DNV·GL

Proposal for Independent Risk Analysis for the Straits Pipelines

State of Michigan

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About this document

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Confidentiality

for Det Norske Veritas (U.S.A.), Inc.

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Table of contents

1 INTRODUCTION AND BACKGROUND 1

2 DNV GL RELEVANT EXPERIENCE 3
Project Team 3

3 PROJECT EXPERIENCE 5

4 SCHEDULE FOR THE REQUESTED APPROACH 10

5 REQUESTED APPROACH AND ALTERNATIVES 11
5.1 Task A. Duration and Magnitude of Worst Case Spills 11
5.2 Task B. Environmental Fate and Transport of Worst Case Spills 13
5.3 Task C. Duration of Activities to Contain and Cleanup Worst Case Spills 14
5.4 Task D. Short and Long Term Public Health and Safety Impacts 15
5.5 Task E. Short and Long Term Ecological Impacts of Worst Case Spills 18
5.6 Task F. Measures to Restore Natural Resources and Mitigate Ecological Impacts of Worst Case Spills 19
5.7 Task G. Natural Resource Damages from Worst Case Spills 20
5.8 Task H. Governmental Costs of Worst Case Spills 20
5.9 Task I. All Other Economic Damages of Worst Case Spills 21
5.10 Deliverables and Communication 21
5.11 Alternatives and/or Optional Work 22

6 PROPOSED BUDGET 28
6.1 Invoicing and Payment 28

7 CONTRACTUAL ITEMS 29
7.1 Contract Basis - Terms and Conditions 29
7.2 Assumptions, Conditions and Limitations (All) 29

8 PROJECT RISK MANAGEMENT AND CONFLICT OF INTEREST 30
8.1 Information Relevant to Potential Actual or Apparent Conflicts of Interest 30
8.2 Factors Critical to Success and Project Risk Management 30

9 REFERENCES 32

Appendix A Det Norske Veritas (U.S.A.), Inc. Standard Terms and Conditions
Appendix B Resumes

1 INTRODUCTION AND BACKGROUND

DNV GL is an international classification society and verification body in the Oil & Gas, Energy, and Maritime industries. The scope of work in this Request for Information and Proposal is ideally aligned with our purpose to safeguard life, property and the environment.

Under the recommends of the Michigan Petroleum Pipeline Task Force (MPPTF), the Michigan Departments of Environmental Quality, the Michigan Department of Natural Resources, the Michigan Agency for Energy, and the Michigan Office of Attorney General (the State) issued a Request for Information and Proposals (RFIP) for an Independent Risk Analysis for the Straits Pipelines. Specific recommendations regarding the Straits Pipelines were:

1. Prevent the transportation of heavy crude oil through the Straits Pipelines.
2. Require an independent risk analysis and adequate financial assurance for the Straits Pipelines.
3. Require an independent analysis of alternatives to the existing Straits Pipelines.
4. Obtain additional information from Enbridge relating to the Straits Pipelines.

The Request for Information and Proposals focuses specifically on Recommendation 2.a.—the analysis of the pipeline operator's potential liability from a worst-case spill or release scenario. In accordance with the Request, DNV GL herein submits this proposal to conduct an independent risk assessment of the consequences of a worst case discharge of oil and LPG from the pipeline. The assessment will provide important information to the State regarding the potential environmental and economic impacts of a worst case spill, as well as financial information related to the response and recovery costs associated with a worst case spill.

In addition, DNV GL suggests an alternative methodology to provide key answers using less time, money, and resources, described in Section 5.11.

The Straits Pipelines are operated by Enbridge and traverse beneath the waters of the Straits of Mackinac. They consist of two, 4.6 mile, 20" pipelines carrying light crude oil, propane, and potentially other petroleum based products.

The Straits of Mackinac connect Lakes Michigan and Huron, two of the five Great Lakes. The Great Lakes are the largest freshwater system on Earth, containing an estimated 20% of all the liquid surface fresh water on Earth. The United States draws more than 40 billion gallons of water from the Great Lakes every day—half of which is used for electrical power production, and is critical to the lives of more than 35 million people in the US and Canada. The Great Lakes support one of the world's largest regional economies, including a $7 billion fishery and $16 billion tourism industry. More than 3,500 species of plants and animals live in the Great Lakes basin. More than 170 species of fish inhabit the Great Lakes, their tributaries and connecting waterways. (University of Wisconsin Sea Grant Institute, 2013).

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL functions as an independent third party and enables organizations to advance the safety and sustainability of their business. We provide independent classification and technical assurance along with software and independent expert

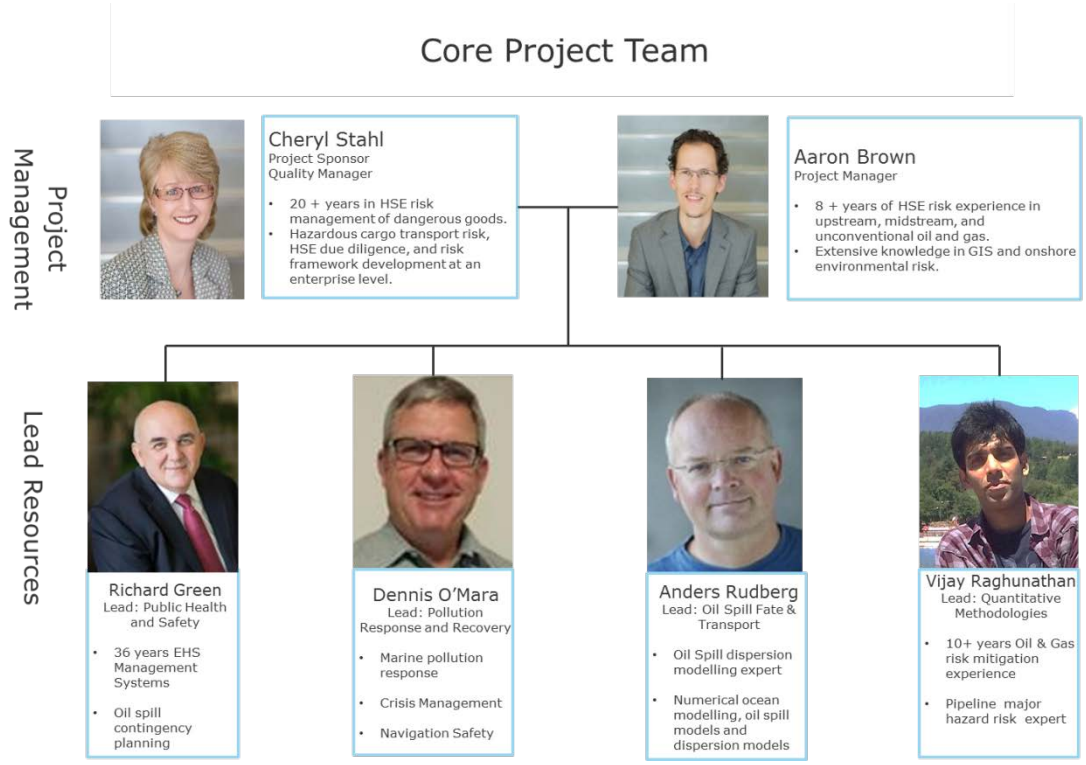
advisory services to the maritime, oil and gas, and energy industries. We also provide independent certification services to customers across a wide range of industries. Operating in more than 100 countries, our 15,000 professionals are dedicated to helping make the world safer, smarter and greener.

Our 151 year history of independent verification services has set us apart as a trusted partner to both industry and regulatory bodies worldwide. Our experience and understanding of pipeline risk make us an ideal choice to bring thorough, accurate, and defendable results to this study.

2 DNV GL RELEVANT EXPERIENCE

This proposal puts forward a team with deep experience in environmental risk, spill modeling, oil spill response and response planning, risk mitigation, and oil and gas risk assessment techniques.

The project organization is shown below.



Project Team

This section provides the names, qualifications and relevant experience of the individuals who will serve as the core project team and which tasks they will perform. Resumes are provided in Appendix B.

Cheryl Stahl will be the Project Sponsor and quality manager. Ms. Stahl has more than 25 years' experience in environmental risk analysis and mitigation, project management, due diligence, and compliance. Career experience includes project management of multi-faceted analyses to identify cost-effective solutions to health, safety and environmental business challenges. Her recent work includes hazardous cargo transport risk, due diligence, and risk framework development at an enterprise level.

Aaron Brown will be the Project Manager. Aaron is a Senior Consultant, specializing in projects relating to the transport of dangerous goods by ship and LNG bunkering / LNG as fuel projects. He has also worked extensively in the Canadian oil sands, refining, midstream (transport & distribution) and in the chemicals industry. Mr. Brown is an experienced project manager and has experience managing many complex and challenging projects. His background using networked multi-commodity flow modelling approaches to design/ evaluate policy proposals will support efficient project execution.

Richard Green has over 36 years' experience developing and delivering EHS compliance and environmental management systems (ISO 14001, 18001, 9000); EHS auditing, environmental due diligence; environmental engineering and operations; municipal and industrial wastewater operations; solid and hazardous waste management operations; waste-to-energy operations, in-plant environmental services in the chemical, automotive, marine, steel, and pharmaceutical industries; experimental design and statistical analyses including mathematical modeling; environmental remediation; groundwater well management. Root cause analysis, barrier analysis, oil spill contingency planning, pipeline management systems, and major project management.

Dennis O'Mara will be the oil spill response and recovery subject matter expert. Recent work includes navigation risk assessment for LNG facilities in British Columbia, Canada and Waterway Suitability Assessments for LPG facilities in the US. He has assessed navigation and oil transport risk on the Columbia River and provided risk awareness training to US Coast Guard vessel inspectors. Mr. O'Mara is a former U.S. Coast Guard officer with marine safety, security, environmental protection, contingency planning, emergency response management, and investigations/analysis experience. He was also a consultant specializing in maritime security requirements, risk management, and training. He has experience with ISM Code and implementing behavioral based safety programs. He has planned and conducted regulatory audits, developed and implemented corrective actions.

Vijay Raghunathan is a Process Safety subject matter expert with 10+ years of experience delivering sustainable risk solutions for the Oil & Gas sector. He has collaborated on transformational projects with Saudi Aramco, Bechtel, BG, PETRONAS, ConocoPhillips, Nexen, and Statoil and also functioned as a thought leader in projects with US and Canadian Government Agencies. He has lead pipeline risk assessments and incident investigations under multiple regulatory regimes. He specializes in identifying, analyzing risks associated with major hazards, assessing their tolerability, impairment of safety functions, global risk benchmarking, and conducting ALARP workshops and drafting mitigation plans.

The core project team will draw on resources from DNV GL's large resource pool as required. This will ensure flexibility where urgent and additional work may be required.

DNV GL would like to emphasize that we have a large pool of highly qualified engineers, consultants, and analysts available within numerous disciplines. If needed, due to changes in the schedule or scope of work, or to resolve other potential challenges, a significant number of very experienced resources can be mobilized for this project.

DNV GL does not anticipate using the services of subcontractors, outside DNV GL affiliates, in the performance of this work.

3 PROJECT EXPERIENCE

DNV GL has a deep history of assessing risk and developing risk mitigation measures in all segments of the oil & gas industry. Through our nearly 400 offices, located in 100 countries, we have performed a range of risk services for pipelines, vessels, marine transfer sites, and offshore wells. Our pipeline risk experience consists of over 1,000 separate projects in the past 10 years including many supporting pipeline integrity. A selection of relevant projects is included in Table 1. Should additional references be desired on any aspect, we will be glad to provide them on request.

Table 1 Selected Project Experience

Project Title	Date	Customer Lead Team Member(s) on the Project	Outcome
Environmental risk analysis for oil spill scenarios off- and nearshore Indonesia	2015-2016	TOTAL SA Anders Rudberg	DNV GL mapped relevant environmental resources combined with oil drift modelling (OSCAR) for oil spills off- and nearshore Indonesia and calculated environmental risk.
Development of a Methodology to Assess Arctic Oil Spill Risk	2014	Undisclosable Cheryl Stahl Aaron Brown	Oil production in Arctic regions poses additional oil spill risks because the ability to respond can be hampered by an inability to arrive quickly and by the presence of ice on the water. DNV GL developed a methodology to estimate oil spill risk from oil production and gathering facilities in the Arctic. The resulting methodology was used to support decision making concerning future developments.
Post-spill litigation support in Asia	2011-2013	Undisclosable Aaron Brown	DNV GL provided post-spill analysis for expert input to government – operator interactions.
Development of a Risk Management Program	2011 – 2012	Undisclosable Cheryl Stahl	DNV GL developed a comprehensive Risk Management Program for integration into their management system. The RMP included communication of existing risks, monitoring the controls related to the highest risks, and tracking risk reduction measures and their effect on risk.
Oil Spill Baseline Risk Assessment	2007	Undisclosable Cheryl Stahl	DNV GL assessed oil spill risk for a large pipeline system, providing the owner with a monetized view of oil spill risk for the system, accounting for oil spill risk to receptors and serval types of spill risk exposure to the company.
System-Wide Risk Assessment for a large pipeline system	2009 - 2011	Undisclosable Cheryl Stahl	DNV GL identified a comprehensive list of threat scenarios in two categories: Human Safety and Financial Exposure, and the risks association with each scenario. DNV GL used the results of the study to develop their Risk Management Program, linked to their Management System.

Project Title	Date	Customer Lead Team Member(s) on the Project	Outcome
Recommended Practice DNVGL-RP-F302 "Offshore Leak Detection"	2015	DNV GL-led joint industry project (JIP) with 19 companies and industry regulators as observers.	This RP is widely accepted as the prominent guideline on the subject, and provides guidance on design, integration and operation of systems for offshore leak detection.
Environmental Risk Assessment / Oil Spill Contingency Analysis for Salander Exploration Drilling	2015	E.ON Norge E&P Anders Rudberg	DNV GL conducted oil spill modelling (OSCAR), oil spill risk assessment, and contingency planning analysis for exploration drilling in the Norwegian Sea.
Pipeline Incident Root Cause Analysis	2016	Undisclosable Richard Green	DNV GL conducted a procedural RCA on a small volume crude oil release event from a pipeline.
Environmental Risk Assessment / Oil Spill Contingency Analysis for Butch Oil Field	2015	Centrica Energy Anders Rudberg	DNV GL conducted oil spill modelling (OSCAR), oil spill risk assessment, and contingency planning analysis for the Butch field development in the North Sea.
Chlorine Pipeline Risk Assessment	2015	Undisclosable	DNV GL performed a safety Quantitative Risk Assessment for a 25 km underground chlorine pipeline.
BG Lake Charles Pipeline Project Reliability Availability, and Maintainability	2015	BG	DNV GL conducted a RAM study that simulated the entire lifetime performance of the pipeline in terms of availability, efficiency and profitability. The model can account for flow networks, maintenance strategies, transport logistics and storage tanks.
Vessel Transit Risk Study	2015	Vancouver Energy Dennis O'Mara Cheryl Stahl Vincent Demay	DNV GL performed a quantitative and a qualitative risk assessment of marine transport and loading of crude oil, including oil spill consequence modelling, marine traffic oil spill risk, and loading risk.
Vessel Traffic Evaluation and Safety Risk Assessment	2016 -	State of Washington Dennis O'Mara	DNV GL is conducting a risk assessment of oil tanker transit and loading and oil-by-rail transit and loading on the Columbia River.
Waterway Suitability Assessment	2015	Pembina Pipeline Dennis O'Mara	DNV GL performed an assessment of the Columbia River for the transport of liquefied propane, which included a comprehensive evaluation of marine pollution response resources, strategies, and plans.

Project Title	Date	Customer Lead Team Member(s) on the Project	Outcome
Angola Oil Spill Risk Management	2012	Total Anders Rudberg	The Dalia field experienced an oil spill in 2008, and the accident investigation had identified improvement opportunities for the oil spill risk management. DNV GL provided state of the art oil spill risk management solutions and provided input to the update of Total's internal guidelines and requirements. Total presented the solutions at the SPE HSE conference in 2012, concluding that the methods had "proved to be effective in assessing the risk through accident scenarios".
Waterway Suitability Assessment	2014	Undisclosable Dennis O'Mara Aaron Brown	DNV GL performed a Waterway Suitability Assessment of the waters of the Caribbean Ocean in the vicinity of St. Thomas and St. Croix. The assessment included an evaluation of local marine pollution response resources, strategies, and plans.
Pipeline Incident Root Cause Analysis	2013	Undisclosable Richard Green	DNV GL conducted an incident investigation of a pipeline leak. The investigation used the RCA and BSCAT methods, arriving at root causes and practical recommendations to improve pipeline integrity and reduce spill risk.
Cold Weather Restart and Contingency Repair Study	2006	Alyeska Pipeline Service Company Cheryl Stahl	During prolonged cold weather in Alaska, startup after an emergency shutdown must occur within a short timeframe, or the oil will not reflow until the end of spring. DNV GL assessed the risk for TAPS to not re-start, and developed a list of possible risk reduction measures. Cost-benefit analysis was used to identify the best risk mitigation for this potential long-term business interruption scenario.
Strategic Reconfiguration Contingency Plan Support	2006	Alyeska Pipeline Service Company Cheryl Stahl	The grants of easement and right of way for TAPS were approved with conditions, one of which was a requirement to demonstrate that reconfiguration of the pipeline would not increase oil spill risk at any location. DNV GL developed a risk-based methodology that identified locations of increased spill risk, causes of the risk, and cost-effective mitigations to reduce the risk to the baseline level.
Risk Review	2016	Undisclosable Vijay Raghunathan	The client had experienced several leaks associated with a specific type of pipeline and conducted a risk assessment with the objectives to understand the reason for these pipeline failures. DNV GL was hired in as a third party to review the risk assessment, comment on the study approach and provide recommendations for improvements.

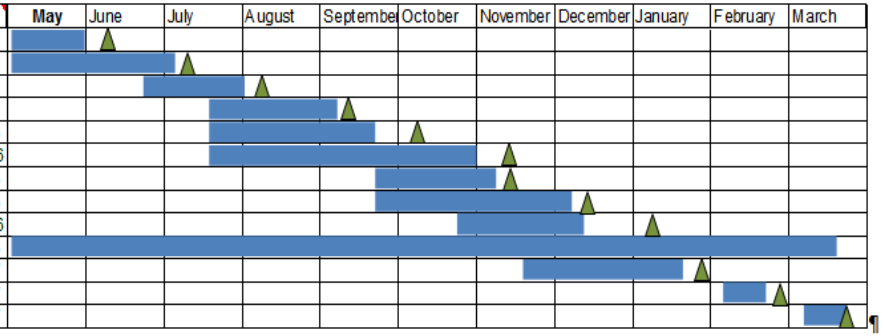
Project Title	Date	Customer Lead Team Member(s) on the Project	Outcome
Jizan-Abha Pipeline Quantitative Risk Assessment (QRA)	2013	Saudi Aramco Vijay Raghunathan	DNV GL evaluated the risk to existing and planned populated areas surrounding the Jizan-Abha pipeline and identified high risk areas and possible mitigation options to manage the risk.
Pipelines Corridor QRA	2012	Saudi Aramco Vijay Raghunathan	Evaluated the risk to existing and planned populated areas close to the pipelines corridor. Established minimum safety zone between the population center and the edge of the pipelines corridor.
Vulnerability Assessment	2007	Phoenix Park Gas Processors Limited (PPGPL), Trinidad Vijay Raghunathan	DNV GL performed a Quantitative Risk Assessment (QRA) on the 54 km long, 8-inch NGL (Natural Gas Liquids) pipeline in Trinidad. The execution of this study included data collection, site visit/survey, Hazard Identification (HAZID) Workshop and Quantitative Risk Assessment (QRA). The observations during the site visit and recommendations raised from the HAZID Study provided input to the QRA for further investigation.
Harmonised Risk Acceptance Criteria for Transport of Dangerous Goods	2013-2014	European Commission - Directorate General for Mobility and Transport (DG-MOVE)	The objective and scope of the study was to analyze the feasibility of defining and using harmonized risk acceptance criteria in decision-making for justification of safety measures in the inland transport of dangerous goods in the European Union.
MEEA Facilities Integrity Audit	2015 - present	Ministry of Energy & Energy Affairs (MEEA), Government of the Republic of Trinidad & Tobago	Following a number of integrity-related interruptions to gas production and incidents including the December 2013 oil leak, the MEEA desired to have a transparent picture of the mechanical integrity of the Nation's oil & gas infrastructure. The primary objective of the audit is to establish the integrity of energy installations in the domestic energy sector. The scope of work is to provide consulting services and conduct of comprehensive facilities audit, encompassing offshore as well as onshore activities, covering infrastructure in the upstream, midstream, and downstream segments of the domestic energy sectors; determine current status of mechanical integrity, HSE policies, procedures and practices of existing facilities; benchmarking against industry standards, codes, and practices; develop recommendations to improve, preparation of action plan for implementing the recommendations.
Shell Supply and Distribution Reliability and Integrity	2010 - 2011	Shell Oil Products US	In 2008, Shell Group issued the Asset Integrity-Process Safety Management (AI-PSM) Standard. The objective of the project was to ensure all Shell Companies and JVs under its operational control, were in full compliance with the Shell Group AI-PSM Standard by end of 2013.

Project Title	Date	Customer Lead Team Member(s) on the Project	Outcome
Fraser River Tanker Traffic Study	2011-2012	Port Metro Vancouver	Port Metro Vancouver (PMV) hired DNV to perform a Fraser River Tanker Traffic Study in order to better understand the logistical and operational impacts of liquid bulk cargo on the south arm of the Fraser River as well as the possible ways of mitigating those risks to acceptable levels.
New Port Infrastructure Risk Analysis Liquid Bulk Terminal	2013 - 2014	The Quebec Port Authority (QPA) Anders Rudberg	The objective and scope of work is to conduct a risk analysis in line with the requirements of Element 3.15 of the TERMPOL process. More specifically, the QPA limits the scope of this study to the liquid bulk transfer facility and did not require an analysis of the maritime domain because the ships that will moor to the new marine facilities are similar to those already operating on the St. Lawrence River between Les Escoumins and Québec. However, the analysis included the navigable section of the river known as the North Traverse and the Port of Québec.

4 SCHEDULE FOR THE REQUESTED APPROACH

The general philosophy behind the schedule is to complete one element of the work every month. The goal is to communicate results from one element in each monthly webinar or meeting involving all appropriate parties, indicated by ▲. The first element's findings would be shared five to six weeks after project kickoff. This approach will facilitate collection of feedback and any additional input as the work progresses. The formal write-up for each element will become an appendix to the main report, which will be issued as a whole document on September 20. This process will efficiently collect comments on each appendix monthly, so that review of the draft assembled report can focus on the findings and key issues.

Budget ID	Description	Days	Start Date	End Date
1	Task A. Duration and Magnitude of a Worst Case Spill	31	5/2/2016	6/2/2016
2	Task B. Environmental Fate and Transport of Worst Case Spills	65	5/2/2016	7/6/2016
3	Task C. Duration of Activities to Contain and Cleanup Worst Case Spills	42	6/20/2016	8/1/2016
4	Task D. Short and Long Term Public Health and Safety Impacts	51	7/17/2016	9/6/2016
5	Task E. Short and Long Term Ecological Impacts of Worst Case Spills	64	7/17/2016	9/19/2016
6	Task F. Measures to Restore Natural Resources and Mitigate Ecological Impacts	106	7/17/2016	10/31/2016
7	Task G. Natural Resource Damages from Worst Case Spills	49	9/19/2016	11/7/2016
8	Task H. Governmental Costs of Worst Case SpillsResponse Costs	77	9/19/2016	12/5/2016
9	Task I. All Other Economic Damages of Worst Case Spills	56	10/17/2016	12/12/2016
10	Project Management, Report Assembly, Comments, and Meetings	316	4/19/2016	3/22/2016
10a	Develop and Issue Draft Report	121	9/20/2016	1/19/2017
10b	Address Comments on Draft Report and Issue Revised Report	11	2/6/2017	2/17/2017
10c	Address Comments on Revised Report and Issue Final Report	14	3/9/2017	3/23/2017



Each webinar constitutes a milestone, and is associated with a specific deliverable for an element or the draft / final report.

The above schedule reflects the Requested Approach, which generally develops a high level of detail for a complete list of aspects, and sums the results to achieve a view of the whole. The schedule for the alternative approach is detailed in Section 5.11.

5 REQUESTED APPROACH AND ALTERNATIVES

This section describes the methods that would be used to perform each of the requested elements of the Scope of Work. Section 2.1.1 lists the technical leader for each of the elements. DNV GL has a significant number of global resources with experience in detailed aspects of spill analysis, impact prediction, spill response, cleanup and restoration, and economic impact estimation. The most relevant supporting resources will make up the execution teams steered and quality assured by the team leaders.

Figure 1 lists the requested scope elements, which are described in Section 6.1 through 6.10. The labels for the tasks have been shortened from those in the Request for the ease of the reader.

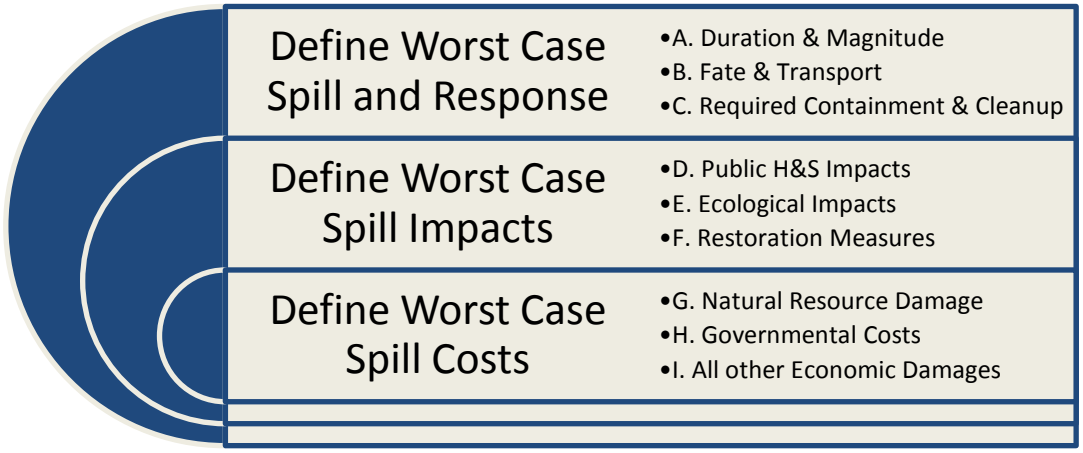


Figure 1 Requested Scope of Work

The stated objectives could also be achieved using semi-quantitative techniques appropriate for wide-scale assessments. This alternative approach would expedite the completion of the work while still achieving the stated objectives of the analysis, which are to identify the level of financial assurance required to cover worst case spills from the Straits Pipelines. The alternative approach is detailed in Section 5.11.

This proposal is based on use of existing scientific data on the environment and impact/cost effects from spilled products. Existing data and studies will be utilized; no new primary or academic research studies are included in this bid.

5.1 Task A. Duration and Magnitude of Worst Case Spills

This task will identify the specific scenarios that will be evaluated in the study, including the regulatory "worst case discharge" (40 CFR 194.5). They are expected to include:

- 3 hole size failures with differing volume / release duration
- 3 products/materials transported in the pipelines
- 2 seasons (summer/winter) represented in the weather and metocean data, including consideration of storm events

Because some products are shipped only during predictable months during a given year, it is anticipated that a maximum of 18 scenarios will be evaluated as “worst case” scenarios. The need to have several base case scenarios is driven by the variety in the outcomes that are evaluated later in the study. Not every product /season combination will need to be modeled, only combinations that will have unique impact sets.

The above combinations account for both sudden and long term releases in the different failure sizes. Based on our previous experience in hydrocarbon risk assessment, particularly with pipelines, longer duration smaller leak size (smaller hole in the pipe) events can release more product to the environment prior to being detected than very large hole, full pipe bore failure events. The duration and the types of impacts would be different for several of the outcomes/cost categories evaluated in the study.

As is common with hydrocarbon equipment risk assessments, procedural controls intended to minimize releases are accounted for only in relationship to the potential for a more severe event to occur – they might reduce or prevent such events. However, procedural and engineering controls have well documented failure frequencies, and so cannot guide an analysis of a worst case event. Exceptions can be made for high reliability equipment that is maintained as such, usually indicated as Safety Integrity Level – 3 (SIL-3).

Design aspects that will be reviewed to identify representative cases include:

1. Design of the existing pipelines
2. Location of the lines (GIS tools will be used in the models)
3. Control system logic and functioning
4. Leak detection methods and response philosophies
5. Shut-off valves, manual valves, and check valves (as relevant to the segment and scenarios being studied)

The estimate of potential worst case discharge volume will be calculated as a time-based discharge curve. The calculation will consider:

1. Leak rate through the hole size being considered at the pipeline design throughput and Maximum Allowable Operating Pressure (MAOP)
2. Time to isolate the section, which will include only high reliability engineered equipment and maximum detection times.
3. The volume of product that could leak out of the hole over time after the section is isolated. This will vary by product, and is highly dependent on elevation changes in the pipeline along the segment and where the hole in relationship to elevation changes in the line. For this Task, no volume reduction will be calculated for response efforts to reduce the spill volume by removing product trapped in the line. If the level of complexity warrants, a multiphase hydraulic Computational Fluid Dynamic (CFD) model will be used to calculate release of the trapped product from the line.

High resolution georeferenced data for the pipeline location and elevation will be needed from Enbridge for this work; together with historical and planned products through the lines; aspects of the control system, logic, and detection systems that might be considered in this study; precise locations of valves in and near the segment and philosophies concerning when and how they are activated. If any systems or items are SIL rated, more specific information concerning assurance of the rating will be requested. All other needed data is already in hand, has already been requested from Enbridge, or will be obtained from public sources.

5.2 Task B. Environmental Fate and Transport of Worst Case Spills

DNV GL proposes to use OSCAR software to study the environmental fate and transport of the products released by the worst case spills. Results are presented as probability maps for the different environmental compartments (water surface, water masses or shoreline). Results will take into consideration seasonal oil spills, accounting for ice coverage. Based on the project needs, DNV GL suggests to model the 18 scenarios defined in Task A.

The SINTEF OSCAR model (MEMW 7.0.1) is a 3-dimensional Oil Spill Contingency and Response model system that calculates and records the distribution (as mass and concentrations) of contaminants on the water surface, on shorelines, in the water column, and in sediments.

For a subsurface pipeline spill, the near field part of the simulation is conducted with a multi-component integral plume model that is embedded in the OSCAR model. The near field model accounts for buoyancy effects of oil and gas (if present), as well as effects of ambient stratification and cross flow on the dilution and rise time of the plume. The effect of lake stratification in the summer and turnover will be evaluated to assure the worst case effects are represented in the model.

The model output is recorded in three physical dimensions plus time. The model databases supply values for water depth, sediment type, ecological habitat, and shoreline type. The system has an oil physical-chemical database that supplies physical and chemical parameters required by the model.

The model computes surface spreading, slick transport, entrainment into the water column, evaporation, emulsification and shoreline interactions to determine oil drift and fate at the surface. In the water column, horizontal and vertical transport by currents, dissolution, adsorption, settling and degradation are simulated.

OSCAR may compute oil or product weathering from crude assay data, although more reliable results are produced if the target oil has been through a standardized set of laboratory weathering procedures established by laboratories. Alternatively, the model may use oil weathering properties from oils for which data already exists, selecting the crude oil in the oil database that most closely matches the composition of the oil of concern.

Both single spill scenarios and stochastic scenarios with variable start times can be simulated. In the stochastic simulations, both historical wind and high resolution current data is required. This is to cover the variations in oil drift and fate due to different wind and current situations. The set of scenarios to be run may be specified either by selecting the number of scenarios to be simulated within a specified time period (single year statistics), or by specifying the number of scenarios to be run each year in a specified season (multiyear statistics).

OSCAR accepts as input both 2- and 3-dimensional current data from hydrodynamic models, and single point or gridded wind data from meteorological models. For these one statistical run will comprise a large number of spills with a specified spill rate and duration with spill start distributed evenly within the period of years with available wind data. The number of spills to be simulated in one statistical run must be large enough to provide a basis for reliable oil drift statistics on a seasonal basis (winter, spring, summer and autumn), but the actual number required depends on the duration of each spill: in order to cover the total variability in wind and current data within the period with wind data, more simulations will be required for spills with short durations than for spills with long durations.

The present version of OSCAR model takes the ice-coverage as an adjusting parameter into the calculations. The fractional ice cover/ice concentration can be provided as grids similar to current, wind or habitat data.

The ice cover affects weathering, spreading, evaporation of surface oil, as well as drifting of oil with ice. The oil preserves in the ice and evaporation and down mixing will be reduced leading to more oil at the surface due to less influence by the wind compared to simulations without ice. Due to the special environmental conditions with ice, a second stage of response capability estimation can be utilized if needed. It is an empirical-based excel model the Oil Recovery Calculator (ORCA), which accounts for ice and logistical challenges. ORCA estimates the mass balance in defined areas, for instance in specific environmentally sensitive areas or at the ice edge. ORCA also estimates the mass balance for the total spill area.

In order to provide data for computing oil drift statistics, certain oil drift parameters are accumulated for each scenario in each impacted grid cell. These results are in the end used to calculate probabilities for impact in a given cell – defined in terms of exceeding certain threshold values for oil concentrations. T

Necessary input for a pipeline leakage modeling:

- Release location
- Water depth at location
- Spill rate and duration
- Area of leakage
- Gas/oil ratio (if gas is present)
- Physical oil characteristics (oil weathering study)

5.3 Task C. Duration of Activities to Contain and Cleanup Worst Case Spills

DNV GL proposes to assess the capabilities and limitations of existing spill response measures by evaluating the Area Contingency Plan (ACP), relevant Spill Prevention, Control and Countermeasures (SPCC) Plans, and Enbridge-specific response plans. Plans will be evaluated against both regulatory criteria and Lessons Learned from multi-agency pollution response exercises conducted in the Straits of Mackinac.

The assessment of response resources will include identification of all response resources that can be brought to bear on a worst case discharge and will include a tiered, response time-based categorization of available resources.

The assessment of response personnel will include an evaluation of state, federal, and local response agencies billeted and available personnel, training criteria, and exercise participation.

A thorough review of exercise and incident After Action Reports, Lessons Learned, and other relevant documents will be conducted to gain an understanding of the duration of activities that may be necessary to contain and cleanup a worst case spill.

DNV GL will rely on the cooperation of a number of agencies to acquire the necessary information to complete this task including the US Coast Guard, US Fish & Wildlife Agency, US EPA, MDEQ, MDNR, MSP, and others. DNV GL may request assistance from MDEQ (or other agencies) to facilitate acquisition of necessary reports, documents, etc.

A qualitative assessment of the aforementioned documents, combined with interviews with relevant agency plan holders, will be performed to evaluate the time and anticipated resource needs to contain and clean up

a worst case spill. DNV GL will identify potential interview subjects and vet them through the MPPTF to ensure adequate representation of the oil spill response community. To manage travel costs, it is envisioned that interviews will primarily be conducted telephonically, though in-person interviews may be conducted in conjunction with other task items, if feasible.

5.4 Task D. Short and Long Term Public Health and Safety Impacts

On April 20, 2010 an explosion, fire and hydrocarbon release from the Deepwater Horizon platform in the Gulf of Mexico resulted in the largest oil spill in U.S. history. In that incident workers, responders, marine life and eventually coastal populations were exposed to varying levels of hydrocarbons, particulate matter, aerosol particles and various gaseous combustion products such as carbon monoxide, carbon dioxide, and nitrous/sulfur dioxides as well as hydrogen sulfide. According to USEPA there were four sources of air pollutants from the Deepwater Horizon incident including:

1. Hydrocarbons evaporating from the oil on the surface,
2. Smoke from deliberately burning of oil slick,
3. Combustion products from flaring of recovered natural gas,
4. Emission from ships involved in the recovery/clean-up effort.

Although a pipeline release in the Strait of Mackinac would be much different in character it is anticipated that similar air pollutants could be generated from the three pipeline products if there was a full bore release, especially in the presence of an ignition source.

The results from Task B will be utilized to determine the distribution of the each released product in the water column, the surface spread of the product involved and any losses to atmosphere, without ignition (Figure 2).

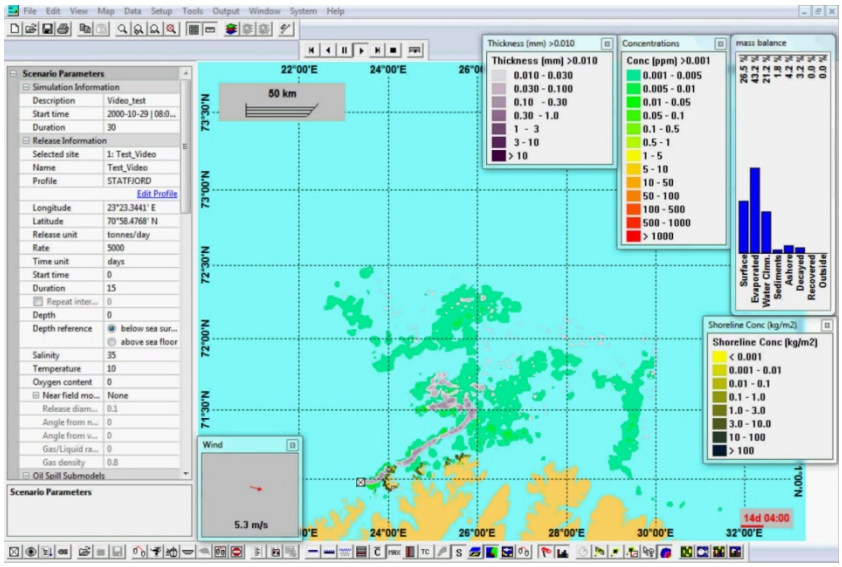


Figure 2 OSCAR Hydrocarbon Surface Model Output

Figure 3 illustrates the OSCAR model output for pollutants released into the water column as well as their general flow direction and concentration.

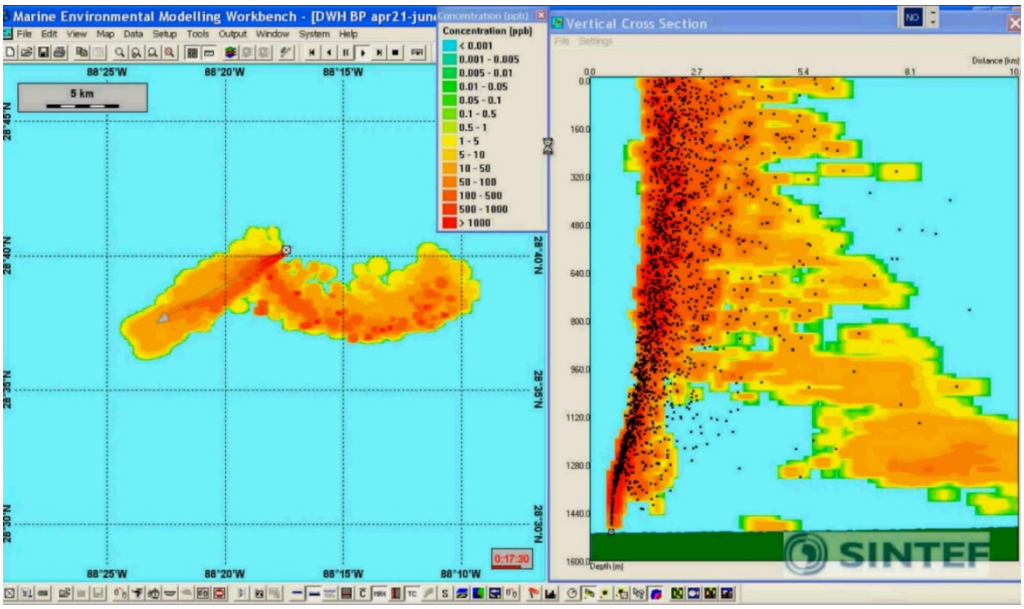


Figure 3 OSCAR Water Column Pollutant Model Results

OSCAR is also capable of modeling shoreline impacts given the volume released, air and wind currents and the distance from landfall (Figure 4).

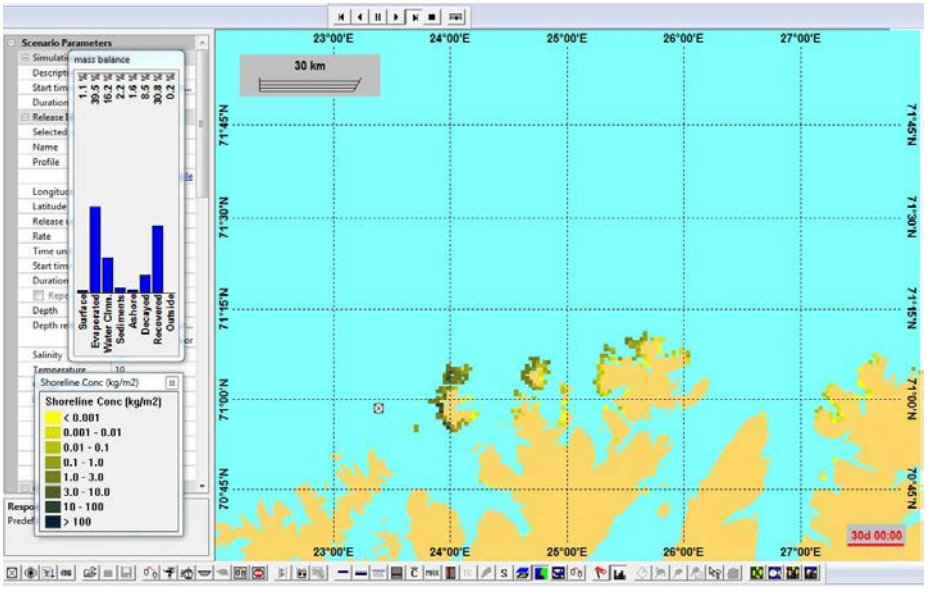


Figure 4 OSCAR Shoreline Impact Model Output

If there was an ignition scenario, then DNV GL PHAST software would be utilized to further define the extent of atmospheric pollutant plumes and or fire/explosion effects. PHAST is the world's most comprehensive process industry hazard analysis software tool for all stages of design and operation. PHAST examines the progress of a potential incident from the initial release to far-field dispersion including modelling of pool spreading and evaporation, and flammable and toxic effects.

To simplify the air pollutant study DNV GL would consider each product release as a single pollutant and consider the following measures:

- Maximum levels of pollutant in a given time period
- Averages of pollutant concentrations in a given time period
- Number of days the pollutant exceeds a standard in a given time period

Due to the high level of this study DNV GL would use OSCAR derived pollutant concentrations of the three products hypothetically released from the Enbridge pipelines and compare them to exposure concentrations documented in the product Material Data Safety Sheets (MSDS) as the initial standard for determining the levels of health risk to humans, flora and fauna species in the lake and/or near shoreline ecosystems and populations. The USEPA Drinking Water Act (Section 1400) and Hazardous Air Pollutants (Section 112) would be supplemental references for determining the extent of exposure to human, animal and plant species.

DNV GL believes that the OSCAR modeling results would be effective in determining those areas exceeding exposure standards outlined in product MSDS sheets for inhalation, ingestion and dermal contact. The modeling results would overlay at risk populations and environmentally sensitive environments to define a worst case exposure scenario for each product.

PHAST results would be used in a similar fashion to define thermal or overpressure contours that would result from fire and explosion events if they were realized due to the presence of an ignition source and the appropriate levels of product concentrations.

DNV GL's software tool PHAST is a comprehensive consequence modeling software tool designed to comply with the regulatory requirements of many countries. Specific modules have been included to ensure compliance with the Dutch Government, US EPA and UK HSE regulations. PHAST is an integrated consequence modeling package which models all stages of a release.

Impact thresholds are used in conjunction with the OSCAR and PHAST modeling to estimate the extent of the consequences to each category. DNV GL would then use a semi-quantitative approach to assessing impacted health on affected populations, and to the extent practicable from modeling results, determine whether or not the risks of exposure in zones that exceed MSDS threshold limit values will result in acute or chronic illness effects or degradation of natural flora and fauna.

Finally, depending upon the geographical distribution of the contaminated zone, DNV GL would estimate the potential health impact of the pollutants on the exposed public, aquatic ecosystems, recreational use and transport activities for the duration of the event.

5.5 Task E. Short and Long Term Ecological Impacts of Worst Case Spills

DNV GL has a long history developing spill risk methods and providing oil spill risk assessments, and was responsible for drafting the published International Oil and Gas Producers guideline on this topic published in 2013 (IOGP/IPIECA, 2013). Our approach is a quantitative impact assessment based on the overlap between the effect area (from the spill modelling in Task B), the distribution of ecological resources, and the sensitivity of these resources towards an oil spill (both on individual level regarding exposure and on population level regarding recovery). Available environmental sensitivity index maps and species distribution maps will be gathered and utilized for this work.

For the various environmental compartments, the effect area will be defined from the oil trajectory and fate as the area where predicted environmental concentrations are above the predicted no-effect concentration level ($P_{EC} > P_{NEC}$) for acute effects. The short term mortality will be quantified and assessed, and the long term ecological impact in will be assessed terms of recovery time of the affected natural resources. Data from historical oil spill events will be used as a reference for estimating the magnitude of impacts and the recovery rates of species and habitats.

Impacts will be described and assessed for:

- Water quality
- Fish and aquatic life
- Wildlife
- Shoreline habitats
- Air quality

Regarding air quality, it is envisaged that only one scenario will be examined focusing on an agreed list of pollutants. The oil spill source will be modelled to understand the dispersion effects under different meteorological conditions. The results (maximum ground level concentrations and concentrations at selected key receptors) will then be compared against relevant short term criteria and conclusions made.

5.6 Task F. Measures to Restore Natural Resources and Mitigate Ecological Impacts of Worst Case Spills

This task will identify specific measures that could mitigate ecological impacts from a spill making use of the results of previous tasks. The approach is to utilize well-established tools to obtain answers in new ways. The process is depicted in Figure 5.

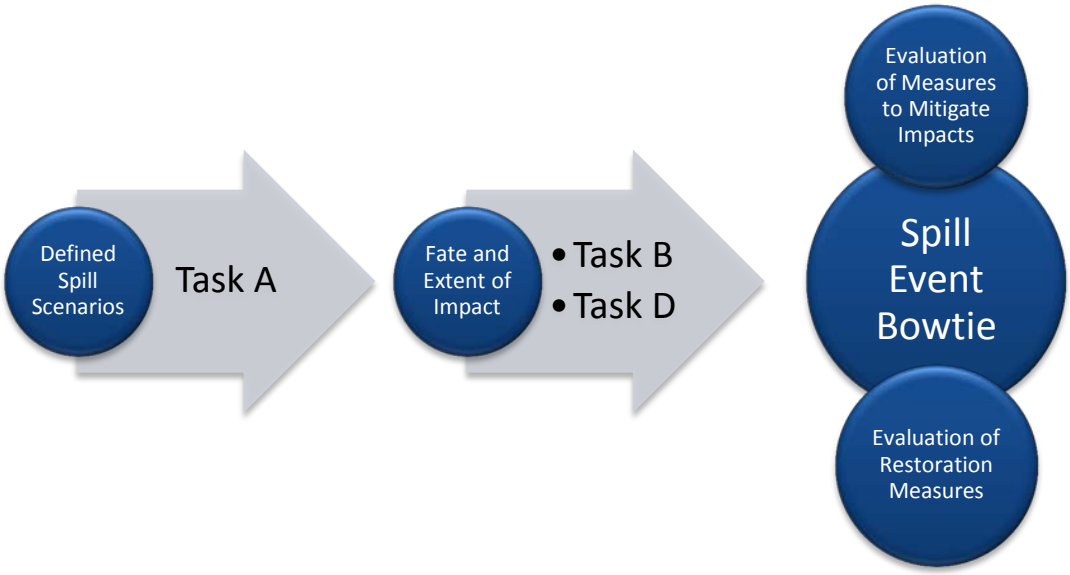


Figure 5 Task F Methodology

One of the key components of this task is one or more bowtie. A bowtie (Figure 6) is a well-known tool in the oil and gas industry, which is well suited to help identify and communicate risk controls, both preventive and mitigative in nature. The hazard being assessed is transport of hazardous material in a pipeline. The left hand side of the bowtie lists the threats and causes that could result in a loss of containment, or spill. The right hand side lists the consequences and effects from the spill. In between are barriers, which could independently reduce the frequency or severity, or prevent them altogether.

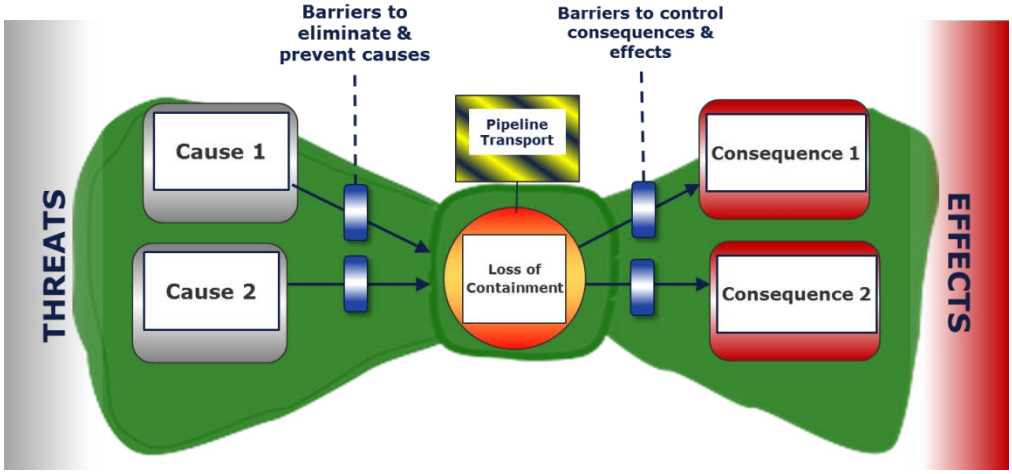


Figure 6 Example Bowtie

The number of bowties will depend on the significance of the differences between the 18 scenarios selected for evaluation. The bowties will be developed in a workshop attended by the technical leads and other key participants that may be identified in the early portion of the study.

Once potential measures are identified, they will be evaluated per affected resource concerning:

- Effectiveness in reducing risk. Effectiveness will be evaluated in a semi-quantitative manner at a sufficient level of detail to allow differentiation between the options.
- Implementability and availability. It is imperative that all recommendations could be enacted and then verified, and that the means to do so is reasonably obtainable. The evaluation will initially be done in a workshop format, with any remaining technical actions followed up by subject matter experts.
- Cost (to facilitate transparent comparison between options).

5.7 Task G. Natural Resource Damages from Worst Case Spills

Building on the results from Task B Environmental Fate and Transport, DNV GL will assess the impacted areas and estimate the associated potential natural resource damage. Scientific principles that will guide the assessment are outlined in 43 CFR Part 11, federal Natural Resource Damage Assessment (NRDA) regulations. Applicable NRDA principles and practices will guide this work, such as published by the Ad-Hoc Industry Natural Resource Management Group (2014). Existing data will be used to support the damage estimate. Any data gaps will be filled in using efficient estimation techniques, relying on expert judgment (if needed, a group of experts). When judgment is used, a discussion of uncertainty will be provided in the report.

The results from Task B will be used to identify potentially affected aspects and their services. A thorough literature review will gather existing data on ecological and natural services and economic conditions, omitting speculative services. Comparative valuations and direct economic contributions will provide input to develop upper and lower bounds for initial damage and residual damage following restoration. The value of temporarily unavailable services will be included in the estimate. Restoration costs will similarly be based on experience with previous projects and literature.

5.8 Task H. Governmental Costs of Worst Case Spills

The resource demands on federal, state, tribal, and local governments for responding to the spill, monitoring cleanup activities, incident oversight, and damage assessment activities will be determined in Task C, Duration of Activities to Contain and Clean up Worst Case Spill.

DNV GL will reference U.S. Coast Guard guidance for determining removal costs for oil discharges to determine governmental costs of a worst case spill. The response activities, resources, and duration (including monitoring, oversight, and damage assessment) will be assessed against reimbursable standard rates in USCG Commandant Instruction 7310.1 for all federal, state, tribal, and local government resources that may be expended on a worst case spill.

5.9 Task I. All Other Economic Damages of Worst Case Spills

This task will consist of first identifying economic damages that are not included in the other tasks using a data gathering and brainstorming method. Input will be sought from relevant stakeholders to assure all possible damages are identified, although they will be evaluated for credibility prior to the next step.

The guidewords to help identify and categorize the types of damages will include:

- Fishing and hunting (subsistence, commercial, and sport)
- Navigation (commercial and recreational)
- Tourism and recreation-related businesses
- Other industries and businesses
- Loss of value (real estate, business, and personal property)
- Loss of tax revenue (e.g., sales, property, business)
- Replacement of product at end use (e.g., household heating and feed stock)
- Replacement of water at end use (e.g. drinking water, cooling water, fire water)
- Healthcare costs
- Other general economic impacts

Following this, an evaluation will be conducted of the credibility of each of the potential damages, which will include a literature review and litigation review. “The next portion of this task will be to collect relevant historical data such as historic incidents, incident reports, socio-economic studies, and collect value data on property, industry revenue, tax revenues, and alternatives for the products.

Finally, estimates will be developed and transparently documented so interested parties can provide additional input, feedback, and comments.

5.10 Deliverables and Communication

The deliverables will include:

1. **Monthly status reports and presentations of Task results.** This is envisaged in a webinar format, but can be conducted in person if desired. The advantages of a webinar format include: easy to hold with any number of desired participants; support presentations by experts wherever they may be located; reduced project time/resources spent on meetings so there is no efficiency driver to minimize the number of meetings. As a result of frequent updates, each task’s results will be presented as the project progresses, and participants who want to understand the details will have opportunity to ask questions without waiting for comment responses in writing. A number of these can be selected to include public information presentations.
2. **Draft Task Appendices.** These will be issued concurrently with the monthly status webinar, and we will request that comments be provided on the issued draft task reports prior to the next monthly meeting. This approach enables the team to learn even more about what is important to stakeholders/reviewers early in the project.

3. **Draft Report**. This document will be issued as a main report supported by the previously-issued appendices, updated per comments. Up to two sets of consolidated comments will be formally responded to and updates made to the report.
4. **Final Report**. The final report will be issued and presented in a public information presentation.

5.11 Alternatives and/or Optional Work

The intent of the request is to meet one of the specific recommendations in the Michigan Petroleum Pipeline Task Force Report (2015), to "Require an independent risk analysis and adequate financial assurance for the Straits Pipelines."

This alternative approach would expedite the completion of the work at reduced duration and cost while still achieving the stated objectives. The Task Force recommendation can be achieved through use of semi-quantitative risk assessment techniques appropriate for wide-scale risk assessments. Quantitative techniques would still be applied when appropriate and every risk contributor will still be accounted for at a level commensurate with its overall risk contribution.

Given certain characteristics in an assessment, a reduction in complexity of a risk assessment can be a more optimal use of resources, including time. Aspects of the Straits Pipelines risk picture that would support simplification have the following characteristics:

- Not significant contributors to the overall risk, and
- Estimable to a reasonable level of certainty using simpler techniques, and increased granularity does not provide value concerning selection of mitigation options

Quantitative techniques will be used for aspects that meet one of the following criteria:

- A high level of granularity is needed to allow comparison and selection of mitigation options
- The Requested Approach is the most simple or more efficient method to estimate the risk

This approach offers the following additional benefits:

1. Suggested risk tolerance criteria in terms of frequency, will be based on duration and impact level
2. An understanding of how worst case spill impacts change seasonally
3. An understanding of the time of year that each suggested mitigation measure would provide impact reduction and how much reduction each one offers.

DNV GL's alternative approach is based on the methodology shown in Figure 7.

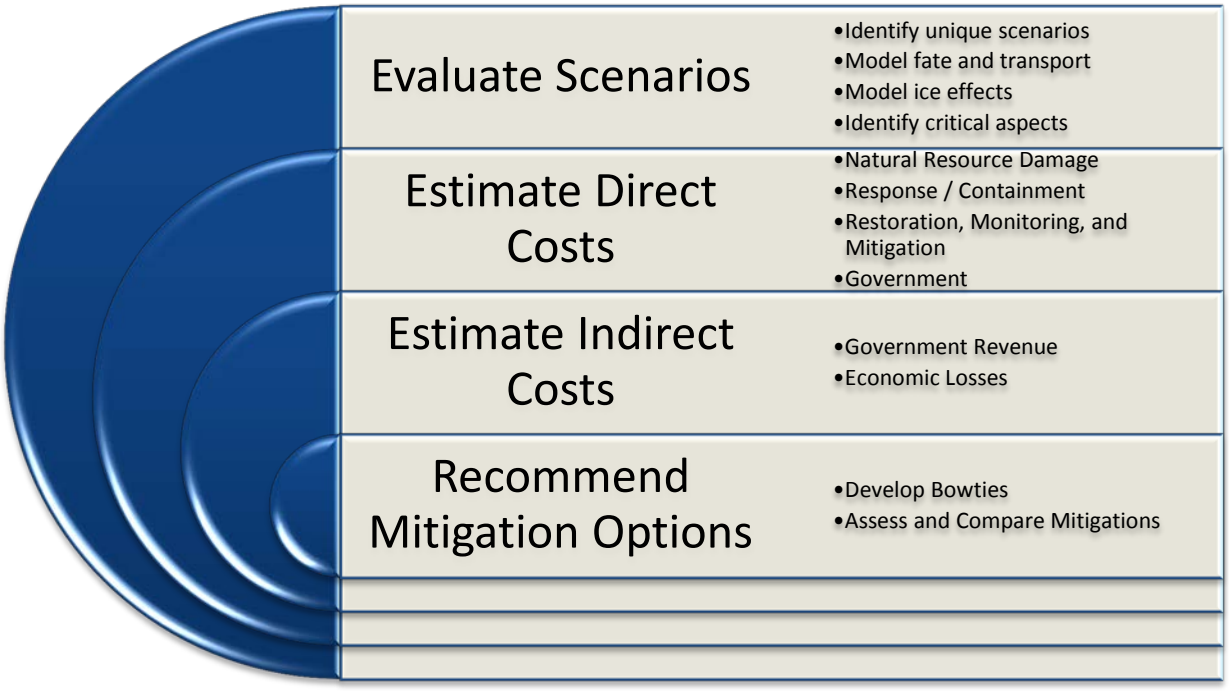


Figure 7 Alternative Assessment Methodology and Project Phases

Publicly available data sources are expected to provide the data needed for this alternative proposal. The same project leadership is put forward, as described in previous Section 2.

The proposed tasks are described in the sections that follow.

5.11.1 Phase 1 - Evaluate Scenarios

This task will first define the worst case spill scenarios and then estimate the extent of risk to receptors. Several models will be applied to achieve these outcomes, as shown in Figure 8. No new data will need to be gathered, as existing datasets will be used as inputs to the models.

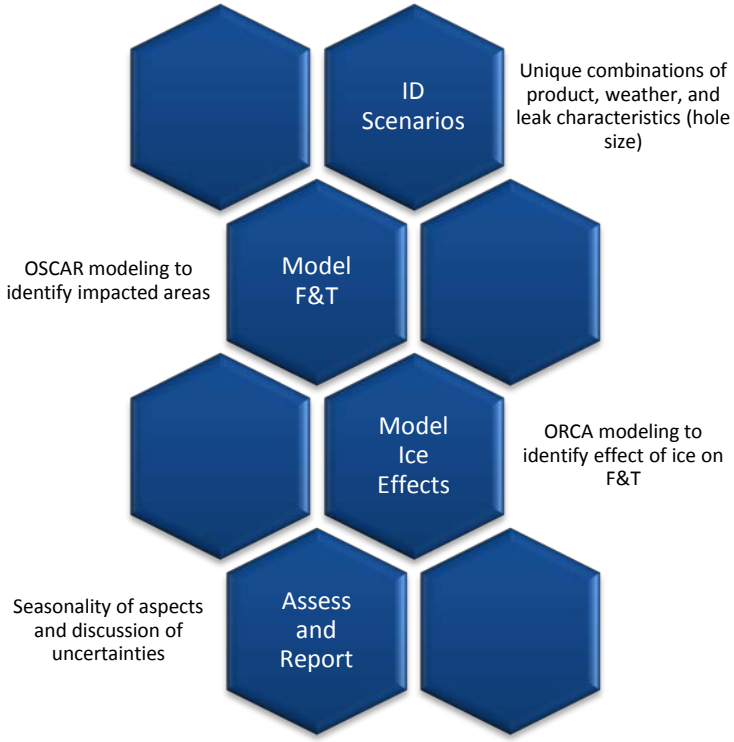


Figure 8 Method to Evaluate Scenarios

Input will be requested concerning the following proposed 18 worst case scenarios:

- 3 pipeline products
- 2 seasons (wind, wave, current, and atmospheric stability inputs)
- 3 leak types (small hole, medium hole, and full bore failure and their relevant detection times)

The definition in 40 CFR 194.5 will be used to guide selection of which design features are accounted for in the analysis, such as the leak detection system, the emergency shutdown system, and check valves in the lines.

Section 1 Task B, describes the OSCAR and ORCA models, so the discussion is not repeated here. In contrast to the approach in that section, this alternative approach suggests conducting only one OSCAR/ORCA model for a single representative event. Modeling only one scenario is not recommended when quantification of all aspects and many receptors is required (as for Task B), but this simplified approach allows efficient use of a single model using scaling factors to estimate the results for the other scenarios, instead of conducting 3D modeling for all of them.

The seasonality of the products flowing through the lines and various weather/environmental conditions will be captured and reported to provide a clear picture of how the scenarios vary over time. The critical inputs, assumptions, and uncertainties will be described to provide transparency to the methodology.

5.11.2 Phase 2 - Estimate Direct Costs

Direct costs will be estimated in this Phase. In contrast to the Requested Approach, a risk-based approach will be used to assess the level of environmental risk and suggest risk criteria for the area. The resulting costs will be estimated to an uncertainty equal to or less than half of a multiple of ten. For example, an estimate might be $10,000,000, with an implied uncertainty of ±$5,000,000. The principle of providing an estimate "within an order of magnitude" is a guiding principle upon which this alternative proposal is based.

This principle allows clear communication and understanding of upper and lower boundaries. Uncertainties in a fully quantified assessment are similarly large, but they are not frequently discussed or measured. This method allows a transparent discussion of uncertainties, and is appropriate for high level risk assessments where the summed risk result is affected by a comparatively low number of potential contributors.

At a minimum, the aspects to be quantified will include:

- Natural Resource Damage. The standard practices in NRDA estimation will be applied, but a screening process will be used to identify those aspects that contribute to the total; the aspects comprising less than 1% of the total will not be estimated.
- Spill response and spill containment costs include initial cleanup actions such as removing hydrocarbon-laden sediments/soils. A matrix will be applied to estimate the costs per extent of affected environmental media. The extent is an output of the Scenario Evaluation task, and so can be directly used to estimate these costs. DNV GL developed a matrix directly applicable to very sensitive and highly valued environmental aspects. The matrix was created based on experience with response and remediation planning, and initially developed for areas with potential for ice to affect the efficiency of the response. It will be adjusted to apply to the specific environment in this study.
- Restoration, monitoring, and mitigation. Similarly, a matrix of extent vs. restoration cost will be adjusted and applied to estimate the costs of these activities. Costs of specific mitigation activities will be estimated separately after mitigations are identified in the final step of this approach.
- Government expenditures related to the spill. Similar to the discussion in Section 5.8 Task H, activities and costs borne by the government will be estimated. In keeping with the philosophy of this alternative, the estimates will be within half an order of magnitude for those costs that contribute more than 1% of the total government cost.

The scale of the unmitigated spill will be evaluated on a source-pathway-receptor model considering severity and duration. The risk tolerability criteria will be an output of the screening assessment. The impacts will be categorized as short term, medium term, long term, and very long term, and also on a scale of significance, from significant to catastrophic, per receptor category.

5.11.3 Phase 3 - Estimate Indirect Costs

Indirect costs will include, at a minimum, consideration of lost revenue, wages, and income due to impacts to:

- Fishing and hunting (subsistence, commercial, and sport)
- Navigation (commercial and recreational)
- Tourism and recreation-related businesses

- Other industries and businesses
- Loss of value (real estate, business, and personal property)
- Loss of tax revenue (e.g., sales, property, business)
- Replacement of product at end use (e.g., household heating and feed stock)
- Replacement of water at end use (e.g. drinking water, cooling water, fire water)
- Healthcare costs
- Other general economic impacts

It is within this scope to review additional aspects as they are brought to the attention of the project team during the work, as a screening process will be applied, so that only aspects that contribute more than 1% of the total will be estimated.

In keeping with the general philosophy for this alternative, the approach will be to efficiently estimate major contributors and allow a high level of uncertainty. Improved, quantitative estimates will be developed if the uncertainty becomes too large to support decision making. This could occur if several of the aspects listed above have costs on a similar scale (e.g., several within 1 million to 10 million dollars).

5.11.4 Phase 4 - Recommend Mitigation Options

Once the risks are well understood as a result of work in the above Phases, bowties will be developed to communicate and understand the existing risk mitigation measures. Once developed, a workshop will be held to identify additional measures that will be evaluated concerning:

- Effectiveness in reducing risk. Effectiveness will be evaluated in a semi-quantitative manner at a sufficient level of detail to allow differentiation between the options.
- Implementability and availability.
- Cost (to facilitate transparent comparison between options)

5.11.5 Deliverables, Schedule, and Budget

The deliverables will correspond to the Phases of the work:

1. Phase 1 Worst Case Spill Scenario Evaluation Report
2. Phase 2 Worst Case Spill Direct Cost Report
3. Phase 3 Worst Case Spill Indirect Cost Report
4. Phase 4 Worst Case Spill Mitigation Options Report
5. Draft and Final Reports containing all of the previous work as chapters, plus a summary and conclusions

The schedule for the alternative scope is significantly compressed, with delivery of the Draft report within 6 months or less of project kickoff. The key factor in the schedule will be obtaining high resolution metocean data for the area, which could be initiated prior to the kickoff. Given similar assumptions concerning review periods proposed for the Requested Approach, closure of the project would occur in less than 9 months from the kickoff. Similar to the Requested Approach, monthly webinars / meetings will be

held to assure the project work continues to align with the intent and that sufficient communication occurs to allow relevant parties to consider and provide feedback on the approaches and assumptions as they come up during the course of the work.

The fixed fee budget for the alternative scope is $294,500. Payment milestones can be negotiated based on deliverables.

6 PROPOSED BUDGET

This section presents the proposed budget for all time and materials for completing the tasks identified in the Requested Scope of Work. This budget is valid until December 31, 2017.

The scope of work in this project strongly reflects DNV GL's purpose to safeguard life, property and the environment. As such, the below budget reflects a 15% discount on standard US rates for risk assessment work in oil and gas.

Recommendations about potential prioritization of, or changes to, the tasks identified in the Scope of Work that could reduce the cost of the work while still achieving the stated objectives of the Analysis are provided in Section 5.11.

6.1 Invoicing and Payment

Invoicing will be according to the following milestones:

Task	Suggested Milestone Payment
Define Worst Case Spill and Response	
A. Duration & Magnitude	$37,500
B. Fate & Transport	$70,000
C. Required Containment & Cleanup	$39,000
Define Worst Case Spill Impacts	
D. Public H&S Impacts	$84,500
E. Ecological Impacts	$77,500
F. Restoration Measures	$59,000
Define Worst Case Spill Costs	
G. Natural Resource Damage	$50,500
H. Governmental Costs	$48,500
I. All other Economic Damages	$72,500
Draft Report	$108,500
Final Report	$108,500
TOTAL	**$756,000**

Payment shall be within 30 days of the invoice date.

A similar milestone payment scheme can be agreed for alternate proposal.

7 CONTRACTUAL ITEMS

7.1 Contract Basis - Terms and Conditions

DNV GL has issued the present proposal based on the assumption that the DNV GL - General Terms and Conditions in Appendix A shall form the contractual basis for this project.

7.2 Assumptions, Conditions and Limitations (All)

In addition to assumptions, conditions and limitation explicitly stated elsewhere in this document, this proposal is issued on the basis of the following assumptions, conditions and limitations with respect to deliverables, scope of work, schedule, costs etc.:

1. Travel costs are included for up to 4 in-person meetings for 2 persons each. Additional meetings / travel should be agreed between the parties, and may incur additional cost. All webinar costs are included in the travel costs. Planned travel includes 4 visits to the project area for 2 people, which are planned for project kickoff, two public presentations, and project closure.
2. The budget assumes that all comments will be assembled and provided to DNV GL as a single set per deliverable. Significant inefficiencies result from “trickle- in” of comments over a period of weeks.

8 PROJECT RISK MANAGEMENT AND CONFLICT OF INTEREST

8.1 Information Relevant to Potential Actual or Apparent Conflicts of Interest

This project does not pose conflict of interest issues for DNV GL, as we provide risk advice to public companies, governments, and rulemaking bodies as a part of fulfilling our purpose. DNV GL is a global company with a broad presence in pipeline risk. Our first pipeline code was issued in 1976. It has achieved global recognition, winning prestigious industry awards and currently 65% of all new projects globally are designed to it. We have conducted over 1,000 projects assessing pipelines in the U.S. in the past 10 years. Since 2013, Det Norske Veritas (U.S.A.), Inc. has performed 124 separate projects for Enbridge or its affiliates. Eight projects are ongoing, including a JIP, several training courses, metallurgical analysis, decommissioning support, and operations/integrity advisory services. This is how we have gained a deep understanding of pipeline risk, and are widely recognized as the leading provider of risk management services regarding pipelines.

Since we are an independent party, some of these projects were conducted for operators, some for government agencies, and some for separate entities. The quality and integrity of our work is not dependent on who our customer is.

As a global organization, DNV GL maintains its position as an independent party providing risk assessment services through strict implementation of integrity principles: we never certify our own work. As a result, a review was undertaken to ascertain whether we could conduct the requested scope without reviewing our own work. The conclusion is that no special knowledge about the pipeline or the management decisions of Enbridge are relevant to this scope of work, and the knowledge we corporately have is not an advantage or disadvantage regarding execution of the work. To assure that no issues arise, no members of the project team are working or will work on projects for Enbridge during the execution of this scope.

8.2 Factors Critical to Success and Project Risk Management

Based upon past relevant engagement history, DNV GL recognizes that high-level risk assessment projects have several critical success factors:

- Knowledge of Industry Leading Practices in Risk Management: At the core of all of our services is a thorough understanding and first-hand experience leading risk management practices across multiple industries.
- Experience in Diverse Risk Categories: Our experience base encompasses a wide range of CI and functional areas, including operations, legal, compliance, financial, human capital, customer and strategic planning.

Below are the identified primary project risks and proposed mitigations to manage those risks to an acceptable level.

Project Risk or Barrier	Mitigation
Inability to gain consensus around key decision points in the project scope, such as priorities for weather-related scenarios, geographic extent, and systems/assets to be included.	Hold weekly webinars to gain broad support for the work and the approaches used in the work.
Lack of early engagement by key stakeholders; project delays caused by any party.	Leverage project team member skills in facilitation and consensus building, which is part of the core of DNV GL's advisory business Monitor the project schedule progress against the schedule baseline on a weekly basis, providing progress reports to the CAM at the agreed intervals, and at lesser intervals, should significant deviations be detected.
Inaccurate or incorrect information or data provided to the project.	Build trust among key stakeholders. The most likely cause of a stakeholder providing inaccurate or incorrect data is misunderstanding about how the data will be used and applied. A relationship of trust built with each of the key stakeholders will form a foundation upon which routine communication and exchange of knowledge and ideas will be a normal part of the work as it progresses.
Perception that DNV GL might have a conflict of interest.	No members of the project team are working or will work on projects for Enbridge during the execution of this scope.

9 REFERENCES

The following data sources and scientific publications are cited in this proposal.

Ad-Hoc Industry Natural Resource Management Group, “Beyond the Headlines: Best Practices to Restore Natural Resources Injured by Long-Term Hazardous Waste Releases, Oil Spills and Transport and Other Accidents”, Bloomberg BNA Daily Environment Report, August 18, 2014.

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International Oil and Gas Producers/IPIECA. Oil spill risk assessment and response planning for offshore installations, Final report, 2013. Available from:
http://oilspillresponseproject.org/sites/default/files/uploads/JIP%206%20-%20Oil%20spill%20risk%20assessment.pdf.

APPENDIX A
Det Norske Veritas (U.S.A.), Inc. Standard Terms and Conditions

1.0 Execution

1.1 DNV GL shall execute the Work in a professional manner and in accordance with the provisions of this Agreement. Customer is defined previously in the Agreement. This Agreement, which includes DNV GL's proposal, is business sensitive to DNV GL and is being transmitted to Customer as CONFIDENTIAL. No part of the proposal may be duplicated or used, or disclosed for any purpose other than to evaluate the proposal.

1.2 Any documented error or defect in the Work will be rectified by DNV GL within a reasonable period of time at DNV GL's sole cost, provided said error or defect is not attributable to Customer or Customer's subcontractor and DNV GL is duly notified of said errors or defects within six months after completion of the Work.

1.3 In no event shall DNV GL or its employees or agent have any obligations or liability for any loss or damage of any nature which results from performing the Work to industry standards or practices, or from errors or omissions due to incorrect, incomplete, insufficient information, data, software, drawings, and/or specifications or preparation provided by Customer.

2.0 Safety, Health and Environment (SHE)

2.1 Customer shall inform DNV GL of any real or potential SHE hazard which may be relevant to or involved or introduced in the Work and/or any necessary safety measures required for the Work, prior to or during the performance of the Work.

2.2 Whenever DNV GL undertakes work on site, Customer shall provide all adequate safety measures to ensure a working environment that is safe and in accordance with all relevant legislation.

2.3 The DNV GL employee has the right to refuse to carry out an activity, when the safety, according to his/her own judgment, is not satisfactory.

3.0 Remuneration

3.1 Customer shall pay DNV GL for the Work, as specified in this Agreement. Payment shall be made to DNV GL's bank account as stated on the invoice unless otherwise specified in this Agreement.

3.2 Prices quoted are exclusive of VAT, any other local sales taxes and/or withholding taxes.

3.3 Payment shall be made within 30 days after receipt of the invoice. For late payment, interest will be charged at a rate of 1% per month or part thereof.

4.0 Variations

4.1 Customer shall be entitled to request additional work (hereinafter referred to as "variations") under this Agreement.

4.2 All variation requests shall be in writing, clearly defining the variation required, including but not limited to remuneration and time schedule.

4.3 No variation shall be implemented before the parties have reached an Agreement regarding the extent and the remuneration thereto and the revised time schedule.

5.0 Termination

5.1 Customer shall have the right to terminate this Agreement at any time upon 30 days written notice to DNV GL.

5.2 In the event of termination according to article 5.1 above, Customer shall reimburse DNV GL for all Work performed up to the date of termination and all costs and expenses reasonably incurred by DNV GL as a consequence of such termination.

5.3 Both Customer and DNV GL shall have the right to terminate this Agreement with immediate effect if the other party is in material breach of its obligations hereunder, if the other party goes bankrupt or enters into liquidation proceedings.

6.0 Confidentiality

6.1 Customer and DNV GL mutually agree not to disclose to any third party without the prior written consent of the other party, any information obtained from the other party related to this Agreement.

6.2 However, each party shall be free to disclose such information as:

a) is known by it prior to the information being disclosed by the other party, or
b) is part of the public domain at the time of disclosure, or
c) has been independently developed by that party without reference to the other party's confidential information, or
d) has been made known to the party by a third party without restriction on disclosure, or
e) is required to be disclosed by public authorities in accordance with applicable law.

6.3 Both parties may disclose information to their subcontractors without prior written consent to the extent necessary to complete the Work, provided that a written confidentiality agreement reflecting the principles above is entered into with such subcontractors.

6.4 In the event DNV GL receives a subpoena or other validly issued administrative or judicial process demanding Confidential Information of Customer, DNV GL shall promptly notify Customer and tender to it the defense of such demand. Unless the demand shall have been timely limited, quashed or extended, DNV GL shall thereafter be entitled to comply with such demand to the extent permitted by law. If requested by Customer, DNV GL shall cooperate (at the expense of Customer) in the defense of a demand.

6.5 The obligations of both parties as defined in this article shall apply notwithstanding the completion of the Work or termination of this Agreement.

7.0 Intellectual Property Rights

7.1 Customer shall have full ownership rights to the deliverables developed by DNV GL as part of the Work, unless otherwise specified. DNV GL shall, subject to this Agreement on a royalty free basis, have free use of such deliverables.

7.2 Any writings (including but not limited to photographs, diagrams, models and computer programs) developed during the course of the Work which are not part of the deliverables, shall be the exclusive property of DNV GL.

7.3 Notwithstanding the above, both parties agree that any pre-existing intellectual property rights and any improvements thereto remain the property of the party who developed them.

7.4 Any inventions, whether patentable or not, developed by DNV GL in the course of the Work shall become the property of DNV GL. Customer shall have the right to use such results and inventions for its own purpose, and in performing its own business, but may not sell or transfer such results and inventions to any third party.

8.0 LIABILITY AND INDEMNITY

8.1 DNV GL SHALL INDEMNIFY AND HOLD HARMLESS CUSTOMER FROM AND AGAINST ANY AND ALL LOSSES, CLAIMS AND LIABILITIES RELATED TO OR ARISING OUT OF THIS AGREEMENT AS A RESULT OF:

a) DEATH OR PERSONAL INJURY TO ANY EMPLOYEES, REPRESENTATIVES OR SUBCONTRACTORS OF DNV GL,
b) THE LOSS OF OR DAMAGE TO PROPERTY OF DNV GL OR ITS EMPLOYEES, REPRESENTATIVES OR SUBCONTRACTORS,

HOWSOEVER CAUSED. THIS APPLIES REGARDLESS OF ANY FORM OF LIABILITY, WHETHER STRICT OR BY NEGLIGENCE, IN WHATEVER FORM, ON THE PART OF CUSTOMER EXCEPT IN THE INSTANCE OF GROSS NEGLIGENCE AND/OR WILLFUL MISCONDUCT.

8.2 CUSTOMER SHALL INDEMNIFY, DEFEND AND HOLD HARMLESS DNV GL FROM AND AGAINST ANY AND ALL LOSSES, CLAIMS AND LIABILITIES RELATED TO OR ARISING OUT THIS AGREEMENT AS A RESULT OF:

a) DEATH OR PERSONAL INJURY TO ANY EMPLOYEES, REPRESENTATIVES OR SUBCONTRACTORS OF CUSTOMER,

b) THE LOSS OF OR DAMAGE TO PROPERTY OF CUSTOMER OR ITS EMPLOYEES, REPRESENTATIVES OR SUBCONTRACTORS,

HOWSOEVER CAUSED. THIS APPLIES REGARDLESS OF ANY FORM OF LIABILITY, WHETHER STRICT OR BY NEGLIGENCE, IN WHATEVER FORM, ON THE PART OF DNV GL EXCEPT IN THE INSTANCE OF GROSS NEGLIGENCE AND/OR WILLFUL MISCONDUCT.

8.3 Save and except as provided in Articles 8.1 and 8.2 above, each party shall be responsible for and accept full liability for its own acts or omissions leading to the loss of or damage to any third party.

8.4 IN NO EVENT SHALL EITHER PARTY HERETO BE LIABLE TO THE OTHER FOR ANY LIQUIDATED, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY TYPE, INCLUDING BUT NOT LIMITED TO LOSS OF BUSINESS, LOSS OF PROFITS, LOSS OF USE, OR LOSS OF PRODUCTION.

8.5 EXCEPT AS STATED IN ARTICLES 1.2 AND 8.1 ABOVE, DNV GL'S MAXIMUM CUMULATIVE LIABILITY ARISING OUT OF OR RELATED TO THIS AGREEMENT SHALL BE LIMITED TO AN AMOUNT EQUAL TO TEN TIMES THE REMUNERATION PAID TO DNV GL BY CUSTOMER UNDER THIS AGREEMENT OR USD 300,000 (OR THE EQUIVALENT THERETO), WHICHEVER IS LESS.

8.6 If either party becomes aware of any incidents likely to give rise to a claim under the above indemnities, he shall notify the other party immediately.

9.0 Insurance

9.1 Both Customer and DNV GL agree to maintain a general liability insurance amounting to no less than USD 1,000,000 (or the equivalent thereto) to cover amounts either Party may be liable to pay pursuant to the conditions in Article 8 of this Agreement or governing law.

10.0 Force Majeure

10.1 Except for Customer's duty to pay DNV GL for the Work, delay in or failure of performance of either party hereto shall not constitute a default hereunder or give rise to any claim for damage if and to the extent such delay or failure is caused by any event beyond the control of the party affected, which the party had no reasonable way of preventing or grounds to anticipate, including but not limited to an act of war, natural disaster, fire, explosion, labor dispute. The affected party shall immediately notify the other party in writing of the causes and expected duration of any such occurrence.

11.0 Attorney's Fees

11.1 If any action or proceeding is brought to enforce, protect, or establish any right or remedy with respect to this Agreement, the prevailing party shall be entitled to recover reasonable attorney's fees.

12.0 Non Solicitation of Employees

12.1 Customer agrees that it will neither directly nor indirectly, on its own behalf or in the service or on behalf of others, solicit, divert or hire for work or attempt to solicit, divert or hire for work in any competing business any person or person who provided services to Customer by virtue of his/her employment with DNV GL, whether or not such employment is pursuant to a written contract with the other party or is for a determined period or at will, for a two year period following the conclusion of the relevant individual providing services to Customer via his/her employment with DNV GL.

13.0 Law

13.1 This Agreement shall be governed and construed in accordance with the laws of **Texas**, without regard to principles of conflicts of law.

13.2 Any dispute arising out of, in relation to, or as a consequence of this Agreement, which cannot be settled amicably through negotiations between the parties, shall be brought exclusively in the federal or state courts of **Harris County, Texas**.

14.0 Entire Agreement

14.1 This Agreement contains all covenants, stipulations and provisions agreed upon by the parties hereto, and neither party shall be bound by nor be liable for any statement, representation, promise or Agreement not set forth herein. No changes, amendments or modifications of the terms hereof shall be valid unless in writing and signed by both parties.
If Customer issues a purchase order, the general terms and conditions stated on the reverse side of the purchase order are null and void. The purchase order is governed by and subject to the terms and conditions of this Agreement which shall govern in all circumstances.

APPENDIX B
Resumes

Cheryl L Stahl

Senior Principal Consultant

Curriculum Vitae:

Academic and Professional Attainment:

Bachelor of Science w\Honours, University of South Florida, Chemistry, 1985

Summary of Professional Experience:

More than 25 years experience in environmental risk management, due diligence, project management and compliance. Career experience includes project management of multi-faceted analyses to identify cost-effective solutions to HSE and related business challenges.

Present Position:

Ms. Stahl is currently a Senior Principal Consultant in Environment and Navigation Risk Section. She provides risk management advice to clients and leads teams who provide services in risk identification, quantification, and management, including management systems and implementation of risk mitigation measures Recent work includes risk assessments of hazardous cargo transport risk, risk-based due diligence, risk framework development at an enterprise level, oil spill risk management, development of a management system, environmental accident investigation, and regulatory research.

Publications and Papers:

Terminal and Transportation Risk Assessment for LNG Export in North America, Offshore Technology Conference 2015, H. Hamedifar, C. Spitzenberger, C. Stahl, A. Brown, B. Nilberg, V. Demay, and O. Aspholm.

Practical Leadership for Sustainable Business: Health and Safety Management, Chapter 5 Risk Management, September 2014, DNV GL Business Assurance. MSM Course Textbook

When Will the Great Lakes Have LNG Bunkering? Great Lakes Seaway Review, January 7, 2015. D Holden, A Brown, C Stahl. Article picked up by gCaptain. http://gcaptain.com/will-great-lakes-lng-bunkering/.

Liquefied Natural Gas (LNG) Bunkering Study, Chapter 4 Regulatory Gaps, U.S. Maritime Administration, C Stahl, September 2014.

Framing a Business Case for Sustainability, Oil Sands & Heavy Oil Technologies Conference and Exhibition, C. Stahl, July 2009, Calgary, Alberta.

Reducing Spill Risk from a Corporate Perspective, International Oil Spill Conference, C. Stahl, May 2008. Savannah, Georgia.

Risk Based versus Consequence Based Response Planning. Clean Gulf Conference. C Stahl, November 2007. Tampa, Florida.

Consequences of LNG Marine Incidents, Center for Chemical Process Safety Conference, R M Pitblado, J Baik, G J Hughes, C Stahl-Ferro, S J Shaw, July 2004, Orlando, Florida..
http://www.energy.ca.gov/lng/documents/CCPS_PAPER_PITBLADO.PDF

Detailed Professional Experience:

DNV GL *2002, present*

Ms. Stahl is currently a Principal Consultant in the Environment and Navigation Risk Advisory Section . Her focus is to reach new markets and lead teas to develop the necessary methodologies. Recent work includes domestic and international risk-based HSE due diligence, risk framework development at an enterprise level, oil spill risk management for a large pipeline reconfiguration project, development of a management system from scratch for

an oil major in South America,, conducting an environmental accident investigation, performing regulatory research for onshore and offshore activities, evaluating environmental impacts and options related to facility siting, and developing audit protocols.

LNG Bunkering Study for MARAD **2013-11, 2014-06**
MARAD identified information needs ?regarding infrastructure and bunkering. Four topics were in the scope of this DNV GL/MARAD cooperation -- all current issues relevant to safety, rulemaking, and oversight of LNG bunkering. Ms. Stahl conducted a portion of the work report focused on required regulations for bunkering infrastructure, needs for regulatory standardization, effect of regulations on international trade, and interaction with environmental regulations. The report will be made available to the public by MARAD.

Method Development for Arctic Oil Spil Risk **2013-10, 2014-03**
An international oil company requested development of a transparent method for evaluation of oil spill risk in the Arctic. The delivered method allows evaluation of risk and response strategies and equipment to enable a transparent discussion with regulators.

TERMPOL study for Two LNG Export Terminals in B.C. **2013-08, 2016-04**
The proponents of two LNG export terminals are participating in Canada's TERMPOL process. Ms. Stahl is the project manager of the work, which consists of 20 separate studies and contributions to the EISs being developed separately for the terminals. The largest study is a combined marine and safety risk assessment, incorporating a limited portion of the scope of a QRA plus a navigation risk study.

High Consequence Analysis for US pipelines **2013-03, 2013-06**
Ms. Stahl led small projects to conduct HCA modeling for liquefied gas pipelines in the U.S. in accordance with U.S. DOT PHMSA regulations in 49 CFR 195.

International Due Diligence **2009-05, 2009-09**
Provided risk-based due diligence services related to acquisition of energy sector assets. Areas of focus included: identification of RECs based on site visit and historical use, comparison of current environmental practices with industry standard, maturity of management system and its implementation; and apparent asset condition.

Medical Waste Due Diligence **2009-03, 2009-06**
Assessed HSE risks for potential acquisition oppotunities in medical waste. Areas of focus included historical use, current HSE practices compared to industry standard, regulatory compliance, and management system maturity.

Project Manager - Refinery Fire Water Demand **2008-12, 2009-07**
Managed an international team to provide a refinery of an estimate of potential fire water demand based on the client's methodology. Project team members were located in Houston, Calgary, and Hyderabad. The project deliverables exceeded quality, time, and cost requirements.

Baseline Oil Spill Risk **2006-04, 2006-12**
Ms. Stahl led a team to estimate the oil spill risk from a pipeline in financial terms. The analysis included detailed transport modeling, estimates of spill impact to rivers and groundwater, and restoration costs. The deliverable was a database providing a visual summary of the overall risk and access to the detail concerning the causes of the risk at any location.

Curriculum Vitae:

DOT HCA Compliance **2004-09, 2005-03**
Ms. Stahl managed a team of consultants to develop and help implement a methodology to comply with DOT High Consequence Area requirements. Enforcement action had been initiated by DOT OPS, therefore prompt and responsive action was taken to address DOT concerns and improve communications. The study included fate and transport modeling for nearly 10,000 spill locations, identification of possible preventive and mitigative measures to reduce oil spill risk. The methodolgy was risk-based, so that segments posing tolerable risk were not evaluated further to identify measures. The final list of recommended measures was prioritized using cost-benefit analysis.

Risk Changes from Pipeline Reconfiguration **2004-06, 2005-12**
Ms. Stahl managed a project team to conduct a risk change study for proposed reconfiguration of a major crude oil pipeline. A high level of detail was developed concerning consequence of spills, including oil spill fate and transport modeling, for segments with a change in impacts related to the reconfiguration. The final deliverable was a list of recommended mitigation measures, which was optimized from a list of all possible effective measures using cost-benefit analysis and input from several state and federal agencies. Implementation of the recommended measures will result in no increase in spill risk to any environmental receptor along the pipeline.

Comparison of Offshore Regulatory Requirements **2003-07, 2003-11**
Ms. Stahl summarized regulations regarding emissions for offshore operations in the US GoM, Alaska, and Canada. The summaries were added to those prepared for several other countries to provide the client a comparative overview of offshore requirements.

Management System Development **2003-05, 2003-08**
Ms. Stahl assisted the client in development of a management system for new upstream operations. Key contributions included review and capture of contractual requirements regarding documentation and communications.

Self-employed Consultant ***1992, 2002***

Worked with DNV for ten years (as a consultant) in environmental compliance and risk management. Experience includes:
- Comparative risk assessment of human health risk and environmental risk for vehicle fuels;
- Qualitative and quantitative environmental risk assessment for proposed activities in sensitive wildlife areas;
- Recorded many PHAs, both offshore and onshore.

Petrostar Refinery QRA **2001-08, 2002-04**
Comparative QRA for methanol vs gasoline fuels **2000-09, 2003-02**

Science Applications International Corporation ***1989, 1993***

- Completed qualitative and quantitative environmental assessments for proposed activities for wildlife areas, nuclear sites, biological research facilities, and radioactive waste sites;
- Prepared environmental assessments and environmental impact statements (NEPA compliance) for large US projects proposed by the Dept of Energy and Dept of Army;
- Conducted environmental compliance audits (including developing protocols); and
- Prepared and presented training courses for clients.

Lawrence Berkeley National Lab NEPA Coordinator **1992**

Cheryl L Stahl
Senior Principal Consultant

Curriculum Vitae:

Envir/Safety Audit for Stanford Linear Accelerator	**1991**
CERCLA Risk Assessment for Stanford Linear Accel.	**1991**
EIS for Army Biological Lab Relocation	**1990**
Environmental Compliance Audit for U.S. Army	**1992**
Environmental Assessments for various LLNL ops	**1992**

Aaron Brown

Senior Consultant

Curriculum Vitae:

Academic and Professional Attainment:

Master of Science, The Johns Hopkins University, Environmental Planning & Mgmt, 2013
Bachelor of Science, The University of Texas, Chemical Engineering, 2006

Summary of Professional Experience:

Mr. Aaron Brown holds a MSc in Environmental Planning and Management from Johns Hopkins University. He has 8 years of experience working in safety risk though his emphasis is in ship navigational risk and environmental risk assessment and management.

Mr. Brown has extensive knowledge in oil spill fate and transport, GIS, remote sensing of oil on water, and onshore environmental risk. Other areas with experience include oil spill leak detection, evaluation of the extent of oil spills through application of remote sensing and oil spill modelling.

Mr. Brown currently oversees several R&D projects which focus on navigational risk modelling, evaluation and consults on big data / data analytics projects for DNV GL Oil & Gas.

Present Position:

Mr. Brown is currently a Senior Consultant in the Navigational & Environmental Risk Section in DNV GL-Houston. He is project manager of major projects (1500+ man-hour projects) within the group and has led and worked on most of the projects relating to the transport of LNG by ship and works extensively on LNG bunkering / LNG as fuel projects.

Mr. Brown also serves on the steering committee for DNV GL's Environmental Technology Leadership Program.

Professional Training

2015: Project Management in Oil & Gas – Intro to our Common Way of Working
2015: DNV GL Code of Conduct – An introduction to expected conduct and behavior in daily business
2015: 2010w DNV GL's approach to Anti-Corruption and Anti-Trust – An Introduction
2015: HSE in DNV GL - Incident reporting
2014: SharePoint – Group sites and Meeting places – Permissions & Libraries and lists
2014: CRM Affinitas - Sales ProcessOil & Gas
2014: WE in DNV GL, web
2013: Actively Caring about SHE
2011: Quantitative Risk Assessment using Phast-Risk (vs6.6+)
2010: Affinitas training
2010: Office Hazard Recognition and Response
2010: Walking and Working Surfaces - Fall Protection
2010: Hazards of Hydrogen Sulfide
2010: Lockout/Tagout
2010: Field Hazard Recognition - Assessing Personal Risk
2010: Violence in the Workplace
2010: DwD – Dealing with Dilemmas, web
2010: Heat and Cold Stress
2010: Basic Health, Safety and Environment, web
2010: Defensive Driving
2010: Office Ergonomics
2010: Personal Protective Equipment
2009: Project Management 2
2009: ISO 14001/OHSAS 18001 North America SHE Management System Training
2009: Project Management 1
2008: USA Harassment Awareness
2008: Energy Services and Segments

Aaron Brown

Senior Consultant

Curriculum Vitae:

2008: Project Manager 0
2008: Risk Management Intro, web
2008: Knowledge Management Introduction
2007: DNV Energy Portal Introduction
2007: Marketing & Communication Skills - 2
2007: DNV Services
2007: SAFETI Training Course
2007: Marketing & Comm Skill -1
2007: Introduction to DNV
2007: SOQRATES Training Course
2007: Offshore QRA Using SOQRATES

Detailed Professional Experience:

DNV GL Risk Advisory Services *2007, present*

LNG Bunkering SIMOPS Comparative Risk Assessment **2015-07, present**

Mr. Brown is the project advisor in comparison study evaluating tradeoffs between different vessels and multiple forms of LNG Bunkering measured in terms of safety risk. The project involved multiple external stakeholders (trade groups, ship owners, investors, oil & gas companies, governmental officials and class societies) to provide risk-based guidance to the marketplace to define an optimal solution for LNG as fuel.

Kitimat LNG Transit and Transshipment Risk Assessm **2014-03, present**

Mr. Brown was project manager for a safety navigational and transshipment risk assessment for the Kitimat LNG project near Kitimat, British Columbia. The project was executed within all requirements and was prepared to be best in class for submission to the Termpol Review Committee. Aspects of this project are ongoing to date.

U.S. Maritime Administration Liquefied Natural Gas **2013-10, 2010-10**

Mr. Brown was project manager for a comprehensive evaluation of LNG bunkering needs, challenges, and risks in the U.S. market. The paper was prepared on behalf of the U.S. Maritime Administration.

Investment Due Diligence **2013-10, 2013-11**

Mr. Brown was lead environmental due diligence assessor for a preliminary evaluation by an investment bank in a company who recently experienced a major offshore incident which resulted in multiple fatalities. Mr. Brown's evaluation was relatively high level and looked at the company practices and plans and historical incidents and any outstanding claims against the company.

U.S. Virgin Island Propane Vessel Transit Risk Ass **2013-09, 2015-07**

Mr. Brown was project manager for a safety navigational and transshipment risk assessment for the proposed conversion of the power plants at St. Thomas and St. Croix to propane. The project went through the US Coast Guard's Waterway Suitability Assessment approval process and was approved by the regulators.

Oil Spill Volume Verification **2011-11, 2013-08**

Mr. Brown led a group of DNV GL staff comprised of experts around the globe in the evaluation and quantification of oil spill volumes. Verification of oil spill volumes looked at all possible data to provide the best estimate of spill volumes.

Aaron Brown

Senior Consultant

Curriculum Vitae:

Offshore Fleet Safety Case Development **2011-08, 2013-08**

Mr. Brown is developing safety cases for a major drilling company for its world-wide assets. He is responsible for developing their safety case based on the company management system and rig-specific documentation to meet the International Association of Drilling Contractors expectations. Simultaneously, he is also reporting back to Transocean with any deficiencies discovered.

Third Party Blowout Risk Assessment **2011-06, 2012-03**

Mr. Brown was the project manager and primary analyst to perform verification on work done by another risk assessment company to meet the requirements of the Mexican regulatory regime. The project was very important to the client because it found significant deficiencies with the assessment that required additional work to overcome the deficiencies.

Aging Asset Risk Reduction Planning **2011-04, 2011-05**

Mr. Brown was responsible for developing the initial risk reduction plans for review / acceptance by the client during a subsequent workshop. The risk reduction plans were developed to address aging infrastructure in the client's asset portfolio. Mr. Brown assessed the cost effectiveness of several options at reducing risk exposure to health, safety, environment and company reputation.

Compressor Station Flare Stack Assessment **2011-01, 2011-02**

This project was won based on work previously executed by Mr. Brown in 2009 with one of the stakeholders in that project. Mr. Brown was responsible for project management, execution, and delivery for this project. Several sensitivities were analyzed (e.g., varying stack height, and location) to determine the most suitable arrangement. The client wanted to know how to reduce exposure to flash fires and high levels of thermal radiation.

ES2 for Oil Sands **2010-07, present**

Mr. Brown was the assistant project manager / led technical resource to research and develop a needs-based solution to address challenges in oil sands operations. The Environmentally Sensitive Extraction Services (ES2) for Oil Sands project was internally funded by DNV in order to determine and develop solutions for the environmental concerns surrounding oil sands operations. He was responsible for internal and external stakeholder engagement to determine the most pressing issues. As a result of his work, DNV continues to engage the oil sands industry to find innovative solutions for complex problems.

Offshore Escape, Evacuation and Rescue Study **2010-05, 2010-06**

Mr. Brown was responsible for the analysis of the escape and evacuation capabilities for one offshore installation. The purpose of the study was for the client to assess their current design to determine if the locations of escape routes and evacuation locations were adequate.

Gulf of Mexico Accident Response Support **2010-04, 2010-08**

Mr. Brown was involved in the primary response efforts made by the client's incident crisis team to stop the flow of oil. His primary responsibilities were to provide technical support during the initial hazard identification workshops. As additional resources from many organizations were involved, his role switched to providing management support for the various simultaneous operations underway. He was seconded to support the operational safety manager directly with team organization and day-to-day needs. Mr. Brown also arranged for additional DNV support as required to support ongoing activities.

Vent Stack Consequence Assessment **2010-03, 2010-06**

Mr. Brown was responsible for executing the analysis and addressing client questions for a vent stack consequence assessment. Several sensitivities were analyzed (e.g., varying stack height, arrangement, location,

release rate, and release conditions). The client wanted to know how to reduce the risk of exposure to high concentrations CO2 for workers at height.

WtE Verification for the Board of Directors **2010-03, 2010-06**

The client requested that DNV GL verify several statements about the impacts of waste-to-energy (WtE) facilities. Mr. Brown was responsible for the overall verification process and delivery of several verified responses ultimately for the client's Board of Directors. The verification scope included HSE impacts (with emphasis on greenhouse gases), facility operations and monitoring activities, waste-to-energy integration into general waste management practices in terms of effectiveness, and economics.

Seven Environmental Due Diligence Projects & Remed **2009-06, 2012-07**

Over the course of 4 years, Mr. Brown participated and managed projects for a company acquiring assets in the Caribbean. Five of the projects were environmental due diligence associated with the acquisition of 2 terminal facilities and hundreds of gas stations. Prior to and subsequent to the earthquake in Haiti, Mr. Brown led separate projects evaluation remedial actions associated with an oil import terminal in Port au Prince, Haiti. His role in a project depended on the need. Typically he was lead analyst or project manager.

At the time of the studies, the client planned to acquire hundreds of assets throughout the Caribbean and Central America. We provided continuous support during their bid process to estimate the environmental liabilities they were acquiring with the assets. Mr. Brown was technically responsible for the delivery and helped develop the methodology of estimating environmental liabilities based on existing studies of the assets and the mobilization and field work to qualify those results.

Refinery-wide Fire Water Analysis **2008-12, 2009-06**

Mr. Brown assisted in an international effort to execute a fire water demand analysis for a large refinery. His responsibilities included analysis of two units, coordination / training / quality assurance for the international project team, and creating a tool for streamlining project execution and consistency.

LNG Pipeline Risk Assessment **2008-01, 2008-10**

This project included a COMAH study. Mr. Brown participated in several aspects including the Quantitative Risk Assessment (QRA) analysis, development of the QRA report, the Hazard and Effect Register from the HAZID session. Mr. Brown also developed competency in part counting methodology.

BP Alaska Facility Siting Study **2007-07, 2007-12**

This study was used to identify the hazardous zones according to BP standards GP 48-50 and CHXO GP 04-30 for Major Accident Risks and Design of Occupied Buildings. Responsibilities included modeling consequences and confirming that the models reflect reality with BP.

Fluor Sour Gas Development, Abu Dhabi **2007-03, 2007-06**

This project included a COMAH study. Mr. Brown participated in several aspects including the Quantitative Risk Assessment (QRA) analysis, development of the QRA report, the Hazard and Effect Register from the HAZID session. Mr. Brown also developed competency in part counting methodology.

Navajo Refining Company ***2006, 2006***

Developed an implementation plan for environmental compliance for emission equipment audits. Also, developed a software tool to calculate the amount of inventory in a release from an process upset.

Vijay Raghunathan

Principal Consultant

Curriculum Vitae:

Academic and Professional Attainment:

Master of Science, Texas A&M University, Chemical Engineering, 2004
Bachelor of Engineering, University of Madras, Chemical Engineering, 2002

Summary of Professional Experience:

Present Position:

11+ years of delivering safe and sustainable solutions for the Upstream, Midstream Oil and Gas, Chemical sector
Collaborated on transformational projects with global leaders like BP, BG, ConocoPhillips, Saudi Aramco, & PETRONAS.
Led EHS Risk Management studies related to the CAPEX, OPEX, Acquisitions to improve business performance
Worked and Networked with Cross functional teams on DNV GL international assignments (Norway, London, India).
Functioned as thought leader, Process Safety SME with US and Canadian Government Agencies
As QA/QC manager, Developed and Delivered internal and external training programs on process safety policies
Worked with NFPA, PHMSA, OSHA PSM, U.K. HSE & NORSOK requirements & co-authored technical papers
Familiar with range of DNV GL software products related to risk management
Languages spoken: English, Spanish, Hindi &Tamil

Publications and Papers:

PUBLICATIONS/CONFERENCES

2006 -“Recent Advancements in Explosion modeling for onshore facilities”- Process Safety Symposium, Texas A&M, College Station.
2006 -“Consequence modeling of LNG marine incidents”- ASSE Conference , Bahrain
2005 -“Parameter comparision of recent LNG consequence studies”- LNG Conference , Vancouver
2004 – “ LNG decision making approaches compared” Process Safety Symposium, Texas A&M College Station.

Professional Training

2016: ISO14001/OHSAS18001 and DNV GL HSE Mgt. System
2016: Introduction to Fieldwork HSE Handbook
2016: CRM Affinitas - Sales ProcessOil & Gas
2016: Confined-space Entry
2016: Defensive Driving
2016: Actively Caring for HSE
2016: Hearing Conservation
2016: Violence in the Workplace
2016: Walking and Working Surfaces - Fall Protection
2016: Excavations and Trench Safety
2016: Personal Protective Equipment
2016: Basic Health, Safety and Environment, web
2016: Back Safety
2016: HSE in DNV GL - Travel safety
2016: Electrical Installations: Energized Parts - Qualified Persons
2016: Basics of Electrical Safety
2016: Hazards of Hydrogen Sulfide
2015: DNV GL Code of Conduct – An introduction to expected conduct and behavior in daily business
2015: 2010w DNV GL’s approach to Anti-Corruption and Anti-Trust – An Introduction
2014: WE in DNV GL, web
2013: Actively Caring about SHE
2013: Knowledge Booster

Vijay Raghunathan

Principal Consultant

Curriculum Vitae:

2013: Affinitas training
2012: Is Leadership for Me?
2012: Office Hazard Recognition and Response
2012: Walking and Working Surfaces - Fall Protection
2012: Lockout/Tagout
2012: Introduction to the CSM role, web
2012: Heat and Cold Stress
2011: Field Hazard Recognition - Assessing Personal Risk
2011: Violence in the Workplace
2011: Basics of Electrical Safety
2011: Basic Health, Safety and Environment, web
2011: Office Ergonomics
2010: Defensive Driving
2010: Personal Protective Equipment
2009: ISO 14001/OHSAS 18001 North America SHE Management System Training
2009: MIP for Employees
2007: DNV Energy Portal Introduction
2007: Offshore QRA Using SOQRATES
2006: Marketing & Communication Skills - 2
2006: Marketing & Comm Skill -1
2006: DNV Consulting Course
2005: DNV Services
2005: USA Harassment Awareness
2003: Emergency Response Planning Training
2003: Project Risk Management Course

Other Information:

PROFESSIONAL TRAINING

2009- Advanced PHAST/SAFETI Training -DNV Energy, Houston

2006- Helicopter Underwater Survival Training (HUET), Houston

2005- ISRS Alpha Assessment - DNV Consulting, Houston.

2004- Project Risk Management Course - DNV Consulting, Houston.

2003- Emergency Response Planning - Texas A&M University/SRA Consultants

SOFTWARE KNOWLEDGE

PHAST	Process Hazard Analysis Software Tool.
SAFETI	QRA tool for Process Hazards
CIRRUS	BP's consequence modeling tool
LEAK	Tool for calculating leak frequencies from equipments
SOQRATES	Offshore QRA tool developed by DNV

Vijay Raghunathan

Principal Consultant

Curriculum Vitae:

Detailed Professional Experience:

DNV GL Risk Advisory 2016, 2016

Business Development Lead, Midstream and Rail Safety
Leading a team of consultants to develop new service lines on rail transportation safety and build the midstream business to meet revenue and growth targets for 2016/17. Select responsibilities include, market intelligence, roadmap development and tracking, competition analysis, product customization, branding and profiling and cross-selling across Business Areas.

DNV GL, Risk Advisory 2007, 2015

Participate and manage medium-large projects for both risk management and quantitative risk analysis related to the design, building, commissioning, operation and maintenance of innovative projects in complex environments, including offshore, pipelines, refineries and chemical plants. Deliver all projects (including sub tasks) according to expectations for quality, schedule and customer objectives. Contribute to risk related projects utilizing process safety knowledge and development of safety reports for the onshore and offshore industry. Guide and support less experienced staff. Contribute to competence development of others in addition to own self. Assist in proposal development, project scope extensions, change order management and report writing.

SBM FRAM FPSO Safety Studies 2012-03, 2012-08

Managed a suite of safety studies for a development in the FRAM field. The range of studies included HAZID workshops, Fire and Explsoion risk studies, Escape Evacuation and Rescue analysis to ALARP workshops. With these preliminary safety studies DNV helped SBM demonstarte ALARP and eventually helped them win the FEED stage contract with SHELL.

Conoco Philips FLNG QRA 2012-02, 2012-08

Managed an FLNG risk assessment work for a conceptual configuration. The objective of the analysis was to evaluate the risk to personnel working on the FLNG facility, identify and rank main contributors to the overall risk and provide recommendations for further risk reduction.

bpTT Accomodation Risk assesment 2012-01, 2013-01

Managing a technical risk assesment work for bpTT's 3 major offhore platforms in Trinidad and Tobago. Projects involves identifying, testing several mitigation options to reduce the inherent risk on these facilties. DNV's offshore QRA tool SOQRATES was used extensively and several mitigation combination runs were run to reccomend the optimal solution from a safety perspective.

QA-Corridor Pipeline QRA 2011-06, 2011-11

Managed a pipeline corridor (17 lines) QRA project to estimate the risks associated with transportation of gas, NGL and crude oil. The project objective was to estimate the sepration distance between the corridor and a potential housing development based on peronnel risk. As part of the study the base case risk was estimated and practical mitigation options were evaluated to demsontrate ALARP. The QA-Corridor is one of the most critical pipeline corridor for Saudi Aramco.

Jizan-Abha Pipeline QRA 2011-05, 2011-11

Managed a pipeline QRA project to estimate the risks associated with transportation of crude oil products. The project objective was to estimate the current risk to the population and identify , evaluate practical mitigation options to demsontrate ALARP. A Cost benefit analysis was also performed to rank the mitigation options.

Vijay Raghunathan

Principal Consultant

Curriculum Vitae:

Maersk FPSO Quantitative Risk Assessment **2011-03, 2011-05**

Worked as the Technical Lead managing resourcesto execute the QRA, fire and explosion studies. The objective of this work was to estimate personnel and asset risk and identify relevant mitigation options at the Concept stage.

bpTT Offshore QRA for 3 platforms **2011-02, 2011-09**

Managed three QRA studies for bpTT platforms as part of their accomodation compliance project associated with SIMOPS activities. The main study objective was to evaluate the risk to the new accomodations module to be installed on these jackets.Project responsibilities also included training junior resources in Offshore QRA techniques.

Pappa Terra TLWP Offshore Safety Studies **2010-03, 2010-08**

Worked as the Technical Lead managing resources from Houston, Brazil and UK offices to execute the QRA, fire and explosion studies. The objective of this work was to estimate personnel and asset risk and identify relevant mitigation options at the FEED stage.

Dammam Pipeline QRA **2009-08, 2009-12**

Managed a pipeline QRA project to estimate the risks associated with drilling, transportation of products. The project objective was to demsontrate ALARP and also impacted the layout, process design.

Technical QA Manager **2009-06, 2009-09**

Worked as the Technical QA Manager for the DNV Global Risk Center. Managed a group of 15 consultants and coached them in the basics of DNV's risk related services. Also help co-ordinate trainign courses for 6 weeks. Served as the technical lead on a few onshore, offshore QRA projects as part of the training.

Eider Rock Concept Safety Evaluation **2009-06, 2009-08**

Managed a Quantiative Risk Assesment project for a refinery to help with some siting decsions at the concept phase of the project. The risk study was execuetd based on the MIACC guidelines and risk mitgation recommendations were provided.

FLNG Risk Assesment study **2009-05, 2009-07**

Executed a Quantitative Risk Assessment (QRA) for a proposed FLNG facility during the pre-FEED conceptualization phase. As part of the project reviewed the exisitng QRA work and helped develop exceedance curves (thermal and explosion) to estimate Design Accidental Loads (DAL) for the platform.

Process Safety Assessment **2009-01, 2009-02**

Performed a HAZID study addressing safety during Lumigen, Inc.'s HPA (Hydroxyphenyl Alkene) process to identify the potential hazards associated with the process. Recommendations were made to improve the process design, opearting procedure that would lower the risk for this manufacturing process.

Vent Gas Dispersion Study **2008-12, 2009-01**

Worked on a vent gas dispersion study to calculate the radiation and vent gas concentration at the 5 critical locations caused by the release of gaslift from the vent at site conditions. Based on the results of the study the the vent tip size was estimated.

Vijay Raghunathan
Principal Consultant

Curriculum Vitae:

Chinook/Cascade Subsea Overpressure Risk Assesment **2008-11, 2009-01**
Conducted a subsea boosting system risk analysis to determine the probability of an over-pressure event happening in their subsea production systems during the timeframe when over-pressurization is possible. The Fault tree analysis approach was used for the top event “Pressure Protection System Fails to Operate on Demand" and the failure routes leading to the top event were identified.

BP North Slope Facility Siting Risk Assessment **2008-10, 2009-08**
Managed a facility siting risk assesment project for all the 64 drill sites/ well pads on the North Slope. The study was executed as per the BP standards for temporary occupied portable buildings. The study included detailed consequency modeling and frequency assessment to estimate the relative risk at the different sites. Key project reponsibilities included technical advise, financial review and detailed QA/QC at all stages during the study.

DNV Consulting *2005, 2007*

Perform risk assessments and analyses for facilities in the oil and gas industries. contribute to other risk related projects utilizing knowledge of risk management techniques. Perform analysis and calculation. Break down and prioritize project issues; collect data, develop skills in use of DNV tools ad methodologies. Interpret results of analysis under guidance and contribute to reports and papers. Contribute to customer service, understand customer needs and be customer focused. Share information and take part in team problem solving. Participate in and attend industry related conferences, workshops, and marketing efforts.

Conoco Philips Facility Siting Study, Alaska **2008-02, 2008-03**
Managing a Facility Siting Study for six processing facilities on the North Slope, Alaska. The study involves analayzing the risk posed by the process activities to the occupied buildings on site. A detailed consequence , frequency analysis is being conducted to identify the potential risks to onsite population. Responsibilites include technical support, managing the resources and also quality assurance support for all associated tasks.

Savonette Offshore QRA, Trinidad **2007-12, 2008-01**
Conducted a QRA study to analyse the risks to personnel associated with the Savonette’s normal operation and various well intervention cases. Functioned as the project manager assisting in the execution of the study. Project responsibilities also included training junior resources in Offshore QRA techniques.

Pipeline Vulnerability Assessment, Trinidad **2007-09, 2007-11**
Worked on a NGL pipeline vulnerability assesment for a cross country pipleine in Trinidad. The study involved identifying the major hazards, quantifying the offsite risk and recommending suitable mitigation measures to minimize the risk.

BP North Slope Facility Siting Study, Alaska **2007-04, 2007-11**
Conducted a facility siting study to identify the hazard zones for all the 18 BPXA facilities on the North Slope. The study was executed as per the BP standards for siting Temporary Occupied Buildings. The study included a detailed facility walk down followed by Consequence modeling and blast load calculations. Functioned as the technical project manager and also helped track the financial performance of the project at different stages.

BP OCC project ,Consequence Modeling, Whiting **2007-01, 2007-03**
Worked on the consequence modeling and fire modeling for the different units in the Whiting refinery (Coker, 12 Pipestill and SRC unit). Performed extensive modeling using CIRRUS software based on the BP guidelines.

Ammonia Plant - HAZOP study, Trinidad **2006-12, 2006-12**
Participated in a two week HAZOP study to identify plant and equipment response to process disturbances and deviations and recommend corrective actions to mitigate or eliminate such detrimental effects. The study used the normal HAZOP technique from the Center for Chemical Process Safety (CCPS).

Vijay Raghunathan

Principal Consultant

Curriculum Vitae:

Mahogany B Offshore QRA, Trinidad **2006-08, 2006-11**

Performed a risk assessment to analyze the overall risk profile of the Mahogany B Platform associated with both normal and workover operations. Offshore Platform visit to identify the main hazards was also a part of this project. Responsibilities also included project management and training of junior resources.

Mango Platform Offshore QRA, Trinidad **2006-04, 2006-05**

Performed a quantitative risk analysis study of the risks to personnel associated with the Mango's normal operation and various well intervention cases.

Amherstia Platform Offshore QRA ,Trinidad **2006-04, 2006-04**

This QRA work was carried out to determine the safety risks to personnel and the installation from major accident hazards associated with the facilities during normal production and workover operations.

Quantitative Risk Assessment of LPG Storage Unit **2006-03, 2006-04**

Performed a risk assessment of the LPG storage unit, which consists of three LPG spheres and their related equipmen to provide a consequence and risk review of the LPG unit. Developed detailed unit model in SAFETI to evaluate the overall risk associated with the facility.

Joint Pipeline Corridor QRA , Trinidad **2005-08, 2005-11**

Conducted a detailed onshore Quantitative Risk Assesment for the natural gas/ liquid condensate pipelines. A complete 76 km onshore pipeline survey was carried out to identify the main hazards along the pipeline route. The work analysed the offsite and onsite risks and recommended suitable mitigation options.

Jetty Relocation -Risk Assesment, USA **2005-07, 2005-08**

Identified the risks, hazards associated with relocating the jetty at a LNG terminal.

Pre-FEED Risk Assesment, Egypt **2005-05, 2005-06**

Conducted a screening level QRA to facilitate the site selection process for an Ammonia-Urea Fertilizer Plant.

Air Dispersion Modeling Study, Canada **2004-06, 2004-07**

Dispersion Modeling of Hydrogen Flouride release for different mitigation response times.

Richard E Green

Senior Principal Consultant

Curriculum Vitae:

Academic and Professional Attainment:

Master of Science, Univ. of Wisconsin, Environmental Science, 1983
Bachelor of Science, Univ. of Wisconsin, Environmental Science, 1977

Summary of Professional Experience:

Qualifications Summary
36 years' experience developing and delivering environmental, health, and safety compliance and environmental management systems (ISO 14001, 18001, 9000); EHS auditing, environmental due diligence; pharmaceutical chemical and fermentation production processes, environmental engineering and operations; municipal and industrial wastewater operations; solid and hazardous waste management operations; landfill gas management, waste-to-energy operations, in-plant environmental services in the chemical, automotive, marine, steel, and pharmaceutical industries; EHS consulting; laboratory management; experimental design and statistical analyses including mathematical modeling; environmental remediation; groundwater well management. GoM SEMS assessments, safety case development, root cause analysis, barrier analysis, oil spill contingency planning, contractor safety, pipeline management systems, contractor management, major project management experience, merger and acquisition assessments and unconventional oil & gas.

Present Position:

Rich currently serves as Technical Lead for Unconventional Oil & Gas in the Americas as well as Manager of Innovation for Risk Management Solutions.

Professional Training

2016: Violence in the Workplace
2015: Project Management in Oil & Gas – Intro to our Common Way of Working
2015: CRM Affinitas - Sales ProcessOil & Gas
2015: 2010w DNV GL's approach to Anti-Corruption and Anti-Trust – An Introduction
2015: DNV GL Code of Conduct – An introduction to expected conduct and behavior in daily business
2015: HSE in DNV GL - Incident reporting
2015: Stress Management
2014: Introduction to the KAM/KCM role in DNV GL, web
2014: WE in DNV GL, web
2013: Project Sponsoring the Oil and Gas Way
2013: Actively Caring about SHE
2011: Management Workshop: Performance Management Workshop
2011: Affinitas training
2011: Basics of Electrical Safety
2010: Office Hazard Recognition and Response
2010: Hazards of Hydrogen Sulfide
2010: Walking and Working Surfaces - Fall Protection
2010: Lockout/Tagout
2010: Field Hazard Recognition - Assessing Personal Risk
2010: Violence in the Workplace
2010: DwD – Dealing with Dilemmas, web
2010: Heat and Cold Stress
2010: Basic Health, Safety and Environment, web
2010: Energy Productivity Management: 2-day
2010: Top Tech
2010: Defensive Driving
2010: Office Ergonomics
2010: Personal Protective Equipment
2009: Climate Risk Management Workshops – Exploiting Cross BA Business Opportunities
2009: ISO 14001/OHSAS 18001 North America SHE Management System Training

Richard E Green

Senior Principal Consultant

Curriculum Vitae:

2009: Validating Carbon Offset Projects
2009: Carbon Market Fundamentals
2009: Compliance for Managers - U.S
2008: The Journey Business Leadership
2008: Energy Services and Segments
2008: The Journey Stepping into Leadership
2008: MIP for Employees
2008: Survival guide for new managers, web
2008: Knowledge Management Introduction
2007: DNV Energy Portal Introduction
2006: USA Harassment Awareness
2006: Project Management Masterclass
2006: ISRS Assessor

Detailed Professional Experience:

DNV GL *2005, 2013*

Joined DNV as a Principal Consultant in October of 2005 and became Deputy Section Head of the Downstream consulting group, interim Section Head and then Section Head in mid-2006, making all financial targets by year-end. In late 2006 was appointed Deputy HOD for Energy Solutions and transitioned to HOD of Energy Solutions in August of 2007 serving until December 2008 generating approximately 140 M NOK in revenue during my tenure. In early 2009 was assigned Deputy Director for Energy Solutions, Director of Services Development and focused on development of a new Envrionmental and Operational service area. Appointed to DNV's Top Tech in mid-2009 and Sniro Principal in early 2011. Current role is Manager of Innovation for Risk Management Solutions and Technical Lead for Unconventional Oil & Gas for the Americas.

Quantification of Hydraulic Fracturing Risk **2015-11, 2016-01**
Determination of event trees and risk of contamination of aquifers from gas or produced water (desk study).

Update DNV GL Shale Recommended Practice (RP) **2015-06, 2015-12**
Update the DNV GL Shale RP to include both oil and natural gas operations while adding topics in seismicity, water treatment, silica management, RAM, flaring reduction and occupational safety.

Root Cause Analysis of Permian Oil Pipeline Spill **2015-06, 2015-08**
Conduct root cause analysis using BSCT barrier analysis of crude oil release.

Avian Influenza Leachate Transmission **2015-05, 2015-07**
Prepared risk assessment of potential avian influenza virus transmission in landfill leachate.

Goldboro LNG Due Diligence **2014-12, 2014-12**
Support due diligence of investor team and law firm. Technical and EHS elements.

BP Americas **2013-08, 2013-10**
Conducted laboratory HAZID workshop for proposed drilling and fracking laboratory in Houston, TX. Completed regulatory review of UK and USA requirements for HSE elements addressing laboratory operations.

Shell Pipeline Root Cause Analysis **2013-05, 2013-09**

Curriculum Vitae:

Root cause analysis of crude oil release from a 16 inch pipeline from Louisiana to the Texas terminal. Utilized BSCAT and TapRoot methodologies. Third party involvement during pipeline right-of-way construction activities.

ConocoPhillips Environmental ALARP **2013-04, 2013-09**
Conducted COP workshop to develop environmental ALARP criteria for drilling in the arctic environment. Main concern is the ability to react to an oil spill in ice and no ice conditions as well as factoring in scenarios using oil mass balance for remediation.

Shell Root Cause Analysis - Pressure Release Valve **2013-01, 2013-02**
Root cause analysis/high level assessment using BSCAT methodology for multiple pressure relief valve incidents at terminals in the Shell network.

Shell Pipeline Root Cause Analysis **2012-05, 2012-08**
Root Cause analysis of Jet A release to the environment at Milwaukee International Airport using TapRoot and BSCAT methodologies.

NOV Risk Matrix Analysis **2012-03, 2012-04**
Completing risk ranking assessment process for risk analyses of new equipment.

Diamond Offshore Incident Investigation **2012-02, 2012-03**
Worked on offshore Brazill drilling rig incident investigation study. Root cause and barrier analyses conducted with management system gap analysis.

BOP Verification **2011-10, 2011-12**
Completed verification study of BOP retrofits for major drilling entity in Malaysia

Oil Terminal Environmental Assessment - Haiti **2011-09, 2011-12**
Partnered with Environ to complete a post-earthquake assessment of the Port au Prince, Haiti oil terminal for the owner.

Project Marlin Environmental Due Diligence **2011-09, 2011-12**
Completed desktop study of environmental risk for 242 oil and gas operations in the Dominican Republic, St. Martens, and Jaimaica. Established Phase 2 study requirements for 2012.

UN Helicopter Study **2011-08, 2011-09**
Completed environmental due diligence of three UN helicopter refueling stations in Haiti for holding company.

Gulf of Mexico SEMS Assessment **2011-08, 2011-09**
Conducted gap analysis of major oil company SEMS to assure conformance with new Gulf of Mexico rules passed by BOEMRE.

Transocean Safety Cases **2011-06, 2012-03**
Deveoping safety cases for 12 offshore Gulf of Mexico drilling rigs.

Richard E Green
Senior Principal Consultant

Curriculum Vitae:

Alyeska PS01 Root Cause Analysis **2011-05, 2011-12**
Conducted root cause analysis of an oil discharge within the Booster Pump Staion PS01. Completed Tap Root analysis through client interviews and workshops. Defined causal factors and their contributing root causes as well as generic causes and contributing factors.

Waste-to-Energy (WTE) Technology Assessment **2009-10, 2009-12**
DNV is providing technical support to the world's largest waste-to-energy operator to implement a new build program in the UK and China of nearly 300 new WTE energy facilities (electrical power generation). This on-going support effort includes assessing the environmental, health and safety effects of WTE operations on communities and the environment as well as the GHG contributions and offsets.

Major Oil Company Asset Divestiture **2009-06, 2009-07**
Conducted merger and acquisiton due diligence for a major holding company buying $300 million dollars in oil assets from a mjor oil company on the island of Haiti. DNV prepared a custom ASTM modified audit approach that focused on the potential environmental remediation cost for over 140 facilities, oil terminals and retail locations, due for transfer in the transaction. Developed and utilized a fast track reporting tool based on information mapping that chunked important information for client quick review.

Project Guayaba Environmental Study **2009-06, 2009-09**
Conducted environmental due diligence for a 167 facility oil and gas acquisition by a holding company.

Medical Waste Due Diligence **2009-04, 2009-05**
Provided environmental, health and safety due diligence support for a $200 million acquisition of medical waste collection, storage and treatment facilities by a $13 billion dollar environmental services company. Developed a modified ASTM Phase 1 environmental assessment methodology and incorporated health and safety requirements and conducted onsite facility audits of thirty operations in ten States. Wastestreams included red bag waste (infectious), chemotherapeutic waste, pathological waste, radilogical, and general medical refuse. Discovered numerous complaince and operational concerns which were not resolved by the seller and the deal was halted. Client appreciated the intervention of DNV and project results.

Coal Mining Company Assessment **2009-01, 2009-02**
Conducted a gap assessment of the EHS program for a large Midwest coal mining operation and introduced the corporate EHS team to the application of bow ties (barrier analysis) for hazard identification, auditing and communications of preventive and reactive systems to operations as well as to share best practices and implement a program of operations integration in the safety management system.

Electrical Utility Health and Safety Assessment **2008-04, 2008-10**
Major electric utility company requested an independent review of its current Health and Safety Management System including special attention on contractor safety. DNV used ISRS7 rating system to enable the client to measure, improve, and demonstrate the current performance of their organization. Signifcant field interviews and auditing in eight business units resulted in a reformed safety management system targeted at employee involvement and included leading indicators for adjusting program effectiveness.

Pandemic Contingency Planning **2007-02, 2007-08**
Completed several workshops with corporate, regional, and district operations personnel to assist in preparation of a compny-wide Avian Influenza Pandemic Contingency Plan for the largest North American environmental services provider.

Curriculum Vitae:

Pipeline Company Contractor Safety Assessment **2006-12, 2007-11**
Conducted an in-depth assessment of a major pipeline company Contractor Safety Management System to determine gaps and advise how to reinvent their approach to managing contractor safety as they increased pipeline construction activities throughout North America. Using an adaptation to isrs7 Alpha Tool a broad range of perception interviews were conducted from the Board level through senior managers, supervisors and operational staff on the company side, as well as, a similar range within numerous contracting organizations over several months. DNV provided workshops throughout the organization to improve the coordination between contractor and client safety organizations and assisted in redefining the safety vision for contractors and subsequent integration of contractor management into the client Safety Management System.

Wind Turbine Supply Chain **2006-08, 2006-12**
Cleaner Energy banking entity requested DNV to re-evaluate the status of their proposed wind turbine technology supplier, and to the extent possible in the time allowed, review progress on supply chain security and/or production processes improvements.

Wind Turbine Assessment **2006-04, 2006-08**
Cleaner Energy banking entity requested DNV perform a fatal flaw due diligence analysis of new wind turbine technology for potential use in two large wind energy development projects in the US.

Pipeline Response Time Model **2006-03, 2006-12**
Developed and designed an oil spill Response Time Model (RTM) for a major pipeline company. The RTM considered small, medium, and full-bore pipeline ruptures along the length of the 850 mile pipeline and predicted the resources and timelines to intercept oil releases on land and in waterways. The model was targeted at predicting the most effcient combination of respources for intial response and remediation. Staged response equipment included trucks loaded with booms and other clean-up equipment, boats, helicopters and response staff. Pre-staged equipment supplemented by transported personnel and oil response equipment provided the asset base for estimating the response time. RTM was used to support contingency planning drills and determining of response resource placement. A secondary study explored whether or not larger payloads in helicopters would enhance response time.

Avian Influenza White Paper **2005-12, 2006-02**
Developed and prepared an extensive research paper regarding avian influenza epidemic history, viral biology, epidemiology, risks to exposed populations, mitigation initiatives, waste handling, packaging, transport and disposal for the world's largest environmental services company. Also addressed employee PPE for a variety of tasks and surveyed regulatory requirements currently in effect from OSHA, USEPA, USDOT, and States. Included extensive analyses of contingency planning by local, state and federal agencies and included recommendations for client operations staff to assure continued operations in the event of a pandemic.

Waste Management Inc. ***1988, 2005***

Responsible for environmental, health and safety compliance and management system development for 1,300 operating locations in North America. Managed environmental, health and safety information systems, intranet training development, regulatory affairs, external and internal environmental reporting, environmental policy development, communications with regulators, and conducted internal environmental, health and safety assessments of all operations including landfills, hauling companies, waste-to-energy operations, wastewater operations, transportation locations, recycling operations, hazardous waste treatment operations (including solvent recovery), industrial customer in-plant services and ancillairy environmental services companies.

Supervised up to 30 staff, more than 150 national account client relationships, and several hundred subcontractors.

ISO14001 Certification **2003-12, 2005-10**

Designed and implemented the environmentsal management system for the US Industrial In-Plant Services organization of Waste Management. With over 200 operating locations the industrial group needed ISO14001 certification to continue to serve the automobile sector primarily. This was the first and only business unit within the company to secure ISO14001 certification at that time.

USEPA Environmental Leadership Project **1994-07, 1995-09**

Selected as one of 12 environmental leadership projects nationally Waste Management worked with USEPA Headquarter's and Oregon DEQ to demonstrate the principles of an environmental management system in both hazardous and nonhazardous waste operations which ultimately contributed to the the design and development of concepts that were incorporated into the emerging ISO 14001 Environmental Management Standard in 1996. USEPA published the project report on their website for knowledge transfer to other companies.

Landfill University **1990-08, 1994-12**

Developed a manager focused "university program" with the help of the University of Wisconsin Madison engineering extension program called Landfill University. This 40 hour course had ten four hour modules covering all the important business, regulatory and technical requirements to successfully run a large landfill operation. Many company landfills had revenue in the $1Million per day range, so there was significant need for competent leaders and managers. This program was targeted at providing key competencies during a growth surge in landfill operations.

EHS Corrective Action System **1990-07, 1993-12**

Designed and implemented a compliance action reporting system for 1,500 operating locations world-wide. System housed audit findings, self-audit findings, regulatory citations and warnings, employee and customer identified issues and other deficiencies that required corrective and preventive actions to resolve and eliminate the possibility of recurrence. Tool was used in monthly operating meetings along with financial reporting to assure facilities addressed compliance issues.

EHS Compliance Management System **1988-08, 1992-08**

Designed and implemented an EHS Compliance Management System for over 1,300 facilites in North America and expanded the system to all international operations in 1991-2. Project included digestion of regulations, permits and other authorizations into tasks assigned to operations management and staff. Calendar system allowed scheduling and documentation of compliance tasks through comapny email and generation of self-audit checklists for facilities to use between corporate audit cycles. Content was also used to train staff in their complaince responsibilities.

Abbott Laboratories, Inc. ***1982, 1988***

Quality/Environmental Microbiologist in support of streptomycin and erythromycin antibiotic fermentation processes including bulk product potency testing and assignment as well as finished product quality assurance. Senior Environmental Engineer supporting industrial wastewater treatment operations for two large production facilities in Lake County Illinois; managed environmental compliance program for corporate environmental services department, supervised environmental laboratory testing services, and assured production wastes were permitted for transport, treatment, and/or disposal. Managed all hazardous and solid waste generated in Illinois operations. Supported fermentation operations in Puerto Rico. Prepared emergency management plans and participated in exercises and drills. Developed environmental impact assessments for new and expanded production facilities. Managed RCRA regulatory affairs projects for Lake County Illinois operations. Conducted

research projects in wastewater operations related to antibiotic toxicity to municipal wastewater treatment plants (bench and pilot plants).

University of Wisconsin - Green Bay 1980, 1982

Research and teaching assistant for Graduate School School of Arts and Sciences. Taught microbiology laboratory sections to undergraduate students, managed the microbial type cultures for the University, and conducted research in the survivability of enteric viruses in the environment and waste water treatment processes. Also supported research in bacterial pathogen survival in sediments and taught lecture sections in Water Microbiology, Microbiology, and Ecology of Human Settlements.

City of DePere Wisconsin 1977, 1980

Responsible for operation of a 10MGD (hydraulic capacity) tertiary level waste water treatment plant including: pump stations, bar screens, dissolved air flotation, grit removal, activated sludge processes, nitrification, multi-media filtration, chlorination systems, dissolved air flotation sludge thickening, chemical treatment, plate and frame filter presses, and multihearth incineration. Also active in process monitoring and laboratory analyses.

Anders Rudberg

Principal Specialist

Curriculum Vitae:

Academic and Professional Attainment:

Master of Science, University of Oslo, Mechanical Engineering, 1991

Summary of Professional Experience:

Anders Rudberg is a Research Scientist in Oceanography within DNV, Environmental Advisory Service at the main office in Norway. He has 22 years' experience related to numerical ocean modelling and environmental impact assessment of offshore activities.
He is a specialist in numerical ocean modelling, including oil spill models and dispersion models. His fields of expertise include development of numerical models, participation in national and international projects concerning Environmental Impact Assessment and Contingency analysis.

Present Position:

Safety, environmental and risk management consultancy in the process and offshore industries. Specific areas of experience include numerical ocean modelling, oil spill models and dispersion models. .

DNV GL project references:

2008 - 2014 Statoil ASA, Environmental Risk Assessment, Okhotsk Sea
ConocoPhillips, Environmental Risk Assessment, Baffin Bay
Quebec Terminal, Oil drift in St. Lawrence river
Ministry of Petroleum and Energy, Oil drift simulations in Lofoten and Vesterålen
Total France, Environmental Risk Assessment Dalia, Angola
AGR Peteroleum Services, Oil drift simulations at Gnatcatcher
RWE, Oil drift simulations at Titan
AGR Peteroleum Services, Oil drift simulations at Chamonix
Det Norske. Oil drift simulations at Ulvetanna
Det Norske. Oil drift simulations at Kalvklumpen
Total Norge, Environmental Risk Assessment at David
Total, Norge, Environmental Risk Assessment at Norvarg
Senergi Ltd, Environmental Risk Assessment at Svaneøgle
Statoil, Environmental Risk Assessment at Snøhvitfeltet
Statoil, Environmental Risk Assessment at Skrugard
Statoil, Environmental Risk Assessment at Lunde
Statoil, Environmental Risk Assessment at Skalle
Statoil, Environmental Risk Assessment at Soleie
AGR Petroleum Services, Environmental Risk Assessment at Breiflabb
ENI Norge, Environmental Risk Assessment at Salina, Barents Sea
ExxonMobil, Environmental Risk Assessment at Jotun/Ringhorne
Lundin, Environmental Risk Assessment at Avaldsnes
Lundin, Environmental Risk Assessment at Barchan
Rambøll, Oil drift simulations at Sørøysundet
StatoilHydro, Environmental Risk Assessment at Quest
StatoilHydro, Environmental Risk Assessment at Haltenbanken
StatoilHydro, Environmental Risk Assessment at Gudruin/Sigrun
StatoilHydro, Environmental Risk Assessment at Gullfaks Sør
StatoilHydro, Oil drift simulations at Frigg Delta
StatoilHydro, Oil drift simulations at Slepiner
StatoilHydro, Oil drift simulations at Gjøk
Shell Norge, Environmental Risk Assessment at Dalsnuten
Talisman Energy, Environmental Risk Assessment at Grevling
DONG Energy, Environmental Risk Assessment at Hejre field
ConocoPhillips, Environmental Risk Assessment at Pelikan

Curriculum Vitae:

AGR Peteroleum Services, Oil drift simulations at Jordbær Øst
AGR Peteroleum Services, Oil drift simulations at David
Acona, Oil drift simulations at Storklakken
Det Norske, Oil drift simulations at Trolla
Kuwait Oil Company, Oil drift simulations
BP, Environmental Risk Assessment at Skarv
ENI Norway, Environmental Risk Assessment at Goliat, Barents Sea
ENI Norway, Environmental Risk Assessment at Lunde
Total Norge, Environmental Risk Assessment at Hild

Professional Training

2015: Commercial Awareness
2011: Basic Health, Safety and Environment, web
2010: Petroleum technology and geoscience course
2008: Modern Energy Technology (Offshore and Onshore)
2008: DNV Energy Portal Introduction
2003: DNV Consulting Course
2000: SHE for employees, DNV Norway

Detailed Professional Experience:

Norwegian Polar Institute *1997, 1999*

Research scientist at Norwegian Polar Institute (NPI),
Department of geophysics.

Project ESOP-2 (European Sub polar Ocean Programme). Calculated the ice transport through the Fram Strait based on satellite imageries (SSM/I)

Norwegian Meteorological Institute *1995, 1996*

Research scientist at the Norwegian Meteorological Institute,
Department of oceanography.

Developed a multilayer, reduced gravity ocean current model (OSMOM - Oslo Multilayered Ocean Model). Verification and validation. Simulations of special physical processes and real time studies.

Nansen Environmental and remote Sensing Centre. *1992, 1994*

Research scientist at Nansen Environmental and remote Sensing Centre.
Process simulations and real time studies. Developed a reduced gravity model (RGT-model)

University in Oslo *1991, 1991*

Project assistant at Department of mechanics,
Mathematical Institute
Programming and model runs with a three layer finite depth ocean current model.

Dennis O'Mara

Principal Consultant

Curriculum Vitae:

Academic and Professional Attainment:

Bachelor of Science, Daniel Webster College, Organization and Leadership,

Summary of Professional Experience:

Mr. O'Mara joined DNV in 2013 and is the former President of his own consulting company where he provided safety, security, response preparedness, training, and audit services to waterfront terminal operators. He is also a former U.S. Coast Guard officer with marine casualty investigations, safety, security, environmental compliance, and emergency response management experience.
His recent experience with DNV GL includes extensive work involving the Columbia River, including a Waterway Suitability Assessment, a Quantitative and a Quantitative Vessel Transit Risk Assessment. He also has performed navigation risk assessments of waters of western Canada, and the Caribbean.

Present Position:

Mr. O'Mara is currently a Principal Consultant in the Environment and Navigation Risk Advisory Section. Recent work includes oil and gas marine transport navigation risk projects, oil spill risk mitigation, regulatory research, and business development.

Professional Training

2016: Introduction to IACS PR 17 - web
2016: Introduction to DMSE
2016: Introduction to Energy's PM standard
2016: Introduction to Port State Control Web Course
2015: Barrier Management in Practice – mobility, analytics and usability
2015: Introduction to Root Cause Analysis (RCA)
2015: Project Management in Oil & Gas – Intro to our Common Way of Working
2015: Project Management in Oil & Gas - Affinitas Training
2015: Documents on the Bridge
2015: 2010w DNV GL's approach to Anti-Corruption and Anti-Trust – An Introduction
2015: DNV GL Code of Conduct – An introduction to expected conduct and behavior in daily business
2015: Ionizing Radiation
2015: Consultative conversations, web
2015: Basics of Electrical Safety
2015: Lockout/Tagout
2014: Project Management the DNV Way
2014: CRM Affinitas - Sales ProcessOil & Gas
2014: WE in DNV GL, classroom
2014: DMSO Introduction - Management System in Oil & Gas
2014: ISO14001/OHSAS18001 and DNV GL HSE Mgt. System
2014: WE in DNV GL, web
2014: Affinitas training
2014: PM Essentials WEB-course
2013: Basic Health, Safety and Environment, web
2013: Actively Caring about SHE
2013: Personal Protective Equipment
2013: Defensive Driving
2013: Field Hazard Recognition - Assessing Personal Risk
2013: Violence in the Workplace
2013: Office Hazard Recognition and Response
2013: Hazards of Hydrogen Sulfide
2013: Heat and Cold Stress
2013: Basic Health, Safety and Environment, web

Dennis O'Mara

Principal Consultant

Curriculum Vitae:

Detailed Professional Experience

Great Lakes Consulting Services, Inc. *2004 - 2013*

Conceived, developed, and implemented all facets of the business.

Performed facility security assessments; Identified security threats and risks to vessel and facility operations. Wrote over 50 Facility Security Plans, attended over 300 Coast Guard inspections with no deficiencies.

Designed and facilitated security drills and exercises. Assessed training needs of facility personnel to meet company and regulatory objectives. Developed and presented customized training programs for individual facilities; trained over 200 marine facility personnel.

Performed audits of facility security programs. Attended over 400 regulatory inspectoins and ensured compleince for all client companies. Zero regulatory deficiencies.

Performed port-wide risk management assessment of the Port of Detroit to prioritize spending of over $5 million Port Security Grant Program Funds. Wrote successful PSGP grant applications, managed grant funds.

Performed all business functions including marketing, advertising, accounting, research, business development, etc.

Projects Completed by Great Lakes Consulting

Detroit/Wayne County Port Authority

Managed marine operations at passenger vessel terminal. Developed and implemented safety, security, and emergency response plans for terminal operations. Hired, trained, and managed terminal personnel.

Served as Facility Security Officer; established and implemented security policies, managed security program, trained facility personnel. Liaised with EMS agencies (Detroit Fire, Detroit Police, US Customs, US Coast Guard, others). Managed Port Security Grant funds for 19 separate grant projects (approx $5M).

American Systems

Developed and delivered Incident Command System and Contingency Planning training courses to the Lebanese Navy. Modified versions of established U.S. training courses for appropriate presentation in Lebanon. Trained over 50% of the Lebanese Naval Officer Corps.

U. S. Coast Guard *1983 - 2004*

Various shipboard assignments (5 years);
Served as inport safety/security watchstander, u/w lookout, helmsman, Quartermaster of the Watch (navigation, watchstanding, record keeping, etc.).
Small boat experience (boat crewman) conducting law enforcement and search and rescue missions.
Electronics Technician 1st Class (5 years); maintained communications and navigation systems on vessels ranging from 41' to 180' in various services.
Attended Officer Candidate School, received commission
Served as Port Security Division Assistant for 17 CG District staff (Alaska)
Served as Chief of Port Operations; Managed Facility Inspection Program; Inspected bulk oil facilities, reviewed and approved Facility Response Plans and Operations Manuals. Maintained Area Contingency Plans, planned and participated in oil spill response exercises; partnered with stakeholders in planning and responding to marine pollution incidents. Managed Container Inspection program; Inspected cargo containers and warehouses to reduce the risk of hazardous material incidents.

Dennis O'Mara
Principal Consultant

Curriculum Vitae:

Served as Senior Investigating Officer; Conducted investigations of maritime casualties. Interviewed witnesses, collected evidence, analyzed data, and presented oral and written findings before Administrative Law Judges. Analyzed casualty data; made safety recommendations to industry and initiated improvements to Coast Guard prevention activity.
Served as Chief of Port Security; Developed regional facility risk assessment guidance and supervised field inspection teams. Planned and coordinated security operations on US/Canadian border. Implemented new maritime security regulatory scheme.

DNV GL