Preliminary Geotechnical HDD Feasibility Assessment
Wedeene River (Crossing #3128)
Proposed Enbridge Northern Gateway Project

Rev R
KP1144.6

Submitted to:

Northern Gateway Pipelines Inc.
Calgary, Alberta

Submitted by:

AMEC Earth & Environmental,
a division of AMEC Americas Limited

Burnaby, BC

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IMPORTANT NOTICE

This report was prepared exclusively for Northern Gateway Pipelines Inc. by AMEC Earth & Environmental Limited, a wholly owned subsidiary of AMEC. The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in AMEC services and based on: i) information available at the time of preparation, ii) data supplied by outside sources, and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by Northern Gateway Pipelines Inc. only, subject to the terms and conditions of its contract with AMEC. Any other use of, or reliance on, this report by any third party is at that party's sole risk.
1.0 PROJECT DESCRIPTION

Northern Gateway Pipelines Inc. (Northern Gateway), a subsidiary of Enbridge Pipelines Inc., initiated the regulatory phase of the Enbridge Northern Gateway Project (the Project) to obtain regulatory approvals to construct and operate the Project. The Project is being developed to provide pipelines and associated facilities for the transportation of approximately 83,400 m³/d (525,000 bbl/d) of oil from Bruderheim, Alberta to Kitimat, British Columbia and the transportation of approximately 30,700 m³/d (193,000 bbl/d) of condensate from Kitimat to Bruderheim.

The Project includes the following major components:

- an oil pipeline, 914 mm OD (NPS 36), approximately 1172 km long extending from the outlet of the Bruderheim station to the Kitimat Terminal
- a condensate pipeline, 508 mm OD (NPS 20), approximately 1172 km long, located in the same right-of-way as the oil pipeline, extending from the Kitimat Terminal to the Bruderheim Station
- the Bruderheim Station, consisting of the oil initiating pump station and the condensate receiving facilities
- eight intermediate pump stations located at intervals along the pipelines
- two tunnels, approximately 6.5 km and 6.6 km long, to route the oil and condensate pipelines between the Clore River and Hoult Creek valleys
- the Kitimat Terminal which will comprise the following:
  - a tank terminal including oil tanks, condensate tanks and associated infrastructure
  - a marine terminal including two tanker berths and one utility berth
  - an initiating condensate pump station
  - oil receiving facilities
2.0 SCOPE

This report provides a preliminary geotechnical and hydrotechnical feasibility assessment of a proposed horizontal directional drill (HDD) crossing and contingency methods of crossing for the Enbridge Northern Gateway Project at the Wedeene River (Crossing #3128), KP 1144.6 of the Rev R Alignment, as shown on Drawing 08-3000-1143-1.
3.0  GEOTECHNICAL & HYDROTECHNICAL SITE CONDITIONS

3.1  Sources of Information

The following sources of information on site conditions were available at the time of report preparation:

1. Aerial photography (30BCC93007 No. 173 to 176 and 232 to 233; 30BCC93010 No. 210 to 212; 15BCB01001 No. 133 to 135 and 154 to 155).
2. Project terrain type mapping (Drawing 08-3000-1143-2).
4. Topographic (bare earth) models generated from LiDAR survey (Drawing 08-3000-1143-2). Note that the resolution of the LiDAR survey and processed bare earth models in this location are lower than normally expected.
5. Helicopter field reconnaissance information from overflights between 2005 and 2008 (including select oblique aerial photos, attached).
7. The Wedeene River is not gauged; therefore, regional projections have been used to provide monthly mean flow information.
8. Drill logs from three boreholes (WR06-05 (2006), WR06-06 (2006) and R03 (2005)). The logs are attached in Appendix A.
9. Geotechnical ground reconnaissances through select parts of the area. No ground reconnaissance work has been done to date by hydrotechnical personnel.
10. Mineral claim information from MINFILE (detailed information in ARD reports under separate cover).

3.2  Topography

The Wedeene River area is located in the Coast Mountains Physiographic Region in western British Columbia. The proposed crossing is located along the western edge of the Kitsumkalum-Kitimat Trough, which is a dominant terrain feature in the region consisting of a 5 to 10 km wide, deeply infilled ancient bedrock valley aligned north-south. Topographically, the trough is a linear valley lined on both sides with steep, bedrock-controlled slopes. It extends south along the lower Kitimat Valley and Douglas Channel and north through Lakelse, Terrace and along the Kitsumkalum River Valley.

In the vicinity of the proposed crossing, the topography within the Kitsumkalum-Kitimat Trough is generally rolling to terraced with infrequent sharper, steeper bedrock features up to 20 m high protruding through the complex valley infill materials. The Wedeene River enters the Kitsumkalum-Kitimat Trough on the west side approximately 7.5 km north of the crossing area.
and flows south. North of the crossing area, the river is confined along the west side of the trough by a north-south trending rock ridge known as Iron Mountain. The river flows to the east around the south end of Iron Mountain at the crossing area in a somewhat confined, irregular channel that is partially controlled by bedrock. Immediately downstream of the crossing area, the river is no longer confined and flows south again. Approximately 6 km downstream (southeast) of the crossing area, the Wedeene River enters the Kitimat River, which flows south into Kitimat Arm.

The upland terrain north of the proposed Wedeene River crossing includes at least two gullied terraces with elevations of approximately 20 and 40 m above river elevation. Rock knobs protrude above the local terrace elevation at a few locations along the north side of the river.

The upland terrain south of the Wedeene River in the crossing area is relatively flat to terraced, and consistent with the valley bottom conditions encountered throughout the Kitsumkalum-Kitimat Trough. The area is approximately 60 m above the river elevation. Bedrock knobs protrude above the surrounding terrain at various locations close to the river and farther back from the river along a low ridge. The Wedeene River Valley slopes on the south side of the crossing area are typically moderately steep (typically slope ranges from 15° to 35°) and include basin-like features, several prominent ridges and gullied and irregular terrain.

Existing infrastructure in the area includes the CN Rail line, which connects Terrace and Kitimat. The railway follows the Wedeene River throughout the area, crossing from the east to the west side of the river about 550 m upstream of the Rev R centreline. The rail bridge abutments appear to be founded on rock outcrops adjacent to the river. About 250 m southeast of the bridge, the rail line is located on the south valley slopes in a throughcut that exposes bedrock on both sides of the CN right-of-way (see Photos 6 and 11).

Photos 1 through 13 show general conditions in the area.

3.3 Geology

3.3.1 Surficial Geology
Regional surficial geology is shown in Clague (1984). As outlined by Clague (1984), the Kitsumkalum-Kitimat valley was submerged at the end of the last ice age due to a relative difference in sea level from the present position. During the geologically brief period of submergence, glacial meltwater deposited a large amount of sediment into the fjord ranging from clay to boulders. Note that some areas of till occur locally as well; however, exposed till is typically located at higher elevations than the crossing area. Zones of extensive muskeg also occur on the valley bottom in some areas.
The variable nature of the regional deposits has resulted in widely distributed but discontinuous deposits of marine clays overlying, interbedded with or below granular deposits or till. The variable and interbedded conditions are a result of the geologic environment at the time of deposition which included large inflows of fresh water and sediment both down the valley and from numerous tributaries along the valley walls. Review of drill holes in the area confirms the variable nature of the deposits and suggests that the clay deposits are typically interbedded as layers between stronger materials such as sand and gravel.

As a result of isostatic rebound and changes in sea level following deglaciation (rebound of the surface due to removal of the weight of thick glacial ice), the regional soil deposits have been raised above sea level. For marine clay deposits subjected to such rebound conditions, leaching with fresh groundwater may result in formation of a sensitive (or possibly quick) condition such that the clay may undergo significant strength losses as a result of stress change due to shearing or additional static loading. While quick clays have been documented farther north in the Kitsumkalum Trough (Geertsema 2004; Geertsema and Torrance, 2005), no evidence of quick clays was identified at the Wedeene crossing during the reconnaissance and drilling work to date. (Sensitive and quick are defined as follows: “sensitive” means the clay has a ratio of peak to residual shear strength >4 while “quick” clays have a ratio of peak to residual shear strength of >30, (almost complete loss of strength).

In general, the proposed route corridor follows an area of glaciofluvial deposits and apparent bedrock ridges across the river. As noted, the glaciofluvial deposits may be interbedded with or overlie glaciomarine clay. At lower elevations, more recent alluvial materials were deposited during valley downcutting and lateral erosion of the river.

### 3.3.2 Bedrock Geology

Regional mapping by Woodsworth, Hill and van der Heyden (1985) indicates that greenschist facies (low to moderate metamorphism) diorite and tonalite are present in the area. Based on recent nearby mapping in connection with the Project, Telkwa Formation rocks may also be present (basalt to rhyolite breccia, tuff and flows, minor sediments). Based on the characteristic steep fjord-like valley wall profiles of the Kitsumkalum-Kitimat Trough, typical conditions in the Coast Mountains, the local mid-trough bedrock ridge (Iron Mountain), and the irregular bedrock outcrops along the Wedeene River, it is expected that the underlying profile of the rock is highly variable. This is confirmed by general field observations in the area and drilling, as discussed below.

Mineral claim information available for the area identifies possible local sulphide mineralization at the Wedeene prospect on the south side of Iron Mountain and J Prospect, interpreted to be near the CN Rail thru-cut area. Both files suggest that the rock in the area could include sulphide mineralization. Potential ARD/ML issues related to this mineralization are discussed under separate cover.
Field reconnaissance in the area has identified several areas with bedrock outcrops, as shown on Drawing 08-3000-1143-2. The outcrops are generally interpreted to be the exposures of an underlying ridged bedrock profile. Small portions of the peaks of these ridges are generally exposed on the upper extents of the valley walls, such as the small upland outcrop shown on Drawing 08-3000-1143-2. More extensive exposures occur on the lower valley slopes or in the river, such as in the channel or along the railway through-cut, as shown on Photos 3, 6 and 9 to 11. There is a prominent bedrock knob and ridge along the southwest side of the river along the Rev R alignment between the Wedeene River and the CN Rail right-of-way. Bedrock is also exposed on the opposite river bank from this exposure (see Photo 3).

Based on existing information, the continuity of the bedrock along proposed HDD alignment discussed below is unknown. Based on the results of borehole R03, bedrock appears to be at variable depths and troughs in the bedrock surface could be infilled with the complex sediment profiles identified in the area (sand, gravels, or silt and clay). The bedrock topography will be important with respect to the feasibility of a directionally drilled crossing.

AMEC completed three investigation boreholes (R03, WR06-05 and WR06-06) in the general area, as shown on Drawing 08-3000-1143-3. The drill holes were located on the southwest side of the Wedeene River on the upland terrain along existing roads and clearings. The holes were drilled with a truck-mounted B-80 rotary rig using air and/or mud circulation, as required. Cone Penetration Testing (CPT) was utilized at R03. Holes WR06-05 and WR06-06 were located along a road running roughly north-south and were about 210 m apart, while R03 was located about 400 m south of WR06-06. The logs for the drill holes are attached in Appendix A.

The general conditions in holes WR06-05 and WR06-06 were about 8 m of granular sediments over 9 to 13 m of soft silt/clay over strong andesite bedrock. The conditions in R03 included 2 m of granular sediments over 32 m of soft silt/clay over coarse sand and gravel to 46 m depth. Bedrock was not encountered in R03. The surficial granular sediments generally included occasional cobbles and a shallow water table, likely perched on the underlying clay. The soft silt/clay was described as sensitive in some areas, low to medium plastic and included sand layers. The silt/clay is generally interpreted to be glaciomarine in origin. The granular sediments below the silt/clay in R03 were described as coarse, dense and wet, and included frequent cobbles and boulders. The bedrock was described as strong and generally intact. Some discontinuities existed throughout the rock mass, but the joints appeared to be relatively tight.

The results of the investigative drilling to date generally agree with the surficial geology mapping, which shows a gravel and sand delta immediately south of the proposed crossing area with a glaciomarine silt and clay deposit to the south. It appears that the glaciomarine deposit extends beneath the delta.
3.4 Slope Stability

Table B.1 in Appendix B includes summaries of currently known stability conditions and conclusions for the valley slopes in the general area of the crossing. The table discusses stability conditions in stability areas defined on Drawing 08-3000-1143-2 on the right and left sides of the river near the proposed crossings. The designation “R” denotes the right side of the river (south and west side) while “L” denotes the left side of the river (north and east side). The discussion is with respect to the conditions prevailing on the valley slopes and, in general, does not include the conditions at the toes of the slopes or along low elevation terraces or floodplains adjacent to the river.

In general, the following types of slides were identified in the area (see Photos 7 and 8 and Drawings 08-3000-1143-2):

1. **Large deep-seated slides**: A large, deep-seated, apparently active slide was identified on the south side of the river upstream of the CN Rail bridge in stability area R1 (Photo 8). This slide is at least 800 m long parallel to the river and appears to have depths of at least a few tens of meters based on the long, gently curved scarps. Recent small tension cracks, tree tilts and tree bends suggest that this slide is continuing to creep. The sliding surface(s) are likely weak zones within sensitive marine clay horizons.

2. **Slides confined in troughs**: Several gullies exist along the south side of the river in stability area R2 (Photos 7 and 8). While active sliding was not identified in any of these areas, it appears that these features may represent areas of previous sliding of valley infill materials. The slides have a trough-like configuration, possibly controlled by the topography of the underlying bedrock. It is possible that controls on the slides included groundwater movements along buried tributary valleys, clay horizons draped on an underlying bedrock slope (and thus sloping toward the river) and/or complex three-dimensional topography of the clay layers. The failure modes of the slides may have been a combination of earthflow, retrogressive sliding and erosion. Seepage was observed at the toes of the steep slopes in a few of the features, which suggests that groundwater was a contributing factor. At this time, it is not known whether these features might retrogress in the future. Further review should be carried out related to suitable long-term setbacks from these features as required by the preferred crossing method.

3. **Retrogressive sliding, groundwater piping and erosion**: Stability area R4 on Drawing 08-3000-1143-3 (Photos 7 and 8) shows evidence of retrogressive sliding, groundwater piping and surficial erosion. The overall drainage pattern has a dendritic pattern, a surficial characteristic noted at various other slides in the Kitimat Valley. Local sliding of this type was identified at several locations, but the individual slides are much smaller than the other slides discussed above in stability areas R1 and R2, and the slides typically occur along the branches of the streams. The overall stream pattern is interpreted to be a result of erosion combined with local sliding in the fine-grained glaciomarine deposits. Low strength sensitive clays are likely a factor in some of the small- to moderately-sized slides; however, it appears that erosion, probably including groundwater piping, is also a major factor in the overall dendritic stream erosion pattern.
The local and regional slope stability conditions are a major factor with respect to route selection at and near the Wedeene River crossing. The projected stability considerations are discussed later in this report relative to individual route options. Further investigations will be required to better understand the slope stability conditions in and around the proposed crossing area including an area close to the south end of Iron Mountain that may be underlain by marine clay.

3.5 Stream Characteristics

The Wedeene River is a gravel bed tributary to the Kitimat River. The Wedeene River has a low gradient (0.7%) and a wetted width varying from 50 to 80 m. The river has an irregular meander pattern that is generally unconfined downstream of the crossing; however, bedrock outcrops provide some local confinement at the crossing, as previously discussed. The channel occasionally flows along the toe of a high steep cutbank, and bedrock outcrops occur at various locations along the banks. The channel bed follows a pool/riffle sequence, and the channel transports abundant sediment from the upper reaches, as evidenced by numerous mid-channel, side and point bars. Channel bed materials vary from gravel to large boulders.

The crossing is located along a reasonably straight channel reach, approximately 100 m downstream of a sharp 120° meander bend and 150 m upstream of a more gradual meander bend. The upstream bend is bedrock controlled. At the crossing, the channel is approximately 30 m wide and confined on the north bank by a terrace and local bedrock knob rising 15 m or more above the river level. On the south bank, the river is bordered by a 50 m wide densely vegetated moderately to steeply sloping terrace with a bank a few meters high above the river, but there is a rock knob on the edge of channel directly downstream. The channel has a moderate potential for waterborne debris.

The presence of bedrock at numerous locations along the channel bed and banks has reduced the lateral mobility of the river. LiDAR mapping downstream of the crossing shows that the channel has been gradually downcutting through the upper sediment layers. Channel bed levels are controlled by bed levels in the Kitimat River, which are in turn controlled by bed levels at the north end of Kitimat Arm. Due to the downstream bed level controls and the volume of sediment being transported by the river, bed levels at the crossing are not expected to undergo any significant degradation over the life of the pipeline.

Flow projections from regional data indicate that mean monthly discharge (flow) is 6 to 10 m³/s from December to March and 13 to 50 m³/s from April to November. Figure 1, below, shows the mean monthly flows.
Discharges at crossing estimated from regional recorded streamflow data.

Figure 1: Mean Monthly Flows of Wedeene River at Crossing
4.0 PRELIMINARY GEOTECHNICAL ASSESSMENT

The geotechnical and hydrotechnical assessments of an HDD crossing and a potential contingency crossing method are summarized below.

4.1 Horizontal Directional Drill (HDD) Crossing

The preliminary HDD crossing is shown on Drawing 08-3000-1143-3. An HDD crossing at the proposed location is considered appropriate for the purposes of project planning based on the preliminary information outlined above and the preliminary no-drill zone shown on Drawing 08-3000-1143-3.

The preliminary no-drill zone was established using the following criteria:

1. Maintaining the static mud pressure in the directional drill hole to a level less than or equal to the vertical overburden total stress under the valley bottom. This methodology has been found to greatly reduce the potential for hydro-fracing and if hydro-fracing occurs, leakage will stop when mud circulation stops, allowing mitigative solutions to be applied.
2. Allowance has been made for slope stability aspects have been on a preliminary basis on both slopes near the river. The depth and mode of potential slope movements will need to be further considered during further work.
3. It was assumed that coarse grained soils, faulted rock and other similar features are not present in locations that would provide a direct seepage path to the river.

Further field studies should be carried out to investigate geotechnical conditions with respect to:

1. Depth, lithology and lateral distribution of deposits underlying the valley within the approximate lateral limits of the HDD path adjacent to the river. The bedrock topography relative to the preliminary drill path, the thickness of glaciomarine clays relative to directional control of the drill path and whether any appreciable deposits of cobbles or boulders occur are of particular interest.
2. Undertake ground reconnaissances along the south end and east side of Iron Mountain to review local stability conditions including near the east end of the crossing alignment. Review stability conditions throughout area.

An HDD crossing is feasible from a hydrotechnical point-of-view.
4.2 Contingency Crossing Method

Other trenchless crossing methods may be feasible from a geotechnical point-of-view subject to further investigations. Specific geotechnical considerations for various other trenchless crossing methods should include:

1. The potential for encountering sensitive marine clays along the crossing alignment.
2. The buried bedrock profile.
3. Surficial geology and stability conditions.

The zone of greatest interest with respect to trenchless methods other than directional drilling would be within the valley bottom area, extending to typical depths of at least 30 m.

Trenchless crossing methods are generally considered feasible from a hydrotechnical point-of-view.
5.0 FUTURE WORK

1. Carry out detailed ground reconnaissance in the proposed crossing area to confirm, or modify, the existing surficial geological interpretation.

2. Obtain and review updated LiDAR information with higher resolution.

3. Confirm, or update, the existing surficial geological interpretation and slope stability assessment.

4. Obtain survey data across the channel as required for scour modelling and to indicate the channel bottom accurately on cross sections.

5. Complete an additional combined drilling investigation and geophysical survey to determine subsurface geological conditions along the preliminary drill path.

6. Provide a combined hydrotechnical and geotechnical report on crossing feasibility.
6.0 CLOSURE

Recommendations presented herein are based on a geotechnical evaluation of the findings of the site investigation noted and other information as discussed in the report. This report is preliminary and recommendations contained herein should be updated and revised as additional information becomes available from further investigations.

This report has been prepared for the exclusive use of Northern Gateway Pipelines Inc. for specific application to the area within this report. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibility of such third parties. AMEC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. It has been prepared in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

Respectfully submitted,

AMEC Earth & Environmental,  
a division of AMEC Americas Limited  
Reviewed by:

Original paper copies signed and sealed by D.S. Cavers, M.Eng., P.Eng., P.Geo.

Per

Principal Engineer

Pete Barlow, M.Sc., P.Eng.  
Principal Geotechnical Engineer
REFERENCES


Minfile Report on Wedeene Prospect
http://minfile.gov.bc.ca/report.aspx?f=PDF&r=Minfile_Detail.rpt&minfilno=103I++014

Minfile report on J Prospect
http://minfile.gov.bc.ca/report.aspx?f=PDF&r=Minfile_Detail.rpt&minfilno=103I++221

Photo 1: Looking northwest at the proposed crossing area. Shallow bedrock is present along parts of the river valley.

Photo 2: Looking southeast at the proposed crossing area. Note the proximity of the CN rail line in the proposed crossing area.

Photo 3: Looking southeast at the proposed crossing area. Note the bedrock exposures and knobs along the river that locally control the flow.

Photo 4: Slope failure apparently in marine clay area (per surficial geology mapping) downstream of the proposed crossing area.

Photo 5: Looking west at the proposed crossing area.

Photo 6: Looking south at the proposed crossing area. Rock is exposed frequently along the CN Rail thru-cut in this area.

NOTE: THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE APPLICABLE AMEC EARTH & ENVIRONMENTAL REPORT ON WEDENE RIVER.

DATE PREPARED: MARCH 2010
REVISION: 1
PREPARED BY: S.BOTTEN / K. EKMAN
PROJECT No: EG0926008.3000.1143

Photos 1 to 6
Taken: 2006 and 2008
Photo 7: Looking southwest across the Wedeene River at the proposed crossing area. Note the approximate boundaries of the stability areas (in blue); selected slide scarps are shown in red. As discussed in the report, Stability Area R2 shows no evidence of recent movement. Stability Area R3 apparently has better stability conditions than the neighbouring areas. Stability Area R4 includes several slides with a dendritic pattern.

Photo 8: Looking west at the south side of the Wedeene River in the proposed crossing area. Note the approximate boundaries of the stability areas (in blue); selected slide scarps are shown in red.

Stability Area R1 encompasses a deep-seated slide upstream (west) of the proposed crossing area. Based on past reconnaissance, the slide is likely moving slowly. Between the toe of the slide and the river there is a wide muskeg-covered terrace which appears to be erosional and is probably not involved with the slide. The slide is likely moving on a low strength clay layer that may be near horizontal.

Stability Area R2 includes several slides with typical longitudinal slopes of about 5° to 15°. These slides appear to be relatively old and show no evidence of recent movement. Most of the slide debris appears to have been eroded. The slides are separated by steep sand and gravel ridges. Further investigation is required to determine if the slide areas are actually stable in the long term.

Stability Area R3 appears to have better stability conditions than either of the neighbouring areas. Stability Area R4 has several slide areas with a dendritic pattern (the red lines are only very general).
Photo 9: Looking north at an upstream bedrock spur on the north side of the river. All of the observed bedrock spurs and knobs along the river have steep slopes along the river and extend to at least 10 m above the river.

Photo 10: Looking north across the Wedeene River with Iron Mountain in the background. The proposed route to the crossing area is along the east side of the mountain. On the north side of the river, there is a rock knob (immediately north of the river at the Rev. R alignment). The apparent old slides of Stability Area R2 (red scarps shown, no recent movement found) are predominantly north and west of the rock knobs on the south side of the river.
Photo 11: Looking along the CN Rail tracks in the proposed crossing area. There was exposed bedrock along both sides of the thru-cut.

Photo 12: Looking northwest across the Wedeene River at the proposed crossing area and lower slopes of Iron Mountain. In the foreground of the photo are the old slides in Stability Area R2 and the east end of the large deep-seated slide in Stability Area R1 (on the left side of the photo). The river bends to the south around a “nose” that is at least partially rock cored.

Photo 13: Looking along the side of one of the sand and gravel ridges between the slides in Stability Area R2. There was minor creep, but no evidence of retrogression or recent sliding.
PRELIMINARY GEOTECHNICAL FEASIBILITY REPORT
PROPOSED HDD WATERCOURSE CROSSING

KP1144.6 (ROUTE REV. R) - SITE No. 3128
WEDEENE RIVER
DETAILED SITE PLAN

ENBRIDGE NORTHERN GATEWAY PROJECT
AMEC Earth & Environmental

NOT FOR CONSTRUCTION

1. Drawing is preliminary and subject to revision during ongoing design as additional information is obtained, and during installation to achieve optimum installation conditions based on the contractor's equipment and on site conditions as they are encountered during the work.

2. Data sources:
   - Pipeline - TRM; BC Gov. Integrated Land Management Bureau (Modified by AMEC) 20 m contour interval.
   - Contour - IEGAR, 1m interval, Terrameq.
   - Imagery - Google Earth; AMEC Infratools Remote Survey Inc. data.
   - SPOT 2.5m resolution.

3. Definition of HDD entry / exit sites and drop section location provided by WorleyParsons Calgary, with input from AMEC.

4. Drawing to be used in conjunction with AMEC Earth and Environmental Report on Weedeene River HDD.

NOTES:

1. Preliminary HDD Specifications
   - East Collar Angle: 12 degrees
   - West Collar Angle: 12 degrees
   - Radius of Curvature: 1100 m
   - Pipe Type: NPS 36” Steel
   - HDD Length: 1218 m
   - Horizontal Length: 1190 m

2. Site Location:
   - WEDEENE RIVER
   - KP1144.6 (ROUTE REV. R)
   - Site No. 3128

3. Drawn by: D. McInerney
   - Date: May 21, 2015

4. This drawing was originally produced in colour.

LEGEND:
- CROSSING CENTRELINE KP
- WEST END MARKER
- EAST END MARKER
- ADDITIONAL MARKER
- PROPOSED HORIZONTAL DRILLING PATH
- ROCK
- SANDSTONE/CLAY
- BOULDERS/COBLES

ISSUED FOR FILING
25 05 2019
SK DSC

ENG APPR

PROPOSED HDD CENTRELINE SECTION

TANGENT APPROX. 445 m LONG
AT 12°

1100 m RADIUS CURVE

PIECE IN ADDITIONAL CURVE

1100 m RADIUS CURVE

TANGENT APPROX. 255 m LONG
AT 12°