2017 NW Trenchless

PROJECT of the YEAR

Congratulations to the Pembina Pipeline Corporation and CCI Inc. on being awarded the 2017 Northwest Trenchless Project of the Year for the Athabasca River Parallel HDD Installations Project!

For more information, please visit *www.ccisolutions.ca/2017-northwest-trenchless-project-of-the-year.*

Project: Athabasca River Parallel HDD Installations – Whitecourt, Alberta

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Pembina Pipeline Corporation (Pembina) proposed the design and construction of the Phase III Pipeline Expansion Project, which follows and expands segments of Pembina's existing pipeline systems from Taylor, British Columbia to Edmonton, Alberta. The core of the Phase III Expansion Project was the Fox Creek to Namao (FCN) construction, which involved the installation of parallel NPS 16 (406.4 mm) and NPS 24 (609.6 mm) pipelines within a shared right-of-way (ROW). The project included more than 20 watercourse crossings requiring detailed engineering designs. One of the crossings identified was the Athabasca River, located approximately 8 km north of Whitecourt, Alberta.

Both new pipelines were designed to transport high vapour pressure (HVP) products, and increase transport capacity by 170,000 bpd and 500,000 bpd, respectively. With the parallel installations complete and placed into service on June 16, 2017, Pembina now has four

BACK TO CONTENTS

pipelines within the Fox Creek to Namao corridor, which allow them to transport four distinct hydrocarbon products (propane-plus, ethane-plus, condensate, and crude oil) within segregated pipelines.

CHALLENGES FACED

The NPS 24 and NPS 16 HDD crossings of the Athabasca River were 1,552 m and 1,462 m long, respectively. Due to surficial geotechnical conditions at the proposed crossing location, temporary surface casing was proposed at both the entry and exit locations. Both HDD crossings were designed to be completed utilizing intersect methodologies and employed the use of two HDD rigs.

The conditions encountered during the construction of the HDD crossings led to significant challenges. Water ingress throughout the duration of both drills presented challenges in fluid management, access restrictions, and hole sealing. Borehole instabilities and stuck drill pipe required creative, skilled problem solving to overcome. After the loss of drill pipe down hole, sidetracking was employed to allow the drills to utilize the previously installed surface casing at entry and exit, greatly reducing the cost impact to the project.

The engineering team, HDD contractor, and client worked together employing multiple mitigation strategies during the construction phase to successfully complete both the NPS 16 and NPS 24 HDD crossings, an improbable outcome due to the conditions encountered.

GETTING TO WORK

The new parallel installations are 286 km long and transport products from Fox Creek to existing processing facilities in the Namao area. Within the acquired ROW, the two pipelines crossed numerous watercourses, roads, and surficial features. CCI Inc. (CCI) was engaged by Pembina in 2014 and worked closely with our client through to the end of construction in 2017. Construction of the horizontal directionally drilled (HDD) crossings began in August of 2016 and was completed in April 2017. CCI's scope of work included 68 detailed crossing designs at 34 crossing locations, including stress analysis, annular pressure modelling, feasibility assessments, and risk assessments. Along with engineering, CCI completed geotechnical investigations at a majority of the crossing locations and at all of the major watercourse crossings. Throughout the duration of the HDD design and construction, CCI provided contract support, assisting with the tender process, contractor negotiations, clarifications, and award. During HDD construction, CCI assisted with cost tracking for the HDD activities and provided knowledgeable HDD Inspectors to act as the Client Representative on site for the duration of HDD activities.

One of the most difficult major crossing locations on the FCN project was the Athabasca River, located approximately 8 km north of Whitecourt, Alberta. The NPS 24 and NPS 16 crossings of the Athabasca River were 1,552 m and 1,462 m in length, and required finished borehole diameters of 24" and 36", respectively.

An extensive geotechnical program was completed at the crossing, with seven boreholes completed along the crossing alignment. These boreholes identified surficial materials of sand, clay, clay (till), and gravel. The gravel identified was extensive, on both the north upland (exit location) and within the valley bottom to the south (entry location). The two boreholes on the north upland identified a significant difference in the thickness of the gravel layer, prompting the completion of an additional geophysical program which utilized electrical resistivity tomography (ERT) in an attempt to define the gravel layer and assist with determining the ideal exit location, as well as the requirements for surficial casing during construction. Bedrock at the crossing location consisted primarily of mudstone and sandstone, with some of it described as fractured and water bearing at, or above, rig elevation. Utilizing this geotechnical data, CCI's geotechnical department created a no-drill zone (NDZ), which provided a minimum 37 m of cover beneath the lowest point in the river channel thalweg, putting the drill at least 15 m into competent bedrock. The NDZ also maintained the drill at, or below, 640 m geodetic elevation as it passed beneath the current river channels and the active flood plain.

Final detailed HDD designs included 35 m of NPS 48 (1219.2 mm) and NPS 36 (914.4 mm) casing on entry and 50 m of casing at the exit locations. Both crossings followed similar drill paths and utilized moderately high entry (18°) and exit (16°) angles (based on industry standards) to reduce the length of casing required. The NPS 24 installation was designed 3 m deeper than the NPS 16, and extended 50 m longer than the NPS 16 on entry and exit to accommodate equipment layout and drilling operations to occur concurrently within a shared workspace. The drills were offset horizontally to meet Pembina's specification for minimum separation requirements, allow for adequate steering tolerances, and minimize the risk of fluid communication between the drills. The geometry of the drills included approximately 80 m of elevation gain from entry to exit, and 120 m of total elevation change from the bottom tangent to the exit location.

Both drills were designed utilizing intersect methodology due to the casing requirements at entry and exit. Annular pressure analysis was run from both the entry and exit locations, and it was identified that expected downhole drilling pressures during the pilot holes quickly exceeded the strength of the overburden formation when drilling from the exit location due to the large elevation change in the topography. Due to this, the intersects were planned within the exit tangent of the drills, with a large portion of the pilot hole being completed from the lower entry side.

Pipe section layout utilized additional workspace to facilitate the layout of both the pipelines, travel, and required pipe support equipment. The NPS 24 utilized two pipe sections, which required a stoppage during pipe pullback operations to complete the closure weld, inspection, and coating. Due to the high exit angle of both drills, additional support equipment was necessary for the safe support of the sections, which reached a maximum height of 9 m within the overbend.

The planned construction schedule included very aggressive timelines due primarily to environmental requirements which restricted access and construction to a set operational window. The schedule involved four rigs to be mobilized and utilized for drilling operations of the NPS 16 and NPS 24 pipelines concurrently. Direct Horizontal Drilling (DHD) was contracted by Pembina to complete the construction of the HDD crossings, including casing installation and extraction. Mobilization to the prepared work pads began in August 2016. Entry and exit rig spreads were setup simultaneously with two full spreads, including mud cleaning and recycling equipment. Specifications for the rigs utilized are as follows:

NPS 16 Entry / NPS 24 Entry
Pullforce – 1,100,000 lb.·f
Rotary Torque – 100,000 ft.-lbs
Pump Capacity – 6 cm/min

NPS 16 Exit / NPS 24 Exit
Pullforce – 440,000 lb.·f
Rotary Torque – 60,000 ft.-lbs
Pump Capacity – 5 cm/min

Surface casing (NPS 48 and NPS 36) was successfully installed on entry to 29 m, where a competent formation was encountered, slightly shorter than the proposed 35 m. On exit, NPS 60 and NPS 48 casing were installed, sized up from the required minimum diameter to allow for the use of telescoping in the event the casing

BACK TO CONTENTS

could not be installed to the required depth without employing this methodology. Exit casing was initially installed to lengths of 66 m and 64 m, exceeding the recommended 50 m due to the variance in the gravel formation on exit.

The NPS 24 drilling activities began prior to the NPS 16, and the 12 ¼" pilot was completed with minimal problems. There were delays when the entry rig had to wait for exit casing installation to be completed so the intersect could be attempted. Once exit casing was complete the exit rig drilled to 166 m, where it intersected the entry pilot in five hours. The first ream pass enlarged the borehole to 24", leaving a plug at exit to ensure borehole stability, followed by a 36" final ream. During the 36" ream the borehole started to produce water at 5m^3/hr, and the rig was shut down for a period due to warm conditions, rain, and access restrictions caused by the sloppy conditions. After a final wiper pass, pipe pull was successfully completed with a maximum pullforce of 115,000 lbs.·f, indicating a clean borehole free of cuttings.

A REDRILL REQUIRED

The NPS 16 drilling began and encountered fluid losses to the parallel bore at approximately 540 m MD from entry. Once the intersect was completed, the bore began producing water to the entry location at a variable rate from 5–7 m^3/hr for the duration of the drill. The shutdown due to weather conditions occurred during pilot immediately after completing the intersect and resulted in high rotary and stuck drill string. It was then determined that the string was unrecoverable and both rigs rotated out of the drill string, retrieving approximately 590 m of drill pipe on entry and 170 m of drill pipe on exit, abandoning the remaining drill pipe in the hole. Due to the amount of drill pipe retrieved, the existing entry and exit casing were still able to be utilized for the second attempt at pilot hole. Both the entry and exit re-drills were successful in side-tracking out of the existing hole once outside the casing. After the second successful intersect, issues arose when attempting to trip both bits out to exit; it was determined that collapsed cobbles at the end of the casing were resulting in deflecting the bottom hole assembly (BHA) outside of the casing. Additional casing was installed on exit from 64 m to 68 m, and the BHA was successfully pushed out to exit and reaming operations commenced.

"The planned construction schedule included very aggressive timelines due primarily to environmental requirements which restricted access and construction to a set operational window."

DHD began forward reaming 24" to approximately 500 m when the rotary torque increased significantly and the exit rig twisted off the reamer. Both rigs tripped to surface with the exit rig retrieving the tail string with a failure just beneath a tool joint and the entry rig successfully retrieving the reamer. The BHA was tripped across the hole to exit and encountered problems getting into the exit casing again; additional casing was installed to 87 m and additional attempts to push out the bit to exit were made. At this time, due to extreme weather conditions, bans were in place on the access roads preventing heavy loads and limiting vacuum trucks and drill pipe loads. Consideration was given to tripping the exit BHA to entry; however, the road bans prevented mobilizing drill pipe and managing fluid returns to entry. After three days and multiple attempts to get the entry BHA out of the exit casing, road bans were lifted, allowing the contractor to mobilize drill pipe from exit to entry to trip the BHA in from the exit to entry, and bits are quickly tripped through the borehole and successfully pushed out on entry. The 24" ream was quickly completed, along with a successful wiper pass. After multiple construction issues and mitigation strategies, failures and successes, the NPS 16 pipeline was installed with no issues during pullback operations and a maximum pullforce of 98,300 lbs.·f.

Entry casings for both the NPS 16 and NPS 24 drills were successfully removed, exit casing removal attempts were unsuccessful and drills were cemented at entry and exit to restrict production of water from hole and to seal the exit casing abandoned in the hole.

The authors would like to thank the entire project team for combining their efforts and utilizing their experience and expertise, resulting in the successful installation of both the NPS 24 and NPS 16 HDDs.