbridge Line 5 from its terminal at Superior, Wisconsin to its terminus in Sarnia, Ontario, and the decommissioning of Line 5.

Alternative 3: The utilization of alternative transportation methods to transport the volume of petroleum products that are currently transported by Enbridge Line 5 from its terminal at Superior, Wisconsin to its terminus in Sarnia, Ontario, and the decommissioning of Line 5:

i. Rail
ii. Tanker Truck
iii. Oil Tankers and Barges
iv. Others

Alternative 4: Replacement of the existing Enbridge Line 5 Straits crossing pipelines with pipeline(s) that utilize the best available design and technology.

Alternative 5: Maintaining the existing Enbridge Line 5 Straits pipelines.

Alternative 6: Elimination of all transportation of petroleum products and NGLs through Line 5, and decommissioning the existing twin pipeline crossing of the Straits.

2.1 Overview of Analysis

A description of the analysis that will be performed is described below for each of the Alternatives as defined above.

<u>Alternative 1 – New Pipeline Route</u>

The analysis will consider regulatory requirements and timeframes associated with pipeline replacement such as permits, siting, land acquisition and routing. In addition, quantitative evaluations of failure probability and associated release magnitudes will be made for the replacement pipeline infrastructure. This will serve as the basis of a risk assessment for the replacement pipeline infrastructure, wherein risk

is defined as the probability of incurring a release and the associated consequences of a release. These consequences will be characterized in the following terms:

i) Potential public health and safety impacts;
ii) Potential environmental impacts;
iii) Potential natural resources damages, including, but not limited to, damages to the Great Lakes;
iv) Potential response and clean-up costs; and
v) Potential economic impacts to the Great Lakes Region.

Alternative 2 – Other Pipeline Infrastructure

The analysis will include consideration of other pipeline infrastructure located in Canada, other states, and elsewhere in Michigan. In addition, the change risk that is associated with this Alternative will be determined as the risk that might be associated with offloading Line 5 volumes onto existing pipeline infrastructure. That risk will be evaluated by determining the incremental failure probability, along with the associated magnitudes of release that are attributed to increased load on existing infrastructure. This risk will be evaluated in terms of the following measures of consequence:

i) Potential public health and safety impacts;
ii) Potential environmental impacts;
iii) Potential natural resources damages, including, but not limited to, damages to the Great Lakes;
iv) Potential response and clean-up costs; and
v) Potential economic impacts to the Great Lakes Region.

Alternative 3 - Utilization of alternative transportation methods

For the rail option associated with this Alternative, the analysis will consider current technology, safety standards and regulatory requirements associated with rail cars. The analysis will also include the magnitude of rail cars needed to meet demand of oil transportation if the Straits Pipelines were shut down. In addition, estimates will be made of incremental spill frequencies and magnitudes associated with incremental rail usage. This incremental spill frequency and associated magnitude of release will serve as the basis of a risk assessment, wherein risk is defined as the probability of incurring a release and the associated consequences of a release. These consequences will be characterized in the following terms:

i) Potential public health and safety impacts;
ii) Potential environmental impacts;
iii) Potential natural resources damages, including, but not limited to, damages to the Great Lakes;
iv) Potential response and clean-up costs; and
v) Potential economic impacts to the Great Lakes Region.

For the tanker truck, oil tanker & barge, and other options associated with this Alternative, a feasibility review will be conducted to establish whether each transportation method could be a volumetrically and environmentally viable option. If any of these options prove viable, then an assessment of spill probability and magnitude will be undertaken for that option, which will serve as the basis of a risk

assessment as described for the rail option. Otherwise, if it is established that the transportation option is not considered viable, no further analysis will be undertaken on this option.

Alternative 4 – Pipeline Replacement

This analysis will include a comprehensive review of technology and design that could be used to replace the current pipeline crossing of the Mackinac Straits. The proponents have preliminarily established two viable options for this Alternative which will be fully-developed in the analysis:

i) **Conventional replacement**, which utilizes current state-of-the art offshore technology to design, construct and install a pipeline, buried in a trench through the length of the Straits crossing; and,
ii) **Tunneling**. Since the time of the original installation of Enbridge Line 5, tunneling technology has evolved to a point where it is no longer considered to be unconventional or technologically challenging to install utility infrastructure, such as pipelines in tunnels beneath oceans, rivers or lake beds that are too long to be considered for horizontal directional drilling. Such tunnels have advantages over other types of installations, in part, because they provide a self-contained environment that is isolated from the natural environment by sealed, concrete walls. Furthermore, a pipeline that is contained within a sealed tunnel can be accessed at any time for routine inspection and maintenance. An added benefit of a tunnel crossing is that it is well suited to existing hydrocarbon detection technologies that can be deployed within the tunnel to detect leaks that would otherwise be below the detection limits of a conventional liquids pipeline mass balance system.

For each of the above two options, quantitative evaluations of failure probability and associated release magnitudes will be made for the replacement pipeline infrastructure. This will serve as the basis of a risk assessment for the replacement pipeline infrastructure, wherein risk is defined as the probability of incurring a release and the associated consequences of a release. These consequences will be characterized in the following terms:

i) Potential public health and safety impacts;
ii) Potential environmental impacts;
iii) Potential natural resources damages, including, but not limited to, damages to the Great Lakes;
iv) Potential response and clean-up costs; and
v) Potential economic impacts to the Great Lakes Region.

Alternative 5 – Existing Pipeline

This analysis will include a comprehensive engineering analysis of the current condition and operation of the existing pipelines. The comprehensive engineering analysis of current conditions will include a review of the Enbridge integrity standards for the pipeline and protocols for detecting and responding to deviations from those standards. The analysis will also consider how long the existing pipelines can reasonably be operated without replacement as well as the course of action for replacement based on the estimated useful life of existing pipelines. This analysis will form the “base case” risk assessment to which all other Alternatives can be compared.

In addition, quantitative evaluations of failure probability and associated release magnitudes will be made for the existing pipeline infrastructure. This will serve as the basis of a risk assessment for the existing pipeline infrastructure, wherein risk is defined as the probability of incurring a release and the associated consequences of a release. These consequences will be characterized in the following terms:

i) Potential public health and safety impacts;
ii) Potential environmental impacts;
iii) Potential natural resources damages, including, but not limited to, damages to the Great Lakes;
iv) Potential response and clean-up costs; and
v) Potential economic impacts to the Great Lakes Region.

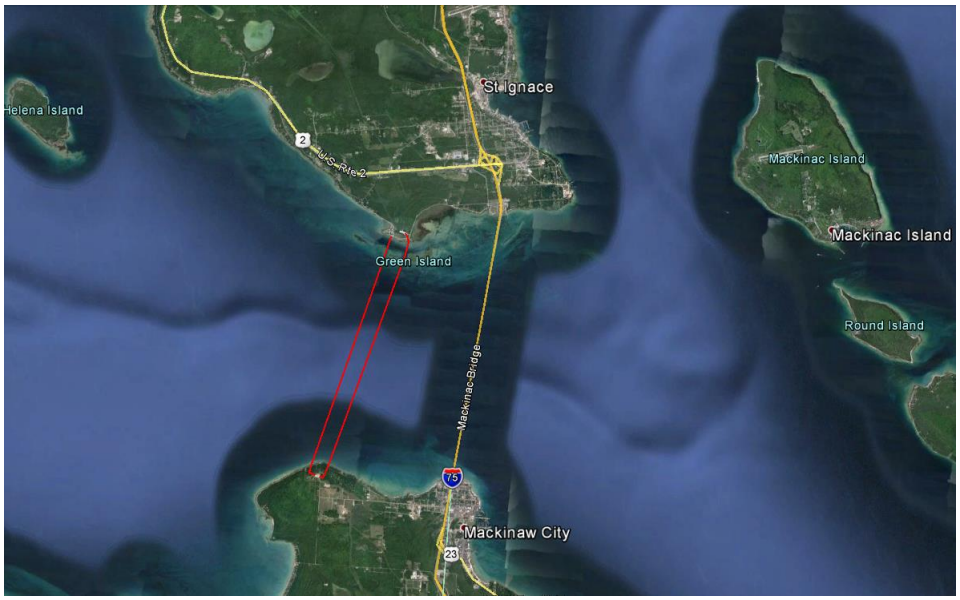
<u>Alternative 6 – Decommissioning the Pipeline</u>

The analysis will consider the feasibility and impacts of two scenarios:

a. Relying on other existing pipeline infrastructure to transport to market the petroleum products and NGLs currently transported through the Straits of Mackinac segment of Enbridge's Line 5.
b. No longer transporting to market the petroleum products and natural gas liquids currently transported through the Straits of Mackinac segment of Enbridge's Line 5 and the remainder of Line 5 located within Michigan

For Scenario (a), the analysis will assess alternative options for transportation of Line 5 volumes to current delivery points south of Mackinac Straits.

For both Scenarios (a) and (b), the analysis will only consider the potential economic impacts to the Great Lakes Region.



Straits of Mackinac – Pipeline Crossing

3 Business Organization (III-A)

Dynamic Risk is a privately held corporation that has been in business since 1996. Our main offices are Calgary, Alberta, Canada; Houston, Texas; Sault Ste Marie, Ontario and Boston, Massachusetts.

3.1 Primary Organization

Dynamic Risk Assessment Systems, Inc.
Privately held corporation
Head Office:
#208, 1324-17th Avenue SW,
Calgary, Alberta T2T 5S8
Designated point of contact: Jim Mihell, Chief Engineer
Phone: (705) 942.4189
Jim_mihell@dynamicrisk.net

3.1.1 Subcontractors

DHI USA Colorado
141 Union Blvd Ste 250,
Lakewood, CO 80228,
Designated point of contact: Tom Foster, EVP, Regional Director – Pacific Management
Phone: (813) 831-4700
tmf@dhigroup.com

Stantec
340 – 1200 59th Avenue SE, Calgary AB T2H 2M4
Designated point of contact: Ziad Saad, Vice President, Pipelines
Phone: (587) 349-5516
Ziad.Saad@stantec.com

H.J. Ruitenbeek Resource Consulting Limited
Privately held corporation
875 Buttercup Road
Gabriola, BC
Designated point of contact and supervisor: Jack Ruitenbeek, President
Phone: (250) 247-9630
ruitenbeek@mac.com

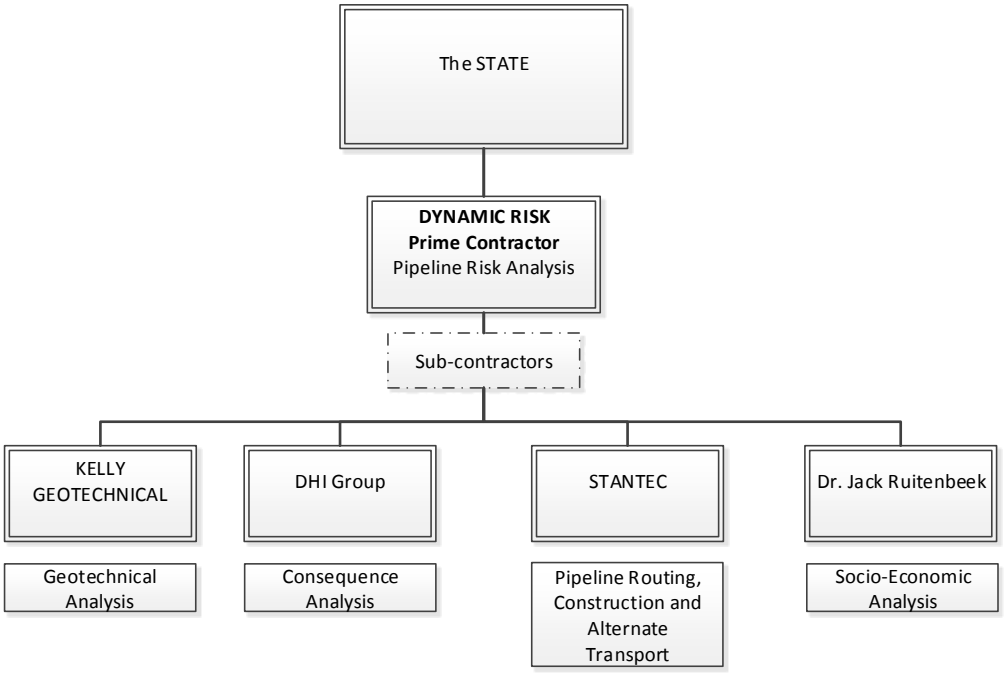
Kelly Geotechnical
Privately held corporation
2959 Ridgeview Dr.
Prince George BC V2K 3T5
Designated point of contact and primary supervisory: Shane Kelly, President
Phone: (778) 415-5234
shane@kellygeotechnical.ca

4 Qualifications and Relevant Experience (III-B)

The following section provides an overview of the project team, companies and company experience that will be conducting the Independent Alternatives Analysis for the Straits Pipelines.

4.1 Project Organizational Chart

Dynamic Risk would act as the Prime Contractor with the State of Michigan and be responsible for all reporting, communication and project deliverables from the project team.



4.2 Project Team

The following table is the proposed project team and their primary roles for the Independent Alternatives Analysis for the Straits Pipelines. Corresponding curricula vitae (CVs) for each team member can be found in Appendix A.

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
Dynamic Risk	Jim Mihell	Technical Lead / Chief Engineer	Technical Leader - project oversight, review and technical guidance. Senior technical resource assigned based on scope/requirements.	Alternatives 1, 2, 3, 4, 5

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
Dynamic Risk	Patrick Vieth	Project Sponsor / Sr. Technical Lead	Responsible for the strategic relationship between all parties. Works closely with the State and Project Manager on communications and progress reporting. Technical advisor and resource.	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Phillip Nidd	Senior Pipeline Risk Expert	Sr. Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Ben Mittelstadt	Sr. Engineer	Sr. Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Nasim Tehrany	Intermediate Engineer	Pipeline Risk and Integrity technical support	Alternatives 1, 2, 3, 4, 5
Dynamic Risk	Bill Ho	Sr. Project Manager	Single point of contact during project execution phase. All project management duties, including communication, scheduling and budget control.	Alternatives 1, 2, 3, 4, 5
DHI	Tom Foster	Technical Lead	Quality Control and overall technical oversight	Alternatives 1, 2, 3, 4, 5
DHI	Dale Kerper	Principal Coastal Engineer	Project Manager / Sr. Hydraulic Support and Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Dr. Guillaume Drillet	Aquaculture	Sr. Aquaculture Support and Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Henrik Skov	Seabird Monitoring	Impact assessment and baseline investigations on birds and marine mammals	Alternatives 1, 2, 3, 4, 5
DHI	Dr. Laura Johnson	Assistant Professor of Biology	Water Quality Analysis	Alternatives 1, 2, 3, 4, 5
DHI	Morten Rugbjerg	Senior Project Manager and Marine Forecasting Coordinator	Oil spills impact assessment, and forecasting	Alternatives 1, 2, 3, 4, 5
DHI	Sonja Pans	Senior Environmental Impact Specialist	Environmental Impact Assessments and Marine Feasibility Studies	Alternatives 1, 2, 3, 4, 5

Company	Name	Project Role	Role Description/Responsibilities	Project Tasks
H.J. Ruitenbeek Resource Consulting Ltd.	Jack Ruitenbeek	Sr. Economist	Sr. Economic and Societal Consequence Support and Analysis	Alternatives 1, 2, 3, 4, 5, 6a, 6b
Stantec	Jim Kenny	Sr. Pipeline Engineer	Technical leader for new pipeline design routes	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Dr. Erez Allouche	Sr. Technical Lead Underground Infrastructure	Technical leader for alternative pipeline options such as tunneling	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Andy Purves	Sr. Technical Support Pipeline Design and Construction	Pipeline design and construction for new pipeline routes	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Harold Henry	Sr. Technical Support Pipeline Construction	Pipeline design and construction for new pipeline routes	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Rick Ponti Jr.	Sr. Technical Support Pipeline Tunneling	Technical design and modeling for pipeline tunneling option	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Riyaz Shivji	Sr. Technical Support - Terminals and Overland Transportation	Technical design and modeling of Terminals and Overland Transportation	Alternatives 1, 2, 3, 4, 6a, 6b
Stantec	Steven Pierce	Sr. Technical Support Rail	Technical design and modeling of Rail option	Alternatives 1, 2, 3, 4, 6a, 6b
Kelly Geotechnical	Shane Kelly	Sr. Geotechnical Engineer	Geotechnical failure probability analysis	Alternatives 1, 2, 3, 4, 5
Kelly Geotechnical	Dr. Brian Bornhold	Marine Geoscience Consultant	Sr. Pipeline Marine Geotechnical Support and Analysis	Alternatives 1, 2, 3, 4, 5
Kelly Geotechnical	Dr. Rodney Read	Sr. Geotechnical Engineer	Sr. Pipeline Geotechnical Support and Analysis	Alternatives 1, 2, 3, 4, 5

4.3 Corporate Overviews, Relevant Experience, References

4.3.1 Dynamic Risk Company Overview

Dynamic Risk is recognized across the liquids and natural gas pipeline industries for our expertise in pipeline risk, integrity and safety management systems. As well, our engineering services and technology solutions help to ensure compliance with applicable regulations and standards. Through these services and solutions, we support decision making across the entire pipeline life-cycle from design to decommissioning with a focus on the risks associated with loss of containment.

We are celebrating our 20th Anniversary in 2016 and have maintained regulatory support and risk and integrity management as our sole focus since our founding. Our primary mission is improve the safety and reliability of pipeline systems with a goal of eliminating pipeline failures.

Our company, executives, engineers and subject matter experts are active industry leaders and have strong reputations with federal and local regulators in both the U.S. and Canada.

We work regularly with interstate and intrastate pipeline system operators. As such, we remain well-versed in federal and local pipeline safety regulations that they must operate under.

Dynamic Risk is also a leader in quantitative risk analysis for the pipeline industry. Our professionals have developed risk algorithms that have shaped the standards for the oil and gas industry.

4.3.2 Safety

A priority at Dynamic Risk is the protection of its employees, contractors, clients and visitors from injury or hazardous situations. Dynamic Risk is committed to developing, implementing and enforcing policies and procedures that promote and provide a safe and healthy work environment for everyone. In meeting our commitment, Dynamic Risk will comply with applicable workplace health and safety legislation, as well as adhere to the applicable policies and procedures of our clients.

4.3.3 Data Governance, Quality Control, Project Accountability

Dynamic Risk has a defined protocol for data governance including the security of information, document control and tracking, retention of documents, and version control. In order to ensure the traceability and security of information produced through various mechanisms (document production, interviews, references, etc.), this procedure provides the necessary guidelines and protocols that should be followed.

Dynamic Risk maintains the highest standards of quality for all of its projects. This is achieved through hiring of qualified individuals, training, and review of the final work product. The program defined in the Dynamic Risk Quality Assurance (QA) Manual will be implemented and followed to ensure quality.

Dynamic Risk follows the PMBOK methodology to ensure delivery of our project on time and budget. The project management process used comprises the five process groups as stated in Project Management Body Of Knowledge (PMBOK) for a project:

- Initiating
- Planning
- Executing
- Monitoring and Controlling and
- Closing

A project manager will be assigned and will be the single point of contact (SPOC) for the project for day to day communications. The Project Manager and Technical Lead will be responsible for managing and controlling the progression of project activities through its lifecycle. The Project Manager will establish a comprehensive project plan, work breakdown structure (WBS), project schedule and RACI chart. The plan will outline and define the processes required to plan, organize, control and mitigate project risks.

Any issues encountered that affects quality, scope, schedule or budget the escalation process is for the SPOC to involve the Project Sponsor. The Project Sponsor will work directly with the client and project team to immediately resolve issues.

4.3.4 Dynamic Risk Project Team Relevant Experience

Consulting to Government Agencies

- Provided independent expert review and input for the negotiation of the Consent Decree between US Department of Justice / US Department of Transportation and El Paso Natural Gas, subsequent to the Carlsbad NM pipeline failure (2007-2010).

- Provided independent expert review of Enbridge Line 9B integrity on behalf of the Government of Quebec Ministry of Sustainable Development, Environment, Wildlife and Parks. A copy of the public report can be found at http://www.mddelcc.gouv.qc.ca/evaluations/enbridge_en.pdf
- An independent assessment of the current and planned inspection programs for crude oil transport piping sections located at the Valdez Marine Terminal (VMT). Inspectability of Piping at Valdez Marine Terminal conducted for the Prince William Sound Regional Citizens' Advisory Council, August, 2014.

Hearing support:

- Alberta Utilities Commission, Application No. 20412-A001, Proceeding No. 20512, ATCO Pipelines Southwest Edmonton Connector Project. Provided oral testimony and written evidence on matters related to pipeline risk. November, 2015.
- Alberta Energy Regulator, Application No. 18006873, Pembina Pipeline Corporation Fox Creek to Namao Junction Expansion Pipeline Project. Provided oral testimony and written evidence on matters related to pipeline risk. September 2015 – October 2015.
- Alberta Utilities Commission, Application No. 1608617, Proceeding ID No., 1995, ATCO Pipelines Urban Pipeline Replacement Project. Testified as an expert witness and provided written evidence on matters related to pipeline risk, September, 2013.
- National Energy Board, Hearing Order OH-001-2014, Trans Mountain Pipeline Expansion Project. Submitted written evidence on matters related to pipeline risk, April, 2014 – July, 2015. https://docs.neb-one.gc.ca
- British Columbia Utilities Commission, Hearing Order C-11-15. FortisBC Energy Inc. Lower Mainland Intermediate Pressure System Upgrade Project. Submitted written evidence on matters related to pipeline risk, December, 2014 – February, 2015
- Joint Review Panel for the Enbridge Northern Gateway Project, Hearing Order OH-4-2011. Provided written evidence and testified as an expert witness as a member of the Engineering Panel and Kitimat Valley Panel on matters related to pipeline risk, October 2012 – March 2013. https://www.ceaa-acee.gc.ca/050/documents/57077/57077E.pdf
- National Energy Board Technical Conference: Estimation of Reliability for TCPL Line 100-1 Conversion to Oil Service Keystone Pipeline Application, November, 2009

4.3.5 Dynamic Risk Project References

In addition to the above projects, Dynamic Risk has worked extensively in the areas of quantitative risk analysis for pipelines. The following is a representative list of projects that include similar methodologies to that being proposed for the Straits Alternatives project.

ATCO Pipelines	**ATCO Pipelines**
Company Details	
In Brief: Risk and integrity management solutions provided include: ○ Consequence analysis (QRA), ○ Regulatory and hearing support ○ System-wide class analysis ○ Quantitative risk assessments for new construction projects. ○ Pipeline risk and integrity management solution implementation	ATCO Pipelines owns and operates natural gas transmission facilities throughout Alberta to transport clean, efficient energy from producers and other pipelines to utilities, power generators and major industries. ATCO Pipelines owns and operates approximately 8,500 kilometers of pipeline with peak delivery of 3.8 billion cubic feet of natural gas per day
Reference Contact Details	
Name Bob Johnston	**Title** Senior Manager, Operations Regulatory Email: Bob.Johnston@atcopipelines.com

Fortis B.C.

Company Details

In Brief:

Risk and integrity management solutions provided include:

- Consequence analysis (QRA),
- Regulatory support
- Engineering analysis and assessment
- Facilities risk assessment

Fortis BC is a Canadian owned and operated company providing approximately 1.1 million customers across BC with energy for their homes, schools and businesses. From electricity, natural gas and natural gas for transportation to propane and thermal energy, Fortis BC delivers approximately 21% of the total energy consumed in BC. This is more than any other utility in the province. Fortis employs approximately 2,200 employees.

Reference Contact Details

Name	Title
Bryan Balmer	Manager, Systems Integrity Programs Email: bryan.balmer@fortisbc.com

PEMBINA	**Pembina Pipeline Corporation**

Company Details

In Brief:

- Engineering analysis support, consequence analysis (outflow and valve optimization analysis) and pipeline design
- Regulatory approval support
- Full IRAS risk and integrity management solution implementation
- Annual ILI, excavation and integrity data management support

Pembina owns and operates pipelines that transport various hydrocarbon liquids including conventional and synthetic crude oil, heavy oil and oil sands products, condensate (diluent) and natural gas liquids produced in western Canada. Pembina also own and operate gas gathering and processing facilities and an oil and natural gas liquids infrastructure and logistics business. With facilities strategically located in western Canada and in natural gas liquids markets in eastern Canada and the U.S., Pembina also offers a full spectrum of midstream and marketing services that spans across its operations.

Reference Contact Details

Name	Title
Greg McKenzie	Senior Manager, Pipeline Integrity, Integrity & Technical Services Email: GMckenzie@pembina.com

KINDER MORGAN CANADA	**Kinder Morgan Canada**
Company Details	
In Brief: Risk assessment and integrity data management solutions include: ○ Quantitative Risk analysis and management solution ○ ILI, Excavation and Inspection Data integration and management ○ Integrity data and program management support ○ Outflow analysis and valve placement analysis ○ New construction planning and risk based design ○ Regulatory and hearing support	Kinder Morgan Canada operates a number of pipeline systems and terminal facilities including the Trans Mountain pipeline, the Cochin pipeline, the Puget Sound and the Trans Mountain Jet Fuel pipelines, the Westridge marine terminal, the Vancouver Wharves terminal in British Columbia and the North Forty terminal in Edmonton, Alberta. Trans Mountain currently transports approximately 300,000 barrels per day (bpd) of crude oil and refined petroleum from the oil sands in Alberta to Vancouver, British Columbia and Washington state. We are pursuing a proposed $5.4 billion expansion of Trans Mountain, which would increase capacity to 890,000 bpd. Canadian producers and oil marketing companies have signed firm contracts supporting the project for approximately 708,000 bpd. Pending regulatory approvals, Kinder Morgan expects the expansion to be completed in the third quarter of 2018.
Reference Contact Details	
Name Paul Huddleston	**Title** Senior Director, Engineering and Technical Services Email: Paul_Huddleston@kindermorgan.com

4.4 DHI Company Overview

DHI are global leaders in water environments with 50 years of dedicated research and real-life experience from more than 140 countries. They have modeled the effects of oil spills in marine environments and are widely recognized as the top experts in this area.

AREAS OF EXPERTISE

Our expertise spans all water environments – from rivers and reservoirs, to oceans and coastlines, to cities and factories. Using our global knowledge, our local teams develop solutions and provide specialized services to solve your specific water challenges.

- Aquaculture and agriculture
- Energy
- Climate change
- Surface and groundwater
- Urban water
- Industry
- Environment and ecosystems
- Product safety and environmental risk

OUR PEOPLE ADVANCE OUR GLOBAL KNOWLEDGE AND DELIVER IT LOCALLY

Our highly qualified staff (80% hold an MSc or a PhD) constantly advance our knowledge in water environments. They make this knowledge accessible to our clients and partners.

OUR CLIENTS, OUR PARTNERS

To drive successful projects, we work closely with our clients. We are committed to addressing their specific challenges. We become their trusted advisors because professional integrity is fundamental to us. The clients we work with range from decision makers to water professionals:

- Public authorities and government organisations
- Industry sectors such as ports, water utilities, energy, infrastructure and transportation companies
- Consulting engineers and contractors

4.4.1 DHI - Relevant Experience

DHI will be completing the oil spill fates and effects analysis component of the risk assessment.

Great Lakes Project Experience

2015 – Ongoing	Operational Surge and Wave forecast system for Great Lakes	Development of an operational flood forecast system for the shoreline of the great lakes in collaboration with the Ontario Ministry of Natural Resources
2013	Design wave conditions at Carmeuse Lime & Stone site, Gary, IN	Hindcast of extreme wind waves in Lake Michigan in support of the design of a revetment protecting the lakeshore front of the project site.
2012	Lake Erie Surge Model - Phase 1, Canada	Development of a refined model mesh along the North-eastern shoreline of Lake Erie and validation of the hydrodynamic model MIKE 21 HD FM for the Great Lakes Storm Surge Operational System developed by DHI.
2011 - 2012	Fullerton Shoreline Protection Project - North Avenue Beach Sand Reuse Evaluation, Chicago, IL	Assessment of the impact of proposed lakebed sand extraction activities on littoral drift as part of the Fullerton Shoreline Protection Project using the spectral waves, hydrodynamics and non-cohesive sediment transport modules of MIKE 21 FM
2011	63rd Street Beach Water Quality Improvements, Chicago, IL	Investigated water circulation at the beach for existing conditions and after remedial interventions using the wave and hydrodynamic modules of MIKE 21 FM for different combinations of wind and waves in Lake Michigan.
2009 - 2010	Wave Study Extension for Chicago Marinas, Chicago, IL	The study included several numerical wave modelling tasks, such as wave hindcast (using PWAVE), propagation of extreme wind-waves (using MIKE 21 SW) and assessment of wave penetration and agitation (using MIKE 21 BW) to aid in the design of Gateway Marina within Chicago Harbor and a new marina at 31st Street.

Additional project experience relevant to this project include:

1) Oil spill modelling aids renewal of port terminal operating license

Brazilian law requires all port terminals – operating under national jurisdiction – to be equipped with an Emergency Plan to deal with possible oil pollution incidents. If a port operator fails to have a government-approved Emergency Plan, their license is not renewed. Our client – a port terminal operator – was in need of such an Emergency Plan. To support the Plan, we conducted an in- depth numerical oil spill modelling study. Based on our studies and contingency plans, our client submitted the Emergency Plan to the government for approval. The Plan was approved and the license was renewed.

Challenge

- Legal requirement of all port terminal operators within the Brazilian jurisdiction to develop an Emergency Plan for oil pollution incidents
- Requirement of detailed oil spill modelling to support the Emergency Plan
- Evident lack of adequate data to model possible oil spill scenarios in the area
- Risk of operational license not being renewed by the authorities, in case of failure to possess an approved Emergency Plan

Solution

- Detailed numerical oil spill modeling to support the Emergency Plan

Value

- Accurate and timely preparation of the Emergency Plan based on the oil spill modelling
- Renewed license awarded to the client

Location / Country

- Guanabara Bay, Rio de Janeiro, Brazil

2) Predicting strong currents accurately is vital for a trustworthy oil spill forecast system

An oil spill will cause havoc leaving widespread ecological and wildlife devastation in its wake. Thus, it has become crucial to model probable oil spills and their impacts. This is required to mitigate the destructive consequences of such spills, as much as possible. Our client – Coastal Dynamics Limited (CDL) conducts numerous oil spill trajectory studies for their own clients. However, they wanted to improve their services, with respect to better current information in the region. As such, the need arose for more advanced 3D hydrodynamic modelling. We provided the necessary software and knowhow for such in-depth oceanographic forecasting and 3D modelling setups, enabling our client to significantly improve their own services. Based on our expertise, their new forecast system is set to commence operations in 2013.

Challenge

- Accurately forecasting oceanographic currents, tidal currents and wind driven currents around Trinidad and Tobago
- Providing CDL clients with timely and trustworthy oil spill forecasts

Solution

- A calibrated oceanographic model for the Trinidad and Tobago area
- The software required to run daily forecasts of currents and water levels using the calibrated model
- An oil spill modelling software to run oil spill forecasts and oil spill scenarios
- The set-up of an operational current and oil spill forecast system at CDL premises, so CDL can provide its clients with oil spill forecasts

Location / Country

- Trinidad and Tobago

3) Oil and Environmental Risk Assessment

Authorities have asked DHI in cooperation with Norconsult and DNV to develop the first Environmental Risk Assessment and an oil spill response plan.

The Albertine Graben and the land along the shores of Lake Albert are among the most fragile environments in Africa, gifted with very high biodiversity and a wide range of habitats. This puts all types of oil-activities in a situation, where even small accidents may have far-reaching consequences for the environment.

DHI has been responsible for developing the Environmental Risk Assessment and to turn the outcome from the assessment into an application in Google Earth. The application gives the authorities and other stakeholder's fast access to information about each well site, distances to vulnerable habitats, distance to oil spill response equipment and information about potential risk of blow-outs and other exploration-related accidents.

DHI has the assignment to carry out the Environmental Risk and Impact Assessment and the results will be used for both a sensitivity analysis and for providing the background for developing the Oil Spill Contingency Plan. The assessment will look at impacts that will potentially disturb the wildlife which may cause surface- and groundwater problems.

In support of the risk assessment DHI has conducted oil spill trajectory model studies on the lake.
The results from the sensitivity analysis will be used to create an online response-database with basic information about each exploration and production platform.

Location / Country

- Albertine Graben Area, Uganda

4) Hydrodynamic Modeling of Pollutants in Lake Mälaren

Lake Mälaren provides drinking water for around 2 million people in Sweden. Norrvatten and Stockholm Vatten are two main water distributors of this fresh water source. To ensure the drinking water quality it's important to be aware of potential risk and threats to the raw water intakes, such as oil spill, viruses, pathogens etc. Norrvatten has commissioned DHI Sweden to set up a hydrodynamic model of the lake Mälaren in order to assess the spreading of various pollutants and potential threats to the water inlets.
The model is set up using DHI's modeling software MIKE by DHI and consist of a coupled hydrodynamic, oil spill and advection-dispersion model. The model simulates how pollutants in the lake are spread under various weather and current conditions, providing a good view of the effect on the raw water quality used for drinking water. The model will be used for decision support in emergency situations as well as for contingency planning purposes and risk and vulnerability assessments.

Location / Country

- Lake Mälaren / Sweden

4.5 H.J. Ruitenbeek Resource Consulting Limited (HJRRCL) Company Overview

HJRRCL is a Canadian private corporation and has been providing economic consulting services to the energy industry and international development community since 1981. Its president – Dr. Jack Ruitenbeek – provides hands on oversight to all of its active assignments, and personally specializes in the economic analysis of social and environmental risks and consequences of private and public investments. The firm prides itself in providing independent scientifically sound policy advice and its clients have included landowner organizations, NGOs, international development organizations, national and local governments, and private sector corporations. Its experience in over 70 countries has included teaching other practitioners in the methods of socio-economic assessment, economic risk management, cost benefit analysis, and the economic valuation of environmental impacts. It has developed tailor made model structures based on best science for landscape approaches to spatial planning, and for decision making in integrated coastal zone management.

HJRRCL has collaborated with Dynamic Risk in developing tools that permit transparent integration of risk (probabilities) and economic consequences for inclusion in socio-economic impact assessments, cost benefit analyses, and evaluations of financial liability. These tools have passed the scrutiny of regulatory processes associated with energy sector projects including natural gas infrastructure in British Columbia (Fortis Energy) and large scale oil pipeline projects (Enbridge Gateway, Kinder Morgan TransMountain Expansion). Such tools and the rigor of the hearing process ensure that scientifically valid methods can be tested by all interested parties.

HJRRCL also maintains its own valuation database of marine and terrestrial spill cleanup and damage costs, through ongoing research and through confidential assessments of specific hazards considered by various clients, insurers, and evaluators for claims relating to oil spills. This is complemented by in-house quality assurance of publicly available valuation databases used for resource damage assessments (including the Environmental Valuation Reference Inventory [EVRI] database of literature maintained by Environment Canada). For socio-economic impact analysis in the United States and Canada, HJRRCL relies on the use of publicly available impact modeling tools (such as the CANSIM input-output accounts maintained by Statistics Canada and RIMS II maintained by the US Department of Commerce – Bureau of Economic Analysis); this ensures results are transparent, replicable, and based on most recent available structural information of the economies being evaluated.

4.5.1 HJRRCL - Relevant Experience

Trans Mountain Expansion, Kinder Morgan, Economic Studies

Provided expert evidence to the National Energy Board relating to the project's benefits, costs, and potential liabilities and costs associated with worst case spills from proposed expansion pipeline. The scope of the work in the public interest analysis included: original analyses regarding potential financial liability costs; associated with spills; reviews of cost benefit analyses of pipeline and various alternatives; socio-economic impact analysis including income, jobs and taxation impacts; reviews of evidence relating to municipal and regional brand valuation; cleanup cost from spills into terrestrial, riparian, and marine environment from tankers, barges, pipelines and terminal; damage costs (NRDA) associated with spills; government costs of spills in Canada and Washington State; costs to Canadian First Nations and US Tribes of spills. Provided selected expert reply evidence on costs of industrial and transportation accidents including refinery explosions and rail spills (Lac Mégantic). [2013-February 2016]

British Columbia Lower Mainland System Upgrade Project, Fortis Energy
Authored a study and provided expert evidence relating to the economic consequences of investments in gas pipeline upgrades that would potentially impact 250,000 customers. The economic study combined risk analyses with economic consequence analyses to inform regulatory proceedings before the BC Utilities Commission. [2014-2015]

Enbridge, Northern Gateway Pipelines Project, Economic Studies
Provided expert evidence to the National Energy Board relating to the project's benefits, costs, and potential liabilities and costs associated with worst case spills from one or both proposed pipelines (diluent and dilbit). The scope of the work in the public interest analysis included: cost benefit analyses of pipeline and various alternatives; socio-economic impact analysis including income, jobs and taxation impacts; cleanup cost from spills into terrestrial, riparian, or marine environment; damage costs (NRDA) associated with spills; impacts of spill costs on tariffs; and, potential financial liability costs. [2012-2013]

Measurement of Ecosystem Goods and Services (MEGS) in Canada, Statistics Canada
Authored a study that draws on three decades of international experience that summarizes the scientific basis of valuation and the different methods for conducting economic valuation for ecosystem goods and services. Included assessments of socio-economic and environmental valuation in riparian and great lakes context. [2011-2012]

Socio-Economic and Environmental Assessment, BC Ministry of Agriculture and Lands
Authored a study to present the findings of a research program spearheaded by the Strategic Land Policy and Legislation Branch of the Crown Land Administration Division in the British Columbia (Canada) Ministry of Agriculture and Lands. The general objective of the program was to provide a practical treatment of environmental and socio-economic valuation methods in land use planning in BC. Specifically, the overall project considers how Total Economic Value (TEV) can be introduced into land-use planning decisions. The work provided review material, and through concrete examples in BC, illustrates how TEV can inform and be informed by the Socio-Economic and Environmental Assessment (SEEA) process. [2008]

Economic Methods for Planning in Integrated Coastal Zone Management, World Bank / Yucatan Mexico
Edited and contributed to volume of economic analyses associated with ICZM in Mexico. Scope included analyses of coastal hazards (hurricanes, oil spill pollution, domestic pollution, erosion) and evaluating economic impacts and mitigation mechanisms for these hazards. Valuation work involved social impact assessment including "Social Accounting Matrix" methods, natural resource damage assessments, human health valuations, use of market-based instruments for environmental management, and land value changes from natural disasters. [2015-2016]

Gulf War Spills Liability and Impact Measurement, IUCN/UN Compensation Commission
Evaluated claims for environmental, natural resource, human health, and other damages associated with oil spills and fires during Gulf War (Kuwait).

Other Selected Energy Sector Assignments Involving Benefit Cost Analysis, Socio-Economic Impact Analysis, Compensation Valuation, and Risk Analysis

- Rim Gas LNG Export, Petro-Canada, Westcoast, and Mitsui Application
- Saskatchewan Heavy Oil Upgrader Project

- Bentpath Pool, Union Gas Natural Gas Storage Compensation
- Slave River Hydroelectric Project
- Shell Peace River In-situ Project
- NEB Natural Gas Export Hearings
- Natural Gas Straddle Plant Project, Alberta
- Sour Gas Development (Caroline Gas Field, Alberta)
- BP North Sea Horizontal Drilling Evaluations
- Baltic Oil Spill Valuations (Peer Reviewer)

Regulatory

Dr Ruitenbeek has appeared as an expert witness providing opinion evidence to numerous regulatory authorities including: National Energy Board (Canada), British Columbia Utilities Commission, Alberta Energy Resources Conservation Board, and the Ontario Energy Board. Topics included cost-benefit analysis, terrestrial marine spill costs and risks, economic impact analysis, economic valuation of environmental damages, socio-economic consequence analysis, and financial liability evaluations.

4.6 Stantec Company Overview

We're active members of the communities we serve. That's why at Stantec, we always design with community in mind. The Stantec community unites more than 15,000 employees working in over 250 locations. Our work—professional consulting in planning, engineering, architecture, interior design, landscape architecture, surveying, environmental sciences, project management, and project economics—begins at the intersection of community, creativity, and client relationships. With a long-term commitment to the people and places we serve, Stantec has the unique ability to connect to projects on a personal level and advance the quality of life in communities across the globe.

Oil & Gas

From the Arctic to the Canadian oil sands and the US shale plays, our Oil & Gas team partners with clients to provide engineering, procurement, construction management (EPCM), permitting, survey and environmental services across the upstream, midstream, and downstream oil and gas industry. We design facilities, pipelines, terminals, and refineries as well as critical infrastructure like processing plants and field facilities. Whether you're creating a new asset or optimizing your existing operations, our team will work with you from conceptual engineering through to construction. Through our partnerships, industry experience, and use of technology, we develop new and inventive ways to solve emerging issues, meet regulations, and increase productivity.

4.6.1 Stantec - Relevant Experience

Pipeline Projects

Pacific Trail Pipeline Project, Prince George / Kitimat, British Columbia, Chevron Canada
Prime Consultant, FEED / detailed engineering

Description of work performed by the Proponent.
For the Pacific Trails Pipeline, we provided design services for a 480 km, 42 inch gas pipeline across the province of British Columbia, near Prince George to Kitimat.

The pipeline crosses three physiographic regions, including the Interior Plateau, the Hazelton, and the Coast Mountains. Each of these regions is characterized by differing terrain and climatic conditions that pose challenges to construction and on-going pipeline operation. We designed unique pipeline sections to account for these challenges. The designs also included a head compressor station and associated meter stations at Summit Lake.

March, 2012 – December, 2015

Energy East Pipeline, Alberta to New Brunswick, Trans Canada Pipelines
Prime Consultant, FEED Engineering

Description of work performed by the Proponent.
FEED services for a crude oil pipeline system that extends from Hardisty, Alberta to St. John, New Brunswick. The pipeline will provide transportation for Western Canadian crude oil production to refineries and terminals in Québec and New Brunswick. The project consists of new NPS 42 pipelines in Alberta, Eastern Ontario, Québec, and New Brunswick, and the conversion of an existing TransCanada NPS 42 mainline located within Saskatchewan, Manitoba, and Ontario from natural gas to crude oil service. Some elements of detailed engineering were also completed. This project included a significant trenchless crossing component which is described in detail in the tunneling section below.

March, 2013 - Ongoing – regulatory support activities

Brunswick Pipeline, New Brunswick, Emera New Brunswick
Prime pipeline consultant

Description of work performed by the Proponent.
The Brunswick Pipeline is a high pressure natural gas transmission pipeline in the province of New Brunswick. The pipeline transports Natural Gas from the Canaport Liquefied Natural Gas terminal located in Saint John, New Brunswick to St. Stephen, New Brunswick where it is tied in to Maritimes & Northeast Pipeline (M&NP). The pipeline is 145 km in length and 30” in diameter.

Stantec completed detailed design and engineering support during construction for the pipeline. This project included a number of terrain and soil challenges. Of particular similarity to the pipeline subject of this proposal, the Brunswick pipeline traversed section of acid rock and the Stantec team successfully engineered mitigation measures to ensure pipeline and the environment are protected within those sections of pipeline.

March, 2008 - August, 2009

Keystone Pipeline, Alberta to US Mid-West, Trans Canada Pipelines
The Keystone Pipeline is a "bullet" pipeline – stretching 3,460 kilometres from Alberta to Illinois and Oklahoma without any intermittent supply or receipt points. At Stantec, we're proud to have been part of its development. Connecting TransCanada to its markets. Connecting North Americans with energy.

Stantec's pipeline experts provided direct input to regulatory, project management, engineering, and environmental services for the Canadian portion of the project, and supported many other project groups required to successfully put the pipeline system into service. Beginning in Hardisty, Alberta, we guided the Canadian portion of the Keystone pipeline that runs east into Manitoba, turns south, and crosses the border in North Dakota.

Our team handled the design and installation of 375 km of new NPS 30 pipeline and the conversion of 864 kilometres of existing NPS 34 pipeline from natural gas to crude service. We followed this up with a similar program for the Keystone Expansion Project, which included 550 kilometres of new NPS 36 pipeline from Hardisty to Monchy, Saskatchewan.

Our commitment to TransCanada and the communities in which it operates also led to activities on the US portion of the pipeline. Overseeing the day-to-day activities of the design and construction companies, one of our project managers was retained as a key individual within the construction support team. His role involved planning and organization in support of the construction contract and ongoing contractor interfacing, issues resolution, and cost control.

Tunneling Projects

Downtown Intensification Storm Trunk – Edmonton, Alberta – City of Edmonton – Soft Ground Tunnel in Soil
Prime Consultant

Description of work being performed by the Proponent.
The City of Edmonton is planning for significant infill development and higher density redevelopment in the City's downtown core. The downtown area is serviced by a combined sewer system, which is at capacity. To allow for the planned infill and redevelopment, additional capacity is being made available in the existing combined sewer system by separating storm water inflows and conveying them in dedicated storm sewers. To provide an outlet for the new storm sewers the City is constructing a new storm trunk to collect the flows from the new storm sewers and convey them to the 111 Avenue storm tunnel. The new storm trunk is a total distance of almost 2.5 km. At 20 m to 25 m below ground through an established neighborhood in Edmonton's downtown core, tunneling is the only viable method for constructing the 2.4 m diameter storm trunk. The ground conditions consisted of clay till characterized with intermittent silt or sand layers ranging from 100 mm to 2 m in thickness.
Stantec services included:

- Preliminary surveys to confirm potential conflicts with buried and above ground infrastructure for locating working shafts. This included identification of building foundation tiebacks that could be in the tunnel zone.

- Preparation of terms of reference for obtaining geotechnical information and completing the necessary environmental assessments. The tunnel alignment crosses under the LRT tunnel at Jasper (101) Avenue, and separation and potential settlement of the LRT tunnel were key components feeding into the design.
- Preparation of the preliminary and detailed design drawings, including finalizing the horizontal and vertical alignments.
- Preparation of all submittals for the project including traffic management plans for areas around working shafts.
- Participation in the stakeholder involvement process including preparation of materials for and attendance at public open houses.
- Preparation of design-build tender documents for the south portion of the tunnel where it crosses the LRT tunnel.
- Working with the City's tunneling crews providing general engineering services and support for construction of the tunnel section north of Jasper Avenue.

August 2014 - December 2016

Ottawa Combined Sewage Storage Tunnel – Ottawa, Ontario – City of Ottawa – Hard Rock Tunnel
Prime Consultant

Description of work being performed by the Proponent.
Stantec is working with the City of Ottawa for achieving one of their priority goals which is achieve zero combined sewer overflows in an average year to the Ottawa River. To help the City meet this goal, Stantec completed an environmental assessment and functional alternatives evaluation including various combinations of localized or inter-linked CSO storage tanks, deep tunnels, and other forms of linear storage facilities. Final design documents based on the preferred alternative were developed and the project is currently in the bid phase. The project location is within the urban core of the City of Ottawa and includes 4.4 km and 1.6 km long rock tunnels predominantly in limestone and shale that will be excavated with a 3 m diameter pressurized face tunnel boring machine in order to provide 45,000 m3 of storage.

Stantec services include:

- Evaluated a wide range of options to identify the short-list of technically feasible alternatives. A storage alternative was assessed to be able to meet the functional objectives of the project and be constructible and operational at an acceptable level of risk to be considered viable. Feasible alternatives were further studied to determine the right balance among environmental, social, and economic factors that will benefit or be affected by the proposed works (triple bottom line analysis).
- Developed a preferred alignment and completed the environmental assessment.
- Developed an extensive subsurface investigation as well as environmental and laboratory testing program. The information supplied the data for design of all shafts in soil and rock and the tunnel components in rock for the project. Design services also included flow control

structures with bending weirs and vortex drop pipes and odor control facilities handling up to 17.5 m3/s.

- Developed complete set of tender documents including Contract Drawings, Contract Specifications, Risk Management Documents, Geotechnical Data Reports and Geotechnical Baseline Reports. The project is currently under the bid phase.
- Construction administration services will include review of contractor submittals as well as roles within the construction management team including but not limited to the lead tunnel Resident Engineer.

August 2013 - December 2019 (estimated)

City of Atlanta Raw Water Delivery System – Atlanta, Georgia USA – City of Atlanta – Hard Rock Tunnel
Major Sub consultant for all underground works

Description of work being performed by the Proponent.
Stantec is designing the City of Atlanta's top priority infrastructure project – the Raw Water Delivery System. Current infrastructure consists of components dating back to the 1890s, with critical portions well beyond their design life. The new system will move raw water from the Chattahoochee River to two water treatment plants and storage facilities and provide water sustainability for over 100 years. The project consists of 5 miles of 12.5-foot excavated diameter tunnels in hard and abrasive Gneiss bedrock, use of the 2.4 billion gallon Bellwood Rock Quarry for raw water storage (one of the largest in the world), design of major construction shafts, a raw water intake, and three pump stations. The tunnel varies in depth from 250 feet to over 500 feet.
Stantec services include:

- Performance of the geotechnical subsurface investigation program, TBM boreability studies, selection of the tunnel horizon, connection to the quarry, lining design, security measures, and surface works
- Design of all shafts and tunnel components of the project including development of construction tender documents including Contract Drawings, Contract Specifications, Geotechnical Data Reports and Geotechnical Baseline Reports
- Performed risk assessments and conducted risk workshops for the project to significantly reduce risk by selecting an alignment for the tunnel in the best rock horizon/geology with shaft locations that minimize impacts. Also implemented risk management tools and defined a living risk register for managing numerous risks associated with design, construction and overall implementation of the program.
- Currently performing construction administration services including review of contractor submittals as well as working with the construction management team for tasks associated with site geological mapping of the excavated rock shafts and tunnels, confirmation of the ground types for selection of initial support and involvement in the grouting program for controlling both infiltration and exfiltration of water.

March 2014 - September 2018 (estimated)

Sanitary Trunks and River Crossing – Fort McMurray, Alberta – Regional Municipality of Wood Buffalo - Soft Ground Tunnel through Soils
Prime Consultant

Description of work being performed by the Proponent.
Stantec worked with the Regional Municipality of Wood Buffalo to increase the capacity of their major sanitary trunk system to allow ongoing development in the lower town site and to the south to proceed. The overall project included upgrades to Lift Stations 1A and 1B, three open cut pipe installation contracts, plus a twin forcemain crossing of the Athabasca River using horizontal directional drilling technology. The twin forcemain crossings involved 900 mm HDPE pipes with the HDD portion being 1,345 m and 1,178 m long. The ground conditions consisted of clays and sand mixed with silts and gravel as well as the presence of very soft weathered limestone in a portion of the alignment.

Stantec services include:

- Alignment selection including river crossing location.
- Stakeholder consultations.
- Environmental assessments, including wildlife habitat and fish habitat, regulatory approvals.
- Site investigations including preliminary surveys and overseeing the geotechnical program.
- Pipe line design including the HDD sections.
- Preparation of prequalification documents and tender documents.
- Participating in a risk assessment.
- Construction services.

July 2007- November 2009

4.7 Kelly Geotechnical Company Overview

The business focus of Kelly Geotechnical is in providing geotechnical engineering input related to terrain analysis, geological hazard assessment, facility and corridor site selection, geotechnical design, as well as construction input for a range of projects related to resource and infrastructure developments in multi-disciplinary project team environments or as an Owner's Engineer advisory role. This focus draws from experience in the execution of projects from basic geotechnical site investigations, through more complex geotechnical engineering planning, design and geological hazard assessments, construction supervision, owner's engineer and community engagement work.

Terrain Analysis
Whether the project is small or large, upfront planning for where your project meets the ground is key to success. Knowledge of the terrain throughout your project area can assist in defining geotechnical considerations early in the feasibility stage of a project cycle and can assist in developing efficient construction solutions that save time and money. We have experience with evaluating terrain for projects of every size and are comfortable working in multi-disciplinary project teams. Terrain analysis may include assignments from desktop study levels using remote sensing data; or it may include large in-depth studies supported by detailed on-the-ground site investigation level data collection and interpretation to help you make the best choice for your project.

Geological Hazard Assessment
We have extensive experience in Geological Hazard Assessment that ranges from reconnaissance level and detailed level terrain stability assessments, as well as landslide investigations and remediation.

A Geological Hazard Assessment (Geohazard Assessment) consists of evaluating the response of the terrain to the changes associated with an existing or proposed project. Conversely, it can also take the form of predicting impacts that the terrain may have on an existing or proposed project. The process is tailored to the type and scope of development, but commonly includes a review of potential hazards in the area (Hazard ID); a desktop level and/or field study to evaluate the terrain within a project area and define potential hazard locations (Terrain Analysis) coupled with a review of the potential consequences of hazard occurrence using industry accepted frameworks. The process necessitates working closely with designers to potentially adjust project locations, designs, and/or construction methods where the identified hazards may exist at higher than acceptable risk thresholds.

Crossing Assessments
Whether as a stand-alone project, or within larger linear corridor level projects, crossings are key project areas where evaluating ground conditions is critical. Whether it's over or under; roads, rail, powerlines and pipelines cross streams and structures along their route. Assignments range from desktop level overview assessments through to detailed field investigations.

Kelly Geotechnical is experienced with crossing assessments for the transportation and pipeline sectors related to resource road and highways bridges as well as pipeline crossings from simple open excavation crossings to trenchless pipeline installation methods.

Facility and Corridor Siting
Using our experience and capabilities in terrain assessment / site investigation, and/or geological hazard assessment, let Kelly Geotechnical help with site selection to optimize the location where your project meets the ground. From pipeline river crossings, highway bridges, building locations, ski lift lines and many more, our assignments range from desktop level overviews through to detailed field investigations and designs.

Geotechnical Engineering Design
At the core of all our services is Geotechnical Engineering Design. We are experienced and capable of providing a broad range of engineered solutions to ground engineering problems. Our geotechnical engineering design experience is applied across the sectors we operate in and rooted with our experience in constructing through the complex ground conditions of Western Canada.

Our experience includes a wide array of earthworks and foundation designs for buildings, industrial structures, grading, bridges, crossings, and related infrastructure applications. From tack-on embankments for a new rail siding, highway or resource road; earthworks along your project corridor, or bridges and utility crossings we are experienced from concept review, preliminary layouts, and detailed design phases and are ready to meet your project needs.

Our experience includes routine field reviews to confirm the assumptions made in project development and planning stages; resident engineer assignments for Owner's Engineer roles; as well as field support for large scale site investigations, temporary excavation certifications, and other related site services.

4.7.1 Kelly Geotechnical - Relevant Experience

Dynamic Risk Assessment, Enbridge Pipelines Minnesota, 2015 to present: Project geotechnical engineer responsible for completing a semi-quantitative geohazard assessment at 8 proposed pipeline watercourse crossings for 2 proposed liquids transmission pipeline projects proposed through the state of Minnesota and border of North Dakota.

Hatch Mott MacDonald, PRGT Pipeline Design Support, 2015/16: Project geotechnical engineer responsible to provide geotechnical design support related to select geohazard assessments for 5 short segments of the overall pipeline route. Also provided geotechnical engineering support related to pipeline engineering integration of geohazard considerations for the project. PRGT pipeline is a proposed NPS48 natural gas pipeline project from northeast BC to Prince Rupert, BC.

Valemount Glacier Destinations, Proposed Resort Development, 2015 to present: Geotechnical engineer responsible for conducting a preliminary rockfall geohazard assessment and route geotechnical assessments for resort access and construction roads as part of the pre-development permitting and planning. The project includes a ski resort and village development with several km of new access roads to be constructed to provincial standards, as well as many lifts and alpine stations as part of the final project footprint near Valemount, BC.

Enbridge Inc., Geotechnical Assessment, Proposed Natural Gas Pipeline Route, 2015: Project geotechnical engineer responsible for assessing a proposed pipeline route for the project development team. Work included desktop terrain assessment and development of documents for the proponent to discuss project scoping from a geotechnical perspective.

Northern Gateway Pipelines Inc., Northern Gateway Pipeline Project, 2005 to 2015: Roles including Project geotechnical engineer through to Enbridge Geotechnical Program Manager for the proposed 1176 km Northern Gateway Pipeline Project from Bruderheim, AB to Kitimat, BC. Responsibilities included increasing roles from conducting geotechnical assessments through to managing the overall project geotechnical program for the project. Project included analyses of; a marine terminal site (20 million barrel storage and shipping transfer components); two 6.5 km long tunnel routes through the Coast Mountains; pipeline routing assignments and alternatives review, establishing and conducting a semi-quantitative geohazard assessment process; conducting detailed geohazard assessments of marine clay and submarine landslide hazard issues, and examining select pipeline routing and trenchless river crossing locations throughout BC and AB. Additional roles included technical liaison for investigation permitting through British Columbia, public presentations for geotechnical topics, generating documents for, testifying at, project National Energy Board hearings, and managing geotechnical engineering contractors for the project.

Alaska Pipeline Project / WP Canada, Kluane Lake CPT Investigation, 2012: Project geotechnical engineer responsible for technical review and analysis of Cone Penetration Testing work being carried out as part of a submarine geohazard assessment of a pipeline route across Kluane Lake, YK. Tasks included on-site review of the work activities conducted from an ice-road on the lake through to reporting on the field results to the project team.

DWB Consultants Ltd., Terrain Stability Field Assessments, 2011: Project Geotechnical Engineer responsible for conducting terrain stability field assessments for roads and cutblocks in various operating areas including the Morkill Valley, Chuchi Lake and Indata Lake areas. Project responsibilities included assessment and reporting according to the requirements of the BCFLNRO standards.

Spectra Energy, Goodrich Extension Re-injection Pipeline, 2009/2010: Project geotechnical engineer assisting senior geotechnical engineer with field assessment and foundations engineering recommendations for pipeline routing, and aerial crossing infrastructure associated with the construction of the project. Tasks included field review of foundation conditions and providing design recommendations for design and field procedures related to installing foundations and completing grading.

Spectra Energy, Ft. Nelson Mainline Looping Projects, 2009 to 2011: Project geotechnical engineer assisting senior geotechnical engineer with field reconnaissance, geotechnical investigations, geotechnical design and reporting for several proposed looping projects along the Ft. Nelson Mainline system. Tasks included review of engineering work, field reviews, crossing and landslide assessments and preparation and/or review of project documents prepared for client and/or regulatory review.

City of Quesnel, West Quesnel Land Stability Study, 2004 to 2011: Project Geotechnical Engineer responsible for ongoing assistance, analysis, and recent reporting for a large, slow-moving urban landslide affecting several hundred structures in Quesnel, BC. Project responsibilities include coordinating drilling investigations, including the installation of deep slope inclinometers and multi-level grouted-in-place VW piezometers complete with datalogger equipment; landslide and groundwater modeling; and reporting.

Thunder Energy Inc., Terrain Stability Assessment of Trutch Creek Road, 2004. Geotechnical Engineer for the terrain analysis of a 2 km extension of the Trutch Creek Oil & Gas Road across steep terrain through the valley bottom to access a potential bridge site. Project located in northeastern BC.

Regional District of Fraser-Fort George, Leona Creek Debris Flow Potential, 2004. Project Manager and Geotechnical Engineer responsible for the evaluation of debris flow potential in a steep mountain drainage near McBride, BC. (Upper Fraser River Valley). Project included on-site review of the drainage and downstream property, predictions for debris flow torrents, and determination of hazard zones and building code requirements to accommodate the hazards.

Terrain Stability Field Assessments in the Forest Sector 1998 to 2003
Staff and Project Geotechnical Engineer providing assistance; fieldwork; analysis; and reporting related to terrain assessment in the BC forest sector for more than 100 proposed cut blocks, new mainline road locations, in-block access roads and bridge sites. Terrain regions covered included central, coastal and northern BC. Projects were carried out for major timber license holders, consultants, and government organizations.

Joe Kopetski Ltd., Kopetski Landfill, 1999-2003: Staff and Project Engineer responsible for annual review and reporting of landfill operations, landslide investigations, inclinometer & piezometer installation and monitoring, liaising with environmental consultants, and design of horizontal dewatering and landslide remediation, at wood-waste landfill, Quesnel, BC.

5 Information Relevant to Potential Actual or Apparent Conflicts of Interest (III-C)

Enbridge Energy is one of the largest pipeline operator in North America. So as expected, some members of the project team assembled have completed projects with Enbridge in the past. These projects are detailed in our experience summary. However, we can confirm that no parties presented in our proposal have any conflict of interest relative to this scope of work.

Neither Dynamic Risk nor any of the subcontractors included in this proposal have engaged in any work with Enbridge directly relative to Line 5 or any work on pipelines in this area. Further, we have not completed any past risk assessment or oil spill modeling projects with Enbridge as part of their existing pipeline infrastructure. Work in this area that has been completed has been focused on new pipeline designs as part of the application and hearing process (Northern Gateway and Sandpiper as two such examples).

We feel very confident that we can provide an independent and technical based analysis of the Straits Alternatives.

Should any potential for conflict arise in the future, we would immediately notify the State of Michigan and also ensure that all project team members associated with this work, are in no way involved in potentially conflicting work.

6 Proposed Methodology and Design for the Analysis in the Scope of Work (III-D)

Dynamic Risk and its partners have completed a detailed review of the Request for Proposal documents, the included references and the public domain documents prepared by Enbridge Energy, such as the *"Operational Reliability Plan, Line 5 and Line 5 Straits of Mackinac Crossing"*. The technical approach we have prepared has been developed in consideration of the objectives set out by the State and the assumptions on available information from the pipeline operator.

Dynamic Risk is proposing a quantitative risk analysis that will quantify the failure probability and consequences for the existing straits pipelines (base case) and each of the proposed alternatives (assuming that they meet the general feasibility requirements). In doing so, the State will be able to compare the risks from the existing straits pipelines to each of the alternatives in a clear and measured way.

6.1 Pipeline Risk Analysis

6.1.1 Estimation of Failure Probability and Associated Magnitude of Release

The risk associated with an oil transmission pipeline spill can be defined as the product of the probability of having a release, and the consequences that are associated with that release magnitude:

$$R = \sum_{All\ i} \left(PF_i \times C_i \right)$$

Where,

PF_i = Probability of having a release of magnitude *i*, and

C_i = Consequences associated with a release of magnitude *i*

Pipeline failures occur over a range of release magnitudes, ranging from small pinhole leaks to full-bore ruptures. Consequently, risk, being a compound measure of both the likelihood of incurring an adverse event and the consequences of that event, must incorporate an assessment of failure probability over a range of potential release magnitudes. A review of the US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) Hazardous Liquids Incident Data illustrates that within a range of possible release magnitudes, the probability of incurring a failure of a given magnitude varies as a function of the underlying cause of failure. These causes of failure are termed 'threats', which are classified into categories, such as corrosion and outside force damage, as well as subcategories (internal corrosion vs. external corrosion, maritime equipment, etc.).

In light of the above, in order to support evaluations of the potential health and safety, environmental and socio-economic consequences associated with a pipeline release, threat-specific estimates of failure

probability per year of operation will be provided as a function of release magnitude. In this way, probabilities of incurring representative release magnitudes will be estimated for each threat. Release magnitudes, in turn, may be estimated from industry incident data, or outflow models, as appropriate. Threat-specific probabilities will then be combined to arrive at all-threat probabilities for each of several representative release magnitudes. Each release magnitude may then be incorporated into a separate assessment of Health & Safety, Environment, and Socioeconomic consequence by considering one or more scenarios that are associated with that release magnitude.

Failure Probability Assessment

For the purposes of the analysis that will be performed, the term 'failure' refers to loss-of-containment, and the release of products. As discussed above, in order to ensure that the context of the failure probability analysis is consistent with other aspects of the study, such as assessment of Health & Safety, Environment, and Socioeconomic consequences, failure probability will always be associated with a given magnitude of release.

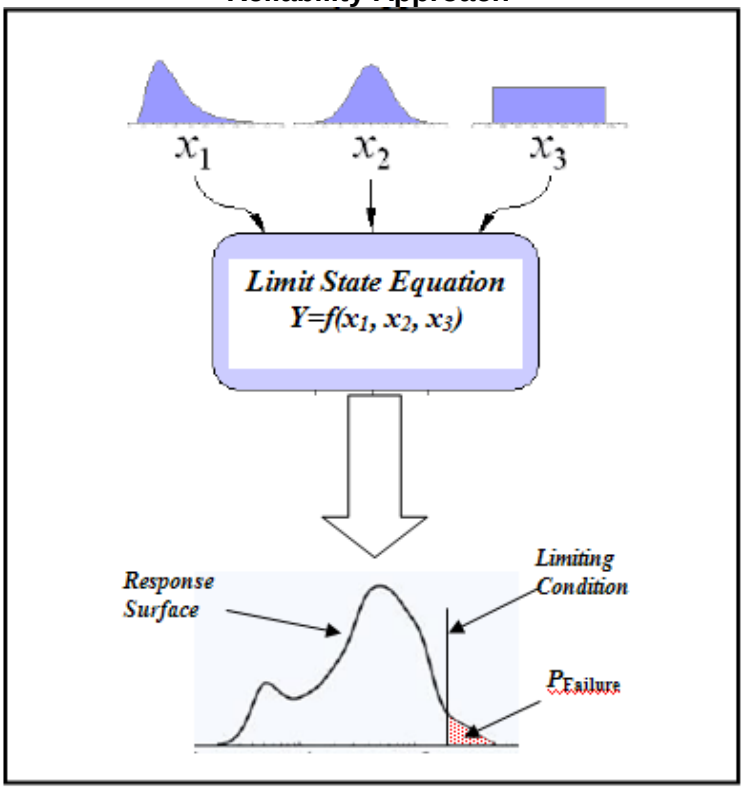
With the above considerations in mind, quantitative estimates of annual failure probability will be made on a threat-by-threat basis. A number of basic approaches for estimating failure probability exist, and will be employed as is appropriate, based on the type and availability of data, as well as the threat being considered. One method of estimating failure probability is to use industry incident statistics, such as the US Department of Transportation PHMSA Hazardous Liquids Incident Data as the basis for the making the estimate. Where this method is employed, care will be taken to select a database that is most representative of the pipeline segment being considered, including type of product, era of installation, and operating environment. In addition, some incident datasets lend themselves to a limited amount of filtering, which may be undertaken in order to account for materials, design and operations considerations.

Another method is to estimate failure probability is based on a first-principles approach, known as 'reliability methods'. Should detailed in-line inspection, material property, and operating data be made available, this would be the preferred approach for assessing the threats that are addressed by the in-line-inspection data.

Reliability methods have been widely adopted in the nuclear and aerospace industry, where they are used to identify and manage threats. In recent years, the pipeline industry has moved towards adopting this as a tool for risk studies, and pipeline industry research organizations such as PRCI and EPRG have spent much time and resources in the past several years in developing reliability-based models for various threats. Reliability models employ limit state functions for the specific damage mechanism of interest in which the load variables and resistance variables are characterized in terms of probability density functions. This enables the use reliability modeling techniques such as Monte Carlo Analysis to characterize the probability of incurring a failure on a pipeline. Reliability methods provide a powerful tool to make accurate, quantitative predictions on likelihood of failure and expected lifespan.

The Figure below illustrates how reliability methods are utilized to quantify the probability of failure, based on a defendable approach:

Reliability Approach



The basis of every reliability model is a limit state function that describes the failure conditions for the mechanism being considered. Furthermore, at least one of the input variables to this limit state equation must be characterized as a probability density function, as illustrated in the above Figure. Therefore, a reliability approach is not possible for threats where these probability density functions or limit state functions are not available.

In the pipeline industry, reliability models exist for the most significant threats, including 3rd Party Damage, Internal Corrosion and External Corrosion.

Straits Pipelines Failure Probability Analysis

The specific circumstances associated with the 20" pipeline crossings of the Straits of Mackinac involve pipelines laid on the surface of the lakebed beneath a busy shipping channel. These circumstances warrant special consideration for the estimation of failure probability through this crossing. In addition to the threat-based analysis described above, the unique threat environment associated with the Straits demands that threats specific to this crossing be addressed in a rigorous, in-depth manner. Through the Straits crossing, threats related to currents, movement or erosion of lake-bottom sediments, and the potential for spanning exist, along with those that are related to ship traffic, such as dragged anchors, dropped objects and ship loss.

The threat imposed on pipelines due to shipping depends on a number of factors, such as:

- Number of ships crossing per period of time (e.g., per year)
- Ship size distribution
- Ship speed distribution
- Water depth
- Protective measures (trenched vs un-trenched, armoring, etc.)

With respect to shipping-related hazards, well-documented approaches, supported by incident data are available to estimate the failure probability[1,2,3,4]. Among these references are a variety of approaches that may be selected, as appropriate, depending upon the information that is available for analysis, and each may be used to estimate the probability of incurring a failure due to shipping activity.

With respect to geohazards and hydrotechnical hazards, a detailed analysis of the Straits will be undertaken that includes hazards related to seismicity, water currents and various forms of ground movement, such as erosion and submarine landslides. The approach that will be adopted involves the systematic characterization of hazards through the Straits crossing to examine how these potential hazards will interact with the pipeline. This assessment methodology follows the framework as set out in Rizkalla (2008)[5] and expresses failure probability as the product of the potential for a geohazard to occur, the frequency of occurrence, the unmitigated system vulnerability, and the effects of the mitigations used in the segment. This analysis will consist of the following steps:

- Project Data Collection and Organization – Within the defined Straits crossing area, collect data from available internal and publically available sources, and organize information within a GIS system;
- Terrain Analysis – Using the available data, produce a description of the physical environment through the Straits crossing, including but not limited to lakebed sediments and bedrock conditions. This is presented on a series of maps and compendium documents as necessary;
- Geohazard List – Develop a list of credible geohazards possible within the Straits crossing.
- Geohazard Inventory – Develop a list of spatial polygons using a general list of potential geohazards through the Straits crossing;
- Susceptibility Calculations – Calculate pipeline susceptibility to geohazards in a systematic fashion according to the product of factors related to the potential for occurrence of a geohazard; the assessed frequency of occurrence; and the system vulnerability to occurrence in each case. This results in an outcome expressed using numerical order-of-magnitude level factors; and,
- Reporting - Complete a final report describing the geohazard assessment and outcomes, including assessment of failure probability associated with geohazards.

References

[1] Recommended Failure Rates for Pipelines", Report No / DNV Reg No.: 2009-1115, Rev 1, 2010-11-16
[2] Stefani, V. and Carr, P. "A Model to Estimate the Failure Rates of Offshore Pipelines", IPC2010-31230, Proceedings of IPC 2010 8th International Pipeline Conference, Calgary, Canada, September, 2010.
[3] OGP Risk Assessment Data Directory, Riser and Pipeline Release Frequencies, Report No. 434-4, March, 2010
[4] Pipeline and Riser Loss of Containment (PARLOC) Report Series, Oil & Gas UK.
[5] Rizkalla, 2008. Pipeline Geo-Environmental Design and Geohazard Management. ASME, New York, NY

6.2 Oil Spill Fates and Effects Analysis

The project team will assess the fate of an oil spill on the aquatic environment and terrestrial ecological environment associated with the six alternatives.

Focus is placed on an oil spill in the Great Lakes either from operation or decommissioning of the pipeline options, plus the water born transportation option associated with Alternative 3. The level of assessment of the transport, fate and consequence of such oil spills in the Great Lakes will be in depth, but will not include the collection of primary data. For the land options, the level of environmental assessment will be qualitative.

6.2.1 Technical Approach

The scope of consequence analysis of this study can be summarized into three main tasks:

Oil spill modelling including:

- Establishing a detailed hydrodynamic and wave model in the area of interest;
- Simulation of a range of spill scenarios, as defined by the failure probability analysis, for various current, wave and wind conditions at the time of spill; and,
- Determine areas that will be impacted and determine the associated amounts.

Environmental Assessment including:

- Investigate sensitive habitats in the project area; and,
- Assess the impact to the environment based on the results of the oil spill modelling.
- Health and safety impacts

Prior to the two main task, a data acquisition and consolidation exercise will ensure that all relevant data is available for the tasks.

6.2.2 Data Collection

The data collection can be split into two separate areas:

- Data collection for the preparation of the models; and,
- Data collection for the environmental habitats.

Collection Hydrodynamic Data, Wave Data and Meteorological Data

The project team has an operational forecast model for the Great Lakes area. The model has been originally prepared for Ontario Ministry for Natural Resources and Forestry (Petersborough, ON) to understand flooding issues of communities along the Great Lakes. We are proposing leveraging this model for this project.

The two dimensional model is set up for Lake Superior, Lake Huron, Lake St. Clair, Lake Erie and Lake Ontario and consists of the following major components of relevance to the project:

- Established link to the existing WISKI database where the near real-time water level data for the lakes are stored
- Data assimilation included in the model. Model is pre-calibrated/validated at the regional scale
- Established link to meteorological forcing from Environment Canada
- A calibrated hydrodynamic model and a wave model for each lake which can be readily integrated to project team's existing model for Lake Michigan

These models will be used as a starting point for the preparation of the dedicated hydrodynamic and wave models for the oil spill modelling. Where available additional bathymetry information will be sourced in the area of the pipeline to increase resolution and local calibration / validation will be carried out against existing data sets.

6.2.3 Model Setup (Hydrodynamic, Wave and Oil Spill)

The hydrodynamic model and wave model will be based on the operational forecast model developed for the Great Lakes. However, these models are only 2 dimensional depth integrated and in order to ensure a realistic representation of an oil spill due to pipeline failure, a 3 dimensional model will be required. The in-house software MIKE model will be used. It is anticipated that a resolution of 50 to 100m (per grid cell) can be achieved in the immediate spill area to account for near field effects with coarser resolution adopted for far field processes. The following will not be include in the model:

- Long-term (>1 year) water level variations
- Riverine inflows

The wave model will be prepared using the spectral wave model software MIKE SW. Even though the wave conditions are considered to be mild in the area of interest, in the oil spill model wave data are used for determining the amount of oil dispersed into the water column. While this is an important process the wave data required do not need to be highly accurate. The existing forecast model calibration and validation is thus considered adequate, with extension of the model to include Lake Michigan. The wave model will be based on the following data:

- Wind data from Environment Canada and/or other publically available data sources
- Ice coverage from publically available data sources

The MIKE 21 SW spectral wave model will be applied using default model parameters and using a quasi-stationary mode with a time step of 3 or 6 hours.

In order to determine the oil drift and weathering under a variety of conditions it is proposed to use data from Environment Canada and the wave model covering the area covering the following periods:

- 3-dimensional hydrodynamic model data covering 1 full year. The data will include velocity components U, V, W, density and temperature (all in 3D) and total water depth (in 2D)
- Wind speed and direction (or U and V) for the same year as hydrodynamic model data
- Wave height (Hs) and period (T02) for the same years as wind data (in 2D)

6.2.4 Selection of Scenarios

The selection of scenarios will be developed by the project team and include:

- Oil type
- Amount of oil spilled
- Instantaneous spill or spilled over a given period of time
- Location and depth
- Length of simulation after spill has stopped (for example 15 or 30 days)

The environmental conditions (currents, waves and wind) during and after the spill determines the area impacted by oil. Each spill is simulated for a large number of environmental conditions, which will enable a statistical analysis. If each spill is simulated for an estimated 120 different environmental conditions throughout the year [essentially one spill start time every 3 days for the 1 year of hydrodynamic data simulated], average and worst case impacts can be determined, plus the probability of exposure.

The following table gives the alternatives and associated suggested modelling scenarios.

ID	Alternative	Scenarios	Conditions investigated
1	Construction of new pipelines that do not cross water Decommissioning of existing pipeline	4 spill scenarios along the new pipeline route 3 decommission scenario spills along the existing route	Matrix of environmental conditions from 1 year HD base, to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure. Decommissioning scenario will exclude ice cover.
2	Utilizing existing alternative pipeline infrastructure that does not cross the Straits Decommissioning of existing pipeline	Qualitative assessment of land based oil spills taking into account different seasonal effects (rain, ice cover etc.) Decommissioning same as alt. 1	

ID	Alternative	Scenarios	Conditions investigated
3	Utilizing alternative transportation methods Decommissioning of existing pipeline	Qualitative assessment of rail and tanker truck 4 spill scenarios based on vessel collision/grounding Decommissioning same as alt. 1	For vessel transport Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure.
4	Replacing the existing Straits Pipelines with new pipelines	4 spill scenarios along the pipeline route Decommissioning same as alt. 1	Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure.

ID	Alternative	Scenarios	Conditions investigated
5	Keeping existing pipeline	4 spill scenarios along the pipeline route [Magnitudes/probability will be different from Alt 4]	Matrix of environmental conditions from 1 year HD base to base statistical analysis on. This includes different seasons and ice cover to determine probability of exposure.
6	Eliminating all transportation of petroleum products and decommissioning of pipeline	Decommissioning same as alt. 1	

6.2.5 Simulation of Oil Spills and Analysis of Simulation Results

The selected scenarios will be simulated using MIKE simulation model for the selected environmental conditions. The output provided at the end of each simulation will include 2D fields of:

- Maximum oil mass / thickness in each grid cell during the simulation
- Shortest drift time to each grid cell
- Stranded amount of oil in grid cells along land
- Oil mass remaining within model area at end of simulation

Many other parameters (e.g. amount of oil divided into oil fractions) may also be saved from each simulation.

Based on approximately 100 simulations for each scenario the following statistics can be prepared:

- Probability of occurrence of oil in each grid cell (in percent)
- Probability of tolerance limits for environmental receptors being exceeded

- Overall shortest / average drift time to environmental receptors
- Statistic of oil mass vs probability in each grid cell
- Statistics of stranded amount vs probability in each grid cell

The deliverables will include a graphical representation of the oil spill based on the trajectory simulations and statistical analysis. These graphical representation will include, but are not limited to:

- Probability of an area being exposed to spilled oil
- Minimum time of exposure after spill for a given area.
- Probability of a given key receptor being exposed
- Description of metocean forcing conditions typically associated with the exposure of key receptors
- Animations of select critical spill situations.

Examples of statistical maps are shown in Figure 1 and Figure 2 below.

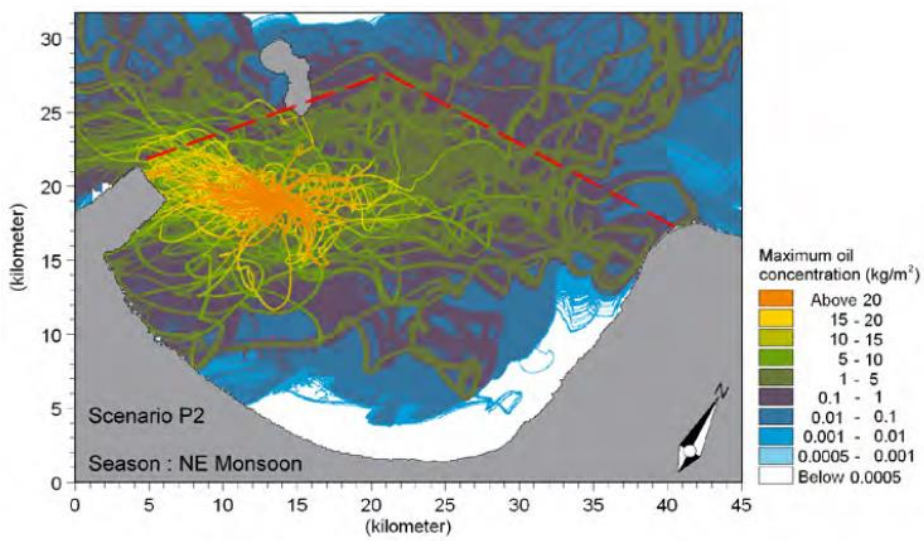


Figure 1 Example of map of maximum oil concentration for a spill scenario

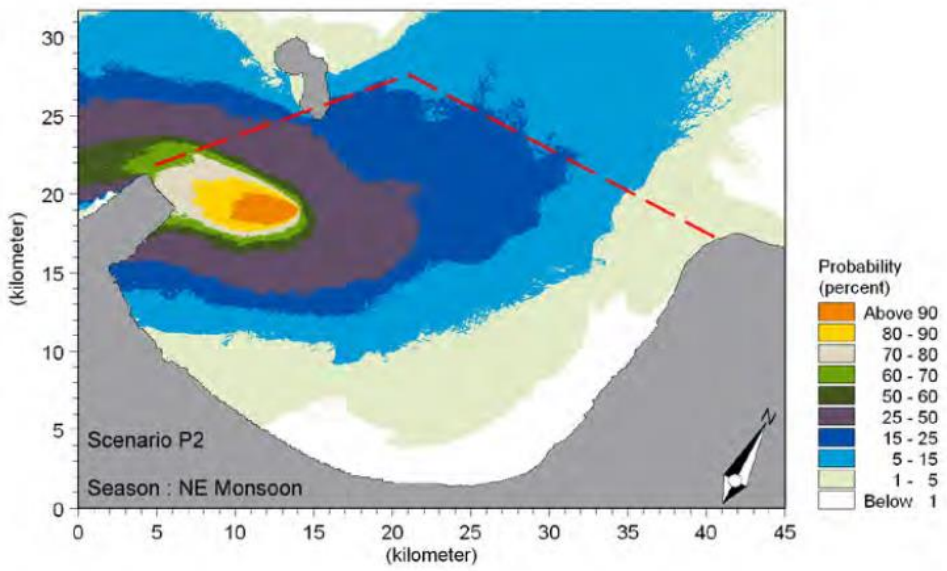


Figure 2 Example of probability map for oil spill scenario

6.2.6 Environmental Habitats

The environment of the Great Lakes is unique and highly vulnerable to spills from petroleum products. A potential oil spill could heavily impact on fish, shoreline mammals, birds as well as vegetation and effects may range from direct contamination of the flora and fauna to prolonged impacts due to toxicity effects due to the oil characteristics.

It is important to map the habitats and sensitive receptors within the project area in order to allow a thorough assessment based on the results of the oil spill modelling.

The following steps will be undertaken as part of this task.

- Data collection and desk survey of available information on habitats within the project area including tolerances to oiling where available
- Data collection of water quality parameters (from literature) or publically available research projects
- Establish any protected/endangered/vulnerable species within the project area (e.g. the piping plover and Kirtland's warbler)
- Consolidate and graphical represent all habitat information in ArcGIS and associated data bases.

Due to the large extent of the project area, no detailed field surveys will be carried out as part of this study. This should be included in the scope of an Environmental Impact Assessment of the chosen alternative in the future.

6.2.7 Environmental Impacts

The project team has a long history of valuation and assessment of environmental impacts. With a large multidisciplinary expert pool, we can evaluate the whole breadth of impacts arising from an oil spill reaching from biological aspect to toxicology effect as well as impacts in the second or third degree (e.g. toxicology effect having an impact on reproduction etc.).

The oil spill in the lake will be evaluated based on the probabilities maps and statistical analysis from the oil spill model that will highlight the areas impacted.

Key focus will be the fauna and flora present in and around the Great Lakes, including but not limited to fish, (shoreline) mammals, (water) birds as well as crustaceans.

As previously mentioned there will be no quantification of the oil spill on terrestrial areas, but any impacts will be evaluated qualitatively. This will include again impacts on any flora and fauna, but will also include impacts on ground water, ground contamination and pathways into the lakes.

The identification for the oil spill within water and on land will follow these four steps:

- Description of the environment likely to be significantly affected by the spill (based on information collected on environmental habitats)
- Description of the potential environmental impacts of the oil spill (incl. impact to water quality, direct impact, toxicology impact etc.) and their significance
- A clear indication of predictive methods (e.g. oil spill modelling) and underlying assumptions
- Identification of gaps in knowledge and uncertainties encountered

The project team will be using an updated version of the well-established RIAM (Rapid Impact Assessment Matrix) methodology that will evaluate potential impact in their magnitude, significance (ecologically and economically) as well as the likelihood of such impacts. In that way, impacts can be compared fairly objectively not only within one alternative, but also across the different alternatives.

If apparent, high level recommendation for mitigation measures that may reduce the impact level significantly may be made, however, a full mitigation recommendation is considered to be outside of the scope.

The mapping of the environmental habitats and sensitive receptors will feed directly into the environmental assessment of the alternatives and associated spill scenarios.

6.2.8 Health and Safety Impacts

Failure of a hydrocarbon liquid pipeline or a storage container (e.g. rail car) has the potential to cause damage to the surrounding public, property and the environment. The consequences of failure are primarily due to the thermal radiation which is produced if the release ignites. The escaping fluid can ignite, resulting in a fireball, crater fire/surface fire or jet fire which generates thermal radiation.

Figure 3 shows a typical Event Tree (ET) used for releases from liquid pipelines on land.

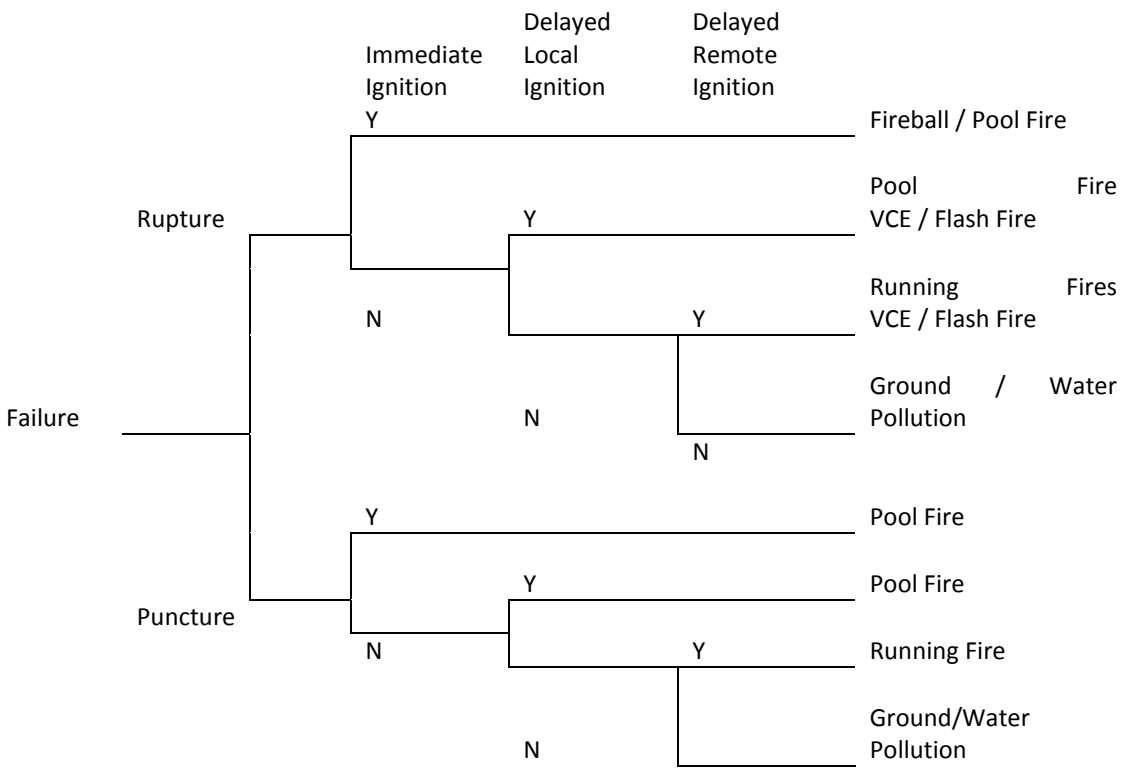


Figure 3: Typical Event Tree Analysis for Releases from Liquid Pipeline on Land (ref. PD 8010 – 3 2009+A1: 2013)

In case of an underwater release, the main concern is surface and running fires, as well as the vapour cloud produced by evaporation from the hydrocarbon pool.

As part of this scope of work, for each alternative listed in Part II-A of the Request for Information and Proposals for an Independent Risk Analysis for the Straits Pipelines, the consequence scenarios are developed for the identified worst-case spill and release scenarios. These consequences and their potential impact on public health and safety is assessed using the PHAST consequence models, version 7.11 (DNV GL Software, Process Hazard Analysis Software Tool).

The modelling includes dispersion and fire calculations to obtain representative impact zones for the dispersing hydrocarbon liquid and the associated vapour cloud.

The analysis will examine the following consequences for each alternative as appropriate:

- **Pool Fire / Surface Fires**: Ignition of the released liquid which does not vaporize and forms a hydrocarbon pool over the surface of land or water.
- **Flash Fire:** Delayed ignition of a flammable vapour cloud (caused by evaporation from the pool) in an uncongested area.
- **Jet Fire:** Immediate ignition of a pressurized release of flammable material
- **Fireball:** Short-lived flames generally resulting from ignition and combustion of turbulent vapour/ two-phase fuels in air. A fireball is usually caused by near instantaneous releases and involves catastrophic failure of pressurized vessels / pipelines.
- **Unignited Hydrocarbon Cloud:** Extent of a hydrocarbon cloud at a concentration which can be harmful to the public.
- **BLEVE:** A BLEVE (Boiling Liquid Expanding Vapour Explosion) occurs when a jet or pool fire is located beside a vessel containing a pressurized liquid. The heat of the fire causes a rise in liquid temperature and pressure which can cause the vessel wall to weaken. Once the vessel walls fail, the pressurized liquid will flash, resulting in an overpressure and potential fireball. This scenario is only applicable to the pressurized vessels (i.e. tanker trucks, and rail cars).

Vapour Cloud Explosions (VCEs) occur when a flammable cloud is ignited in a congested area (such as areas with high density of piping and process equipment). The area surrounding pipelines are generally considered unobstructed, and do not provide the type of confinement that are required to cause vapour cloud explosions. Therefore, the VCEs are excluded from the scope of this analysis.

The following data are used as inputs to the consequence modelling:

- Pipeline/vessel operating conditions and composition of released material
- Magnitude of spill (i.e. outflow rate or release inventory) – see 'Failure Probability and Associated Magnitude of Release'
- Extent of overland / overwater pooling (i.e. hydrocarbon pool)
- Average weather conditions (i.e. average temperature and wind speeds for both Summer and Winter conditions)

The consequence modelling produces the following outputs which are used as inputs to the risk analysis along with the associated event frequency.

- Maximum distance to thermal radiation levels which are considered harmful and can cause fatality
- Maximum distance to LFL (Lower Flammability Limit) cloud which may cause a flash fire event
- Maximum distance travelled by an unignited hydrocarbon cloud at a concentration which is considered harmful to public

Figure 4 shows an example of output for radiation distances resulted from a pool fire event.

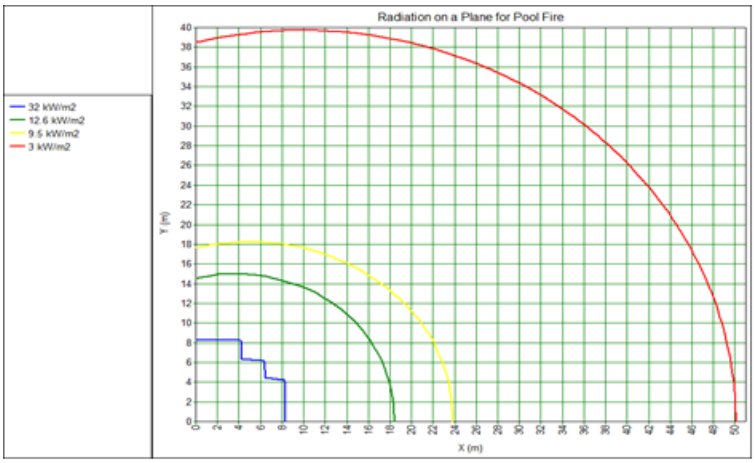


Figure 4: Example of Thermal Radiation Contours From Pool Fire

6.3 Economic Impact and Analysis

Economic Analyses & Evaluations

The Study will include a number of economic analyses and evaluations at different stages. As a general principle, the approach undertaken will be to rely on methods that: (i) use publicly available information that is transparent and has withstood the scrutiny of peer review, regulatory processes, or independent quality assurance; (ii) permits application to the different alternatives in a consistent fashion; and, (iii) can be used or updated with little incremental cost at a future date if other alternatives are identified.

The economic analysis approach has further been streamlined to address Study requirements in four distinct modules and a final synthesis of these modules for reporting purposes. These are described in further detail below.

Module 1 – Economic Baseline Forecast

During the initial phase of the Study, a baseline forecast will be prepared that involves collecting basic historical economic information of relevance within the study area, and presenting that data in a manner consistent with other components of the Study. Specific tasks will include (but are not necessarily limited to) the following:

i. Define the spatial dimensions of the Study's primary Area of Interest (AOI) in the Michigan Great Lakes Region, as well as focal sub-areas within the primary AOI. The AOI will include all anticipated alternatives to be considered, and will include definitions at the sub-area level that correspond to county boundaries in the State. Use of the county boundaries will be consistently used across all analyses where relevant as this is the most detailed spatial unit on which demographic and economic information is collected and made available through the US Bureau of Economic Analysis.

ii. Obtain historical price and income deflators for Michigan and (where available) major urban areas within the AOI. These will be selected based on official Michigan statistical accounts made available during the Study. The deflators will be used for standardizing facility cost estimates and oil spill costs, as well as in the market impact analysis.

iii. Specify assumptions for future economic conditions that may impact any of the economic analyses (exchange rates, unemployment rates, growth rates, tax rates, inflation). Analytical assumptions (discount rates, rates of return on invested capital, analytical base year, length of analysis for discounting purposes [years]) will also be selected within this task, with sources and rationales clearly documented.

iv. Organize and document all information in a transparent fashion and make it available for use in cost estimating and in analytical models.

v. Summarize a Baseline Economic forecast (for analytical purposes) and one low-growth sensitivity forecast (for qualitative discussion purposes).

Module 2 – Financial Feasibility Analyses

The financial feasibility analyses will be developed for each alternative considered, and will be based on a cash flow profile of capital and operating costs needed to deliver a volume equivalent to that of the current pipeline infrastructure (approximately 540,000 BPD). This volume is selected as a benchmark to permit comparisons of alternatives independent of selected upstream and downstream impacts (which will be addressed elsewhere). Key metrics will include present value and cost-of-service (or levelized cost in $/bbl terms). The levelized costs will be subsequently used in market analyses to determine the degree to which producers, refiners, major industrial customers, and other consumers of energy products may be impacted.

The financial analyses will also reflect potential co-benefits from any given alternative if there are potential cost savings or cost-sharing opportunities of new infrastructure. For example, tunnels (Alternative 4) permit the use of cost-saving and higher quality inspection tools; in some jurisdictions tunnels are also shared with other utilities. Such co-benefits are analytically treated as a reduction in cost of the Alternative, resulting also in a reduction in any cost-of-service calculation attributable to the Alternative in a market analysis.

The core deliverable of this module will be a Financial/Economic Feasibility Interim Report (to be integrated subsequently into project Draft and Final Report) showing results for each alternative and a comparison of all alternatives using transparent and consistent assumptions.

Module 3 – Spill Cost Analyses

Spill cost analyses are treated as two separate activities within the Study:

3.1 Scenario Independent Socio-economic Spill Vulnerability

The purpose of this activity is to identify and map those areas in the AOI that may have the highest negative socio-economic impacts in the event of a spill from any source. From previous experience, we recommend the use of a simplified vulnerability index that can be used to identify a potential economically high consequence area (HCA). This reflects a notion that a worst-case spill from a technical perspective (in terms of water column or shoreline environmental impacts) may not be the highest consequence spill from an economic perspective. A Vulnerability index will be constructed for the AOI and mapped similarly to environmental sensitivity. The index does not need to include many variables: a simple overlay of population density, land-use, local income levels, and up to three other variables is typically adequate to create a “heat map” of vulnerable zones. These variables will be sourced from public statistics and land-use/land-cover data. Such a heat map will be created and used to inform the selection of worst-case spills across all alternative scenarios.

3.2 Scenario Dependent Spill Costs

Spill costs will be estimated for up to three scenarios in each alternative. The three scenarios will be characterized as: (i) technical worst case spill to reflect an outflow and conditions associated with greatest volumes or environmental impacts; (ii) economic worst case spill to reflect an outflow of potentially lesser volume into a HCA as defined in 3.1 above; and, (iii) a most credible worst case scenario.

For each alternative and spill scenario, the spill costs will be disaggregated into two main components consistent with current literature: clean-up (including response) costs; and, damage costs. Each of these can also be disaggregated further to reflect: natural resource damages (including human uses) as defined in Natural Resource Damage Assessments which quantify public goods and services; government costs (which are also publicly borne but are not associated with direct damage to goods and services); and, private costs which include any privately borne costs that can be directly linked to an oil spill event (this could include changes in property values, lost business income, health impacts, or a range of other private impacts).

The approach to estimating the core spill costs will be to rely on spill cost statistics maintained by the consultants (including spill cost data in PHMSA, data documented in regulatory hearings in Canada and the United States, data accessible through the International Oil Pollution Compensation Fund, in-house estimates of ecosystem values based on the international database of Environmental Valuation Reference Inventory [EVRI], and other sources). The spill data that will be used in this Study have also been vetted specifically by intervenor and regulator examination in recent hearings before Canada's National Energy Board for hypothetical spills from Northern Gateway and from the Trans Mountain Expansion.

In addition, where applicable, a spill that coincides with a service disruption (of delivered product) may result in a prolonged outage period. This may impact downstream refiners or customers, and/or upstream producers in the US and Canada. The economic consequences of this outage will be estimated using "worst case" assumptions whereby the entire product value is lost during a period of unmet demand for a specified length of time, after which partial value is lost until transportation services are re-established. It should be noted that in some instances – typically those involving unit shipments on barges or trucking – these economic consequences of unmet demand are negligible.

A final analytical step that will be taken in the Study will be to place the spill costs in the context of the probability of such a spill occurring. In theoretical welfare economics (which is the basis for cost benefit analysis) the "expected" cost of a spill is the probability of the spill occurring multiplied by the resultant costs and consequences of that spill; such a metric permits the comparison of spill costs against events with different likelihoods. It also permits comparison of hypothetical low-probability spill costs from a given transportation alternative to the certain (i.e., probability of unity) benefits associated with that alternative.

A spill cost summary will be presented in a stand-alone Spill Cost Interim Report which documents spill costs across all alternatives and scenarios. This Interim Report will also form part of the Draft Final Report, which will also document all sources and provide a qualitative discussion of any limitations of the spill cost estimates. It is important to note that each spill is different and that any spill cost estimation of a hypothetical event should be regarded as a best estimate; the methods that will be employed in this Study cannot be compared to those used after a spill event occurs. The methods are, however, regarded as reliable and appropriate for looking at a comparison of different alternatives that may have different risk profiles.

Module 4 – Socio-Economic Impact Analyses

Socio-economic impacts will be examined for each alternative, both from the development of the alternative transportation mode, and for the oil spill event that corresponds to that transportation mode. Three types of analyses will be provided: (i) qualitative discussion of unmeasurable socio-economic costs associated with oil spills and facility development; (ii) quantitative assessment of measurable job, income and taxation benefits associated with facility development for each alternative; and, (iii) quantitative assessment of market impacts of changes to supply and demand patterns arising from a shift in or elimination of a transportation mode for each alternative.

The Study will provide a stand-alone Socio-economic Impact Draft Report showing results for each alternative.

4.1 Qualitative socio-economic impacts

Many socio-economic impacts can be described but are not readily estimated. Cultural impacts, noise, congestion, traffic disruptions, and other negative consequences may all be associated with a given facility development (e.g., tunneling, pipeline construction, trucking traffic, rail cars). The precise monetary quantification of such impacts is not typically possible for hypothetical projects as they require public consultation at affected sites alongside original data collection to be meaningful in the context of a given project or alternative; each negative impact will also typically have an acceptable mitigation mechanism which can be internalized within a project's cost. The facility and operations cost estimates that will be prepared for this Study will generally include best available technologies that reduce such impacts. Nonetheless, residual impacts may still occur and the Study will document and assess these impacts using a simple screening tool that is used in social impact assessments. Such tools generally address five accepted categories of impacts (UN Public Administration Network, A Comprehensive Guide for Social Impact Assessment, 2006) categorized as: lifestyle impacts; cultural impacts; community impacts; quality of life impacts; and, health impacts. The tool will be adapted as appropriate for this Study and applied as a qualitative screening mechanism to compare alternatives. As the Study does not include primary data collection, the tool will be used based on consultant knowledge of the technologies and of impacts usually considered in projects before regulatory authorities in the US and Canada.

A qualitative discussion will also be provided of omitted socio-economic impacts arising from oil spills. Experience has shown that a spill event does lead to localized positive benefits in some industries for a short period after the spill due to cleanup activities. Simply put: a proportion of the cleanup costs would be injected into the local economy and generate income, job and taxation benefits just as any other outside economic stimulus might. For this Study, we assume that such an analysis is not required and experience elsewhere indicates that such analyses are not generally well received by the general public, which can perceive the analyses as down-playing the significant negative impacts that accompany oil spills. This proposal thus recommends that such a quantitative analysis not be undertaken, except to discuss the concept in more general terms and in the context of a different and more general investment in oil spill preparedness. It is more balanced to argue that certain types of oil spill preparedness can have positive impacts in terms of jobs and income generation: training of responders; equipping individuals, vessels and vehicles for oil spill response; exercising emergency procedures; and,

public information sessions. All such activities can have direct socio-economic benefits and can also enhance preparedness for any emergency to greater social benefit. Again, the Study will address such benefits qualitatively through general discussions in the Draft and Final Reports.

4.2 Quantitative socio-economic impacts – direct, indirect and induced impacts

The Study will provide a quantitative assessment of the direct, indirect and induced impacts of the project based on standard multiplier techniques using a built-for-purpose model that relies primarily on the RIMS II November 2015 model (Bureau of Economic Analysis, US Department of Commerce; Regional Input-Output Modeling System). The structure of RIMS II provides an appropriate model for estimating impacts at a local and regional basis; it features 369 industries and provides multipliers on user-defined regions. The team has extensive experience with input-output (IO) accounts and the use of such models in other jurisdictions (CANSIM in Canada, various IO models internationally); the RIMS II IO structure readily permits simulation of demand shocks to determine the impacts on total gross output, value added, earnings, and employment in the region. The team regards the RIMS II structure as best in class for estimating impacts in Michigan: it permits user-defined regions; it permits isolation of local impacts at a county level; it is updated annually with high credibility and transparency; and, it can be cost-effectively applied for this purpose to permit comparative analyses of different alternatives.

This Study will define up to 14 different regions and sub-regions for analytical purposes including: Michigan as a whole; an AOI that includes the Michigan Great Lakes Region; and, up to 12 sub-areas within the AOI to permit investigation of more localized impacts. To initialize the model, the multipliers associated with the November 2015 release of RIMS II will be used; the model will be updated once if another update of the RIMS II regional data is released on a timely basis that permits its incorporation within the Draft Report (an update is expected in 2016 but the precise date is not available at time of writing). To complement the model, the Study will introduce a separate tax impact model based on current (2016) tax rates to generate tax multipliers that permit estimation of tax impacts from the RIMS II structure.

For each alternative, the impact model will be used to simulate spending shocks arising from two expenditure sources: (i) total capital expenditure; and, (ii) annual recurrent expenditure. The direct impacts of each of these will be identified by assigning the expenditures to appropriate industry classes in the appropriate region to determine the impacts throughout that region, the AOI, and Michigan. Resultant impacts will be reported for the following economic indicators: employment, income, and taxes. Discussion of these impacts will include standard caveats associated with IO models and multipliers; notably, the reader will be reminded that high cost projects will have high economic impacts because of their direct impacts on the economy, but they are rarely the least expensive means of achieving a given objective (which would have lower costs, for example, to deliver the same output or throughput). Model results will also be placed in the context of current income and employment information to show percentage changes from the status quo.

4.3 Quantitative socio-economic impacts – energy market adjustments

As described previously, changes in transportation mode can engender impacts beyond the direct and induced socio-economic impacts captured in a linear IO framework. Line 5 transports approximately 540,000 bpd of petroleum products; this volume represents approximately 15% of Canada's total

current production of approximately 3.7 million bpd. Also, by comparison, Michigan is within the Midwest Petroleum Administration Defense District (PADD 2), which has refinery capacity of approximately 2.4 million bpd (Source: American Fuel & Petrochemical Manufacturers, 2015). A shift in transportation mode, and a change in the unit costs of such transportation, has the potential to impact both suppliers and consumers throughout North America.

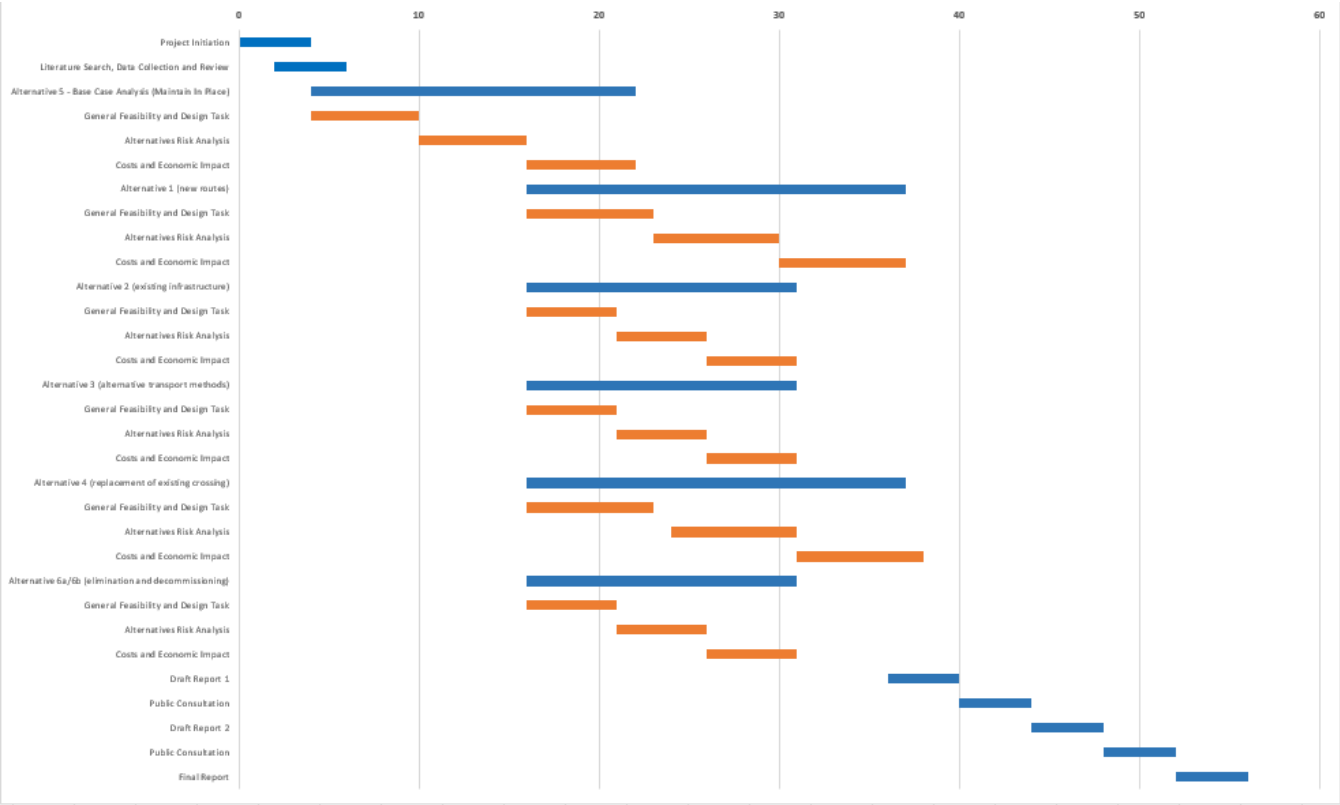
It is beyond the scope of the present study to Model all of the supply and demand impacts of a change of this nature, but a partial analysis of energy market adjustments will be conducted that focuses on PADD 2 and Eastern Canada. Most of the alternatives being considered in this Study still propose shipping the same volume (540,000 bpd) over the same time frame. For other pipeline routings or for the tunneling alternative, all of the impacts will thus be price related: price impacts can be modeled over the long-term on the basis of changes to the applicable cost-of-service arising from the alternative transportation mode. The increase (or decrease) in costs will potentially have a demand impact on final users or on refiner margins in the Sarnia refinery complex in Canada. A first order estimate will be made of such impacts for this Study. The alternatives relating to a complete abandonment of all petroleum shipments would, at the extreme, result in shut-in production in selected areas. Although Michigan has some oil production, it is minimal (approximately 15,000 bpd [US Energy Information Administration]) and most of the shut-in capacity would be outside of the State; the Study will, however, evaluate the likely impacts on producers, consumers, and refiners based on public information within PADD 2 in the United States, and on refiners in Eastern Canada. The analysis will also consider the possibility that exports from both Canada and the United States may drop if transportation capacity becomes constrained; any price and demand impacts of changes in transportation costs may be negligible or not discernible in the context of anticipated international oil price volatility.

Synthesis of Economic Analyses

The Draft Report and Final Report will include a synthesis of all economic analyses, including summaries of assumptions, methods, and results. Qualitative discussions will provide guidance on the interpretation of the results.

7 Proposed Schedule (III-E)

The proposed schedule is based on a May award, and a June 1, 2016 start date and a 52 week duration. A detailed project schedule will developed as part of the project initiation task.



8 Proposed Budget (III-F)

The following pricing has been provided for each of the key alternatives in the assessment along with overall project management, status reporting, final reporting and travel. This is an all-inclusive cost based on the assumptions noted and was derived using hours and competitive market rates for professional services.

Task Description	Fixed Fee Quotation (USD)
Project Management and Status Reporting	$233,600
Alternative 1: New Pipeline Route	$423,500
Alternative 2: Other Pipeline Infrastructure	$204,400
Alternative 3: Other Transportation Methods	$350,400
Alternative 4: Pipeline Replacement	$525,600
Alternative 5: Existing Pipeline (Base Case)	$408,800
Alternative 6: Decommissioning the Pipeline	$321,200
Final Reporting and Travel	$452,700
Total (Fixed Fee) *	**$2,920,200 ***

Notes and Assumptions (*):

1. *Travel costs have been included in our price and assumes full project team visits to Lansing, Michigan for the project kick off, the first draft report/review and the final report/review (3 trips in total).*
2. *Project pricing assumes a project completion date of June 1, 2017.*
3. *For Alternative 3, the assumption is that a desktop feasibility analysis for the Tanker Truck and Oil Tanker / Barge will be sufficient to determine viability of this option.*
4. *As this work will leverage pre-existing models and intellectual property of the consultant, our assumption is that the project team will retain ownership of all existing and developed intellectual property utilized for the project.*
5. *Upon approval of this proposal, Dynamic Risk will work with The State to develop a detailed Statement of Work (SOW) that will form the basis for a detailed project execution plan.*
6. *Payment Milestones would be negotiated with the State to ensure approximately equal monthly payments over the course of the project.*

7. *Enbridge will appoint a representative(s) who will be accountable for timely responses to data and information requests from the project team. Delays in responses may effect the project schedule and budget.*

9 Appendix A: Curricula Vitae

James Mihell, P. Eng.

Chief Engineer, Dynamic Risk Assessment Systems, Inc.

SUMMARY

As Chief Engineer at Dynamic Risk Assessment Systems Inc., James Mihell is responsible for engineering products and services development. Mr. Mihell has had extensive experience in the areas of failure and consequence modeling, pipeline fitness-for-service analyses, metallurgical failure investigations, engineering assessments of operating pipelines and pipeline risk algorithm development. James has authored several papers related to pipeline inspection, fracture control and consequence modeling, and has testified as an expert witness in these fields.

PROFESSIONAL EXPERIENCE

DYNAMIC RISK ASSESSMENT SYSTEMS, INC

Chief Engineer

August 2014 – present

The main responsibilities associated with this position are Engineering product/services development; Final approval of all Engineering Assessments and functions.

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.

Vice President, Engineering

July 2006 – August 2014

The main responsibilities associated with this position are Engineering product/services development; Final approval of all Engineering Assessments and functions; Resource planning; and business development.

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.

Director, Engineering

October 2000 – July 2006

The main responsibilities associated with this position were to lead the engineering group in the performance of functions related to pipeline integrity management. Specific duties were development of failure models to support quantitative risk assessment studies; performance of fracture control assessments; performance of fitness-for-purpose evaluations; development of fracture mechanics – based defect acceptance criteria; performance of engineering studies related to welding and weldability; developing materials standards for procurement of pipe and components, as well as pipeline integrity management practices.

UNION GAS, LTD.

Metallurgist

January 1999 – October 2000

The main responsibilities of this position are to ensure that natural gas transmission and storage facilities are constructed and are operating with appropriate materials, and are suitable for the purpose intended. Specific duties include developing and maintaining materials, joining, and non-destructive testing standards and specifications pertaining to natural gas transmission and storage facilities. Developing fracture control plans for new high-pressure natural gas transmission pipeline designs. Developing strategies to manage threats to pipeline integrity, such as Stress Corrosion Cracking, general corrosion and manufacturing defects. Developing fracture-mechanics-based girth weld defect acceptance criteria using Engineering Critical Assessment strategies. Developing line pipe field welding procedures and reviewing and approving fabrication welding procedures. Performing fitness-for-purpose investigations on pressure-containing components of natural gas transmission and storage facilities; and Performing failure investigations on natural gas transmission and storage facilities

TRANSCANADA PIPELINES, LTD.

Manager, Technical Services

July 1997 – December 1998

The main responsibility of this position was to manage a department of 22 people, which included the following disciplines, as they pertain to high-pressure natural gas transmission facilities: non-destructive testing, fitness-for-purpose analysis, Stress Corrosion Cracking management, failure investigations, materials research and development, corrosion control engineering, welding engineering, pipe and component vendor quality assurance, and materials standards development. Additional responsibilities associated with this position included acting as an expert witness on fracture control issues in protracted National Energy Board hearings, and liaising with community leaders and town councils on planned responses to high-pressure natural gas transmission pipeline ruptures.

TRANSCANADA PIPELINES, LTD

Assistant Manager, Materials Engineering

September 1993 - July 1997

The main responsibility of this position was to act as front-line supervisor of a group of six people, which included the following disciplines, as they pertain to high-pressure natural gas transmission facilities: non-destructive testing, fitness-for-purpose analysis, Stress Corrosion Cracking management, failure investigations, materials research and development, welding engineering and materials standards development.

FLINT ENGINEERING AND CONSTRUCTION

Quality Control Manager

March 1991 – September 1993

The main responsibility of this position was to ensure that all petroleum product gathering systems, pipelines, and related facilities were designed and constructed in accordance with the pertinent codes, acts, regulations, and customer specifications. Specific duties included developing new field welding procedures for oil and natural gas producing systems, gathering systems, and transmission systems, intervening and taking corrective action during the occurrence of welding or materials-related problems encountered during field installations of oil and natural gas producing systems, gathering systems, and transmission systems, designing welded connections for facilities designed in accordance with CSA S16.1 and developing and maintaining a quality assurance program for the installation of oil and natural gas producing systems, gathering systems, and transmission systems.

ALGOMA STEEL CORP. LTD.

Mill Metallurgist – 106" Hot Mill

March 1990 – March 1991

The main responsibility of this position was to ensure that all products rolled on Algoma's 106" Hot Mill conformed to customer and society specifications. Specific duties included reviewing new order inquiries to assess whether the

customer's requested physical and chemical properties were within the capabilities of the mill, designing and reviewing standard practices for all products rolled on the mill reviewing nonconforming physical test results, and allocating causes and corrective actions for those nonconforming results and monitoring and maintaining control of product properties through the utilization of statistical process control techniques.

ALGOMA STEEL CORP. LTD.
Product and Process Development Metallurgist

March 1988 – March 1990

The main responsibility of this position was to manage projects focused on steel product improvements, innovations, and/or problem solving. Specific duties included developing new steel grades in compliance with the company's interest in future market opportunities, improving existing products and processes in assisting Mill Metallurgists to address cost and quality concerns and employing statistical tools, such as process capability evaluation, measurement system evaluation, and design of experiments, in order to arrive at solutions to problems.

UNION GAS, LTD.
Pipeline Engineer

October 1984 – March 1988

The main responsibility of this position was to manage the budget, design, and installation of new natural gas storage and transmission facilities, ranging in capital cost from $0.6 million to $20.4 million. Additional duties included performing failure investigations, performing fitness-for-purpose evaluations, coordinating and auditing third party inspection activities during line pipe production.

GOVERNMENT TECHNICAL COLLEGE, NIGERIA (AUSPICES OF CUSCO)
Welding/Metallurgy Instructor

The main responsibility of this position was to teach welding and metallurgy to welding technology students in Northern Nigeria under the auspices of Canadian International Development Agency sponsored CUSO.

PREVIOUS WORK HISTORY

Metallurgist, Union Gas, Ltd., 1999-2000
Manager, Technical Services, TransCanada Pipelines, Ltd. 1997 - 1998
Assistant Manager, Materials Engineering, TransCanada Pipelines, Ltd. 1993 - 1997
Quality Control Manager, Flint Engineering and Construction, Ltd. 1991 - 1993
Mill Metallurgist, Algoma Steel Corp. Ltd. 1990 - 1991
Product and Process Development Metallurgist, Algoma Steel Corp. Ltd. 1988 – 1990
Pipeline Engineer, Union Gas, Ltd. 1984 - 1988
Welding/Metallurgy Instructor, Government Technical College, Nigeria (auspices of CUSO)

PROFESSIONAL ACTIVITIES

Registered Professional Engineer since 1985

Materials Session Co-Chairman, International Pipeline Conference, Calgary, October, 2000

Past Focus-Area Chairman, Joining of High Strength Materials, and Materials for Severe Service, Pipeline Research Committee International

Past Ad-Hoc Working Group Chairman, Feasibility of Nd-YAG Laser & Hybrid Laser/Arc Welding Processes for Pipeline Girth Welding Applications, Pipeline Research Committee International and Edison Welding Institute

Past Ad-Hoc Working Group Chairman, Factors Affecting Productivity and Mechanical Properties of Weld Metals for X80 and Higher Strength Pipe, Pipeline Research Committee International and Edison Welding Institute

Past Ad-Hoc Working Group Member, Interaction of Multiple Defects Under Plastic Collapse Conditions, Pipeline Research Committee International and University of Ghent

Past Ad-Hoc Working Group Member, Effect on Base Metal Yield Strength Due to Repair Welding of TMCP Steels, Pipeline Research Committee International and University of Ghent

Past Ad-Hoc Working Group Member, The Effect of Weld Metal Yield Strength and Yield-to-Ultimate Tensile Strength Ratio on the Structural Integrity of Girth Welds in API 5L X80 Pipe, Pipeline Research Committee International and University of Ghent

Past Ad-Hoc Working Group Member, Compendium of Updated Pipeline Girth Weld ECA Methodologies to Support Revisions to Code Practices, Pipeline Research Committee International and Engineering Mechanics Corporation of Columbus

Past Member of Materials Sub-Committee, CSA Z662 “Oil and Natural Gas Pipeline Systems

Past Member of Pipeline Integrity Sub-Committee, CSA Z662 “Oil and Natural Gas Pipeline Systems

Member, Professional Engineers of Ontario

EDUCATION

Queen’s University
Bachelor of Science in Metallurgical Engineering

Registered Professional Engineer since 1985

RECOGNIZED TECHNICAL ACTIVITIES

25 years of experience in pipeline and materials engineering and pipeline integrity management
Pipeline Integrity Management Program development
Risk Management
Hazard and Threat Analysis
Pipeline fracture mechanics investigations and failure analysis

Patrick H. Vieth

President, Dynamic Risk USA, Inc.
Senior Vice President, Technical Services, Dynamic Risk Assessment Systems, Inc.

SUMMARY

Patrick Vieth has 25 years of experience solving problems related to materials, corrosion, fitness for service, and reliability with primary focus on the production, transportation and distribution pipeline network. Mr. Vieth earned a Bachelor of Science Degree in Mechanical Engineering from The Ohio State University and is actively involved in ASME (B31.4 and the Pipeline Systems Division). His areas of expertise include pipeline integrity management programs, incident investigations and root cause analysis, defect assessment, codes and regulatory and litigation. Mr. Vieth leads the Dynamic Risk USA operations headquartered in The Woodlands (Houston), TX.

PROFESSIONAL EXPERIENCE

DYNAMIC RISK USA, INC.

President

November 2011 - Present

Mr. Vieth leads the Dynamic Risk USA operations headquartered in The Woodlands (Houston), TX. The opening of the Dynamic Risk USA operations is a strategic decision to best service clients and Mr. Vieth's technical and business operations experience are well-suited to continue expanding the US-based operations.

BP

Exploration & Production Technology (EPT)

Pipelines and Civil Engineering

February 2010 – November 2011

As part of the Senior Level Leadership (SLL) Team, responsible for refining the corporate risk assessment for pipelines and associated infrastructure. Significantly involved with BP's response to the 2010 Gulf Oil Spill (Macondo incident) and worked in the Incident Command Center for the first 6-weeks of the incident. Since the Macondo incident, have led assessments and strategy development to quantify, prioritize and mitigate corporate risk specifically related to the pipeline infrastructure.

DNV COLUMBUS, INC.

President, DNV Columbus, Inc. (f.k.a. CC Technologies) Director, Asset Risk Management

1999 - 2010

Primary responsibility for 75 employees, as well as HR, Contracts, Sales/Marketing/Business Development, Facilities, and SHEQ. Lead a group of professionals and industry-recognized multi-disciplinary experts that provide consulting and engineering services in the areas of corrosion, materials, welding, engineering analysis, and integrity assessments.

As a shareholder and member of the executive management team for CC Technologies, Inc. (*acquired by DNV in 2005*), assembled world-renowned team of seasoned industry-recognized experts and created an environment to develop a group of young engineers. Executive team managed growth from approximately 50 to 150 employees between 1999 and 2005. Managed a successful sale and integration of CC Technologies into DNV.

Increased responsibility and experience in corporate operational activities commencing in 2002 when appointed Vice President.

PIPELINE INTEGRITY INTERNATIONAL

Manager, Integrity Solutions

February - November 1999

Started the pipeline integrity group for an in-line inspection company that was formerly British Gas and is now GE PII. Role was to build an engineering and integrity group to support pipeline operators that had performed in-line inspection surveys.

KIEFNER & ASSOCIATES, INC.

Associate and Mechanical Engineer

1991 - 1999

Was the first engineer to join Dr. John Kiefner and helped to build the company into an industry-recognized firm that provides niche services to the pipeline industry. Projects performed during this time period helped to establish this firm as a go-to group for challenging assessments, failure analyses, and support in dealing with regulatory agencies.

BATTELLE MEMORIAL INSTITUTE

Research Scientist

1985 - 1991

Began working as an intern while completing college. Once working full-time, became involved in full-scale testing projects for the nuclear industry and the pipeline industry. Executed and managed research for the International Pipeline Integrity Research Group (IPIRG) that was comprised of nuclear agencies from around the world. Performed several projects for PRC *International* related to corrosion assessment (RSTRENG), pipeline industry failure data trending, and risk assessment methods.

PREVIOUS WORK HISTORY

President, Dynamic Risk USA, 2011 to Present

Senior Vice President – Technical Services, Dynamic Risk USA, 2014 to Present

Senior Level Leadership Team, BP Exploration & Production Technology, 2010-2011

President, DNV Columbus, 2009-2010

Director & Head of Department, Asset Risk management, DNV Columbus, Inc. 2005-2010

Executive Vice President, CC Technologies, Inc., 2003-2005

Senior Vice President, CC Technologies, Inc. 2002-2003

Senior Project Manager, CC Technologies, Inc., 1999-2002

Associate and Mechanical Engineer, Kiefner & Associates, Inc., 1991 - 1999

Researcher Scientist, Battelle Memorial Institute, 1990 - 1991

Researcher, Battelle Memorial Institute, 1987-1990

College Intern, Battelle Memorial Institute, 1985 – 1987

PROFESSIONAL ACTIVITIES

American Society of Mechanical Engineers (ASME)

- *ASME Fellow*
- *Vice Chairman – ASME B31.4*
- *Past Chairman – ASME Pipeline Systems Division*
- *Past Chairman – Central Ohio Section of ASME*
- *International Petroleum Technology Institute (IPTI) – Board Member*

National Association of Corrosion Engineers (NACE)

TECHNICAL ACTIVITIES

RSTRENG. Co-developer of the RSTRENG corrosion assessment method. Performed numerous studies to evaluate the applicability and validation for the RSTRENG method and have given countless presentations and courses on the subject.

Risk Assessment. Involved in development of early-generation pipeline risk assessment. More recently involved in pipeline risk assessment model development, prioritization of results, development of methods to obtain information for further assessing risk, and developing response plans to reduce risk.

Pressure Cycle Fatigue. Developed analysis tools for evaluating the effects of operational pressure cycles and published (Pipeline Rules of Thumb)

In-Line Inspection. Leadership role in developing and validating the first transverse field inspection (TFI) tool for evaluating longitudinal seam weld defects. Actively involved in the continued validation and application of results produced by ultrasonic crack detection tools (USCD) and phased array tools.

Failure Investigations. Significant involvement in notable pipeline incidents including Bellingham WA (June 1999), Greenville TX (March 2000), Carlsbad NM (August 2000), Piney Point MD (April 2000), Prudhoe Bay AK (2006), Clearbrook MN (November 2007). Support has included on-site technical expertise, preservation of evidence, metallurgical failure analysis, root-cause analysis, regulatory aspects, fitness for service/return to service, and litigation support.

Reliability Assessments. Developed recognized tools within the pipeline industry that integrate engineering solutions and statistical analysis techniques. Namely, Probability of Exceedance (POE), Statistical Active Corrosion (SAC), and Pressure Cycle Fatigue – Statistical Analysis (PCFStat).

Fuel Grade Ethanol Transportation. Managed the PRC *International* program that funded and directed the research to evaluate limits for transporting ethanol while minimizing the risk of internal stress corrosion crack and degradation of non-metallics. Task Force member commissioned by National Commission on Energy Policy (NCEP) to examine the infrastructure implications of the federal Renewable Fuels Standard.

Professional Development. Member of the Executive Committee for ASME Pipeline Systems Division (PSD) that is dedicated to knowledge transfer and development within the global pipeline industry. PSD was formally commissioned in 2007 and has been the leader group for the International Pipeline Conference (IPC) since its inception. Have instructed numerous courses for customers and have taught through the Clarion organization for over 10 years.

Litigation Support. Served as a testifying expert and have provided expert consulting services on numerous projects involving litigation. Primarily support defense claims against pipeline operators.

Management Training. Leadership development program designed to build managerial competence and stimulate personal growth among mid-level managers and candidates for senior manager positions. This was provided by DNV and is offered to about 40 staff annually (of the 8,000 employees) and involves 6-weeks of course work at IMD (Lausanne, Switzerland) and Fudan University (Shanghai China).

SELECTED PUBLICATIONS

Risk Assessment

Vieth, PH., Maier, CJ, Harper, WV, Johnson, ER, Neogi, B., Baskurt, UJ, "*Probabilistic Assessment of Minor Mechanical Damage*", Pending Publication, 6th International Pipeline Conference, September 25–29, 2006 (Calgary, Alberta, Canada), IPC2006-10409.

Vieth, P. H., Moghissi, O. C., and Beavers, John A., "*Integrity-Verification Methods Support US Efforts in Pipeline Safety*", Oil & Gas Journal, Vol. 100.51, December 16, 2002, pp. 52-59.

Kiefner, J. F., Vieth, P. H., Orban, J. E., and Feder, P. I., "*Methods for Prioritizing Pipeline Maintenance and Rehabilitation*", American Gas Association, Pipeline Research Committee, Catalog No. L51631, September 28, 1990.

Corrosion Assessment

Vieth, P. H., and Kiefner, J. F., Database of Corroded Pipe Test", American Gas Association, Pipeline Research Committee, Pipeline Research Committee, Catalog No. L51689, April 4, 1989.

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Kiefner, J. F., and Vieth, P. H., Evaluating Pipe: New Method Corrects Criterion for Evaluating Corroded Pipe, Oil and Gas Journal, August 6, 1990.

Kiefner, J. F., and Vieth, P. H., Evaluating Pipe: PC Program Speeds New Criterion for Evaluating Corroded Pipe, Oil and Gas Journal, August 20, 1990.

Vieth, P. H., and Kiefner, J. F., RSTRENG User's Manual, American Gas Association, Pipeline Research Committee, Catalog No. L51688, March 31, 1993.

Kiefner, J. F., and Vieth, P. H., The Remaining Strength of Corroded Pipe, American Gas Association, Eighth Symposium on Line Pipe Research, Houston, Texas, September 1993.

P. H. Vieth, J. A. Beavers, T. A. Bubenik, and R. D. Kane, Biofuels Industry Takes a Searching Look at Using Pipelines, Pipeline and Gas Journal, Vol. 235, No. 1, November 2008, pp. 56-62.

Pipeline Failures

Maier, CJ, Beavers, JA, Shie, TM, and Vieth, PH, Interpretation of External Cracking On Underground Pipelines, Pending Publication, 6th International Pipeline Conference, September 25–29, 2006 (Calgary, Alberta, Canada), IPC2006-10176

Vieth, P. H., Roytman, I., Mesloh, R. E., and Kiefner, J. F., Analysis of DOT Reportable Incidents for Gas Transmission and Gathering Pipelines – 1985 through 1994, American Gas Association, Pipeline Research Committee.

Vieth, P. H., et al., DOT Incident Data Analysis, American Gas Association, PRC International, 9th Symposium on Line Pipe Research, Houston, Texas, September 1996.

Vieth, P. H., Maxey, W. A., Mesloh, R. E., Kiefner, J. F., and Williams, G. W., Investigation of the Failure in GRI's Pipeline Simulation Facility Flow Loop, Gas Research Institute, March 15, 1996.

Michiel P. Brongers, Clifford J. Maier, Carl E. Jaske, Patrick H. Vieth, Mark D. Wright, and Robert J. Smyth, Evaluation and Use of a Steel Compression Sleeve to Repair Longitudinal Seam-Weld Defects, 52nd Annual Pipeline Conference, San Antonio, TX, USA, April 17-18, 2001.

Michiel P. Brongers, Clifford J. Maier, Carl E. Jaske, Patrick H. Vieth, Mark D. Wright, and Robert J. Smyth, Tests, Field Use Support Compression Sleeve for Seam-Weld Repair, Oil & Gas Journal, PennWell Corporation, Houston, Volume 99.24, June 11, 2001, pp. 60-66.

In-Line Inspection

Vieth, P. H., Rust, S. W., Johnson, E. R., and Cox, M. J., In-Line Characterization and Assessment, American Gas Association, PRC International, 9th Symposium on Line Pipe Research, Houston, Texas, September 1996.

Rust, S. W., Vieth, P. H., Johnson, E. R., and Cox, M. J., Corrosion Pig Performance and Risk Assessment, Pipes and Pipelines International, Pipeline Pigging Conference, Houston, Texas, February 1996.

Vieth, P. H., Rust, S. W., Johnson, E. R., and Cox, M. J., Corrosion Pig Performance Evaluation, American Society of Mechanical Engineers, American Petroleum Institute, 7th Annual Energy Week Conference, Houston, Texas, and January 1996.

Rust, S. W., Vieth, P. H., Johnson, E. R., and Cox, M. J., Quantitative Corrosion Risk Assessment Based on Pig Data, National Association of Corrosion Engineers (NACE), NACE/96, Denver, Colorado, March 1996.

Flaw Growth

Maxey, W. A., Vieth, P. H., and Kiefner, J. F., An Enhanced Model for Predicting Pipeline Retest Intervals to Control Cyclic-Pressure-Induced Crack Growth, American Society of Mechanical Engineers (ASME), Offshore Mechanics and Arctic Engineering (OMAE) 1993, Proceedings of the 12th International Conference, Volume V (Pipeline Technology), 1993.

Full-Scale Testing

Scott, P., Kramer, G, Vieth, P., Francini, R., and Wilkowski, G., The Effects of Cyclic Loading During Ductile Tearing on Circumferentially Cracked Pipe – Experimental Results, ASME PVP Volume 280, June 1994, pp 207-220.

Wilkowski, G., Vieth, P., Kramer, G., Marschall, C., and Landow, M., Results of Separate-Effects Pipe Fracture Experiments, Post-SMiRT-11 Conference, August 1991, Paper 4.2.

EDUCATION

The Ohio State University
Bachelor of Science in Mechanical Engineering

IMD (Lausanne, Switzerland)
Senior Level Management Training Course (2007) Included segment at Fudan University (Shanghai, China)

Phillip G. Nidd

Vice President, Operations and Technical Services, Dynamic Risk USA, Inc.

SUMMARY

Over 35 years of technical and management experience in the asset integrity business, having served in Asset Integrity senior management positions for a major pipeline operator and several large engineering consulting companies. As Vice President, Operations and Technical Services for Dynamic Risk USA Inc., responsibilities include providing leadership for Operations and technical support services for US operations, developing and commercializing industry leading engineering technology, and working closely with the US-based clients in account management functions.

As a recognized expert in the field of pipeline integrity, asset risk management, regulation compliance and issues related to failure analysis and litigation, Mr. Nidd has traveled extensively for technical meetings and has performed project consulting in Russia, Ecuador, Argentina, USA, Canada, and the Middle East, acting as a management consultant on major investigation root cause investigation projects including Deepwater Horizon explosion in 2010 and response to San Bruno pipeline Failure- 2011-2013.

Most recently, Phillip has been involved with development of Dynamic Risk audit and root cause investigation processes and leading several Integrity Management and Management System regulatory and Best Practice audits for major liquid and gas pipeline operators in both the US and Canada.

Mr. Nidd has published several articles and presentations relating to Asset Integrity matters and is a member of the National Association of Corrosion Engineers (NACE), American Society for Metals (ASM) and the American Society of Certified Engineering Technicians (ASCET).

PROFESSIONAL EXPERIENCE

DYNAMIC RISK USA, INC.
Vice President, Operations and Technical Services

August 2012 – Present

As Vice President, Operations and Technical Services Mr. Nidd is responsible for senior project management, providing leadership for technical services with particular focus on Litigation Support, Failure Root Cause Analysis Investigations, Management System Regulatory Audits, Integrity Management Plan best practice audits, along with the functions of staff mentoring and working closely with the US-based clients in account management functions.

DET NORSKE VERITAS (DNV)
Deputy Director, DNV Litigation

September 2009 – August 2012

As Deputy Director of the DNV Litigation Group, had responsibility for market development, directing large scale litigation projects, attorney communication, providing asset integrity management technical support, daily project coordination and coaching / mentoring staff. As Manager for several large DNV investigation projects relating to:

- 2010-2012- Forensic examination of the Deepwater Horizon blowout preventer (BOP), (Co-Project Manager), was responsible for project day to day operations involving 500 project participants and communications with attorneys representing involved parties and the U.S. Bureau of Ocean Energy Management, Regulation and Enforcement.

- 2011-2012- Following the San Bruno incident, was responsible for development and implementation of several large

continuous improvement projects to pipeline integrity management and risk assessment for Pacific Gas And Electric Company.

INTERTEK-APTECH
Director, Pipeline and Litigation Services

2005 - 2009

As Director of Pipeline and Litigation Services for was fully responsible for pipeline fitness-for-service assessment programs, pipeline rehabilitation management, pipeline integrity management plan development and management of large scale pipeline related litigation technical support projects. In addition, provided training to engineers in the area of Pipeline Integrity and Project Management and directed the development of document management systems for large scale litigation support projects.

- Litigation Project Management

  Led a multi-disciplined litigation engineering support team offering technical support regarding pipeline failure litigation proceedings leading to trial in 2009.

- Litigation Project Management

  Acted as a manager of several multi-disciplined litigation engineering support teams that provided engineering support during pipeline failure litigation proceedings leading to settlements in 2007 and 2008.

AMEC PIPELINE PROFESSIONALS
VICE PRESIDENT, OPERATIONS

1997 – 2005

Responsible for leading a diverse technical team providing a complete "turn-key" pipeline integrity management service, including all aspects of pipeline integrity assessment, regulatory compliance, in-line inspection, pipeline rehabilitation and repair, rehabilitation program management, and related engineering support.

- Pipeline Rehabilitation Program

  Managed the field engineering and technical requirements involved in a response to a major pipeline failure including pipeline assessment programs, pipeline rehabilitation, regulatory communications, community program updates, establishment of procedures and criteria for repair.

- Pipeline Performance Testing Program

  Reporting to the Ecuadorian Oil Ministry, managed all aspects of the Pipeline Performance Testing Program implemented to validate the pipeline construction practices, quality control and pressure and capacity performance aspects.

- Construction Quality Assessment Program

  Managed quality control program and established assessment and removal criteria for pipeline dents created during construction of the Pipeline in Ecuador, SA.

- 20" Pipeline Rehabilitation Program

  Was a member of a team that managed the technical aspects of a major cross country pipeline assessment and rehabilitation program involving in line inspection, hydrostatic testing and over 1000 excavations and pipe examinations.

ENCANA
MANAGER, PIPELINE INTEGRITY

1981 – 1997

Development and implementation of the Company's USA and Canadian system pipeline integrity management program, which included over 2500 miles of in line inspection and over 3500 specific pipeline integrity excavations along with related defect assessment and repair. Development and implementation of the Company's Stress Corrosion Cracking and corrosion susceptibility and risk assessment models.

Development of the Company's Stress Corrosion Cracking Research Program and implementation of pipeline integrity data management systems.

Pipeline Assessment And Rehabilitation
Development and implementation of the Company's USA and Canadian system pipeline integrity management program, which included over 2500 miles of in line inspection and over 3500 specific pipeline integrity excavations along with related defect assessment and repair.

Development of the Company's procedures for all pipeline integrity activities, including Nondestructive Examination, clock spring applications, defect assessment, defect repair methodologies, coating selection, in line inspection

Stress Corrosion Cracking Investigation
Development and implementation of the Company's Stress Corrosion Cracking and corrosion susceptibility and risk assessment models.

Development of the Company's Stress Corrosion Cracking Research Program and implementation of pipeline integrity data management systems.

Development and implementation of the Company's defect assessment criterion and repair methodology for Stress Corrosion Cracking and corrosion and provided representation on several technical committees, including the Canadian Energy Pipeline Association (CEPA) commission on stress corrosion cracking (SCC).

NOVA / TRANSCANADA
PIPELINE INTEGRITY MANAGER TECHNICAL LEAD

1975 – 1981

As an original member of the Nova pipeline transmission system Integrity Management Group was responsible for implementation of Risk Management applications, ILI programs, cathodic protection, external coating test programs, excavation and NDE programs.

PREVIOUS WORK HISTORY

Deputy Director, DNV Litigation, Det Norske Veritas (DNV), 2009 – 2012

Director of Pipeline and Litigation Services, Intertek-APTECH, 2005 – 2009

VP Operations- AMEC Pipeline Professionals, 1997 – 2005

Consultant, Manager, Pipeline Integrity- EnCana, 1981 – 1997

Nova / TransCanada, 1975 – 1981

PROFESSIONAL ACTIVITIES

National Association of Corrosion Engineers (NACE) – Member - 186766-00

American Society for Metals (ASM) – Member 7798960

American Society of Certified Engineering Technicians (ASCET)- Member – 01876Y American Society for Quality (ASQ) - Member

American Society Of Non Destructive Testing (ASNT) - Member

RECOGNIZED TECHNICAL ACTIVITIES

Two day training course relating to Integrity Management for Pipelines" held in Johannesburg, South Africa, November, 2011.

Two day training course relating to "Pipeline Integrity Management Choices" held in Doha, Qatar, September 2010.

Two day training course relating to "Pipeline Corrosion Control and Integrity Management" held in Bangkok, Thailand, September, 2009.

One-day "Pipeline Integrity Training" seminar at the Africa/Middle East Oil & Gas Flow Assurance Summit held in Cairo, Egypt, May 6-8, 2008.

"Control of Black Dust; Presentation of Case Studies"- Middle East Oil and Gas Flow Assurance Summit held in Cairo, Egypt, (May 6-8), 2008

"OCP in Line Inspection Program: Technical Challenges and Unique Contractual Approaches" - Rio Pipeline Conference, 2007.

Two-part magazine article: Pipeline Oil and gas Journal, relating to "Litigation Consequences of Pipeline Integrity Management Choices." Published in June and September, 2007.

Three-day training course in South Africa entitled; "Program on Pipeline Management And Integrity" attended by oil industry management and technical personnel, 2007

"Practical Considerations for Formation of an Integrity Management Plan," Gas Association Meetings, (September 2003).

"Innovative Solution to Hydrostatic Testing" – IPC Conference-Calgary (Co-Author -2001) / "Platte Inspection Program

Supports Alternative to Hydrostatic Testing," Oil and Gas Journal, (Co-author - 2001).

"Evaluation of Pipeline Integrity Using Instrumented Pigging Tools," Pipeline Integrity

Conference, Calgary, (1999).

"Clock Spring Repair Sleeves and Pipeline Rehabilitation," Banff Pipeline Conference, (1998).

MANAGEMENT EXPERIENCE

- Vice President of Operations for major pipeline construction and consulting firm; AMEC International
- Director of Litigation Support activities for consulting companies; Intertek and DNV.
- Co- Manager of DNV 2 year multi discipline investigation of Deepwater Horizon explosion initiating in 2010.
- Technical Lead- Several extensive litigation support projects leading to settlements; Intertek
- Technical Lead- Several large scale pipeline Root Cause Analysis and Management System Audit investigations- Dynamic Risk.
- Co-Chair; 2014 International Pipeline Conference; Track 6 - Pipeline Integrity.

EDUCATION

Engineering College in Canada- Mount Royal College 1971-1974

NACE Corrosion Course Training – 1975/1976

ASM – Metallurgical Levels 1-3 - 1976/1977

Ben Mittelstadt

Manager, Consulting, Dynamic Risk Assessment Systems, Inc.

SUMMARY

Ben has 14 years of experience related to engineering, project management, and integrity management of pipelines. Ben also has significant experience working with regulators as a representative for pipeline operators through regulatory audit proceedings and follow up to PHMSA corrective action orders.

Ben earned a Bachelor of Science degree in Mechanical Engineering from Colorado State University in 2001 and has served as a senior level integrity engineer and manager of risk management for two major pipeline operators. Ben has led or provided support to a wide array of projects over his career including root cause investigations, integrity management program planning and execution, integrity verification and remediation planning following pipeline failures, regulatory audits, and development of risk based mitigation programs. He has extensive experience with integrity assessments including in-line inspection (ILI) and hydrostatic testing for integrity management. Ben also brings to Dynamic Risk six years of direct field experience related to vintage pipelines, pipeline construction, NDE techniques, and defect assessment.

PROFESSIONAL EXPERIENCE

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.

Manager, Consulting

January 2014 - Present

Ben currently leads a team of consulting engineers based in Houston, TX, and Calgary, AB. Responsibilities include oversight of consequence modeling for liquid pipeline systems, pipeline threat assessments, qualitative and quantitative risk assessments for new and existing pipeline systems, integrity management program support including in-line inspection data analysis, and consulting with clients regarding integrity management practices

PACIFIC GAS AND ELECTRIC COMPANY

Manager, Risk Management, Transmission Integrity Management

September 2012 – December 2013

Ben led a team of seven (7) engineers responsible for HCA identification per 49CFR192 Subpart O and risk evaluation of PG&E's approximately 5700 mile-length Transmission Pipeline System per 49CFR192 Subpart O. Other responsibilities included oversight of HCA assessment plan (BAP) implementation, start up and oversight of integrity evaluations of various in-flight company initiatives including newly identified encroachments, geo-technical hazards, and shallow pipe assessment and mitigation programs.

EL PASO CORPORATION/KINDER MORGAN

Principal Engineer, Pipeline Integrity Management

August 2011 – August 2012

Developed a geo-technical hazard assessment and mitigation program to address landslide and other earth movement threats to natural gas pipelines. Assisted in the development and then oversaw implementation of an Integrity Verification

and Remediation Plan (IVRP) as required by PHMSA following a Corrective Action Order and a Consent Order on El Paso Corporation's Gas Pipeline system. Oversight at a program level of two Integrity Roadmap efforts to address non-piggable pipeline segments and auto shut/remote control valves.

EL PASO NATURAL GAS COMPANY

Principal Engineer, Pipeline Services

June 2005 – July 2011

Management and execution of Pipeline Integrity Program ILI remediation work in the field. Personally managed project work as an on-site project manager. Performed ILI data analysis and interpretation. Performed ILI anomaly evaluation on the pipeline. Interfaced extensively with EPNG Pipeline Maintenance, Welding Shops, and Gas Control personnel for project work. Worked closely with EPNG operations group during the completion of ILI remediation, and with technical support of pipeline related issues. Provides support for area operations including interpretation of Pipeline Operating Procedures and O&M manuals, recommending and overseeing completion of repairs of pipeline and compressor station piping, and providing pipeline related engineering technical support.

EL PASO NATURAL GAS COMPANY

(Concurrent with Pipeline Services Work) Principal Engineer, Consent Decree Compliance -

June 2008 – June 2010

Managed project work as required by the Carlsbad Consent Decree including development of work plans and oversight of completion for approximately 300 internal corrosion inspections with automated and manual ultrasonic inspection over a two year period.

EL PASO CORPORATION

Project Coordinator, Project Management

June 2002 – May 2005

Management of Pipeline Integrity Program "Make Ready" work – responsible for approximately 1200 miles of transmission line make ready for ILI construction between 2003 and 2005. Worked closely with Pipeline Services in the design and planning stages of PIP projects to ensure optimal design for ILI. Provided support for Pipeline Services as necessary during repair activities, i.e. welding calculations during welding for sleeve installations on loaded lines. Responsible for project management duties relating to new construction and maintenance capital projects – including meter stations and pipeline construction. Daily project duties including cost estimating and tracking.

TERRACON CONSULTANTS WESTERN, INC.

Engineering Technician, Construction Services

September 2001 – June 2002

Soils testing including moisture/density relations and R-Values. Performed mix design and destructive testing of concrete and asphalt. Daily responsibilities included digital data acquisition, analysis, and reporting.

WOODWARD GOVERNOR COMPANY

Mechanical Engineering Intern, Testing and Development Laboratory

March 1988 – March 1990

Design and execution of testing on existing fluid control equipment, liquid and gas, as well as developmental projects.

Performed data acquisition, analysis and reporting.

COMMITTEES

ASME B31.4 – Pipeline Transportation Systems for Liquids and Slurries - Section Committee Member 2015 – 2016.

SKILLS

ASME B31.8S – Managing System Integrity of Gas Pipelines

Thermodynamics of Compressible Fluids, and Feedback Control Systems

Extensive work with RSTRENG, Pipeline Toolbox

Field defect evaluations including Corrosion Evaluation (RSTRENG), Mechanical Damage Evaluation, Magnetic Particle Inspection, Ultrasonic Inspection

2009-2012, PRCI Technical Committee (Operations and Integrity)

EDUCATION

Colorado State University
Bachelor of Science in Mechanical Engineering, August 2001

Nasim Tehrany, P.Eng.

Process Safety Engineer, Dynamic Risk Assessment Systems, Inc.

SUMMARY

Nasim Tehrany, P. Eng. is a Process Safety Engineer with 8 years of experience in the Oil and Gas industry. Nasim has been involved in development of various Process Safety studies, philosophies, procedures, and specifications. As part of the engineering team, she has worked on a range of projects including Heavy Oil, Natural Gas, and Liquefied Natural Gas (LNG) projects for both offshore and onshore facilities.

In addition, she has experience in management of the safety deliverables for several major projects. The scope of these projects included Process Safety and Fire Protection, Human Factors, Structural and Blast Assessments, and Fire Protection studies. She is familiar with technical safety software packages such as PHAST, PHA Pro, CFAST, and QRA Tools.

PROFESSIONAL EXPERIENCE

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.
Process Safety Engineer

2016 – Present

Primary responsibility is to provide Process Safety support and project management to different projects in the oil and gas industry.

ATKINS CANADA
Process Safety and Risk Engineer

2013 – Present

Primary responsibility is to provide Process Safety support and project management to different projects in the oil and gas industry. Projects include:

- **Fort Hills Oil Sands Project** – Project Manager for Safety In Design (SID) work for Fort Hills facility. The Fort Hills Oil Sands Project is an open pit mine and extraction complex (north of Fort McMurray, Alberta, Canada) which is expected to produce approximately 164,000 – 180,000 barrels of bitumen per day. Atkins' scope includes Consequence Modelling, Quantitative Risk Assessment (QRA), Structural Analysis, and Fire Protection studies (~$3M).

- **Process Safety and Human Factor Projects** – Project Manager for various process safety and human factor projects undertaken by Atkins for onshore and offshore facilities throughout Canada.

- Provided Support to British Columbia Oil and Gas Commission on development of LNG Facility Permit Application and Operations Manual

ATKINS GLOBAL – UNITED KINGDOM
Process Safety Engineer

MAY 2013 – May 2014

Roles and responsibilities included providing process safety support to projects within Energy business with focus on the oil and gas industry. Projects include:

- **Abadi Floating Liquefied Natural Gas Facility (FLNG)** – Responsible for development of the Escape, Evacuation, and Rescue Assessment (EERA) for Abadi FLNG which is located in Arafura Sea, Indonesia. The EERA assessment included:

    - Identification of means of escape, evacuation, and recue provided on the installation
    - Assessment of credible accident events (fire, explosion, and cryogenic spills) for their potential to cause impairment within escape and evacuation routes
    - Assessment of the adequacy of the procedures and provisions made for effective Escape, Evacuation and Rescue (EER)
    - Assessment of compliance of the EER performance against recommended practice

- **Gorgon LNG Facility Expansion** – Responsible for development of a QRA and Siting Study. Gorgon is an onshore Liquefied Natural Gas Plant located on an island off the coast of Australia. The study included:

    - Quantitative assessment of the increased risk due to the expansion equipment – reported risk results included: Location Specific Risks, Individual Risks per Annum, Societal Risk, and Potential Loss of Life
    - Update of Explosion and Overpressure results and Design Accidental Loads for the Safety Critical Equipment and occupied buildings
    - Assessment of additional sensitivity cases to investigate the effect of further design modifications on the risk results
    - Qualitative assessment of the impact of expansion phase on the escape and evacuation provisions

- **Risers and Deep Water Flow lines QRA** – Consequence Analysis and QRA for releases from risers and deepwater flow-lines. The objective of the assessment was to investigate any risks to the personnel on the FPSO and nearby vessels caused by failures of risers and flow-lines.

- **Subsea Gas Export Pipeline QRA** – Consequence Analysis and QRA for deep and shallow water subsea releases caused by gas export pipeline failures. The potential risks to personnel on FPSOs and nearby vessels were assessed.

ATKINS CANADA
Process Safety Engineer

FEB 2010-APP 2013

Main projects included:

- **Joslyn North Mine Project** – Process Safety Engineer during the basic engineering and validation phases of Joslyn North Mine Project. Joslyn North Mine is an Oil Sands Extraction project in Alberta, Canada. Activities included:

    - Providing input for development of plot plan based on safety requirements and consequence modelling outputs
    - Development of Preliminary and Detailed Risk Assessments and Fire and Explosion Analysis
    - Development of Safety and Fire Protection Reports, Specifications, and Philosophies including Safety Critical Equipment Register and Standard
    - Conduct of process hazard identification and risk reduction workshops on proposed design modifications
    - Project Management (Atkins' scope) – Managing budget and schedule for safety deliverables and ensuring successful integration of safety schedule in the project's overall plans

- **Husky Corporate Emergency Management Program** – Developed a standard and a procedure for Corporate Emergency Management including Emergency Response, Security, and Business Continuity for Husky's global operations.

- **Husky Corporate Emergency Response Program** – Developed a gap assessment report for the Corporate Emergency Response Program. Main tasks included review of Husky ER document, industry standards, and best practices to ensure comprehensive coverage of emergency events in the corporate emergency response program.

- **Husky Sunrise HSE Bridging Document** – Developed an HSE Bridging Document and Simultaneous Operations Plan for Husky Sunrise SAGD project. Activities involved:
    - Preparation of a high level Strategy Document and an HSE Bridging Document
    - Development of a Construction SIMOPs Plan and presentation of the plan to the team members and stakeholders

- Other projects:
    - Suncor Fort Hills Project – Facility Siting
    - MEG Christina Lake Project – Fire Protection System Design
    - Joslyn North Mine Project – HAZOP, HAZID, and SIL workshops
    - Development of an onshore Facility Siting Procedure for occupied buildings
    - Development of performance standards for BHP facilities
    - Development of HEMP for Shell Canada Albian Sand project
    - Development of Major Accident Hazard Risk Assessment for Denali Gas Plant

EM ENGINEERING
Construction Manager / Site Engineer

OCT 2009 – JAN 2010

Construction Manager / Site Engineer on a project aimed at upgrading the central data processing facility for Alberta Credit Union.

SAIT POLYTECHNIC
Research Assistance

DEC. 2009 – JAN. 2010

Developed mathematical modeling for comparison of different filtration membranes for treatment of oily water produced in oil and gas activities such as SAGD. *(Research Title: Beneficial Use of Pre-treated Produced Water and Related Salt Impacted Water using Advanced Ceramic Membranes)*

WORLEYPARSONS CANADA
Mechanical Engineer

MAY 2008 – MAY 2009

Mechanical Engineering Intern on several natural gas projects including well sites, pipelines, and refrigeration plant.

EDUCATION

Bachelor of Science, Mechanical Engineering, University of Calgary (May 2008)
Additional Courses:

- Fire Dynamics and Modelling Course (University of Leeds)
- Consequence Modelling PHAST (DNV)
- Unconventional Oil Exploitation: Reservoir simulations and different heavy oil recovery methods (University of Calgary)
- Introduction to Drilling: On-shore and off-shore drilling (University of Calgary)
- Material Aspects of Oil and Gas: Materials used in oil and gas industry, and failures due to corrosion (University of Calgary)

Bill Ho, B.Sc., PMP

Manager, PMO, Dynamic Risk Assessment Systems, Inc.

SUMMARY

Over 25 years of experience in oil and gas industry working with major pipeline operators in North America. As PMO Manager at Dynamic Risk Assessment Systems Inc., Bill Ho is responsible for overall project governance and compliance.

Mr. Ho has experience in managing projects for the pipeline industry including projects such as software implementation, engineering assessments and regulatory application support. His areas of expertise include project management, project governance, business analysis and software implementation.

PROFESSIONAL EXPERIENCE

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.
Manager, PMO

2013 – Present

Roles and responsibilities include Project governance and Project Management for liquids and gas transmission system and

Project Governance Development experience includes:

- Development of Dynamic Risk Project Lifecycle with related project templates
- Development and management of company initiatives relating to projects
- Auditing and performing project reviews to ensure compliance to standards
- Maintains a centralized archive of lessons learned and ensures that improvements are disseminated and applied throughout the organization
- Directed, supervised, supported, mentored and coordinated the technical staff

DYNAMIC RISK ASSESSMENT SYSTEMS, INC.
Senior Project Manager

2010 – 2013

Roles and responsibilities included providing project management for Project Management for liquids and gas transmission system companies.

- Defined the project scope of work, its goals, timelines and deliverables
- Management of project change management process
- Managed the operational, financial and technical aspects of projects based on timelines and work plans
- Identified resource requirements, assigned responsibilities and coordinated directly and indirectly project staff to ensure successful completion of the project
- Tracked project deliveries using project management tools

- Resolved, traced and escalated critical issues to minimize project risk factors
- Managed project QA process
- Successfully stewarded projects over 40 projects to completion

SKYSTONE ENGINEERING LP
Manager, IT Services

2007-2010

- Managed the software development team and implementation of the new version of web based software (Spectrel) to clients, SharePoint portal within the organization
- Developed change and release management standards to data management and application upgrades for Spectrel
- Mentored technical staff, and stewarded project schedule and budget
- Analyzed best-practices to integrate existing MS-Office and MS-project with SharePoint
- Developed a network plan that would ensure scalability for a three to five-year timeframe to increase reliability
- Worked with senior management to develop strategic plans for the IT department
- Worked with external vendors to evaluate different technology including VMware to reduce the number of servers at Skystone

GREENPIPE INDUSTRIES LTD.
Manager, Software Development & Data Services

1996-2007

- Managed the design and development of features and associated database tables for the commercial release of custom software
- Developed feature lists for incremental releases of the software
- Developed five-year technology plan for the software
- Managed the implementations of PipeCraft at oil and gas companies (i.e., GOM/GOB(Bolivia), Imperial Oil, PanCanadian Petroleum, AEC and Talisman Energy)

PROGRAMMER ANALYST
SNC Lavalin

1990 -1996

- Designed, implemented, documented and maintenance of various real-time and simulation software packages.

PROFESSIONAL ACTIVITES

Industrial Research Assistance Program Award Finalist (2002)

Member of Project Management Institute

Publication: "Internal corrosion model predicts corrosion severity in pipelines", G. Cameron, D. Helgeland, B. Ho and K Caleb, Pipeline World, October 2004

EDUCATION

University of Calgary
Bachelor of Science, Computer Science (1990)

PMP Certification

Shane A. Kelly, M.Eng, P. Eng

Senior Geotechnical Engineer, Kelly Geotechnical.

SUMMARY

Shane Kelly, is a Senior Geotechnical Engineer based in Prince George, BC. He obtained an undergraduate degree in Geological Engineering from the University of New Brunswick, and a Masters of Engineering (Geotechnical) degree at the University of Alberta. His focus area of practice has been in providing terrain analysis, geological hazard assessment, geotechnical design, and construction input for resource development and linear corridor infrastructure projects in multi-disciplinary project team environments.

Mr. Kelly has been involved in the execution of varied degrees of geotechnical site investigation, hazard assessment, design, construction supervision, and community engagement for many aspects of infrastructure projects. Work spans from traditional geotechnical foundation design assignments through to more complex infrastructure feasibility evaluation and design for pipelines, highways, railways and bridges. Mr. Kelly has experience related to geotechnical investigation, geohazard assessment, remote sensing, resident engineering assignments, and construction reviews. As part of his focus area on linear corridor infrastructure geotechnical work, Mr. Kelly has carried out extensive work related to pipeline project specific geotechnical assessments, including defining and executing assessment processes for terrestrial and marine assignments.

PROFESSIONAL EXPERIENCE

KELLY GEOTECHNICAL LTD.
President
2011 - Present

AMEC EARTH & ENVIRONMENTAL
Associate Geotechnical Engineer
2004 - 2011

UNIVERSITY OF ALBERTA
Program, M.Eng.
2003 - 2004

GEONORTH ENGINEERING LTD.
Geotechnical Engineer
2002 -2003

KNIGHT PIESOLD, LTD.
Staff Geotechnical Engineer
2001 - 2002

GEONORTH ENGINEERING LTD
Staff Geotechnical Engineer
1990 -1996

PROFESSIONAL ACTIVITIES

Professional Engineer, British Columbia, Canada, 2003

Professional Engineer, Alberta, Canada, 2006

Professional Engineer, Yukon, Canada, 2007

EXPERIENCE RECORD

Infrastructure (Pipelines and Facilities)
Mr. Kelly has been involved in site investigations, preliminary design and/or construction of several major infrastructure projects including large diameter oil pipelines, gas transmission pipelines and facilities, a proposed wind turbine generation site, and the feasibility assessment and construction of run-of-river hydroelectric facilities. Highlights in this area include geotechnical investigation, conceptual analysis, and/or construction review for project components including; geotechnical route analysis and river crossing assessment for numerous HDD and aerial crossings for several pipeline projects in BC and Alberta; upstream production and processing plants design and construction; alpine tunnel geological assessment work; site analysis for proposed wind turbine foundations; tailings dam siting studies; and numerous municipal service systems for water and waste treatment and mine site infrastructure.

Slope Stability / Terrain Assessment
Mr. Kelly has extensive experience in reconnaissance level and detailed terrain stability assessment, landslide investigation, and geological hazard assessment. For industrial development applications, Mr. Kelly has completed terrain stability field assessments throughout the interior, northern, and coastal locations throughout BC and Alberta related to road and pipeline alignments, mitigation, and forest development planning. Investigation types range from overview aerial photo review, to remote field reconnaissance, through to detailed drilling investigation, instrumentation installation and monitoring. Mr. Kelly has worked extensively throughout central and northern BC and Alberta in this practice, an area that encompasses a wide variety of terrain types and geological hazards. Design and construction experience on slope stability remediation projects includes numerical analysis of the slide, design and construction of horizontal dewatering systems, instrument monitoring and evaluation of data, and remedial design. Mr. Kelly has carried out projects in this field related to land use and development, forestry applications, pipelines, and road corridors for government and industrial clients.

Infrastructure (Roads and Rail)
Mr. Kelly has significant experience on a wide variety of road projects including industrial level access roads, stream crossings and bridges, smaller Province of BC secondary roads and bridges, and main numbered highways. More recently Mr. Kelly has been involved in construction and QA review for ground preparation and embankment construction for rail projects in Saskatchewan and Alberta. The work for resource roads includes route geotechnical/geohazards evaluation, design, and construction projects throughout British Columbia. Assignments have included a wide array of tasks from road upgrades and widening, subgrade material assessment, causeway construction review cut slope (soil and rock) and embankment stability design, initial response work, mechanically stabilized earth structures, soil anchored walls and geosynthetic applications, QA construction review and instrumentation monitoring.

Foundations (Bridges, Buildings, Structures)

Mr. Kelly has conducted numerous geotechnical investigations and foundation design assignments for shallow and deep foundations for a variety of soil and rock conditions. Work for moderate to large structures has included in-river geotechnical investigations for two crossings of the Fraser River, and one over the Nechako River in BC. Project work included preliminary evaluations and foundation concept designs for long, multi-span bridge foundations associated with the Site C Clean Energy Project. Other bridge investigation and foundation designs have included simple-span forestry bridges on pre-cast spread footing foundations, and multi-span Highway bridges on various soil and rock conditions. Typical clients include BC Ministry of Highways, property developers, industrial clients (including mining and forestry clients), and other government organizations. Building foundation experience includes numerous bridges, buildings, and industrial mill applications. Mr. Kelly also has

experience in the investigation, design and installation of soil and rock anchors for various applications including penstock foundation anchorages, bridge foundation abutments, permanent retaining walls, and rock cut stabilization.

Infrastructure (Mining)
Experience in the mining industry has included geotechnical design for plant structures and work associated with tailings dam siting. Project work included assistance with designing an 80 m high centreline tailings dam in central British Columbia. Additional work experience in this area includes geotechnical design of a 17 m high vertical MSE wall in the Ft. McMurray area, coal mine haul road design, and assistance with performance bonding calculations and trade-off studies with respect to mine site access routes.

Terrain Assessment / Geohazard Assessment
Dynamic Risk Assessment, Enbridge Pipelines Minnesota, 2015 to present: Project geotechnical engineer responsible for completing a semi-quantitative geohazard assessment at 8 proposed pipeline watercourse crossings for 2 proposed liquids transmission pipeline projects proposed through the state of Minnesota and border of North Dakota.

Hatch Mott MacDonald, PRGT Pipeline Design Support, 2015/16:
Project geotechnical engineer responsible to provide geotechnical design support related to select geohazard assessments for 5 short segments of the overall pipeline route. Also provided geotechnical engineering support related to pipeline engineering integration of geohazard considerations for the project. PRGT pipeline is a proposed NPS48 natural gas pipeline project from northeast BC to Prince Rupert, BC.

Valemount Glacier Destinations, Proposed Resort Development, 2015 to present:
Geotechnical engineer responsible for conducting a preliminary rockfall geohazard assessment and route geotechnical assessments for resort access and construction roads as part of the pre-development permitting and planning. The project includes a ski resort and village development with several km of new access roads to be constructed to provincial standards, as well as many lifts and alpine stations as part of the final project footprint near Valemount, BC.

Enbridge Inc., Geotechnical Assessment, Proposed Natural Gas Pipeline Route, 2015:
Project geotechnical engineer responsible for assessing a proposed pipeline route for the project development team. Work included desktop terrain assessment and development of documents for the proponent to discuss project scoping from a geotechnical perspective.

***Northern Gateway Pipelines Inc., Northern Gateway Pipeline Project, 2005 to 2015*:**
Roles including Project geotechnical engineer through to Enbridge Geotechnical Program Manager for the proposed 1176 km Northern Gateway Pipeline Project from Bruderheim, AB to Kitimat, BC. Responsibilities included increasing roles from conducting geotechnical assessments through to managing the overall project geotechnical program for the project. Project included analyses of; a marine terminal site (20 million barrel storage and shipping transfer components); two 6.5 km long tunnel routes through the Coast Mountains; pipeline routing assignments and alternatives review, establishing and conducting a semi-quantitative geohazard assessment process; conducting detailed geohazard assessments of marine clay and submarine landslide hazard issues, and examining select pipeline routing and trenchless river crossing locations throughout BC and AB. Additional roles included technical liaison for investigation permitting through British Columbia, public presentations for geotechnical topics, generating documents for, testifying at, project National Energy Board hearings, and managing geotechnical engineering contractors for the project.

Alaska Pipeline Project / WP Canada, Kluane Lake CPT Investigation, 2012:
Project geotechnical engineer responsible for technical review and analysis of Cone Penetration Testing work being carried out as part of a submarine geohazard assessment of a pipeline route across Kluane Lake, YK. Tasks included on-site review of the work activities conducted from an ice-road on the lake through to reporting on the field results to the project team.

DWB Consultants Ltd., Terrain Stability Field Assessments, 2011:
Project Geotechnical Engineer responsible for conducting terrain stability field assessments for roads and cutblocks in various operating areas including the Morkill Valley, Chuchi Lake and Indata Lake areas. Project responsibilities included assessment and reporting according to the requirements of the BCFLNRO standards.

Spectra Energy, Goodrich Extension Re-injection Pipeline, 2009/2010:

Project geotechnical engineer assisting senior geotechnical engineer with field assessment and foundations engineering recommendations for pipeline routing, and aerial crossing infrastructure associated with the construction of the project. Tasks included field review of foundation conditions and providing design recommendations for design and field procedures related to installing foundations and completing grading.

Spectra Energy, Ft. Nelson Mainline Looping Projects, 2009 to 2011:
Project geotechnical engineer assisting senior geotechnical engineer with field reconnaissance, geotechnical investigations, geotechnical design and reporting for several proposed looping projects along the Ft. Nelson Mainline system. Tasks included review of engineering work, field reviews, crossing and landslide assessments and preparation and/or review of project documents prepared for client and/or regulatory review.

***City of Quesnel, West Quesnel Land Stability Study, 2004 to 2011*:**
Project Geotechnical Engineer responsible for ongoing assistance, analysis, and recent reporting for a large, slow-moving urban landslide affecting several hundred structures in Quesnel, BC. Project responsibilities include coordinating drilling investigations, including the installation of deep slope inclinometers and multi-level grouted-in-place VW piezometers complete with datalogger equipment; landslide and groundwater modeling; and reporting**.**

***Thunder Energy Inc., Terrain Stability Assessment of Trutch Creek Road, 2004*.**
Geotechnical Engineer for the terrain analysis of a 2 km extension of the Trutch Creek Oil & Gas Road across steep terrain through the valley bottom to access a potential bridge site. Project located in northeastern BC.

Regional District of Fraser-Fort George, Leona Creek Debris Flow Potential, 2004.
Project Manager and Geotechnical Engineer responsible for the evaluation of debris flow potential in a steep mountain drainage near McBride, BC. (Upper Fraser River Valley). Project included on-site review of the drainage and downstream property, predictions for debris flow torrents, and determination of hazard zones and building code requirements to accommodate the hazards.

Terrain Stability Field Assessments in the Forest Sector 1998 to 2003
Staff and Project Geotechnical Engineer providing assistance; fieldwork; analysis; and reporting related to terrain assessment in the BC forest sector for more than 100 proposed cut blocks, new mainline road locations, in-block access roads and bridge sites. Terrain regions covered included central, coastal and northern BC. Projects were carried out for major timber license holders, consultants, and government organizations**.**

***Joe Kopetski Ltd., Kopetski Landfill, 1999-2003*:**
Staff and Project Engineer responsible for annual review and reporting of landfill operations, landslide investigations, inclinometer & piezometer installation and monitoring, liaising with environmental consultants, and design of horizontal dewatering and landslide remediation, at wood-waste landfill, Quesnel, BC.

EDUCATION

University of New Brunswick, Fredericton, NB
B.SC. Eng. Geol. Engineering (1998)

University of Alberta, Edmonton, AB
M.Eng. Geotechnical Engineering

Brian D. Bornhold, Ph.D., P.Geo

Marine GeoScience Consultant, Kelly Geotechnical

SUMMARY

Dr. Bornhold works at Shane Kelly Consulting and has 43 years of pipeline geohazard experience, and has authored numerous papers.

PROFESSIONAL EXPERIENCE

BOARD OF DIRECTORS CANADIAN SCIENTIFIC SUBMERSIBLE FACILITY
Member – Executive Committee

2012 - 2014

NEPTUNE Canada, UNIVERSITY OF VICTORIA
Project Scientist/ Co-Chief Scientist

2004 – 2010

COASTAL AND OCEAN RESOURCES, INC.
Vice President

1998 – 2012

INTERNATIONAL TSUNAMI RESEARCH, INC.
President

1988 - Present

SCHOOL OF EARTH AND OCEANSCIENCES, UNIVERTY OF VICTORIA
Profession – Adjunct

1988 – 2014

PACIFIC GEOSCIENCE CENTRE, GEOLOGICAL SURVEY OF CANADA, NATURAL RESOURCES CANADA
Research Scientist

1977 - 1997

ROYAL SOCIETY OF CANADA, CANADIAN GLOBAL CHANGE PROGRAM
Director

1992 – 1993

NATIONAL DEFENCE COLLEGE OF CANADA
Participant

1990 – 1991

UNITED NATIONS DEVELOPMENT PROGRAM, MINISTRY OF GEOLOGY (CHINA)
Consultant

June 1988

PACIFIC GEOSCIENCE CENTRE, MARINEGEOSCIENCE SECTION
Head, Marine Geoscience Section

1988 – 1991

UNIVERSITY OF PERPIGNAN

Visiting Scientist

1975 – 1977

GEOLOGICAL SURVEY OF CANADADA
Research Scientist, Terrain Sciences Division

1975 – 1977

ONTARIO EDUCATIONAL COMMUNICATIONS AUTHORITY, TV
Consultant

1973 – 1974

GEOLOGY DEPARTMENT, UNIVERSITY OF TORONTO
Lecturer

1973 – 1974

SELECTED PUBLICATIONS

Van Zeyl, D. P., Stead, D., Sturzenegger, M., Bornhold, B.D. and Clague, J.J., 2015, Structure, stability and tsunami hazard associated with a rock slope in Knight Inlet, British Columbia, Natural Hazards and Earth Systems Sciences, vol. 3, 161-2011.

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Blais-Stevens, A., Geertsma, M., Schwab, J.W., Bornhold, B.D. and Mosher, D.C., 2006, A brief overview of landslide-generated tsunamis affecting North America. 1st Specialty Conference on Disaster Mitigation, Canadian Civil Engineering Association, Calgary, Paper DM-024, May 2006.

Good, T.M., Barrie, J.V. and Bornhold, B.D., 2005, Impact of offshoreaggregate extraction in the Prince Rupert area of British Columbia, Canada. In: Marine Geological and Benthic Habitat Mapping, Todd, B. and Greene, H.G. (eds.), Geological Association of Canada, Special Paper 4.

Bornhold, B.D., Jay, C.V., McConnaughey, R., Rathwell, G., Rhynas, K. and Collins, W., 2005, Walrus foraging marks on the seafloor in Bristol Bay, Alaska – A reconnaissance survey. Geo-Marine Letters, 25, 293-299.

Fine, I.V., Rabinovich, A.B., Bornhold, B.D., Thomson, R.E., and Kulikov, E.A., 2005, The Grand Banks landslide-generated tsunami of November 18, 1929: preliminary analysis and numerical modeling. Marine Geology, 215, 45-57.

Bornhold, B.D., Rabinovich, A.B., Fine, I.V., Kulikov, E.A., and Thomson, R.E., 2004, Landslide-generated tsunamis and their risk in coastal areas. Proceedings GeoQuebec, Canadian Geotechnical Society, 28-33.

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Bornhold, B.D. and Kemp, A.E.S. (Editors) 2001, Late Quaternary Sedimentation in Saanich Inlet, British Columbia, Canada. Special Volume, Marine Geology.

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Rabinovich, A.B., Thomson, R.E., Bornhold, B.D., Fine, I.V. and Kulikov, E.A., 2003, Numerical estimation of tsunami risk associated with landslide-generated tsunamis with application to the Strait of Georgia, British Columbia. Pure and Applied Geophysics, 160, 1273-1313.

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Prior, D.B., Yang, Z.S., Bornhold, B.D., Keller, G.H., Lu, N.Z., Wiseman, W.J., Wright, L.D., and Zhang, J., 1986, Active slope failure, sediment collapse and silt flows on the modern subaqueous Huanghe (Yellow River) Delta: Geo-Marine Letters, v. 6, p. 85-95.

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Ludwig, W.L., Krasenninikov, V. et al., 1980, Tertiary and Cretaceous paleoenvironments in the southwest Atlantic Ocean: Preliminary results of Deep Sea Drilling Project, Leg 71: Geol. Soc. Amer., Bull., v. 91, p. 655-664.

Bornhold, B.D. and Bonardi, M. 1979, Magnetic spherules in Arctic Ocean sediments: Canadian Journal of Earth Sciences, v. 16, p. 1778-1788.

Summerhayes, C.P., Bornhold, B.D. and Embley, R.W., 1979, Surficial slides and slumps on the continental slope and rise off South West Africa; a reconnaissance study: Marine Geology, v. 31, p. 265-277.

Yorath, C.J., Bornhold, B.D. and Thomson, R.E., 1979, Oscillation ripples on the northeast Pacific continental shelf: Marine Geology, v. 31, p. 45-58.

Bornhold, B.D., 1978, Carbon/nitrogen (C/N) ratios in surficial marine sediments of British Columbia. Current Research, Geological Survey of Canada, Paper 78-1C, 108-112.

Bornhold, B.D. and Summerhayes, C.P., 1977, Scour and deposition at the foot of the Walvis Ridge in the northernmost Cape Basin, South Atlantic: Deep-Sea Research, v. 24, p. 743-752.

Bornhold, B.D., Finlayson, N.M. and Monahan, D., 1976, Submerged drainage patterns in Barrow Strait, Canadian Arctic: Canadian Journal of Earth Sciences, v. 13, p. 305-311.

Bornhold, B.D., 1976, Suspended matter in the Southern Beaufort Sea: Final Report, Beaufort Sea Project, Study F-4, 11 pp.

Bornhold, B.D., 1973, Late Quaternary sedimentation in the eastern Angola Basin: Woods Hole Oceanographic Institution, Technical Report 73-80, 213 pp.

Milliman, B.D. and Bornhold, B.D., 1973 Peak-height versus peak intensity analysis of X-ray diffraction data: Sedimentology, v. 20, p. 445-448.

Mascle, J.R., Bornhold, B.D. and Renard, V., 1973, Diapiric structures off the Niger Delta: American Association of Petroleum Geologists, Bulletin, v. 57, 1672-1678.

Bornhold, B.D., Mascle, J.R. and Harada, K., 1973, Suspended matter in surface waters of the eastern Gulf of Guinea: Marine Geology, v. 14, p. M21-M31.

Bornhold, B.D. and Milliman, J.D., 1973, Generic and environmental considerations in the carbonate mineralogy and composition of Serpulid (Polychaete) tubes: Journal of Geology, v. 81, p. 863-873.

Bornhold, B.D., Mascle, J.R. and Harada, K., 1972, Sediments in surface waters of the eastern Gulf of Guinea: Woods Hole Oceanographic Institution, Technical Report 72-76, 17 pp.

Bornhold, B.D. and Pilkey, O.H., 1971, Bioclastic turbidite sedimentation in Columbus Basin, Bahamas: Geological Society of America, Bulletin, v. 82, p. 1341-1354.

Pilkey, O.H. and Bornhold, B.D., 1970, Gold distribution on the Carolina continental margin - a preliminary report: U.S. Geological Survey, Professional Paper 700C, p. C30-C34.

EDUCATION

University of Waterloo
B.Sc. Earth Sciences (1967)

Duke University, North Carolina
M.A. Geology (1970)

Massachusetts Institute of Technology and Woods Hold
Ph.D. Marine Geology, (1973)

Defence College of Canada, Kingston, Ontario
Ndc (1991)

RODNEY STEWART READ, PH.D., P.Eng., P.GeoL., P.Geo.

President and Principal, RS Read Consulting, Inc.

SUMMARY

Dr. R.S. (Rod) Read, P.Eng., P.Geol., P.Geo. is President and Principal Consultant of RSRead Consulting Inc., a Canadian engineering consulting firm specializing in applied rock mechanics and geotechnical engineering. Dr. Read has over 30 years of experience in projects related to nuclear waste management, pipeline geotechnics, natural hazards, petroleum geomechanics, transportation (railways and highways), dams, and civil/mining geotechnics. Highlights of this experience include:

Nuclear waste management research - Principal Investigator/Experiment Manager at Atomic Energy of Canada Limited's (AECL's) Underground Research Laboratory for large multi-disciplinary in-situ investigations, including the Mine-by Experiment, Heated Failure Tests, Excavation Stability Study, and Thermal-Mechanical Stability Studies, addressing fundamental issues related to rock mass response to excavation and heating, tunnel instability and excavation damage zone (EDZ) development. Consultant to AECL, Ontario Power Generation, Nuclear Waste Management Organization, and several international organizations regarding geomechanics and monitoring issues associated with nuclear waste disposal. Recent studies include a comprehensive summary of EDZ findings from international programs, identification of Features, Events and Processes (FEPs) related to geology and/or rock mechanics, assessment of potential for large-scale fracturing around a geologic repos- itory, and planning of large-scale laboratory testing to investigate earthquake- induced rock shear effects on emplaced waste containers.

Geohazard assessment - Development and application of geohazard assessment approaches for several major pipeline projects (Mackenzie Gas Project, northern Canada; Alaska Pipeline Project, Alaska and Canada; Camisea pipeline, Peru; pro- posed pipeline in northern British Columbia near Kitimat, Canada; and others) and co-author of ASME 2008 book "Pipeline Geo-Environmental Design and Geohazard Management." Ongoing development of pipeline geohazard assessment software and supporting data management systems.

Geomechanical analysis of pipeline and petroleum-related processes – analysis of uplift resistance and geomechanical testing of frozen soil, right-of-way preparation methods and quantities, Arctic trenching trials, pipeline deformations due to slope movement, potential karst collapse under pipelines, gas storage feasibility and associated applications of microseismic monitoring, water disposal issues related to oil sands development, borehole stability analysis of petroleum wells and horizontal directional drillholes, and drilling/laboratory testing program planning.

Surface and underground instrumentation and monitoring systems – planning and installation of geotechnical monitoring systems for underground nuclear waste disposal research, railway tunnel stability assessment, and landslide monitoring and early warning system development as part of the Turtle Mountain Monitoring Project in Crowsnest Pass, Alberta – the site of the 1903 Frank Slide. Analysis of data from complex monitoring systems to assess stability conditions and to back analyze fundamental geomechanical response characteristics was the basis for Doctoral Thesis "Interpreting Excavation-Induced Displacements around a Tunnel in Highly Stressed Granite" (University of Manitoba, 1994).

Dr. Read is experienced in the application of FLAC and other numerical codes to conduct complex analyses, and has managed diverse field characterization and laboratory testing programs. He has also been involved in a number of dam projects, including the Revel- stoke Dam, the Oldman River Dam, and the St. Mary's Dam spillway replacement project. He is a member of several professional organizations, and is registered as a Professional Engineer in Manitoba. He carries dual registration as a Professional Engineer and Professional Geologist in Alberta and British Columbia. Since 1987, Dr. Read has authored or co- authored over 100 published articles and reports on various technical aspects of his work, and has received awards from the Tunnelling Association of Canada and the Association of Professional Engineers of Manitoba. RSRead Consulting Inc. operates from its main office in Okotoks, Alberta and a field office in Revelstoke, BC.

PROFESSIONAL EXPERIENCE

RS READH CONSULTING, INC.
President and Principal Consultant

2000 - Present

Principal consultant focused on geomechanical analysis, geohazard assessment, geotechnical engineering related to pipeline and rail- way geotechnics, instrumentation, slope stability analysis, rock mechanics research and development, project/program planning and management, and technical peer review of issues related to inter- national nuclear waste disposal. Involved in geotechnical design, geohazard assessment and engineering for the Mackenzie Gas Project, the Alaska Pipeline Project, the Camisea Project and other major pipeline projects. Consultant to WorleyParsons and other clients (see website www.rsrci.com for more information).

ADVANCED GEOTECHNOLOGY, INC.
Senior Geomechanics Engineer / Manager, Geotechnical

1990 - 1996

Senior geomechanics engineer and geotechnical engineering man- ager specializing in project planning, analysis, and numerical model- ling related to petroleum production, heavy oil extraction using SAGD and other thermal processes, borehole stability, in situ stress determination, site characterization, and application of microseismic and geotechnical monitoring technology.

BGC ENGINEERING, INC.
Senior Geotechnical Engineer,

1998 – 2000

Senior geotechnical engineer specializing in geomechanics-related projects. Typical projects: coordination and technical direction of thermal-mechanical stability studies at AECL's Underground Re- search Laboratory; geotechnical engineering gap analysis and project planning for Ontario Power Generation's Used Fuel Disposal Technology Program; numerical analysis of slope stability and soil/pipeline interaction; stability assessment of directionally-drilled boreholes; railway rock slope stabilization; foundation investigation and evaluation of stability of South Peak of Turtle Mountain – the site of the 1903 Frank Slide.

KLOHN-CRIPPEN CONSULTANTS, LTD.
Senior Geotechnical Engineer

1997 – 1998

Senior geotechnical engineer specializing in rock mechanics-related projects. Typical projects: analysis and interpretation of results from geotechnical research at AECL's Underground Research Laboratory; assessment of instrumentation and rock bolt performance in spillway replacement project at St. Mary dam; analysis of drain design criteria; project management of geotechnical site investigations.

AECL, UNDERGROUND REASEACH LABORATORY
Geomechanics Research Engineer

1987 - 1997

Senior rock mechanics engineer for Geotechnical Science & Engineering Branch. Design, project management/ coordination, con- tract administration, analysis and reporting related to geomechanics research conducted to support the Canadian Nuclear Fuel Waste Management Program and Ontario Hydro's Used Fuel Disposal Project. Experiment Manager and Principal Investigator for the Mine- by Experiment, one of the world's foremost rock mechanics experiments addressing issues related to the Canadian concept for nuclear fuel waste disposal. Specialist in fundamental rock mechanics re- search related to tunnel design and excavation-induced damage for several large experiments, including the Tunnel Sealing Experiment, Excavation Stability Study, Heated Failure Tests and In Situ Characterization program.

GOLDER ASSOCIATES
Geotechnical Engineer (EIT)

1985 – 1987

Geotechnical engineer (EIT) on various geotechnical projects including the Oldman River Dam site investigation and test diversion tunnel project in Alberta; quarry investigation in the NWT; Cigar Lake mine study in Saskatchewan; and other civil projects.

CP RAIL SPECIAL PROJECTS
Geotechnical Engineer (EIT)

1984 – 1985

Construction supervision of twinning of the Rogers Pass section of the CPR mainline including aspects of rock and soil engineering, grade design, concrete testing, and contract administration.

BC HYDROP, MINISTRY OF HIGHWAYS, CP RAIL
Summer Student

1979 – 1984

Construction supervision of twinning of the Rogers Pass section of the CPR mainline including aspects of rock and soil engineering, grade design, concrete testing, and contract administration.

AWARDS

1997 Association of Professional Engineers of the Province of Manitoba's Early Achievement Award

1996 Short-listed in 1996 International Society for Rock Mechanics (ISRM) Rocha Medal thesis competition

1995 First Prize in Tunneling Association of Canada (TAC) Graduate Student Thesis Award competition

1995 Nominated for Natural Sciences and Engineering Research Council of Canada (NSERC) Doctoral Prize competition

1983 George E. Winkler Memorial Scholarship

PROFESSIONAL ACTIVITIES

(2013 – present) Registered Professional Geoscientist, British Columbia (APEGBC)

(2002 – present),Registered Professional Geologist, Alberta (APEGA)

(2002 – present) Registered Professional Engineer, British Columbia (APEGBC)

(1997 – present) Registered Professional Engineer, Alberta (APEGA)

(1987 – present) Registered Professional Engineer, Manitoba (APEGM)

(2012 – present) Member, American Society of Mechanical Engineers

(2000 – present) Member, Society of Petroleum Engineers

(1989 – present) Member, Tunneling Association of Canada (TAC)

(1999 – present) Member, American Rock Mechanics Association

(1998 – present) Member, International Society for Rock Mechanics (ISRM)

(1998 – present) Member, Canadian Geotechnical Society (CGS)

(1998 – 1999) Adjunct Professor, Dept. of Civil Engineering, University of Calgary

(1998 – 1999) Committee Member, Calgary Chapter of CGS

(1984 – 1987) Engineer-in-training, (APEBC)

(1984 – 1987) Member, Vancouver Geotechnical Society

SELECTED PUBLICATIONS

Books and Journal Publications

Read, R.S. 2015 (in press). Excavation response studies at AECL's Underground Research Laboratory – 1982 to 2010. Chapter in Rock Mechanics and Engineering, CRC Press/Balkema.

Rizkalla, M., R.S. Read, and G. O'Neil. 2008. Pipeline Geo-Environmental Design and Geohazard Management. Chapter 6 Geohazard Management. ASME, 352 pp.

Read, R.S. 2004. 20 years of excavation response studies at AECL's Underground Research Laboratory. Int. J. Rock Mech. & Min. Sci. 41: 1251-1275.

Eberhardt, E., D. Stead, B. Stimpson, and R. Read. 1998. Identifying crack initiation and propagation thresholds in brittle rock. Can. Geotech. J., 35(2): 222-233.

Read, R.S., N.A. Chandler, and E.J. Dzik. 1998. In situ strength criteria for tunnel design in highly- stressed rock masses. Int. J. Rock Mech. & Min. Sci., 35(3): 261-278.

Maxwell, S.C., R.P. Young, and R.S. Read. 1998. A microvelocity logging tool to assess the excavation damaged zone. Int. J. Rock Mech. & Min. Sci., 35(2):235-247.

Eberhardt, E., D. Stead, B. Stimpson, and R.S. Read. 1997. Changes in acoustic event properties with progressive fracture damage. Int. J. Rock Mech. & Min. Sci., 34:3-4, Paper No. 071B.

Martin, C.D., R.S. Read, and J.B. Martino. 1997. Observations of brittle failure around a circular test tunnel. Int. J. Rock Mech. & Min. Sci., 34(7): 1065-1073.

Martin, C. Derek, Neil A. Chandler, and Rodney S. Read. 1996. The role of convergence measurements in characterizing a rock mass. Can. Geotech. J., 33: 363-370.

Martino, Jason B., and Rodney S. Read. 1996. An overview of AECL's Heated Failure Tests. ISRM Newsjournal, 4(1): 24-31.

Read, R.S., and C.D. Martin. 1991. The Underground Research Laboratory Mine-by Experiment - A research perspective on tunnel design. Canadian Tunnelling, 7:75-88.

Read, R.S., S.C. Maxwell, and R.P. Young. In prep. Characterizing excavation damage around tunnels using micro-velocity measurements - an example from AECL's Underground Research Laboratory. Int. J. Rock Mech. & Min. Sci.

Read, Rodney S. In prep. Back analysis of 3D stresses from radial displacements near the face of a single circular tunnel. Int. J. Rock Mech. & Min. Sci.

Conference Publications

Read, R.S. and M. Rizkalla. 2015. Bridging the gap between qualitative, semi-quantitative and quantitative risk assessment of pipeline geohazards – the role of engineering judgment. Proceedings of the 2nd ASME International Pipeline Geotechnical Conference IPG2015, July 15-17, 2015, Bogo- tá, Colombia, Paper IPG2015-8523.

Rizkalla, M. and R.S. Read. 2013. Overview of pipeline geohazard assessment approaches and strategies. Paper No. IPG2013-1950, ASME 2013 International Pipeline Geotechnical Conference, Bogotá, Colombia, July 24-26, 2013.

Read, R.S., Birch, K. 2008. The role of rock engineering in developing a deep geological repository in sedimentary rocks. ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May 2009 (Ed: M. Diederichs and G. Grasselli), Paper 4146.

Read, R.S., Birch, K. 2008. Reasoned argument why large-scale fracturing will not be induced by a deep geological repository. ROCKENG09: Proceedings of the 3rd CANUS Rock Mechanics Symposium, Toronto, May 2009 (Ed: M. Diederichs and G. Grasselli), Paper 4147.

Rizkalla, M., and R.S. Read. 2007. The assessment and management of pipeline geohazards. Paper IBP1205_07. In Proc. Rio Pipeline 2007 Conference and Exposition, Rio de Janeiro, Brazil.

Read, R.S, W. Langenberg, D. Cruden, M. Field, R. Stewart, H. Bland, Z. Chen, C.R. Froese, D.S. Cavers, A.K. Bidwell, C. Murray, W.S. Anderson, A. Jones, J. Chen, D. McIntyre, D. Kenway, D.K. Bingham, I. Weir-Jones, J. Seraphim, J. Freeman, D. Spratt, M. Lamb, E. Herd, D. Martin, P. McLellan, & D. Pana. 2005. Frank Slide a Century Later: The Turtle Mountain Monitoring Project. In Proc. of the International Conference on Landslide Risk Management, Vancouver, B.C. Canada. Balkema Publishers, Netherlands. pp. 713-723.

Froese, C.R., Murray, C.M., Cavers, D.S., Anderson, W.S., Bidwell, A.K., Read, R.S., Cruden, D.M., & Langenberg, W. 2005. The development of a warning system for the South Peak of Turtle Mountain. Proceedings of the International Conference on Landslide Risk Management, Vancouver, B.C. Canada. Balkema Publishers, Netherlands. pp. 705-712.

Read, R.S. 2003. A framework for monitoring the South Peak of Turtle Mountain - the aftermath of the Frank Slide. In Proc. 3rd Canadian Conference on Geotechnique and Natural Hazards, Edmonton, Alberta, Canada June 9 - 10, 2003. pp 261-268.
Read, R.S. 2003. The role of tunnel design in controlling excavation damage development. Presented at EURATOM CLUSTER Conference, Nov 2004, Luxembourg.

Read, R.S. and J.B. Martino. 2002. To arch or not to arch – the role of tunnel design in controlling excavation damage development. In Proc. of the EDZ Workshop, NARMS-TAC 2002, July 6, 2002, Toronto, Ontario, Canada.

Chandler, N.A., J.B. Martino, and R.S. Read. 2002. The EDZ exists – So what? In Proc. of the EDZ Workshop, NARMS-TAC 2002, July 6, 2002, Toronto, Ontario, Canada.

Isherwood, A., K.W. Savigny, A. Samchek and R.S. Read. 2002. Deformation analysis of a pipeline river crossing. Proc. IPC 2002: International Pipeline Conference, Sept 29 – Oct 3, 2002, Calgary, Alberta, Canada.
Chandler, N.A., R.S. Read, D. Potyondy, R.P. Young, and J. Hazzard. 2002. Computing brittle rock fracture and excavation stability using the Particle Flow Code. In Proc. 2nd Canadian Specialty Conference on Computer Applications in Geotechnique, April 28-30, 2002. Winnipeg, Manitoba, Canada.

McLellan, P.J., C.D. Hawkes, and R.S. Read. 2000. Sand production and control in horizontal wells for gas-storage reservoirs. In Proc. 4th International Conference and Exhibition on Horizontal Well Technology, Nov. 6-8, Calgary AB.

McLellan, P.J., R.S. Read, and K. Gillen. 2000. Assessing caprock integrity for steam assisted gravity drainage projects in heavy oil reservoirs. In Proc. 4th International Conference and Exhibition on Horizontal Well Technology, Nov. 6-8, Calgary AB.
Chandler, N.A., R. Read, P. Cundall, D. Potyondy, E. Detournay, R.P. Young, and J.S.O. Lau. 2000. An integrated approach to excavation design – a project within Canada's used fuel disposal pro- gram. In Proc. 4th North American Rock Mechanics Symposium, Seattle, WA, pp. 1271-1278.

Read, R.S., and N.A. Chandler. 2000. Linkage between performance assessment, repository design and site characterization – a Canadian perspective. In Proc. 2nd International Workshop on Ge- omechanics of Nuclear Waste Repositories, July 2000, Seattle, WA.

Read, R.S., K.W. Savigny, F. Oboni, D.M. Cruden, and W. Langenberg. 2000. Geotechnical hazard assessment of the south flank of Frank Slide. In Proc. GeoCanada 2000, Calgary, AB.
Read, R.S., and N.A. Chandler. 1999. Excavation damage and stability studies at the URL - rock mechanics considerations for nuclear fuel waste disposal in Canada. In Proc. 37th US Rock Mech. Symp., Vail, CO: Balkema: Rotterdam, pp. 861-868.

Chandler, N.A., and R.S. Read. 1998. The long-term behaviour of excavations in granite - In situ evidence from Canada's URL and implications for waste retrieval. In Proc. International Workshop on Reversibility, Paris, ANDRA.
Leite, Maria Helena, Robert Corthèsy, Denis E. Gill, and Rodney Read. 1997. Some aspects of a stress calculation model for deep measurements using the modified doorstopper cell. In Proc. Int. Symp. on Rock Stresses, Kumamoto, Japan: Balkema: Rotterdam, pp. 65-70.

Read, R. S., and N. A. Chandler. 1997. Minimizing excavation damage through tunnel design in ad- verse stress conditions. In Proc. 23rd General Assembly - Int. Tunnel. Assoc., World Tunnel Congress `97, Vienna. Balkema: Rotterdam, pp. 23-28.

Read, R. S. 1996. Characterizing excavation damage in highly-stressed granite at AECL's Under- ground Research Laboratory. In Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, EDZ Workshop, Winnipeg, pp. 35-46.

Martin, C. D., E. J. Dzik, and R. S. Read. 1996. Designing an effective excavation damaged zone cut- off in high stress environments. In Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, EDZ Workshop, Winnipeg, pp. 155-164.

Read, R. S. 1996. Rock mechanics research at AECL's Underground Research Laboratory - An over- view. In Prog. Symp. on Contributions to Geology by the Canadian Nuclear Fuel Waste Management Program, Winnipeg, p. A-78.

Read, R. S., and J. B. Martino. 1996. Effect of thermal stresses on progressive rock failure at AECL's Underground Research Laboratory. In Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, Winnipeg, pp. 7-43 - 7-53.

Read, Rodney S., and Jason B. Martino. 1996. In situ thermal testing at AECL's Underground Re- search Laboratory. In M. Aubertin, F. Hassani and H. Mitri, editors, Proc. 2nd North American Rock Mech. Symp., Montreal: Balkema: Rotterdam, pp. 1487-1494.

Martin, C. Derek, and Rodney S. Read. 1996 AECL's Mine-by Experiment: A test tunnel in brittle rock. In M. Aubertin, F. Hassani, and H. Mitri, editors, Proc. 2nd North American Rock Mech. Symp., Montreal: Balkema: Rotterdam, pp. 13-24.

Chandler, Neil A., Rodney S. Read, and C. Derek Martin. 1996. In situ stress measurements for nuclear fuel waste repository design. In M. Aubertin, F. Hassani and H. Mitri, editors, Proc. 2nd North American Rock Mech. Symp., Montreal: Balkema: Rotterdam, pp. 929-936.

Chandler, Neil A., Rodney S. Read, and Alan W. L. Wan. 1996. Implications of the results of URL experiments on the design of repository seals in granite. In Proc. Int. Conf. on Deep Geological Disposal of Radioactive Waste, Winnipeg, pp. 7-1 - 7-10.
Hayles, J.G., M.H. Serzu, G.S. Lodha, and R.S. Read. 1996. Cross-hole seismic tomography for the Mine-by Experiment. In Proc. Soc. Expl. Geophysicists Int. Exposition, Denver, Vol. 1, pp. 904-907.

Lodha, G.S., J.G. Hayles, G.W. Kuzyk, and R.S. Read. 1996. Review of geophysical techniques used for understanding rock mass damage with examples from controlled experiments at the Underground Research Laboratory, Pinawa, Manitoba, Canada. Presented at FRAGBLAST `96 Conference, Montreal.

Read, Rodney S., C. Derek Martin, and Edward J. Dzik. 1995. Asymmetric borehole breakouts at the URL. In J. Daemen and R. Schultz, editors, Proc. 35th U.S. Rock Mech. Symp., Lake Tahoe: Balkema: Rotterdam, pp. 879-884.

Martin, C.D., R.S. Read, and E.J. Dzik. 1995. Near-face cracking and strength around underground openings. In H. P. Rossmanith, editor, Proc. 2nd Int. Conf. on Mechanics of Jointed and Faulted Rock, Vienna: Balkema: Rotterdam, pp. 747-752.

Martin, C.D., N.A. Chandler, and R.S. Read. 1994. The role of convergence measurements in characterizing a rock mass. In Proc. 47th Can. Geotech. Conf., Halifax, pp. 408-417.

Read, R.S., and C.D. Martin. 1992. Monitoring the excavation-induced response of granite. In J. R. Tillerson and W. R. Wawersik, editors, Proc. 33rd U.S. Symp. on Rock Mech., Santa Fe: Balkema: Rotterdam, pp. 201-210.

Martin, C.D., and R.S. Read. 1992. The in situ strength of massive granite around excavations. In PK. Kaiser and D. McCreath, editors, Proc. 16th Can. Rock Mech. Conf., Sudbury, pp. 1-10.

Thompson, P.M., B.H. Kjartanson, and R.S. Read. 1992. Design and construction of two major exper- iments at the URL. In Proc. 1992 International High-Level Radioactive Waste Management Con- ference, Las Vegas, NV, Vol. 1, pp. 1082-1089.
Onagi, D.P., R.S. Read, and G.W. Kuzyk. 1991. AECL's Mine-by Experiment - from concept to con- struction. In Proc. SME Conference, Denver.

Read, R.S., and C.D. Martin. 1990. The Underground Research Laboratory Mine-by Experiment - A research perspective on tunnel design. In Proc. 8th Canadian Tunnelling Conf., Vancouver, BC: BiTech: Vancouver, pp. 213-226.

Martin, C.D., R.S. Read, and P.A. Lang. 1990. Seven years of in situ stress measurements at the URL - An overview. In W. A. Hustrulid and G. A. Johnson, editors, Proc. 31st U.S. Symp. Rock Mech., Golden, CO: Balkema: Rotterdam, pp. 15-26.

Martin, C.D., R.S. Read, and N.A. Chandler. 1990. Does scale influence in situ stress measurements? - Some findings at the Underground Research Laboratory. In A. Pinto da Cunha, editor, Proc. 1st Int. Workshop on Scale Effects in Rock Masses, Loen, Norway, Balkema: Rotterdam, pp. 307-316.

NWMO, AECL, SKB and Other Publications

Read, Rodney S. 2011. Effects of earthquake induced rock shear on containment system integrity. Laboratory testing plan development. Swedish Nuclear Fuel and Waste Management Company Report SKB R-11-21.

Read, R.S. 2010. Rock mechanics features, events, and processes for a used fuel deep geologic repository in crystalline rock. Nuclear Waste Management Organization Technical Report NWMO TR-2010-??. (in press)

Read, R.S. 2009. Implications of excavation damage for design and performance of repository excavations and sealing systems. Nuclear Waste Management Organization Technical Report NWMO TR-2009-??. (in press)

Read, R.S. 2008. Developing a reasoned argument that no large-scale fracturing or faulting will be induced in the host rock by a deep geological repository. Nuclear Waste Management Organization Technical Report NWMO TR-2008-14.

Read, R.S. 2008. The role of rock engineering in developing a deep geological repository in sedimentary rock. Nuclear Waste Management Organization Technical Report NWMO TR-2008-16.

Read, R.S. 2008. Laboratory testing of rock shear effects on containment system integrity (2008 update). Nuclear waste Management Organization Technical Memorandum, November 2008 (R0)

Read, R.S. 2006. Laboratory testing to support the Rock Shear Experiment (ROSE). RSRead Consulting Inc. Report 10-019.2 to Swedish Nuclear Fuel and Waste Management Company, December 7, 2006.

Read, R.S. and N.A. Chandler. 2002. An approach to excavation design for a nuclear fuel waste repository – the Thermal-Mechanical Stability Study final report. UFDP Report 06819-REP-01200- 10086-R00.

Read, R.S. and N.A. Chandler. 2002. Development and integration of tools for engineering design of repository sealing systems (ENDRES), Project status – March 2002. UFDP Report 06819-REP- 01300-10051-R00.

Martino, J.B., N.A. Chandler, R.S. Read and C. Baker. 2002. Response of the Tunnel Sealing Experiment concrete bulkhead to pressurization. Ontario Power Generation Report No. 06819-REP- 01200-10085-R00.

Read, R.S. and N.A. Chandler. 2001. Engineering design of repository sealing systems (ENDRES) project plan. Ontario Power Generation Technical Memorandum 06819(UF)-03782.04-T10.

Read, R.S., N.A. Chandler, J.B. Martino, R.P. Young, P.Cundall, D. Potyondy, J. Lau, B. Gorski, E. De tournay, and Y. Ates. 2001. The Thermal-Mechanical Stability Study: excavation design for a nu- clear waste repository. Ontario Power Generation Report (in press).

Chandler, N.A., and R.S. Read. 2000. Thermal-Mechanical Stability Studies Project Status – March 2000. UFDP Report 06819-REP-01200-10030-R00.

Read, R.S. 1999. Engineering gap analysis for the Used Fuel Disposal Program – Geotechnical engineering tools and capabilities. Ontario Power Generation Report 06819-REP-01200-10010-R00.

Chandler, N.A., and R.S. Read. 1999. Thermal-Mechanical Stability Studies Project Status – 1999 March. UFDP Report 06819-REP-01200-10001-R00.

Martino, J.B., P.M. Thompson, N.A. Chandler, and R.S. Read. 1998. The in situ stress program at AECL's Underground Research Laboratory – 15 years of research (1982-1997). UFDP Report 06819-REP-01200-0053-R00.

Read, R.S., J.B. Martino, N.A. Chandler, and E.J. Dzik. 1998. Excavation stability study - analysis and interpretation of results. UFDP Report 06819-REP-01200-0028 R00.

Read, R.S., J.B. Martino, N.A. Chandler, E.J. Dzik, S. Oliver, S. Falls and R.P. Young. 1998. Analysis and interpretation of AECL's Heated failure Tests. UFDP Report 06819-REP-01200-0070-R00.

Read, R.S. 1997. Progress report on development and integration of acoustic emission/microseismic (AE/MS) technology and numerical modelling. UFDP Report 06819-REP-01200-0042 R00.

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Martino, J.B., and R.S. Read. 1994. Mine-by Experiment Phase III -- Heated Failure Tests: Technical progress report and summary of Stage 1. Technical Report TR-652, COG-94-478, Atomic Energy of Canada Limited.

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Read, R.S., and C.D. Martin. 1993. Mine-by Experiment plan, Underground Research Laboratory - Addendum 1: Mine-by Experiment Heated Failure Tests. Quality Assurance Document DE010.086, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, J.H. Mitchell, and M.H. Spinney. 1994. Mine-by Experiment data summary: Part 3 - Extensometer results. Technical Report RC-1078, COG-93-354, Atomic Energy of Canada Limited.

Read, R.S., J.B. Martino, and J.H. Mitchell. 1993. Mine-by Experiment data summary: Part 4 - Convergence results. Technical Report TR-595, COG-93-177, Atomic Energy of Canada Limited.

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Read, R.S. and C.D. Martin. 1991. Mine-by Experiment final design report. Report AECL-10430, Atomic Energy of Canada Limited.

Read, R.S. 1990. Methodology for the acquisition, analysis and presentation of geological data from the Underground Research Laboratory subsurface drilling program, Volume I and II. Technical Record TR-484, Atomic Energy of Canada Limited.

Read, R.S. 1990. Residual strain, scale effects and time-dependent behaviour at the 240-m level of the Underground Research Laboratory. Report AECL-10038, Atomic Energy of Canada Limited.

Everitt, R.A., and R.S. Read. 1990. Geology of the 240 Level of the Underground Research Laboratory, Volumes I and II. Technical Record TR-491, Atomic Energy of Canada Limited.

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Woodcock, D.R., R.S. Read, and A. Knight. 1990. Geological data summary for overcore boreholes drilled from the 300-m level of the Underground Research Laboratory 1988 May 25 to 1988 July 25. Technical Record TR-485, Atomic Energy of Canada Limited.

Read, R.S., and C.D. Martin. 1990. Mine-by Experiment preliminary design report. Technical Memorandum URL-EXP-022-M044, Atomic Energy of Canada Limited.

Read, R.S. 1990. Geological data summary for boreholes drilled for the 384-m instrument array at the Underground Research Laboratory. Technical Record TR-483, Atomic Energy of Canada Limited.

Read, R.S. 1989. Geological data summary for boreholes drilled at the 352-m level of the Under- ground Research Laboratory 1988 February 5. Technical Record TR-477, Atomic Energy of Canada Limited.

Read, R.S. 1989. Geological data summary for boreholes drilled from the 300-m Level of the Under- ground Research Laboratory 1987 December 5 to 1988 May 17, Volume 1 and 2. Technical Record TR-473, Atomic Energy of Canada Limited.

Read, R.S., and R.A. Everitt. 1988. Summary of geology for URL probehole 206-020-PH1. Technical memorandum, Atomic Energy of Canada Limited.

Read, R.S., and R.A. Everitt. 1987. Fracture zone #2 characterization - summary of geology near grouting experiment. Technical Memorandum GSEB-87-330, Atomic Energy of Canada Limited.

CONFERENCE VOLUNTEER

2013 Banff Pipeline Workshop, Banff, Alberta. Co-chair Geohazards working session.

2014 International Pipeline Conference, Calgary Alberta. Chair, Session 6-3-1: Weather Related & Outside Forces— Water Hazard

2015 Banff Pipeline Workshop, Banff, Alberta. Co-chair Geohazards working session.

EDUCATION

University of Manitoba
Ph.D., Department of Civil & Geological Engineering (1994)

University of British Columbia
B.A.Sc., Department of Geological Engineering (1984)

Jack Ruitenbeek

President, H.J. Ruitenbeek Resource Consulting Limited

SUMMARY

Dr. Ruitenbeek has 35 years of experience in financial analysis and natural resource and environmental economics, as an independent consultant and researcher. He is a specialist in the areas of financial sustainability analysis, natural resource and ecosystem valuation, and environmental and human security and risk issues. His work over the past three decades has spanned projects in North America, Eastern Europe, Asia, Africa, and Latin America & the Caribbean, for clients that include national governments, international aid and lending agencies, the private sector, and international environmental NGOs. He has been qualified as expert witness to various regulatory commissions and tribunals, and has published work in peer-reviewed journals relating to ecosystem valuation, conservation finance and complex system analysis. His work in economic modeling includes cost-benefit analysis, economic impact analysis, and risk assessment. As an Adjunct Professor at the University of Victoria Geography Department and as Scientific Advisor to IDRC's Environmental Economics Program for South East Asia (EEPSEA) in Singapore, he has advised and overseen hundreds of researchers in the practical aspects of natural resource valuation and economic modeling. His work with finance ministries and with environmental management agencies, through the World Bank and International Finance Corporation, has made him an acknowledged expert in the area of coastal zone economics, environmental economic valuation, and risk analysis.

Dr. Ruitenbeek's career commenced in Canada's energy sector in the early 1980s, concurrent with completion of a Master's Thesis on enhanced oil recovery economics (1984) and ongoing consultancies with the Alberta Oil Sands Technology and Research Authority (AOSTRA). During this period he contributed to the preparation of socio-economic impact, cost benefit, and financial risk analyses of development projects relating to oil and gas supply, hydroelectricity, and mining, working primarily as an economist in an advisory capacity to the private sector. In the past decade his work in North America has focused on issues relating to the valuation of ecosystem goods and services, impacts of development projects on local communities and regional economies, and to economic risk management. Recent experience (2012-2016) includes qualification as expert witness before Canada's National Energy Board and the British Columbia Utility Commission to present expert evidence relating to socio-economic costs, benefits, and impacts of pipeline projects. His international energy-related assignments have more recently included economic evaluations of social and environmental impacts associated with: (i) LNG development and exports from East Africa; (ii) energy sector development strategies in Thailand; and, (iii) oil spills in Kuwait arising from the 1991 Gulf War.

PROFESSIONAL EXPERIENCE

KINDER MORGAN
Trans-Mountain Expansion – Economic Studies

2013 - 2016

Provided expert evidence to the National Energy Board relating to the project's benefits, costs, and potential liabilities and costs associated with worst case spills from proposed expansion pipeline. The scope of the work in the public interest analysis included: original analyses regarding potential financial liability costs; associated with spills; reviews of cost benefit analyses of pipeline and various alternatives; socio-economic impact analysis including income, jobs and taxation impacts; reviews of evidence relating to municipal and regional brand valuation; cleanup cost from spills into terrestrial, riparian, and marine environment from tankers, barges, pipelines and terminal; damage costs (NRDA) associated with spills; government costs of spills in Canada and Washington State; costs to Canadian First Nations and US Tribes of spills. Provided selected expert reply evidence on costs of industrial and transportation accidents including refinery explosions and rail spills (Lac Mégantic).

FORTIS ENERGY
British Columbia Lower Mainland System Upgrade Project

2014 - 2015

Authored a study and provided expert evidence relating to the economic consequences of investments in gas pipeline upgrades that would potentially impact 250,000 customers. The economic study combined risk analyses with economic consequence analyses to inform regulatory proceedings before the BC Utilities Commission.

ENBRIDGE
Northern Gateway Pipelines Project, Economic Studies

2012 - 2013

Provided expert evidence to the National Energy Board relating to the project's benefits, costs, and potential liabilities and costs associated with worst case spills from one or both proposed pipelines (diluent and dilbit). The scope of the work in the public interest analysis included: cost benefit analyses of pipeline and various alternatives; socio-economic impact analysis including income, jobs and taxation impacts; cleanup cost from spills into terrestrial, riparian, or marine environment; damage costs (NRDA) associated with spills; impacts of spill costs on tariffs; and, potential financial liability costs.

STATISTICS CANADA
Measurement of Ecosystem Goods and Services (MEGS) in Canada

2011 - 2012

Authored a study that draws on three decades of international experience that summarizes the scientific basis of valuation and the different methods for conducting economic valuation for ecosystem goods and services. Included assessments of socio-economic and environmental valuation in riparian and great lakes context.

MINISTRY OF AGRICULTURE AND LANDS, BC
Socio-Economic and Environmental Assessment

2008

Authored a study to present the findings of a research program spearheaded by the Strategic Land Policy and Legislation Branch of the Crown Land Administration Division in the British Columbia (Canada) Ministry of Agriculture and Lands. The general objective of the program was to provide a practical treatment of environmental and socio-economic valuation methods in land use planning in BC. Specifically, the overall project considers how Total Economic Value (TEV) can be introduced into land-use planning decisions. The work provided review material, and through concrete examples in BC, illustrates how TEV can inform and be informed by the Socio-Economic and Environmental Assessment (SEEA) process.

WORLD BANK – YUCATAN MEXICO
Economic Methods for Planning in Integrated Coastal Zone Management

2015 - 2016

Edited and contributed to volume of economic analyses associated with ICZM in Mexico. Scope included analyses of coastal hazards (hurricanes, oil spill pollution, domestic pollution, erosion) and evaluating economic impacts and mitigation mechanisms for these hazards. Valuation work involved social impact assessment including "Social Accounting Matrix" methods, natural resource damage assessments, human health valuations, use of market-based instruments for environmental management, and land value changes from natural disasters.

IUCN/UN – COMPENSATION COMMISSION
Gulf War Spills Liability and Impact Measurement

2006

Evaluated claims for environmental, natural resource, human health, and other damages associated with oil spills and fires during Gulf War (Kuwait).

REGULATORY

Dr. Ruitenbeek has appeared as an expert witness providing opinion evidence to numerous regulatory authorities including: National Energy Board (Canada), British Columbia Utilities Commission, Alberta Energy Resources Conservation Board, and the Ontario Energy Board. Topics included cost-benefit analysis, terrestrial marine spill costs and risks, economic impact analysis, economic valuation of environmental damages, socio-economic consequence analysis, and financial liability evaluations.

OTHER SELECTED ENERGY SECTOR ASSIGNMENTS
SOCIO-ECONOMIC IMPACT ANALYSIS, COMPENSATION VALUATION, AND RISK ANALYSIS

Rim Gas LNG Export, Petro-Canada, Westcoast, and Mitsui Application
Saskatchewan Heavy Oil Upgrader Project
Bentpath Pool, Union Gas Natural Gas Storage Compensation
Slave River Hydroelectric Project
Shell Peace River In-situ Project
NEB Natural Gas Export Hearings
Natural Gas Straddle Plant Project, Alberta
Sour Gas Development (Caroline Gas Field, Alberta)
BP North Sea Horizontal Drilling Evaluations
Baltic Oil Spill Valuations (Peer Reviewer)

COUNTRIES OF EXPERIENCE

North America
Canada, USA, Mexico

Asia/Middle East/Europe
Azerbaijan, Bangladesh, Bhutan, Bosnia & Herzegovina, Cambodia, China, Croatia, France, Germany, India, Indonesia, Kazakhstan, Kuwait, Kyrgyzstan, Malaysia, Maldives, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, Sri Lanka, Thailand, Turkey, U.K., Vietnam

Africa
Botswana, Cameroon, DRCongo, Egypt, Ethiopia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Rwanda, São Tomé & Principe, Senegal, South Africa, Sudan, Tanzania, Uganda, Zambia, Zimbabwe

Latin America/Caribbean
Barbados, Bolivia, Brazil, Chile, Curaçao, Guyana, Jamaica, Mexico, Peru, Trinidad and Tobago, Venezuela, OECS States (Anguilla, Antigua and Barbuda, British Virgin Islands, Dominica, Grenada, Montserrat, St. Kitts & Nevis, St. Lucia, St. Vincent and the Grenadines)

Regional/Global Issues
High Seas MPAs (Global), Fisheries Management (Indian Ocean), “Wet Carbon” (Global), Regional Coastal Management (Black Sea, Lake Victoria, Great Lakes)

PROFESSIONAL ACTIVITIES

Founding Member – Canadian Society of Ecological Economics

World Bank Staff Consultant (Economist), Washington D.C., 1990-present

Adjunct Professor, Geography Department / University of Victoria, Canada, 1993–2000

Reviewer, Various Journals including: Ecological Economics (USA), Environmental Development Economics (UK), Environmental & Resource Economics (Netherlands), Global Environmental Change (UK); 1993–present

Scientific Advisor, Environmental Economics Program for Southeast Asia, Singapore; 1995–2011

Reviewer, intergovernmental Panel for climate Change, 2000

Invited Author/Reviewer, Millennium Ecosystem Assessment (UNESCO), Economic Policy Working group/Coastal Working Group, 2002

Associate (Researcher/Co-Author), Tyndall Centre for Climate Change Research, University of East Anglia (Norwich, UK); Socio-economic Resilience and Adaptation; 2006–2011

Lecturer, Geneva Center for Education and Research in Humanitarian Action (University of Geneva, Switzerland), Disaster Risk management, 2009–2012

Financing Advisor/ Economics Advisor, International Union for the Conservation of Nature (IUCN, Gland, Switzerland), Biodiversity Business & Global Marine Programme 2002–present

Associate (Supervisory), Christian-Albrechts-University, Kiel (Germany), Department of Economics – Cluster of Excellence: The Future Ocean, 2008–2014

EDUCATION

London School of Economics, London, U.K. 1990
Ph.D. Economics

University of Calgary, Canada 1984
M.A. Natural Resource Economics

University of Calgary, Canada 1980
B.A. (Distinction – Chancellor's Award) Economics

University of Calgary, Canada 1979
B.Sc. (Distinction) Astrophysics

James W. Kenny, P.Eng.

Manager, Pipeline Development, Stantec

SUMMARY

James is a Mechanical Engineer with over 25 years or experience in the oil and gas industry specializing in pipeline and project engineering. He has played a key role in both the detailed engineering and construction management phases of numerous mainline pipeline and well tie-in projects.

EXPERIENCE RECORD

Parkway Looping
Performed project manager role for the Detailed Engineering of this 13.5 km long NPS 42 sweet natural gas loop pipeline in the Mississauga area of Southern Ontario.

Pipeline Design Department
Performed detailed engineering and construction management duties on various pipeline facilities on the TransCanada system. This involved a number of looping projects as well and pipeline replacement, re-testing and abandonment projects.

Excel Engineering Alliance
Performed the project engineering duties on numerous well tie-in projects, including the mechanical design function.

Pipeline Project, Alliance Pipeline
Performed detailed engineering and construction management duties on one-third of the Canadian Mainline portion of the Alliance Pipeline Project. This involved four mainline pipeline spreads totaling 82 km of 24", 248 km of 36" and 174 km of 42" pipeline construction and six major HDD crossings.

Pipeline Project, Alliance Pipeline
Construction Engineer performing field engineering and construction management duties on Halifax Lateral portion of the Maritimes & Northeast Pipeline Project. This involved one mainline pipeline spread and one smaller contract totaling 124 km of 12" pipeline construction and two HDD crossings.

Grizzly Pipeline Extension Project
Performed detailed project engineering and construction management for the project, including 10 km of 6", 5 km of 10" and 110 km of 16" sour gas pipeline construction with one major open cut, one HDD, and one aerial span river crossing.

Cutbank Ridge Development
Lead client contact. Group leader of six to eight professionals in design and procurement for pipeline, well site and compression facilities over a multi-season development.

Portland Montreal Pipeline
Performed the project engineer role on a planned reversal of a crude oil pipeline including design of the two pump stations and a new ship loading terminal and vapor handling system.

Emera Brunswick Pipeline
Performed detailed project engineering for the project, including 145 km of 30" sweet natural gas pipeline in both urban and rural settings in New Brunswick including an HDD crossing of the St. John River.

Sweet Dilbit Pipeline
Performed project manager role for the FEED Study and Detailed Engineering of this 138 km long NPS 36" sweet dilbit pipeline in the Fort McMurray area of Northeastern Alberta.

2012 T-North Expansion
Performed project manager role for the FEED Study and Detailed Engineering of this 24.15 km long NPS 42 sweet natural gas loop pipeline in the Hudson's Hope area of Northeastern British Columbia.

Sturgeon Refinery External Interface Pipelines
Performed project manager role for the Detailed Engineering of 18 pipelines bringing raw materials onto the site and transporting finished product to market all in the Redwater area of central Alberta.

PROFESSIONAL ACTIVITIES

Professional Engineer, Professional Engineers Ontario

Professional Engineer, Association of Professional Engineers and Geoscientists of Saskatchewan

Professional Engineer, Association of Professional Engineers and Geoscientists of British Columbia

Professional Engineer, Association of Professional Engineers and Geoscientists of Alberta

EDUCATION

University of Alberta
Bachelor of Science, Mechanical Engineering (1988)

University of Calgary
Numerous Master's Level Engineering and Management Courses (1996)

Erez Allouche PhD, P.Eng.

Technology Manager, Stantec

SUMMARY

Dr. Erez Allouche has devoted much of the past 16 years to research and practice in the area of underground infrastructure. His work focuses on the development of new condition assessment technologies and design and analysis models for underground construction using trenchless methods. He specializes in the design of complex HDD crossings, evaluating the soil/structure/liner interaction, and design of unique rehabilitation solutions to pressure pipes (AC, DI, CI, RCP) and large diameter gravity pipes. He is familiar with nearly 60 different rehabilitation systems, and has design experience with 18 such methods.

Prior to joining Stantec, Dr. Allouche was an Associate Professor of Civil Engineering at Louisiana Tech University and the Director of the Trenchless Technology Center, where he managed a staff of 45 graduate students, research engineers, and technicians. Over the past 13 years, he won and managed 117 research projects in the area of buried infrastructure totaling $14,000,000, including investigation of failure mechanisms of ductile iron pipes on the behalf of AWWA. He is also the inventor or co-inventor of 17 patents in the area of trenchless technologies, and the author (and co-author) of more than 200 publications in the areas of buried infrastructure management and pipeline installation using trenchless techniques, including 62 peer-reviewed journal papers (academic and trade publications).

Dr. Allouche is a Board Member of the North American Society for Trenchless Technology, Associate Editor of the ASCE Journal of Pipeline Systems, and has served as a reviewer for numerous technical journals, technical conferences, and grant awarding agencies.

EDUCATION

Queen's University, Kingston, Ontario, (1994)
BS, Civil Engineering

Queen's University, Kingston, Ontario, (1996)
MS, Structural Engineering

University of Alberta, Edmonton, Alberta, (2000)
PhD, Construction Engineering

EXPERIENCE RECORD

Trenchless Technology

ELKO Area Expansion Project*, Elko, Nevada (Project Manager)
Design of multiple HDD and auger boring crossings for 8" diameter, high pressure natural gas line.

Regional Municipality of Wood Buffalo Sanitary Trunks and River Crossing*, Fort McMurray, Alberta (Project Engineer)
Design of a twin barrel, 1,250-meter long, 914 mm diameter directionally drilled crossing of the Athabasca River. Selected as NASTT's Northwest Chapter 2010 Trenchless Project of the Year.

Trans-Mountain Pipeline*, Vancouver, British Columbia (Project Engineer)
Design review of a 1,400-meter long, 609 mm diameter directional crossing of the Frazer River.

Cameron Heights Lift Station*, Edmonton, Alberta (Project Engineer)
Design review of a 420-meter long, 254 mm diameter forcemain directional crossing.

North Saskatchewan River Directional Crossing*, Edmonton, Alberta (Project Engineer)
Design review of a 660-meter long, 406 mm diameter directional crossing of the North Saskatchewan River.

North Saskatchewan River Crossing*, Edmonton, Alberta (Project Engineer)
Design review of a 451-meter long, 610 mm diameter directional crossing of the North Saskatchewan River.

False Creek Crossing*, Vancouver, British Columbia (Project Engineer)
Design of a 472-meter long, 1,016 mm diameter force main crossing of False Creek using HDD.

Yellow Trail Transportation Corridor Crossing*, Edmonton, Alberta (Project Engineer)
Design of a 531-meter long, 914 mm diameter steel conduit crossing of the Yellow Trail transportation corridor using HDD.

Parkland Sanitary Transmission System Forcemain Replacement Program, Edmonton, Alberta (Project Engineer)
Design of a 400-meter long, 1066 mm diameter HDD crossing of sanitary forcemain.

Orleans Watermain Link East, Ottawa, Ontario (Project Engineer)
Design support for a 42" diameter, 390 m long HDD crossing.

Loveland Pipeline Replacement Project, Loveland, Colorado (Project Engineer)
Design of three HDD crossings across the Big Thompson River and an irrigation ditch, 8" diameter water main.

Industrial Waterline, Fort Saskatchewan, Alberta (Project Engineer)
Design of four HDD crossings, 200 - 250 m in length, 400 mm HDPE pipe and 559 mm steel casing.

Permanent Canal Closures and Pump Station, Orleans Avenue Station, New Orleans, Louisiana
Design of multiple HDD installations of 4" PVC conduits for electrical lines along the toe of a USACE's levee.

Electrical Line HDD Crossings*, Edmonton, Alberta (Project Engineer)
Design of two HDD crossings, one 600 m long and one 200 m long (200 mm conduits for 25 kV electrical lines).

Baqa al-Gharbiyeh Water Transmission Line*, Israel (Project Manager)
Design of a 187-meter long, 813 mm diameter directionally drilled crossing of Highway 6.

Truckee River Siphon*, Reno, Nevada (Project Manager)
Evaluation of a 420-foot long, 54-inch diameter siphon passing under the Truckee River.

HDD Crossing of the Red River*, Red Deer, Alberta (Project Manager)
Design of an 800-meter long HDD crossing of a triple-barrel (600, 700, and 800 mm diameter) siphon across the Red River.

Utility Corridor HDD Crossing*, Edmonton, Alberta (Project Manager)
Design of a 700 m long HDD crossing of a utility corridor (five 200 mm conduits for 25 kV electrical lines).

Watermain HDD Installation*, Tel Aviv, Israel (Project Engineer)
Design of a 1,371-meter long, 800 mm diameter watermain installation using HDD.

Multi-duct HDD Installation*, Fort McMurray, Alberta (Project Manager)
Design of a 750 m long crossing of multi-ducts (three ducts, 200 mm and 100 mm diameter) installation using HDD beneath the Athabasca River.

Electrical Line, Edmonton, Alberta (Project Manager)
Design of two HDD crossings, one 600 m long and one 200 m long (200 mm conduits for 25 kV electrical lines).

Conveyance

Effect of Water Quality on Mortar Cement Lining Selection Technical Report*, Tel Aviv, Israel (Project Manager)
Prepared a technical report titled "Effect of Water Quality on Mortar Cement Lining Selection".

State of Technology for Rehabilitation of Wastewater Collection Systems* (Project Manager)
A set of five (5) comprehensive reports prepared for the Environmental Protection Agency (EPA) covering rehabilitation of sewage conveyance systems, assent management practices, rehabilitation of pressure pipes and retrospective evaluation of CIPP liners in North America

Decision analysis Guide for Corrugated Metal Culvert Rehabilitation and Replacement Using Trenchless Technology* (Project Manager)
A comprehensive guideline developed for the United States Department of Agriculture

Culvert Rehabilitation to Maximize Service Life while Minimizing Direct Costs and Traffic Disruption (Transportation Research Board project 14-19)*
Conducted full-scale experimental testing, modeling and literature review of CMPs rehabilitation system; develop a design manual for construction methods used in the rehabilitation of corrugated metal pipes.

Rehabilitation of a 66" Prestressed Cylindrical Concrete Pipe*, Tel-Aviv, Israel
Developed a slipline solution for the rehabilitation of failed a 600 m long, 66" diameter PCCP.

Elm Fork Interceptor Modeling*, Texas
Forensic examination and Finite Element Analysis modeling in support of technical evaluation of selected rehabilitation methods for the 17,200-foot long, 96-inch diameter reinforced concrete Elm Fork interceptor. Modeling included fiber-reinforced CIPP liner and Grout in Place liner.

Waterline Rehabilitation*, New York City, New York (Project Manager)
Design role in the rehabilitation of water main lines running within or under bridge structures using a structural CIPP liner

Effect of Water Quality on Mortar Cement Lining Selection Technical Report*, Tel Aviv, Israel (Project Manager)
Prepared a technical report titled "Effect of Water Quality on Mortar Cement Lining Selection".

Modeling and Simulation
Elm Fork Interceptor Modeling*, Texas (Modeling)
Finite Element Analysis modeling in support of technical evaluation of selected rehabilitation methods for the 17,200-foot long, 96-inch diameter reinforced concrete Elm Fork interceptor.

Microtunnel

Hafetz-Haim Water Supply Line*, Tel-Aviv, Israel
Construction of a 96" diameter, 960 m long steel pipe that was encased in a RCP jacking pipe for conveying desalinated water at pressures up to 300 psi. Pipe deploys a unique joint design that enables a single-pass installation, accommodates minor alignment deviations that take place during a pipe-jacking process, while providing high pressure rating.

Project Inspections

Development and Testing of the FutureScan System*
in-pipe high-resolution radar system; Demonstrations projects were performed in New York City, NY; Boston, MA; Orlando, FL; Dallas, TX; Shreveport, LA; New Orleans, La; etc.

Truckee River Siphon*, Reno, Nevada
Evaluation of a 420-foot long, 54-inch diameter steel pipe siphon passing under the Truckee River.

151 St. Deep Sanitary Tunnel, Edmonton, Alberta
Evaluation of 4,000 lf of 60" oval shape deep wastewater conveyance tunnel, evaluation of structural stability and development of rehabilitation options

Groat Road Trunk Sewer, Edmonton, Alberta
Evaluation of 13,000 lf of 68" and 92" corrugated metal pipe utilizing LIDAR/CCTV, as well as collection of in-situ coupon.

Evaluation of a 1800 mm (72") Prestressed Cylindrical Concrete Pipe*, Region of Peel, Ontario
Performed a forensic investigation of a 20 km long, 10 yr. old, 1800 mm diameter PCCP pipe, in which several segments exhibited signs of distress in the form of multiple wire breaks.

Drilling Equipment Design
Trans-Mountain Pipeline*, Vancouver, British Columbia (Project Engineer)
Design review of a 1,400-meter long, 609 mm diameter directional crossing of the Frazer River

Regional Municipality of Wood Buffalo Sanitary Trunks and River Crossing, Fort McMurray, Alberta (Project Engineer)
Design of a twin barrel, 1,250-meter long, 914 mm diameter directionally drilled crossing of the Athabasca River. Selected as NASTT's Northwest Chapter 2010 Trenchless Project of the Year.

PROFESSIONAL ACTIVITIES

Standards Committee Member (Pipe Renewal Methods), American Water Works Association

Board Member, North American Society for Trenchless Technology

Member - PINS Task Group, American Society of Civil Engineers

Member, Canadian Society for Civil Engineering

Member - R&D Committee, Common Ground Alliance

G.A. (Andy) Purves P.Eng.

Director, Oil & Gas - Client Program, Stantec

SUMMARY

Andy has more than 40 years of successful progressive experience in all phases of heavy civil, offshore and oil and gas industries. He has specialized in the areas of onshore/offshore pipelines, pump and compressor stations with emphasis on design engineering, estimation and project construction management.

EXPERIENCE RECORD

Oil & Gas

Enbridge - Edmonton to Cromer Pipeline
Field engineer for two summer construction seasons for mainline pipeline.

TransCanada PipeLines Limited
Director overseeing all Oil & Gas projects being undertaken by Stantec for TransCanada.

TransCanada PipeLines Limited
Specialist Engineer assisting in a variety of pipeline and facilities project planning, conceptual engineering and cost estimation.

Enbridge Pipelines Inc.
Specialist Engineer assisting in a variety of pipeline and facilities project planning, conceptual engineering and cost estimation.

Enbridge Pipelines (Athabasca) Inc.
Project Director for the Woodland Pipeline Extension FEED. 380 km of new NPS 36 pipeline from Enbridge's Cheecham Terminal to Edmonton.

Enbridge Pipelines (Athabasca) Inc.
Project Director for the Woodland Pipeline FEED and detailed engineering. 140 km of new NPS 36 pipeline from IOL Kearl Plant to Enbridge's Cheecham Terminal.

Enbridge Pipelines (Athabasca) Inc., Multiple Sites, Canada- Alberta
Conceptual design and cost estimates for multiple large tank facilities in Fort McMurray and Fort Saskatchewan, Alberta. Front-End work and detailed design for Woodland Pipeline.

TransCanada PipeLines Limited
Project Director for the KXL Pipeline Project in Canada. 530 km of new NPS 36 in Alberta and Saskatchewan.

TransCanada PipeLines Limited
Project Manager for the Keystone Pipeline Project in Canada. 370 km of new NPS 30 and 864 km of NPS 34 conversion.

Enbridge Alaska Gas Pipeline Study, Multiple Sites, North America- Alaska, Alberta
Conceptual engineering and costing for a large diameter pipeline from Prudhoe Bay, Alaska to Ft. Saskatchewan, Alberta.

Oredo Flow Station Upgrade
Project Sponsor for crude oil production facilities design.

Iroquois Eastchester Extension Project
Managed engineering and procurement for five compressor facilities in New York State.

BC Gas Southern Crossing Project
Managed the engineering and procurement for four compression facilities in various locations throughout southern British Columbia.

TransCanada PipeLines Limited
Managed the engineering related to the LM2500+ and RB211 unit addition at five compressor stations.

Foothills Pipe Lines Eastern Leg Expansion
Managed the demolition and retrofitting design for an RB211 unit replacement and four station upgrades.

IPL Energy Inc. Quebec to Montreal Products Pipeline Project
Managed design and regulatory permitting for NPS 10 products pipeline system.

BC Gas South Okanagan Natural Gas Project
Managed construction of 20 km of NPS 16 mainline and 10 km of lake crossing pipeline in environmentally sensitive areas.

Westcoast Energy Projects: Brazion, Pine River, Tumbler Ridge, Williams Lake to Powell River, Milligan-Peejay & Flatrock
Managed engineering design for pipelines located in severe mountainous terrain in northern British Columbia.

TransCanada PipeLines Limited

- 7 Solar Mars Stations
- 2 Solar Saturn Stations
- 3 Station Upgrades, Crowsnest to Kingsgate
- 37,0000 HP Cooper Rolls RB211

IPL (NW) - Norman Wells to Zama Pipeline
Field engineer for pipeline and major crossings.

Land & Marine Engineering, UK*
Miscellaneous marine pipeline, outfall and offshore structure design, estimating and construction support.

Civil Engineering

Tony Gee & Partners, UK*
Bridge design engineering and construction. Including Orwell Bridge & Keswick Bridge, and other bridge installation gantries.

Christinai & Neilsen Ltd., UK*
Field engineer on Peterhead Tanker Jetty for piling and trestleway construction. Estimator for miscellaneous heavy civil/structural engineering projects.

PROFESSIONAL ACTIVITIES

Professional Engineer, Association of Professional Engineers and Geoscientists of Alberta

Professional Engineer, Association of Professional Engineers and Geoscientists of Saskatchewan

Professional Engineer, Association of Professional Engineers and Geoscientists of British Columbia

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

EDUCATION

University of Dundee, Dundee, Scotland, (1976)
B.Sc. (Honors) Civil Engineering

Harold Henry

Director, Construction Management - Pipeline and Facilities, Stantec

SUMMARY

Harold is the Director of Construction with 25 years' of oil and gas industry experience specializing in engineering, procurement, and construction (EPC) and engineering, procurement, and construction management (EPCM) projects. He has extensive project experience including cost/benefit statistical analysis, project planning, budgeting, tracking, and capital and human resource optimization including employee relations for both unions and non-unions. Additionally, Harold's intimate knowledge of the project management process makes him uniquely qualified to take any project from conception to commission through all phases of engineering and construction.

Harold's strong background in integrity programs and past certification in most non- destructive examination methods provides a comprehensive approach to qualitative and quantitative methods of reliable risk assessment/analysis, root cause failure analysis, non-conformance reporting including tracking and resolution.

His project experience includes inland and marine tank terminals, pipeline project of all sizes, including multiple pump stations and facilities. Harold also has experience working on natural gas facilities including the commissioning and decommissioning of sour gas plants, heavy H2S power plants (geothermal), and coal and nuclear facilities.

Originally, from the United States, Harold has worked in Alberta for the past 13 years and has the ability to provide cross border services to clients. His 25 year career has granted him significant international experience; helping clients from Denver to the Philippines accomplish their goals.

EXPERIENCE RECORDS

Oil & Gas

Energy East Pipeline Terminals, TransCanada PipeLines Limited, Multiple Sites, Alberta, Saskatchewan, Quebec, and New Brunswick (Project Manager)

Project management responsibilities for the front end engineering design and value engineering phases to design four separate crude oil terminals to support the Energy East pipeline project. Terminals are located in Hardisty, Alberta and Moosomin, Saskatchewan, with marine terminals located in Cacouna, Quebec and Saint John, New Brunswick. Terminals include tank farm with a total 47 product tanks of 350,000 bbl and 650,000 bbl.

Cold Lake West Quarter Points and Cold Lake Kirby South Projects, Inter Pipeline Ltd.*, Cold Lake and Bruderheim, Alberta (Owner's Project Manager)

This EPCM project included a 36" mainline and associated pump and metering facilities with two new pumping stations at Beaverhill and Ashmont and the modification of three existing brownfield stations. The Kirby South EPCM project including a 30" mainline, associated pump, and metering facilities with new pump stations at Kirby and Winefred, as well as the construction of an 8 km access road (brownfield and greenfield).

Sherwood Terminal Expansion, Shell Canada Products*, Edmonton, Alberta (Project Manager)

Project consisted of upgrading terminal facilities infrastructure to accommodate the additional product from the Scotford refinery. This Brownfield project with limited footprint conditions required Pump system upgrades including piping infrastructure and truck-loading facilities.

Sherwood Terminal Biofuels, Shell Canada Products*, Edmonton, Alberta (Project Manager)
Project consisted of front end engineering design, detailed design, procurement, and construction activities including start-up and commissioning. A multi-discipline brownfield project to blend biofuels products (ethanol/biodiesel) with traditional fuel supplies. Procurement and installation of rotating equipment (pump packages), storage tanks with internal floating roofs, and interconnecting piping/valves.

Line 4 Expansion, Enbridge*, Edmonton, Kingman, and Strome, Alberta (Project Manager)
Supervised, coordinated, and directed the application of policies, plans, and procedures for efficient operations of the project under his responsibility. Identified, recruited, and retained senior key project and staff roles. Prepared and reviewed execution plans on current projects and prepared cost estimates and contractual commitments for new projects/proposals. Ensured that each contract/project was delivered using the project management guidelines and the construction manual procedures. Reviewed and approved project plans, cost estimates, budgets, forecasts, and schedules against budget and for conformity to meet Stakeholder expectations. Developed and maintained relationships within clients and prospective clients.

Marine/Waterfront Engineering
Ridley Marine Terminal Expansion, Prince Rupert Port Authority*, Prince Rupert, British Columbia (Project Manager)
The project was a joint venture between the Canadian government and a private venture corporation to double the capacity of a vessel loading facility including on-shore and off-shore loading and berthing facilities and marine (off-shore) upgrades. Assembled and commissioned new 300 stacker reclaimer. Additional scope added during the execution phase included rock blasting of an additional 44 acres and the installation and upgrade of rail infrastructure 12 km (CN Rail).

Integrity

North Slope Integrity Management System, Conoco Phillips*, Prudhoe Bay, Alaska (Project Manager/Director of Advanced Technology)
Developed and retained competent, motivated, and loyal staff. Developed and implemented human resource plans, including strategies for recruitment, training/development, and succession. Managed direct and indirect labor to maximize utilization. Developed and mentored subordinates to produce effective leaders. Delegated responsibility to ensure staff were empowered and learned management responsibilities. Participated in the management of human resource activities including staffing, hiring, performance reviews, successor planning, promotion, counseling, discipline, and dismissals. Worked closely with other general managers to support cross-utilization of personnel, ensure that the company's resources were deployed in the most effective manner. Responsibility for P&L statements within the business unit. Analyzed and adjusted P&L on the monthly, qrt basis. Set limits of authority with staff to ensure wise decisions were made with respect to the company resources. Established a well-defined organization with clear lines and limits of authority. Managed operational and capital budgets. Managed resources including facilities, vehicles, and equipment to ensure safe, secure, cost-effective, and efficient operations. Oversaw administrative functions to eliminate errors and increase efficiencies. Participated in the development and management of operational and capital budgets.

Mining

North Slope Pipeline Integrity Program, British Petroleum*, Prudhoe Bay, Alaska (Director of Advanced Technology/Manager of Projects)

Managed the corporate advanced technologies department based in Edmonton with satellite offices in Fort McMurray, Calgary and Anchorage AK. Developed and executed a strategic turnaround plan for the business unit. Added business lines outside of traditional offerings. Recruited highly skilled and qualified candidates from Canada and the United States to form a highly efficient local management team. Decreased total indirect spending through employee optimization process and the implementation of stringent business controls. Responsible for all contract negotiations involving advanced Technology work in Canada and Alaska. Lowered regional injury frequency rate from 2.9 (2005) to 0.97 (2007). Introduced new technologies that increased labor efficiencies (phased array ultrasonic, computerized radiography). Designed and built the first real-time radiography crawler to inspect through wall corrosion piping while traveling outside of pipe (patented).

Fuel Storage and Distribution

Denver International Airport Tank Farm, City of Denver*, Denver, Colorado (Project Manager/Construction Manager)

Managed three full service industrial construction (EPCM, EPC) offices in Denver, Seattle, and Salt Lake City. Provided HSE, technical, financial, and logistical support for capital project and turnaround plan development and execution. Developed an economics-driven turnaround and maintenance planning program resulting in shorter, more developed, and better planned maintenance outages. Performed detailed HSE and financial risk assessments for "Clean Fuels" projects. Participated in FCCU and reformer reliability and optimization studies and consulted on a capacity increase project. Developed and implemented a risk-based inspection program for fixed and rotating plant equipment. Created risk management plans for plant equipment based on calculated HSE and financial risk impact. Projects include the jet fuel tank farm located at the Denver International airport and the Rocky Mountain arsenal (nuclear supply point) for U.S department of defense.

Generation

Mindanao Power Plant, Power Engineers*, Mindanao, Philippines (Project Manager/General Manager)

Managed a branch office and contracts, technicians, and support personnel. Planned, estimated, and allocated resources for on-stream and project quality assurance/quality control (QA/QC) services. Managed process safety management team. Led QA/QC representative on turnarounds, capital projects, and major maintenance initiatives. Designed, build and fabricate rotating and process equipment skid assemblies including power plant process units at Mindanao power plant project and chemical waste disposal (incinerator) at Pine Bluff AR. Army Depot.

PROFESSIONAL ACTIVITIES

Project Management Professional, Project Management Institute

Rick Ponti Jr., BA

Senior Engineering Geologist, Stantec

SUMMARY

Rick Ponti has extensive geologic and inspection experience on major domestic and foreign hydro/thermal/nuclear power plants, earth/concrete dams, tunnels, heavy railway, marine shipyards, regional planning, recreational and office development projects. His experience includes development, management, inspection and field direction of large/small construction projects, land evaluation studies involving geo-hydrological, environmental and geotechnical engineering investigations to determine: groundwater and surface water flow regimes; soil and water contaminant distribution; wetlands characterization; and soil or rock conditions related to foundations, rock and soil tunnels, rock slopes and slope stability of large earthfill dams. Rick has also developed quantity/cost estimates, managed and directed extensive field construction and inspection activities for earthworks, dams, roads, utilities, soft ground and hard rock tunnels, drill and blast, slurry walls, secant wall shafts, pre-cast pile, deep pile and caisson foundations; established ground and aerial topographic survey programs; and monitored bathymetric and hydrographic surveys. Site investigations have ranged between 30 and 1,800 acres involving diversified geologic environments among 20 states within the eastern, central and southwestern sections of the US, Kuwait, Peru and India. He has also guest lectured for post graduate deep foundation courses, and authored/co-authored several state- of- the-art technical/case study papers.

EXPERIENCE RECORDS

Water

University of Chicago FERMILAB, Braidwood, Illinois (Senior Technical Specialist)

Rick developed and conducted borings, developed logs, and a zoned bedrock hydraulic conductivity testing program within two 650-foot-deep bedrock boreholes for two proposed 40-foot-diameter shafts associated with neutrino particle experiments.

Niagara Mohawk Power Company, Croghan, New York (Project Engineering Geologist)

Responsible for conducting subsurface investigation program to evaluate the stability of three large earth fill dams (120-180 feet high) in upstate New York as part of a FERC inspection; Mr. Ponti developed the procedures for the first installation of multiple pneumatic piezometers in a single borehole for dam investigations.

Maine Site Reconnaissance, Maine (Project Geologist)

Rick conducted site reconnaissance and pump tests in an existing bedrock well to determine suitability of converting the existing surface water supply to on-site wells for a 160 acre site.

Staten Island Water Quality Program, Staten Island, New York (Project Engineering Geologist)

Ricki implemented groundwater monitoring and water quality program, including the installation of staff gauges at selected wetlands along a proposed 8-mile soft ground sewer tunnel corridor along Hylan Boulevard to evaluate the dewatering effects on the adjacent ponds, streams and wetland vegetation.

Fletcher Quarry Dam, Chelmsford, Massachusetts (Senior Engineering Geologist / Inspector)

Comprehensive inspection for a granite curbstone/concrete slab earth fill dam, 12 feet high, 250 feet long, for a process water pond; first inspection report for the dam.

Goodnough Dike, Palmer, Massachusetts (Senior Engineering Geologist)
Responsible for repair to existing pneumatic piezometers in the dike, and inspection of the downstream toe of slope area for surface boils. Investigation involved subsurface piezometer installations, seismic survey (H-RGI) and camera survey to reveal a leaking, partially intact, 50 year old cmp construction diversion pipe in very poor condition. Investigation resulted in a significant upgrade to the toe of slope area.

Dallas-Fort Worth Alignment Evaluation Plan, Dallas-Fort Worth, Texas (Senior Technical Specialist)
Worked on the alternative alignment evaluation plan for a 72-inch diameter soft ground, potable water supply pipeline alignment near

Ministry of Mining, Kudremuhk, India (Senior Technical Specialist)
Rick conducted an evaluation of a 200-foot-high, 1,000-foot-long tailings dam to eliminate particulate entry into the existing process water for the largest low grade iron ore mine in the world.

Subsurface Investigation - Confidential, Illinois (Senior Engineering Geologist)
Rick was responsible for conducting a comprehensive subsurface investigation program involving HQ rock core logging of 18 boreholes advanced between 160 and 300 feet deep. He also conducted more than 100 zoned packer tests to estimate bedrock hydraulic conductivities for permitting of a proposed rock/aggregate quarry.

Indian Point Nuclear Power Plant Groundwater Protection Initiative, Buchanan, New York (Senior Engineering Geologist)
Rick was responsible for staff training for rock core logging, zoned packer testing and pneumatic recovery well tests for a comprehensive hydrogeological investigation to evaluate the bedrock fracture flow properties in marble along the Hudson River. He developed a geostructural database and geostructural-hydrogeological bedrock model using DIPS to analyze potential Tritium/Strontium release pathways by applying a porous media approach using MODFLOW. This involved review of heat pulse, acoustic/optical televiewer (ATV/OTV) well logs, and the establishment of a comprehensive geostructural-hydrogeological database which utilized projected joint/fracture plane geometries to establish the effective support for a porous media approach to groundwater flow through fractured rock.

World Trade Center*, Boston, Massachusetts (Senior Engineering Geologist)
Rick conducted the comprehensive pre-characterization and geotechnical subsurface investigation program. His responsibilities included managing the continuous split spoon sampling for 71 borings within Boston Blue Clay and Argillite, installation of monitoring wells, bedrock core sampling, and the implementation of technical and environmental QA/QC procedures throughout the program.

Several Sub-contracts within Central Artery Tunnel Project*, Boston, Massachusetts (Senior Technical Specialist / Inspector)
For over a 14-year period, Rick conducted preliminary, 12-hour pump tests to evaluate bedrock drawdown and potential impacts on adjacent historic structures, and determined the bedrock suitability of Argillite in the field for 6-foot-diameter, 140-foot deep, temporary 8-foot diameter pin piles. For several other sites, he conducted slurry wall boring investigation to determine effectiveness of slurry wall-bedrock interface seal, for 8 miles of slurry wall; developed and evaluated effectiveness of high pressure grout infilling of void spaces discovered between top of bedrock and slurry wall base. For another sub-contract, Rick was a tunnel inspector for the South Station mixed face, stacked drift tunnels through sodium-silicate grouted sand and gravel overlying argillite bedrock. Involved inspection of excavation, structural steel/re-bar support and QA/QC for several, massive concrete (36 hours continuous) pours, and provided dispute resolution to avoid construction claims.

MetroWest Water Supply Tunnel - Phase 1*, Boston, Massachusetts (Senior Engineering Geologist)
Rick was part of the Phase I evaluation to construct 18 miles of new bedrock tunnel. This involved logging approximately 2,500 feet of rock core using wireline drilling techniques in borings 300 to 600 feet deep and high-pressure jacking tests. Subsequent duties included QA/QC bedrock mapping of the tunnel alignment.

Rock Inspections for Retail/Wholesale Facility*, Braintree, Massachusetts (Senior Engineering Geologist)
Supervised and managed a 5-week blasting and excavation operation, and vibration monitoring for the construction of a 35 to 60-foot deep rock cut involving the removal of over 60,000 cubic yards of material associated with a proposed two-story retail/wholesale facility located 1.5 feet away from the rock face. This project involved inspection of 60 rock anchor installations; Rick developed a rock screen/rock bolt system for vertical shear zones and rock cavities in rhyolite tuff bedrock intruded by a basalt/diabase dike. His additional responsibilities included QA/QC specification compliance for a concrete rockface retaining wall and building footings and site drainage system.

Boston Harbor Inter-Island Tunnel Project*, Boston, Massachusetts (Project Engineering Geologist)
The goal of this project was to update the sanitary sewer system. It involved mapping 1.5 miles of geologic structure within the tunnel below Boston Harbor using RMR and Q classification systems.

Geological Survey Report for the Catskill and Delaware Watershed Dams*, New York (Senior Engineering Geologist)
Primary author for preliminary geological survey report for the detailed evaluation of the reconstruction of the New York City water supply Upstate Dams. This involved a comprehensive literature search, engineering archive review, photograph review and detailed site-specific geologic reconnaissance of six major dams serving the New York City water supply. In addition, he reviewed development of the subsurface investigation program and the technical QA/QC program.

Braintree-Weymouth Shaft and Tunnel*, Massachusetts (Senior Engineering Geologist / Senior Technical Specialist)
Responsible for inspection and mapping geologic conditions for a large diameter slurry wall shaft and tunnel adjacent to and below Boston Harbor. He developed and supervised a subsurface investigation program to evaluate rock quality and hydrogeologic properties along the shaft face which was discharging over 400 gpm along the upper bedrock overburden contact. The project included 300 feet of 4"D, horizontal, NQ wireline rock logging, angled borings, hydraulic permeability pressure testing, dye testing and data analysis. Rick identified significant structural features requiring shaft re-design and was successful in producing documentation and expert witness presentations made before a Dispute Review Board involving a several million dollar claim.

MetroWest Water Supply Tunnel*, Marlborough to Boston, Massachusetts (Senior Engineering Geologist)
Responsible for executing field activities and QA/QC for the world's first NQ-size directionally drilled rock borehole with core recovery. He was also responsible for the implementation of innovative technology through very hard granite, clay gauge fault zone and Argillite; borehole drilling along tunnel crest from ground surface for 1,752 linear feet with an international team; supervision of the team and the conduction of a 1,850-foot-long directional borehole through a suspected 600-foot-long fracture zone; development of a high pressure hydraulic conductivity testing program to design a high pressure grouting program ahead of a working TBM; successful grouting of fracture zones resulting in significant reduction of ground support and groundwater control effort; and estimation of several million dollars in savings.

Second Avenue Subway Project*, Manhattan, New York (Senior Engineering Geologist / Senior Technical Specialist)
Responsible for specification writing, review, inspector training program and QA/QC for a comprehensive subsurface investigation program along a proposed $20B, 8-mile long, and 120-foot deep tunnel alignment below Second Avenue. He trained a young staff to describe/classify soils in accordance with Burmister, Unified and NYC Building Code Systems, as well as bedrock in accordance with ISRM standards. This training also included oriented core, goniometer analysis, bedrock, hydraulic conductivity testing, constant/falling head tests, undisturbed tubes, compressive strength tests, borehole log review, acoustic televiewer data review, fault/sheer/fracture zone structural interpretation, structural geologic profiles and Q/RMR evaluation.

Robert Moses Power Dam*, Massena, New York (Senior Technical Specialist)
Responsible for conducting two vertical, and two 45 degree angles, 50 feet long boreholes below the dam within a 7x9 feet galley tunnel; rock core logging and zoned borehole pressure tests conducted to evaluate the condition of weak, very thin gypsum layers within a shale to determine dam stability.

Willow Mill Dam*, Lee, Massachusetts (Senior Technical Specialist)
Resident engineer responsible for cyclopean masonry dam rehabilitation, including stone re-facing, coring and installation of 10 passive rock anchors. He also wrote summary reports for the client.

7 Line Extension New York City Transit*, New York, New York (Senior Engineering Geologist)
Responsible for QA/QC review of existing rock core, ATV, and subsurface information, development of subsurface profiles, and evaluation of Q and RMR rock mass systems. He also developed a subsurface investigation program for final design and geologic interpretation for construction of a 1.5-mile twin tunnel subway extension beneath 11th Avenue in New York City.

District of Columbia Water and Sewer Authority (WASA) Combined Sewer Outfall*, Washington, D.C. (Senior Technical Specialist)
Under the Geotechnical Exploration Program for the Alternative Facilities Plan, Rick served as the sub-task manager responsible for managing the geotechnical investigations program, sampling and laboratory testing QA/QC program, core storage facility, risk register review analyses, in-situ permeability analyses, project review board presentations and report writing for a 14 mile long, 22 feet diameter, TBM driven soft ground tunnel. Rick is the primary author of the publication and development for soil characterization criteria currently used as the baseline for soft ground tunneling by DC Water.

Microtunnel Sewer Relocation*, Fairfax County, Virginia (Senior Technical Specialist)
Responsible for specification writing and bid evaluation support. He served as the resident engineer for a 550-foot long microtunnel and secant wall shafts associated with a sewer relocation in loose sands within a closely spaced neighborhood. The tunnel was completed to within 1mm of designed horizontal and vertical elevations.

Homestead Tunnel Project*, Hartford, Connecticut (Senior Inspector / Field Engineer)
Responsible for field supervision and QA/QC review/compliance for one 6 feet diameter, 700 feet long microtunnel in very soft clay. The second tunnel was 600 feet long, and the first curved, segment lined, microtunnel in North America; the crest of the tunnel passed 2.5 feet below the main water supply line to the city of Harford, CT, without incident. Both tunnels were completed to within 1mm of designed horizontal alignment and vertical elevation.

Department of Public Works Project*, Indianapolis, Indiana (Senior Engineering Geologist)
Responsible for specification writing, geological QA/QC review, sample selection and testing for bedrock geotechnical evaluation including SINTEF, geostructural interpretation using DIPS software, lineament analyses, Q system data, risk register input, and section writing for the project GBR, for a 20 feet diameter,8 mile long bedrock TBM driven CSO tunnel. Served on the VE team for a similar size project as the next phase.

Simandou Ore Project*, Mamou, Guinea, West Africa (Senior Engineering Geologist)
Responsible for conceptual design evaluation for two 11km long and one, 1.4km long, 6mX8m, 200m-500m deep drill and blast rail tunnels for ore transport in Mamou, Guinea. Responsible for conceptual site model development, subsurface investigation plan method, evaluation, design input parameters, specification writing, GBR report author, and client presentations.

Geologic Studies
Az Zour Oil Fired Power Plant and Desalination Plant, Az Zour, Kuwait (Resident Engineer / Project Administrator)
Largest oil fired power plant (4800MW) and desalination plant (1MGPD) in the world. Involved daily client contact, inspection of substations, deep pile/spread footing foundations, dewatering, earthworks, intake/discharge canals, 1 mile long jetties, turbine buildings, transmission towers, and ancillary structures, and dispute/claims resolution Responsible for contractor invoice review and payment.

Cape Cod Air Force, Sagamore, Massachusetts (Project Geologist)
Rick installed mini-piezometers and conducted soil-gas survey. The project entailed a Security Clearance: Q.

Polkton Geologic Mapping, Polkton, North Carolina (Project Engineering Geologist)
Rick conducted preliminary geologic reconnaissance mapping, fracture trace analyses and 53 borings using auger/wireline and air hammer methods on a +1,200 acre site to characterize the geologic, seismic and hydrogeologic conditions of saprolite deposits and bedrock for a proposed solid waste landfill. Involved report writing, development of a bedrock hydraulic conductivity model using MODFLOW

Charlestown Central Artery Project, Charlestown, Massachusetts (Project Technician Specialist)
Rick assisted with the installation of soil and concrete instrumentation for 120 feet deep slurry walls associated with the Central Artery Project. He also installed strain gauges, tilt meters, load cells and deep extensometers.

Blasting and Excavation Operation, Braintree, Massachusetts (Senior Engineering Geologist)
Rick supervised and managed a 5-week blasting and excavation operation, and vibration monitoring for the construction of a 35- to 60-foot-deep rock cut involving the removal of + 60,000 cubic yards of material associated with a proposed two-story retail/wholesale facility located 1.5 feet away from the rock face. This project involved inspection of 60 rock anchor installations; He also developed a rock screen/rock bolt system for vertical shear zones and rock cavities in rhyolite tuff bedrock intruded by a basalt/diabase dike. His additional responsibilities included QA/QC specification compliance for a concrete rockface retaining wall and building footings and site drainage system.

Logan Airport, International Walkways, Boston, Massachusetts (Senior Technical Specialist)Rick was selected as the field inspector responsible for over 100 mini-pile installations and QA/QC for over 50, deep, 8-foot to 4-foot-diameter "step" pile foundation system. This was the first application of European step pile design in North America.

Charles River Laboratories, Wilmington, Massachusetts (Senior Engineering Geologist) Rick developed a preliminary rock slope stability evaluation to determine toppling, planar sliding and wedge sliding potential using DIPS software for a proposed roadway cut.

Shrewsbury High School, Shrewsbury, Massachusetts (Senior Engineering Geologist)
Rick developed a rock slope stability evaluation, litigation strategy, and dispute resolution for a 1,200-foot-long, 60-foot-high 300 feet wide, drill and blast rock slope. He also developed a 20 year slope stabilization plan. As a result of the work, a $2M claim against the owner resulted in a $100K credit to the owner.

Rhode Island Resource Recovery Corporation (Senior Engineering Geologist)
Rick was responsible for establishing a structural geologic database for a contaminated landfill, the acoustic televiewer interpretation used to input into DIPS program, and the development of a joint/fracture set database for a comprehensive bedrock fracture flow model using FRACMAN/MAFIC.

Cote Nord Railway Project*, Quebec, Canada (Senior Engineering Geologist)
Responsible for geostructural evaluation for a 240km long ore railway, involving four 8mX6m drill and blast tunnels in granitic/ gneiss. Involved lineament analyses, geologic assessment along the alignment corridor, and report writing.

DRTC Project, Indianapolis, Indiana (Senior Engineering Geologist)
Responsible for initial rock support inspection and geologic mapping for an 8 mile long, 20 feet diameter tunnel in limestone/dolomite, for QA/QC compliance.

PROFESSIONAL ACTIVITIES

Professional Geologist #426, State of North Carolina

Professional Geologist #671, State of New Hampshire

Instructor, Well Drilling Licensing Soil/Rock Workshop, Department of Conservation, Commonwealth of Massachusetts

Member, State Mapping Advisory Committee, Commonwealth of Massachusetts

Member, Core Repository Advisory Committee, Office of the State Geologist, Commonwealth of Massachusetts

Member, New England Chapter, Association of Environmental & Engineering Geologists

EDUCATION

University of Maine, Orono, Maine, (1978)
BA, Geological Science

Riyaz Shivji CET, P.Eng

Director, Oil & Gas - Terminals, Stantec

SUMMARY

As the Director for Terminals, Riyaz is responsible for developing Stantec's overall business in this sector and across North America. In this position, he provides direction in strategic planning, business development, project management, operations, partnerships, contracting strategies, and client relationships. Riyaz has been in this business for over 25 years and has held various management positions at Stantec for the past 20 years.

Riyaz has successfully led and completed projects for clients nationally and internationally, ranging from a few thousand to hundreds of millions of dollars.

Riyaz takes a lead role in developing long-term client relationships and is a primary corporate sponsor for many of Stantec's oil and gas projects, ensuring that client requirements are met, adequate resources are assigned, and contracts and associated business requirements are in place and followed. He works closely with other groups within Stantec to provide clients with an integrated team solution including the environmental, surveying, geotechnical, and transportation disciplines.

EXPERIENCE RECORDS

Chemicals & Polymers

Unit 5R Expansion, Celanese EVA Performance Polymers Inc., Edmonton, Alberta (Mechanical Engineer)
Responsible for performing audits and authenticating the mechanical/piping drawings designed offshore for Canadian codes and standards.

Impact Scale Installation (Phosphate), Sherritt Inc. (Mechanical/Piping Designer)
Responsible for the conceptual design, demolition/construction piping drawings, and bill of materials.

Multiple Projects, Agrium (Mechanical/Piping Design Lead)
On the Railcar Unloading project, was responsible for the conceptual design and all pertinent demolition/construction piping drawings.

On the Granulation Debottleneck project, was responsible for the conceptual design of a granulation unit debottleneck. Involved in the detail design of the addition of an in-line knockout pot to retrieve granulation contained in process air, and a replacement exhaust plenum for a scrubber system to increase scrubber efficiency. Responsible for all pertinent demolition/construction drawings.

On the Water Re-use project, was responsible for the conceptual design of pumping the collected drainage and sump water from a remote lift station for re-use in the phosphate unit operation.

Responsible for all pertinent construction drawings.

On the Nitric Acid/Nitrate Debottleneck Study project, was responsible for estimating the costs associated with this project. Worked closely with the process engineering team in making certain that all anticipated changes on P&IDs were reflected in the design and MTOs.

Desalter Project, Husky BPU (Mechanical/Piping Designer)

Responsible for the conceptual design and all pertinent demolition and construction piping drawings.

Multiple Projects, Dow Chemicals (Mechanical/Piping Design)
Responsible for providing construction packages for the following projects:

- Vinyl Distillation Upgrade
- Groundwater Remediation
- EO Demolition/Remediation
- Railcar Recycle Wash
- Air Compressor Relocation
- Steam to Block IGO
- E321 Rundown Lines

Waste Water Containment, Alberta Envirofuels Inc. (Mechanical/Piping Designer)
Responsible for as-builts from field redlined drawings, including orthographics and isometrics.

VA Piping Modification, Celanese Canada Inc. (Mechanical/Piping Designer)
Responsible for re-routing piping and relocating equipment. Involved in field sketches marking up of all existing and new P&IDs, and generating demolition isometrics.

Compost Facilities

Barbados Solid Waste Management, Barbados (Mechanical/Piping Design Lead)
Was a part of Stantec's multi-disciplined project team which completed a comprehensive study for a new landfill site in Barbados. This included containment; collection and disposal; source reduction; private recycling; yard and special waste composting; and policy, financial, and legal frameworks. The team selected the site, designed, and tendered the facility, as well as provided ongoing advice during the construction program.

Co-Composting Facility, Transalta (Mechanical/Piping Design Lead)
Responsible for the conceptual design and preparing a construction package for the Lagoon pump house. This pump house handles 22,500 tonnes of municipal sewage sludge per year, which is used as a feedstock in producing 180,000 tonnes of compost from municipal solid waste.

Construction-Addition

ALPAC Pulp Mill and Husky's Bi-Provincial Upgrader, Comstock Canada*, Boyle and Lloydminster, Alberta and Saskatchewan (Cost Controller and Electrical/Instrumentation Coordinator)
Responsible for modifications, revisions, and additional work to the original scope of work (change order). Monitored all costs associated with regards to a change order, labour, materials, subcontractors, and equipment rentals. Responsible for claiming all expenditures due to changes in the scope of work. Approximately 1,500 change orders valued at over C$8 million.

Responsible for the coordination of systems turnover. Scheduled work in conjunction with the general contractor and owner. Identified instruments and electrical equipment associated within each system. Set up crews to identify deficiencies and verify system completion. Provided the general contractor with an electrical turnover package.

Husky Bi-Provincial Upgrader, The State Group* (Electrical/Instrumentation Coordinator)
Responsible for design, drafting, and specification of various electrical equipment. Worked with electrical drawings in conjunction with the Canadian Electrical Code. Performed estimating duties and project coordination.

Design Development

Plant 09 and Plant 01 P&ID As-Built Projects, Agrium (Project Manager)
Project Manager responsible for coordinating all activities. Responsibilities included supervision and coordination of four field personnel, six CADD personnel, and two QA/QC checkers. Provided the client with status and man-hour utilization reports. Project was completed using the MCT software.

PCL Industrial* (Piping Designer/Coordinator)
Responsible for preparation of pipe fabrication drawings, working in conjunction with provided construction drawings and specifications. Performed estimating duties and project coordination for the following projects:

- Dow Chemical PolyTrain II, Fort Saskatchewan, Alberta
- Praxair Prentiss II, Caroline, Alberta
- Foothills Pipe Lines Monchy Compressor Station
- Dow Chemical Expansion, Fort Saskatchewan, Alberta
- ALPAC Pulp Mill, Boyle, Alberta
- Husky Bi-Provincial Upgrader, Lloydminster, Alberta
- Shell Refinery, Caroline, Alberta
- Nova Compressor Station, Wainwright, Alberta

Fire Protection and Safety Showers System, Alberta Power Ltd. (Mechanical/Piping Designer)
Responsible for the preparation of process and instrumentation diagrams.

Millennium Pipelines, Suncor Energy (As-Builts)
Created as-builts for the tailings pipelines, hydrotransport pipelines, cold water pipeline, and hot water pipeline.

Multiple Projects, TransAlta (formerly Suncor Energy Services) (Coordinator)
On the Plants 31, 32, 35, and 38 P&ID As-Built Project, acted as office coordinator responsible for all activities in cadding over 300 as-built P&IDs. Responsibilities included supervision and coordination of six CADD personnel and two checkers, coordination of work with field coordinator, control of all documents, office man-hour reporting, and providing assistance to the project manager. This project was completed with AutoPLANT software creating intelligent P&IDs. Responsibilities also included the development of new standards to achieve this.

On the PFD development for all utilities plants project, acted as project coordinator responsible for supervision and coordination of three process engineers, one CADD draftsman, and one checker. Updated status reports and tracked man-hours.

Multiple Projects, Melloy And Associates* (Mechanical/Piping Designer)
Responsible for vessel fabrication drawings and all pertinent details. Projects worked on included:

- Syncrude Third Stage Centrifuge Project
- AT Plastics #2 Booster Compressor
- Amoco Amine Stripper Repair
- TARO Compression Systems Canadian Occidental Suction Scrubber

1994 Critical Drawings Upgrade, Imperial Oil Resources Limited (Mechanical/Piping Designer)
Responsible for providing P&ID as-builts from field redlined drawings. Drawings were done on AutoCAD, using MCT software.

Manufacturing

Climate Master Inc.* (Mechanical Technologist)
Responsible for designing commercial size HVAC equipment as specified by client. Selected the right size components and casing for a particular application. Developed a bill of materials for each HVAC unit and overlooked its fabrication.

Material Handling Systems

Royal Oak Mines, PKS Constructors (Rebis/Project Coordinator)
Responsible for providing training in Rebis and generating Rebis specifications and training.

Millennium Project, Suncor Energy (Mechanical/Materials Handling Design Coordinator)
Responsible for generating construction drawings packages for one 72" 700 HP feed conveyor, two 72" 1400 HP stacking conveyors, two 72" 1400 HP reclaim conveyors, and all related equipment and facilities using AutoCAD release 14. Duties involved project inter-disciplinary/fabrication coordination as well as project scheduling and design supervision.

Oil and Gas Pipelines

Energy East Tank Terminals, TransCanada Pipelines Limited, Multiple Sites, Alberta, Saskatchewan, Quebec, and New Brunswick (Project Engineer)
Led a multi-disciplinary engineering team through the front end engineering design of 4 new tank terminals including 14 tanks at Hardisty, Alberta; 3 tanks at Moosomin, Saskatchewan; 12 tanks at Cacouna, Quebec; and 18 tanks at Saint John, New Brunswick. The terminals included metering manifolds, valve manifolds, sending and receiving traps, booster pumps, associated piping and firewater and foam systems, and transfer lines to existing facilities. Participated with the project design team in the preparation of scope of work, schedule, budget, design criteria, design basis memorandum, and standards and specifications review. Responsible for ensuring the quality and completeness of the overall engineering design.

Line RW 2431 Retrofit, Suncor Energy (Project Manager)
Responsible for managing the engineering work associated with retrofitting this raw water line and the associated supporting structures. As part of this scope of work, Stantec produced a transient analysis model in AFT Impulse®, which was linked to COADE Caesar II® stress analysis model, which provided the locations of the necessary supports.

Core Capital 2012 Class V Estimates, Enbridge, Edmonton, Alberta (Lead Engineer Mechanical/Piping)
Provided bases of estimates, project scope definitions, assumptions, allowances, exclusions, and necessary reference documentation and drawings in order to complete the five Class V estimates.

Core Capital 2011 Class V Estimates, Enbridge, Edmonton, Alberta (Lead Engineer Mechanical/Piping)
Provided bases of estimates, project scope definitions, assumptions, allowances, exclusions, and necessary reference documentation and drawings in order to complete the nine Class V estimates.

Multiple Projects, Enbridge, Multiple Sites, Canada (Project Manager)
Responsible for the overall quality, cost, and schedule for the following projects: Small-Bore Piping Vibration Analysis; Line 4 Supports Modifications at Cactus Lake, Saskatchewan and Cromer, Manitoba; Line 18 and Line 19 Small-Bore Vibration Analysis; Standard Details 2011; Athabasca Terminal Build-Out Strategy; Safe Setback Distances for Hydrotesting Above Grade and Below Grade Piping; Standard Details 2012; and PCV Mechanical Limit Stop.

Polaris Expansion 1, Inter Pipeline Fund, Kearl and Lamont, Alberta (Lead Mechanical Engineer)

Responsible for the evaluation, selection, and ordering of a wide range of mechanical equipment during the detailed design phase. Interacted with the piping team to develop piping specifications and renew the stress analysis report. Supervised intermediate and junior engineers in project-related mechanical activities.

Multiple Projects, Enbridge, Edmonton, Alberta (Project Design Coordinator)
Responsible for the interdisciplinary design coordination of the entire project and managing field queries. Worked closely with the project engineering manager to ensure deliverables meet quality and schedule requirements and provided progress updates on a regular basis. Projects included Hardisty Contract Tankage, Keystone Connections, Southern Lights Connection, Southern Lights Line 13 Reversal, and IPF Corridor Expansion.

Fort Hills CS&S Bitumen Production and Bitumen Upgrading Facilities and Infrastructure DBM Preparation, Petro-Canada Oil Sands Inc., Fort McMurray and Sturgeon County, Alberta (AutoPlant/CAD Administrator and Design Standards Administrator)
Responsible for mentoring and guiding all Stantec design/CAD staff involved on this project. As this was a multi-practice area project, we had people from various profit centers participating in this project from within Stantec and Morrison Hershfield. Responsible for making sure that all design/CAD staff interpreted and applied the various Petro-Canada Oil Sands Inc. (PCOSI) design standards in a consistent manner. Responsible for distribution and maintenance of all PCOSI design standards and provided consolidated feedback to PCOSI for future implementation.

Gas Oil Tanks, Petro-Canada, Edmonton, Alberta (Field Engineer)
Coordinated the mechanical and structural contractor on site. Stantec was responsible for engineering, procurement, and project and construction management services in support of converting Petro-Canada's refinery to low sulfur diesel. The project involved site infrastructure work including off-sites, pipe racks, electrical, site civil preparation, undergrounds, installation of two 210,000 barrel gas oil storage tanks, pumps and mixers, and relocation of a propane load out facility.

Gas Oil Tanks, Petro-Canada (Piping Design Lead)
Responsible for coordinating the production of all mechanical and piping IFC deliverables.

Station Consolidation Rebis, Terasen Pipelines (Administrator)
Responsible for generating all pipe specifications and training designers to use the 3D-tool proficiently. This project comprised of detailed engineering to consolidate scraper traps, isolation valves, manifolds, booster facilities, and provers scattered on the plant site into a sheltered, common area. It also included the construction of a new 480V MCC building complete with diesel generator for back-up power purposes. Capital cost of this project was C$4.5 million.

Gainford Containment Upgrade, Terasen Pipelines (Mechanical/Piping Design Lead)
Responsible for the conceptual design and preparing a construction package for the containment upgrade project. This was a unique project in which we had to mitigate environmental risks at Gainford Station. Previously buried piping was brought above ground and the station header and unit valves were moved into the pump room. This provided spill containment for the equipment and all flanged connections, as well as visual inspection of piping. In addition the existing oily water sump tank system and drain lines were also replaced. This project was engineered and designed to be completed in stages to keep the crude flowing at all times.

Multiple Projects, Suncor Energy (Mechanical/Piping Designer)

On the Steepbank Pipelines project, responsible for generating a 3D model of the entire pipeline corridor between the ore preparation plant and the existing Suncor plant. A high degree of coordination was required since there were multiple consulting engineers and a bridge contractor involved in successfully completing this project. On the Millennium Pipelines project, responsible for generating all construction deliverables for all hydrotransport, tailings, and hot water and cold water pipelines in the various pipeline corridors. A high degree of coordination was required since there were multiple consulting engineers involved in successfully completing this project. On the HT5 Hydrotransport Piping project, responsible for generating a 2D and 3D model using AutoPlant software for the pipelines between Milliennium and Steepbank for the existing Suncor Plant. Project involved a high degree of coordination with various engineering companies, site construction, and the existing operating facility. This project was delivered on time and on budget and was the first functioning system of the Millennium plant design. The system paid for its installation in the first two months of operation.

Multiple Projects, Enbridge (Mechanical/Piping Designer)
Responsible for the conceptual design, demolition, construction drawings, and bills of material. Projects worked on included Regina Rupture Disc Addition, Gretna Rupture Disk Addition, Regina Line 1 Delivery Manifold, Gretna Firewater Jockey Pump, Milden Remote Control Facility, and Hardisty Station Piping Modifications.

Horizon Extraction Plant Design Basis Memorandum, Canadian Natural Resources Limited (Lead Mechanical/Piping Designer)
Responsible for coordinating the production of all process flow diagrams, process equipment diagrams, 3D conceptual plant layout, material take-off, and other ancillary details necessary to complete a level III estimate. This project will be constructed in three phases over a duration of 10 years, and as such, all the deliverables needed to be demarcated in to these phases. Coordinated all activities of eleven designers over the course of 16 months to successfully complete this project.

Odyssey/Firebag Design Basis Memorandum, Suncor Energy (Lead Mechanical/Piping Designer)
Responsible for coordinating the production of all process flow diagrams, 3D conceptual plant layout, material take-off, and other ancillary details necessary to complete a level III estimate. Coordinated all activities of four designers over the course of six months to successfully complete this project.

Power

Co-Generation Facility, ATCO Electric (Mechanical/Piping Designer)
Responsible for producing complete construction packages for a waste heat recovery system. The steam produced from an existing LM6000 was to be used for heating purposes for Husky Oil and ATCO at the Rainbow Lake site, as well as for ATCO NOx control on the LM6000 gas turbine. The project design included a water treatment plant, once through steam generator, and utility and disposal piping connections to Husky Oil facilities. The design also made consideration for the future addition of a gas turbine. Capital cost of this project was C$25 million.

Condenser Tube Cleaning, Edmonton Power, Edmonton, Alberta (Mechanical/Piping Design Lead)
Responsible for the conceptual design of tube cleaning piping for units G1 and G2. Responsible for all pertinent construction drawings.

Plant 35 Boiler Replacement, Suncor Energy (Mechanical/Piping Designer)
Responsible for providing the conceptual design, equipment layout, and piping drawings. Drawings were completed using AutoPlant software.

PROFESSIONAL ACTIVITIES

Certified Engineering Technologist #16776, The Association of Science and Engineering Technology Professionals of Alberta

Professional Engineer #66797, Association of Professional Engineers and Geoscientists of Alberta

EDUCATION

Codes and Standards Training Institute, Edmonton, Alberta, (2013)
CSA-Z662-11 Oil and Gas Pipeline Systems

Peter Smith, Edmonton, Alberta, (2010)
Mainline Pump Hydraulics Course

Coade, Edmonton, Alberta, (2009)
Caesar II Stress Analysis Course

University of Alberta, Edmonton, Alberta, (2009)
Mechanical Engineering Courses to Satisfy APEGA Requirements

APEGA, Edmonton, Alberta, (2009)
Fundamental in Engineering Exam

Edmonton, Alberta, (1996)
Best Practice Workshop on Composting

Northern Alberta Institute of Technology, Edmonton, Alberta, (1988)
Engineering Design and Drafting Technology

Steven C. Pierce, P.Eng.

Senior Rail Engineer, Stantec.

SUMMARY

Steve is a senior rail engineer with more than 16 years of experience working with private engineering firms, Class 1 railways, and rail contractors. He has a diverse background in rail projects involving yard expansions, bridge replacements, and facilities upgrades. Steve also has extensive operational experience in the planning, scheduling, and execution of mainline workblocks, worktrains, and the movement of OCS cars. Steve has led heavy rail projects in both Canada and the United States.

Steve is responsible for ensuring that the client's operations are maintained with a strict adherence to safety, while providing project deliverables on time and on budget.

EXPERIENCE RECORD

Heavy Rail

Entrance Realignment, McBain Intermodal Terminal, Edmonton, Alberta (Project Manager)
Developed conceptual plans then designs for the realignment of the facilities main entrance to improve volume of trucks passing through the main gates. Coordinated with the Railway and other Technology Experts to find a solution that fit the space and the technology desired for the installation.

Chassis Parking Area, McBain Intermodal Terminal, Edmonton, Alberta (Project Manager)
Worked with the Client to develop an onsite chassis storage and pick-up area to improve facility efficiency. Coordinated with the Railway and other designers to complete the project and meet Client needs. Offered support from design through construction.

RCC Pad & Track Expansion, McBain Intermodal Terminal, Edmonton, Alberta (Project Manager)
Worked with the Client to design an expansion to an existing RCC Pad and add a track with roadway to an existing rail yard. Worked the client from the conceptual phase through construction support.

Lynton Yard East End Reconfiguration, Fort McMurray, Alberta (Project Manager)
In order to improve operations on the yards East end changes were needed to the existing track layout. Coordinating with CN, Stantec developed several plans for reconfiguration of the yard's East end. Limited space and the need for independent leads made this a challenging task.

Lynton Yard Master Drainage Plan, Fort McMurray, Alberta (Project Manager)
With several development projects working independently CN asked Stantec to review the individual plans and current site conditions and develop a master drainage plan for the yard. We coordinated with the Railway and the three other project teams to gather the required information and then develop a plan that met the Municipal Region's requirements without significant impact to the ongoing projects.

Bridge Replacement over Hwy 27, MP 137 Detroit Lakes Subdivision Canadian Pacific Railway, Alexandria, Minnesota (Project Engineer)
Oversaw the installation of a new thru-plate girder ballasted deck bridge over Hwy. 27 in Alexandria, MN. This project required coordination with local agencies to close the highway during phases of the bridge erection and installation. Coordination was also performed with various work forces to complete the work within the set trackblocks.

Canadian Pacific Railway*, Calgary, Alberta (Operations Management Trainee)
Worked as a train-master on the Northern Ontario Siding Extension project. Coordinated with the Network Management Centre to maintain productivity without impacting train operations, prepared daily operations plans, and addressed work site safety issues.

Canadian Pacific Railway*, Minneapolis, Minnesota (Project Engineer - Structures and Projects Group)
Completed a multiphase upgrade of the Bensenville Intermodal Facility and two American customs inspection facilities. Worked closely with the clients to develop scopes and budgets and coordinated CPR and contractors to complete projects on time, within budget, and within specifications.

Canadian Pacific Railway*, Bensenville, Illinois (Manager Structures - Chicago Service Area)
Managed crews and equipment for new construction and maintenance of bridges, culverts, and buildings. Responsible for work scopes, coordinating work schedules, and ensuring that regulatory and industry standards, policies, and practices were followed on project sites.

PNR Railworks Inc.*, Cochrane, Alberta (Assistant Manager - Prairie Region)
Fulfilled the role of project manager for various Calgary LRT projects including Oliver Bowen Maintenance Facility, NE and NW LRT Extensions, and 7th Avenue Rehabilitation. Acted as the primary contact for Preferred Service Provider contracts. Reviewed and successfully completed tenders, RFQs, and RFPs. Tracked project progress and costs to maintain budgets while managing crews and equipment, and coaching employees in safe work practices.

Railroads

Functional Design Study of CPR Yards Crossing, Winnipeg, Manitoba (Rail Design Team Lead)
Responsible for the Rail design team for this multi discipline project, Functional Design Study for Crossing the CPR Yard located in North West Winnipeg. The Arlington Bridge over the CPR Yard is nearing the end of its functional life and needs to be decommissioned. The scope of this assignment was to develop a plan to remove the existing aging 29 span, steel truss and girder bridge and determine if another crossing or replacement of the existing crossing is required. The Rail design team was responsible to evaluate spur line removal alternative as well as evaluate impact on rail operation in regards to decommissioning planning. Scope of work also included development of rail detour alternative for McPhillips Street underpass reconstruction.

Track Expansion, Husky Refinery, Lloydminster, Alberta (Project Engineer)
Coordinated the project teams' conceptual planning, field survey and geotechnical investigation for this proposed track expansion within the existing Husky facility. Several restrictions on track placement as well as meeting operational expectations of the client made the development of this project challenging.

Existing Trans-load Facility Review, Illinois (Project Engineer)
Worked with a team to conduct a review and evaluation of an oil trans-loading facility that was under construction and up for sale. The review included the suitability of the facility for oil trans-loading. A risk analysis of the deficiencies found during the review, an opinion of cost for making changes prior to construction completion and after as well as potential schedule impacts.

Frac-Sand Expansion, Sylvan Lake, Alberta (Project Engineer)
Coordinated the project team from conceptual planning through detailed design to produce construction drawing for the client's Frac-Sand unloading track. With an aggressive schedule this project was designed and constructed in the seven months. Interfaced with the railway, design team and the client to gain plan approvals needed to advance through construction. Construction completed Dec 2014

Upstream and Downstream Trans-loading Facility Conceptual Plans, British Columbia (Project Engineer)
Developed conceptual plans for both Upstream and Downstream facilities to facilitate the shipment of Methanol products. Conducted a route analysis to provide recommendations on railcar fleet sizing and cycle times. Provided cost estimates for the various options.

Conceptual Planning, Belle Plaine, Saskatchewan (Project Engineer)
Coordinated with an Industrial Process team to develop a site layout for a proposed fertilizer plant. The proposed site offered several challenges with connection to two railways being possible and several utilities crossing the site. Our plan minimized the need to relocate or protect existing utilities while providing the site a functioning fertilizer plant with a supporting rail trans-loading car storage tracks.

Barr Trans-load Facility, Barr, Alberta (Project Manager)

Lead project team from conceptual planning through detailed design of Trackwork and Civil to produce construction package. This design was developed to allow for phased construction to suite the client's need and projected volume increases. Interfaced with the railway team and the client to gain plan approvals needed to advance into construction.

Trackwork Conceptual Plan, Edmonton, Alberta (Project Manager)
Investigate the technical feasibility of providing a rail spur into the property owned by the Client following railway design guidelines and to identify any additional property needed to facilitate the track's construction.

Crude Loading Facility Rail Yard Expansion Phase 1 Detailed Design, Alberta Diluent Terminal, Edmonton, Alberta (Discipline Lead - Transportation)
Coordinated efforts of the transportation team to develop the detailed design for the rail yard. Developed specifications and tender documents for trackwork construction. Interfaced with other disciplines within Stantec, third party engineering firms, and the client to resolve design issues and meet project requirements. Construction completed in November 2014.

Trackwork Conceptual Design, Edmonton, Alberta (Project Manager)
Developed a conceptual plan to suit the Clients car volumes and site size. Coordinated with the railway to develop an operations plan for the site. Provided a final plan, operations report and opinion of construction cost for Client consideration.

NATH Facility, Graymont, Bruderheim, Alberta (Project Manager)
Lead project team from conceptual planning through detailed design to produce construction drawing for the client's trans-loading facility. Interfaced with the railway team and the client to gain plan approvals needed to advance into construction.

Trackwork Conceptual Plan, Edmonton, Alberta (Project Manager)
Investigate the technical feasibility of providing a rail spur into the property owned by the Client following railway design guidelines and to identify any additional property needed to facilitate the track's construction.

Trackwork Expansion, Edmonton, Alberta (Project Manager)
Lead project team to develop construction plans for the expansion of an existing industrial siding to expand storage capacity, improve facility fluidity and add an additional trans-loading area. Coordinated with the Railway for the review and approval of design and construction plans. Produced construction drawings and specifications the Client used for tendering and construction.

Steen River Trans-loading Facility, Steen River, Alberta (Project Manager)
Lead project team to develop plans for the expansion of an existing railway siding to allow for the trans-loading of oil products. Coordinated with the Railway to develop a site operations plan and meet set-back requirements.

Synthetic Fuel Trans-loading Facility Conceptual Plans, Alberta (Project Manager)
Developed conceptual plans for a synthetic fuel trans-loading operation that allowed for multiple phases of development. The multiple phases matched facility volume increase and new product streams coming on line. Layout of the facility also allowed for minimal disruption during construction of later phases on existing operations. Construction costing was also provided.

Trackwork Expansion, Vermilion, Alberta (Project Manager)
Coordinated with the Client to develop a conceptual plan that would allow the addition of a Hazardous Goods trans-loading track to an existing grain loading facility. With limited space on the site and the need to minimize cost of implementation our team came up with an innovative solution that met the Clients and the Railways needs while meeting Government regulations.

Facility Plan Development (Project Engineer)
Working with an Industrial Process Team we developed conceptual layouts and facility plans for a proposed oil trans-loading facility. The Client, in-turn, used this information and plan to locate a suitable site for their proposed operation.

Trackwork Conceptual Plan, Cheecham, Alberta (Project Manager)
Developed a conceptual plan that would expand an existing siding and allow space for trans-loading goods. Three different products were considered for this site; oil (outbound), steel (inbound), aggregate (inbound). Stantec provided a final plan, operations report and opinion of construction cost for Client consideration.

Roads and Highways

D R Estey Engineering Ltd.*, Prince George, British Columbia (Civil Technologist)
Responsible for road survey and design and site plans and bridges. He headed crew to survey proposed road alignments and bridge locations, determined erosion/design sensitive areas and designed horizontal and vertical alignment, mass haul diagrams, culvert, and cross drain locations. Developed topographical plans for site using Eagle Point.
Created site plan and general arrangement drawings form survey data and engineer's sketches/specs using AutoCAD.

Transit

South LRT Extension*, Edmonton, Alberta (Project Manager)
Oversaw installation of track structure and road crossings at University Avenue and South Campus Station.

7th Avenue Rehabilitation*, Calgary, Alberta (Project Manager)
Oversaw the program which involved the removal and replacement of 1 City block of embedded track on an annual basis for the term of the contract. Removal of the concrete slab was done in advance of a 3 day long weekend work block, in which the track structure was removed, replaced, and concrete in-fill placed.

Northwest LRT Extension*, Calgary, Alberta (Project Manager)
Oversaw the construction of ballasted track extending the LRT route from Dalhousie Station to Crowfoot Station. 3.8 Km of ballasted track; 1 diamond; 4 - #8 switches; and 2 maintenance crossings.

Oliver Bowen Maintenance Facility*, Calgary, Alberta (Project Manager)
Oversaw the construction and installation of all trackwork within the facility. 4.8 Km of ballasted track; 900 m of embedded track; 200 m direct fixation; 32 switches; and 7 crossings.

Government

North of Yellowhead Railway Crossing Review, Strathcona County, Alberta (Project Engineer)
Coordinated with the Railway on behalf of the Client to develop a memorandum of understanding for a proposed grade separation. Coordinated with the Client, the Railway and Transportation Planners to develop plans for a temporary detour crossing to be used during construction.

Edmonton Energy Technology Park (EETP) Linear Corridor Analysis, Edmonton, Alberta (Project Engineer)
Contributed to the development of corridors within the defined EETP area to facilitate the development of the area for industrial purposes. Coordinated with others to identify special needs and routing of the corridors to accommodate Transportation and Utility Service's needs. Produced a final report that provided layout options that in turn would maximize the area's potential.

Industrial County Industrial Plan, County of Lamont, Alberta (Project Engineer)
The information gathered will allow the County to plan what steps are needed next to facilitate industrial investment.

Annual Replacement Cost Report, Alberta (Project Engineer)
Oversaw the development of annual replacement cost summaries for railway infrastructure in Alberta. Information was gathered from Class 1 Railways, Industry Contractors as well as government databases. The information was them compiled to produce a current cost/value of railway infrastructure in Alberta.

PROFESSIONAL ACTIVITIES

Member, Association of Professional Engineers and Geoscientists of Alberta

Member, American Railway Engineering and Maintenance-of-Way Association

EDUCATION

University of Wisconsin, Madison, Wisconsin
Design of Railway Track Systems (2005)

University of Wisconsin, Madison Wisconsin
Engineering Fundamentals of Terminal Yard and Intermodal Facilities (2004)

University of Alberta
Bachelor of Science - Civil Engineering (2000)

College of New Caledonia, Prince George, British Columbia
Graduated with Co-op Option (1993)

University of Wisconsin, Madison Wisconsin
Railway Bridge Engineering (2006)

Tom Foster

EVP, Regional Director - Pacific, DHI Group

SUMMARY

Mr. Foster's professional experience lies predominantly with integrated impact assessments of large marine and coastal infrastructure development projects, particularly those relating to marine oil and gas, reclamation and dredging activities, spanning subjects as diverse as morphology, water quality, habitat and navigation impacts.

In 2004, Mr. Foster acted as project director for the joint International Tribunal on the Law of the Sea (ITLOS) study carried out for the Malaysian and Singapore governments on impacts arising from the Pulau Tekong and Tuas View land reclamation, one of the most comprehensive marine impact assessments on reclamation works ever carried out.

The work executed by DHI under Mr. Foster's management for the environmental monitoring and management of the Bali Turtle Island reclamation project in 1997 is widely viewed as setting the standard for environmental management of reclamation works in Asia, being recognized by the International Association of Dredging Contractors, PIANC and UNEP as representing international best practice. These feedback management methods have been widely adopted in Singapore, Malaysia and recently in Australia for the Chevron Wheatstone project.

Mr. Foster was the Chair of PIANC Environment Commission WG108 Dredging and Port Construction around Coral Reefs and is co-Chair of PIANC WG 157 Dredging and Port Construction around Coastal vegetation

PROFESSIONAL EXPERIENCE

DHI GROUP
Group Executive Vice President/President DHI USA: Regional Manager Asia and Americas
2015 - Present

DHI GROUP
Group Executive Vice President: Regional Manager Asia
2013- 2014

DHI GROUP
Regional Manager Asia
2011 - 2013

DHI WATER AND ENVIRONMENT (S) PTE. LTD.
Managing Director DHI-Singapore
2003 - 2013

DHI GROUP
Regional Manager SE Asia
2003 -2010

DHI WATER AND ENVIRONMENT (M) SDN. BHD.
Managing Director DHI Malaysia
1999 - 2002

DANISH HYDRAULIC INSTITUTE SABAH, MALAYSIA
Senior Coastal Engineer
1989 - 1996

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2015	Singapore Second LNG Terminal	Quality Director; Responsible for overall project technical quality
2014	Marina East OCS	Quality Director; Responsible for overall project technical quality
2013	Tuas Port Phase 2, Singapore	Project Director, EIA for major port development Scope includes modelling studies to determine impacts to currents, waves, water quality, flooding, ecology, morphology, mooring and navigation conditions.
2013	Kalimantan Sand Source, Indonesia	Project Director, Detailed site screening, geotechnical surveys and EIA for offshore sand borrow area.
2013	Site Specific Engineering Studies for Climate Change Adaptation, Singapore	Project Director, Detailed studies of the effect of climate change on coastal flooding in an urban environment and assessment of mitigating options.
2013	Pulau Muara Besar Development, Brunei	Project Director, EMMP for dredging and reclamation works for petrochemical facility. Includes online turbidity monitoring, daily measurements of sediment spill from the dredger/reclamation overflow, daily hindcast modelling and daily reporting of compliance with environmental quality objectives.
2012	Ayer Chawan Phase 2, Singapore	Project Director, EMMP for dredging and reclamation works for petrochemical facility. Includes online turbidity monitoring, daily measurements of sediment spill from the dredger/reclamation overflow, daily hindcast modelling and daily reporting of compliance with environmental quality objectives
2011 - 2012	Manila Bay Coastal21, Philippines	Project Director, Flooding and flushing study to optimise the Coastal 21 reclamation design to avoid or minimise flooding or flushing impacts in the Las Pinas/Paranque areas.
2011 - 2012	Pulau Muara Besar Development, Brunei	Project Director, Layout optimisation and impact assessment for the proposed reclamation, channel dredging and port development at Pulau Muara Besar for petrochemical facility development. Scope includes modelling studies to determine impacts to currents, waves, water quality, flooding, ecology, fisheries, morphology, mooring and navigation conditions.
2009 - 2012	Sungai Buloh Wetland Reserve, Singapore	Project Director, Mangrove rehabilitation project, Services included environmental impact assessment and subsequent environmental management on site
2006 - 2012	Pasir Panjang Container Terminal Expansion EMMP, Singapore	Project Director, Pasir Panjang terminal expansion EMMP. Includes online turbidity monitoring, daily measurements of sediment spill from the dredger/reclamation overflow, daily hindcast modelling and daily reporting, with quarterly habitat surveys to verify hindcast modelpredictions and provide feedback on tolerance limits etc.
2001 - 2011	JIP4 VLCC current forecast, Singapore	Project Manager, Current forecast of approach and berthing conditions for Sinki Fairway SPM's and VLCC berths. Current forecast is updated every 10 days with daily validation against ADCP measurements

Year	Project, Country	Position and activities
2008 - 2010	Ayer Chawan Reclamation EIA, Singapore	Project Director, Extensive field surveys and numerical modelling studies to determine potential impacts of proposed reclamation at Ayer Chawan.
2008 - 2010	Brunei Port Development Masterplan Studies, Brunei	Project Director, Comprehensive field surveys and modelling studies undertaken to support preparation of a masterplan for the proposed development of a deep water port in Brunei. Scope included EIA, Navigation Study and Met-Ocean Design Conditions.
2008 - 2009	NEA Recreational Beach Water Quality Study, Singapore	Project Director, Extensive field survey and modelling project to evaluate existing beach water quality at six beaches in Singapore, and to develop a mitigation strategy for the future water quality conditions, with full compliance with both existing (2008) and old guidelines (2007 and earlier) for beach water quality in Singapore
2008 - 2009	Marangkayu Coal Terminal Layout Optimisation, Indonesia	Project Director, Met-Ocean design study to optimise layout of proposed coal terminal at Marangkayu. Scope includes modelling to determine design currents, waves and wind.
2007 - 2009	EMMP for Sentosa Integrated Resort, Singapore	Project Director, Feedback management of marine reclamation and dredging works inclusive of spill monitoring and water quality surveys
2007 - 2009	Feasibility Study for Integrated Cruise Terminal Development, Singapore	Project Manager, Feasibility study for a proposed integrated cruise terminal at Marina South. Scope included extensive field studies, an EIA and numerical modelling studies
2008	Pulau Ular Propeller Wash Study	Project Director, Modelling study to assess sediment plume impacts due to propeller wash generated by vessels berthing at a jetty on the southern side of Pulau Ular. Extensive field measurements were used to validate the modelling.
2008	Storm water discharge impact on VLCC berthing at Jurong Island, Singapore	Project Director, Modelling study to determine impacts to VLCC's berthing at Jurong Island due to a new storm water discharge adjacent to the jetty
2008	Sungei Buloh Wetland Reserve Baseline Surveys and Hydraulic Modelling Studies, Singapore	Project Manager, extensive field studies to establish baseline conditions for the mangroves at SBWR and hydraulic studies to identify cause of impacts and propose mitigation measures
2008	Laguna Hue Resort EIA, Vietnam	Project Director, Comprehensive terrestrial and marine EIA for a proposed resort development in Vietnam, addressing the requirements of the IFC's Equator Principles
2008	EMMP for Jurong Island to Ular Pipeline Bundle, Singapore, Singapore	Project Director, Comprehensive environmental monitoring and management plan for trenching, pipelay and backfilling operations for pipeline bundle between Jurong Island and Pulau Ular
2008	Dredging EIA, Singapore	Project Director, Comprehensive environmental impact assessment for a proposed dredging project. Scope included coral surveys, assessment of sediment plume & current impacts, and development of an environmental management plan
2008	Biodiversity Impact Assessment for LNG Terminal, Singapore, Singapore	Project Director, Biodiversity impact assessment for proposed LNG receival terminal. Scope included coral surveys, thermal plume and sediment modelling
2008	Met-ocean Design Study for Batam Shipyard	Project Director, Met-ocean design study for proposed shipyard in Batam. Scope included bathymetry & topography surveys, current & wave modelling and provision of met-

Year	Project, Country	Position and activities
		ocean design conditions
2007 - 2008	EIA studies for proposed Tidal Power project, Singapore	Project Director, EIA considered impacts to currents, seabed and marine fauna associated with proposed installation of tidal power generators at three locations within Singapore waters
2006 - 2008	Pulau Ular Reclamation EMMP, Singapore	Project Director, Shell Pulau Ular EMMP. Includes online turbidity monitoring, daily measurements of sediment spill from the dredger/reclamation overflow, daily hindcast modelling and daily reporting, with quarterly habitat surveys to verify hindcast model predictions and provide feedback on tolerance limits etc
2007	EIA for Sentosa Integrated Resort, Singapore	Project Director, Comprehensive Marine EIA covering dredging and reclamation activities for the construction of the Sentosa Integrated Resort
2007	Jurong Island to Ular Pipeline Bundle QRA and FSA, Singapore	Project Director, Comprehensive assessment of safety, navigation and marine risk from trenching (dredging and blasting) and backfilling to install a pipeline bundle. QRA addressed safety, marine and navigation risks during construction and operation of the pipeline, and FSA specifically addressed navigational risks during the construction phase
2005 - 2007	Bund wall construction EIA	Project Manager, EIA for construction of a large bund wall using a combination of sand and cement stabilised dredge fill. Impact assessment addressed short-term sediment plume and water quality impacts during construction and long-term hydrodynamic, morphological and water quality impacts
2006	Pulau Ular Coral Relocation, Singapore	Project Manager, Relocation of corals from Terumbu Bayan to Pulau Semakau prior to start of reclamation activities for Pulau Ular reclamation. Largest coral relocation project undertaken in SE Asia
2005 - 2006	South Pahang Integrated Shoreline Management Plan, Malaysia	Chief Technical Advisor, Development of Integrated Coastal Zone Management Plan for South Pahang, Malaysia, covering physical, chemical, biological and economic issues
2005 - 2006	Dredging Environmental Impact Assessments, Singapore	Project Manager, Series of EIAs to quantify potential impacts of dredging activities in Southern Singapore on sensitive ecological receptors, with specific focus on sediment plume impacts on seagrasses, mangroves, corals and process water intakes. Included detailed baseline surveys of seagrass and mangroves
2004 - 2006	Environmental Monitoring and Management Plan, Singapore	Project Manager, Feedback management of marine dredging works including spill monitoring, habitat monitoring and spill hindcast
2005	Environmental Impact Assessment for Disposal of Dredged Material, Singapore	Project Manager, EIA to assess potential impacts from disposal of contaminated dredged material, including impacts on currents, morphology, water quality and corals.
2005	EMMP for Keppel Island dredging and reclamation activities, Singapore	Project Director, EMMP for dredging and reclamation activities at Keppel Island
2004 - 2005	Pasir Panjang Container Terminal Expansion Environmental Impact Assessment, Singapore	Project Director, Detailed EIA covering impacts caused by marine constructions works, including impacts on current, morphology, water quality, corals and seagrass.
2004	Bintulu Port Development Borrow	Project Director, Feedback monitoring of marine dredging

Year	Project, Country	Position and activities
	Dredging Environmental Monitoring and Management Plan, Malaysia	works offshore from Bintulu. Scope included spill monitoring and habitat monitoring.
2004	Detailed Impact Assessment of Tuas View Extension and Pulau Tekong Land Reclamations, Malaysia and Singapore	Project Director, Detailed independent multi-disciplinary impact assessment as part of ITLOS proceedings between Malaysia and Singapore relating to cross-border environmental impacts from reclamation works
2003	Tuas View Extension Impact Assessment, Singapore	Project Manager, Impact Assessment of Tuas View Extension on adjacent waters.
2003	East Coast of Sabah Shoreline Management Plan, Malaysia	Project Director, Integrated Shoreline Management Plan for coastal defence and sustainable development of the East Sabah Coastline. Services include full range of physical and ecological assessments plus assessments of tourism, housing and industrial development potential.
2002	Tuas View Extension Sediment Plume Hindcast, Singapore	Project Manager, Sediment plume impact study for Jurong Island Phase 4 and Tuas View Extension Projects, including detailed field validation of spill from reclamation activities.
2002	Shell SMDS, Malaysia	Project Manager, Site selection and impact assessment study for a coastal petrochemical plant. Services included field surveys, ecological and physical suitability assessments.
2002	Kuala Terengganu River Mouth Improvement, Malaysia	Project Manager, Detailed hydraulic model studies, including physical model testing of breakwaters and numerical model studies of current, salinity, morphology and navigation impacts.
2001	Sapangar Bay Container Terminal, Malaysia	Project Manager, Environment monitoring and management plan for the construction and completion of proposed Sapangar Bay Container Port Facilities
2000	North Pahang, Malaysia	Chief Technical Advisor, Integrated Shoreline Management Plan for coastal defence and sustainable development of the North Pahang Coastline.
2000	Malaysia	Project Manager, Comprehensive third party review of marine engineering, navigation and environmental design aspects of major port expansion project.
1998 - 1999	Likas Bay, Malaysia	Comprehensive Marine EIA covering dredging and reclamation activities for the construction of the Rainbow Bay development in Kota Kinabalu. Services included full range of physical and ecological impact assessment
1998	Kertih Port EMMP, Malaysia	Project Manager, Environmental management plan for marine dredging operation
1997 - 1998	West Coast of Sabah Shoreline Management Plan, Malaysia	Project Manager, Integrated Shoreline Management Plan for coastal defence and sustainable development of the West Sabah Coastline. Services include full range of physical and ecological assessments plus assessments of tourism, housing and industrial development potential.
1997	Bali Turtle Island, Indonesia	Project manager, Feedback Monitoring of tropical marine habitats impacted by dredging activities.
1995	Beachy Head to South Foreland, United Kingdom	Technical Advisor, Coastal erosion and coastal protection. Integrated Shoreline Management Plan for littoral cell 4C, South Coast of United Kingdom.

PROFESSIONAL ACTIVITIES

Young Elite Researcher Award; Danish Ministry of Independent Research 2011, Denmark

Best Scientific Communication Award, Symposium "Integrating Environmental Sciences in Decision Making", 2008, Denmark

World Aquaculture Society 2006-Present

World Association of Copepodologists 2005-2009

Aquacaen Association (2003-Present)

D (Lausanne, Switzerland) and Fudan University (Shanghai China).

LANGUAGES

Languages	Speaking	Reading	Writing
English	excellent	excellent	excellent

SELECTED PUBLICATIONS

Papers published in international conference proceedings

Foster, TM; Oliver, M; Embi, A; Jaafar, E and Zyserman, J. Integrated Shoreline Management at Kertih Port. Proc. 27th ICCE 2000 International Conference on Coastal Engineering, Singapore, July 2000.

Foster, TM; Chia, M; Wong, D and Chong, A. West Coast of Sabah Shoreline Management Plan. Proc. International Symposium and Exposition on Coastal Environment and Management: Challenges in the new Millenium, Kuala Lumpur, October 1999.

Foster, TM. West Coast of Sabah Shoreline Management Plan. Proc. Oceanology International 1999 Pacific Rim Conf. Singapore, April 1999.

Foster, TM and Driscoll, AM. Environmental Monitoring and Management of Marine Dredging Operations in a Tropical Environment. Proc International Workshop on Dredging and Reclamation, Kuantan September 1997.

Driscoll, AM; Foster, TM; Pedersen, C and Tateishi, Y. Integrated Design Optimization for a Tropical Land Reclamation: Bali Turtle Island. Proc International Conference on Land Reclamation and Rehabilitation, Penang August 1997.

Foster, TM; Jacobsen, V; Brøker, I and Johnson, H. A Deterministic Approach to Burial Depth Requirements for Pipeline Shore Approach Design on an Eroding Coast. Proc. 10th Offshore South East Asia, Conf. Singapore, December 1994.

Sørensen, T and Foster, TM. Beaches and Coast Protection, Annual Conference of Municipal Engineers, Brighton, England, July 1991.

Foster, TM and Mangor, KM. Controlling Parameters on Littoral Transport and Coastaline Development. Proc Coastal Zone 91, Longbeach, California, July 1991.
Doorn-Groen S.M., Foster T.M. (2007). Environmental Monitoring and Management of Reclamation Works Close to Sensitive Habitats. Presented at WODCON XVIII World Dredging Conference, Orlando USA. Received Best IADC Paper Award for authors below 35 years old.

Other publications:

PIANC (2010) Guidelines for Dredging and Port Construction around Coral Reefs. Report 108-2010 of PIANC WG15 Chiard by T.M. Foster

EDUCATION

University of London, 1988
MSc with Distinction, River, Estuary and Coastal Engineering, Imperial College of Science and Technology

University of London, 1988
DIC with Distinction, River Morphology, Imperial College of Science and Technology

University of London, 1987
BEng, 1st Class Hons Civil Engineering, Imperial College of Science and Technology

Dale Kerper, P.E.

Principal Coastal Engineer, DHI

SUMMARY

Dale Kerper has more than 28 years of experience performing engineering studies in the marine, coastal, estuarine and riverine environments. Specific areas of expertise are in regards to physical and numerical modeling of hydrodynamics (water levels, currents and waves), coastal flooding, salinity, temperature, sediment transport, moored vessel response, and dam break flooding. Mr. Kerper has extensive experience applying DHI's MIKE3, MIKE 21, MIKE 11 and MIKE FLOOD numerical models within these application areas.

PROFESSIONAL EXPERIENCE

DHI WATER & ENVIRONMENT, INC., USA.
Principal Coastal Engineer

1996-2007

Responsible for performing and managing modeling studies for marine, coastal, estuarine and riverine engineering projects.

DANISH HYDRAULIC INSTITUTE
Hydraulic Engineer

1993 -1998

Responsible for performing and managing modeling studies for marine, coastal, estuarine and riverine engineering projects.

ARCTEC OFFSHORE CORPORATION.
Project Engineer

1988 - 1993

Performed physical and numerical modeling of coastal and offshore engineering projects. Also responsible for the design, manufacture and installation of hydrodynamic laboratory equipment, including wave generators, measurement instrumentation, ship testing dynamometers, control and data acquisition systems.

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2015-2016	Baseline and Modification Modeling (BAMM), US Army Corps of Engineers (USACE), Jacksonville, FL.	Expert Advisor. Providing training, expert advice, code development and on-the-fly review for complex and expansive 2D flood model being developed by the USACE using DHI's MIKE FLOOD modeling system.
2015-2016	Engineering Consultancy Services for Singapore 2nd Liquefied Natural Gas (LNG) Terminal. Singapore.	Task manager for Mooring Studies. Performed passing vessel wave (drawdown and Kelvin) modeling analysis, and moored vessel response (motions and forces) under forcing of the passing vessel waves and metocean conditions (currents, waves and wind).
2015	Large Vessel Response to landslide generated tsunami wave. British Columbia, Canada	Project Manager / Lead modeler. Setup and developed complex model to predict the non-linear response (motions and forces) of a moored vessel under landslide generated tsunami forcing.

Year	Project, Country	Position and activities
2015-2016	200-year coastal flood inundation study. British Columbia, Canada	Project Manager. Planned and managed a flood study for determination of the 200-year coastal flood using Canada guidelines for performing coastal flood.
2015	LNG Oil Spill Modeling Study, British Columbia, Canada.	Project Manager. Lead a modeling study to predict the fate of fuel oil spill from LNG carriers at a site in British Columbia. The study included modeling of currents and waves, and predicting where the oil would travel, and applying a probabilistic analysis from ensemble of multiple run scenarios.
2014 - present	LNGC Passing Vessel Study, Vessel Response Study. British Columbia, Canada	Lead Modeler / Project Manager. 2D hydrodynamic and wave modelling of waves generated from vessels in the Douglas Channel, passing the project site. The passing vessel waves were then applied to local modeling of berthed vessel response (motions and mooring loads).
2015	Oswego River Basin, New York Canal Corporation, New York, USA	Expert Advisor. Provided advice and review for complex 2D flood forecast modeling for reaches Oswego River Basin including the Erie Canal.
2014 - present	FEMA study of Coastal Flood Hazards for San Diego Bay, CA, USA	Project Manager. Performing baywide modeling of storm surge and wave heights for the entire San Diego Bay shoreline for FEMA Coastal Hazards Analysis and mapping study.
2014 – present	Sea Level Rise Study , Alameda County, CA, USA	Project Manager. Perform hydrodynamic and wave modeling of the entire San Francisco Bay under various Sea Level Rise (SLR) scenarios to quantify baywide response to SLR, and to assess possible mitigation strategies, both regionally and locally.
2014 – present	Coastal Hazard Analysis, Santa Clara County, CA, USA	Project Manager. Coastal flooding analyses and mapping of 100-year storm surge water levels and waves along the Santa Clara County Shoreline of San Francisco Bay. The study includes mitigation of risk by considering breaching of levees and adding tide gates.
2014 - present	Landslide Generated Tsunami study at LNG site. British Columbia, Canada	Project Manager. Lead reviewer. Managed and reviewed technical study of landslide generated tsunami wave risk at the Kitimat LNG site in the Douglas Channel.
2014	Coastal Hazard Analysis, Alameda County, CA, USA	Project Manager. Coastal flooding analyses and mapping of 100-year storm surge water levels and waves within a system of levees, marshes, ponds along the Alameda County Shoreline of San Francisco Bay.
2013 - present	FEMA Southern CA Counties, Coastal Hazards TAP, USA	Technical Advisor. Member of a Technical Advisory Panel (TAP) to review and advise on study methodologies for coastal hazard analysis of Southern CA County FEMA restudies
2012	Table Bay Erosion Study, Capetown, South Africa, South Africa	Lead Wave Modeler. Calibrated and operated a detailed spectral wave model of Table Bay in Capetown. The model was simulated for a 10-year wave hindcast for use in sediment transport modeling.
2012	Bayport Channel Deepening	Project Manager, Modeler. Developed 3D current, water level and salinity model of Galveston Bay to assess impacts due to deepening of

	Study, Galveston Bay, TX, USA	Bayport channel for post-Panamex vessel arrival, and for construction of beneficial reuse landfills of dredge material from channel sediment placement.
Year	**Project, Country**	**Position and activities**
2011 – 2013	FEMA Northern CA Counties, Coastal Hazards TAP, USA	Technical Advisor. Member of a Technical Advisory Panel (TAP) to review and advise on study methodologies for coastal hazard analysis of Northern CA County FEMA restudies
2011	Imetame Port Development, Wave Agitation Study Brazil, Brazil	Lead Modeler. Performed Boussinesq wave model agitation tests to optimize outer harbor breakwater design to reduce wave heights in the harbor.
2011	Richmond Long Wharf Wave Hindcast, San Francisco Bay, Richmond, CA, USA	Project Manager. Performed 10-year wave hindcast (seas and swell) for determination of wave conditions at Chevron's Richmond Long Wharf for environmental permitting.
2010	Salmon River Estuary, Highway 101 Hydraulic Analysis Oregon, USA	Modeling Coordinator. Supervised a 2D hydrodynamic modeling effort of the Salmon River Estuary to assess impacts due to bridge and highway berm re-design, and to compute flow velocities around bridge piers to aid in structural design.
2008	Mina Zayed Waterfront Development, Flushing Study Abu Dhabi, UAE, United Arab Emirates	Lead Modeler. Lead modeler performing numerical modeling to determine retention time of substance released in harbor basins. Multiple scenarios tested to optimize flushing efficiency.
2008	2D water surface prediction model of Chesapeake Bay NASA, Greenbelt, MD, USA	Project Manager. Developed, calibrated and operated a high resolution 2D hydrodynamic flow model of the entire Chesapeake Bay for the simulation of normal and storm surge conditions to support instrumentation research for NASA's Goddard Space Flight Center.
2008	State of Texas Coastal Storm Surge Study Review, TX, USA	Technical Reviewer. Participating member of an independent peer review team (IPRT) which was formed to review hurricane storm surge flood elevation mapping study for the entire coastline of Texas. The mapping study is for FEMA, and is being performed by the US Army Corps of Engineers.
2006 - 2007	State of Louisiana Coastal Storm Surge Study Review, USA	Project Manager and Study Advisor. Member of an independent peer review team (IPRT) to review hurricane storm surge flood elevation mapping for the coastline of Louisiana.
2005	Brisbane Airport Expansion, Brisbane Queensland, Australia, Australia	Expert Advisor. Expert adviser to modeling team for the setup and implementation of 2D storm surge modeling supporting the design of new runways inside Brisbane Harbor.
2004 – 2011	San Francisco Bay FEMA Flood Insurance Study San Francisco, CA, USA	Project Manager, Modeling Coordinator. Coordinator of numerical extreme storm surge and extreme wave modeling tasks for San Francisco Bay Coastal Hazards Analysis and Mapping Flood Insurance Study for FEMA. Included review of tsunami risk in the Bay, including 2D modeling of landslide generated tsunamis to assess potential risk for internally generated tsunamis.
2004	Wave Refraction Study Tema, Ghana, Africa	Project Manager. Performed numerical model study and provided wave refraction analysis for nearshore marine pipeline study.

2004	Long Period Wave Modeling for Port of Long Beach Long Beach, CA	Project Manager. Setup, calibration and validation of a 2D Boussinesq wave model for prediction of long wave response in the Port of Long Beach.
Year	**Project, Country**	**Position and activities**
2004	FEMA Coastal Guidelines and Specifications,	TWG Member. Member of a Technical Working Group (TWG) to develop new FEMA Guidelines and Specifications for the US Pacific west coast.
2003 - 2008	Del Norte County, FIS Del Norte County, CA, USA	Project Manager. Performed combined riverine and coastal storm surge flood hazard numerical modeling, analysis and hazard mapping for FEMA FIS.
2003	Burdekin Shire Cyclone Storm Surge Study, North Queensland, Australia, Australia	Project Engineer. Developed and operated 2D storm surge and wave models for cyclone flood inundation mapping and for use in development of an online forecast warning system.
2003	Shell Pipeline Study, Qatar, Qatar	Project Engineer. Performed numerical modeling and hindcasting of waves, currents and water levels, providing Met-Ocean environmental data for offshore and nearshore pipeline and facilities design.
2003	Wave Refraction Study for Bioko Island, Equatorial Guinea, Africa, USA	Project Manager. Performed numerical model study and provided wave refraction analysis for nearshore marine pipeline study.
2002	Napa Salt Ponds Wetland Restoration San Francisco Bay, CA, USA	Project Engineer and Principal Modeler. Developed a combined 1D and 2D hydrodynamic and advection-dispersion salinity model of San Francisco Bay, including the complex system of sloughs, creeks and ponds feeding into the lower Napa River and Sonoma Creek.
2002	South San Diego Bay Salt Ponds, Wetland Restoration, San Diego, CA, USA	Project Engineer and Principal Modeler. Developed and operated a combined 1D and 2D hydrodynamic and advection-dispersion salinity model of south San Diego Bay to study the feasibility of returning the salt ponds to the bay system.
2001	Fisherman's Wharf Circulation Study, USA	Project Engineer. Set-up and calibrated a 2D hydrodynamic model of Fisherman's Wharf for a water quality circulation study.
2001	Hamilton Army Airfield Wetland Restoration, USA	Project Engineer and Lead Modeler. Performed cohesive sediment transport modeling of morphological wetland evolution for the reclamation of Hamilton Airfield to the San Francisco Bay. 10-years of morphological evolution was modeled and analyzed.
2000	San Francisco Airport Runway Expansion, USA	Advisor, Lead Wave Modeler. Performed wind wave hindcast study covering the entire San Francisco Bay. Waves were used for morphological modeling. Also provided modeling support for hydrodynamic and morphological modeling.
2000	Kennedy Space Center, Cape Canaveral, FL, USA	Project Manager and Lead Modeler. Coordination and execution of 2D numerical modeling tasks (hydrodynamic flow, wind and waves) used for hurricane storm surge flood impact analysis, and GIS database development in connection with the Hurricane Damage Assessment Study.
1999	Venice Flood Forecasting System, Venice, Italy, Italy	Project Engineer. Designed and Developed an automated flood forecast system for protective flood gate operations at the three inlets of Venice Lagoon. The forecast system was comprised of three nested hydrodynamic models coupled to online weather forecasts of

		wind and atmospheric pressure and assimilated to real-time water level measurements around the Adriatic and Mediterranean Seas.
Year	**Project, Country**	**Position and activities**
1999	Arabian Gulf Hindcast Study, Saudi Arabia, Saudi Arabia	Project Manager. Responsible for the determination of design wind, current, level and wave conditions for the Saudi Aramco Operational Areas of the Arabian Gulf. A database was developed providing a convenient tool for presentation of design results.
1997	North European Storm Surge Hindcast Study, NESS,	Project Engineer. Responsible for automization of Hydrodynamic modeling system to hindcast 30 years of current and water levels for the North Sea and Northern Atlantic Ocean.
1997	Obidos Lagoon Study, Obidos, Portugal, Portugal	Project Engineer. Responsible for the setting up and calibration of a hydrodynamic model of the Obidos Lagoon for the purpose of investigating various design scenarios related to improving the environmental quality of the lagoon.
1995 - 1997	Red Sea Hindcast Study, Saudi Arabia, Saudi Arabia	Project Engineer. Responsible for the determination of design wind, current, water level and wave conditions for the entire Red Sea, including detailed analysis of 5 local concession areas in Saudi Arabia, including the development of a database for presentation of design results.
1994	Current and Water Quality Study, Bideford Bay, England, United Kingdom	Project Engineer. Responsible for performing numerical hydrodynamic and advection-dispersion modeling in Bideford Bay, Bristol Channel, England.
1993	Wave, Current and Morphological Study, Yunlin Development Project, Taiwan, Taiwan	Project Engineer. Performed river jet-plume discharge sedimentation studies, wave and current studies, sediment budget and morphological studies as part of a Masterplan Report for the Yunlin Development Project, Taiwan.
1993	Movable Bed Physical Model Study, Batiquitos Lagoon, Carlsbad, CA, USA	Project Engineer. Responsible for the design, construction, operation, and analysis of a movable bed physical model test to investigate the closure mechanism of a lagoon inlet due to the movement of shingle material, and to test various jetty configurations to determine an optimal configuration which would keep the inlet open to the sea.
1992	Harbor Tranquility and Wave Study, Masila, Yemen, Republic of Yemen	Project Engineer. Performed numerical modeling study for the prediction of wave conditions inside a proposed service harbor. Various breakwater configurations and wave conditions were simulated. An extreme value statistical analysis was performed.
1992	Laboratory Wave Generation Equipment, Texas A&M University Galveston, Galveston, TX, USA	Project Manager. Designed, built, tested, installed and gave training on the use of a hinged flap wave generation system for Texas A&M University at Galveston's Offshore Engineering Laboratory.
1992	Laboratory Wave Generating Equipment, University of Delaware, Lewes, Delaware, USA	Project Manager. Designed, built, tested, installed and gave training on the use of a plunger type wave generation system for the Air-Sea Interaction Laboratory at the College of Marine studies at the University of Delaware.
1991	Space Capsule Recovery Tests,	Project Engineer. Performed physical model tests of at-sea rocket capsule recovery operations as part of the "ALS" (Advanced Launch

	Boeing. USA	System) program sponsored by NASA and DOD.

Year	Project, Country	Position and activities
1991	Physical Model Tests of Towed Tunnel Sections, Boston Harbor, Boston, MA, USA	Project Engineer. Responsible for performing physical model sea-keeping and towing tests of floating tunnel sections to determine the feasibility of towing the tunnel sections without the use of barges from the construction site to Boston Harbor.
1990	Shallow Water Semi-submersible Model Study, USA	Project Engineer. Performed physical modeling of a semi-submersible drilling ship to determine the feasibility of operating in shallow water, and to verify results of a numerical model.
1990	Laboratory Wave Generation and Ship Testing Equipment, University of New Orleans, New Orleans, LA, USA	Project Manager. Designed, built, tested, installed and gave training on the use of a hinged flap wave generation system, a high-precision planar motion mechanism for ship maneuvering testing, ship towing dynamometers, a propeller dynamometer and data acquisition and control systems for the School of Naval Architecture, University of New Orleans.
1989	Santa Ana Rivermouth Jetties, USA, USA	Project Engineer. Designed and constructed a physical coastal model for the prediction of wave conditions at a highway bridge located inside the inlet, due to the construction of jetties at the Santa Ana Rivermouth.
1989	Movable Bed Physical Model Tests, Luddington, MI, USA	Project Engineer. Performed a movable bed physical model study to determine the longshore transport rates and beach profiles of various size materials, and to determine the feasibility of using coarse gravel fills to reduce erosion along a shoreline of Lake Michigan.
1989	Deep-draft Semi-submersible Model Study, USA	Project Engineer. Performed physical model seakeeping tests of a deep draft semi-submersible oil production unit to study the effects of using dampers on the mooring lines and risers to reduce heave motions for flexible riser coupling considerations.
1989	Laboratory Wave Generation Equipment, KORDI, Ansan, South Korea, Korea, Democratic Peoples Republic of	Project Manager. Designed built, tested, installed and gave training on the use of a piston flap wave generation system for the Korea Ocean Research and Development Institute

PROFESSIONAL ACTIVITIES

American Society of Mechanical Engineers (ASME)

SELECTED PUBLICATIONS

Kerper, Dale, Christian M. Appendini, Henrik Kofoed-Hansen, Ida Brøker. Wave Setup in Inlets: Some Practical Considerations. ASME OMAE, Robert Dean Symposium on Coastal and Ocean Engineering. 2007. San Diego.

Zyserman, JA: Kerper, DR and Shen, T: A Discussion on the Influence of Wave Setup on Water Levels in San Francisco Bay. Proceedings of the 2011 Solutions to Coastal Disasters Conference, Anchorage, AK. June 2011. Al-Mashouk, Motaz A.; Dale Kerper and Vagner Jacobsen. Red Sea Hindcast Study: Development of a Sea State Design Database for the Red Sea. The Saudi

Aramco Journal of Technology, Winter 97/98.

Heinzer, Thomas; Michael Sebhat; Bruce Feinberg and Dale Kerper: The Use of GIS to Manage LIDAR Elevation Data and Facilitate Integration with the MIKE21 2-D Hydraulic Model in a Flood. ESRI Users Conference, San Diego, June 2000.

Kerper, Dale; Lars Christian Larsen; Maurizio Di Donato and Giovanni Cecconi. Coastal Modeling Systems in Storm Surge Prediction and Flood Management. Solutions for Coastal Disasters, Conference Proceedings, ASCE, Feb 2002.

Kerper, Dale; Eric Damgaard Christensen, Ida Broker and Julio Zyserman. Application of Coastal Modeling Systems as Support of Integrated Coastal Zone Management. Solutions for Coastal Disasters, Conference Proceedings, ASCE, Feb 2002.

Savioli, Juan, Claus Pedersen, Stefan Szylkarski and Dale Kerper. Modeling the threat of Tropical Cyclone Storm Tide to the Burdekin Shire, Queensland, Australia. Australasian Coasts and Ports Conference, 2003.

French, Bruce and Dale Kerper. Salinity Control as a Mitigation Strategy for Habitat Improvement of Impacted Estuaries. 7'th Annual EPA Workshop on Wetlands and Watersheds, Atlantic City, NJ, October 2004.

Kofoed-Hansen, H., Kerper, D.R, Sørensen, O.R., Kirkegaard, J. Simulation of Long Wave Agitation in Ports and Harbours using a Time-Domain Boussinesq Model. Proceedings of the Fifth International Symposium on Ocean Wave Measurement and Analysis. WAVES 2005. July 3rd to 7th, 2005, Madrid, Spain

Kerper, Dale, Leslie Sakumoto, Julio Zyserman and Seungjin Baek. Application of FEMA Guidelines for Coastal Flood Hazards Mapping to a Site in Northern California. Proceedings, ICCE, 2006, San Diego, CA.

Goosby, Stanley. Andrea Chatman, Jene Michaud, Dale Kerper. Dam Break Inundation Study for the State of Hawaii. Solutions to Coastal Disasters, Conference Proceedings, ASCE, April 2008.

Conner, K: Kerper, D, May, K, Schaefer, K, Coastal Flood Hazards in San Francisco Bay—A Detailed Look at Variable Local Flood Responses. Proceedings of the 2011 Solutions to Coastal Disasters Conference, Anchorage, AK. June 2011.

EDUCATION

Oregon State University
Master of Science in Civil Engineering

Oregon State University
Bachelor of Science in Civil Engineering

Guillaume Drillet

Business Development Coordinator, Agriculture, DHI Group

SUMMARY

Guillaume Drillet has 20 years of experience and has a strong background and interest in aquatic ecology and ecosystem functioning, fisheries and aquaculture production (coastal resources management and farming), ballast Water (regulation and plankton biology), project management and project proposal development. His qualifications also include exceptional communication (oral and writing skills), and teaching (many experiences in teaching and mentoring) Mr. Drillet's native language is French, and he is fluent in many languages such as English, Danish, Slovak and Spanish.

PROFESSIONAL EXPERIENCE

DHIGROUP (SINGAPORE)
Business Development Coordinator

2013 - Present

Aquaculture (APAC region), Coordination of Aquaculture activities. Proposal preparation, strategy development, communication.

DHIGROUP (SINGAPORE)
Plankton and Aquaculture Research Group Leader

2011 - 2013

Development of a group of 5 scientists working on plankton research from bacteria to fish larvae. Development of proposal and project management for research and commercial activities related to aquaculture and plankton ecology. Scientific support to Ballast water testing activities.

DHIGROUP (SINGAPORE)
Senior Scientist

2010 - 2011

Development of capacities at the Ballast Water Centre (Plankton culturing) - Development of capacities at the DHI Environmental Laboratories (Plankton analysis) Training of staffs

AKVAGROUP A/S (DENMARK)
Consultant

2010

Process Development, Participation in the development of the IControl Decision Support System.

ROSKILDE UNIVERSITY (DENMARK)
PhD Student / Administrative Assistant

2006 -2010

Research and ecology and physiology of plankton and its application in aquaculture Research stay at the Marine Laboratory of Scotland (Aberdeen) to study the effect of damersal fishing gear on the resuspension of plankton benthic resting stages Administration involvement in the PhD student Board (representation of 40 PhD student at the Department board) Fund raising and research grant proposal preparation (EU-FP7, Danish Ministry of Independent Research and Strategic Research Council of Denmark) Teaching activities (840 hours).

FISH LAB A/S (DENMARK)
Research Proposal Administrator

2009

Research proposal development under FP7 (European Research Council).

TECHNICAL UNIVERSITY OF DENMARK
Research Assistant

2006

Review of the state of knowledge on Pseudocalanus acuspes in the Baltic Sea - Experimental work on Acartia tonsa.

SLOVAK ACADEMY OF SCIENCES
Research Assistant (voluntary)

2005 -2006

Review of aquarium trade activities related to live feed for fish larvae Ecological importance of resting stages in fresh water habitats in Central Europe

FLORIDA STATE UNIVERSITY MARINE LABORATORY (USA)
Research Assistant

2005

Development of phytoplankton and zooplankton production for fish feeding of fish larvae (Floridian Pompano) - Florida Sea Grant

ROSKIILDE UNIVERSITY (DENMARK)
Research Assistant

2003 -2005

Experimental and field work under the European project POCEFF, Preservation of copepod eggs for fish farming (EU-Craft)

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2012 - 2016	RD DHI-NTU Centre General BD - Phase 2, Singapore	Head of Plankton and Aquaculture research / New business, Business Development in Ecology and aquaculture. Preparation of the DHI-APAC Aquaculture strategy. Preparation of research proposals. Development of new consulting projects in Singapore and Malaysia. Activities supporting Ballast Water testing worldwide
2014 - 2015	Proposed Recreational Lagoon at Palawan Beach, Singapore	Senior Scientist, Support to the development of recreational developments
2014 - 2015	Adaptation of an IMO BWTF to Accommodate Certification Testing under USCG ETV Rules, Singapore	Senior Scientist, Technical support for the development of methodology to align ballast water testing to the US coast Guard requirements
2014 - 2015	Forest City Reclamation EIA,	Senior Scientist, Technical report on water quality

Year	Project, Country	Position and activities
	Singapore	
2012 - 2015	Environmental monitoring and management plan, Singapore	Senior Scientist, Review and report on plankton resting stages and invasive species
2014	PGH Fish Trial, Malaysia	Project Manager, Support in Research proposal preparation
2014	Ballast Water Conference SG-ETC, Singapore	Organization of the Ballast Water Conference (ICBWM 2014)
2014	NOREL Thailand Shrimp tests, Singapore	Project Manager, Testing of feed additives for aquaculture product developers
2014	KadalNeer Technologies BW, Singapore	Senior Scientist, Technical support for the development of a Ballast Water management system testing scheme
2013 - 2014	Made In Plankton research project, Singapore	Project Manager, Survey of the biodiversity of zooplankton in Singapore waters Ecology of plankton communities over the course of one year (Primary production, grazing, resting stages)
2013 - 2014	Environmental monitoring and management plan, Singapore	Senior Scientist, Quality control and scientific support
2013 - 2014	Copepod culturing development, Singapore	Project Manager, Production of culturing protocols and culture starters for supporting Eco toxicological testing's at the Tropical Marine and Science Institute
2011 - 2014	Den-Select: Density and selection effects on copepod culturing techniques, Denmark	Project Manager, Elite Forsk Project Experimental approach and field approach to plankton ecology and culturing of copepods to fill gap of knowledge in the production of copepods as live feed for fish larvae
2010 - 2014	Environmental monitoring and management plan in Pulau Tekong, Singapore	Senior Scientist, Scientific support for the sampling and implementation plan; Plankton ecology
2013	Ballast Water Land Based Testing, Singapore	Senior Scientist, Project scientific support related to size classes defined by the International Maritime Organization guidelines for testing Ballast Water treatment systems (G8-G9)
2013	ConeBay Aquaculture Environmental Impact Assessment, Australia	Project Manager, Management of the Singapore project team (plankton analysis and scientific reporting) and administrative support
2013	Plankton Ecology and Ballast water issues (PEPER), Singapore	Senior Scientist, Training support for FYP students at the Ballast Water Technology and Innovation Centre
2013	Ballast Water Land Based Testing, Singapore	Senior Scientist, Support on the application of International Maritime Organization Guidelines

Year	Project, Country	Position and activities
2013	Ballast Water laboratory scale pre-testing, Hong Kong	Senior Scientist, Support to develop experimental design for plankton laboratory works
2013	Water quality survey, Singapore	Project Manager, Analysis of water quality in the Johor Strait over the course of different climatic and anthropologic events affecting fish farming activities
2013	Water quality analysis, Singapore	Project Manager, Collaboration on testing feed additives and water treatment for aquaculture production; water quality analysis
2012 - 2013	Ballast Water Land Based Testing, Singapore	Senior Scientist, Project scientific support related to the effects of temperature on plankton ecology and physiology in the process of testing ballast water treatment systems following the International Maritime Organization (IMO) G8-G9 guidelines
2011 - 2013	Research stay at National Taiwan Ocean University, Taiwan R.O.C.	Project Manager, Pond production of live feeds and aquaculture pond ecology- Sexual behaviour of plankton under high adult density (copepods)
2011 - 2013	Development of copepod cultivation systems, Singapore	Project Manager, Development of live feed culturing systems, plankton biology and physiology research
2012	Research stay at Villefranche Oceanographic Laboratory (Paris 6 University), France	Project Manager, Measurements of the physiological rates of zooplankton (respiration) under different density conditions - Mathematical modeling of plankton production systems
2012	Support in research proposal preparation, Malaysia	Project Manager, Support in the development of research proposal to the Ministry of Technology and Innovation
2012	RD 7591 Roskilde University Research Study of fish feeding behaviour, Denmark, Denmark	Project manager, Project management
2011 - 2012	AMEWS: Monitoring and early warning systems, Singapore	Senior Scientist, Support with expertise in plankton ecology
2010 - 2012	Ballast Water Technology Innovation Centre, Singapore	Senior scientist, Capacity building at the DHI Ballast Water Technology and Innovation Centre. Production of plankton cultures (zoo and phytoplankton), plankton sampling procedures, laboratory analysis of plankton using vital stains
2010 - 2012	RD 7050 DHI-NTU Centre General BD, Singapore	Business Development Coordinator, Plankton and Aquaculture, Preparation of the DHI-APAC Aquaculture strategy. Preparation of research proposals. Development of new consulting projects in Singapore and Malaysia.
2011	RD 7800 DHI-NTU Training & Education Hub, Singapore	Senior Scientist, responsible for Business development initiatives
2011	International Ballast Water Conference, Singapore	Senior Scientist, Review of international guidelines and preparation of scientific communications

Year	Project, Country	Position and activities
2010	Research proposal development, Denmark	Administrative Assistant, Research proposal development to the European FP7 framework, Danish Council for Strategic Research and Ministry of Independent Research
2010	Research proposal development, Denmark	Consultant in Process Development, Research proposal development to the European FP7 framework, Danish Council for Strategic Research and Ministry of Independent Research
2009 - 2010	Research Proposal development	Administrative Assistant, Research proposal development to the European FP7 framework
2008 - 2009	Effects of probiotic preparation on plankton, Denmark	Project Manager, Testing of Sorbial-Danisco microbial preparations on copepod (Crustacean) physiological performances
2006	Experimental work for the support of modeling, Denmark	Research Assistant, Review of the ecology and physiology of some plankton organisms from the Baltic Sea - Research cruise (Barents Sea)
2003 - 2005	Preservation Of Copepod Eggs for Fish Farming, Denmark	Research Assistant, Experimental work on plankton biology and physiology - Mesocosm studies in outdoor culturing facility - Plankton cultures - reporting
2001 - 2002	Aquaculture trainee, France	Student, Oyster and trout farming trainee
2000	Influence of the Rhone River fresh water plume on the planktonic community of the Gulf of Lions (RHOFI), France	Student, Research cruise - Analysis of the influence of the freshwater plume in the Mediterranean plankton communities (pigment analysis)

PROFESSIONAL ACTIVITIES

Young Elite Researcher Award; Danish Ministry of Independent Research 2011, Denmark

Best Scientific Communication Award, Symposium "Integrating Environmental Sciences in Decision Making", 2008, Denmark

World Aquaculture Society 2006-Present

World Association of Copepodologists 2005-2009

Aquacaen Association (2003-Present)

D (Lausanne, Switzerland) and Fudan University (Shanghai China).

LANGUAGES

Languages	Speaking	Reading	Writing

French	native	native	native
English	excellent	excellent	excellent
Danish	fair	poor	poor
Slovak	poor		
Spanish	poor	fair	poor

SELECTED PUBLICATIONS

Papers published in peer-reviewed international journals

Gedefaw T, Nielsen M, Nielsen R, Drillet G, Jepsen PM, Hansen BW. Economic Feasibility of Copepod Production for Commercial Scale: Result from a Prototype Production Facility. 2015, Aquaculture

Drillet G, Chan N, Drillet Z, Foulsham AJ, Ducheyne A, Eikaas HS, Schmoker C, Hansen BW, Lybaek R. 2014. Opinions on the sustainable development of Aquaculture. Journal of Fisheries & Livestock Production 2: 1-3.

Blanda E, Drillet G, Huang C-C, Hwang J-S, Jakobsen HH, Rayner TA, Su H-M, Wu C-H, Hansen BW. 2015. Trophic interactions and productivity of copepods as live feed from tropical Taiwanese outdoor aquaculture ponds. Aquaculture

Drillet G, Novac A, Rais M, Jepsen PM, Mahjoub MS, Hansen BW. Total egg harvest by the calanoid copepod Acartia tonsa (Dana) in intensive culture – effects of high stocking densities on daily egg harvest and egg quality. In press, Aquaculture Research

Mahjoub MS, Wu CH, Leeper A, Hwang JS, Drillet G. Population density and mate selection in the copepod Acartia tonsa? In Press, Journal of Plankton Research

Drillet G, Hay S, Hansen BW, O'Neil B. Effects of demersal otter trawls on the re-suspension of copepod resting eggs and its potential effects on recruitment. In Press

Schmoker C. Trottet A. Mahjoub MS, Larsen, O. Drillet G. Historical reports of zooplankton from Singapore: A review. In press
Drillet G, Maguet R, Mahjoub MS, Roullier F., Fielding MJ. Egg cannibalism in Acartia tonsa: effects of stocking density, algal concentration, and egg availability. In Press, Aquaculture International

Drillet G, Lombard F. A first step toward improving copepod cultivation using modelling: the effects of density, crowding, cannibalism, and tank design and strain selection on copepod egg production yields. In Press. Aquaculture Research
Drillet G and Dutz J. Dealing with the presence of the ciliate Euplotes sp. in cultures of the copepod Acartia tonsa. Accepted. Aquaculture International

Hansen BW and Drillet G. Comparative oxygen consumption rates of subitaneous and delayed hatching eggs of the calanoid copepod Acartia tonsa Dana? Journal of Experimental Marine Biology and Ecology 442:66-69.

Guillaume Drillet, Schmoker C., Trottet A., Mahjoub M-S, Duchemin M., Andersen M. Effects of temperature on type approval testing of ballast water treatment systems. Integrated Environmental Assessment and Management 9:192-195

Martin Holmstrup, Johannes Overgaard, Thomas F. Sørensen, Guillaume Drillet, Benni W. Hansen, Hans Ramløv and Kirsten Engell-Sørensen. Influence of storage conditions on viability of quiescent copepod eggs (Acartia tonsa Dana): effects of temperature, salinity and anoxia. 2006. Aquaculture Research 37; 625-631

Guillaume Drillet, Morton H. Iversen, Thomas F. Sørensen, Hans Ramløv, Torben Lund and Benni W. Hansen. Effect of cold storage upon eggs of a Calanoid copepod, Acartia tonsa (Dana) and their offspring. 2006. Aquaculture 254; 714-725

Guillaume Drillet, Niels OG. Jørgensen, Thomas F. Sørensen, Hans Ramløv and Benni W. Hansen. Biochemical and technical observations supporting the use of copepods as relevant live feed organisms in marine larviculture. 2006. Aquaculture Research 37; 756-772

Guillaume Drillet, Laban Lindley, Alan Michels, Jeffrey Wilcox, Nancy H. Marcus. Improving cold storage of subitaneous eggs of the copepod Acartia tonsa Dana from the Gulf of Mexico (USA-Florida). 2007. Aquaculture Research 38; 457-466

Thomas F. Sørensen, Guillaume Drillet, Hans Romløv, Benni W. Hansen. Effect of environmental conditions on eggs production of calanoid copepods in an extensive nutrients enriched aquaculture bassin of the Limfjorden region (Denmark). 2007. Aquaculture 263; 84-96

Guillaume Drillet, Per M. Jepsen, Jonas K. Højgaard, Niels O. G. Jørgensen, Benni W. Hansen. Strain-specific vital rates in four Acartia tonsa cultures II: Life history traits and biochemical contents of eggs and adults. 2008. Aquaculture 279; 47-54

Guillaume Drillet, Per M. Jepsen, Jonas K. Højgaard, Erica Goetze, Benni W. Hansen. Strain-specific vital rates in four Acartia tonsa cultures, I: Strain origin, genetic differentiation and egg survivorship. 2008. Aquaculture 280; 109-116

Benni W. Hansen · Guillaume Drillet · Reinhardt M. Kristensen · Thomas F. Sørensen ·Majken T. Tøttrup. B. Production, hatching success and surface ornamentation of eggs of calanoid copepods during a winter at 57°N 2009. Marine Biology 157: 59-68.

Benni W. Hansen, Drillet G., Kozmar A., Pedersen K., Pedersen M.F., Sørensen T.F. 2009. Temperature dependent hatching rates, hatching success and protein composition of eggs from a culture of the calanoid copepod Acartia tonsa (Dana). Journal of Plankton Research 32: 305-315.

Guillaume Drillet, Tahina Rabarimanantsoa, Stéphane Frouël, Jacob S. Lamson, Anette M. Christensen, Sandra Kim-Tiam, Benni W. Hansen. 2011. Do microbial preparations improve life history traits of the copepod Acartia tonsa? Marine Biotechnology 13: 831–836.

Guillaume Drillet, Stephane Frouël; Mie H Sichlau; Per M Jepsen; Jonas K Højgaard; Almagir K Joarder; Benni W Hansen. 2011. Status and recommendations on marine copepod cultivation for use as live feed. Aquaculture 315: 155-166

Guillaume Drillet, Benni W Hansen, Thomas Kiorboe. 2011. Resting egg production induced by food limitation in the calanoid copepod Acartia tonsa. Limnology Oceanography 56(6): 2064-2070

Benni W. Hansen, Guillaume Drillet, Kristian P. Sjøgreen, Bent Vismann 2012. Do Acartia tonsa (Dana) eggs regulate their volume and osmolality as salinity changes? Journal of Comparative Physiology - B. 10.1007/s00360-012-0646-y

Papers published in international conference proceedings

Martin Andersen, Edina Chua, Lemuel R. Casten and Guillaume Drillet. Challenges and Opportunities in Developing a Land Based Test Facility for Ballast Water Treatment Systems in Singapore. Proceedings of MTEC2011 - 13-15 Apr, 2011, Singapore

Books and book chapters:

Mohamed-Sofiane Mahjoub, Claire Schmoker, Guillaume Drillet. 'Live feeds in larval fish rearing: production, use, and future' in Larval Fish Aquaculture. Editor: Jian G. Qin Nova publishers. 2013

Other publications:

International Maritime Organization. MEPC 63/2/16/ Marine Environment Protection Committee 27 February to 2 March 2012.Submitted by Singapore and Norway. Proposed amendment to the guidelines for improvement of ballast water management systems (G8).

EDUCATION

University of Denmark / Roskilde University, (Denmark) 2010
PhD, Life sciences

University of Caen/Basse-Normandy, (France), 2003
Master of Sciences, Coastal resources management and aquaculture

University of Rennes 1 (France), 2001
Bachelor of Science, Population biology

LEGTA le Rheu (France), 1996
Scientific baccalaureate, Agriculture and environmental sciences

Courses

Implement A/S, 2014
Sales training program and coaching sales

DHIgroup, 2012
DHI Project management course, personal preferences, situational leadership, project planning and budgeting

University of Copenhagen, 2010
Innovation and intellectual property rights in biotechnology

Nordic Marine Academy, 2009
Challenges of pelagic feeding: From Prey detection to secondary production. The challenge of measuring from bottles to oceans

Roskilde University, 2009
How to write a successful research proposal

Roskilde University, 2008
A guided tour of essential statistical methods for environmental scientists

World Association of Copepodologists, 2005
Biology and Systematics "Evolution and behavior of Copepods"

Temasek Polytechnic, Singapore
Teaching in Higher Education Certificate

Global Aquaculture Alliance
Best Aquaculture Practices Auditor Course

Henrik Skov, B.Sc.

Principal Coastal Engineer, DHI

SUMMARY

More than 28 years of experience in application of field and analytical methods for assessing marine habitats for and the effects of human activities at sea. Method development includes dynamic habitat modelling, GIS-based decision support systems i.r.t. assessment of wetland importance and sensitivity mapping. The experience record includes small- and large-scale marine protected areas, oil & gas, sustainable commercial and artisanal fisheries, sustainable offshore wind farms and dredging activities.

PROFESSIONAL EXPERIENCE

DHI, HORSHOLM, DENMARK
Project Manager

2003 - 2030

HEDESELSKABET ENERGY & ENVIRONMENT A/S, ROSKILDE, DENMARK
Project Manager

2002 - 2003

ORNIS CONSULT LTD. BIOLOGICAL CONSULTANTS, COPENHAGEN, DENMARK
Project Manager

1986 - 2002

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2013 - 2016	Q10 monitoring seabirds, The Netherlands	Project Manager, Monitoring of seabirds at the Q10 Offshore Wind Farm
2012 - 2015	Krieger's Flak Havmøller VVM, Denmark	Project Manager, Krieger's Flak Offshore Wind Farm. Impact Assessment and baseline investigations on birds and marine mammals.
2013 - 2014	Øresund Offshore Wind Farms, Denmark	Task Manager, Øresund Offshore Wind Farms. Impact Assessment and baseline studies in relation to birds.
2013 - 2014	JNCC - UK Marine Mammal Evidence base, United Kingdom	Task Manager, Long-term data analyses and habitat modelling of the distribution of harbour porpoises in UK waters in support of designation of SACs
2013 - 2014	StUK Plus, Germany	Task Manager, Long-term data analyses and habitat modelling of harbour porpoise distribution in the German Bight.
2013 - 2014	Tanjung Piai Petroleum Terminal DEIA, Johor, Malaysia	Task Manager, Tg. Piai reclamation and oil terminal construction. Impact assessment and habitat modelling
2012 - 2014	Birds. DHI DK, Poland	Task Leader, Polish Offshore Wind Farms. Impact assessment and baseline investigations on birds.
2013	Risk Assessment, Norway	Task Manager, Risk assessment on seabirds and marine mammals in relation to planned offshore oil drilling activities

Year	Project, Country	Position and activities
		in the North Sea.
2013	Review of modelling work, United Kingdom	Project Manager, Review of modelling work carried out in support of designation of marine SPAs for seabirds in Scotland.
2013	Marine Birds and Mammals, United Kingdom	Task Manager, Development of guidelines for analyzing survey data on marine birds and mammals in relation to offshore wind farms.
2013	Risk Assessment, Norway	Task Manager, Risk assessment on seabirds and marine mammals in relation to planned offshore oil drilling activities in the Norwegian Sea.
2013	Risk Assessment, Norway	Task Manager, Risk assessment on seabirds and marine mammals in relation to planned offshore oil drilling activities in the Barents Sea.
2013	Statoil Dynamic Risk Assessment Model for Acoustic Disturbance, Norway	Task Manager, Development of new risk assessment methods on seabirds and marine mammals in relation to planned offshore oil drilling activities.
2013	NATURAL ENGLAND - SOL - Independent review for SPA's - Falmouth Bay to St Austell, United Kingdom	Project Manager, Review of SPA designation, Falmouth Bay, England
2012 - 2013	Habitat Modelling, Norway	Task Manager, Habitat modelling of marine mammals as input to risk-based assessment of underwater noise on marine mammals in the Chukchi Sea, Alaska
2012 - 2013	MSFD Support, Belgium	Task Leader, Assessment of national progress with development of indicators for the EU Marine Strategy Directive, Denmark
2010 - 2013	London Array Offshore Wind Farm, Denmark	Project Manager, Habitat modelling and effect assessment of red-throated divers in relation to phase 2.
2012	Horns Rev 2 Offshore Wind Farm, Denmark	Project Manager, Post-construction monitoring of bird migration.
2011 - 2012	Harmony, Denmark	Task Leader, Demonstration project regarding development of biodiversity indicators for GES descriptors under the Marine Strategy Directive.
2011 - 2012	Anholt 2 Offshore Wind Farm, Denmark	Project Manager, Extended baseline monitoring of raptor migration in relation to Anholt Offshore Wind Farm.
2011 - 2012	Anholt Extended Bird baseline, Denmark	Project Manager, Extended baseline monitoring of raptor migration in relation to Anholt Offshore Wind Farm.
2011 - 2012	HARMONY Birds and Mammals, Denmark	Project Manager, Modelling of filter-feeder indices for clams in the North Sea 2011 using integrated water quality and habitat models.
2011 - 2012	Rødsand 2 Red Kite, Denmark	Project Manager, Collision risk modelling of raptor migration in relation to Rødsand II Offshore Wind Farm
2010 - 2012	London Array Diver Model, United Kingdom	Project Manager, London Array Offshore Windfarm. Habitat modelling and effect assessment of red-throated divers in relation to phase 2.
2010 - 2011	Survey and Assessment Methods, Denmark	Technical advisor, Review of survey and assessment methods for EIAs related to birds in connection with offshore wind farm developments in Denmark.
2010 - 2011	FEBI EIA Services 2009-2011(ENV030027), Denmark	Project manager, Environmental impact assessment of a fixed link across Fehmarnbelt on Birds.
2008 - 2011	Fixed Link Across Fehmarnbelt, Denmark	Task Manager, Statistics and modelling related to the assessment of a fixed link across Fehmarnbelt on Marine Mammals.

Year	Project, Country	Position and activities
2008 - 2011	Akustisk overvågning af pattedyr (54013-01), Denmark	Project Manager, Acoustic monitoring of small cetaceans in central North Sea
2009 - 2010	Seabirds in the German Bight, Germany	Project Manager, Habitat models on seabirds in the German Bight
2008 - 2010	Horns Rev 2 - Resting Birds, Denmark	Task Leader, Monitoring of resting birds at Horns Rev 2 Offshore Wind Farm
2008 - 2010	Horns Rev 2 - Bird Migration, Denmark	Task Leader, Monitoring of bird migration at Horns Rev 2 Offshore Wind Farm
2008 - 2010	Horns Rev - Modelling, Denmark	Task Leader, Modelling of American razor clam populations as food for seaducks associated with the Horns Rev 2 Offshore Wind Farm
2009	Anholt ATR-F Marsvin, Denmark	Task Leader, Environmental impact assessment of an offshore wind farm in the Kattegat on Birds and Marine Mammals.
2008 - 2009	EU Habitat Directive Annex I species, Denmark	Project Manager, Habitat models for habitat-forming species and assessment tools for EU Habitat Directive Annex I species in the Baltic Sea
2008 - 2009	Denmark	Task Leader, Development of waterbird habitat indicators from water quality model and remote sensing data. Service demonstration project for Danish end users.
2008 - 2009	Coast of Karas and Hardap, Namibia	Project manager/GIS and Biodiversity expert, Strategic Environmental Assessment of the Coast of Karas and Hardap, Namibia
2008 - 2009	Coastal biodiversity data, Namibia	Project manager/GIS expert, Development of an information portal for coastal biodiversity data in Namibia.
2008 - 2009	Mærsk - Havfugleovervågning (53708-01), Denmark	Project Manager, Aerial monitoring of seabirds and marine mammals in central North Sea
2008 - 2009	NACOMA SEA Karas and Hardap, Namibia	Project manager/GIS and Biodiversity expert, Strategic Environmental Assessment of the Coast of Karas and Hardap, Namibia
2007 - 2009	Greenland	Field work. Bird census Scoresbysund, Greenland
2008	VVM Stigsnæs, Denmark	Task Leader, VVM Stigsnæs Kulhavn. Birds, marine mammals and terrestrial habitats
2008	Denmark	Technical input. Ideas for a future national nature and environmental monitoring programme
2008	Denmark	-, Technical input. Conceptual System for Inte-grated Coastal Zone Management DSS
2007 - 2008	Denmark	Project Manager, Statistical methods for assessment of impacts from offshore wind farms on waterbirds
2007 - 2008	EMPAS, Germany	Input to analyses of spatial overlaps between fisheries and seabirds in German marine NATURA 2000 areas
2007 - 2008	Nordic Council of Ministers, Denmark	Project Manager, Coordinated Baltic Waterbird Census and Status of waterbird populations
2006 - 2008	Baltic Sea 2000-2005, Finland	Technical input/habitat l. Strategy for developing the Periodic Assessment of Bio-diversity for the Baltic Sea 2000-2005.
2006 - 2008	HELCOM Waterbird Monitoring in the Baltic Sea, Finland	Project Manager, Development and implementation of plan for long-term HELCOM Waterbird Monitoring in the Baltic Sea
2007	United Kingdom	Project Manager, Environmental Impact Assessment. Marine mammals and planned offshore wind farm in Liverpool Bay.
2007	Denmark	Technical input. European Marine Directives: Concepts, Overlap and Synergy
2007	ASMA	Technical input. ASMA tracking of sub-merged oil and assessment of impacts on sensitive resources
2007	Aerial waterbird counts	Technical input. Enhancing statistical power of aerial

Year	Project, Country	Position and activities
		waterbird counts
2007	Acoustic monitoring	Project Manager, Acoustic monitoring of baleen whales, Mid Atlantic Ridge
2006 - 2007	Rødsand 2 Wind Farm EIA; Fish, Denmark	Project Manager, Environmental Impact Assessment Rødsand 2 Wind Farm: Fish
2006 - 2007	Rødsand 2 Wind Farm, WQ, Denmark	Project Manager, Environmental Impact Assessment Rødsand 2 Wind Farm: Water quality
2006 - 2007	Rødsand 2 Wind Farm; Benthic Biology, Denmark	Project Manager, Environmental Impact Assessment Rødsand 2 Wind Farm: Benthic biology
2006 - 2007	Horns Rev 2; Wind Farm; Marine Mammals, Denmark	Project manager/habitat modelling, Environmental Impact Assessment Horns Rev 2 Wind Farm: Marine Mammals
2006 - 2007	Horns Rev 2; Wind Farm, Fish, Denmark	Technical input/GIS expert, Environmental Impact Assessment Horns Rev 2 Wind Farm: fish
2005 - 2007	SPREEX	Project manager and DHI/GIS expert, SPREEX (Spill Response Experience Coordination Action) Lead on WP4: research on decision support technologies in relation to assessments of environmental effects of oil spills
2006	Denmark	Planning Workshop for Coordinated Baltic Waterbird Census 2007
2006	Rønland Wind Farm, Denmark	Project Manager, Environmental Impact Assessment Rønland Wind Farm: marine ecology
2006	Denmark	Technical input. Synergies and convergences between the EU WFD and HD.
2006	Horns Rev 1 Wind Farm, Denmark	Technical input. Assessment of impacts of construction of Horns Rev 1 Windfarm on marine mammals.
2006	Denmark	Project manager/habitat mapping, Identification of candidate areas for marine Special Areas of Conservation in the Danish EEZ of the North Sea.
2006	COWRIE	Technical input. Assessment of statistical power of aerial waterbird counts in relation to off-shore wind farms
2004 - 2006	Scotland	Technical advisor, Development of Monitoring Design for small cetaceans in European waters
2003 - 2006	Denmark	Project Manager, Monitoring of benthic vegetation at Rønland Offshore Wind Farm
2005	Ireland	Project Manager, Environmental Impact Assessment in relation to planned offshore wind farms (marine mammals) in the Irish Sea
2005	Sweden	Input to policy paper regarding offshore EU Special Protection Area
2005	Germany	Project manager/GIS expert, Course in application of Geo-statistics and advanced GIS for selection of marine conservation areas for waterbirds.
2005	Denmark	Input to evaluation paper on synergies between EU Water framework Directive and Habitats directive
2005	Denmark	Project manager/habitat modelling, Analysis of habitat selection of cetaceans and seabirds along the Mid Atlantic Ridge
2005	Denmark	Project manager/habitat modelling, Delivery of fine-scale hydrodynamic data for habitat evaluation of marine mammals in relation to offshore wind farms
2004 - 2005	Denmark	Project manager/GIS mapping, Marine GIS and mapping of environmental resources in the Danish part of the North Sea
2004 - 2005	Denmark	Project manager, Environmental Impact Assessment in

Year	Project, Country	Position and activities
		relation to planned expansion of oil production activities in the North Sea.
2004 - 2005	Denmark	Assessment of effects of establishment of dumping facilities on coastal and marine biodiversity. Input to Environmental Impact Assessment.
2003 - 2005	Denmark	Cruise leader, Small cetacean monitoring in relation to offshore wind farms
2003 - 2005	Denmark	Project Manager, Modelling of collision risks for waterbirds at Rønland Offshore Wind Farm
2004	Singapore	Project manager/GIS modeller, Input to Environmental Impact Assessment (dugongs) in relation to dredging activities in Singapore Harbour
2004	Denmark	Project Manager, Dilution model in relation to produced water emissions in the Central North Sea.
2004	Denmark	Project Manager, Habitat modelling. Analysis of habitat selection of cetaceans and seabirds along the Mid-Atlantic Ridge
2004	Sweden	Project manager/GIS expert, Assessment of Marine Biodiversity and sensitive areas to oil spill in the Baltic Sea in relation to PSSA management areas.
2004		Project Manager, Survey and assessment of distribution and abundance of cetaceans and seabirds along the Mid-Atlantic Ridge
2003 - 2004	Denmark	Assessment of effects of harbour expansion on terrestrial, limnic and marine biodiversity. Input to Environmental Impact Assessment
2003 - 2004	Greenland	Project manager/GIS mapping, Terrestrial and Marine Biodiversity Inventory and GIS Mapping at Thule Air Base, Northwest Greenland
2000 - 2004		Development of GIS-based analytical methods to gauge negative ecosystem effects of commercial fisheries on coastal wetland habitats for top predators. Western North Sea
2003	Denmark	Input to assessment of oil pollution in water-birds in the Wadden Sea region
2003	Denmark	Input to Environmental Impact Assessment (Waterbirds) in relation to sand dredging activities in the Danish part of the North Sea
2003	Greenland	Survey and assessment of distribution and abundance of cetaceans and seabirds in West Greenland offshore waters
2003	Germany	Assistance to Environmental Impact Assessment in relation planned Offshore Wind Farms in the Baltic Sea (Waterbirds)
2003	Denmark	Assessment of effects of enlargement of shipping route waterbirds
2003		Assessment of effects of establishment of new beach and harbour facilities on coastal and marine biodiversity. Input to Environmental Impact Assessment
2002 - 2003	Germany	Project Manager, Assessment of the importance of the DanTysk and Nördliche Grund areas, central German North Sea, for seabirds and marine mammals. Integration of biological (visual, acoustic) and physical (climate, surface and subsurface hydrography, topography)
2002 - 2003	Germany	Analysis of acoustic data on harbour porpoise activity. The Arkona Basin

Year	Project, Country	Position and activities
2002 - 2003	Germany	Project Manager, Baseline investigations and impact assessment of the planned wind-farm in the DanTysk and Nördliche Grund areas, central German North Sea, on marine mammals. Acoustic investigations (mobile and stationary hydrophones), ship-based and aerial surveys and modelling of offshore distributions of marine mammals
2000 - 2003	Germany	Baseline investigations and impact assessment of the planned wind-farm, on marine mammals. Acoustic investigations (mobile and stationary hydrophones), ship-based surveys and modelling of offshore distributions of marine mammals. Mecklenburg Bay
2000 - 2003	Germany	Assessment of impacts on marine mammals from offshore windmill farms. Mecklenburg Bay
2000 - 2002	Germany	Project Manager, Assessment of impacts on waterbirds and marine mammals from offshore windmill farms in the German part of the North Sea
2000 - 2001	Germany	Pre-study of site suitability for marine windmill farms in relation to waterbirds and marine mammals. The German part of the North Sea
1999 - 2001	Sweden	Project Manager, Preparatory for the development of marine protected areas in the central Baltic Sea. Ecological baseline investigations of the diversity of benthic habitats, fauna and flora, seabird diet, distribution and mortality at offshore banks south of Gotland
1995 - 2001	Denmark	Project Manager, Impact assessment and follow-up studies for the fixed link across the Great Belt in relation to eider ducks

SELECTED PUBLICATIONS

Hamer, K.C., E. M. Humphreys, M. C. Magalhães, S. Garthe, J. Hennicke, G. Peters, D. Grémillet, H. Skov, & S. Wanless. Fine-scale foraging behaviour of a medium-ranging marine predator. Journal of Animal Ecology 2009, 78:880 889.

Skov, H., Humphreys, E., Garthe, S., Geitner, K., Grémillet, D., Hamer, K.C., Hennicke, J., Parner, P., Wanless, S. 2008. Application of habitat suitability modelling to tracking data of marine animals as a means of analyzing their feeding habitats. Ecological Modelling 212: 504-512.

Skov, H. & Thomsen, F. 2008. Resolving fine-scale tempo-spatial dynamics of harbour porpoise Phocoena phocoena. Marine Ecology Progress Series 373: 173 186.

Skov, H., Gunnlaugsson, T., Budgell, W.P., Horne, J., Nøttestad, L., Olsen, E., Søiland, H., Víkingsson, G., Waring, G. 2008. Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. Deep Sea-Research II 55: 254-268.

Larsen, J.l., Durinck, J. & H. Skov. 2007. Trends in chronic marine oil pollution in Danish waters assessed using 22 years of beached bird surveys. Marine Pollution Bulletin 54: 1333 1340.

Skov, H. 2007. Decision Support Systems for Oil Spill Response. Pp. 480-485 in Bertram, V. (Ed.). Proceedings 6th International Conference on Computer and IT Applications in the Maritime Industries. Cortona, 23-25. April 2007.

Fauchald, P., Skov, H. Johns, D. & P. Budgell. 2007. Seabirds of the North Sea ecosystem - scale-dependent responses to oceanographic and prey dynamics. Proceedings 31st Annual Meeting of the Waterbird Society. Barcelona 30. October - 5

November 2007.

Pedersen, S.A., Fock, H., Sell, A., Böttcher, U., Piet, G., Mills,C. Rogers, S., Sköld, M., Podolska, M., Skov, H., Pusch, C., Krause, J. & J. Rice. 2007. Natura 2000 sites and Fisheries in German Offshore Waters. Proceedings European Symposium on MPAs as a Tool for Fisheries Management & Ecosystem Conservation. Murcia, Spain 25-28 September. 2007.

Skov, H., Durinck, J., Leopold, M. & M.L. Tasker. 2007. A quantitative method for evaluating the importance of marine areas for conservation of birds. Biological Conservation 136: 362 371.

Skov, H. Tasker, M., Leopold, M. & Durinck, J. 2007. A quantitative method for evaluating the importance of marine areas for conservation of birds. Biological conservation 136: 362-371.

Skov, H., Dinesen, G. 2007. Mapping and modelling of marine habitats in the Baltic Sea region. BALANCE WP2 report.

Skov, H. & Durinck, J. 2001. Seabird attraction to fishing vessels is a local process. Mar. Ecol. Prog. Ser. 214: 289-298.

Skov, H. & Prins, E. 2001. The impact of estuarine fronts on the dispersal of piscivorous birds in the German Bight. Mar. Ecol. Prog. Ser. 214: 279-287.

Skov, H. & Durinck, J. 2000. Seabird distribution in relation to hydrography in the Skagerrak. Cont. Shelf Res. 20: 169-187.

Skov, H. & Durinck, J. 1999. Associations between wintering avian predators and schooling fish in the Skagerrak-Kattegat suggest reliance on predictable aggregations of herring Clupea harengus. Journ. Avian Biol. 31: 135-143.

Skov, H. & J. Durinck. 1998. Constancy of frontal aggregations of seabirds at the shelf break in the Skagerrak. Journal of Sea Research. 39: 305-311

Skov, H., Christensen, K.D. & Durinck J. 1996. Trends in marine oil pollution in Denmark 1985-1995. An analysis of beached bird surveys. Danish Environmental Protection Agency, Danish Ministry of Environment: Working report no. 75, 62 pp.

Skov H., Durinck J., Leopold, M.F. & Tasker M.L. 1995. Important bird areas for seabirds in the North Sea. Birdlife International, Cambridge, 156 pp.

Skov, H., Durinck J., Danielsen F. & Bloch D. 1995. Co-occurrence of cetaceans and seabirds in the Northeast Atlantic. J. Biogeog. 22: 71-88.

Dahlmann, G., Timm, D., Averbeck, C., Skov, H. & Durinck, J. 1994. Oiled seabirds - Comparative investigations on oiled seabirds and oiled beaches in the Netherlands and Germany (1990-93). Mar. Pol. Bull. 28(5): 305-310.

Durinck, J., Skov, H., Jensen, F. P. & Pihl, S. 1994. Important marine areas for wintering birds in the Baltic Sea. - EU DG XI research contract no. 2242/90-09-01 Ornis Consult report 1994, 110 pp.

Skov, H., Durinck J., Leopold M.F. & Offringa H. 1994. Habitats at sea: Action preparatory to the establishment of a protected areas network at sea in the south-eastern North Sea and the southern Baltic. EU DG XI ACE contract no. 445-45 Final Report. NIOZReport 1994-6. Netherlands Institute for Sea Research, Texel.

Skov, H. & Durinck J. 1992. Atlas of seabird vulnerability to oil pollution in the Danish sector of the open North Sea. - North Sea Operators Committee, Denmark, pp. 33.

EDUCATION

University of Malaya, Kuala Lampur (1988)
Diploma, Mangrove Ecology

University of Copenhagen (1985)
Bachelor of Science, Biology

Laura Johnson

Assistant Professor of Biology, DHI Group

SUMMARY

Laura Johnson recently joined the National Center for Water Quality Research (NCWQR) in January 2013. Prior to this, she was a postdoctoral research associate in Dr. Todd Royer's Laboratory at Indiana University in Bloomington. Laura received her Ph.D. from the University of Notre Dame in 2008 where she worked with Dr. Jennifer Tank on the effect of human land use on stream nutrient processing. Laura started conducting research as an undergraduate at Virginia Tech in the Stream Team- a collaborative laboratory of Drs. Jack Webster, Fred Benfield, and Maury Valett. She graduated in 2002 with a B.S. in Biology.

PROFESSIONAL EXPERIENCE

HEIDELBERG UNIVERSITY - NATIONAL CENTER FOR WATER QUALITY RESEARCH
Research Scientist
2013 - Present

INDIANA UNIVERSITY, BLOOMINGTON, IN - SCHOOL OF PUBLIC AND ENVIRONMENTAL AFFAIRS
Research Associate
2008 - 2012

Postdoctoral with Dr. Todd V. Royer

UNIVERSITY OF NOTRE DAME – DEPARTMENT OF BIOLOGICAL SCIENCES
Research Assistant
2006 - 2007

The Nature Conservancy Two Stage Ditch Project

UNIVERSITY OF NOTRE DAME – DEPARTMENT OF BIOLOGICAL SCIENCE
Teaching Assistant
2002 - 2008

VIRGINIA TECH – STREAM ECOLOGY LABORATORY
Research Experience for Undergraduates (REU) internship and laboratory assistant
2000 -2002

PROFESSIONAL EXPERIENCE

Aquatic ecosystem ecology and biogeochemistry, i.e., the transport and storage of materials (nutrients, gases, sediment, organic matter) in aquatic environments

CURRENT RESEARCH

At the NCWQR, Laura is primarily focused on watershed export and riverine dynamics of phosphorus, nitrogen, and sediment. She is working on projects investigating the influence of soil phosphorus stratification on dissolved phosphorus runoff and is involved in the Tributary Loading Program

PAST RESEARCH

Before arriving at the NCWQR, Laura was involved in a variety of projects from her postdoc and graduate career. These include (but are not limited to):

- The role of artificial subsurface drainage on greenhouse gas emissions (CO2, CH4, N2O) from an agricultural watershed
- Linkages among dissolved organic carbon availability, microbial diversity, and nitrogen removal via denitrification, the microbially-mediated reduction of nitrate to N2 and N2O
- Interactions between nitrogen and phosphorus in a forested stream- the influence of changing nutrient concentrations on retention and saturation kinetics
- Nutrient limitation of benthic algae and phytoplankton along a salinity gradient in the Altamaha River estuary on the coast of Georgia
- The effect of human land use on dissolved organic carbon and nitrogen uptake in streams
- The influence of human land use on biofilm nutrient limitation in 72 streams across North America

Laura was also involved in two large collaborative projects during graduate school including:

- The Lotic Intersite Nitrogen eXperiment II (LINX II) - a project that examined the influence of human land use on the fate of nitrate in streams using 24-h 15N-nitrate tracer additions.
- The Nature Conservancy Two Stage Ditch project- a study investigating the effect of expanding the area riparian benches on nitrate removal in an agricultural stream. These riparian benches are within the incised channel act and as act as mini-floodplains when inundated during high flows.

PROFESSIONAL ACTIVITIES

Society for Freshwater Science
American Society for Limnology and Oceanography
Ecological Society of America
International Association of Great Lake Research
Sigma Xi, The Scientific Research Society
National Society of Collegiate Scholars

SELECTED PUBLICATIONS

Publications

Baxter, A.M., L.T. Johnson, T.V. Royer, and L.G. Leff. In Press. Spatial differences in denitrification and bacterial community structure of streams: relationships with environmental conditions. Aquatic Sciences. DOI: 10.1007/s00027-012-0272-5.

Johnson, L.T., T.V. Royer, J.M. Edgerton, and L.G. Leff. 2012. Manipulation of the dissolved organic carbon pool in an agricultural stream: responses in microbial community structure, denitrification, and assimilatory nitrogen uptake. Ecosystems 15: 1027-1038.

Baxter, A.M., L.T. Johnson, J. Edgerton, T.V. Royer, and L.G. Leff. 2012. Structure and function of denitrifying bacterial assemblages in low order Indiana streams. Freshwater Science (formerly Journal of the North American Benthological Society) 31: 304-317.

Roley S.S., J.L.Tank, M.L. Stephen, L.T. Johnson, and J.J. Beaulieu. 2012. Floodplain restoration enhances denitrification and reach-scale nitrogen removal in an agricultural stream. Ecological Applications 22: 281-297.

Beaulieu, J.J., J.L. Tank, S.K. Hamilton, W.M. Wollheim, R.O. Hall, P.J. Mulholland, B.J. Peterson, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, N.B. Grimm, S.L. Johnson, W.H. McDowell, G.C. Poole, J.L. Meyer, H.M. Valett, J.R. Webster, C.P. Arango, M.J. Bernot, A.J. Burgin, C.L. Crenshaw, A.M. Helton, L.T. Johnson, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D. J. Sobota, and S.M. Thomas. 2010. Nitrous oxide emission from denitrification in stream and river networks. Proceedings of the National Academy of Sciences 108: 214-219.

Bernot, M.J., D.J. Sobota, R.O. Hall, P.J. Mulholland, W.K. Dodds, J.R. Webster, J.L. Tank, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, N.B. Grimm, S.V. Gregory, S.K. Hamilton, S.L. Johnson, W.H. McDowell, J.L. Meyer, B.J. Peterson, G.C. Poole, H.M. Valett, C.P. Arango, J.J. Beaulieu, A.J. Burgin, C.L. Crenshaw, A.M. Helton, L.T. Johnson, J. Merriam, B.R. Niederlehner, J.M. O'Brien, J.D. Potter, R.W. Sheibley, S.M. Thomas, and K.Wilson. 2010. Inter-regional comparison of land-use effects on stream metabolism. Freshwater Biology 55: 1874-1890.

Johnson, L.T., C.P. Arango, and J.L.Tank. 2009. The effect of land use on dissolved organic carbon and nitrogen uptake in streams. Freshwater Biology 54: 2335-2350.

Johnson, L.T., and J.L. Tank. 2009. Diurnal variations in dissolved organic matter and ammonium uptake in six open-canopy streams. Journal of the North American Benthological Society 28(3): 694-708.

Johnson, L.T., J.L. Tank, and W.K. Dodds. 2009. The influence of land use on stream biofilm nutrient limitation across eight North American ecoregions. Canadian Journal of Fisheries and Aquatic Sciences 66: 1081-1094.

Mulholland, P.J., R.O. Hall, D. J. Sobota, W.K. Dodds, S.E. Findlay, N.B. Grimm, S.K. Hamilton, W.H. McDowell, J.M. O'Brien, J.L. Tank, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, S.V. Gregory, S.L. Johnson, J.L. Meyer, B.J. Peterson, G.C. Poole, H.M. Valett, J.R.

Webster, C.P. Arango, J.J. Beaulieu, M.J. Bernot, A.J. Burgin, C.L. Crenshaw, A.M. Helton, L.T. Johnson, B.R. Niederlehner, J.D. Potter, R.W. Sheibley, and S.M. Thomas. 2009. Nitrate removal in stream ecosystems measured by 15N addition experiments: Denitrification. Limnology and Oceanography 54(3): 666-680.

Hall, R.O., J.L. Tank, D. J. Sobota, P.J. Mulholland, J.M. O'Brien, W.K. Dodds, J.R. Webster, H.M. Valett, G.C. Poole, B.J. Peterson, J.L. Meyer, W.H. McDowell, S.L. Johnson, S.K. Hamilton, N.B. Grimm, S.V. Gregory, C.N. Dahm, L.W. Cooper, L.R. Ashkenas, S.M. Thomas, R.W. Sheibley, J.D. Potter, B.R. Niederlehner, L.T. Johnson, A.M. Helton, C.L. Crenshaw, A.J. Burgin, M.J. Bernot, J.J. Beaulieu, and C.P. Arango. 2009. Nitrate removal in stream ecosystems measured by 15N addition experiments: Total uptake. Limnology and Oceanography 54(3): 653-665.

Arango, C.P., J.L. Tank, L.T. Johnson, and S.K. Hamilton. 2008. Assimilatory uptake rather than dissimilary transformation determines seasonal patterns in nitrogen removal in streams of varying land use. Limnology and Oceanography 53(6): 2558-2572.

Mulholland, P.J., A.M. Helton, G.C. Poole, R.O. Hall, S.K. Hamilton, B.J. Peterson, J.L. Tank, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, S.E. Findlay, S.V. Gregory, N.B. Grimm, S.L. Johnson, W.H. McDowell, J.L. Meyer, H.M. Valett, J.R. Webster, C.P. Arango, J.J. Beaulieu, M.J. Bernot, A.J. Burgin, C.L. Crenshaw, L.T. Johnson, B.R. Niederlehner, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D. J. Sobota, and S.M. Thomas. 2008. Stream denitrification across biomes and its response to anthropogenic nitrate loading. Nature 452: 202-246.

First- Author Presentations at Scientific Conferences

Johnson, L.T., T.V. Royer, R.P. Phillips, and D. Oviedo-Vargas. The role of artificial subsurface drainage in greenhouse gas emissions from an agricultural watershed. 60th annual Society for Freshwater Science meeting. Louisville, KY, May 2012

Johnson, L.T., T.V. Royer, D. Oviedo-Vargas, and L.G. Leff. Effect of a labile carbon addition on nitrogen cycling in a nitrate-rich stream in Indiana, USA. 59th annual North American Benthological Society Conference. Providence, RI, May 2011.

Johnson, L.T., T.V. Royer, J.M. Edgerton, and L.G. Leff. Effect of a labile DOC addition on nitrogen cycling in an agricultural stream. 58th annual North American Benthological Society Conference joint with the American Society of Limnology and Oceanography summer meeting. Santa Fe, NM, June 2010.

Johnson, L.T., T.V. Royer, L.G. Leff, J.M. Edgerton, A.M. Baxter, M.P. Brennan, and D.Oviedo-Vargas. The influence of dissolved organic matter on denitrifier community composition and denitrification rates in an agricultural headwater stream. 94th annual Ecological Society of America meeting. Albuquerque, NM, August 2009. Poster.

Johnson, L.T., J.L. Tank, P.J. Mulholland, R.O. Hall, S. Findlay, W.H. McDowell, H. M. Valett, S.K. Hamilton, B.J. Peterson, L.R. Ashkenas, L.W. Cooper, C.N. Dahm, W.K. Dodds, S.V. Gregory, N.B. Grimm, S.L. Johnson, J.L. Meyer, G.C. Poole, J.R. Webster, C.P. Arango, J,J. Beaulieu, M.J. Bernot, A.J. Burgin, C.L. Crenshaw, A. M. Helton, B.R. Niederlehner, J.M. O'Brien, J.D. Potter, R.W. Sheibley, D.J. Sobota, and S.M. Thomas. The fate of assimilated 15N-nitrate in 71 headwater streams. 56th annual North American Benthological Society Conference. Salt Lake City, UT, May 2008.

Johnson, L.T., J.L. Tank, R.O. Hall, and P.J. Mulholland. The influence of land use on autochthonous DON production in streams from two contrasting biomes. 55th annual North American Benthological Society Conference. Columbia, SC, June 2007.

Johnson, L.T. and J.L. Tank. The effect of land use on DOC and DON uptake in headwaters stream in the Kalamazoo River basin, Michigan. American Society of Limnology and Oceanography Aquatic Sciences Meeting. Sante Fe, NM, February 2007.

Johnson, L.T. and J.L. Tank. Diel fluctuations of DOC and DON uptake in streams. 54th annual North American Benthological Society Conference. Anchorage, AK, June 2006.

Taylor, L.C. and J.L. Tank. The effect of land use on DOC and DON uptake in headwater streams in the Kalamazoo River basin, Michigan.53rd annual North American Benthological Society Conference. New Orleans, LA, June 2005.

Taylor, L.C., J.L. Tank, W.K. Dodds, and K.C. Wilson. The influence of land use on biofilm nutrient limitation across 8 North American biomes. 52nd annual North American Benthological Society Conference. Vancouver, BC, Canada, June 2004.

Taylor, L.C., J.L. Tank, and G.A. Lamberti. 2003. How the addition of salmon carcasses vs. salmon analog affects nutrient export in an Alaskan stream. 51st annual North American Benthological Society Conference. Athens, GA, May 2003. Poster.

EDUCATION

Virginia Tech
B.Sc.

University of Notre Dame
Ph.D.

Morten Rugbjerg

Senior Project Manager and Marine Forecasting Coordinator, DHI Group

SUMMARY

Morten Rugbjerg has more than 30 years of experience within the offshore, ports and coastal / marine sector. He has special experience within numerical modelling of metocean / hydrographic conditions as required for design purposes, impact assessment, oil spills and forecasting. Furthermore, he has worked as business area manager for oil & gas for a number of years with focus on developing existing and new business areas within the marine area. This was also the case when he together with a colleague opened up a new DHI office in 2006 in Perth, Australia.

PROFESSIONAL EXPERIENCE

DHI (DENMARK)
Senior Project Manager and Marine Forecasting Coordinator
2010 - Present

Ports & Offshore Technology, Ecology and Environment

DHI WATER AND ENVIRONMENT PTY LTD. (PERTH, AUSTRALIA)
Principal Engineer
2006 - 2009

Ports and Offshore Technology, Australia and New Zealand

DHI (DENMARK)
Senior Engineer (Computational Hydraulics)
2003 - 2006

Ports & Offshore Technology

DHI (DENMARK)
Senior Engineer (in Computational Hydraulics)
1988 - 2003

Offshore Technology Department

DHI (DENMARK)
Hydraulic Engineer
1981 -1988

In the group at the Computational Hydraulics Centre working with research, development, and applications of mathematical modelling systems. Took part in the development and was responsible for the implementation of the DHI Wind Wave Model (MIKE 21 OSW) and the DHI Spectral Refraction Model (SYSTEM 10)

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2015 - 2016	West Nile Delta Detailed Current	Project manager, Quality control and project management

Year	Project, Country	Position and activities
	Modelling, United Kingdom	
2015 - 2016	Prince Rupert Marine Pipeline MetOcean Study, Canada	Project manager and modelling specialist, 3D current modelling and project management
2015	Oljespredningsanalyse Bjønnholmen, Norway	Oil spill modelling specialist, Performing detailed oil spill modelling
2015	Oljespredningsberegning for 6407/10-5 Portrush PL 793, Norway	Oil spill modelling specialist, Performing detailed oil spill modelling
2010 - 2015	Forecast for Caspian Sea Oil and Gas Fields, Kazakhstan	Marine Forecasting Coordinator, Development of tailor-made marine forecast system including online measurements.
2014	Environmental criteria for decommissioning of GNSC B11, Norway	Project Manager, Delivery of design conditions and weather windows to be used when removing the B11 booster platform in the German part of the North Sea.
2014	Oil spill modelling for environmental impact assessments for three operators/locations, Norway	Oil Spill Modelling Specialist, Provision of risk based oil spill modelling for spills in Norwegian waters.
2013 - 2014	Northern North Sea Current Hindcast, 2008-2012 and 13 storms, Norway	Project Manager, Development of detailed oceanographic model for use in design of structures used in oil/gas production.
2013 - 2014	Duqm Cyclone Modelling, Oman	Team Manager, Modelling of cyclonic winds and the associated waves and surges in connection with design of power plant.
2013	Environmental impact assessment, oil spill, Alvheim Field, Norway	Modelling Specialist, Responsible for oceanographic model of the Northern North Sea and for oil spill simulations.
2013	Environmental impact assessment, oil spill, Tvillingen S, Norway	Modelling Specialist, Responsible for oceanographic model of the Norwegian Sea and for oil spill simulations.
2013	Operational current forecast system for the Port of Gothenburg, Sweden	Forecast Coordinator, Implementation and operation of forecast system of currents for the Port of Gothenburg
2012 - 2013	Environmental impact assessment, oil spill, Langlitinden, Norway	Modelling Specialist, Responsible for oceanographic model of the Barents Sea and for oil spill simulations.
2010 - 2013	Forecast for London Array Offshore Wind Farm, United Kingdom	Marine Forecasting Coordinator, Development of tailor-made marine forecast system including online measurements.

Year	Project, Country	Position and activities
2011 - 2012	Coastal Embankment Improvement Programme (CEIP), Bangladesh	Modelling Specialist, Review/update of design conditions for coastal embankments including the effects of climate change.
2001 - 2012	The WaterForecast: North Sea, Inner Danish Waters, and the Baltic Sea	Responsible, Development and implementation of online wave forecasting system.
2011	Changes to waves, water levels and currents in Danish Waters due to Climate Change, Denmark	Project Manager, Research project focussing on changes to design conditions for waves, water levels and current for selected IPCC scenarios.
2011	Evaluation of wave conditions at Kribi Port, Cameroon	Modelling Specialist, Review/update of design conditions for iron ore terminal.
2010 - 2011	ALNG, Angola	Project Manager, Development of design wave conditions for an LNG terminal.
2010	Oil Spill Modelling, North Sea, Denmark	Oil Spill Modelling Specialist, Oil spill modelling for EIA.
2010	Oil Spill Modelling, Wheatstone, Australia	Oil Spill Modelling Specialist, Oil spill modelling for EIA.
2008 - 2009	Browse Environmental Modelling, Australia	Project Manager, Development of a three-dimensional hydrodynamic model for the Scott Reef area. Application of models for environmental approvals (oil spill, drill cuttings, Produced Formation Water, etc).
2007 - 2009	Alkatell Point, Karratha, WA, Australia	Modelling Specialist, Development of a MIKE 21 hydrodynamic model of the Dampier Archipelago for the assessment of dredge impacts.
2006 - 2008	Woodside Energy Ltd, Perth WA, Australia	Secondment, The Metocean department at Woodside Energy Ltd.
2007	Wellington Weir, Lake Alexandrina, SA, Australia	Project Manager, Establishment of water levels and waves for the design of a proposed weir.
2007	Wave and water level forecast system for the Canadian Great Lakes, Canada	Forecast Specialist, Set-up of wave and water level models for a dedicated forecast system.
2006	Butinge SPM, offshore the coast, Lithuania	Project Manager, Establishment of metocean conditions (incl. design conditions and operational conditions) for Single Point Mooring.
2006	Ras Laffan Port Extension, Qatar	Project Manager, Establishment of design wave conditions outside the extended Ras Laffan Port.

Year	Project, Country	Position and activities
2006	The WaterForecast: Burbo Offshore Wind Farm, the Irish Sea, UK and Lillgrund Offshore Wind Farm the Sound, Sweden	Wave Forecasting Specialist, Set-up of dedicated wave forecasting systems.
2006	Horns Rev 2 Offshore Wind Farm, Denmark	Project Supervisor, Establishment of design conditions and operational conditions for offshore wind farm.
2004 - 2006	Rudong LNG Terminal, Old Yangzy River Delta, China	Numerical Modelling Specialist, Design wave conditions (including effects of typhoons).
2003 - 2006	Iranian Seas Wave Modelling Study, Iran	Project Manager, Database with design and operational wave conditions for Iranian waters.
2003 - 2006	Sakhalin Island Meteorological and Oceanographic Study - 3, Russia	Project Manager, Water level, current and wave conditions for offshore operations.
2005	PERGOS Metocean Hindcast Database, the Gulf	Project Supervisor, Extension of metocean hindcast database to include detailed water levels and currents.
2005	Caspian Sea Meteorological and Oceanographic Study, Phase 2 (CASMOS-2), Kazakhstan	Project Manager, Three-dimensional hydrodynamic modelling of currents, salinity, and temperature of 50 years and 120 storms for the entire Caspian Sea.
2005	Cartagena Wave Study, the Caribbean Sea, Colombia	Project Manager, Assessment of hurricane-generated wave conditions along pipeline for design purposes.
2005	PARS LNG - South Pars 11, Iran	Project Supervisor, Metocean study for platform and pipeline design.
2005	Coast of Dubai, United Arab Emirates	Project Manager, Study of design water levels and waves along the Dubai Coast.
2005	Cyclone Assessment, Bay of Bangkok, Thailand	Project Manager, Assessment of cyclone-generated surges and waves along proposed causeway.
2004	Borkum Riffgrund, German Bight, Germany	Project Manager, Hydrographic design conditions and operational conditions for offshore wind farm.
2004	The WaterForecast, Global Wave Forecasting Model	Wave Forecasting Specialist, Set-up of global wave forecasting model.
2004	The WaterForecast, Sea of Chiloe, Chile	Wave Forecasting Specialist, Set-up of dedicated wave forecasting system component.
2003 - 2004	Three Ship Yards, Korea (Republic Korea)	Project Manager, Water level conditions during the passage of typhoons.
2001 - 2003	The WaterForecast: Horns Rev, the North Sea, Denmark	Project Manager, Development of wave forecasting system for an offshore wind farm.

Year	Project, Country	Position and activities
1995 - 2003	Development of DHI's WWW site, Denmark	Webmaster, Development and maintenance of DHI's Internet web pages.
2001	Klasården, Sweden	Project Manager, Hydrographic design conditions and operational conditions for offshore wind farm.
1998 - 2001	DHI Offshore Wind-Wave Model	Software Product Responsible, Responsible for development of DHI's Offshore Wind-Wave Model, MIKE 21 OSW.
2000	Rødsand, Denmark	Project Manager, Hydrographic design conditions and operational conditions for offshore wind farm.
2000	Yell Sound Current Study, United Kingdom	Project Manager, Design current conditions along proposed pipeline route in Yell Sound, Shetland Islands.
1999	Horns Rev and Læsø, Denmark	Project Manager, Hydrographic design conditions and operational conditions for two offshore wind farms.
1999	The North Sea, Denmark	Project Manager, Wave energy potential in the Danish part of the North Sea.
1995 - 1998	Meghna Estuary Study, Bangladesh	Modelling Specialist and Advisor for Hydrodynamical Modelling, Improvement of the physical and social security of the population living in the Meghna Estuary.
1991 - 1998	Ringkøbing Fjord, Denmark	Project Manager, Improvement of water quality in estuary using numerical modelling techniques. Carried out in collaboration with Ecological Modelling Centre.
1996 - 1997	NESS Current Modelling Study, The North Sea	Project Manager, Extension of North European Storm Study to produce a tide and storm surge current database for the period 1964-1995.
1995 - 1996	Cyclone Shelter Preparatory Study, Bangladesh	Project Supervisor, Establishment of High Risk Area in relationship to cyclone-generated surges.
1995 - 1996	Current Forecast for the Danish Olympic Sailing Team, OL '96, USA	Project Manager, Daily numerical forecast of current conditions for the area used for the sailing competitions during the Olympics '96 near Savannah.
1991 - 1993	Ras Laffan Port Project, Qatar	Modelling Specialist, Determination of design conditions and testing of proposed layouts with respect to currents and waves (long as well as short ones) using numerical models.
1990 - 1991	Cyclone Protection Project II, Bangladesh	Project Engineer, Responsible for the hydraulic studies including mathematical modelling of cyclonic surges carried out in Bangladesh, and training of local staff.
1990	MIKE 21 Documentation	Technical Writer and Coordinator, Development, design and writing of user documentation for the micro-computer based hydrodynamic model, MIKE 21.

Year	Project, Country	Position and activities
1986 - 1988	Northern European Storm Study (NESS), UK, NL, N and DK	DHI Project Manager for storm and current hindcast task, Assessment of environmental conditions in the Northern European continental shelf areas.

PROFESSIONAL ACTIVITIES

Danish Society of Chemical, Civil, Electrical and Mechanical Engineers
Danish Society of Hydraulic Engineering

SELECTED PUBLICATIONS

Papers published in international conference proceedings

Rugbjerg, M., Uhrenholdt, T., van Gastel, P., Wake, G., and Jarvis, S. (2009): "Hydrodynamic and Environmental Modelling in the Vicinity of Scott Reef". Coasts & Ports 2009 Conference, Wellington, New Zealand.

Jacobsen, V. and Rugbjerg, M., (2005): "Offshore Wind Farms - the Need for Metocean Data". Copenhagen Offshore Wind 2005, Copenhagen, Denmark.

Sørensen, O.R., Rugbjerg, M., Kofoed-Hansen, H., Sørensen, L.S. (2004): "A third-generation spectral wave model using an unstructured finite volume technique". 29th International Conference on Coastal Engineering, Lisbon, Portugal.

Rugbjerg, M., Nielsen, K. Christensen, J. H., and Jacobsen, V. (2000): "Wave Energy in the North Sea". Fourth European Wave Energy Conference, Aalborg, Denmark.

Jakobsen, J.B. and Rugbjerg, M. (1997): "Circulation Modelling and Forecasts for the Danish Sailors during the 1996 Olympic Yachting Events." 5th International Conference on Estuarine and Coastal Modelling, Alexandria, Virginia, USA.

Rugbjerg, M. and Basse, P. (1991): "Protection against cyclonic surges in Bangladesh". Third Int. Conf. on Coastal and Port Engineering in Developing Countries, Mombassa, Kenya, September 1991.

Jensen, O.J., Rugbjerg, M., and Sand, S.E. (1989): "Hydraulic modelling techniques and manoeuvre simulations in the field of ports and coastal structures". Second Congress of A.I.O.M., Napoli, Italy.

Rugbjerg, M., Vatvani, D. and Nielsen, J.B. (1989): "Numerical modelling of tides and storm surges on the North European Shelf". Int. Conf. of Hydraulic and Environmental Modelling of Coastal, Estuarine and River Waters, Bradford, United Kingdom.

Madsen, P.A., Rugbjerg, M., and Warren, I.R. (1988): "Subgrid modelling in depth integrated flows". Coastal Engineering Conference, Vol. 1, pp. 501-511, Malaga, Spain.

Yu Kuang-ming, Rugbjerg, M. and Kej, A. (1987): "Numerical modelling of harbour disturbances in comparison with physical modelling and field measurements". Second Int. Conf. on Coastal & Port Eng. in Developing Countries, Beijing, China, September 1987.

Rugbjerg M. (1987): "Numerical modelling of large, medium and small scale wind-wave fields for use in harbour design". Baltic Conf. on Design, Construction and Maintenance of Harbour Structures, Norrköping, Sweden.

Berenguer, I., Rugbjerg, M., Madsen, P., and Kej, A. (1986): "Mathematical and physical wave disturbance modelling - Complementary tools". Coastal Eng. Conf., Taipei, Taiwan.

Brink-Kjær, O., Knudsen, J., Rodenhuis, G.S., and Rugbjerg, M. (1984): "Extreme wave conditions in the Central North Sea". Ocean Technology Conference, 1984. Paper No. OTC 4809.

EDUCATION

Post-Secondary

Technical University of Denmark, 1981
MSc, Civil and Structural Engineering

Sonja Pans

Senior EIA Specialist, DHI Group

SUMMARY

Sonja Pans has more than 13 years of experience in environmental consultancy. Sonja has been guiding several major Environmental Impact Assessments and Marine Feasibility Studies in South East Asia, Middle East and Europe. These studies typical include impacts to the physical and biological environment with a strong focus on the impact on specific habitats. Sonja's professional experience lies predominantly with planning and project management of complex environmental projects, particularly for projects relating to industrial and marine activities. Her thorough understanding of environmental processes and related modelling tools allows her to translate the complex contexts of these projects into easy understandable, yet scientific, reports and presentations

PROFESSIONAL EXPERIENCE

DHI WATER AND ENVIRONMENT, INC.
Senior EIA Specialist and DHI Representative Western Canada
2015 - Present

DHI WATER ENVIRONMENTS UK LTD.
Senior EIA Specialist and Business Area Manager (Marine / Energy)
2012 - 2015

DHI WATER AND ENVIRONMENT (S) PTE. LTD.
DHI Representative Scotland
2008 - 2011

DHI WATER AND ENVIRONMENT (S) PTE. LTD.
Head of Environmental Management Services
2006 - 2008

DHI WATER AND ENVIRONMENT (S) PTE. LTD.
Project Manager
2005 - 2006

BOOZ ALLEN HAMILTON
Senior Consultant
2005 - 2005

TEBODIN CONSULTANTS AND ENGINEERS B.V.
Consultant/Project Manager
2002 - 2004

EXPERIENCE RECORD

Year	Project, Country	Position and activities
2016	EIA for desalination plant (east),	EIA expert

Year	Project, Country	Position and activities
	Singapore	
2015-2016	Policy review of mixing zone regulation in UK and Ireland	Technical expert
2015	EIA for desalination plant (west), Singapore	EIA expert
2015	EIA for sand sourcing in Vietnam	EIA expert
2014-2016	ORJIP Collision Prevention Study on birds in wind farms	Project Manager
2014	Marine Mammal Evidence Base for UK waters	Project Manager
2014	Due Diligence for renewable energy projects (wave & tidal)	Assessor of technical feasibility
2014	EIA for large coastal development in Singapore (incl. coastal structures, infrastructure and reclamation)	Quality Assurance
2014	Investigating flooding due to wave overtopping of coastal defenses for refinery, Oman	Project Manager of study to determine flooding risk due to wave overtopping (including cyclones, tsunamis and climate change) as well as rainfall runoff
2014	EIA for land reclamation in Singapore, Singapore	EIA expert for air quality modelling (dust).
2013 - 2014	Marine Modelling Enabling Action Programme: Model for the Pentland Firth and Orkney Islands area, United Kingdom	Project Manager for joint industry modelling study aiming to improve understanding of resource in the Pentland Firth and Orkney Island area.
2013	Environmental Impact Assessment for coastal and port development in Jakarta, Indonesia	EIA expert for mitigation and monitoring plan.
2013	Environmental Impact Assessment for coastal development in Singapore, Singapore	EIA expert for mitigation and monitoring plan.
2013	Inner Sound Tidal Array, Pentland Firth, array optimization, United Kingdom	Local project manager and quality assurance.
2012 - 2013	Environmental Impact Assessment for Petrochemical Development in Brunei, Brunei	EIA expert for mitigation and monitoring plan.
2011	Inner Sound Tidal Array, Pentland Firth, Environmental impact assessment and coastal processes modelling, United	EIA expert and project manager, assessment of hydrodynamics, waves and morphology.

Year	Project, Country	Position and activities
	Kingdom	
2011	Inner Sound Tidal Array, Pentland Firth, Wave conditions for detailed design, United Kingdom	Local project manager and quality assurance.
2011	Inner Sound Tidal Array, Pentland Firth FEED engineering design including resource calculation and optimization against CFD results, United Kingdom	Project Manager.
2010	Environmental Impact Assessment for Land Reclamation, Singapore	EIA expert for a land reclamation in Singapore close to coral habitats.
2010	Site Selection Assistance for Tidal Power Generation in India, India	Project manager for site assessment including detailed numerical modelling in Gujarat, India.
2009 - 2011	Site Selection Assistance for Tidal Power Generation in Northern Australia, Australia	Project manager for site assessment including detailed numerical modelling and data collection.
2009 - 2011	Site Selection Assistance for Tidal Power Generation in UK (Pentland Firth), United Kingdom	Project manager for site assessment including detailed numerical modelling and field data collection, scoping and optimization of tidal power arrays.
2009	POP Sources and Emission Monitoring, Singapore	Expert for POP monitoring in Air Quality.
2009	Environmental Assessment of Jetty Construction at Sebarok Island, Singapore	Project manager for environmental impact assessment.
2009	Environmental Impact Assessment for Offshore Supply Base, Singapore	Quality Assurance of deliverables of the Environmental Impact Assessment.
2009	Feasibility Assessment for floating structures, Singapore	Quality Assurance of deliverables of the Feasibility Assessment.
2009	Breakwater construction at Ferry Terminal in South East Singapore, Singapore	Task manager for environmental impact assessment.
2009	EIA for Proposed Marina Coastal Expressway, Singapore	Task manager for environmental impact assessment.
2008 - 2011	Masterplan Brunei, Brunei	Air Modelling Expert for emissions from port development.
2008 - 2009	Environmental Monitoring & Management Plan for Island	Environmental Monitoring & Management Plan for Island Reclamation in western Singapore Project manager for

Year	Project, Country	Position and activities
	Reclamation in western Singapore, Singapore	marine dredging and reclamation works including spill monitoring, habitat monitoring and current forecast.
2008 - 2009	Mangrove Erosion Assessment Study, Singapore, Singapore	Project manager for mangrove erosion study and assessment of protection measures.
2008	Environmental Impact Assessment for Resort & Golf Course development in Vietnam, Vietnam	Project manager for Environmental Impact Assessment for the development of a resort & golf course in central Vietnam.
2008	Environmental Impact Statement for dredging works for port development, Singapore	Project manager for Environmental Impact Statement for dredging works for upgrading of berthing facilities, including sediment plume modelling and sediment toxicity.
2008	Data collection for Master plan development in the Bay of Algiers, Algeria, Algeria	Project manager for the preparation of desk-top site assessment and environmental SWOT analysis for a potential mixed use development in the Bay of Algiers.
2008	Beach Water Quality Monitoring Singapore, Singapore	Quality assurance of data collection and analysis.
2008	EIA for Waterfront Development, Singapore	Task manager for environmental impact assessment.
2008	EIA Training Courses, Singapore	Trainer for Courses on Environmental Impact Assessment covering general principles, country specific laws and requirements and extensive case studies.

LANGUAGES

Languages	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent
Dutch	Excellent	Excellent	Excellent
French	Fair	Good	Poor
German	Native	Native	Native

SELECTED PUBLICATIONS

Papers published in international conference proceedings

Pans S., Rasch P., Lochinvar Sim Abundo M. (2013) Making Space for Offshore Renewables - Spatial Planning for marine energy. EWTEC conference 2013, Aalborg, Denmark.

Pans S, Gari J, Tan C A, Phipatanasuphorn V, Skovgaard Rasch P (2011). A decision support tool for the optimisation of large tidal power arrays. EWTEC conference 2011, Southampton, United Kingdom.

Other publications:

Oetken S. (2002). The Role of Accountancy in the Sustainability Debate. Thesis, Technical University Cottbus, Cottbus, Germany.

Oetken S. (2000). The Development of an Environmental Truck Transport Indicator. Thesis, Chalmers University of Technology, Gothenburg, Sweden.

EDUCATION

Chalmers University of Technology, 2000
Master of Science, Environmental Science

Technical University Cottbus, 2002
Master of Science, Industrial Engineering and Management