Technical Memorandum

To: James Clift (EGLE) and Ryan Mitchell (MDOT)	Project:	Enbridge Line 5 Tunnel Project
From: Sam Swartz	cc:	Dan Adams, Peter Raleigh, David Crouthamel, Marco Moccichino
Date: January 12, 2021	Job No.:	6191.0
Subject: Potential Gas Encounters in the Enbridge Line 5 Tunnel Project		

1.0 Introduction and Information Request

The Enbridge Line 5 Tunnel Project is anticipated to use a slurry tunnel boring machine (TBM) to excavate an approximately 4 mile long tunnel below the Straits of Mackinaw. The new section of the Line 5 pipeline will replace the two existing pipelines on the lakebed of the Straits. The TBM is anticipated to excavate through bedrock with zones of high hydrostatic pressure (up to 17 bars from available information) and with the potential for highly fractured and poor rock conditions. Depth to the tunnel ranges from 60 feet to over 350 feet.

This document discusses the potential risks associated with gas encounters during the excavation of the Line 5 Tunnel Project. Also included is a discussion of possible risk mitigation measures incorporated into the design via TBM equipment requirements, shaft construction, monitoring and detection, and contingency plans. It addresses the following request for information made by the EGLE Representative on October 20, 2020 (received via email) as part of the permit review process:

"Provide information on risks associated with gas encounters, requirements under OSHA, and any variations depending upon location of the project in the US. The focus should be on TBM equipment requirements, shaft construction, monitoring and detection, and contingency plans."

2.0 Requested Information on Potential Gas Encounters

Encountering gas is a known risk for tunneling through certain ground conditions. The most common gases to encounter are methane and hydrogen sulfide, both of which can be very dangerous if encountered in higher concentrations and allowed to accumulate in the tunnel where exposure to personnel and equipment creates a hazard. These gases are often encountered in conjunction with groundwater inflows, as they are often dissolved in the water and are released when entering the tunnel atmosphere. Thus, controlling larger inflows will help to mitigate risks associated with gas.

In general, while sedimentary bedrock often present higher risk for gas, these risks vary depending on the type of rock, depositional environment, age and other variables. While gas is known to occur within the

bedrock of the Michigan Basin, in general, rock closer to the Straits is not known to be as likely to produce gas. In addition, no gas was encountered during any of the geotechnical exploration program borings for this project. However, it is our understanding that the tunnel has been classified as Potentially Gassy, and the design and construction phases will need to account for this designation.

If encountered, gases pose both explosion and/or fire risks, and could be toxic to workers in the tunnel. Gases are typically reported in percentages of lower explosive limit (LEL) for methane, and in parts per million (ppm) for hydrogen sulfide gas. Typical regulations provide multiple trigger levels where mitigation measures are required to be implemented. At 20% of LEL for methane the tunnel will be required to be evacuated. For hydrogen sulfide at 20 ppm increased ventilation rate and potential evacuation would be required.

Both State and Federal regulations are in place for underground construction in the State of Michigan, specifically with regards to encountering gas in tunnels. At the State level, MIOSHA has two main provisions that govern underground work:

- MIOSHA-STD-1402, Construction Safety and Health Standard Part 665, Underground Construction, Caissons, Cofferdams, and Compressed Air (Filed Oct. 1995, amended Feb. 1998 and Dec. 2004).

- MIOSHA-STD-1311, Construction Safety and Health Standard Part 14, Tunnels, Shafts, Caissons, and Cofferdams (Filed Nov. 1978, amended multiple times, but most recently Jan. 2020).

At the Federal level, OSHA governs underground regulations, with the following primary requirements for dealing with gas in tunnels:

- OHSA 1926.800, Underground Construction (last revised May 2019).

- OHSA 315-06R, Underground Construction (Tunneling) (2003).

- By reference, certain portions of requirements from the Mine Safety and Health Association (MSHA) are also incorporated, especially with regards to equipment requirements in tunnels.

The combination of these regulations will govern requirements for the Line 5 Tunnel Project.

With regards to tunneling operations and provisions for dealing with gas, mitigation measures for gas risks depend upon various factors including the type of TBM being used, lining system, operations of the TBM, and control of water. Using a slurry TBM with a closed circuit will limit exposure risk in the tunnel, as excavated material and water will typically be confined within the closed face excavation and working chambers and within the slurry pipes, and will not be released to the atmosphere until it reaches the slurry treatment plant on the surface. The lining system foreseen will be continuously double gasketed which should limit water ingress to very low levels and hence the associated gas intrusion. In the event

that the slurry TBM is used in "open mode", that is without pressurizing the face through the closed circuit slurry method, protection of the tunnel atmosphere by the excavation chamber bulkhead occurs as long as access to excavation and working chambers remain closed. If the excavation chamber is under free air during an intervention for inspection and maintenance, gas could enter the tunnel atmosphere if encountered.

The main provisions for TBMs in Potentially Gassy conditions are the following: All electrical equipment including transformers, motors, controllers, electrical panels, lighting, ventilation and air quality monitoring equipment are required to be to National Electrical Code (NEC) Class 1 Division 2; ventilation designed per OSHA for air flow quantity requirements; continuous air quality monitoring equipment on the TBM and trailing gear; fire suppression systems at all energy transfer locations; SCSRs on the TBM for all personnel; and transportation equipment in tunnels meeting MSHA requirements.

For monitoring and detection, TBM equipment is required to have air quality monitoring operating on a continuous basis with alarms and equipment shut down if explosive thresholds are reached. Hand-held monitoring detectors are also required, with trained personnel.

Since the shafts will be open to the environment, risks are not as severe as at the heading of the tunnel. Typically, ventilation and gas monitoring is required at the bottom of the shaft, and evacuation procedures clearly planned and identified.

Emergency egress plans from both tunnel and shafts will be required in addition to specific responses to gas alarms, TBM shutdowns, and evacuations; and fire suppression.

These requirements are typical components of project specifications, and in particular the specifications for both the TBM and tunneling. TBM submittals would normally cover the equipment to be used on the TBM monitoring air quality and potentially Gassy environment. In addition to the Tunnel Safety Plan, a coordinated Tunnel Excavation Plan (TEP) will be required to integrate safety information with construction activities. The TEP typically mandates to have contingency plans in place for situations where gas is detected.

3.0 Discussion

Section 2.0 covers information in detail for most topics. The following sections provide more detail on a few specific topics, although most information is covered in detail in Section 2.0.

3.1 Ground Conditions and Gas Risks

The ground that the tunnel will go through is sedimentary bedrock, and there have been instances of gas encounters in similar rock. Shales and certain other rocks are known to have higher concentrations of gas, especially hydrocarbons. As one example, the Detroit Outfall Project was overwhelmed by hydrogen sulfide gas that came into the tunnel during a large in-rush of groundwater associated with karstic conditions in limestone. Other projects in Los Angeles and Utah (Upper Diamond Fork), for example, have encountered gas during tunnel excavation.

However, the bedrock beneath the Straits is not known as a natural source of hydrocarbons, compared to other areas of the Michigan Basin. No gas was actually encountered during the any of the geotechnical exploration program, based upon approximately 5,200 feet of overall borings in bedrock. While Potentially Gassy conditions are still anticipated, the lack of actual gas encounters during the borings is a positive sign in terms of potential risks from gas.

3.2 State and Federal Regulations for Gas in Tunnels

Both State and Federal regulations are in place for underground construction in the State of Michigan, specifically with regards to encountering gas. At the State level, MIOSHA has two main provisions that govern underground work, with more information specific to each provision provided below. Links for these standards are included in Section 4.

- MIOSHA-STD-1402, Construction Safety and Health Standard Part 665, Underground Construction, Caissons, Cofferdams, and Compressed Air (Filed Oct. 1995, amended Feb. 1998 and Dec. 2004). Specific sections applicable to gassy conditions, air monitoring and quality, and ventilation are 1926.800, Sections (h), (i), (j), and (k).

- MIOSHA-STD-1311, Construction Safety and Health Standard Part 14, Tunnels, Shafts, Caissons, and Cofferdams (Filed Nov. 1978, amended multiple times, but most recently Jan. 2020). This Part is more general in nature, although some requirements for issues related to gas and air monitoring are covered in Sections R408.41462, R408.41463, and R408.41464.

At the Federal level, OSHA governs underground regulations, with the following primary requirements for dealing with gas in tunnels:

- OHSA 1926.800, Underground Construction (last revised May 2019).

- OHSA 315-06R, Underground Construction (Tunneling) (2003). Specific sections are provided on Gassy or Potentially Gassy Operations, and ventilation and air monitoring requirements. This document mostly references back to OSHA 1926.800. In general, requirements are similar to MIOSHA requirements.

- By reference, certain portions of requirements from the Mine Safety and Health Association (MSHA) are also incorporated, especially with regards to equipment requirements in tunnels. These requirements are based upon transport vehicles in the tunnel, related to diesel transmissions and similar issues.

These requirements are typically referenced in key specifications in the contract documents, and are required to be followed by the Contractors working on the project. Specifications are usually Division 01 specifications on general project requirements and safety, and in a handful of Division 31 specifications related to earthworks, i.e. tunneling and shaft construction.

4.0 References and Additional Information

Websites for MIOSHA and OSHA:

- https://www.michigan.gov/documents/CIS_WSH_part665_35659_7.pdf
- https://www.michigan.gov/documents/lara/lara_miosha_CS_14_418399_7.pdf
- https://www.osha.gov/Publications/osha3115.html
- https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.800