Appendix A

Summary of Construction Methods and Procedures





Summary of Construction Methods and Procedures

Enbridge Energy, Limited Partnership • Line 3 Replacement Project

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ENBRIDGE®

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TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

ATWS	additional temporary workspace
BMP	best management practice
contractor yard or yard	pipeline, staging areas, and storage yards
EI	Environmental Inspector
EMCP	Environmental Monitor Control Plan
Enbridge	Enbridge Energy, Limited Partnership
EPP	Environmental Protection Plan
ESB	Electrical service building
HDD	horizontal directional drill
L3R or Project	Line 3 Replacement Project
OHWM	ordinary high water mark

1.0 INTRODUCTION

This Summary of Construction Methods and Procedures ("Summary") describes the various construction methods that Enbridge Energy, Limited Partnership ("Enbridge") will utilize to construct the Line 3 Replacement Project ("L3R" or "Project") through uplands, wetlands and waterbodies, and the decision-making process that occurs during design and in the field when identifying the appropriate crossing technique. The discussion of each construction method includes:

- Description of the construction methods and procedures;
- Conditions required to employ the method (applicability of the method);
- Site characteristics that require modification to standard construction techniques; and
- Environmental and/or constructability advantages and disadvantages associated with the method.

The purpose of this document is to provide a more complete description of the construction techniques that are outlined in Enbridge's Environmental Protection Plan ("EPP"). The EPP contains elements of industry and company-wide best management practices ("BMPs") that would be implemented during the execution of these construction techniques, such as erosion and sediment control measures; construction spill prevention, containment, and control; measures to prevent and contain inadvertent drilling fluid releases; invasive and noxious species control; and restoration/revegetation measures.

1.1 DESIGN PROCESS AND METHOD SELECTION OVERVIEW

The design process is iterative and starts with developing a basic design that satisfies the intended Project purpose and meets engineering design standards established by the U.S. Department of Transportation. Enbridge gathers, examines, and analyzes both field and desktop environmental data to inform the route and construction techniques, which is further refined by consultations with federal, state, and local regulatory agencies, landowners, and other stakeholders.

During the design and planning process, Enbridge identifies the preferred method of pipeline installation based on the engineering design standards (e.g., U.S. Department of Transportation), presence of wetland features, waterbody features, sensitive resources, landowner/community considerations, environmental regulations, and constructability considerations, including the ability to safely and effectively construct through the area. Specifically, these considerations include the following:

- Sensitive Resources:
    - Federally or state-designated high value waters (e.g., Wild and Scenic Rivers, canoe routes, Nationwide Rivers Inventory)
    - Wildlife or aquatic management areas
    - Section 303(d) impaired waters and other water quality considerations

    - Infested waters (presence of aquatic invasive or noxious species)
    - Presence of sensitive aquatic resources (e.g., federally or state-listed species, trout fisheries)
    - Sensitive ecological communities (e.g., Sites of Biodiversity Significance)
    - Fisheries concerns
    - Wetland resources (types, extent)
    - Recreational use
    - Archaeological and historic resources
    - Other issues identified by resource agencies
- Landowner/Community Considerations:
    - Homeowner and/or business access
    - Noise and/or lighting impacts
    - Traffic
    - Community access to sites (e.g., recreational areas, hunting)
    - Adjoining land use activities (e.g., grazing, organic farms)
    - Safety, security, and exposure of the public and workers
    - Other issues identified by land-managing agencies (e.g., off-road vehicle access)
- Constructability:
    - Season of construction
    - Topography
    - Geology and soils (e.g., presence of bedrock, cobble/boulders, soil competency/ stability)
    - Geometry of the waterbody (straight, meanders)
    - Ability to manage water during crossing
    - Hydrology and soil saturation/inundation
    - Workspace limitations (e.g., roads, railroads, topography, sensitive resources)
    - Availability of equipment and access

- Duration of activity
- Risk (or probability of success)
- Cost

Enbridge identifies a primary and alternative crossing method for each waterbody crossing method, with some exceptions (discussed further in Section 4.0), based on these criteria and site-specific crossing conditions. In some cases, primary and alternative crossing methods are also defined for wetland crossings (discussed further in Section 3.0). Enbridge gathers information, such as wetland and waterbody field delineations, stream geomorphic field surveys, and/or geotechnical borings, and conducts risk assessments to inform these decisions. Enbridge also reviews construction reports from prior projects that have occurred in the vicinity of the proposed installations to determine if methods employed were successful or had complications.

The following sections describe the types of construction methods that could be employed to install the pipeline across uplands, wetlands, and waterbodies, and the specific conditions required for those methods to be feasible. These sections also describe the circumstances where a decision may be proposed in the field to change a construction method, or where additional tools may be utilized to ensure successful installation of the pipeline while minimizing adverse effects to the natural and/or human environment.

2.0 PROJECT COMPONENTS AND ASSOCIATED CONSTRUCTION PROCEDURES

The following describes standard construction methods and procedures that may apply to both upland and wetland environments, as noted. Additional details on the upland construction method BMPs are provided in Sections 1.8 through 1.21 of the EPP.

2.1 RIGHT-OF-WAY ACCESS

As described in Section 1.4 of the EPP, Enbridge will utilize the haul routes, access roads, or shoo-flies to access the construction workspace.

Enbridge will maintain existing roads, improve existing trails or roads, or build new roads as needed and approved through applicable permits. Maintenance activities may include back-blading, and/or placement of fill or construction mats where needed on the existing road grade and as agreed upon with the road authority. Gravel will only be added to maintain existing roads that have an existing gravel road base, or to develop permanent access roads, if needed. If gravel is installed on a road that is not permanently maintained for the Project, it will be removed and the area will be restored to pre-construction conditions following construction unless the road authority or landowner requests that it remain in place.

Activities that occur beyond the existing road grade, such as widening (including tree removal), placement of construction mats in wetlands, placement of structures within the Ordinary High Water Mark ("OHWM") of waterbodies, or development of a new road, are considered improvements requiring environmental survey and applicable permits and authorizations. Enbridge will confine maintenance and improvements on haul routes to the legal road easement as established by the corresponding road authority. Haul routes will only be improved where needed and in most cases, these improvements will be left in place once construction is complete and where agreed to by the road authority.

Construction mats (see Section 3.1) or rock on top of geotextile fabric will be used for roads within wetlands and will be removed once construction is complete. Ice/frost roads may be used during frozen conditions as described in Enbridge's Winter Construction Plan. Typical drawings for rock and construction mat approaches are provided in Figures 1 and 2 of the EPP.

Temporary access roads and shoo-files utilized during construction will be widened to approximately 30 feet. After construction, Enbridge will return improved temporary access roads and shoo-flies to their pre-construction condition unless the road authority, landowner, or land-managing agency requests that the improvements be left in place. Enbridge will maintain permanent access roads to aboveground facilities (e.g., pump stations, mainline valves) throughout Project operation.

2.1.1 Bridges and Culverts

As described above, Enbridge will utilize existing public roads as haul routes and to access the workspace as much as possible. Generally, the bridges and culverts associated with existing roads will be sufficient to allow the passage of construction equipment and vehicles. However, in some cases, improvements to existing infrastructure may be needed, such as:

- Air bridges or construction mats over existing infrastructure;
- Extension of culverts to widen the travel lane; and/or
- Additional in-stream supports.

For new access roads or shoo-flies over a waterbody, and road approaches to the construction workspace, the following infrastructure may be installed as appropriate for site-specific conditions:

- Clear span bridges: Temporary clear span bridges will typically be used to cross waterbodies that are less than 13 feet from top of bank to top of bank with stable banks. No direct excavation of the waterbody bed or in-stream supports are required.

- Non-clear span bridges: Typically used to cross waterbodies with top of bank to top of bank 13 feet wide or greater as required by Enbridge's engineering specifications, or where additional stabilization is required to ensure the bridge installation allows for the safe passage of construction equipment and vehicles. Installation of infrastructure or supports within the OHWM are required.

- Culverts/flumes: Cylinder or box-shaped structures placed in the waterbody channel below the OHWM to allow water flow. The size and shape of the culvert is dependent on the waterbody.

Table 2.1-1 summarizes the site-specific conditions, advantages, and disadvantages associated with these bridge and culver types.

TABLE 2.1-1
Types of Bridges

Type	Description	Applicability	Advantages	Disadvantages
Clear Span Type Bridge (construction mats or engineered structures)	Construction of temporary bridge utilizing construction mats or an imported engineered portable bridge material from top of bank to top of bank without instream supports (refer to Figure 3 of the EPP).	Suitable for waterbodies less than 13 feet wide top of bank to top of bank with stable banks. Regular bridge maintenance required. Preferred bridge type to provide safe crossing for heavy construction equipment.	• Strong, removable, and portable bridge that can be optimally located • Limited in-stream disturbance • Limited sediment release • Maintains streamflow • Maintains fish passage	• Specialized equipment/crew required • Substantial amount of work may be necessary to transport and/or construct • Limited span for construction mat bridges and cap may be required • Regular maintenance of erosion and sediment controls required • Possible sediment release from bank and approach disturbance or if cap used over construction mat bridge • May cause interference on navigable waterways • Bridges need to be keyed into the banks
Non-clear Span Bridge (construction mats or engineered structures with instream supports)	Construction of temporary bridge utilizing construction mats or an imported engineered portable bridge material from top of bank to top of bank with instream supports (e.g., mats or flume) (refer to Figure 4 of the EPP).	Suitable for waterbody crossings 13 feet wide or greater top of bank to top of bank with stable banks. Can be used on larger watercourses with multiple bridge spans and instream supports. Regular bridge maintenance required. Preferred bridge type to provide safe crossing for heavy construction equipment.	• Strong, removable, and portable bridge that can be optimally located • Limited in-stream disturbance • Limited sediment release • Maintains streamflow • Maintains fish passage	• Specialized equipment/crew required • Substantial amount of work may be necessary to transport and/or construct • Limited span for construction mat bridges and cap may be required • Regular maintenance of erosion and sediment controls required • Possible sediment release from bank, approach, and instream support disturbance or if cap used over construction mat bridge • May cause interference on navigable waterways • Bridges need to be keyed into the banks

TABLE 2.1-1
Types of Bridges

Type	Description	Applicability	Advantages	Disadvantages
Culvert/Flume	Place steel flume pipe or culvert to allow waterbody flow. Place ramp over culvert or flume using construction mats. Rock may be placed on top geotextile fabric over culvert or flume in waterbodies or ditches at road approaches to support construction traffic (refer to Figure 1 of the EPP).	Appropriate for small or medium-sized waterbodies with or without flow and with defined channel and banks. Used where streamflow and fish passage are of concern.	• Limited sediment release • Maintains stream flow and fish passage	• Sediment release when filling around the culvert/flume and upon removal • Susceptible to washout during high flow • Icing in winter may block flow and fish passage • May require bank grading • Some culverts may not be able to withstand heavy construction traffic • Requires specialized materials such as sand bags and select fill
Source: Canadian Association of Petroleum Producers, Canadian Energy Pipeline Association, and Canadian Gas Association, 2005.				

2.1.2 Bridge and Culvert Design

Equipment bridges and culverts will be designed to meet the requirements of the applicable agencies and local authorities. Bridges will be installed parallel to the pipeline centerline so that equipment does not need to turn while working or crossing the bridge. For bridges that are installed on designated canoe routes, the bridge height will be designed to allow for adequate clearance to allow recreational users to pass safely under the bridge. Enbridge may also prepare site-specific bridge or culvert designs at specific wetland or waterbody crossings for agency approval, as required.

Enbridge has engineering specifications that require in-stream supports on bridges crossing waterbodies 13 feet wide or greater top of bank to top of bank with stable banks. In-stream supports will not be installed in or removed from waterbodies during agency-timing restrictions unless approved by the agency. Bridges will not restrict flow or pool water while the bridge is in place and will be constructed with clean materials. Bridges will be designed to prevent soil from entering the waterbody (refer to Figures 3 and 4 of the EPP).

2.2 CONSTRUCTION YARDS

In order to construct the pipeline, staging areas, and storage yards (collectively referred to as "construction yards" or "yards") will be strategically located outside of the right-of-way along the route. Yards will be sited in accordance with local permits, as required. These areas are used to stockpile pipe, and other equipment required during construction. Yards provide parking for construction equipment and employee trucks, and locations for offices and trailers. Yards may also be used to clean equipment, or prepare materials for use, such as concrete coating of pipe segments.

Enbridge will seek previously disturbed areas in proximity to the route to utilize as a yard site, such as gravel pits, railroad yards, cleared fields, or parking areas. Yards will be cleared and may be covered in rough stone gravel and/or construction mats as needed. Yards may also be fenced for security purposes. After construction is complete, yards will be restored back to pre-construction conditions unless otherwise requested by the landowner.

2.3 TEMPORARY AND PERMANENT RIGHTS-OF-WAY

Construction in upland[1] areas will generally require a 120-foot-wide construction workspace.[2] The construction workspace will allow for temporary storage of topsoil and trench spoil (nonworking side), as well as accommodate the safe operation of construction equipment and a travel lane (working side) (refer to Section 2.4). Topsoil will also be stored on the working side. The 50-foot-

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1 Uplands: Uplands are defined as an elevated region of land lying above the level where water flows or collects in basins.

2 The terms "construction right-of-way," "temporary construction right-of-way," "construction workspace," and "temporary construction workspace" define the primary mainline workspace area required for installation of L3R. For clarity, Enbridge will generically use "construction workspace" instead of "temporary construction right-of-way," temporary construction workspace," or "construction right-of-way" as the terminology for 1) the permanent right-of-way; and 2) the temporary construction area (which includes the following defined terms: Temporary Workspace and Additional Temporary Workspace). All construction equipment and vehicles will be confined to this approved construction workspace.

wide permanent right-of-way[3] will be wholly contained within the 120-foot-wide construction workspace. Table 2.3-1 presents the typical construction workspace and permanent right-of-way dimensions that will be used for pipeline construction and operation in upland and wetland areas (refer to Section 3.0 for a description of construction methods and workspace dimensions in wetland areas). Figure 5 of the EPP presents the temporary construction workspace[4] and permanent right-of-way configurations when co-located with existing Enbridge or third-party pipelines or utilities, and in greenfield[5] locations. Overall, the L3R will be co-located[6] with other Enbridge pipelines; third-party pipelines or utilities; or roads, railroads, or highways for the majority of the route.

Table 2.3-1
Typical Construction Workspace and Permanent Right-of-Way Dimensions for the Line 3 Replacement Project

Route Segment	Permanent Right-of-Way (feet)	Temporary Construction Workspace (feet)	Total Land Requirements (feet)
Co-located with Enbridge Pipeline	50 (~25 new)	70 (uplands)	120 (uplands)
		45 (wetlands)	95 (wetlands
Co-located with Foreign (Third-Party) Utility	50	70 (uplands)	120 (uplands)
		45 (wetlands)	95 (wetlands
Co-located with Foreign Utility in Saturated Wetlands	50	70 (uplands)	120 (uplands)
		45 (wetlands)	95 (wetlands
Greenfield	50	70 (uplands)	120 (uplands)
		45 (wetlands)	95 (wetlands

During construction, topsoil and subsoil will be separated and stored within the construction workspace.

Where co-located with Enbridge's existing pipelines, Enbridge will use approximately 40 feet of existing permanent right-of-way as temporary workspace that will revert back to permanent right-of-way after construction (see Figure 5 of the EPP). The offset distance between L3R and an existing foreign pipeline or utility will vary, as presented in Figure 5 of the EPP.

2.4 TRAVEL LANES

As described in Section 2.3, the working side of the construction workspace will include a travel lane to allow for the safe passage of construction vehicles and equipment. Temporary equipment bridges will be used (upon approval by the appropriate agency) at waterbody crossings (including small waterways such as ditches and intermittent streams) where there is a potential for stormwater runoff or rain events to transport sediment downstream from equipment crossing the waterway. Refer to Sections 2.1.1 and 2.1.2 for additional information on bridge and culvert types and design.

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[3] Permanent right-of-way: The legally acquired land rights used to install, maintain, operate, and access L3R.

[4] Temporary workspace: Land located adjacent to and contiguous with the proposed right-of-way.

[5] Greenfield: The term "greenfield" refers to land that has not previously been used for another pipeline, utility, road, or railroad right-of-way. For the purposes of this document, the term greenfield is applied to land that is more than 250 feet away from an existing parallel pipeline, utility, road, or railroad right-of-way.

[6] Co-located: Co-located is any portion of the route that is within 250-feet from the centerline of a known utility.

2.5 ADDITIONAL TEMPORARY WORKSPACES

Additional temporary workspaces ("ATWS")[7] will be required outside of the typical construction workspace to facilitate specific aspects of construction. For example, ATWS will be needed at select locations such as steep slopes, roads, waterbodies, and some wetland crossings, and where it is necessary to cross under existing pipelines or foreign utilities, HDD sites, and other special circumstances to stage equipment and materials, and store spoil. Enbridge will also use ATWS to accommodate equipment and resources used for appropriating and discharging water. The dimensions of ATWS will vary according to site-specific conditions.

Enbridge may also require ATWS for:

- construction equipment and working personnel to travel safely within the Project's construction site;
- environmental monitoring and mitigation to be employed as required; and
- continuous ingress/egress for emergency equipment and personnel.

Enbridge attempts to locate ATWS outside of wetlands wherever practicable. However, ATWS may be sited in select wetlands where the wetland is adjacent to a waterbody, road, railroad, foreign utility crossing, pipeline cross-over, and/or where required based on site-specific conditions with prior approval from the applicable regulatory agencies.

2.6 PIPELINE CONSTRUCTION SEQUENCE

Enbridge will install the replacement pipeline using industry-accepted construction methods. Pipeline construction will typically follow a sequential process, which includes: development of construction yards, survey and staking of the construction workspace and roads, access road and haul route improvements, clearing, installation of erosion and sediment control BMPs, site preparation, pipe stringing, bending, welding, coating, trenching, lowering-in, backfilling, hydrostatic testing,[8] and cleanup, grading, and restoration. In most areas, these construction processes will proceed in an orderly assembly-line fashion with construction crews moving along the construction workspace (see Figure 2.6-1). Appropriate safety measures will be implemented before excavation begins, including notification through the One-Call system to ensure third-party utilities and adjacent pipelines are properly marked. Four-way sweeps[9] will also be conducted to positively locate any existing underground utilities. Pipe, valves, and fittings will be transported to the workspace and placed along the workspace. Construction crews will use temporary access roads and shoo-flies for ingress/egress to the Project workspace where travel down the workspace is not feasible.

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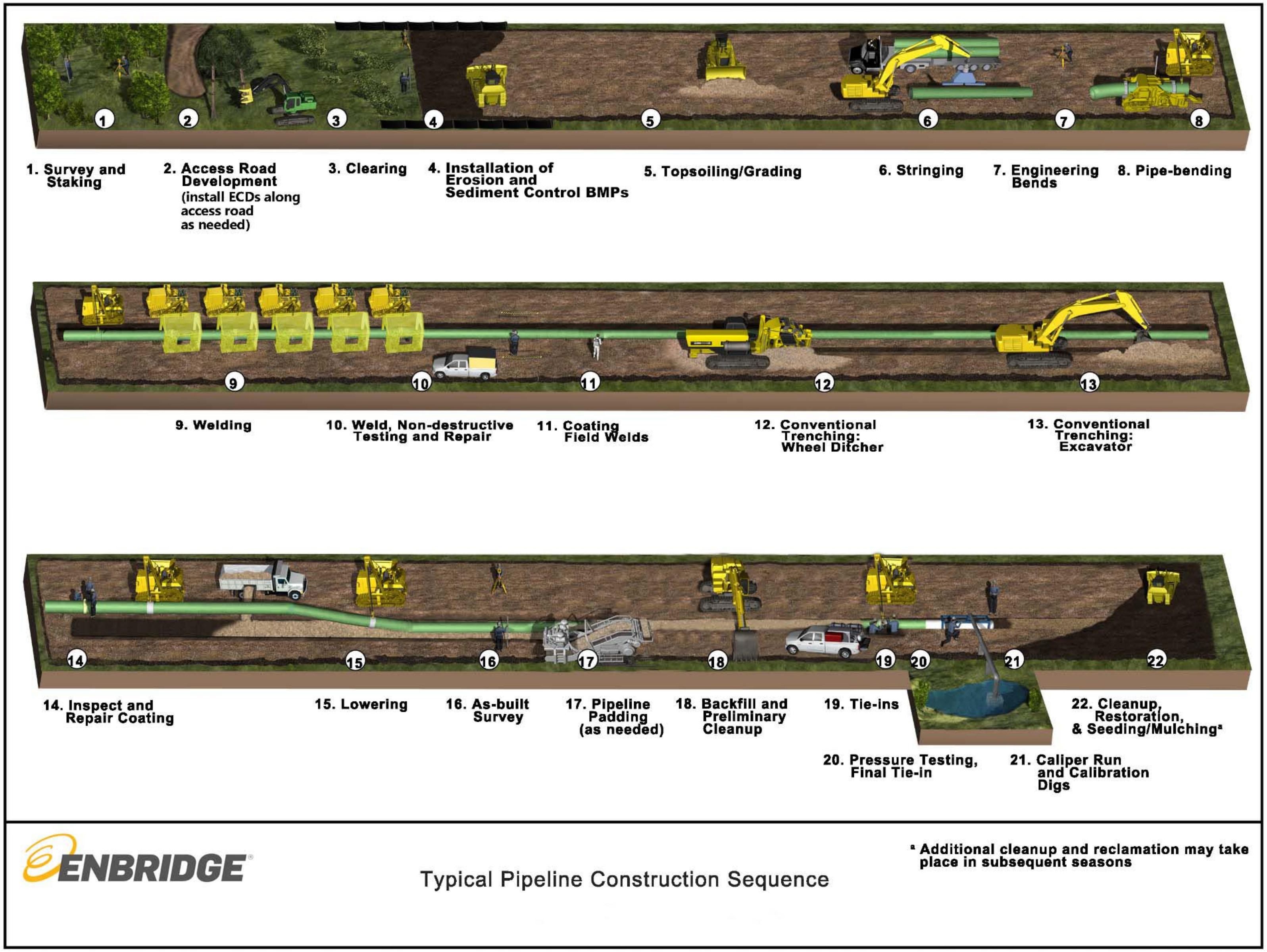
[7] ATWS: ATWS is temporary construction workspace needed when encountering environmental features that require special construction methods.

[8] Hydrostatic testing: Hydrostatic testing is a process of verifying the integrity of the pipeline before it is placed into service. Hydrostatic testing involves filling the pipeline with water to a designated pressure and holding it for a specified period of time.

[9] A four-way sweep is a method of locating underground utilities that involves scanning the ground with electromagnetic induction or ground-penetrating radar equipment to detect the presence of buried features; it does not involve digging or other ground-disturbing activities. The term "four-way sweep" comes from the fact that an area typically is scanned (or swept) in at least four directions.

Figure 2.6-1: Typical Pipeline Construction Sequence



2.7 MINIMUM DEPTH OF COVER

In accordance with federal requirements (49 Code of Federal Regulations 195.248), the depth of cover between the top of the pipe and the ground level, road bed, or river bottom can range between 18 to 48 inches, depending on the location of the pipe and the presence of rock, which is provided below (see Table 2.7-1).

Table 2.7-1
Depth of Cover Requirements

Location	Cover in inches	
	Normal Excavation	Rock Excavation [a]
Industrial, commercial, and residential areas	36	30
Crossing of inland bodies of water with a width of at least 100 ft. from high water mark to high water mark	48	18
Drainage ditches at public roads and railroads	36	36
Deepwater port safety zones	48	24
Gulf of Mexico and its inlets in waters less than 15 feet deep as measured from mean low water	36	18
Other offshore areas under water less than 12 feet deep as measured from mean low water	36	18
Any other area	30	18

[a] Rock excavation is any excavation that requires blasting or removal by equivalent means.

Minnesota Statute § 216G.07, Subd. 1 requires that the pipeline trench be excavated to a depth of at least 54 inches of backfill from ground surface to the top of pipeline in all areas where the pipeline crosses the right-of-way of any public drainage facility; or any county, town, or municipal street or highway; and where the pipeline crosses cultivated agricultural land. This depth requirement may be waived as described in Minnesota Statute § 216G.07, Subd. 2; however, the pipe must still be buried to a minimum depth that complies with the federal requirements outlined in Table 2.7-1. While Enbridge will seek waivers for Minnesota state depth of cover requirements in some circumstances, it will meet all federal depth of cover requirements and also target a nominal 48 inches of cover across the Project.

In addition, agencies have requested additional depth of coverage at certain wetland and waterbody crossings. Enbridge will work with the agencies to determine the appropriate depth of cover at these locations. This design change will be reflected in the construction alignment sheets and applicable site-specific drawings. Following installation of the pipeline, Enbridge will confirm that the pipe depth meets federal and state requirements through civil survey.

2.8 ASSOCIATED FACILITIES

Facility construction will follow the same initial sequential process as mainline pipeline construction, including survey and staking, clearing, and site preparation.

2.8.1 Pump Stations

Pump stations will be located at regular intervals along the pipeline to boost the pressure lost due to friction as the liquids move through the pipe. All pump stations will be installed on property that has been or will be purchased by Enbridge in fee. Construction of each pump station will occur over an approximate 10-month period.

Each pump station property will include a:

- Pumphouse building;
- Electrical service building ("ESB");
- Substation;
- Permanent access road and parking area;
- Snow storage area(s);
- Containment basin; and
- Infiltration basin or wet sedimentation basin.

Prior to excavation, four-way sweeps will be conducted to positively locate any existing underground utilities. Temporary construction trailers will be placed, material laydown areas[10] prepared, and temporary utilities (e.g., power, telephone) will be installed at the site. Topsoil will be stripped and stored prior to initiating excavation work.

The pumphouse building footprint will measure approximately 120 feet by 70 feet and the excavation will vary between approximately 5 to 10 feet deep depending on site-specific conditions. Typical construction procedures for the building foundation are to excavate the foundation base depth, establish concrete foundations, fill, and construct. Dewatering of the excavations will occur as described in Section 5.0 of the EPP and applicable permit conditions.

Several components at the pump station site will require foundation footings, including the pumphouse, ESB, and substations. Foundation footings will consist of either poured concrete piers or helical footings that will average between 10 to 15 feet deep but may extend up to 40 feet deep depending on site specific conditions.

The piping associated with the pump stations will either be welded onsite or pre-fabricated spools made from fabrication shops will be installed. All station piping will be pressure tested after on-site installation. Pressure testing will be completed with a liquid test medium that will be trucked on- and off-site. Piping will be tested for 4.25 hours if above grade; below grade piping will be tested for 8.25 hours. There will be three pressure tests per facility; one test for the mainline piping inside the station, one test for the station piping, and one for the drain line piping.

The modular-designed ESBs will be placed onsite and all associated electrical and controls equipment will be installed. Power and control cables will be routed, and additional pre-operational testing can begin once the system(s) are energized. All sites will require the construction of a new electrical substation.

The containment basin, wet sedimentation basin, or infiltration basin associated with each facility will be designed and constructed in accordance with the applicable federal and Minnesota Pollution Control Agency requirements.

Upon completion of all pre-operational testing, the equipment will be flooded with crude oil according to the detailed flood plans developed for each site. Equipment operation will then be verified. Final site civil work and painting will be completed, and the pump station property will be fenced in and gated to restrict access to the site. The area within the fence will be graveled and/or

[10] Material laydown area: A material laydown area is a piece of land where materials are stored and staged for construction.

maintained as grass. Once all final checks have been completed, the facility will be turned over to Enbridge Operations for service.

2.8.2 Valves

Valves[11] will be installed concurrently with the mainline pipe. Each valve site will consist of:

- one 8-foot by 14-foot building constructed 3 feet above grade on helical footings that do not require excavations or grout to install;
- one 36-inch mainline gate valve with electrical actuator and pressure transmitters on both upstream and downstream of the valve;
- ESB and associated electrical and controls equipment;
- service entrance and permanent access road; and
- security fencing and signage.

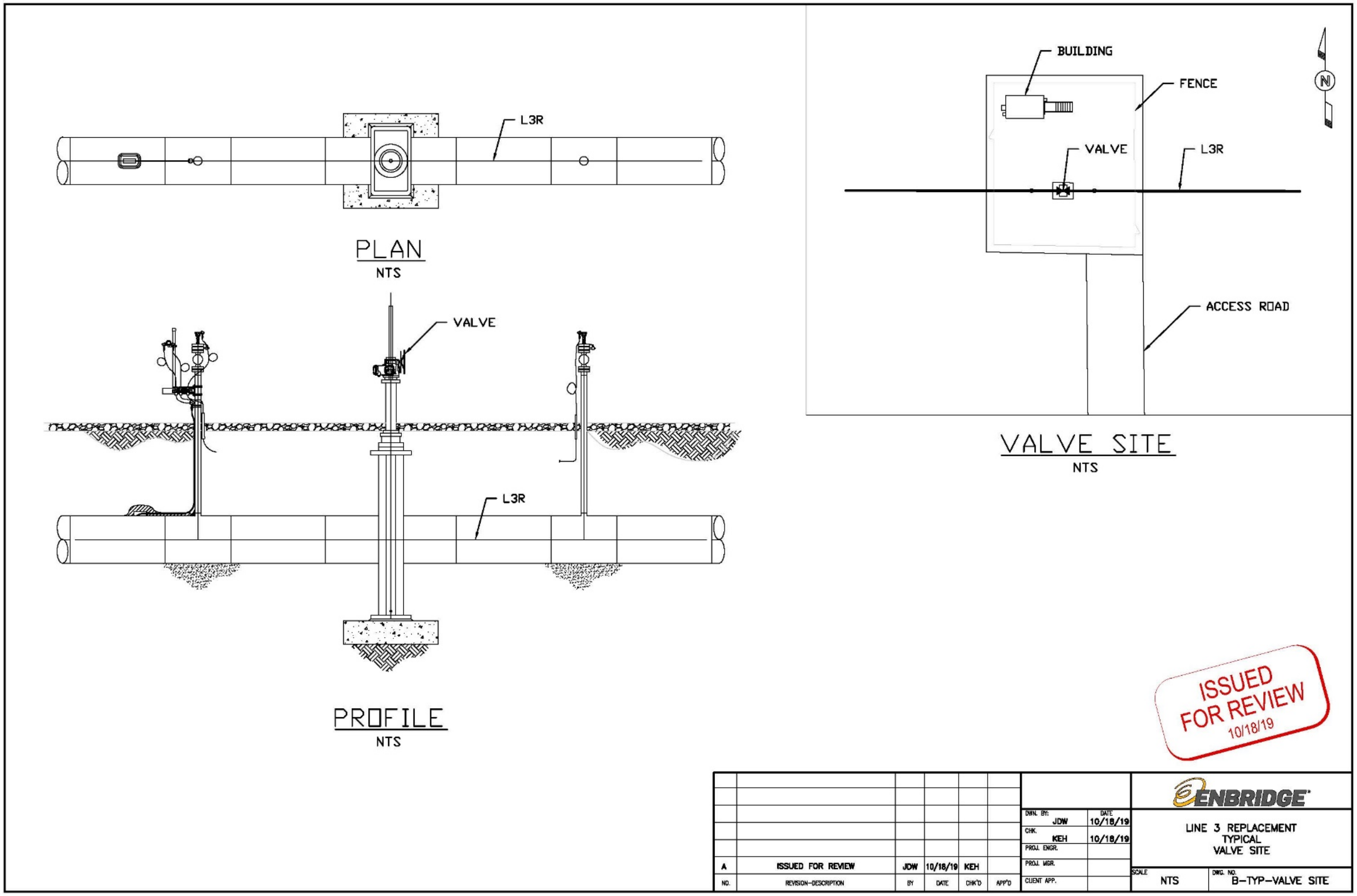
Refer to Figure 2.8-1 for a typical mainline valve layout.

Excavations at valve sites will be required to connect valve components to the belowground pipeline. The excavation dimensions are approximately 15 feet wide by 15 feet long by 15 feet deep, stepped back to 20 feet wide by 20 feet long at the ground surface. The mainline valve footing will be concrete 1.5 feet thick on a 1-foot thick gravel pad with the footing surface located just over 5 feet (5 feet 1 3/8 inches) below the installed centerline of the pipe. Total depth of the excavation is therefore anticipated to be approximately 13 to 15 feet below ground surface. Additional excavation will include cable routing trenches that will be approximately 24 inches deep and 12 inches wide.

After backfilling is complete, the valve will be filled with water and hydrostatically tested as part of the mainline spread hydrostatic test. The ESB will be placed and all associated electrical and controls equipment will be installed. Power and control cables will be routed, and additional pre-operational testing will begin once the system(s) are energized. Some sites will require the construction of a new electrical service.

[11] Valve: A valve is a piece of equipment used to control the flow of crude oil inside the pipeline. The valve acts as a gateway that can be opened and closed. A mainline valve describes an entire aboveground facility on the pipeline that is equipped with shutoff valves capable of stopping pipeline flow in the event of an emergency or for maintenance. A slide gate valve is a particular type of shutoff valve that operates by sliding a steel plate across the entire diameter of the pipe to seal off flow.

Figure 2.8-1: Line 3 Replacement Project Typical Mainline Valve Layout



Upon completion of all pre-operational testing, the valve will be ready for use. Equipment operation will be re-checked and final site civil work including fencing installation, permanent access road construction, and painting will be completed. The valve site within the fenced area will be graveled. After the final site civil work is complete, the site will be cleaned up and restored. After all final checks have been completed, the valve site will be turned over to Enbridge Operations for service.

2.8.3 Corrosion Protection

A cathodic protection[12] and impressed current mitigation systems will be constructed for L3R. Construction of this system includes both anode arrays installed in both conventional beds near the surface as well as in deep wells. Construction of cathodic protection systems includes excavation of soils at the site of installation. Methods utilized typically involve digging a trench for a cable using a mini-excavator, or ground trenching equipment such as a Ditch Witch. The technique used to install the cables associated with the cathodic protection system is similar to the methods used for installing fiber optic or telephone lines used for communications, which typically requires an approximately 30-foot-wide construction workspace.

Conventional surface bed type cathodic protection systems will be installed between 300 and 600 feet perpendicular to the pipeline. Anodes will be installed in either vertical or horizontal fashion and cables will be trenched to connect the anodes electrically to the protected metallic structures. Enbridge will also construct deep well cathodic protection systems where the anodes will be installed vertically in a well using construction methods similar to that of water wells. Deep well cathodic protection systems are normally installed closer to the pipeline, with the anodes themselves installed deeper (200 to 400 feet deep) than a conventional surface bed.

Both types of systems utilize native backfill for areas where trenching for the cable occurs. However, the area directly around the anodes will be backfilled with a more suitable backfill such as coke breeze.[13] Additionally, in a deep well cathodic protection system, a natural clay plug will be installed above the anodes to seal the well and prevent water from entering the hole.

2.8.4 Pipeline Maintenance Shops

Pipeline Maintenance ("PLM") shops are strategically located along the pipeline route and are staffed by operations personnel. The PLM shops are stocked with equipment needed during operations and maintenance of the pipeline.

Construction will proceed similar to the pump stations, beginning with initial survey, staking, and four-way sweeps. The site will then be cleared and stripped of topsoil to prepare for excavation activities. Excavations will be made for the building foundations, septic and well, power, and

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[12] Cathodic protection: Cathodic protection is a method for safeguarding the pipeline against corrosion. In a cathodic protection system, the metal to be protected (the pipeline) is connected to a metal that corrodes more easily (*anode array* or *anode groundbed*). The metal that corrodes more easily corrodes instead of the pipeline. Cathodic protection can be achieved by using reactive anode metals that are electrically connected to the pipeline (also known as a *galvanic anode* systems) or by using inert anode metals and impressing an electric current on the system (also known as an *impressed current* system). Enbridge's proposed cathodic protection system includes anode arrays installed in conventional beds near the ground surface as well as in deeper wells.

[13] Coke Breeze: Coke breeze is common carbonaceous backfill material used in cathodic protection. It provides a conductive path for current flow and ensures optimal effectiveness of the cathodic protection system.

communication. The excavation for the building will be approximately 125 feet by 75 feet by 6 feet deep to accommodate the foundations. Once foundations are poured, the excavation will be backfilled to rough grade and the building will be constructed.

After the building is constructed, the site will be stabilized, fenced, signed, and turned over to Enbridge Operations for their use.

3.0 PIPELINE CONSTRUCTION THROUGH WETLANDS

3.1 RIGHT-OF-WAY ACCESS

Enbridge will use the construction workspace and only approved roads to access wetland areas. Construction mats will be placed along the travel lane within delineated wetlands within the construction workspace and along access roads (refer to Section 2.1). Enbridge may use the following types of construction mats:

- Timber Mats: Timber mats are available in a variety of sizes and are constructed of hardwood materials that are bolted together. Timber mats are suitable for all vehicle types present on the construction workspace, have high durability under traffic, and are easily installed and removed using typical construction equipment. Timber mats are suitable for use in all soil conditions for all pipeline construction activities.

- Laminated Mats: Laminated mats are available in a variety of sizes and are constructed of laminated wood materials. Laminated mats are suitable for all vehicle types but are limited in their weight bearing capacity (e.g., 600 pounds per square inch). They have high durability and are easily installed and removed using typical construction equipment. Laminated mats are suitable for use in most soil conditions but should not be used in extremely saturated conditions. Laminated mats can be used on access roads, at drill pads, and for storage and staging of equipment.

3.2 CHOOSING A CONSTRUCTION METHOD

Table 3.2-1 summarizes the wetland crossing techniques Enbridge intends to utilize during construction, the site-specific conditions required for the method to be feasible, and the advantages and disadvantages associated with each technique. Enbridge will typically install the pipelines through wetlands with moderate- to high-bearing strength soils using standard upland crossing methods utilizing construction mats or equivalent to avoid rutting, minimizing disturbance to soils and vegetation, and to ensure safe and stable working surfaces for construction equipment and personnel.

Enbridge may install the pipeline through saturated wetlands with low bearing strength soils by using push-pull techniques, if practicable, or by using standard upland crossing techniques with frost/ice roads during frozen conditions (see Enbridge's Winter Construction Plan for additional information). In some cases, Enbridge may install sheet piling within the trench to stabilize the trench walls. Enbridge may install the pipelines through narrow wetlands or ditches adjacent to roads or railroads and sensitive wetlands or riparian areas adjacent to waterbody crossings using trenchless techniques such as a non-pressurized horizontal bore method or the HDD (pressurized) method.

TABLE 3.2-1
Pipeline Wetland Installation Methods

Method (Season)	Description [a]	Site Characteristics	Applicable Wetland Type(s)[b]	Advantages	Disadvantages
Trench: Modified Upland Construction Method (open cut) (Spring-Fall/non-frozen)	Conduct construction from construction mats or equivalent (refer to Figures 30 and 31 from the EPP). Multiple layers of construction mats may be required in saturated wetland conditions (refer to Figures 32 and 33 of the EPP). Vegetation is cut at ground surface to maintain the root structure and seed bank in the soil profile along the travel lane.	Suitable in wetlands with unsaturated mineral soils constructed during non-frozen conditions. Also, suitable in saturated wetlands (typically <12-inch inundation) with moderate to high bearing strength, shallow peat soils over mineral substrate, or forested peatlands where roots provide a relatively firm foundation for construction mats or equivalent.	The following wetland types are typically suitable, as along as the criteria described in the Site Characteristics column is also met: • Wet/Wet Mesic Prairie • Fresh (Wet) Meadow • Sedge Meadow • Alder Thicket • Shrub-Carr • Floodplain Forest • Hardwood Swamp • Coniferous Swamp	• Relatively quick construction/installation • No need for specialized equipment • Minimizes impacts on soils and vegetation by limiting disturbance to Trench-Line only and operating off of construction mats • Facilitates revegetation from seedbank and provides favorable plant growth conditions	• Clearing and brush removal required along travel lane in forested wetlands • Potential need for wider than normal trench and therefore additional construction workspace to avoid trench sidewall slump in loose, poorly graded sands • Multiple mat layers may be required in some wetlands; additional time for installation and removal of construction mats, • Potential compaction of the travel lane; additional restoration efforts of travel lane may be needed as compressed surface rebounds
Trench: Modified Upland Construction Method (open cut) (Winter/Freeze down)	Conduct construction from frost/ice roads, and/or construction mats, or equivalent (refer to Appendix A of the Winter Construction Plan). Topsoil segregation performed as practicable but modified dependent on depth of frost and thickness of topsoil. May use a ripper to break up frozen topsoil over the trench line only. Topsoil in spoil storage graded smooth to minimize mixing during backfilling. Vegetation is cut at ground surface to maintain the root structure and seed bank in soil profile along the travel lane.	Suitable for wetlands with unsaturated mineral soils or saturated wetlands with moderate to low strength peat over mineral soils during frozen conditions.	The following wetland types are typically suitable, as along as the criteria described in the Site Characteristics column is also met: Wet/Wet Mesic Prairie • Fresh (Wet) Meadow • Sedge Meadow • Alder Thicket • Shrub-Carr • Floodplain Forest • Hardwood Swamp • Coniferous Swamp	• Relatively quick construction/installation • Minimizes impacts on wetland soils and vegetation by limiting to disturbance to Trench-Line only and operating off of frost/ice roads or construction mats • Stable foundations for spoil storage and travel lane • Facilitates revegetation from seedbank and provides favorable plant growth conditions	• Potential need for wider than normal trench and therefore additional construction workspace to avoid trench sidewall slump in loose, poorly graded sands • Susceptible to winter thaw; limited to freezing conditions and contingency required for thawing conditions • Additional safety concerns associated with cold weather work • Potential for mixing of topsoil and subsoil during excavation • Backfilling of frozen spoil piles may result in subsidence of the trench during thaw introducing potential increase in backfill volume and/or additional restoration efforts • If post-thaw restoration is necessary, mats will typically be left in place increasing the period of disturbance • Frost/ice roads often require a water source

TABLE 3.2-1
Pipeline Wetland Installation Methods

Method (Season)	Description [a]	Site Characteristics	Applicable Wetland Type(s)[b]	Advantages	Disadvantages
Trench: Push-Pull Method: Backhoe (Spring-Fall)	Use a backhoe (or equivalent) to excavate the trench operating from construction mats "walked" down the trenchline (refer to Figures 35 and 36 of the EPP). Push-pull or float and sink the pre-assembled pipe then backfill. May or may not use a travel lane depending on conditions with backfilling occurring from the spoil storage side or the working side. When a travel lane is used, vegetation will be cut above the ground surface to maintain the root structure and seed bank in the soil profile. May or may not require trench dewatering.	Suitable in saturated wetlands (typically >12-inch inundation) with relatively competent peat soils, shallow peat over mineral soils, or forested peatlands with moderate bearing strength soils.	The following wetland types are typically suitable, as along as the criteria described in the Site Characteristics column is also met: • Shallow Marsh • Deep Marsh • Shallow, Open Water • Coniferous Bog • Open Bog	• Minimizes impacts on wetland soils and vegetation • No specialized equipment needed and allows for construction in unfrozen, saturated wetlands • Reduced heavy equipment traffic	• Topsoil segregation typically not practical; inability to maintain a cohesive spoil pile due to liquid nature of soil • Potential for stranding of the excavator if extremely loose, deep peat soils are encountered unexpectedly • Additional workspace required for pipe assembly or pipe may be fabricated off-site and brought in as a drag section • Due to lack of travel lane, additional adjacent workspace required for equipment turnarounds • May require spread move around

TABLE 3.2-1
Pipeline Wetland Installation Methods

Method (Season)	Description [a]	Site Characteristics	Applicable Wetland Type(s)[b]	Advantages	Disadvantages
Push-Pull Method: Swamphoe (Spring-Fall)	Excavate the trench using a backhoe (or equivalent) mounted on tracked pontoons operating along the trenchline (refer to Figures 35 and 36 of the EPP). Push-pull or float and sink the pre-assembled pipe then backfill. May or may not use a travel lane depending on conditions with backfilling occurring from the spoil storage side or the working side. When a travel lane is used, vegetation will be cut above the ground surface to maintain the root structure and seed bank in the soil profile. May or may not require trench dewatering.	Suitable in saturated (typically > 12-inch inundation) emergent and scrub-shrub wetlands with loose, deep peat soils or floating mat peat, low-bearing strength soils.	The following wetland types are typically suitable, as along as the criteria described in the Site Characteristics column is also met: • Shallow Marsh • Deep Marsh • Shallow, Open Water • Coniferous Bog • Open Bog	• Allows for construction in saturated wetlands during unfrozen conditions • Reduced heavy equipment traffic	• Specialized equipment (i.e., swamphoe) required • Topsoil segregation typically not practical; inability to maintain a cohesive spoil pile due to liquid nature of soil • Potential for spoil settlement preventing complete replacement of backfill and potentially resulting in open water along the trenchline • Additional adjacent workspace required for pipe assembly or pipe may be fabricated off-site and brought in as a drag section • Additional adjacent workspace may be required for equipment turnarounds • Slower than normal construction progress in the wetland due to equipment speed • May require spread move around
Trenchless: Bore (Non-Pressurized)	Bore under feature from bore pit on one side to bore pit on the other side with or without casing (see Figures 40 and 41 of the EPP). Non-pressurized water or bentonite may be introduced if soil conditions dictate; any release will travel back along the path of the pipe and into the bore pit.	Suitable for narrow highways, roads, railroads, and watercourses. Not suitable where there are high water tables, loose sand/gravel substrates, or adjacent steep slopes.	The following wetland types are typically suitable, as along as the criteria described in the Site Characteristics column is also met: • Wet/Wet Mesic Prairie • Fresh (Wet) Meadow • Sedge Meadow • Alder Thicket • Shrub-Carr • Floodplain Forest • Hardwood Swamp • Coniferous Swamp	• Avoids surface ground disturbance in the wetland or ditch adjacent to the feature crossed • No sediment release • No potential for inadvertent release outside of the bore pits	• Requires additional workspace for bore pits, spoil piles, and sump(s) • Large excavations required on both sides of the crossing • Deep bore pits may require sump pump or well point dewatering system and/or sheet-piling • Slower than trench crossing techniques

TABLE 3.2-1
Pipeline Wetland Installation Methods

Method (Season)	Description [a]	Site Characteristics	Applicable Wetland Type(s)[b]	Advantages	Disadvantages
Trenchless: HDD (Pressurized)	Place a rig on one side of the wetland and drill a small-diameter pilot-hole under the feature along a prescribed profile (see Figure 26 of the EPP). Upon completion of the pilot-hole, use a combination of cutting and reaming tools to accommodate the desired pipeline diameter. Drilling mud is necessary to remove cuttings and maintain the integrity of the hole. Once the hole is reamed to the appropriate size, the welded pipe section is then pulled back through the hole.	Suitable to cross sensitive wetland areas and riparian wetlands adjacent to waterbody crossings depending on site-specific topography and the local geologic substrate. Feasibility limitations in high flow artesian conditions, areas of glacial till or outwash interspersed with boulder and cobbles, fractured bedrock, or non-cohesive coarse sands and gravels. Geotechnical borings and hydrofracture risk analysis are performed to determine HDD feasibility and potential for inadvertent returns.	All wetland types that meet the criteria described in the Site Characteristics column.	• No sediment release unless an inadvertent return occurs • Avoids surface ground disturbance in riparian wetlands adjacent to sensitive or large waterbodies • Limits vegetation disturbance to within the permanently maintained easement • Significantly reduces clean-up and restoration between entry and exit points	• Potential for inadvertent release of drilling fluids (refer to Section 11.0 of the EPP) • Requires ATWS on both sides of the crossings to stage construction, fabricate the pipeline, and store materials • Tree and brush clearing is necessary for operations • Requires obtaining water to formulate the drilling fluid, buoyancy control, as well as hydrostatic testing • Feasibility and success depends on substrate • Requires specialized equipment (limited availability) • Pull string area along the alignment for the same length of the crossing to allow continuous pullback • Requires a straight alignment for the length of the HDD • May require several weeks to complete the HDD

Notes:

[a] For all methods except HDD, vegetation and trees within wetlands will be cut off at ground level along the entire workspace, leaving existing root systems intact; clearing debris will be removed from the wetland for disposal. For the HDD method, vegetation and trees within the wetland will be removed along 30 feet of the permanent right-of-way to allow for aerial inspection of the pipe during operations.

[b] Typical wetland types (Eggers and Reed, 2014) suitable for the referenced crossing method; the construction technique selected will depend on the site-specific conditions described in the site characteristics column.

Source: Canadian Energy Pipeline Association, Canadian Association of Petroleum Producers, Canadian Gas Association, 2018.

3.3 TRENCH: MODIFIED UPLAND CONSTRUCTION METHOD

The modified upland construction method (also referred to as open cut or the standard wetland construction method) differs from standard upland construction method to minimize disturbance to the wetland features. These main differences, described in more detail in Section 3.0 of the EPP, include:

1) Reducing the construction workspace compared to uplands (from 120 to 95 feet) (refer to Table 2.3-1, and Figure 5 of the EPP);

2) Performing workspace clearing using low ground-pressure equipment or operating off construction mats or ice/frost roads to limit disturbance to the wetland (Section 3.2 of the EPP and the Winter Construction Plan);

3) Clearing vegetation in wetlands to the ground level, but leaving intact root wads except over the trench line (Section 3.2 of the EPP);

4) Installing and maintaining erosion and sediment control BMPs to prevent sediment flow from uplands into wetlands (Section 3.4 of the EPP);

5) Trench-Line-Only topsoil segregation, involving stripping and segregating up to 1 foot of the organic layer/topsoil from the trench line and storing the material separate from trench spoil to preserve the native seed stock from wetlands without standing water. In standing water wetlands, the Contractor will attempt to segregate as much of the soil surface as possible based on site and saturation conditions (Section 3.6.1 of the EPP); and

6) Implementing restoration techniques suitable to wetland conditions, as described in Section 7.7 of the EPP.

As described in Table 3.2-1, this technique is suitable in wetlands with unsaturated mineral soils constructed during unfrozen conditions or can be used in saturated wetlands (typically <12-inch inundation) with moderate to high bearing strength, shallow peat soils over mineral substrate, or forested peatlands where roots provide a relatively firm foundation for construction mats or equivalent. It can also be used in wetlands with unsaturated mineral soils or saturated wetlands with moderate to low strength peat over mineral soils during frozen conditions.

Because this method does not require any specialized equipment, it proceeds more quickly than other wetland construction methods, which further minimizes disturbance to wetland soils and vegetation. By limiting the removal of root wads to the trench line, the integrity of adjacent soils is maintained, and the seed bed remains undisturbed. The use of low-ground pressure equipment, construction mats, and/or ice/frost roads also further reduces soil compaction issues.

Mat travel lanes are typically a single layer (Figures 30 and 31 of the EPP); however, there may be cases in saturated areas where more than one layer of mats must be placed to provide a stable working surface (Figures 32 and 33 of the EPP). Enbridge will remove the mats during final cleanup activities. If there are multiple layers of mats, Enbridge will probe the soil after mats have been removed to verify that no additional mats remain.

Sheet-piling may be used at wetland crossing locations in order to stabilize the trench, or to assist with water management. At potential sheet-piling locations, a test hole may be dug in proximity to the crossing location to assess soil stability and other conditions (e.g., bedrock, cobbles, boulders), and to determine if the crossing will be conducive to the installation of sheet piling. Based on these results, a decision will be made between Enbridge Construction and the Environmental Compliance team.

Once the pipe has been installed, trench breakers will be installed as appropriate (see Section 1.13 of the EPP). As described in Section 3.9 of the EPP, Enbridge will backfill the trench in wetlands to an elevation similar to the adjacent areas outside the ditch line and will add a slight crown of approximately 3 to 6 inches (depending on soil type) over the backfilled trench to allow for subsidence. Periodic breaks in the crown will be implemented to allow for normal hydrologic flow across the backfilled trench. Crowning will not extend beyond the previously excavated trench limits. Restoration will proceed as described in Section 7.0 of the EPP. Enbridge will monitor wetlands after construction as described in Enbridge's Post-Construction Monitoring Plan.

3.4 TRENCH: PUSH-PULL METHOD

Push-pull technique can only be utilized in non-frozen conditions where there is sufficient inundation to push-pull or float the pipe. If these conditions do not exist at the time of the crossing, then the modified upland construction technique will be utilized.

The push-pull method is utilized in saturated wetlands (greater than 12-inch inundation) with relatively competent peat soils, shallow peat over mineral soils, floating mat peat, forested peatlands with moderate bearing soils strengths, emergent and scrub-shrub wetlands with loose, deep peat soils, or floating mat peat, low-bearing strength soils (refer to Section 3.7.1 and Figures 35 and 36 of the EPP). This technique can also be used to cross waterbodies located within these wetland complexes. The trench is excavated using a backhoe (or equivalent) operating either from construction mats in more stable soils, or from an excavator mounted on tracked pontoons along the trenchline. As discussed in Section 3.3, multiple layers of construction mats may be installed to provide a stable surface in these saturated wetland areas. Sheet-piling may also be installed to assist with trench stability and groundwater management.

The pre-assembled pipe is then pushed-pulled or floated into position across the wetland. Usually this fabrication requires use of ATWS adjacent to the construction workspace. Once the pipeline is in position, floats, if used, will be removed and the pipe will sink; buoyancy control methods may be used (refer to Section 3.7.3 and Figures 37 and 38 of the EPP). Trench breakers will be used as appropriate. The trench will then be backfilled using a backhoe or equivalent working from construction mats or by low ground pressure equipment, and the wetland will be restored as near as practicable to pre-construction conditions.

Enbridge will monitor wetlands after construction as described in Enbridge's Post-Construction Monitoring Plan.

3.5 TRENCHLESS: BORE (NON-PRESSURIZED)

The conventional non-pressurized bore method is typically used to cross features such as road or railroad features; however, wetlands and waterbodies adjacent to these features may also be crossed in conjunction with the bore crossing (refer to Section 4.0 of the EPP).

To prepare for a bore, a bore pit is excavated on both sides of the feature being crossed of sufficient size to house the boring machine and tracks or cradle. The excavations have to be deep enough to ensure the equipment is laid on the correct grade and in line in order to ensure that the bore is drilled correctly. Excavations vary in length depending on the depth of the feature being crossed, length of the bore, and soil conditions, but average around 15 feet deep and 15 feet wide.

An auger bore uses a revolving cutting head that is located at the leading end of an auger assembly to excavate the soil. Common practice is to use a sacrificial casing pipe the same diameter and length as the carrier pipe at the crossing. The spoil is then transported back to the shaft area by the rotation of the helical auger within the sacrificial casing pipe.

A pneumatic hammer (also called a thumper) may be used in place of the auger system and may be used on moderate length bores (under 200 feet) in good to fair soil conditions. Thumping uses an air compressor and hammering device attached to the end of the sacrificial casing pipe. The open-ended casing pipe is then driven through the crossing, filling itself with spoil material until it reaches the exit point. Proper elevation and direction are monitored by line of sight, water level, electronic smart level and/or a transit.

Water and bentonites can be introduced if soil conditions dictate in order to lubricate the sacrificial casing pipe, allowing it to move through the ground more freely; approved chemical additives may also be introduced. Pressurized water or drilling mud is never used to hold the hole open, as it will be during an HDD (see Section 3.6); therefore, there is no risk for an inadvertent return of drilling mud at these locations. If drilling mud is needed at these locations, any release will travel back along the path of the pipe and into the bore pit. Once the sacrificial casing pipe has ran the length of the bore, the carrier pipe is temporarily attached and pulled through.

Once the bore is completed, the bore pits will be backfilled and any wetland impacts will be restored as described in Section 7.0 of the EPP after the tie-in has been completed. Enbridge will monitor these wetland areas after construction as discussed in the Post-Construction Monitoring Plan.

3.6 TRENCHLESS: HORIZONTAL DIRECTIONAL DRILL METHOD (PRESSURIZED)

The HDD method is a trenchless crossing technique that involves drilling a hole underneath sensitive resources and installing a pre-fabricated pipe segment through the hole. No direct excavation to the banks or beds of the feature being crossed is involved. Installation of a pipeline by HDD is accomplished in three stages as illustrated in Figure 3.6-1. The first stage consists of directionally drilling a small-diameter pilot hole at an entry point along a designed directional path to an exit point. The second stage involves enlarging this pilot hole to a diameter suitable for installation of the pipeline. The third stage consists of pulling the prefabricated pipe section from the exit point back into the enlarged hole to the entry point. A guidance system is used to accurately track the location of the drill cutting head.

The HDD method utilizes drilling fluid (also referred to as drilling mud) that is pumped under pressure through the inside of the drill pipe to lubricate the drill bit and convey drill cuttings back to the drill entry point, where it is reconditioned and re-used in a closed, circulating process (refer to Section 3.6.1 for additional discussion of drilling fluids).

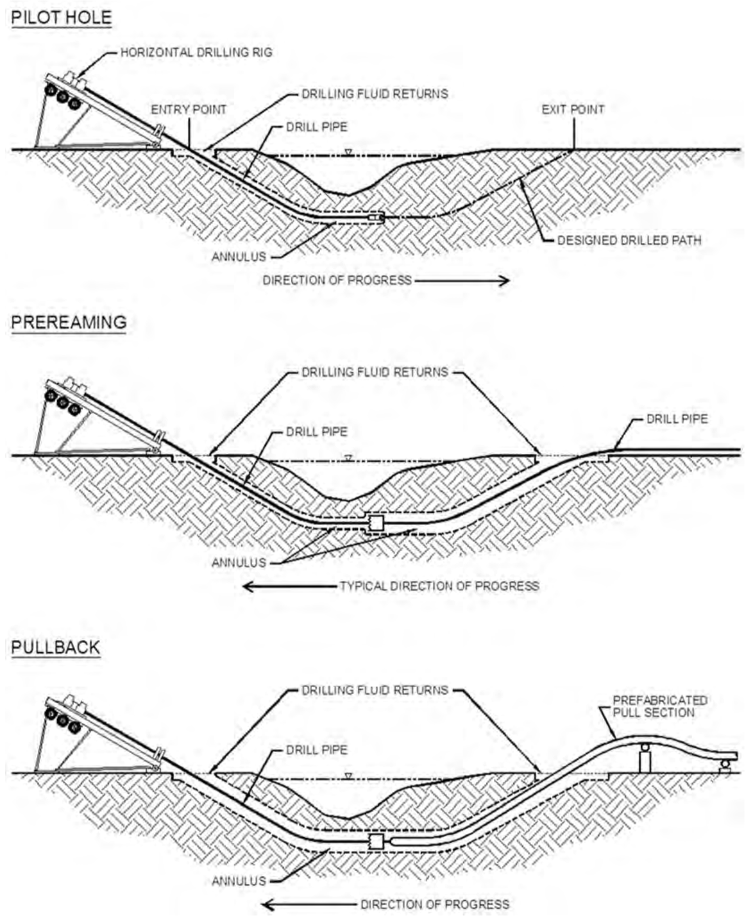


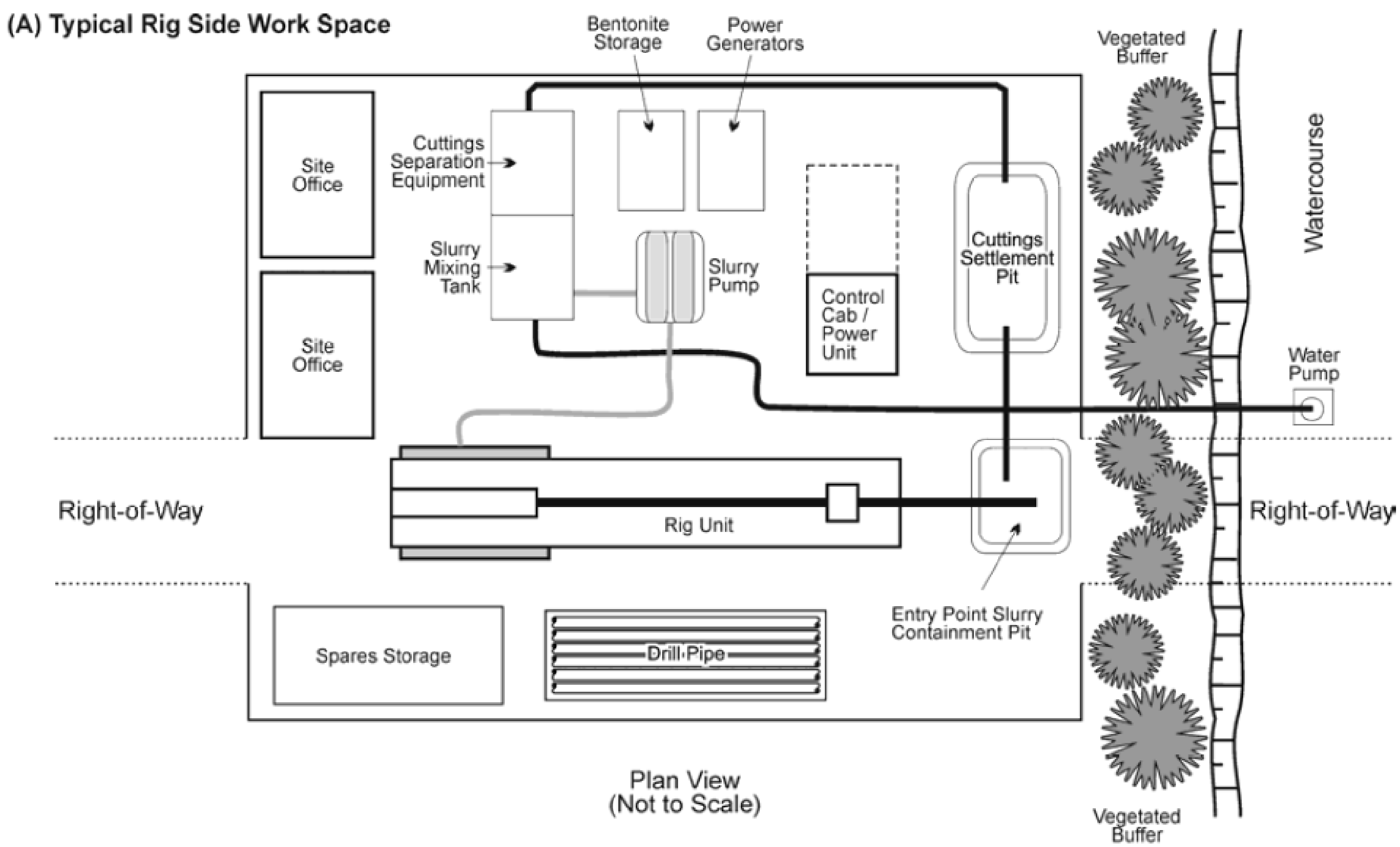
Figure 3.6-1: General Stages of an HDD

The entry pit is where the main drilling activities occur and where drill rig and drilling mud system is staged. Refer to Figure 3.6-2 for a typical configuration of an HDD entry workspace (rig side).

The exit point is where pipe installation is accomplished by attaching a pipeline pull section behind a reaming assembly at the exit point, then pulling the reaming assembly and pull section back to the drilling rig. Refer to Figure 3.6-3 for a typical configuration of an HDD exit workspace (pullback).

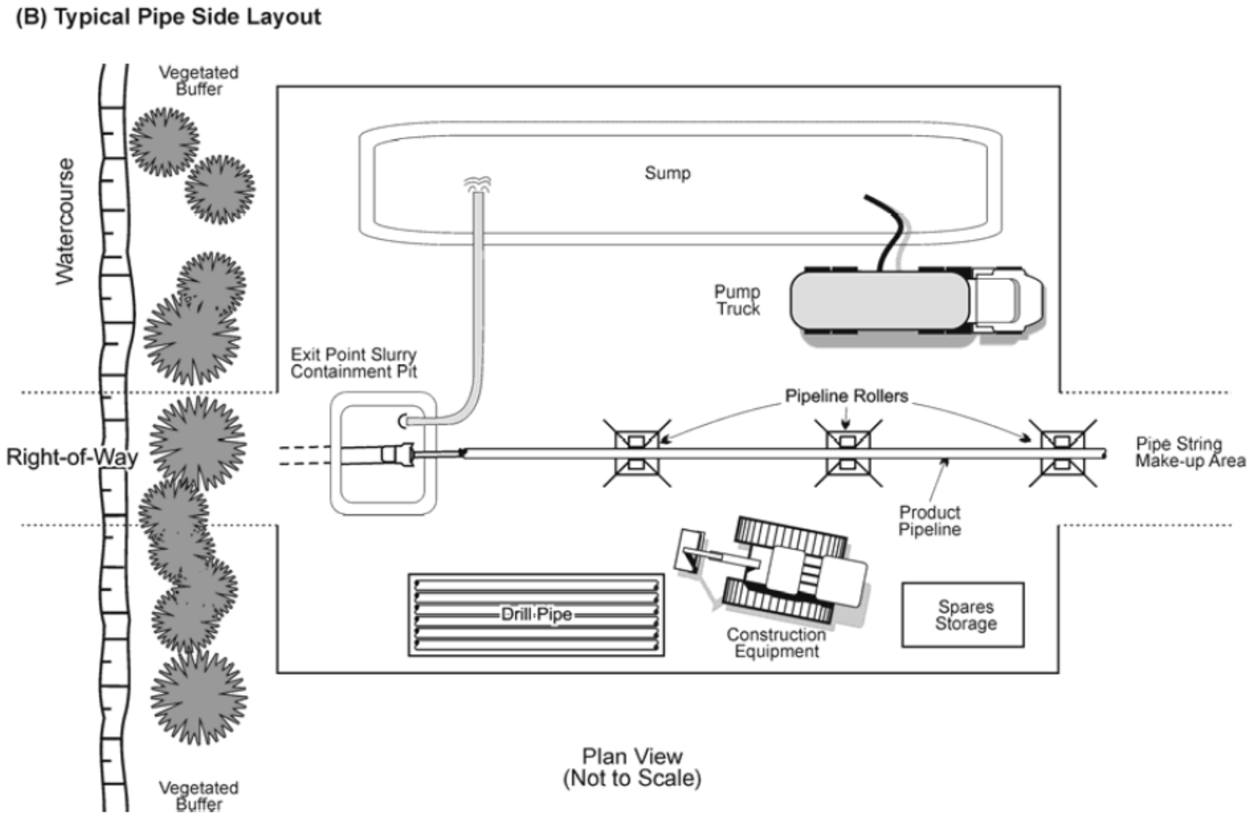
Should the entry or exit points be located within wetlands, Enbridge will mat the entire workspace within wetlands for the staging of equipment and materials. Once the drill and tie-in is completed, the construction mats will be removed, the entry and exit pits will be backfilled and the wetland will be restored as described in Section 7.0 of the EPP. Enbridge will monitor these wetland areas after construction as discussed in the Post-Construction Monitoring Plan.

Figure 3.6-2: HDD Typical Workspace Configuration – Entry/Rig Side



Source: Canadian Association of Petroleum Producers, 2005. Pipeline Associated Watercourse Crossings, 3rd Edition.

Figure 3.6-3: HDD Typical Workspace Configuration – Exit/Pullback



Source: Canadian Association of Petroleum Producers, 2005. Pipeline Associated Watercourse Crossings, 3rd Edition.

Enbridge does not present an alternate crossing method for proposed HDD crossings. If the primary drill path fails during the crossing, Enbridge will consider an alternate drill path before abandoning use of the HDD method for an alternative, non-HDD crossing method. If necessary, alternate drill paths will be selected by analyzing geotechnical studies and after review of site-specific conditions. Enbridge will consult with the appropriate permitting agencies as needed for approval of new drill paths and workspace.

3.6.1 Technical Feasibility Considerations

The design and feasibility of an HDD is determined by factors including the length, depth, and curvature (i.e., profile) of the proposed drill; surrounding topography; pipeline diameter; availability and orientation of land on which to assemble the HDD pipeline segment; land use constraints; and geotechnical suitability of the subsurface environment. Enbridge conducts geotechnical surveys at each the proposed HDD site to determine the subsurface conditions and identify potential obstacles. This information, along with the HDD design and layout and any other available data, is used to model the capacity of the soil to withstand the pressures of the drill and avoid widening or creating a fracture (hydraulic fracturing) through which drilling mud fluid will migrate. This information is consolidated in a Hydrofracture Report for each site.

3.6.1.1 Composition of Drilling Fluid

Drilling fluid is primarily composed of water and a viscosifier,[14] typically naturally occurring clay in the form of bentonite mixed with small amounts of extending polymers to increase its yield (high yield bentonite); meaning that more drilling fluid can be produced with less bentonite clay.

Various additives may also be used to enhance the performance of the bentonite-based drilling mud. Chemical drilling additives help control sand content and flow, water hardness, keep the bore hole open and stable, prevent groundwater inundation and allow the bentonite to yield properly. Small amounts of drilling mud additives are added to the bentonite and water slurry. Enbridge will only use those drilling mud additives approved by the appropriate agencies.

3.6.1.2 Functions of Drilling Fluid

The principal functions of drilling fluid in HDD pipeline installation include:

- Transportation of Spoil – Drilled spoil, consisting of excavated soil or rock cuttings, is suspended in the fluid and carried to the surface by the fluid stream flowing in the annulus between the wall of the hole and the pipe.

- Cleaning and Cooling of Cutters – High velocity fluid streams directed at the cutters remove drilled spoil build-up on bit or reamer cutters. The fluid also cools the cutters.

- Reduction of Friction – Friction between the pipe and the wall of the hole is reduced by the lubricating properties of the drilling fluid.

- Hole Stabilization – The drilling fluid stabilizes the drilled or reamed hole. This is critical in HDD pipeline installation as holes are often in loose soil formations and are uncased. Stabilization is accomplished by the drilling fluid building up a wall cake and exerting a

[14] A viscosifier is a thickening agent.

positive pressure on the hole wall. Ideally, the wall cake will seal pores and produce a bridging mechanism to hold soil particles in place.

- Transmission of Hydraulic Power – Power required to turn a bit and mechanically drill a hole is transmitted to a downhole motor by the drilling fluid.
- Hydraulic Excavation – Soil is excavated by erosion from high velocity fluid streams directed from jet nozzles on bits or reaming tools.
- Soil Modification – Mixing of the drilling fluid with the soil along the drilled path facilitates installation of a pipeline by reducing the shear strength of the soil to a near fluid condition. The resulting soil mixture can then be displaced as a pipeline is pulled into it.

3.6.1.3 Inadvertent Returns

HDD involves the subsurface discharge of drilling fluids. Because the drilling fluid is pressurized, it can be lost beyond the immediate vicinity of the drill hole and will flow in the path of least resistance, resulting in lost drilling fluids in the subsurface environment or inadvertent returns to the ground surface. This loss of drilling fluid is also referred to as an inadvertent release.

Drilling parameters may be adjusted to maximize drilling fluid circulation and minimize the risk of inadvertent returns. However, the possibility of lost circulation and inadvertent returns cannot be eliminated. Enbridge has developed contingency plans addressing possible remedial action for review by the appropriate agencies.

Section 11.0 of the EPP describe the procedures that will be implemented during the execution of an HDD to monitor, contain, and recover a potential inadvertent release.

4.0 PIPELINE CONSTRUCTION THROUGH WATERBODIES

Table 4.0-1 describes the waterbody crossing techniques Enbridge intends to utilize during construction, the site-specific conditions required for the method to be feasible, and the advantages and disadvantages associated with each technique. Enbridge will typically use the open cut technique through dry or frozen waterbodies, or where flow isolation is not feasible. Dry crossing techniques are suitable for low flow streams with defined banks where isolation is feasible. Similar to wetland crossings, sheet-piling may be used at waterbody crossing locations in order to stabilize the trench, stabilize the stream banks, or to assist with water management (see Section 3.3). Enbridge may also install the pipelines through narrow waterbodies or ditches adjacent to roads or railroads and sensitive waterbodies or riparian areas adjacent to waterbody crossings using trenchless techniques such as a non-pressurized bore method or the HDD (pressurized) method.

Enbridge's construction contractor(s) and Environmental Inspectors ("EIs") will monitor upcoming weather forecasts to determine if significant rainfall is anticipated during construction.

Refer to Sections 2.1 through 2.4 and 2.6 of the EPP for details regarding construction procedures and mitigation measures for each crossing method. The EPP also details procedures for temporary and permanent stabilization. When construction is complete at each waterbody crossing, revegetation and monitoring will occur as described in Section 7.0 of the EPP. After construction, Enbridge will monitor waterbodies crossed by the construction workspace as discussed in Enbridge's Post-Construction Monitoring Plan.

TABLE 4.0-1
Pipeline Waterbody Installation Methods

Method	Description	Applicability	Advantages	Disadvantages
Trench: Open Cut (Non-Isolated)	Open-cut crossing technique that involves trenching through the dry or frozen waterbody with no perceptible flow, or while water continues to flow across the in-stream work area (refer to Figure 22 of the EPP).	Suitable for ephemeral and intermittent waterbodies where there is no perceptible flow (dry or frozen), such as agricultural ditches. This method may also be used in waterbodies that are part of a wetland complex where isolating the flow is not feasible. In Minnesota, these are primarily waterbodies located within large, saturated wetlands, and waterbodies impacted by beaver dams.	• Rapid construction/installation • No need for specialized equipment • Compatible with granular substrates and some rock • Minimizes period of in-stream activity • Maintains streamflow • No sediment release or relatively short duration of sediment release (<24 hours)	• May require implementation of erosion and sediment control BMPs to mitigate sediment release during excavation and backfilling • May interrupt streamflow
Trench: Dry Crossing (Isolated): Dam and Pump	Create a dry work area by damming the flow up- and downstream of the crossing and pumping water around. Dam materials may include but are not limited to: sand bags, aqua dams, sheet piling, or street plates (refer to Figure 23 of the EPP).	Suitable for streams with low flow and defined banks where fish passage is not of concern. Works best in non-permeable substrate and preferred for crossing meandering channels.	• Maintains streamflow • Minimal release and transport of sediment downstream that is not likely to result in effects on aquatic habitat • Relatively dry working conditions • May reduce trench sloughing and trench width	• Minor sediment release during dam construction, dam removal and as water flushes over area of construction • Fish salvage may be required from dried up reach within the workspace • Short-term barrier to fish movement • Specialized equipment and materials required • Seepage may occur in coarse, permeable substrate
Trench: Dry Crossing (Isolated): Flume	Create a dry work area by damming the flow up- and downstream of the crossing and installing flume to convey water. Dam materials may include but are not limited to: sand bags, aqua dams, sheet piling, or street plates (refer to Figure 24 from the EPP).	Suitable for crossing relatively narrow streams that have straight channels and are relatively free of large rocks and bedrock at the point of crossing where fish passage is of concern. The waterbody should have defined banks and channel with solid, fine-textured substrate.	• Maintains streamflow • May allow fish passage • Minimal release and transport of sediment downstream that is not likely to result in negative effects on aquatic habitat • Relatively dry or no flow working conditions • May reduce trench sloughing and trench width	• Minor sediment release during dam construction, removal and as water flushes over area of construction • Fish salvage may be required from dried up reach within the construction workspace • Short-term barrier fish passage if water velocity in culvert is too high • Difficult to trench and lay pipe, especially large diameter pipe, under flume pipe • Work area may not stay dry in coarse, permeable substrate • Seepage may occur in coarse, permeable substrate

TABLE 4.0-1
Pipeline Waterbody Installation Methods

Method	Description	Applicability	Advantages	Disadvantages
Trenchless: Bore (Non-Pressurized)	Bore under watercourse from bore pit on one side to bore pit on the other side with or without casing (see Figures 40 and 41 of the EPP). Non-pressurized water or bentonite may be introduced if soil conditions dictate; any release will travel back along the path of the pipe and into the bore pit.	Suitable for fine-textured impermeable soils and deep water table. Used most commonly for highway, road, and railroad crossings and can include adjacent ditches. Requires a slightly incised watercourse with approach slopes that are absent or slight.	• Avoids surface ground disturbance in the waterbody or ditch adjacent to the feature crossed. • No sediment release • No potential for inadvertent release outside of the bore pits • No disturbance of streambed or banks • Maintains normal streamflow • Maintains fish passage	• Requires additional workspace for bore pits, spoil piles, and sump(s) • Large excavations required both sides of the crossing • Deep bore pits may require sump pump or well point dewatering system and/or sheet-piling • Slower than trench crossing techniques
Trenchless: HDD (Pressurized)	Place a rig on one side of the waterbody and drill a small-diameter pilot hole under the feature along a prescribed profile (see Figure 26 of the EPP). Upon completion of the pilot hole, the use a combination of cutting and reaming tools to accommodate the desired pipeline diameter. Drilling mud is necessary to remove cuttings and maintain the integrity of the hole. Once the hole is reamed to the appropriate size, the welded pipe section is then pulsed back through the hole.	Suitable to cross sensitive or particularly deep, wide, or high-flow waterbodies depending on site-specific topography and the local geologic substrate. Feasibility limitations in areas of glacial till or outwash interspersed with boulder and cobbles, fractured bedrock, or non-cohesive coarse sands and gravels. Geotechnical borings and hydrofracture risk analysis are performed to determine HDD feasibility and potential for inadvertent returns.	• No sediment release unless an inadvertent return occurs • Avoids surface disturbance of the riparian area and stream bed and banks • Limits vegetation disturbance to within the permanently maintained easement • Maintains normal streamflow • Maintains fish passage • May enable construction during restricted activity windows for sensitive fisheries with agency approval • Significantly reduces clean-up and restoration between entry and exit points	• Potential for inadvertent release of drilling fluids (refer to Section 11.0 of the EPP) • Requires ATWS on both sides of the crossings to stage construction, fabricate the pipeline, and store materials • Tree and brush clearing is necessary for operations • Requires obtaining water to formulate the drilling fluid, buoyancy control, as well as hydrostatic testing • Feasibility and success depends on substrate • Requires specialized equipment (limited availability) • Pull string area along the alignment for the same length of the crossing to allow continuous pullback • Requires a straight alignment for the length of the HDD • May require several weeks to complete the HDD

Sources:
Canadian Association of Petroleum Producers, Canadian Energy Pipeline Association, and Canadian Gas Association, 2005.
Canadian Energy Pipeline Association, Canadian Association of Petroleum Producers, Canadian Gas Association, 2018.

4.1 TRENCH: OPEN CUT (NON-ISOLATED) METHOD

The open cut (non-isolated) crossing method involves digging a trench through the waterbody, placing the pipe in the trench, backfilling the trench, and restoring the contours of the stream bed and banks to pre-construction conditions. Enbridge will further reduce the workspace by 25 feet starting 20 feet from the OHWM at waterbody crossings (95-foot-wide corridor) (refer to Figure 22 of the EPP). In order to excavate a trench and install the pipe across the waterbody, vegetation will need to be cleared from the top of the stream bank to the water's edge within the 95-foot-wide construction workspace. Following restoration, Enbridge will maintain a 10-foot-wide corridor centered on the pipeline free of woody shrubs, and a 30-foot-wide corridor free of trees within the riparian area of the waterbody crossing to maintain the integrity of the pipeline (see Figure 4.1-1).

Open cut crossings are typically completed within 24 to 48 hours depending on the size of the watercourse as described in Section 2.1 of the EPP. Open cut crossing methods typically involve trenching through the waterbody while it is dry or frozen to the bottom (no perceptible flow) and direct excavation of the trench through the banks and bed of the watercourse can proceed similar to upland construction techniques. Construction while the waterbody is dry or frozen avoids the potential for sediment release during in-channel work.

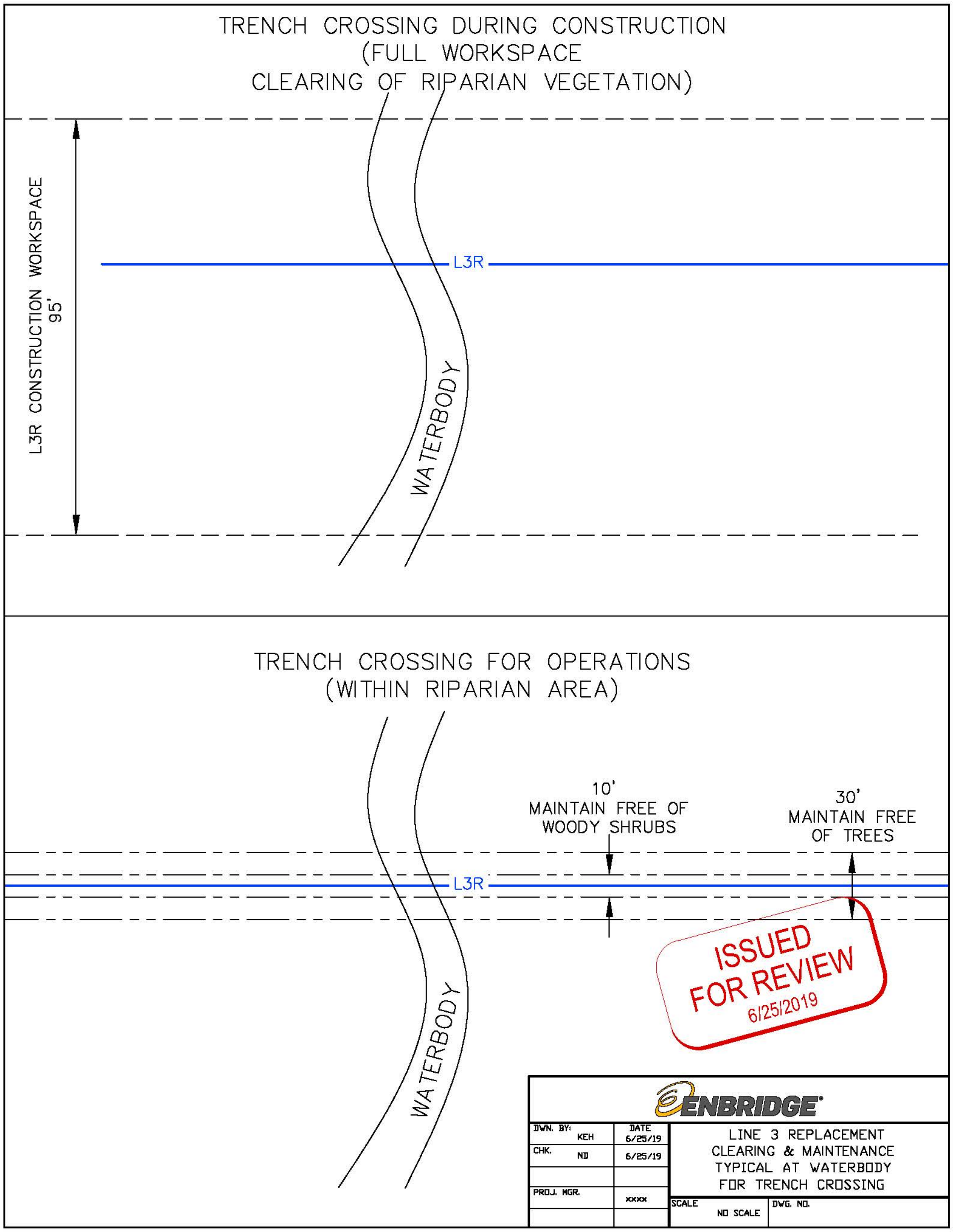
Crossing of waterbodies when they are dry or frozen and not flowing may proceed using the open cut trench crossing technique in accordance with the EPP, provided that the EI verifies that water is unlikely to flow between initial disturbance and final stabilization of the feature. This applies to features that an agency has identified as waterbodies, but that field delineations determined were wetlands based on conditions at the time of survey. If unanticipated flow conditions develop during construction of a given waterbody, Enbridge's EIs will be notified immediately to determine the extent of the flow and will install additional erosion and sediment control BMPs as necessary. If flows are significant, and sedimentation is likely to occur, work will be stopped, or Enbridge will switch to a dry crossing technique with agency approval.

There are additional locations where, due to surrounding saturated wetlands, it is not feasible to isolate the waterbody flow and an open cut trench crossing may be proposed. The push-pull method can sometimes be implemented at these locations (refer to Section 3.4). However, if there is no manner to isolate the feature and/or manage water, a standard open cut through the flowing waterbody may be the only feasible method for pipe installation.

4.2 TRENCH: DRY (ISOLATED) METHODS

Dry crossing (isolated) methods also involve digging a trench through the waterbody, placing the pipe in the trench, backfilling the trench, and restoring the contours of the stream bed and banks to pre-construction conditions, but the stream is diverted around the work area. Dry (isolated) crossings use either the dam and pump or flume technique. Both methods dam the stream both upstream and downstream of the crossing. The water is then routed around the dry work area either by pumping water through hoses or through a flume pipe. As described in Section 2.5.2 of the EPP, dams may consist of sand bags, inflatable dams, aqua-dams, sheet piling, and/or steel plates. The trench is then excavated in the dry work area to install the pipe. The construction work area will also be dewatered and discharged into well-vegetated area on an adjacent stream bank as described in Section 5.1 of the EPP. Dry crossings are typically completed within 24 to 48 hours depending on the size of the watercourse as described in Section 2.1 of the EPP.

Figure 4.1-1: Vegetation Clearing during Construction and Operations at Trench Crossings of Waterbodies



As with the open cut crossing method, Enbridge will further reduce the workspace by 25 feet starting 20 feet from the OHWM at waterbody crossings (95-foot-wide corridor) (refer to Section 2.2, and Figures 23 and 24 of the EPP). In order to excavate a trench and install the pipe across the waterbody, vegetation will need to be cleared from the top of the stream bank to the water's edge within the 95-foot-wide construction workspace. Following restoration, Enbridge will maintain a 10-foot-wide corridor centered on the pipeline free of woody shrubs, and a 30-foot-wide corridor free of trees within the riparian area of the waterbody crossing to maintain the integrity of the pipeline (see Figure 4.1-1).

In locations where the stream banks are stable, but conditions are too saturated to effectively dewater from the construction workspace, Enbridge will conduct a modified dam and pump method. The only difference from the standard dam and pump method and this modified technique is that Enbridge will not dewater the trench and will utilize buoyancy control methods (see Section 3.7.3 of the EPP) as appropriate to sink the pipe to the bottom of the trench.

The dry crossing technique can also be implemented in frozen conditions if there is perceptible flow. Winter construction procedures for dry crossing techniques are described in Enbridge's Winter Construction Plan.

Enbridge will consider switching to an open cut crossing technique at a waterbody previously identified as a dry crossing if:

- the waterbody is dry or frozen at the time of crossing as described in Section 4.1; or
- when there are water management concerns based on field conditions at the time of the crossing, such as downstream obstructions that cause ponding, or a high water table.

In either case, Enbridge will seek agency concurrence on any changes to crossing methods prior to initiating the crossing.

4.3 TRENCHLESS: BORE (NON-PRESSURIZED)

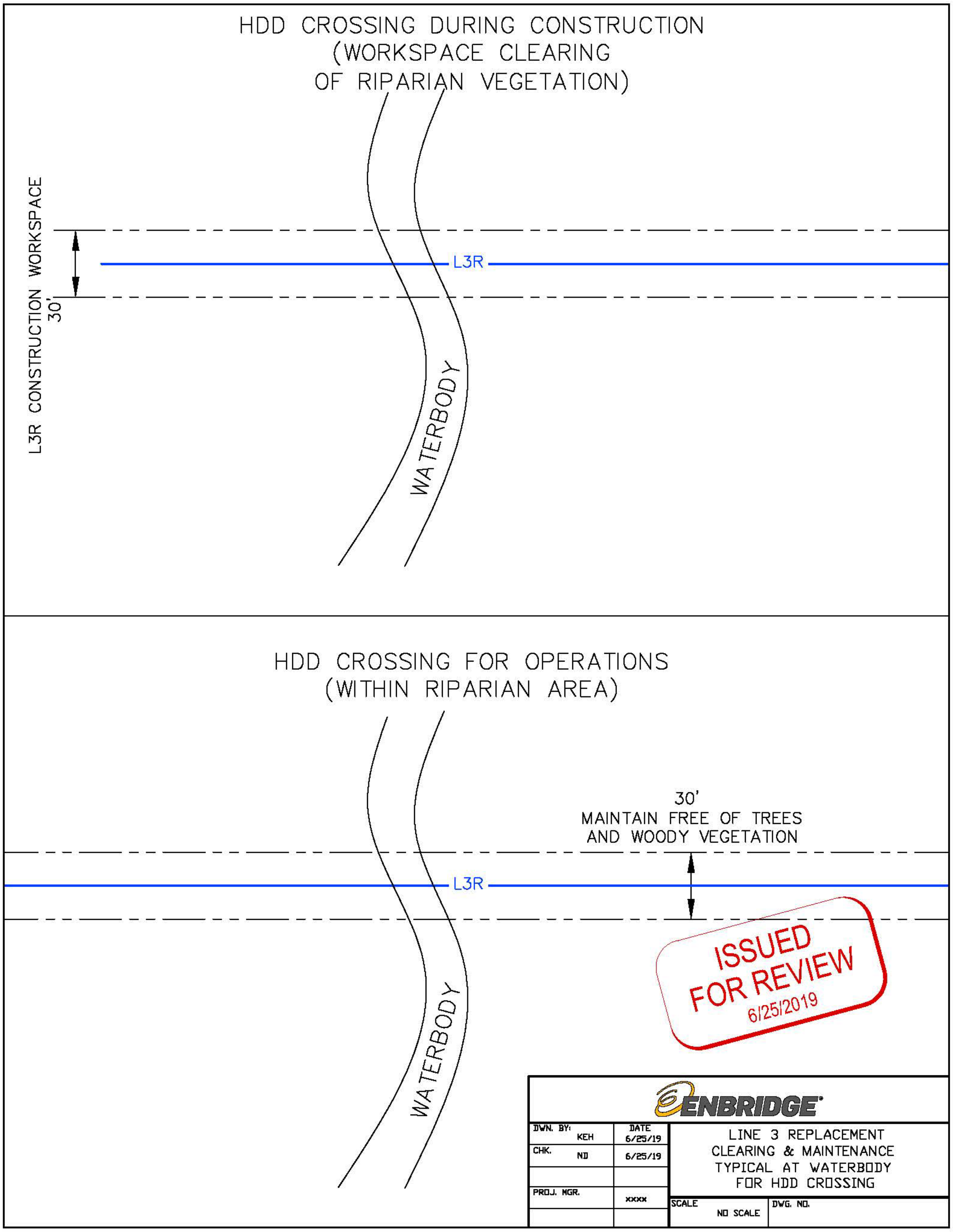
Refer to Section 3.5 for a discussion of this method.

4.4 TRENCHLESS: HORIZONTAL DIRECTIONAL DRILL METHOD (PRESSURIZED)

Refer to Section 3.6 for a full description of this method. In order to monitor for inadvertent drilling fluid release, and to allow access to the waterbody for water appropriation, riparian vegetation will need to be cleared within a 30-foot-wide corridor along the drill path. Following restoration, Enbridge will maintain the 30-foot-wide corridor centered on the pipeline free of woody vegetation to maintain the integrity of the pipeline and to facilitate aerial inspection (see Figure 4.4-1).

The containment and recovery methods of an inadvertent release in a waterbody differ from a release in a wetland and are described in Section 11.0 of the EPP.

Figure 4.4-1: Vegetation Clearing during Construction and Operations at Horizontal Directional Drill Crossings of Waterbodies



4.5 UNFORESEEN CONDITIONS

Enbridge may need to implement alternative crossing methods or locations due to the following situations, including but not specifically limited to:

- Significant fluctuation in water level (i.e., up or down) at the time of installation and/or significant changes to soil conditions at the time of installation (e.g., trench wall stability);
- Change in time of year of construction due to the timing of permit issuance (i.e., timing restrictions);
- Weather conditions at the time of installation; and
- Failure of HDD method.

Enbridge identifies a primary and alternative crossing method for waterbody crossings, with the exception of HDD crossings (see Section 3.6). In the case of an unforeseen condition that makes the primary crossing method not practicable, Enbridge will proceed with the alternative crossing method with agency approval.

5.0 REFERENCES

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