GOLDER

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TECHNICAL MEMORANDUM

DATE May 4, 2018 **Project No.** 1791377

TO Dennis L. Miller (Andeavor)

CC Jeremy Yeglin, PE

FROM Bailey Theriault, PG **EMAIL btheriault@golder.com**

PRELIMINARY REVIEW OF LANDSLIDE CONDITIONS

This technical memorandum summarizes Golder Associates Inc.'s (Golder's) preliminary, high-level review of the terrain and potential landslide conditions in proximity to Andeavor's proposed natural gas liquids (NGL) project in North Dakota. The NGL project consists of the proposed Y-Grade North, Y-Grade South, and Product Transfer Line pipelines. The three pipeline alignments are located in the North Dakota counties of McKenzie, Billings, and Stark. Golder conducted this additional review in response to a letter that the North Dakota Public Service Commission (Commission) received from the North Dakota Geological Survey (NDGS) on April 2, 2018, which identified possible localized landslide areas at two locations along the proposed pipeline routes. Note that the specific locations listed in the letter from NDGS do not appear to occur along the proposed routes; thus, Golder reviewed the dataset referenced in the letter to determine the likely locations the letter intended to reference. Golder also conducted the review in accordance with the Commission's Avoidance Area siting criteria, specifically Section 69-06-08-02(2)(d) of the North Dakota Administrative Code (N.D.A.C.), for areas which are geologically unstable.

Preliminary Observations

The Y-Grade South and Product Transfer Line proposed pipeline routes traverse relatively flat terrain with limited topographic relief. The alignments cross a few small meandering streams where minor, localized bank slumping/sloughing may be present. However, the current alignments appear to cross each stream where there is minimal relief (e.g., limited, or no defined stream valley outside of the channel). Based on the NDGS 1:24k scale landslide maps, there are two mapped landslides within 500 feet of the project route. The two landslides are adjacent to one another, and are located at approximate coordinates 46.922489, -103.230695, along the border between Township 140 North, Range 100 West and Township 140 North, Range 99 West. Based on a preliminary review of Google Earth™ imagery at this location, there is possible geomorphic evidence that supports the presence of landslides. However, the closer of the two features, based on the NDGS mapped boundary, is more than 100 feet from the temporary work space, and about 175 feet from the proposed centerline. The features are therefore not located within the proposed 200 foot-wide corridor, and the project is not anticipated to effect the possible landslide areas.

The Y-Grade North proposed pipeline route traverses topography dissected by tributaries to the Little Missouri River. The current alignment crosses tributaries with stream valleys that have moderate relief. Based on the

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NDGS 1:24k scale landslide maps, there are four mapped landslides within 500 feet of the project. The four landslides are located in two clusters of two at approximate coordinates 47.697227, -103.270896, and 47.717115, -103.204197, in Township 149 North, Range 98 West. Based on a preliminary review of Google Earth™ imagery at these locations, there is possible geomorphic evidence that supports the presence of landslides. Three of the four landslides have NDGS mapped boundaries located more than 100 feet outside of any planned work areas. The features are therefore not located within the proposed 200 foot-wide corridor, and the project is not anticipated to effect the possible landslide areas. One of the four landslides (at approximately 47.696876, -103.272032) crosses into the temporary work space but does not cross the proposed alignment (based on the NDGS mapped boundary). However, based on further review of this possible landslide in Google Earth™, the questionable geomorphic expressions that indicate the possible presence of a landslide at this location do not appear to extend into the temporary work space; the questionable landslide boundary appears to be approximately 70 feet from the temporary work space boundary and approximately 140 feet from the proposed centerline. Thus, the project is not anticipated to effect this fourth possible landslide area.

Ongoing Detailed Assessment

Golder is conducting a detailed review of North Dakota State LiDAR data for geomorphic evidence of landslides for the entire length of the route, to identify and delineate possible landslides in the vicinity of the project, as well as to better delineate and characterize the possible landslides described above. If landslides are identified in areas that will be disturbed by the project, the landslides will be characterized to the extent considered necessary (e.g., desk-top only, ground reconnaissance, sub-surface investigation, etc.) such that appropriate, targeted mitigation measures can be designed and implemented. Possible targeted mitigation measures that can be utilized during construction to address landslide sites may include, but are not limited to the following:

- Avoidance through routing of the pipe beneath the landslide (e.g., deep burial, horizontal directional drill [HDD], etc.)
- Removal of the entire landslide through excavation
- Targeted site management and diversion of surface water around landslide site, including ditches, berms, slope breakers, grading, etc.
- Targeted mitigation of seeps, springs, or other subsurface water encountered along the excavated ROW using subsurface drains or special drainage measures
- Installation of deformable backfill around the pipeline

Depending on the mitigation measure selected, or a combination of measures, and following construction, slope and pipe monitoring may be installed. This would be to monitor the performance of the mitigation measures, and response of the pipe to future slope movement.

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