Northern Gateway Response to Request for Additional Information

from the

Joint Review Panel Session Results and Decision, dated January 19, 2011

ENBRIDGE NORTHERN GATEWAY PROJECT

March 2011

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Preamble

The Joint Review Panel (JRP) established to review the Enbridge Northern Gateway Project (the Project), in its Panel Session Results and Decision (Decision) dated January 19, 2011, determined that additional information on the design and risk assessment of the pipelines is required prior to issuing a hearing order for the Project. The additional information requested in the Decision, pages 19 and 20, is as follows.

"Section 3.6.1 Additional Information Required

Given the unique characteristics of the Project, we have determined that additional information is required to conduct our review.

We require further information about the conceptual design of the pipeline that demonstrates:

- *how the risk factors resulting from the geotechnical and geographic aspects of the applied-for corridor and terminal will be taken into account; and*
- *the integration of the risk factors with the environmental and socio-economic consequences from potential hydrocarbon releases.*
- *This information will assist all parties and the Panel to better understand the consequences of hydrocarbon releases and how these consequences will influence project design and operation.*

At a minimum, we require the following information to be filed before continuing further with the review process.

A. Maps showing consequence areas of potential volume releases

Geographically referenced maps at a 1:25,000 scale (i.e. GIS) describing the geographical extent, on land and water, from potential hydrocarbon releases on consequence area.[3] *The potential hydrocarbon release volumes shall be determined based on full-bore ruptures within each kilometre post distance, as indicated in the route atlas imagery maps (Volume 3, Appendix C), considering, but not limited to:*

- *pipeline flow rate and elevation profile*
- *combined static and dynamic drain-out release volume*
- *fluid properties*
- *operational detection, isolation and response*
- *valve type and location*
- *geographical and terrain conditions*

[3] Consequence areas can be onshore and/or offshore including, but not limited to: wildlife reserves, occupied areas, Indian Reserves, urban areas or towns, water bodies, federal or provincial campgrounds and parks and town water intake locations.

Maps shall also visually reflect the topographical contour (e.g. photographic and/or Digital Elevation Model) of both pipelines and associated facilities.

B. Pipeline plots showing elevation and potential volume from releases

Release volume plot[4] *describing the pipeline elevation profile and the combined static and dynamic drain-out volume at the worst-case discharge location caused by a full-bore rupture within each kilometre post distance, as indicated in the route atlas imagery maps (Volume 3, Appendix C) along the Project. These plots should be shown at a 1:25,000 scale, with pipeline chainage on the X-axis, and two Y-axes showing both barrels and cubic metres of product released, and the estimated elevation in metres for both pipelines and associated facilities. The proposed location of valves and stations should be shown on the plots. The plots should also show on the X-axis the linear extent of the consequence areas along the pipeline and facilities.*

C. Risk-based approach to design and operation

Demonstration that a risk-based approach to engineering design was used to account for the unique Project characteristics (such as geotechnical and seismic areas) of the proposed pipeline corridor.

At a minimum, the applicant is required to provide information on where requirements beyond CSA Z662-07 or supplemental design are/will be used on the Project. Also, to be provided is information on how the design will address the following Project life cycle components and/or challenges:

- *line pipe material properties including effective strain capacity after construction;*
- *line pipe welding design and quality control in geotechnical and seismic areas;*
- *right-of-way monitoring in geotechnical and seismic areas;*
- *tank capacity at stations for potential pipeline repairs;*
- *valve design and location for spill consequence reduction;*
- *pipeline and facility risk assessment and associated risk reduction strategies in consequence areas; and*
- *spill containment structures (e.g. ponds) and emergency response strategies in consequence areas."*

[4] All plots and maps referred to in this section shall be formatted for tabloid paper size (i.e. 279 x 432 mm or 11 x 17 inch)

Structure of the Response

Northern Gateway has responded to the Decision for additional information as follows:

Section A – Maps showing consequence areas of potential volume releases.

This section describes the assumptions, caveats and cautions, and consequence areas relating to the requested information shown on the maps. The maps are located in Appendix A of this Response.

Section B - Pipeline plots showing elevation and potential volume from releases.

This section describes the assumptions, caveats and cautions, and associated details relating to the pipeline plots. The pipeline plots are located in Appendix B of this Response.

Section C - Risk-based approach to design and operation.

This section is structured into three subsections as follows:

C.1, Description of the risk-based approach to design and a listing of the Enbridge design standards beyond CSA Z662-07 to be used for the Project.

C.2, Northern Gateway's response to the unique characteristics of the Project as identified in the Decision, page 18.

C.3, Northern Gateway's response to the Project life cycle components and challenges identified in the Decision.

A Maps Showing Consequence Areas of Potential Volume Releases

Request:

A. Maps showing consequence areas of potential volume releases

Geographically referenced maps at a 1:25,000 scale (i.e. GIS) describing the geographical extent, on land and water, from potential hydrocarbon releases on consequence areas[3]*. The potential hydrocarbon release volumes shall be determined based on full-bore ruptures within each kilometre post distance, as indicated in the route atlas imagery maps (Volume 3, Appendix C), considering, but not limited to:*

- *pipeline flow rate and elevation profile*
- *combined static and dynamic drain-out release volume*
- *fluid properties*
- *operational detection, isolation and response*
- *valve type and location*
- *geographical and terrain conditions*

The maps shall also visually reflect the topographical contour (e.g., photographic and/or Digital Elevation Model) of both pipelines and associated facilities.

Reference

Page 19 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

Pipeline maps showing potential hydrocarbon releases and consequence areas are located in Appendix A. The following describes the assumptions, caveats and cautions, and consequence areas relating to the information shown on the maps.

[3] Consequence areas can be onshore and/or offshore including, but not limited to: wildlife reserves, occupied areas, Indian Reserves, urban areas or towns, water bodies, federal or provincial campgrounds and parks and town water intake locations.

A.1 Assumptions

Potential hydrocarbon release volumes onto consequence areas have been computer modeled for the oil pipeline because it is the larger of the two pipelines and has the larger potential release volume. The modelling results show the potential maximum volumes from a full-bore (a full and complete break across the entire circumference of the pipeline) release within each 1-km segment of the pipeline. The modelling was conducted by Applied Science Associates, Inc., Rhode Island (ASA) using their proprietary OILMAPLAND™ software. The following assumptions were used:

- Route Rev. T centreline and KPs
- preliminary valve locations based on the December 2010 Update filing, Volume 3
- surface water features and direction flows from the National Hydro Network (NHN) (http://www.geobase.ca/geobase/e/data/nhn/index.html) provided by Natural Resources Canada
- surface water feature names provided by IHS Inc. (http://www.ihs.com)
- watercourse flow rates based on annual maximum mean monthly discharges
- watercourse flow velocities calculated using relationships between discharge, channel gradient and drainage area for each crossing or affected downstream channel reach
- terrain elevation data from the Canadian Digital Elevation Data (CDED website) provided by Natural Resources Canada
- land cover from the Canada-wide 1-km Advanced Very High Resolution Radiometer (AVHRR) Composite land cover data downloaded from the NASA web site (http://gcmd.nasa.gov/records/CANADACGDI_Canada_GeoGratis_DataABC3Softwa.html)
- hydrocarbon release modelling is based on full bore volume releases from the oil pipeline
- release volume within each 1-km segment is the maximum value of 20 volume calculations done within the segment
- release rate is based on oil flowing at maximum throughput (92,700 cu m/d). After valve closure, the remainder of the product is released by gravity drainage based on rates proportional to slope at either side of the rupture location.
- all the oil is immediately released to the surface
- modelling includes land and freshwater spill extents but does not include marine spill extents
- modelling was set for a 12 hour duration following the full-bore rupture
- modelling has been done for releases at the tunnel portals but not for each kilometre within the tunnels
- oil viscosity is based on synthetic crude with a density of 0.873 g/cm^3 and a viscosity of 5 cP @ 25°C

A.2 Caveats and Cautions

The following caveats and cautions should be noted when reviewing the maps in Appendix A:

- The maps show hypothetical maximum full-bore volume releases and resultant spill extents within each 1-km segment of the oil pipeline. Each map is a hypothetical illustration only and represents a multi-spill situation that could not occur during pipeline operations.
- The maps are a tool to be used in conjunction with design, mitigation, emergency response, and other aspects when designing and operating the pipelines. The maps are limited in value when viewed in isolation.
- Site-specific mitigation measures and emergency response are excluded from the spill modelling represented in the maps, because these details will be developed during detailed engineering. As a result, the hypothetical spills shown on the maps are unmitigated and the potential spill extents are overstated.
- As stated in the Application, Volume 7B: “considering the modern design features, detection measures, mitigation and response, the likelihood of a spill occurring along the pipeline route is low”.
- Many of the assumptions used for the spill extent modelling, described in Section A.1, are conservative; for example, maximum volume release of hydrocarbons, maximum throughput, release of entire volume to surface and watercourse discharges based on maximum mean monthly discharges. Combining these conservative assumptions results in reduced likelihood that any of these hypothetical spill extents would represent an actual situation.
- The pipeline route and valve locations are preliminary and will be finalized during detailed engineering. This will result in modifications to the potential maximum release volumes.

A.3 Consequence Areas

The Decision states the following guideline for consequence areas:

"*Consequence areas can be onshore and/or offshore including, but not limited to: wildlife reserves, occupied areas, Indian Reserves, urban areas or towns, water bodies, federal or provincial campgrounds and parks and town water intake locations*"

Northern Gateway has elaborated on this guideline and has described consequence areas according to the following broad categories.

Officially Designated Protected Areas

Federal and provincial protected areas that are shown as consequence areas include:

- federal national parks
- provincial parks (in British Columbia, Class A, B, and C parks)
- provincial conservancies
- provincial ecological reserves
- provincial wildlife reserves

Campgrounds within federal and provincial parks and protected areas are also included as consequence areas.

Settlements

Human settlements that are shown as consequence areas include hamlets, villages, towns and cities, but not rural areas with sparse and isolated settlements or isolated residential parcels.

Indian Reserves

Areas that are designated by the federal government as Indian Reserves under the *Indian Act* are shown as consequence areas.

Water Use

Licenses related to human consumption and other uses (e.g., industrial, agricultural) are shown as consequence areas.

In Alberta, water licence data were obtained from Alberta Environment (Alberta Environment 2010). This includes both ground water and surface water intake locations for all purposes with sufficient attribute information on licenses to allow Northern Gateway to segregate licenses by purpose, such as human consumption.

In British Columbia, water licence data were obtained from GeoBC's data discovery provincial government service (GeoBC 2011). The data included:

- British Columbia points of diversion such as licensed surface water intake sites for all purposes but excludes groundwater intakes
- water intake extraction points for human consumption such as for human drinking water systems under the authorization of a Health Authority in BC. The information includes both surface and groundwater sources but does not include storage or treatment facilities.

Watercourses

Watercourses are shown as consequence areas if they contain fish species that are either at risk or harvested. Watercourses that do not contain at risk or harvested fish species are shown on the map but not designated as consequence areas.

Information on fish distribution was based on field programs carried out for Northern Gateway from 2005 to 2009 (Whelen et al. 2010), as well as other available data. The presence of species at risk was a criterion for defining a fisheries consequence area, because these species are of management concern and would be vulnerable to contact with oil.

Wildlife

Wildlife habitat is shown as a consequence area if it meets the following conditions:

- It contains species likely to interact strongly with oil. An interaction is considered strong when the species is both likely to contact oil (should a spill occur) and to have elevated mortality rates. Amphibians are considered the group most sensitive to spills, followed by some aquatic birds that actively forage in wetlands (described below).
- It is likely to have species at risk. This analysis focuses on species federally listed by *SARA* or COSEWIC as Endangered, Threatened, or Special Concern (COSEWIC 2008); by British Columbia as Blue or Red listed (BC CDC 2008); or by Alberta as At Risk.

The most sensitive stream dwelling species at risk is likely to be the coastal tailed frog (which is federally listed as Special Concern and Blue-listed in British Columbia). Both field data and habitat suitability modelling were used to identify streams with habitat for coastal tailed frog.

Wetlands

Fens and marshes are shown as consequence areas for two reasons. First, herbaceous and bryophyte cover could be affected by contact with oil and their recovery rate may be slow. Second, these open water wetlands may be important as wildlife habitat, fish habitat or potential rare plant habitat, and they have unique hydrological regimes.

Wildlife species at risk that use open water include horned grebe, trumpeter swan, white-winged scoter, American bittern, great blue heron, sandhill crane, yellow rail, rusty blackbird, coastal tailed frog, and western toad. Several species at risk use wetlands but forage above water and are less likely to be exposed to oil (Nelson's sparrow, Le Conte's sparrow and rusty blackbird). Three ecosystems (bogs, swamps and floodplains) are not considered as consequence areas because they are dominated by tree and/or shrub species whose root structure would be less affected by an oil spill than lowland types (Walker et. al. 1978).

Information on wetlands was developed as part of terrestrial ecosystem mapping (TEM) for the Project. In Alberta, the wetlands are typically mapped according to ecosite phase (Beckingham and Archibald 1996; Beckingham et al. 1996; Wheatley and Bentz 2002). In British Columbia, wetlands are mapped according to the guide Wetlands of British Columbia (Mackenzie and Moran 2004), as well as the Ministry of Forest's BEC field guides (Banner et al. 1993a,1993b; DeLong 2003, 2004; Delong et al. 1990, 1993, 1994). Fens and marshes were mapped in the project effects assessment area (PEAA) from 2008 to 2009 and following standards for TEM in British Columbia (RIC 1998).

B Pipeline Plots Showing Elevation and Potential Volume from Releases

Request

B. Pipeline plots showing elevation and potential volume from releases

Release volume plots[4] *describing the pipeline elevation profile and the combined static and dynamic drain-out volume at the worst-case discharge location caused by a full-bore rupture within each kilometre post distance, as indicated in the route atlas imagery maps (Volume 3, Appendix C) along the Project. These plots should be shown at a 1:25,000 scale, with pipeline chainage on the X-axis, and two Y-axes showing both barrels and cubic metres of product released, and the estimated elevation in metres for both pipelines and associated facilities. The proposed location of valves and stations should be shown on the plots. The plots should also show on the X-axis the linear extent of the consequence areas along the pipeline and facilities.*

Reference

Page 20 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

Pipeline plots showing elevations and potential volumes from releases are in Appendix B. Assumptions, caveats and cautions described in Section A should be noted when reviewing these plots. The following describes the information and the process used to develop the plots in Appendix B.

B.1 Pipeline elevation profile

Pipeline elevations are based on 50-metre samplings along the route using the Canadian digital elevation data (CDED, 50k, Edition 2, 2009) provided by Natural Resources Canada.

B.2 Release volume plots

The maximum potential oil volume release within each 1-km segment of the pipeline has been calculated for the plots in Appendix B, which show the location of the maximum release within each slack KP segment (X axis) and the volume in m^3 (left Y axis) and barrels (right Y axis) using the conversion of 1 m^3 equals 6.29 barrels.

[4] All plots and maps referred to in this section shall be formatted for tabloid paper size (i.e. 279 x 432 mm or 11 x 17 inch)

B.3 Linear Extent of Consequence Areas

The linear extent of consequence areas, where they intersect the 25-metre pipeline permanent RoW, is indicated in the lower section of the plot.

C Risk-based Approach to Design and Operation

Request

C. Risk-based approach to design and operations

Demonstration that a risk-based approach to engineering design was used to account for the unique Project characteristics (such as geotechnical and seismic areas) of the proposed pipeline corridor.

At a minimum, the applicant is required to provide information on where requirements beyond CSA Z662-07 or supplemental design are/will be used on the Project. Also, to be provided is information on how the design will address the following Project life cycle components and/or challenges:

- *line pipe material properties including effective strain capacity after construction;*
- *line pipe welding design and quality control in geotechnical and seismic areas;*
- *right-of-way monitoring in geotechnical and seismic areas;*
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- *valve design and location for spill consequence reduction;*
- *pipeline and facility risk assessment and associated risk reduction strategies in consequence areas; and*
- *spill containment structures (e.g. ponds) and emergency response strategies in consequence areas."*

Reference

Page 20 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

This section is structured into three subsections as follows:

- Description of the risk-based approach to design and operations and a listing of the Enbridge design standards beyond CSA Z662-07 to be used for the Project (Section C.1)
- Northern Gateway's response (Section C.2) to the characteristics of the Project as identified in the Decision
- Northern Gateway's response(Section C.3) to the Project life cycle components and/or challenges identified in the Decision

C.1 Risk Based Approach

The following is a general description of the risk-based approach used by Northern Gateway for design and operations.

C.1.1 Design

During preliminary engineering, Northern Gateway completed a considerable amount of work focused on identifying, evaluating and preparing engineering solutions using a risk-based approach for the Project. This included the following:

- pipeline routing, including extensive studies and route evolution up to the current Route Rev T., as described in the December Update 2010, Volume 3 (Section 2) and Volume 3
- geotechnical engineering and field work, for the pipelines, facilities and tunnels, as described in the Application, Volume 3, Section 3 and in this Response, Section C.2.4
- watercourse crossing evaluations, engineering and field work as described in the Application Volume 3, Section 6 and in this Response, Sections C.2.2 and C.3.6
- evaluation of valve site locations, as described in the Application, Volume 3, Section 5.5 and in this Response, Section C.3.5
- Kitimat Terminal engineering, as described in the Application, Volume 3, Section 9 and in this Response, Section C.6.2

Northern Gateway will design, construct and operate the Project consistent with, or exceeding the NEB Regulations, CSA Z662-07 and the Enbridge Engineering Standards. A risk-based approach is imbedded in Enbridge's Engineering Standards. Accordingly, Northern Gateway's use of a risk-based approach for designing the Project occurs through the application and use of the Enbridge Engineering Standards, which in turn incorporate Canadian regulatory and industry standards.

For example, Enbridge Standard D06-101 for Piping Design and Construction for the Mainline (the Standard) demonstrates the risk-based approach employed. First, the Standard includes the details for determining minimum wall thickness using Barlow's formula. Second, Section 4.1.2 of the Standard states that the pipe may be subjected to other loads for which the calculated wall thickness may be insufficient. Therefore, the design of the pipe should also consider the effect of resultant longitudinal, axial bending, torsional, and hoop stresses in addition to the stress interactions and reactions at significant points in the pipeline system. The Standard directs that "The Project Engineer shall determine whether these combined loadings warrant additional pipe strength or protection means."

The Standard lists typical loads on a pipeline system as including:

- internal pressure
- thermal expansion and contraction
- differential movements (thaw settlement, frost heave, etc.)
- self weight of the pipe and contents and gravity loads

- static wind loads and static fluid loads
- external hydrostatic pressure
- buoyancy effects
- geotechnical loads (slope failures and soil movements)
- cyclic or vibratory loads
- external live loads (overburden, vehicles, etc.)
- dynamic or seismic loads
- ice loads

The Standard also includes Enbridge's extensive direction on pipeline design and construction, including valve selection and placement, construction practices, crossings, pressure testing, buoyancy control and other pipeline design and construction details.

The Enbridge Engineering Standards have been developed over Enbridge's operating history using risk-based approaches, which are supplemented with CSA and general pipeline industry experience.

The design of the pipeline and facilities described in the Application, Volume 3 will be further defined during detailed engineering and prior to commencement of construction. For instance, Enbridge's design approach and strain management plan, which is a risk-based approach, will be used for the design of areas with expected geotechnical and seismic movements by minimizing the probability of failure at all areas susceptible to externally applied longitudinal strain.

C.1.2 Geotechnical

Northern Gateway has, during the route selection process, conducted extensive geotechnical assessments. The geotechnical assessment process has used a risk-based approach to critically examine the geographical, geological and geotechnical features along the route to identify locations, areas or features that should be avoided with the pipeline route. To the extent that identified hazards cannot be avoided, mitigation measures to address these hazards have been identified.

Section C.3.6.1 of this Response explains in greater detail the risk-based approach used by Northern Gateway regarding geotechnical and seismicity areas of concern along the pipeline corridor.

C.1.3 Operations

Northern Gateway's operations will use a risk-based approach for integrity management, which includes risk identification and assessment of project operations. This risk-based integrity management system will use documented policies, procedures and practices to confirm operational reliability of the system components, including pipelines, pump stations, tank terminal and marine terminal piping and tanks. Integrity management programs will confirm compliance with internal procedures, practices and standards as well as with regulations.

Northern Gateway's System Operations and System Integrity are described in the Application, Volume 3, Sections 11 and 12. These sections describe the pipeline control centre operations located in Edmonton:

the SCADA System, communication, control and monitoring. Northern Gateway's entire pipeline and terminal operations will be constantly monitored, including pipeline operating pressure, pipeline flows, pumps and pump station operation and leak detection. Should operating abnormalities or a pipeline leak occur, alarms will notify qualified operators and the pipeline system will be shut-down.

C.1.4 Engineering Standards

The pipelines will be designed, constructed and operated to comply with the latest NEB regulations, including the Onshore Pipeline Regulations, 1999 (OPR-99), which incorporate by reference, the Canadian Standards Association (CSA) Z662-07, Oil and Gas Pipeline Systems. These standards in turn reference other standards and publications, which will be followed as appropriate in the design (see Table C-1). Beyond the CSA Z662-07 requirements, Northern Gateway's pipelines and facilities will be designed and constructed in accordance with Enbridge's Engineering Standards and Construction Specifications (see Table C-1). Additionally, specific examples where Northern Gateway is taking measures beyond CSA Z662-07 are provided in this Response, Section C.3.

Table C-1 Enbridge Pipelines Inc. Engineering Standards and Specifications

Number	Title
D01-101	Use of Engineering Standards Rev. Jan 2005
D01-102	Policy and Style for Engineering Standards Rev. Oct 20, 2008
D02-101	Design basis, Electrical Rev. Jul 20, 2006
D02-102	Design Basis, Main Line Rev. Aug 01, 2007
D02-103	Design Basis, Station and Terminal Rev. Jan 9, 2007
D02-104*	Hazardous Area Classification Rev. May 26, 2010
D02-105	Fire Protection, Extinguishment Rev. Jan 6, 2000
D02-106	Noise and Acoustic Dampening Rev. Sep 1, 1999
D02-107	Station Manual, Preparation Rev. Sep 01, 1999
D03-101	Pipeline Corrosion Assessment Rev. Sep 01, 1999
D03-102	Integrity Assessment, Oil Tank Rev. Jul 16, 2001
D03-103	Internal Inspection, Main Line Rev. Sep 01, 1999
D03-104*	Weld Inspection Rev. Jun 03, 2010
D03-105	Shop Inspection Rev. Sep 1, 1999
D04-101	Cathodic Protection Rev. Apr 20, 2006
D04-102	Painting, Coating and Lining Rev. Jul 28, 2006
D05-101*	Facility and Tank Containment Systems Rev. Nov 6, 2008
D05-102	Site Preparation, Earthwork, Grading, Road and Pavement Rev. Sep 1, 1999
D05-103	Trenches, Underground Lines Rev. Sep 1, 1999
D05-201	Foundation, Oil Storage Tank Rev. Sep 01, 1999
D05-202	Foundation, Station and Terminal Rev. Sep 1, 1999

Table C-1 Enbridge Pipelines Inc. Engineering Standards and Specifications (cont'd)

Number	Title
D05-301	Building, Station and Terminal Rev. June 10, 2009
D05-302	Laboratory, Sample & Sample Storage Buildings Rev. Sep 01, 1999
D05-401	Platforms, Stairs and Ladders Rev. Apr 29, 2003
D06-101	Piping Design and Construction, Main Line, Dec 13, 2006
D06-102	Piping Design, Station and Terminal Rev. May 1, 2008
D06-103	Crossing Design, Main Line Rev. Dec 13, 2006
D06-104	Pipe and Fittings, Steel Rev. Aug 1, 2007
D06-105	Valve, Steel Rev. Jun 15, 2000
D06-105TB	B Valve Application Table Rev. Jan. 4, 2008
D06-106*	Piping Design and Construction, Auxiliary Rev. Nov 19, 2010
D07-101	Pump, Main Line Rev. Nov. 15, 1999
D07-102	Pump, Booster Rev. Nov 15, 1999
D07-201	HVAC, Building, Station & Terminal Rev. Dec. 18, 2009
D07-202	Heat Tracing Rev. Nov 15, 1999
D07-203	HVAC, Pipeline Maintenance Building Rev. Nov 15, 1999
D07-301	Sump System Design Rev. Nov. 15, 1999
D07-302	Flare Stacks & Pits Rev. Nov 15, 1999
D08-101*	Oil Storage Tank Rev. Sep. 28, 2010
D08-102	Oil Storage Tank Roof Rev. Nov. 15, 1999
D08-103	Oil Storage Tank, Accessories Rev. Nov 15, 1999
D09-104	Custody Transfer Metering Systems, Mar 19, 2008
D10-101	Power System Design Rev. Oct 29, 2002
D10-102	Substation Design Rev. Dec 01, 1999
D10-103	Switchgear & Motor Control Center Rev. May 03, 2007
D10-104	Auxiliary Power Supplies Rev. Dec 1, 1999
D10-105	Power System Protective Relaying Rev. Apr 18, 2007
D10-106	Substation Grounding Rev. Dec 01, 1999
D10-107	Surge Protection & Insulation Coordination Rev. Dec 1, 1999
D10-201	Wiring Methods Rev. Jul 20, 2006
D10-202	Grounding Methods Rev, Dec 1, 1999
D11-101	Motor, Main Line Pump Rev. Dec 01 1999
D11-102	Variable Frequency Drive Rev. June 11, 2008
D11-103	Motor Protection Rev. Dec 01, 1999
D11-201	Lighting, Indoor Rev. Dec 01, 1999

Table C-1 Enbridge Pipelines Inc. Engineering Standards and Specifications (cont'd)

Number	Title
D11-202	Lighting, Outdoor Rev. Dec 01, 1999
D11-301	Valve Actuation and Control Rev. Jan 11, 2007
D12-101	Control, Pump Station Rev. Jul 20, 2006
D12-102	Control, Injection & Delivery Facility Rev. Jul 20, 2006
D12-104	Pressure Relief Rev. Oct 02, 2003
D12-201	Instrumentation, General Rev. Nov 26, 2002
D12-202*	Gas Detection Rev. Jun 02, 2010
D12-203	Fire Detection Rev. Dec 01, 1999
D12-204	Vibration Monitoring Rev. Dec. 01, 1999
D12-205	Programmable Logic Controllers Rev. Jan 04, 2008
D12-208	Pressure Control System Rev. Feb 21, 2006
**These standards were revised subsequent to the Application, Volume 3 being filed*	
Specifications for Facility Construction (Canada)	
Section 01	Site Preparation Rev. Mar 14, 2003
Section 02	Piping and Electrical Rev. Mar. 14, 2003
Section 03	Sewers and Drains. Rev. Mar 14, 2003
Section 04	Roads and Asphalt Paving Rev. Mar 14, 2003
Section 05	Grouting Rev. Dec 5, 2008
Section 06	Concrete Rev. Mar 14, 2003
Section 07	Concrete Piles Rev. Mar 14, 2003
Section 08	Steel Pipe Piles Rev. June 26, 2009
Section 09	Precast Concrete Piles Rev. Mar 14, 2003
Section 10	Electrical Rev. Mar 14, 2003
Section 11	Instrument Rev. Mar 14, 2003
Section 12	Station Piping Rev. April 30, 2009
Section 13	Piping Classes Rev. Aug 1, 2007
Section 14	Pressure Testing Facility Piping Rev. Aug. 17, 2009
Section 15	Mechanical Equipment Installation Rev. Aug. 11, 2009
Section 16	PE & PVC Pressure Piping Rev. Mar 14, 2003
Section 17	Coatings Rev. Mar 14, 2003
Section 18	Structural Steel Rev. Sept. 14, 2009
Section 19	Painting Rev. Mar. 14, 2003
Section 20	Preservation of Mechanical Equipment Aug. 7, 2009

C.2 Project Characteristics

The Decision states that many characteristics make the Project unique. While the Project does have characteristics that require thorough investigation and specific engineering, construction, and operations solutions, these characteristics are not unique to this Project.

All technical issues identified for the pipelines have been successfully addressed on other existing pipelines operated by Enbridge and other pipeline operators in British Columbia and elsewhere. Northern Gateway is using these existing solutions as the basis to design, construct and operate the pipelines for this Project.

Northern Gateway's responses to the unique Project characteristics identified on pages 18 and 19 of the Decision dated January 19, 2011 are in this Response, Sections C.2.1 to C.2.7. Each characteristic has been assessed using a risk-based approach. Northern Gateway will further address each characteristic during detailed engineering and during construction and operations.

C.2.1 "Much of the route traverses mountainous terrain (more than half of the length)"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

The two areas of mountainous terrain along the pipeline route are in the Rocky Mountains (approximately 103 km of the pipeline route) and Coastal Mountains (approximately 105 km of the pipeline route) physiographic regions. The total length of the pipeline route in these regions is approximately 208 km, which is 18% of the pipeline route.

As described in the Application, Volume 3, Section 3, the remaining approximately 82% (968 km) of the pipeline route crosses several physiographic regions from east to west, each described briefly below:

- Eastern Alberta Plains—(approximately 166 km); the topography is flat to gently rolling
- Southern Alberta Uplands—(approximately 354 km); the topography is gently rolling
- Alberta Plateau—(approximately 44 km); the topography is rolling to steep
- Interior Plateau—(approximately 404 km); the topography is rolling to ridged

An important element of the route selection process is related to geotechnical engineering, which includes an approach to minimize risk throughout the life cycle of the pipeline portion of the Project, including design, construction, operation and abandonment of the pipelines and facilities. Northern Gateway's geotechnical engineering approach is summarized in this Response, Section C.3.6.1, together with examples of the mitigation measures to reduce project life cycle risks.

The pipeline routing and engineering considers the various issues and hazards inherent in the mountainous sections of the pipeline route. These issues and hazards are addressed in the Application, Volume 3. This includes the following documents that will be referenced throughout this Response, and which contain the additional engineering information requested in the Decision:

- Appendix E-1: Overall Geotechnical Report on the Pipeline Route Rev. R for the Enbridge Northern Gateway Project, Bruderheim, Alberta to Kitimat, BC.
- Appendix E-1-1: Acid Rock Drainage and Metal Leaching Field Investigation, Enbridge Northern Gateway Project.
- Appendix E-1-2: Identification and Mitigation of Acid Rock Drainage and Metal Leaching During Construction, Enbridge Northern Gateway Project.
- Appendix E-2: Preliminary Geotechnical Report on Proposed Coast Mountain Tunnels Route (Rev R KP1072-1087), Enbridge Northern Gateway Project.
- Appendix E-3: Preliminary Geotechnical Report on the Proposed Kitimat Terminal Enbridge Northern Gateway Project Kitimat, British Columbia.

C.2.2 "The route crosses areas of high geotechnical risk (avalanches, slides, earthquakes, faults, etc) and unique environmental habitat (fish habitat) and communities dependent on the land (subsistence, cultural, etc)"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

Areas of High Geotechnical Risk

Northern Gateway recognizes that some areas of potentially high geotechnical hazards occur in locations traversed by the pipeline route. Northern Gateway has focused considerable effort investigating and designing to avoid or mitigate these various hazards.

A major criterion in routing is to avoid areas of geotechnical concern wherever possible. Examples of areas where the pipeline route was moved or refined are described in this Response, Section C.3.6.1. In the area of the most challenging terrain, the Coast Mountains, two tunnels are proposed to avoid high alpine areas with hazards.

The Overall Geotechnical Report (see the Application, Volume 3, Appendix E-1) presents:

- a description of the geotechnical conditions along the entire route in detail on a kilometre-by-kilometre basis (see Table B-1 of the Report)
- terrain hazards and risk analysis (see Section 4 of the Report)
- a detailed risk assessment of geotechnical hazards (see the results summarized in Table C-1 of the Report)

The geotechnical hazards and resulting risks will be managed to acceptable levels using avoidance, where possible, and planned mitigation measures where avoidance is not feasible.

With respect to remaining hazards along the proposed route, Northern Gateway states (see Application, Volume 3, Section 3.1) that: "The geotechnical considerations to be addressed and standard mitigation measures are summarized in Table 3-2. These considerations will be addressed during detailed engineering so that the pipelines are properly designed to meet pipeline integrity, operational safety and environmental considerations." For ease of reference, Table 3-2 (as Table C-2) is reproduced here and identifies these geotechnical considerations and the standard mitigation measures.

Table C-2 Primary Geotechnical Considerations and Standard Mitigation Measures

Primary Geotechnical Considerations	Standard Mitigation Measures
Deep seated slides	• locate pipelines and facilities to avoid deep seated slides • install ground and surface water control • install berm and riprap toe reinforcements • site monitoring
Shallow to moderately deep slides	• locate pipelines and facilities to avoid slides • install ground and surface water control • design cuts and fills to minimize instability • install anchors, shotcrete or mechanical stabilized earth
Rock falls and rock toppling	• locate pipelines and facilities to avoid rock falls • design rock cuts to minimize instability • install stabilization measures, including scaling, anchoring, shotcrete, and mesh • install rock fall protection measures, including berms, catchment areas and ditches • install reinforced concrete slabs over pipelines in selected areas • remove potential problem boulders on slopes
Debris flows	• locate pipelines and facilities to avoid debris flows • locate above ground structures away from alluvial fans and streams subject to debris flow • install pipelines at a deeper depth in selected areas • install concrete coated pipe in selected areas • install debris flow berms • monitor weather and snow melt conditions during construction in areas subject to debris flows, and remove personnel and equipment if necessary • set temporary bridges to appropriate elevations on debris flow streams during construction

Table C-2 Primary Geotechnical Considerations and Standard Mitigation Measures (cont'd)

Primary Geotechnical Considerations	Standard Mitigation Measures
Avalanches	• locate pipelines and facilities to avoid avalanches • consider avalanche issues when locating key facilities such as tunnel portals that will require year-round construction • conduct avalanche monitoring and control during construction • conduct avalanche monitoring and control where required during operations • install pipeline at a deeper depth or install a concrete coated pipe in locations prone to avalanche caused avulsion
Sedimentation and erosion	• design cuts and fills to minimize sedimentation and erosion • install ground and surface water control • avoid diversion of surface water flows along the pipeline • install silt fencing and temporary water control • revegetate disturbed areas • install sedimentation ponds, sediment collection berms and filtration berms in selected areas
Karst	• locate pipelines and facilities to avoid karst formations
Acid Rock Drainage (ARD)	• locate pipelines and facilities to avoid acid rock drainage (ARD) • conduct visual assessment followed by sampling and analysis when required during construction. • carry out mitigation measures including disposal in designated areas where oxidation will be avoided (capped or under water), mixing with buffer material and shotcreting of bedrock surfaces. • carry out ARD mitigation protocols in conformance with Guidelines for Metal Leaching and Acid Rock Drainage at Mine Sites in British Columbia.
Seismicity	• locate pipelines and facilities away from areas of potential liquefaction • design pipelines and facilities to current seismic standards
Tsunamis	• locate facilities away from areas of high tsunami risk • design facilities to minimize potential tsunami damage

The detailed pipeline route will be finalized within the 1-km wide pipeline corridor during detailed engineering. During detailed route selection, if geotechnical hazard areas are identified along the proposed right-of-way (RoW), further examination and assessment will be conducted to determine if the route should be modified to avoid these areas or if mitigation measures should be used to reduce any associated risks from these hazards.

The geotechnical issues relating to the Project are discussed briefly in the following.

Avalanches

As stated in the Overall Geotechnical Report, Section 3.2.1.5: "Avalanches include the movement of snow, and movement of sediment and debris by snow down a slope. Even large avalanches do not usually directly affect buried pipelines; however, above ground structures such as aerial crossings, valves or expansion bends could be affected. Avalanches may also block stream channels, subsequently resulting in avulsion or downcutting erosion. Changes to surface drainage conditions following major avalanches coupled with periods of rapid snow melt are an important consideration that could potentially result in exposure of the pipelines if suitable mitigation measures are not undertaken. Avalanches across access roads could also affect the ability to access and respond to various situations. The direct and indirect consequences of avalanches may include denting or mechanical damage, coating damage or exposure. Avalanche impact on above-ground structures could potentially include rupture, but no such areas are presently known and avalanche paths have been avoided during planning for above-ground structures. Mitigation methods include avoidance of above ground pipeline structures in vulnerable areas, detailed analysis of avalanche conditions, deep cover, deflector berms, various avalanche control techniques and consideration of the possible secondary effects of stream diversions."

One primary consideration is the locations of tunnel portals relative to avalanche areas and maintenance of construction and operational access to the tunnel portals. For a discussion of locations of avalanche areas along the pipeline route, see the Overall Geotechnical Report, Table B-1. Other considerations are access and the potential for avulsion on large alluvial fans. Both of these hazards can be mitigated by suitable design and operational procedures. It is anticipated that avalanche control may be required in some areas to maintain safe access conditions.

Slides

As discussed in the Overall Geotechnical Report, Section 3.2.1 and subsequent subsections, large slide areas are a primary hazard that were avoided wherever possible by routing changes. Extensive analysis and field work has been done to date on slide areas. These analyses included aerial photograph and LiDAR review, review of key areas on the ground and, in some cases, drilling investigations. Additional work during detailed engineering to refine mitigation measures will include further field and LiDAR review, drilling investigations, and installation of monitoring instrumentation, where necessary.

The areas where slides occur and cannot be avoided by routing are discussed in detail in the Application (see the Overall Geotechnical Report, Table B-1) and are assessed with respect to hazard and risk (see the Overall Geotechnical Report, Table C-1). Slides and slope stability conditions have been a major focus during route selection. Extensive geotechnical input was used in the pipeline routing and risk evaluation during the planning stages and further input will be provided during the detailed engineering, construction and operational phases. Based on the work conducted, Northern Gateway concludes that slide and stability considerations can be mitigated satisfactorily to provide suitably low-risk conditions.

Earthquakes and Faults

Seismicity is discussed in the Overall Geotechnical Report, Section 3.3 and subsequent subsections. In general, the seismic design accelerations are relatively low compared to Vancouver, due to the large distance from the Queen Charlotte Fault, which is the primary source of large magnitude events in the general area. From the Overall Geotechnical Report, page 27, last paragraph: "No active faults are known near the proposed route. Within the study area, earthquakes typically occur at depths of 5 to 20 km on faults that have no surface expression. Furthermore, faults mapped on the surface in western Canada were formed hundreds of thousands to millions of years ago and bear little relation to current seismic activity. Thus, there is no clear-cut relationship between observed faults and seismicity and the pipeline route does not cross any known active faults that are exposed at surface."

Seismic conditions will be considered during detailed pipeline and facility engineering and will be considered with respect to other natural hazards such as slides. No areas of liquefiable sediments are crossed (potential areas in the lower Kitimat River valley identified to date are avoided by the pipeline route). As far as other hazards are concerned, the avoidance and mitigation methods proposed will also suitably mitigate seismically triggered hazards. For example, slope movements that might be triggered by a seismic event have been considered and the previously proposed mitigation methods will address the potential seismically induced movements.

Facility design will use design accelerations that are compatible in methodology with the recent seismic work undertaken in connection with the National Building Code.

During operation, occurrence of a seismic event will trigger reviewing and monitoring of specific areas of the route and facilities and, in some situations, may trigger a shut-down of the pipelines. These requirements will be defined in detailed hazard and operability (HAZOP) studies during detailed engineering.

Unique Environmental Habitat

Fish Habitat

The pipeline route will cross 773 streams, 669 of which are fish bearing. Northern Gateway has assessed the route and many of these streams through on-site examinations, conducting biophysical evaluations to assess existing fish populations, fish habitat values, riparian conditions and other aquatic features. These evaluations have been conducted by environmental experts with some assistance by local Aboriginal community members.

Northern Gateway has developed a fish and fish habitat risk management framework (RMF), which has refined the framework and methods proposed by Fisheries and Oceans Canada (DFO) and the Canadian Association of Petroleum Producers (CAPP); see the Application, Volume 6A, Part 2, Appendix 11A. Using the specific biophysical features of each watercourse to be crossed, Northern Gateway has determined the fish habitat sensitivity of each watercourse and established the residual negative effects from the initially proposed pipeline crossing method. The RMF is designed as an iterative process for relocating crossings, revising crossing techniques and modifying mitigation measures to reduce risk. This approach fulfills the relocate, redesign and mitigation requirements of the Policy for the Management of

Fish Habitat (DFO 1986). The residual risk can then be managed through additional mitigation (e.g. best practices), if appropriate and possible, or by habitat compensation.

The most sensitive fish habitat watercourses are proposed to be crossed using trenchless methods, which are incorporated into the pipeline design (see the Application, Volume 3, Section 6).

Communities Dependent on the Land

Subsistence and Cultural

Northern Gateway has considered land use and input from Aboriginal groups and communities during the development of the pipeline route and the associated engineering work. During detailed engineering and pipeline route selection, Northern Gateway will incorporate results of Aboriginal Traditional Knowledge (ATK) studies, and additional input received from Aboriginal groups, communities, landowners, and government agencies to further identify sites used for subsistence and cultural purposes. This information will be used in selecting the detailed pipeline route within the 1-km wide pipeline corridor and also in selecting other mitigation measures that may be incorporated in the Project.

C.2.3 "Routing is through Rocky and Coastal Mountains with areas of mass wasting"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

As stated in the Overall Geotechnical Report, mass wasting is the down-slope movement of bedrock and surficial deposits under the influence of gravity. Mass wasting includes deep-seated landslides, shallow to moderately deep landslides, rockfall, debris flows, avalanches, lateral spreading, lateral stream erosion (scour) and sedimentation, and wind, shallow stream or overland (flow) erosion.

Pipeline routing has avoided key areas of mass wasting wherever possible. The remaining areas of mass wasting have been identified. The hazards in these areas are generally understood and will be managed during detailed engineering, construction and operations using standard approaches and mitigation measures.

The Overall Geotechnical Report incorporated an assessment of significant terrain hazards, including preliminary evaluation of likelihood and consequences of these hazards. The assessment in that Report includes a full range of hazards that can be considered to fall into the category of mass wasting. The results are summarized in the Report, Figures 4-1 to 4-7 and in Appendix C, Table C-1. (Figures 4.1 and 4.2 present Risk Assessment Matrices for the entire pipeline route for unmitigated and mitigated hazard cases, respectively. Risk Assessment Matrices broken down by physiographic regions for both unmitigated and mitigated cases are shown on Figures 4.3 through 4.7, respectively.)

For general characteristics of types of mass wasting hazards, see the Application, Volume 3, Section 2, and for details onr the entire route, see the Overall Geotechnical Report, Table B-1 (the Application, Volume 3, Appendix E-1). For a detailed discussion of mitigation methods and risk for individual terrain segments, see the Overall Geotechnical Report, Section 4 (numerous tables). For the general mitigation methods that will be used for different types of mass wasting, see this Response, Section C.2.2, Table C-2. Extensive analysis and assessment of mass wasting has been conducted as outlined in the Overall Geotechnical Report.

Additional detailed work will be done during detailed engineering, and additional refinement will occur during construction when grading and trench excavation will create additional exposures. Risk management for mass wasting will continue through operational phases of the pipeline and related facilities and eventual abandonment.

C.2.4 "Requires the construction of tunnels through mountains (i.e. approximately 13 km of potential acid generating rock and uncertain ground stability)"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

As an alternative to going over the Coastal Mountains, Northern Gateway has elected to construct the Clore and Hoult tunnels, approximately 50 km northeast of Kitimat, to:

- enhance pipeline construction and operational safety
- avoid areas of terrain hazards
- avoid high alpine areas that would be difficult to restore
- reduce RoW reclamation and restoration relative to conventional pipeline design and construction in the upper reaches of the Clore River and Hoult Creek valleys

Therefore, the selection of tunnels is a routing solution to reduce construction and operational risk relative to an overland high alpine route. This should be considered to be a major advantage in the overall pipeline design (see the Application, Volume 3, Section 7 and Appendix E-2).

Northern Gateway currently anticipates that there will be limited occurrences of acid generating rock within the tunnels, based on a preliminary assessment. Potential acid generating rock, including established protocols for identification and mitigation, has been addressed in two reports (see the Application, Volume 3, Appendices E-1-1 and E-1-2). These reports provide supplemental design information that will be incorporated into the design of the pipelines. Further investigations, including additional deep core holes, will be done during detailed engineering and standard methods will be employed to control and mitigate any acid rock conditions identified. The tunnel design will also incorporate groundwater drainage control, as required, to control any acid drainage. Regular testing of tunnel waste rock and ground water seepage from the tunnels during construction will be incorporated into the environmental monitoring program to confirm conditions and ensure appropriate measures are taken should acid rock metal leaching conditions be encountered. Overall, while acid rock drainage is a consideration, considerable effort has been undertaken to date on this issue and it is viewed as a potential hazard that can be mitigated satisfactorily during the construction and operational phases of the Project.

The tunnels will be constructed either by conventional means using drill and blast or by tunnel boring machines, or a combination of both methods. The final decision on construction method will be made during detailed engineering.

The tunnels will be designed, constructed and maintained as permanent structures incorporating stable, long-term structural support systems. Similar examples would be tunnels constructed for rail, highway, subway or hydroelectric power use. The tunnels will meet the same design requirements, standards, codes, and regulations required of other permanent tunnel structures.

The tunnel alignments and the locations of the tunnel portals were selected based on an evaluation of anticipated tunnelling conditions and the need to limit exposure to geotechnical issues at the portals (see the Application, Volume 3, Appendix E, Report E-2). Selection of the route for the approach segments of the pipelines to the tunnel portals considered constructability, exposure to geotechnical issues and environmental sensitivities.

The tunnel geometry established in the preliminary design assumes the tunnels will have a finished diameter of about 5 m, which will meet the functional requirements for construction, operation and maintenance of the proposed pipelines. Preliminary layouts include allowance for a pickup-truck sized inspection and maintenance vehicle. Permanent lighting and ventilation will be provided. The tunnels will be fitted with portal doors to prevent entry by the public and animals. A tunnel monitoring and control system will be included and linked to the Edmonton operations control centre. Permanent operational access is planned for each tunnel portal.

A preliminary assessment of the geotechnical conditions for the proposed Hoult and Clore tunnels was completed as part of the preliminary engineering investigation and assessment for the Project (see the Application, Volume 3, Appendix E, Report E-2). The geotechnical work to support the preliminary analysis and design for the tunnels consisted of:

- site reconnaissance
- field data collection and mapping of detailed geology and surface rock structure data
- select geophysical investigations at portal locations
- diamond drilling investigations along select preliminary tunnel alignments and key geologic structures logging of rock core and laboratory testing of core samples
- development of a geological characterization for the area

A preliminary assessment of anticipated geotechnical conditions along selected and alternate tunnel alignments was developed based on geological characterization, which included an assessment of expected range of rock mass characteristics based on lithology and structure and following industry standards for classification of rock mass characteristics. Inactive fault zones, formed hundreds of thousands to millions of years ago, intersecting the tunnels were included and evaluated separately.

A preliminary assessment of anticipated tunnelling conditions was completed for each tunnel based on geotechnical characterization and two industry standard methods for estimating tunnel construction and support requirements. The first method used a rock mass classifications approach, which provides an empirical basis for determining tunnelling conditions and rock support requirements for a wide range of ground conditions. The second method used closed form solutions to evaluate tunnelling conditions and support requirements in areas with squeezing ground or very high stress conditions. Preliminary estimates of ground support requirements for the two tunnels used both methods and the criterion that the tunnels would be supported as permanent facilities with no tolerance for rockfall or lining failure.

The preliminary geotechnical characterization identified areas within the tunnels with potential for high groundwater inflow, specifically in inactive fault zones and portal areas. During construction, drilling of probe holes ahead of the tunnel face will provide the contractor with advance information on poor ground conditions, areas with high ground water pressures and potential high water-inflows. A number of groundwater control strategies are available to ensure safety of the work and limit inflows into the tunnel both during construction and for long-term operations, including zone grouting, specialized linings and drainage.

C.2.5 "High transportation and potential release volumes (approximate flow rates of 20,000 barrels or 3,400 cubic metres per hour of oil and 8,000 barrels or 1,200 cubic metres per hour of condensate)"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

Northern Gateway has applied for approval to construct and operate the oil pipeline with an average annual throughput capacity of 83,400 m^3/d (525,000 bbl/d) and the condensate pipeline with an average annual throughput capacity of 30,700 m^3/d (193,000 bbl/d) (see the Application, Volume 3, Section 1)

These flow volumes, and the associated pipeline sizes and operating pressures, do not present unique engineering, construction, or operations issues beyond those successfully addressed and proven by Enbridge and other pipeline operating companies in Canada and around the world. Other approved oil pipelines in Canada have capacities and theoretical flow rates that exceed the Project's pipeline capacities.

Potential release volumes will be controlled by valve location selection. The valve locations and topography (not the pipeline flow rates) primarily determine the potential release volumes. As stated in Volume 3, Section 5.5, "Northern Gateway will install valves at strategic locations along the oil and condensate pipelines, including at pump stations, major river crossings and other locations based on a review of engineering, environmental, Aboriginal Traditional Knowledge studies, geotechnical and release volume factors and operations and maintenance needs."

C.2.6 "Potential for far-reaching environmental and human consequences in the event of a hydrocarbon release in populated and environmentally sensitive areas"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

Careful engineering planning as described in the Application (Volume 3), including the pipeline route, geotechnical investigation and mitigation, watercourse crossing location and crossing method selection and selection of suitable construction materials, will ensure a high quality pipeline installation. These design considerations will contribute to minimizing potential risk of a hydrocarbon release.

The pipeline route avoids populated and environmentally sensitive areas to the extent practical, as described in the Application, Volume 3, Section 2, and the route will be further refined during detailed engineering.

Northern Gateway will implement prevention and risk programs that will include:

- pipeline design
- construction and operation reviews
- development of construction practices and material specifications
- incorporation of QA/QC measures, including non-destructive testing procedures and properly trained personnel to implement integrity related activities

During operations, as described in the Application, Volume 3, Section 11, the pipelines will be continually monitored using the SCADA system, which monitors all the pumps on the pipeline, pump stations, meters, flow rates, operating pressures and temperatures along the pipelines, including each valve. In addition, the SCADA system will monitor tanker loading and unloading facilities, custody transfer metering and monitoring of the site facilities at the Kitimat Terminal. Operation and maintenance will be conducted pursuant to established practices outlined in operation and maintenance manuals, which address routine pipeline and facility operations and maintenance requirements. As well, prevention, monitoring and integrity programs will be used to monitor the integrity of the pipelines and the RoW. These manuals and programs will be filed with the NEB prior to the commencement of operations.

The Application, Volume 3, Section 12 describes pipeline system integrity management, which entails risk identification and assessment. The primary goal of Northern Gateway's pipeline integrity program is to prevent leaks and ruptures caused by duty-related deterioration of the pipelines. Monitoring programs that include cathodic protection, in-line inspection, investigative excavations and slope stability monitoring will be conducted to confirm integrity of the pipelines. The principal objectives of this pipeline integrity program are:

- safety of the public and employees
- protect the environment

- strive to achieve zero leaks or ruptures
- provide reliable pipelines
- maintain the system as a long-life asset

The RoW will be monitored by trained individuals to identify any geotechnical or seismic event that could affect pipeline integrity. Should areas of concern be identified, maintenance measures will be undertaken. Right-of-way monitoring will also identify any areas of encroachment, erosion, and trespass activity.

In addition, valve placement and operation, mitigation measures and response plans, which will be in place prior to operation of the pipelines, will limit the extent of a release in populated and environmentally sensitive areas.

C.2.7 "Difficult access to pipeline right-of-way (terrain and in tunnels) in all seasons"

Reference

Page 18 of the JRP Panel Session Results and Decision dated January 19, 2011.

Response

As described in Section C.2.1, the majority of the pipeline route follows flat to rolling terrain. Access to these areas will generally be good, both during construction and operations.

Access road locations, other means of access, and the emergency response plan for the pipelines, including spill control point locations, will all consider the prevalent all season weather conditions along the pipeline route. To ensure that those areas on the pipeline RoW with difficult access are properly managed, road clearing during winter and the use of all terrain vehicles and helicopters with strategically located landing pads will be considered for access, where required. Northern Gateway will use Enbridge's experience on the existing Norman Wells pipeline as guidance for further developing access and emergency response plans.

Further, as described in the Application, Volume 3, Section 10.1.4, access to the pipeline RoW and facility sites will maximize use of existing roads and, in particular, forestry roads. Some road upgrading and new access road construction will be needed in remote areas to assure safety for pipeline construction and work crew transportation. Access across watercourses will use existing bridges, where possible. Other crossings would include temporary crossing structures and/or bridges that will be constructed to meet applicable regulations and guidelines. Consistent with pipeline route selection, planning and construction of access roads, both for construction and operations, will consider safety for workers, equipment and environment.

Permanent access roads during operations will be constructed, where needed, to pump stations, valve sites, tunnel portals, and environmental control points (see the Application, Volume 3, Section 5.13). For example, the tunnel portals have been located to facilitate long-term permanent access. Avalanche and other hazards on the road access have been considered relative to construction and operational access. In addition, the routing of the pipelines was also revised in some areas to facilitate access, as discussed in this Response, Section C.3.6.1.

Selected construction access roads will become permanent access for operations and will be planned as such during design and construction. Access will be addressed in greater detail in the construction safety manual, which will be filed with the NEB consistent with the *Onshore Pipeline Regulations - 1999*, and in the final Construction Environmental Protection and Management Plan, which will also be filed with the NEB.

C.3 Project Life Cycle Components and/or Challenges

Consistent with OPR-99—to anticipate, prevent, mitigate and manage conditions that may adversely affect the safety and security of its pipelines and facilities, employees, the general public, as well as property and the environment—Northern Gateway will develop and implement the following management and protection specifications, plans, manuals, programs, and systems and file the associated documentation with the NEB as required:

- specifications for pipe and components
- a joining program
- a construction safety manual
- pressure testing program
- a safety program that applies to operation and emergency situations
- an environmental protection plan for construction and operations
- emergency management and response plans for construction and operations
- surveillance, monitoring and security for pipelines and facilities
- pipeline control system
- integrity program for pipeline and right-of-way
- pipeline crossing procedures
- operation and maintenance manuals
- continuing education program for employees
- training program for employees

This Response, Sections C.3.1 to C.3.7, describes Northern Gateway's project specific, risk-based approach to address the Project life cycle components and/or challenges.

C.3.1 "Line Pipe Material Properties Including Effective Strain Capacity after Construction"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

As the pipelines will transport a low vapour pressure (LVP) liquid and be subjected to liquid pressure tests, CSA Z662 (Table 5.1) allows for the use of Category I pipe (i.e., pipe without proven notch toughness). During detailed engineering, the use of Category II pipe (i.e., pipe with proven notch toughness in the form of both absorbed energy and ductile fracture appearance) will be evaluated. Category II pipe would provide additional resistance to fracture initiation and propagation. Unlike gas, the decompression characteristics of LVP liquids are such that the liquid decompression velocity is much greater than ductile or brittle pipe-fracture propagation velocities. This results in a very low driving force for fracture propagation and the potential for large ruptures is greatly reduced. The additional toughness requirements further alleviates the rupture potential.

Preliminary work has been undertaken along the entire route and areas of potential geotechnical (including seismic) hazards have been defined. Further detailed geotechnical risk assessment will be undertaken during detailed engineering. Areas of geotechnical hazards have been avoided during route selection wherever possible. While every practical effort will be made to avoid such areas, in the event that the pipeline route is required to traverse such areas, various design mitigation techniques will be employed. This may include the installation of heavier wall pipe to reduce strain in the pipe and limit the possibility of buckling.

Although the pipeline design will adhere to a standard stress-based criteria, geotechnical conditions at specific locations may require that pipeline strains be addressed. The expected strain demand at these locations will be determined using industry accepted and/or project specific methodologies, such as pipe-soil interaction finite element analyses. The line pipe compressive and tensile strain capacity will be calculated in conformance with CSA Z662. In order to ensure that this is achieved, supplementary longitudinal tensile testing and the associated required mechanical properties will be specified. The effects of strain ageing will also be considered and addressed in the longitudinal tensile requirements. The girthweld mechanical properties and flaw acceptance criteria will be selected to ensure that the strain capacity of the girthwelds exceeds the expected strain demand on the pipe.

Modern pipeline steels and pipe production processes have resulted in pipe with fewer imperfections than those produced decades ago. The advent of steel with very low sulphur content (less than 0.005% versus 0.010%) has reduced the occurrence of non-metallic inclusions. The application of 100% non-destructive examination of welds, including using automated, multi-probe ultrasonic systems has reduced the number of injurious weld defects. Quality control systems in suitably qualified pipe mills are also much improved, which has resulted in higher overall product quality. This is further supplemented by independent third party audits of the pipe production processes and the actual pipe properties achieved.

C.3.2 "Line Pipe Welding Design and Quality Control in Geotechnical and Seismic Areas"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

All welding, whether in-plant or in the field, will be carried out using suitably qualified weld procedures and qualified welders. The weld procedures for pipeline girth welds in geotechnical or seismic areas will be developed to achieve a strength overmatch in comparison to the specified minimum values for the pipe material. This will ensure that the weld will be at least the same strength as the matching pipe. In the event that longitudinal loads must be sustained, both the pipe and adjoining welds would be capable of maintaining their integrity.

Supplemental weld metal and heat affected zone toughness will be specified and verified by qualification testing. Typically, this is accomplished by the specification of Charpy V-notch absorbed energy and this will be a normal component of the weld procedures and qualifications. If necessary, crack tip opening displacement (CTOD) testing of the weld and heat affected zone (HAZ) can also be specified and conducted to confirm weld zone toughness.

Pipeline girth welds will be subject to 100% non-destructive examination (NDE) using automated ultrasonic or film radiographic methods. These examination methods will provide full weld volume inspection and should eliminate any injurious defects in the welds. The NDE methods and procedures will be documented and qualified to ensure effectiveness.

All NDE will be conducted by suitably qualified and certified inspection personnel. Certification in accordance with Canadian General Standards Board (CGSB) or American Society for Nondestructive Testing (ASNT) will be required. As a minimum, any defect indications will be assessed by at least a Level II certified inspector. Inspection acceptance criteria will comply with CSA Z662 and, if appropriate, the supplemental Engineering Critical Assessment requirements of CSA Z662, Annex J and K will be applied.

As a part of the construction quality control requirements, inspection during welding and NDE will be conducted. Quality assurance audits of these processes will further ensure full compliance. Welds, welders and inspectors will be identified and all required inspection records and reports completed, duly signed and maintained. Non-compliances will be recorded and a suitable resolution or corrective action will be implemented and documented.

Following construction, active geotechnical locations will be managed. This will comprise routine line patrols, site reconnaissance by geotechnical engineers, and strain measurement using in-line inspections as required. These activities will be used to evaluate the need for remediation activities such as slope stabilization and stress relief.

C.3.3 "Right-of-Way Monitoring in Geotechnical and Seismic Areas"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

Northern Gateway has used and will continue to use a risk-based approach to design and operation relative to the route selection and mitigation of geotechnical hazards as described in the Overall Geotechnical Report (see the Application, Volume 3, Appendix E-1).

For a preliminary outline of areas requiring monitoring, see the Overall Geotechnical Report, Table B-1, and for a discussion of risk and hazard mitigation, see the Overall Geotechnical Report, Section 4. Detailed monitoring plans and procedures for the construction and operational phases of the Project are typically developed during detailed engineering and prior to construction, and commencement of operations.

Detailed monitoring plans will be developed, where required, during detailed engineering, and the following elements and planning will be incorporated:

- Areas requiring geotechnical monitoring will be identified during detailed engineering based in part on the areas previously defined (see the Overall Geotechnical Report, Table B-1).
- Geotechnical instrumentation-based monitoring will include movement monitoring of slides by slope indicators, survey monitoring, global position system (GPS) monitoring and/or interferometric satellite ranging (InSAR), groundwater monitoring (piezometers and standpipes), documentation of existing wells near the route and monitoring, where required, of selected wells and monitoring of water flows from the tunnels.
- Selected instrumentation will be incorporated during detailed engineering and design. Instrumentation will be installed during construction. Additional monitoring instrumentation may be installed, as required, during operations if specific concerns are identified.
- The occurrence of earthquakes that could potentially affect the pipeline RoW, or project facilities, will be monitored using a notification process from United States Geological Survey (USGS) or the Geological Survey of Canada (GSC).
- Weather and snow pack conditions will be monitored at selected locations along the route using automated weather stations combined with consideration of automated snow pack measurement (e.g., snow pillows) in selected areas. Consideration will be given to installing at least some of the weather stations during detailed engineering. This equipment will be operated through the life of the pipelines.
- Avalanche and snow conditions will be monitored using standard avalanche methods including snow pack measurements obtained using remote methods or via observation in pits.
- During construction, other visual monitoring will be carried out using both aerial and ground methods. The protocols for visual monitoring during operations will be developed during detailed engineering but will include periodic inspection of the entire route to identify areas of potential concern that may require mitigation.

C.3.4 "Tank Capacity at Stations for Potential Pipeline Repairs"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

The pump stations have hard-piped sump tanks for inside battery-limit piping repairs and in-station line drain-downs. The pump stations have no storage capacity for volumes outside of the station battery limits. For pipeline repairs, the pipeline section would be isolated at an upstream location and the hydrocarbons would be pushed down the pipeline until it reaches a downstream isolation location.

At the pump stations, the sumps will be tied to the piping drain lines, including the drain lines at the mainline traps. The number of sumps varies between the station sites, depending on the number of pump units and the total length of piping. There are independent sumps for the oil and condensate systems. The tank sizes will be finalized during detailed engineering, once the final pump station layout has been completed.

In addition to the sump tanks, each station has a site containment system. These site containment systems are a compilation of site perimeter berm and an on-site reservoir. The interior berm space is sloped to drain to the on-site reservoir. The on-site reservoir will be sized to accommodate the worst credible spill volume in addition to the on-site storm water accumulations. There is an interior berm within the site containment berm in the areas of the station traps to capture small spills in the trap areas. Any spills in this area will be collected and placed in the respective sump tank.

C.3.5 "Valve Design and Location for Spill Consequence Reduction"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

Valve site locations, design, construction and testing standards, power supply and communications are described in the Application, Volume 3, Section 5.5.

Remotely controlled block valves will be installed on the pipelines to allow them to be shut down in a controlled fashion. In the event of a failure of or damage to the pipeline, these remotely controlled block valves will enable Enbridge Operations to minimize release volumes and isolate an outage.

A preliminary list of valve locations (see the December 2010 Update, Volume 3, Appendix F, Table F-1) was determined using Northern Gateway's valve location assessment process. This process is part of an overall risk management process, which incorporates considerations for potential release volumes, environmental sensitivity and potential environmental effects. Potential release volumes were calculated with a comprehensive proprietary model using a detailed profile of the proposed pipelines. Specific locations were also adjusted taking into account terrain and service access requirements. Valve site locations will be finalized during detailed engineering.

In addition to the CSA standards listed in the Application, Volume 3, Section 5.5, valves will also be designed in accordance with Enbridge Engineering Standard No. D06-105. The valves, power supplies, and communications network will be designed, constructed, and maintained and by taking into consideration the operational requirements and prevailing site conditions to ensure that the valves will function properly. Remote control will always be available at the Enbridge Control Centre.

C.3.6 "Pipeline and Facility Risk Assessment and Associated Risk Reduction Strategies in Consequence Areas"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

Northern Gateway has used a risk-based approach and will continue to use this approach during detailed engineering. Pipeline and facility risk–based approaches have been conducted and are ongoing. Associated risk reduction strategies in consequence areas have been identified and will be further developed during detailed engineering. The following sections address the risk-based approach.

- Pipeline Routing and Geotechnical Hazard and Risk Assessment (see Section C.3.6.1)
- Pump Stations and Kitimat Terminal (see Section C.3.6.2)
- Strategic Watercourse Assessment Team (SWAT) (see Section C.3.6.3)
- Operational Risk Management (see Section C.3.6.4)

C.3.6.1 Geotechnical Hazard and Risk Assessment and Pipeline Routing

A risk-based approach to project-specific risk factors has been used throughout the design process and is extensively discussed in the Application (see Volume 3, Appendix E-1). Most of the following material has been included in Volume 3, Appendix E-1 and is provided below for convenience.

C.3.6.1.1 Overview

Risk was discussed in the Overall Geotechnical Report (see the Application, Volume 3, Appendix E-1, Section 4). The aim of the geotechnical work is to minimize risk to the greatest possible extent through the entire lifecycle (design, construction, operations and abandonment) of the pipelines and related facilities by identifying high-risk factors or conditions and eliminating or reducing the risk to satisfactory levels using mitigation strategies. The mitigation strategies include avoidance of high hazard areas during the routing and site location processes, wherever possible. Where avoidance was not possible, other mitigation measures were identified to reduce risks to satisfactorily low levels during construction, operation and abandonment.

Geotechnical hazards and risk have been considered on an ongoing basis to date and this process is anticipated to continue throughout the life of the Project, including design, construction, operations and abandonment. At the present preliminary design stage, the geotechnical risk-based input has been incorporated into the project decision-making process on a formal basis through the Route Review

Committee and on an informal basis by ongoing (often daily) discussions between the various disciplines involved in the overall decision-making process.

During detailed engineering, additional detailed geotechnical investigations will be undertaken to assist in defining geotechnical conditions and hazards and to aid in the design of mitigation measures. Installation of monitoring instrumentation and monitoring will be initiated at selected locations during the detailed design process. This geotechnical work will be integrated with the overall project design process through a similar informal process to that used to date and formal processes to include the Route Review Committee, detailed design processes for facilities, and overall risk management processes such as the hazard and operability (HAZOP) process.

During construction, detailed geotechnical input will continue. This will include further monitoring (both instrumentation and visual), review of additional exposures created by grading and trenching, identification and mitigation of hazards specific to construction or operational risks identified during construction and ongoing recommendations to reduce hazards and control operational risks.

The extensive geotechnical work during initial design, detailed engineering and construction will reduce the need for geotechnical input during operations. However, during operation of the pipeline and related facilities, continued geotechnical input will be provided, similar to other Enbridge pipelines. Ongoing geotechnical input will include:

- monitoring and review of areas where there are stability considerations
- erosion and sedimentation issues if they arise
- stream erosion issues and similar conditions
- other aspects such as debris flow events
- maintenance of key access routes

Experience indicates that even where events (for example, a debris flow event) are within the range of events expected at the design stage, it is prudent to review the operational implications and to continue to refine the mitigation methodology.

Enbridge’s integrity programs will be used to monitor the integrity of the pipeline, slides and natural hazards, as well as the RoW during the operations phase of the Project. The monitoring and integrity programs will be consistent with CSA Z662 Annex N and Enbridge’s Engineering Standards and Specifications. Northern Gateway will file these manuals and programs with the NEB prior to commencement of operations. The monitoring and risk assessment and management process will be ongoing and active over the entire life of the pipeline and related systems. Monitoring may include the installation of site specific monitoring devices prior to or during construction.

Geotechnical input into abandonment is typically related to stability considerations and sediment and erosion aspects in conjunction with other considerations such as the extent of future access that may be required. The extensive earlier stages of geotechnical work that have reduced and controlled geotechnical risks are important to the final abandonment stages, which may occur decades after the initial construction. A key aspect is the decision as to what extent grades are restored to initial pre-construction topography since, at the time of abandonment, fill slopes may be well treed and the additional disruption of those trees may be counterproductive. Other key issues are the extent to which streams are disturbed by removal of the pipelines and whether the pipelines are removed or left in place (possibly with cathodic protection) and filled with inert materials. Typically, the abandonment strategies vary depending in part on geotechnical input and conditions.

C.3.6.1.2 Geotechnical Risk-based Methodology

The detailed geotechnical methodology used for assessing hazards and risks to date and during further design stages is summarized in the Overall Geotechnical Report and includes the following topics:

- reviewing aerial photographs
- reviewing LiDAR data
- reviewing published and unpublished information and data
- conducting aerial and ground reconnaissance
- conducting drilling investigations in selected areas
- liaising with other disciplines

For a summary of physiographic regions, see the Overall Geotechnical Report, Section 2. The regions were used as an overall framework for hazard and risk. These regions conform to usage by various authorities and are the same framework as used in other disciplines including the environmental work. The physiographic regions were defined on the basis of terrain conditions (principally topography, major rivers, and bedrock geology). The discussion in the Report also includes surficial geology, ground and surface water, and other regional geotechnical aspects such as seismicity and typical conditions for each region.

For a discussion of general geotechnical hazards, such as mass wasting (including various types of slides), seismicity, avalanches, and other identified geotechnical and hydrologic hazards, see the Overall Geotechnical Report, Section 3. For a summary of specific hazard locations, see the Overall Geotechnical Report, Table B-1.

For a summary of detailed terrain, hazard and risk considerations on a kilometre-by-kilometre basis, see the Overall Geotechnical Report, Table B-1, which also outlines proposed mitigation measures for the pipeline route.

For a discussion of the geotechnical risk assessment, see the Overall Geotechnical Report, Section 4. The approach used was termed a qualitative methodology but is identical to what other users have termed a semi-quantitative approach. The information presented includes the specific geotechnical hazards identified on a kilometre by kilometre basis (see the Overall Geotechnical Report, Table B-1) and includes a description of the risk assessment approach used. The risk assessment methodology provides a clear decision framework, and facilitated incorporating the geotechnical hazards and risks into the broader decision-making process for the Project. Data and information used in the assessment of hazards includes:

- information from aerial and ground reconnaissance by qualified professionals during pipeline routing studies and studies of crossings

- aerial photograph interpretation and terrain typing
- LiDAR data acquired for many selected locations along the pipeline route and the LiDAR hill shade and slope shade models were used
- topography vector data and orthomosaics
- other photography including oblique aerial photography taken during various reconnaissance trips
- published information
- extensive mapping and sampling of available outcrops carried out during investigations into the potential for acid rock drainage (ARD). For the results of this work, see the Application, Volume 3, Appendix E-1-1
- drilling investigations were carried out in selected areas
- geological bedrock mapping was carried out at the western end of the Project over the course of two field seasons
- other information available to Northern Gateway from previous work in various areas along the proposed route

The geotechnical risk-based information has been incorporated into the overall design of the pipeline and related facilities. The Overall Geotechnical Report, Section 4.2.2, indicates that Northern Gateway has "evaluated the hazards during the course of routing and preliminary design work undertaken along the route." Geotechnical input was provided using a hazard and risk-based framework into the pipeline routing, facility location, and preliminary construction methods and design throughout the preliminary design process and continuing to the present.

The Overall Geotechnical Report (Application, Volume 3, Appendix E-1, Section 4 and Table C-1), identifies the hazard consequence and resulting risk values at specific locations for specific hazards (conditions) along the entire pipeline route. This information by physiographic region is summarized in the Overall Geotechnical Report in Figures 4.1 to 4.7. The summaries include both the unmitigated risk assessment after applying the avoidance strategies discussed above and the mitigated risk after applying the mitigation strategies indicated. (For an outline of the mitigation methods, see the Overall Geotechnical Report, Table B-1.)

In summary, geotechnical engineering input has been incorporated on an ongoing basis throughout the development of the pipeline route, facility locations and preliminary design. Where the ongoing and often iterative geotechnical route analysis identified areas of high hazard, recommendations for alternative routing (avoidance of hazards) was provided as a primary mitigation method wherever possible to reduce risk. Where a potential hazard could not be avoided, various mitigation methods were considered to reduce the potential consequences of the various hazards (and hence risk) to the Project. For an outline of this mitigation process, see the Overall Geotechnical Report, Tables B-1 and C-1, and Section 4.

It should be noted that only Route R is discussed in detail in the Overall Geotechnical Report, Table B-1. Major route revisions and alternatives are also discussed in the Application, Volume 3, Section 2 and in the December 2010 update to Volume 3, Section 2.

C.3.6.1.3 Examples of Risk-based Geotechnical Process

To illustrate the risk-based process used, including primary hazard avoidance, ten examples relating pipeline routing, watercourse crossings, tunnels and the Kitimat Terminal location are provided in Tables C-3 to C-12. Refer to the Overall Geotechnical Report, Tables B-1 and C-1, and the risk matrices in Section 4 of that Report for further information.

It should be noted that the kilometre post (KP) references in Tables C-3 to C-12 are with respect to Route Rev. T, whereas the Overall Geotechnical Report is based on Route Rev. R. If required, the small differences between the KPs for the same location can be understood by consulting the Route Rev R and Route Rev. T maps (see the December 2010 Update).

Each table summarizes the data, geotechnical methodology and conclusions with respect to the original route, the presently proposed route and mitigation measures. Each table references a corresponding figure showing the current route and a previous route that has been considered. These figures, located in Appendix C, also contain extracts from the risk summary, risk matrices and reductions in risk that have occurred during the geotechnical design process (see the Overall Geotechnical Report, Table C-1).

Table C-3 Simonette River Crossing and Central Alberta Routing

KP 312 to 400 Appendix C, Figure C-1	**Simonette River Crossing and Central Alberta Routing**
General	The Simonette River crossing was moved from the originally considered route south approximately 15 km due to slope stability concerns that resulted in high geohazards at the originally considered crossing. At the same time, other regulatory input was also considered outside of the geotechnical process. The revised route is parallel to the Alliance Pipeline and other pipelines and infrastructure for much of the reroute across central Alberta.
Available Data	**Original crossing** • Topographic data • LiDAR data • Air photo review • Aerial and ground based surveys • Drilling program was undertaken to assess surficial and bedrock geology conditions relative to directional drilling **Revised Crossing** • Reviews of the Simonette Valley were undertaken from north of the original crossing south to the presently proposed crossing (aerial and selected ground surveys) • Air photo review of overall area

Table C-3 Simonette River Crossing and Central Alberta Routing (cont'd)

KP 312 to 400 Appendix C, Figure C-1	**Simonette River Crossing and Central Alberta Routing**
Description and Issues Originally Proposed Crossing	**Description** • Moderately steep slopes along both sides of the valley • West of the river, the route was constrained over a long area of gentle slopes between tributary valleys and meanders of the Simonette River valley • At crossing, river was meandering with wide areas of gravel terraces **Geohazards and Issues** • Active deep-seated slides on the east side of the crossing • Results of the drilling investigations indicated that directional drilling was not a favoured crossing method due to deep gravel, the extent of the deep-seated slides, the bedrock geology conditions and the surficial geology east of the crossing • Lateral slides into a tributary creek were also a concern **Conclusion** • Significant geohazards that could not be satisfactorily mitigated at the original crossing • An additional, non-geotechnical issue was regulatory concern and input with respect to the general route through central Alberta relative to other infrastructure

Description and Issues
 	
Presently Proposed Crossing
	Description
	• Presently proposed crossing is parallel to the Alliance Pipeline which is followed for a substantial distance east and west of the crossing
	• Moderate slopes on both sides of the crossing
	• River is partially constrained by the valley walls and is meandering to some extent
	Geohazards and Issues
	• No major stability issues identified
	• Some lateral erosion issues and potential for local undercutting of slopes
	• Mitigation (from Table B-1 of the Overall Geotechnical Report):
	  - Long crossing due to potential for lateral erosion and reoccupation of subchannels
	  - Ground and surface water control should be coordinated with existing controls on nearby RoWs
	Conclusion
	• Geohazards at revised location are manageable with appropriate mitigation

Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Geotechnical ground reconnaissances and acquisition/review of LiDAR • Detailed design of crossing

Table C-4 Wapiti River Crossing

KP 492 to 498 Appendix C, Figure C-2	Wapiti River Crossing
General	The Wapiti River crossing was moved from the originally considered route due to deep-seated slides that could not be satisfactorily mitigated or avoided locally. Extensive study of the Wapiti River valley from west of Grande Prairie to the Narraway River confluence was undertaken during reviews of alternative crossing locations The Wapiti River flows in a meandering channel deeply incised into the surrounding plateau. The valley downcutting is geologically very young and cuts through sequences of fine grained soils, granular terrace deposits as well as the underlying weak sedimentary bedrock. Landslides are frequent along the steep slopes of the river valley. The Wapiti River crossing was included in the December 2010 Update, Volume 3, Section 2.4.
Available Data	**Original crossing** • Air photo interpretation • LiDAR data acquisition and review • Extensive aerial reconnaissances and several ground reconnaissances • Drilling program with holes on both sides of the river **Revised Crossing** • Reviews of the Wapiti valley from west of Grande Prairie to the confluence of the Narraway River • Hydrotechnical studies were carried out to determine whether the river was downcutting at the proposed crossing • Additional interpretation of LiDAR data • Hydrotechnical evaluation based on regional and local data
Description and Issues Originally Proposed Crossing	**Description** • Very steep high slopes along east side of the valley • Terraced slope on west side of valley • Crossing was located at large meander bend pointed to east **Geohazards and Issues** • Active deep-seated slides in bedrock on the east side of the crossing • Drilling indicated a long directional drill under the slides was not feasible for a large diameter pipeline due to a combination of granular materials on the west side of the river and deep glacial till deposits containing boulders on the east side • LiDAR data indicated very extensive sliding on the east side of the river **Conclusion** • Significant geohazards that could not be satisfactorily mitigated at the original crossing

Table C-4 Wapiti River Crossing (cont'd)

KP 492 to 498 Appendix C, Figure C-2	Wapiti River Crossing
Description and Issues Presently Proposed Crossing	**Description** • High terraced slope on east side • High ridge with some terraces on west side • River meander around end of ridge • Access to river is feasible • Revised route would allow conventional trenched pipeline installation on the valley slopes, together with an in-valley directionally drilled trenchless crossing of the river channel • Trenched crossing is a backup **Geohazards and Issues** • No major stability issues identified on main approach slopes • Further review of narrow area close to slides at west end of ridge on west side is recommended. Mitigation methods are available if required but route is presently considered to be outside slide areas • River does not appear to be downcutting **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Grading of route up front of ridge on west side. A route slightly on the sidehill to the north side of the ridge may assist with ground and surface water control • Surface and ground water control required including cross berms, trench blocks and drains **Conclusion** • Geohazards at revised crossing are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Further review of local stability at west end of ridge during detailed design • Detailed design of directionally drilled crossing and back-up method

Table C-5 Five Cabin Creek Crossing

KP 583 to 584.2 Appendix C, Figure C-3	Five Cabin Creek Crossing
General	The Five Cabin Creek Crossing is located on a portion of the route that follows the Kinuseo Creek valley. The route crosses high gradient streams that drain south from the steep slopes to the north. The Kinuseo Creek valley is U-shaped, and Five Cabin Creek has deposited a broad alluvial fan where the gradients decrease in the valley bottom
Available Data	**Original crossing** • Air photo assessment and review • Project mapping and survey information • Site reconnaissances including surficial geological mapping • Several aerial reconnaissance trips • Drilling investigations to examine the deep soil and bedrock conditions at the site relative to potential crossing methods
Description and Issues Originally and Presently Proposed Crossing	**Description** The channel has been subject to frequent channel switching (avulsion). The present creek channel is high relative to the surrounding fan indicating that future avulsion is likely. There is a remnant of an old access road bridge that has been washed out by a past erosion event. **Geohazards and Issues** • Significant avulsion across a broad alluvial fan could potentially expose the pipeline unless suitable mitigation measures are provided • Alternative routes higher up the fan have been reviewed **Conclusion and Mitigation Measures** • At present, the original (and presently proposed) route location is preferred compared to a route north of the apex of the alluvial fan since the steep slopes on the reroute would require significant cuts and the length of the pipelines would be significantly increased • Geohazard can be reduced if the crossing is designed with significant cover and/or protection against scour during a stream avulsion
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** Further investigation and consideration of potential routes to check route conclusion to date Design of crossing including hydrotechnical and geotechnical input

Table C-6 Upper Missinka Routing

KP 636 to 643 Appendix C, Figure C-4	Upper Missinka Routing
General	The upper portions of the Missinka River valley are located on the western slopes of the Rocky Mountains. The terrain is typically rolling to irregular, moderate to steep forested slopes and ridges with frequent bedrock outcrops. The proposed route is located along a tributary valley with shallower overall slope gradients along the realignment than the previously considered route.
Available Data	**Previous Route** • Ground traverses • Air photo assessment • Topographic data • Several aerial reconnaissances • ARD sampling and reporting **Revised Route** • Airphoto review • Aerial field reconnaissance • Review of LiDAR data (both routes) • Ground traverses
Description and Issues Previous Route	**Description** • Initial route between about KP 636 and KP 643 was located on the crest of a prominent ridge southeast of the current route location • Route had very steep longitudinal grades on west side and high elevations (up to elevation 1,595 m) • Major side slope cuts and fills on marginally stable or unstable terrain would have been required to develop construction access through area and from KP 636 west to the pass through the Rocky Mountains at KP 626 • Karst terrain in limestone across top of ridge and on east end • Dolines and areas of karst subsidence, some of which appeared to be active
Description and Issues Previous Route	**Geohazards and Issues** • Route crossed areas of karstic subsidence • Stability issues for large cuts along access route on the west end of the ridge **Conclusion** Geohazards could not be satisfactorily mitigated

Table C-6 Upper Missinka Routing (cont'd)

KP 636 to 643 Appendix C, Figure C-4	Upper Missinka Routing
Description and Issues Presently Proposed Route	**Description** • Route follows north side of upper part of tributary to Missinka River, crossing to south farther downstream • Gentle to moderate sidehill with a few short steep bedrock slope segments • Cut may be required on one bedrock step • Shallow bedrock with colluvium or till overlying • Generally favourable bedrock conditions with bedrock dipping into slope • Some areas of fine grained soils identified throughout the lower reaches of the valley **Geohazards and Issues** • Streams may be subject to high flow or debris flow • Small scale shallow slides in local areas • Erosion and sedimentation, particularly on lower parts of route. The route crosses avalanche and possible debris flow path. **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Sidehill rock cut required up steep rock ridge step approximately 60 m high • Approach slope to one creek crossing has steep bedrock steps. Steep areas will need to be cut back. • Surface and ground water control required including cross berms, trench blocks and drains • Assess burial and pipe protection requirements for avalanche/debris flow path • Acid rock drainage (ARD) considerations are discussed in Appendix E-1-2 "Identification and Mitigation of Acid Rock Drainage and Metal Leaching During Construction, Enbridge Northern Gateway Project" **Conclusion** • Geohazards along revised crossing are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Further field reconnaissance during detailed engineering • Avalanche and debris flow hazard assessment during detailed engineering • ARD sampling and reporting • Detailed design of route, cuts and construction methodology

Table C-7 Stuart River Crossing

KP 814 to 837 (Approx) Appendix C, Figure C-5	Stuart River Crossing
General	The Stuart River Crossing is located south of the town of Ft. St. James, BC. The area south of the lake is covered by thick deposits of glaciolacustrine and glaciofluvial materials. The river valley has relatively steep, geologically young slopes incised into the surrounding flat to gently terrain. The Stuart River flows south from Stuart Lake into the Nechako River about 60 km to the southeast. Stuart River Provincial Park starts south of the original crossing and continues along the river most of the way to the confluence with the Nechako River. The original crossing location was based in part on minimizing pipeline length. The revised crossing is located farther north and results in the pipeline route running generally northwest to the crossing and then southwest to the west of the river.
Available Data	**Original crossing** • Aerial reconnaissance • Ground reconnaissance • Air photo review • LiDAR review (data became available part way through review process) • Review of BC water well database to determine regional geologic conditions • Drilling investigations to examine the potential for deep directionally drilled installation set below the valley slopes and river **Revised Crossing** • Additional airphoto review including extensive areas north and south of original crossing • Aerial field reconnaissance north and south of original crossing • Additional LiDAR data • Ground based reconnaissances on lower slopes where access was available. Reconnaissance access was not available to upper parts of slopes
Description and Issues Originally Proposed Crossing	**Description** • River lies in a deep valley incised in thick glaciolacustrine sediments • Moderate slopes with numerous small benches (slide blocks) on both sides of river • Straight channel with slopes extending directly into river

Table C-7 Stuart River Crossing (cont'd)

KP 814 to 837 (Approx) Appendix C, Figure C-5	Stuart River Crossing
Description and Issues Originally Proposed Crossing (cont'd)	**Geohazards and Issues** • The drilling identified potentially difficult conditions for a directional drill option and at the same time, LiDAR data confirmed the presence of widespread deep-seated slides • Active deep-seated slides in deep glaciolacustrine sediments on both sides of river • Determined a long valley crest to valley crest directional drill under the slides was not feasible for a large diameter pipeline due to granular materials at depth • Conventional crossing not feasible due to extensive sliding • Extensive sliding was identified to the south and options in this direction were further constrained by a provincial park **Conclusion** Geohazards could not be satisfactorily mitigated at the original crossing
Description and Issues Presently Proposed Crossing	**Description** • Gentle to moderate slopes with prominent alluvial/erosional terraces with some moderate to steep slopes on terrace fronts and upper part of east slope • East slope is gullied on upper parts • River upstream of the crossing area is confined in a bedrock controlled channel **Geohazards and Issues** • No major stability issues identified on east approach slope. Subject to further review, the route on the east slope avoids the deep-seated slides that occur farther to the south. • Gullies on east slope appear to have been produced by ancient surficial flows (possibly during deglaciation) and appear to be dry • Slide on lower terrace on west side of river • Upper terraces on west side of river appear to be stable **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Trenchless crossing to allow pipelines to be installed under river and under slide on lower terrace on west side • Directional drilling may be feasible based on regional geology • Other trenchless methods also appear feasible subject to further investigation • Surface and ground water control required

Table C-7 Stuart River Crossing (cont'd)

KP 814 to 837 (Approx) Appendix C, Figure C-5	Stuart River Crossing
Description and Issues Presently Proposed Crossing (cont'd)	**Conclusion:** Geohazards at revised crossing are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Further field review of stability and conditions on both slopes when access is available • Drilling and geophysics investigations to determine subsurface conditions including elevation of top of major gravel deposits underlying glaciolacustrine clay deposits (relevant to feasibility of directional drill) • Detailed engineering of crossing method and back up method

Table C-8 Clore and Hoult Tunnels

KP 1070 to 1095 Appendix C, Figure C-6	Clore and Hoult Tunnels
General	The Clore and Hoult tunnels are located where the route crosses the highest portion of the Coast Mountains from the upper Clore west to the Hoult Creek watershed. Maximum elevations in the general area include Mount Nimbus at 1,645 m. Relief from valley bottoms to mountain tops is on the order of 1,500 m.
Available Data	**Previous Route** • Ground traverses • Air photo assessment, topographic data • Aerial reconnaissances **Revised Route** • Airphoto review • Aerial field reconnaissance • LiDAR data • Ground traverses. Bedrock geology mapping. Avalanche hazard assessment. • Diamond drilling • Piezometric measurement • ARD sampling and assessment

Table C-8 Clore and Hoult Tunnels (cont'd)

KP 1070 to 1095 **Appendix C, Figure C-6**	**Clore and Hoult Tunnels**
Description and Issues Previous Route	**Description** Crossing of the Burnie River is required to access steep slopes up to west to avoid the very rugged terrain north of the Clore Canyon. From the route above the Clore Canyon a descent on a very steep and narrow ridge down to an aerial crossing of the Clore River is required. From the Clore crossing a steep climb to the alpine terrain over the northern shoulder of Nimbus Mountain leads to another steep descent into the upper Hoult Creek valley. **Geohazards and Issues** • Construction grading for two pipelines down the steep ridges to the Clore River and upper Hoult Creek would encounter very steep terrain and local stability concerns • Rock toppling failures on steep slope into upper Hoult Creek **Conclusion** • Significant geohazards that could not be satisfactorily mitigated
Description and Issues Presently Proposed Route	**Description** The alternate route using tunnels through the area does not require a crossing of the Burnie River. The Clore Tunnel east portal is upstream of Clore Canyon and a west portal near the proposed aerial crossing of a tributary of the Clore River. After the tributary crossing, the route goes into the Hoult Tunnel then west to a portal near Hoult Creek. The route remains at the base of the valleys in the area and avoids steep gradients and alpine terrain. A tunnelling feasibility assessment based on surface and subsurface investigations was carried out to confirm the viability of the route. **Geohazards and Issues** • Groundwater conditions – potential zones with high pressure and or inflows • Possibility of local ARD **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Tunnelling support systems will be designed to provide permanent support for the anticipated range of ground conditions • Portals located to avoid areas with avalanche hazards • Groundwater control measures will be part of tunnel design and construction • Design methods to control and mitigate ARD, if encountered (see below) **Conclusion** • Geohazards along the tunnel routes are manageable with appropriate mitigation. ARD considerations are discussed in Appendix E-1-2 "Identification and Mitigation of Acid Rock Drainage and Metal Leaching During Construction, Enbridge Northern Gateway Project"

Table C-8 Clore and Hoult Tunnels (cont'd)

KP 1070 to 1095 Appendix C, Figure C-6	Clore and Hoult Tunnels
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Further investigational drilling, including groundwater measurements in selected areas • Further field reconnaissances in selected areas including additional local mapping • Geotechnical input during detailed tunnel engineering

Table C-9 Hoult Creek Routing

KP 1091.5 to 1101 Appendix C, Figure C-7	Hoult Creek Routing
General	The route between the western portal of the Hoult Tunnel and the Upper Kitimat River valley follows the north side of the Hoult Creek valley. To the west, the route roughly parallels an existing logging road in the valley bottom. Small route adjustments have been made between various versions.
Available Data	• Aerial photography and LiDAR review • Aerial and ground reconnaissances • Bedrock geology mapping • Avalanche hazard assessment • ARD sampling and reporting
Description and Issues	**Description** • Concave up-slopes (U-shaped valley) with frequent incised creeks • Route is close to existing logging road on lower valley slopes • Steep cross slopes • Several avalanche runout areas **Geohazards and Issues** • Local slope stability issues (groundwater piping erosion, small shallow sloughs, erosion, and avulsion) • Deeply incised creek channels, some subject to debris flows • Potential ARD in rock cuts • Avalanche slide paths

Table C-9 Hoult Creek Routing (cont'd)

KP 1091.5 to 1101 Appendix C, Figure C-7	Hoult Creek Routing
Description and Issues (cont'd)	**Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Development of a grading design for the construction corridor • Groundwater discharge control measures including filter berms, drains and rock blankets, as required • Additional measures to protect the pipeline as required, including concrete coating, buried shotcrete or concrete protection covers in rock trench, and protection berms and fills • ARD considerations are discussed in Appendix E-1-2"Identification and Mitigation of Acid Rock Drainage and Metal Leaching During Construction, Enbridge Northern Gateway Project" **Conclusion** Geohazards along the route are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Grading and mitigation design with geotechnical input • Further field investigations at key areas

Table C-10 Hunter Creek Crossing

KP 1102 to 1105 Appendix C, Figure C-8	Hunter Creek Crossing
General	Hunter Creek has a large active alluvial fan in the base of the valley along the planned project route. The fan is subject to avulsion (channel switching). The geotechnical work has focused on routing and construction methodology to avoid the potential influence of the alluvial fan.
Available Data	• Aerial and ground reconnaissances • Air photo and LiDAR review • Drilling investigations
Description and Issues Originally Proposed Crossing	**Description** • Route located on alluvial fan and on steep sideslopes **Geohazards and Issues** • Stream avulsion • Channel erosion during flood event • Debris flow event in main channel **Conclusion** • Significant geohazards that could not be satisfactorily mitigated at the original location

Table C-10 Hunter Creek Crossing (cont'd)

KP 1102 to 1105 Appendix C, Figure C-8	Hunter Creek Crossing
Description and Issues Presently Proposed Crossing (cont'd)	**Description** • Route was revised to be suitable for directional drilling **Geohazards and Issues** • Cut required for west end of proposed directional drill (see below) • Mitigation (from Table B-1 of the Overall Geotechnical Report) • Trenchless crossing to allow pipelines to be installed below fan **Conclusion** • Geohazards at the present crossing are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Further drilling and geophysics investigations to determine subsurface conditions including confirmation of shallow rock at west end • Detailed engineering of crossing method

Table C-11 Lower Kitimat River Valley

(KP 1137 to KP 1143) Appendix C, Figure C-9	Lower Kitimat River Valley
General	Route segment extends south across a mix of flat-lying, irregular and/or ridged terrain from Cecil Creek along the east side of Iron Mountain to north of the Wedeene River crossing
Available Data	**Previous Route** • Airphoto review • Aerial field reconnaissances • Regional subsurface investigation program that included drilling and cone penetration test holes to look for suspected buried marine clays • ARD sampling and reporting **Revised Route** • Airphoto, LiDAR review and terrain typing • Aerial field reconnaissance
Description and Issues Previous Route	**Description** • The northern part of the route segment crosses terrain apparently underlain by sensitive glaciomarine clays • Retrogressive failures and erosion occurred in the past east of KP 1139 to 1140 on the original route **Geohazards and Issues** • Potential for retrogressive failures would have potentially affected pipeline on original route **Conclusion** • Significant geohazards that could not be satisfactorily mitigated

Table C-11 Lower Kitimat River Valley (cont'd)

(KP 1137 to KP 1143) Appendix C, Figure C-9	Lower Kitimat River Valley
Description and Issues Presently Proposed Route	**Description** • Revised route runs along lower slopes of Iron Mountain • At the north end of Iron Mountain, route is on or close to old road where the pipelines will be on either glacial till or rock • Toward the south, the route is located on benched surficial deposits. No evidence of major stability issues has been identified to date. **Geohazards and Issues** • There may be areas along local route segment where further investigations suggest that marine clays could result in stability issues • Some areas of rock fall may exist • Potential local ARD considerations **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • If stability concerns are identified in the KP 1142 to 1144 area, a route farther west into the bedrock along the edge of Iron Mountain could potentially be considered to move the route off a problem area • Rock fall mitigation methods would be used in potential rockfall zones • ARD considerations are discussed in Appendix E-1-2 "Identification and Mitigation of Acid Rock Drainage and Metal Leaching during Construction, Enbridge Northern Gateway Project" **Conclusion** • Geohazards at the present route are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)**: • Further field reconnaissances and ground traverses • Further LiDAR data acquisition • ARD sampling and reporting • Detailed design of route

Table C-12 Kitimat Terminal Tank Lot

(KP 1137 to KP 1143) Appendix C, Figure C-10	Kitimat Terminal Tank Lot
General	Located adjacent to Douglas Channel. The marine terminal tank site was originally chosen in an area characterized by gentle rolling slopes above the steep bedrock controlled slopes at the marine berth sites
Available Data	• Airphoto review • Aerial and field reconnaissances including bedrock geology mapping • Site specific LiDAR acquisition and review • Extensive ground investigation program including soil and bedrock drilling, CPT and vane testing, test pitting and seismic geophysical surveys • ARD sampling and reporting

Table C-12 Kitimat Terminal Tank Lot (cont'd)

(KP 1137 to KP 1143) Appendix C, Figure C-10	Kitimat Terminal Tank Lot
Description and Issues Original Location	**Description** • The tank lot was to be located about 120 m above sea level on relatively gentle, irregular slopes • Investigations showed that initially proposed tank lot was located on areas of thick marine clay **Geohazards and Issues** • Excess consolidation settlement, seismically induced lateral spreading and deep-seated landslides **Conclusion** • Significant geohazards that could not be satisfactorily mitigated
Description and Issues Presently Proposed Site	**Description** • The tank lot was relocated to rock-dominated irregular terrain several hundred metres north of the initial location (hazard avoidance) **Geohazards and Issues** • Potential rockfall hazard in some areas • Some small channels in the study area are potentially subject to debris flows **Mitigation (from Table B-1 of the Overall Geotechnical Report)** • Rock fall retention and catchment systems will be used, as required. • Removal of clay underlying foundation areas • ARD considerations are discussed in Appendix E-1-2 "Identification and Mitigation of Acid Rock Drainage and Metal Leaching During Construction, Enbridge Northern Gateway Project" **Conclusion** • Geohazards at the tank lot are manageable with appropriate mitigation
Further Work	**Detailed Engineering (from Table B-1 of the Overall Geotechnical Report)** • Detailed engineering

C.3.6.2 Pump Stations and Kitimat Terminal

Pump Stations

At each pump station, there is no anticipated release of hydrocarbon or uncontrolled release of on-site storm water outside of the battery limits.

Each pump station site is designed to contain the maximum credible spill volume on site. On-site containment systems include a perimeter berm, an internal berm area around the station traps, and an on-site reservoir. The on-site reservoir is designed to contain the maximum credible spill volume in addition to the on-site storm water accumulations.

Each pump station site is also equipped with independent sump tanks for oil and condensate. The number of tanks and their size will be finalized during detailed engineering, once the station piping arrangement has been finalized. The sumps will have sufficient volume to accommodate any necessary inside battery limit piping-drain downs.

Kitimat Terminal

The following risk reduction strategies will be incorporated into the design and operation of the Kitimat Terminal:

- Examples of the use of a risk-based approach for the Kitimat Terminal design including tank overfill protection, vapour emissions controls, site access and security, site containment systems (including tank lot area and other areas where there is an increased possibility of hydrocarbon exposure), site water management systems, seismic design criteria and fire-protection system design. Site emergency shutdown systems are discussed in the Application, Volume 3, Section 9. Some specific examples of the risk-based approach to the Kitimat Terminal design include using:
  - redundant hydrocarbon detectors in the on-site storm water management system so that any water discharged to the environment meets or exceeds the acceptable standards for hydrocarbons
  - loading platforms have containment immediately around areas where hydrocarbon leak potential is higher as well as curbing around the full perimeter of the working deck
  - curbing and valves to limit uncontained discharge volumes within the terminal
  - curbing areas with drains installed under areas with higher risk for leaks to collect storm water
  - real-time monitoring of tanker berthing
  - quick release moorings
  - powered-emergency release couplings on loading arms
  - closed loading and vapour recovery systems
  - redundant firefighting system with sea-water intake pumps and ring main
  - mooring structures onshore to minimize environmental effects
  - booms for deployment around all tankers being loaded
- The tank lot is bermed and has a continuous liner to contain hydrocarbon releases. The tank lot also has a common impoundment reservoir to capture and store hydrocarbon releases. The tank lot system is sized for 110% of the volume of a single tank plus an allowance for water volume that may accumulate immediately after a 1-in-100 year storm event. Under typical operating conditions, the impoundment reservoir will be continuously drawn-down through the storm water release system.
- The impoundment reservoir has been sized to simultaneously accommodate 100% the volume of a tank rupture (a very low probability event) and a 1-in-100 year rainfall event (a second very low probability event). The impoundment reservoir’s total storage volume is approximately three times the volume of a single tank if there were no storm water present. In the event that more than one tank were to be compromised, the water level in the impoundment reservoir could be drawn down to accommodate the volume of up to three full tanks. Including the capacity inside the berm immediately surrounding the tanks, there is more than four full tanks of on-site containment. This coincides with the maximum number of tanks (four) within any common tank lot grouping. The

Application, Volume 3, Section 9 describes the safeguards in-place to ensure there is no hydrocarbon release through the storm water management system.

- The tank lines from each tank in the tank lot will be equipped with remote controlled, motor operated valves. Coupled with the tank line valves at the tank manifold, these significantly reduce the potential release volumes in the event that a tank line were to rupture outside of the containment berm (i.e., along the pipe rack).
- A further risk reduction strategy will be employed in the detailed design of the drainage system along the various terminal access roads. In the event of a hydrocarbon release outside the designed containment systems, these ditches are available to channel any released hydrocarbons to controlled areas (such as the impoundment pond and the foreshore sump). Additional localized containment ponds along the drainage system will be incorporated as appropriate in detailed design. Although designed for storm water management, this system could also be used in the event of a hydrocarbon release. This is particularly important for the area to the west of the terminal (Bish Creek valley) and for the area underneath the main pipe rack to the foreshore. It should be noted that the severity of the slope underneath the main pipe rack will likely result in a baffle system being designed to manage the storm water that will flow down the slope. The storm water baffle system could also be used to manage hydrocarbon releases. Depending on the maximum expected release, the storm water, down the pipe rack channel to the foreshore, may be directed to the foreshore sump area for additional containment.
- The primary risk reduction strategy for spill prevention at the Kitimat Terminal during operations is comprehensive inspection and monitoring activities. Northern Gateway's operational and maintenance inspection procedures will meet the specific needs for risk reduction at the Kitimat Terminal. This may include such activities as increased visual inspection schedules, maintenance schedules, pipeline integrity examinations, or the use of smart inspection tools (not typical within Terminal piping). It may also include installation of monitoring equipment and CCTV to allow quicker visual evaluation of the facilities from a central location.

C.3.6.3 Strategic Watercourse Assessment Team (SWAT)

A strategic watercourse assessment team (SWAT) approach is used to screen for environmental, geotechnical, and construction risks at selected pipeline watercourse crossings. Most of these watercourses are fish bearing and would meet the definition of a consequence area as described in this Response, Section A.3.

The SWAT comprises personnel with geotechnical, hydrotechnical, fisheries, environmental and pipeline construction expertise. Field assessments are conducted with the following primary objectives:

- provide a multidisciplinary screening of major risk factors (e.g., slope instabilities, fish spawning areas, construction safety and logistical issues based on the proposed crossing alignment)
- recommend, if necessary, relocation of the crossing alignment to reduce risks and environmental effects

- recommend, if necessary, a change to the proposed pipeline crossing method to reduce risks and environmental effects
- provide site specific mitigation measures that reduce the environmental effects of construction consistent with Fisheries and Oceans (DFO) Habitat Conservation and Protection Guidelines.

In this multi-year program, 227 watercourse crossings have been visited by SWAT. Recommendations have included relocations of the crossing location at 40% of the sites visited. This program will continue throughout detailed engineering.

C.3.6.4 Operational Risk Management

Enbridge Inc. is the operator of the longest liquids pipeline system in the world. As part of Enbridge's commitment to continuous improvement, a suite of risk assessment tools are under development for use in operational settings. This includes development of semi-quantitative risk assessment matrices and consequence decision tree-based models for mainline and facilities operations. When completed in 2012, these will assist Enbridge Operations in evaluating and prioritizing operational safety initiatives and programs, and will provide an important supplement to ongoing pipeline integrity management programs.

These risk management tools and innovations will be available to Northern Gateway as it proceeds into detailed design, construction and operations.

C.3.7 "Spill Containment Structures (e.g. ponds) and Emergency Response Strategies in Consequence Areas"

Reference

Page 20 of the JRP Panel Results and Decision dated January 19, 2011.

Response

A General Oil Spill Response Plan (GOSRP) has been prepared to support Northern Gateway's emergency response preparedness and planning. The GOSRP provides a framework for emergency preparedness and plans of mitigation measures specific to a spill as a result of a release of hydrocarbons either on land, at the Kitimat Terminal, or along the marine transportation routes. The GOSRP includes the high-level spill response concepts for the Project and is not intended to be used as a stand-alone spill contingency plan. The focus of the GOSRP is on the response to spills (i.e., recovering hydrocarbons and associated response activities) based on the project design concepts at the time of preparation.

The GOSRP provides an overarching strategy and a coordinated management and operational approach for emergency response across all operating environments. Planned spill response capabilities and procedures for environmental protection will meet or be better than applicable government regulations and standards.

Pipeline and Facilities Oil Spill Response Plans will be developed during detailed engineering and will describe site specific emergency response strategies, requirements and mitigation measures. The following measures to prevent or minimize hydrocarbon releases into consequence areas will be evaluated during detailed engineering and spill response planning:

- strategically located valves to reduce potential release volumes
- RoW grading and diversion berms to divert the flow of potential releases away from consequence areas
- strategically located pond structures to capture potential hydrocarbon releases
- increased depth of cover over the pipelines
- additional physical protection for the pipelines
- additional visual and instrumentation monitoring and inspection near consequence areas during operations
- robust access to spill control locations
- strategically located response personnel and equipment

See this Response, Section C.3.6.2 for information about containment structures at the pump stations and Kitimat Terminal.

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