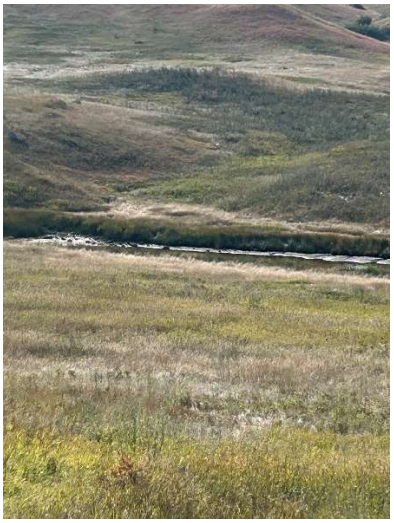
9/18/2024

Subject: Depth of Cover for the Thunder Butte Pipeline

Thunder Butte Pipeline (TBPL) will consist of the new pipeline and an existing pipeline that was purchased by TBPL. The new pipeline will have a minimum depth of cover (DOC) of 72" across the entire route. The existing pipeline, TBPL had 3 independent sources test and verify the DOC. TBPL used a certified civil survey contractor (Golden Field Services), a certified geologist (Arcadis), and an operations hand who handles all of the one-call and field locating for the existing pipeline currently. All contractors used very similar technology which uses GPS coordinates and conductive precision to locate and determine the depth of cover of the existing pipeline. They connected to the test lead wires on the pipeline so that they could trace the pipeline and locate it with GPS coordinates and use the finder to determine the depth of cover at each location. They did locates in any area that could be accessed without causing damage to the crops. They tried to gather data in the middle of fields, at section lines, and at the bottom of roadside ditches to give an all-encompassing depth of cover for the pipeline.

The results can be found on the attached pages to this memo. All of the depths checked meet the requirement of 48" or 72" minimum DOC except for 2 spots that are of potential concern. Both locations were found by the geologist, and one is at a spot where there is a pond in a farmers field the other is at a possible washed-out area at the top of a slope to a creek crossing. The pond location in the farmer's field was at 3'11" and the spot at the potential wash out location was shot at 3'0". We had our operations guy go out and check the potential washed out area as it was unclear from the geologist report if this wash out was on our pipeline or to side of our pipeline by 15' (see report from geologist provided in the submittal package). Our operations guy searched the whole area and the minimum depth of cover that he found was 5'11" as shown below in the pictures.



During construction of the new pipeline, this area will be checked again and if found to be less than 48", then proper repair of the area will be done to ensure 48" minimum DOC is obtained over the existing pipe. The farmer's pond location will be checked further once crops are cleared, and

access is easy to obtain and if depth of cover is less than 48” then proper repairs will be made to obtain the proper DOC. If we continue to get bad readings on the depth at either of these locations, then potholing will occur to expose the top of pipe, and a hard tape measurement reading will be conducted to determine the DOC.

As part of the as-built drawings and survey that will be completed for the entire pipeline, DOC will be obtained since farmer fields will not be of any concern. If any additional areas are identified being less than 48” DOC, or 72” DOC at section lines, then proper repairs will be made to ensure proper DOC is obtained.

Thunder Butte Pipeline, LLC certifies that the proposed and existing pipelines will be buried to a minimum depth from the ground surface to the top of the pipe of 48 inches in range land, 48 inches for cultivated land, 48 inches at the bottom of the ditch for road crossings, and 72 includes across undeveloped section lines.

Company: Thunder Butte Pipeline, LLC

Name: Jake Richardson

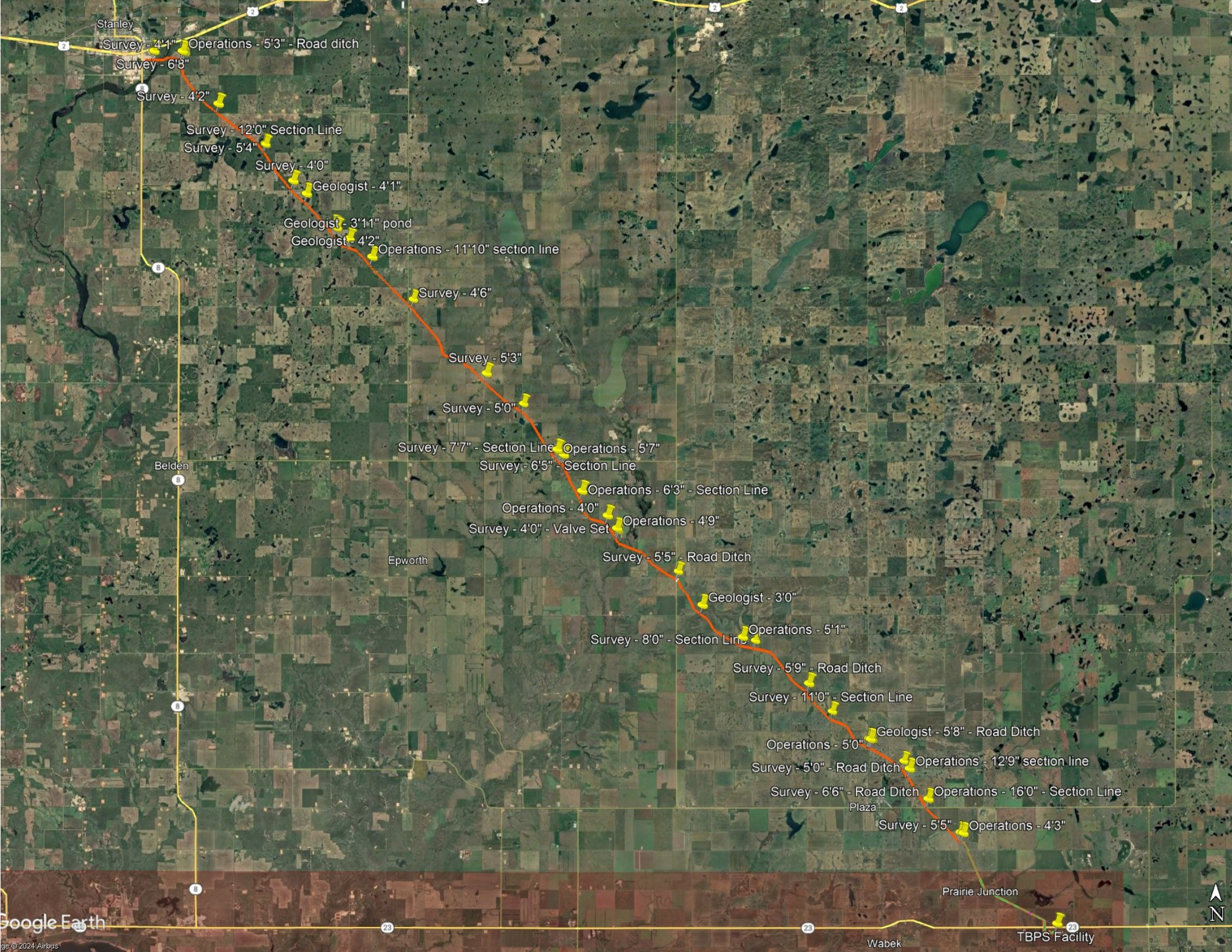
Signature:  Date: September 18,2024

Existing Pipeline Depth of Cover

-depth of cover determined using GPS line locating and depth equipment

GPS Location	Depth of Cover	Description	DOC By
48°18'14.16"N ; 102°22'10.56"W	6' 8"	Enbridge Stanley Facility	Survey
48°18'13.90"N ; 102°21'12.71"W	5' 3"	Bottom of Road Ditch	Operations
48°18'12.63"N ; 102°21'8.91"W	4' 1"	Field	Survey
48°17'2.77"N ; 102°19'59.17"W	4' 2"	Field	Survey
48°16'10.53"N ; 102°18'23.66"W	5' 4"	Field	Survey
48°15'18.72"N ; 102°17'26.51"W	4' 0"	Field	Survey
48°15'1.44"N ; 102°16'59.16"W	4' 1"	Under bottom of pond in farmer field	Geologist
48°14'18.35"N ; 102°16'3.07"W	5' 0"	Bottom of Road Ditch	Survey
48°14'15.36"N ; 102°15'57.60"W	4' 2"	Under bottom of pond in farmer field	Geologist
48°14'0.60"N ; 102°15'32.04"W	3' 11"	Under bottom of pond in farmer field	Geologist
48°13'36.20"N ; 102°14'45.60"W	11' 10"	Section Line	Operations
48°12'40.02"N ; 102°13'21.96"W	4' 6"	Field	Survey
48°10'59.13"N ; 102°10'53.58"W	5' 3"	Field	Survey
48°10'19.34"N ; 102° 9'38.28"W	5' 0"	Field	Survey
48° 9'16.17"N ; 102° 8'30.09"W	5' 7"	Field	Operations
48° 9'12.43"N ; 102° 8'25.74"W	6' 5"	Section Line	Survey
48° 9'9.11"N ; 102° 8'17.25"W	7' 7"	Section Line	Survey
48° 8'20.25"N ; 102° 7'39.92"W	6' 3"	Section line in middle of field	Operations
48° 7'47.07"N ; 102° 6'48.26"W	4' 0"	Field	Operations
48° 7'29.70"N ; 102° 6'29.20"W	4' 9"	Field	Operations
48° 7'27.67"N ; 102° 6'27.12"W	4' 0"	Field at above ground valve set	Survey
48° 6'32.74"N ; 102° 4'24.58"W	5' 5"	Bottom of Road Ditch	Survey
48° 5'46.02"N ; 102° 3'36.18"W	3' 0"	Crest of steep bank at perennial stream	Geologist
48° 5'2.71"N ; 102° 2'14.63"W	5' 1"	Field	Operations
48° 4'59.15"N ; 102° 1'48.59"W	8' 0"	Section Line	Survey
48° 3'59.96"N ; 102° 0'0.71"W	5' 9"	Bottom of Road Ditch	Survey
48° 3'23.17"N ; 101°59'13.07"W	11' 0"	Section Line	Survey
48° 2'45.05"N ; 101°57'59.05"W	4' 0"	Field	Survey
48° 2'44.39"N ; 101°57'56.08"W	5' 8"	Bottom of Road Ditch	Geologist
48° 2'44.22"N ; 101°57'53.06"W	5'0"	Field	Operations
48° 2'15.86"N ; 101°56'48.38"W	5' 0"	Bottom of Road Ditch	Survey
48° 2'4.41"N ; 101°56'37.85"W	5' 0"	Field	Survey
48° 2'4.37"N ; 101°56'37.19"W	12' 9"	Section Line	Operations
48° 1'23.41"N ; 101°55'59.53"W	16' 0"	Section Line	Operations
48° 1'22.34"N ; 101°55'59.54"W	6' 6"	Field	Survey
48° 0'37.73"N ; 101°54'54.45"W	5' 5"	Field	Survey
48° 0'36.90"N ; 101°54'48.79"W	4' 3"	Field at pig trap near Plaza, ND	Operations

The yellow highlighted items above will be addressed during construction and evaluated further in the field to make sure that they depth of cover is 48" minimum since neither location is at a Section Line.


Stanley
Survey - 4'1"
Operations - 5'3" - Road ditch
Survey - 6'8"
Survey - 4'2"
Survey - 12'0" Section Line
Survey - 5'4"
Survey - 4'0"
Geologist - 4'1"
Geologist - 3'11" pond
Geologist - 4'2"
Operations - 11'10" section line
Survey - 4'6"
Survey - 5'3"
Survey - 5'0"
Survey - 7'7" - Section Line
Operations - 5'7"
Survey - 6'5" - Section Line
Belden
Operations - 6'3" - Section Line
Operations - 4'0"
Operations - 4'9"
Survey - 4'0" - Valve Set
Epworth
Survey - 5'5" - Road Ditch
Geologist - 3'0"
Operations - 5'1"
Survey - 8'0" - Section Line
Survey - 5'9" - Road Ditch
Survey - 11'0" - Section Line
Geologist - 5'8" - Road Ditch
Operations - 5'0"
Operations - 12'9" section line
Survey - 5'0" - Road Ditch
Survey - 6'6" - Road Ditch
Operations - 16'0" - Section Line
Plaza
Survey - 5'5"
Operations - 4'3"
Prairie Junction
TBPS Facility
Wabek
Google Earth
N

Thunder Butte Pipeline, LLC

Geohazard Investigation

Thunder Butte Pipeline Project

September 2024

Geohazard Investigation

Thunder Butte Pipeline Project

September 2024

Prepared By:
Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch, Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535

Prepared For:
Thunder Butte Pipeline, LLC
37685 24th Avenue SW
Plaza, North Dakota 58771

Our Ref:
30192665

Tim Newton, PG

Tim Webb-Horvath

Kathryn Cloutier
Project Manager

Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

AEP	Annual Exceedance Probability
AOC	area of concern
Arcadis	Arcadis U.S., Inc.
ASSET	Arcadis Scour Screening and Erosion Tool
DOC	depth of cover
GIS	Geographic Information System
GPS	Global Positioning System
NDGS	North Dakota Geological Survey
NWI	National Wetlands Inventory
NRCS	Natural Resources Conservation Service
project	Thunder Butte Pipeline Project
ROW	right-of-way
TBPS Facility	Thunder Butte Petroleum Services, Inc. Crude Storage and Loading Facility
USGS	U.S. Geological Survey
VIV	vortex-induced vibration

1 Introduction

Thunder Butte Pipeline, LLC proposes the Thunder Butte Pipeline Project (the project) to transport crude oil from the existing Thunder Butte Petroleum Services, Inc. Crude Storage and Loading Facility (TBPS Facility) within the Fort Berthold Indian Reservation, approximately 2.6 miles northwest of Makoti, North Dakota, to the existing Enbridge Stanley Pump Station and Terminal (i.e., Enbridge Storage Facility) in Stanley, North Dakota.

The project will consist of three primary components:

- Construction of a new 3.84-mile-long underground pipeline; and
- Conversion of an existing 30.8-mile-long collector (gathering) pipeline to a transmission pipeline.
- Construction of a midline pump station on a 2-acre site adjacent to the existing pipeline.

The new pipeline will commence at the TBPS Facility and terminate at the interconnection with the existing gathering pipeline. The existing pipeline was previously owned by Enbridge Pipelines North Dakota (Line 82-111). From the interconnection point with the existing pipeline approximately 2.1 miles southeast of Plaza, North Dakota, the existing pipeline will transport crude oil to the Enbridge Facility. All but the southern 3.84 miles of the project is an existing pipeline. The project extends across Montrail County and into Ward County.

Geohazards are a class of threats related to an external loading of a pipeline in response to the occurrence of a geological process. A geohazard assessment was performed on the project to determine any areas of unstable ground in the project corridors that may impact the existing pipeline or the proposed pipeline. This report describes the process where the susceptibility of the project to potential geohazards was evaluated by Arcadis.

The process included a desktop review to evaluate regional geological conditions, establish a project-specific geographic information system (GIS), and make a preliminary assessment of geotechnical and hydrotechnical issues that needed to be verified in the field. The desktop review was followed by a field study where each feature was located, photographed, and assessed. This report presents the results of the geologic hazard desktop and field evaluations, summaries of findings, and conclusions of risk.

The Field Survey Areas (defined as the “project corridors”) for the geohazard study were a 50-foot-wide project corridor (25 feet on either side of the pipeline centerline) for the existing pipeline and a 200-foot-wide project corridor (100 feet on either side of the pipeline centerline) for the proposed pipeline. The Study Area used for the desktop analysis for both the existing pipeline and proposed pipeline is a 1-mile-wide area (0.5 mile on either side of the pipeline centerlines) as shown on the Avoidance Areas map sheets in **Appendix A**.

2 Geologic Setting

Developing an understanding of the geological and environmental conditions along the Study Area and project corridors is the first step in a geohazard investigation.

2.1 Geology of Study Area

The project is in the semi-arid climate of the northern Great Plains Province and falls within the area of the Coteau Slope in Montrail County as shown in **Figure 1**. The project lies between the Little Knife Valley on the north end and the Shell Valley at the southern terminus. The Coteau Slope is a rolling, hilly landscape that contains both glacial and erosional landforms. Some glacial deposits in the area are relatively thin and did not significantly alter the topography.

The Coteau Slope is drained by several tributaries of the Missouri River that form major watersheds in Montrail and Ward County. The Little Knife River originates near the town of Stanley and flows to the southwest, draining the west-central part of the Coteau Slope. Shell Creek drains the eastern part of the County while East Fork Shell Creek and Deepwater Creek drain the southeastern portion.

The most widespread surface formation in Montrail and Ward Counties is the Coleharbor Formation. It is more than 300 feet thick in the northeastern part of the county and thins to the southwest. The Coleharbor Formation is underlain by the Tongue River, Sentinel Butte, and Golden Vally formations of the Fort Union Group. The Fort Union Group includes layers of sandstone, siltstone, mudstone, and coal deposits (Clayton 1972).

Mineral resources include ceramic clay, sand and gravel and lignite coal. Lignite is a dark brown low-grade coal that is softer than ordinary bituminous coal. Lignite occurs primarily in the Sentinel Butte and Tongue River formations of the Fourt Union Group. In Mountrail County, lignite layers range from an inch to a few feet thick, but layers 10 to 15 feet thick have been reported in drill logs. Most springs in the county come from lignite layers.

Hundreds of lakes and ponds occur in the northeastern half of Mountrail County, and most are intermittent (i.e., have no water standing in them during periods of little rain), but some are perennial (i.e., always have standing water). Intermittent and perennial lakes and ponds are major areas of groundwater discharge. The lakes at lower elevations may be brackish or saline because they are fed by groundwater that has moved much farther and much deeper through formations with sodium sulfate.

North Dakota is located within the stable interior of the North American Plate and in an area of low earthquake probability. North Dakota has small, inactive fault lines that are the source of infrequent earthquakes that are unlikely to cause any serious damage. The closest fault to the Study Area is the Makoti Fault in Ward County, which extends from near Makoti and runs in a southeasterly direction (Anderson 2016).

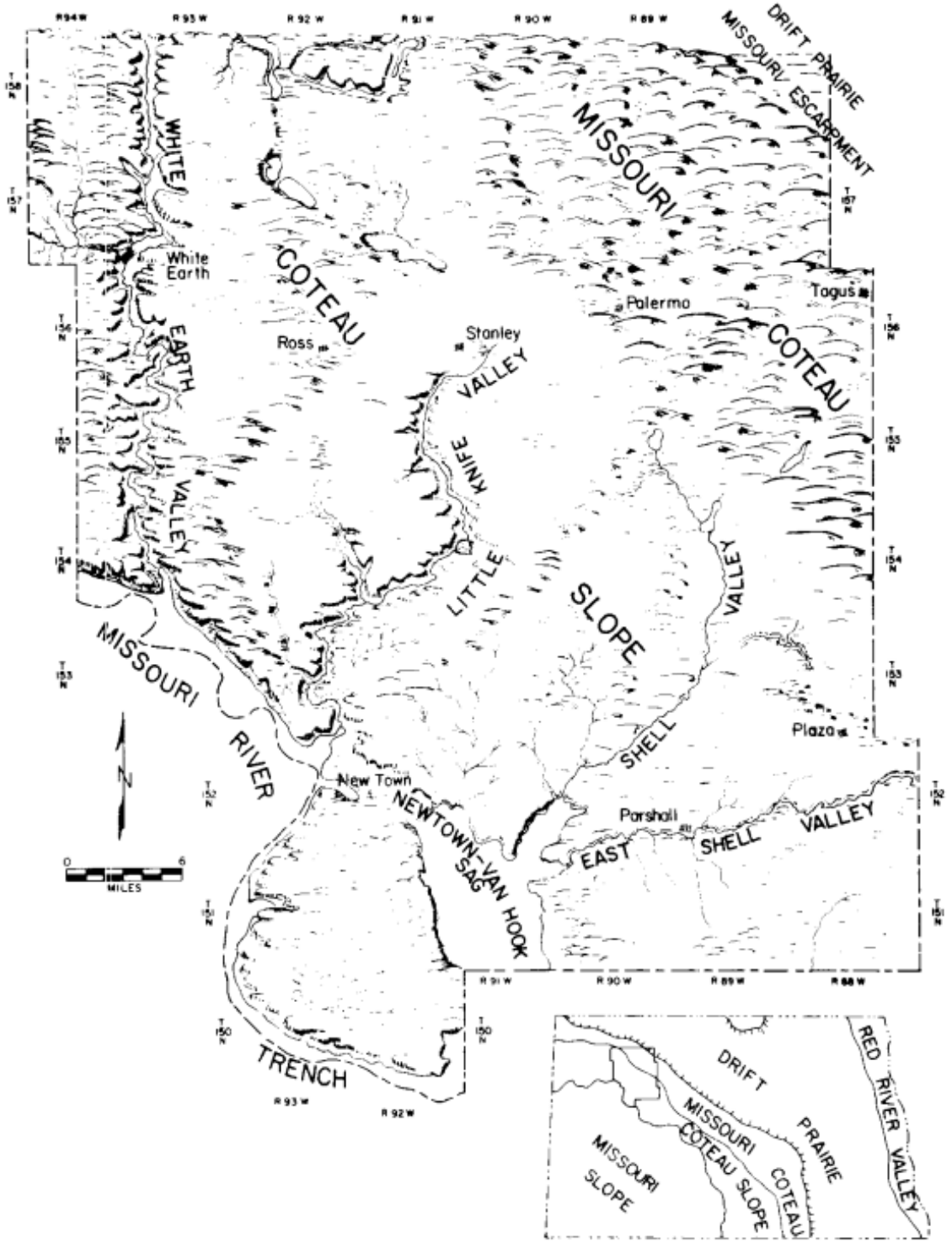


Figure 1 Physiographic features of Montrail County (Clayton 1972)

2.2 Soils

The project corridor mostly lies within the soil types of the Coleharbor formation as determined by the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) soils data base (NRCS 2023). Soil delineation data were imported into the GIS to identify soils pertaining to the recognized geohazards and facilitate evaluation of stability and susceptibility to erosion of pipeline cover. The following categories of soils were identified within the project corridors of the existing and proposed pipelines.

- Glacial Till: All of the project corridor except areas of streams and ponds have soils described as pebbly, sandy, silty clay (glacial till). Some cobbles and boulders as much as a few feet in diameter are present. Glacial till makes up 87% of Coleharbor Soils Group.
- River and Beach Sediment: Stream banks are typically sand and gravel of the Coleharbor Formation that was deposited by large rivers during glacial times, but not necessarily by meltwater rivers.
- Glacial Lake Sediment: Lakes and large ponds typically consist of silt and clay that is free of pebbles and also belongs to the Coleharbor Group.
- Shell creek valley dips into the Sentinel Butte Formation, which consists of dull gray layers of silt, clay, and sand, and some sandstone, lignite, scoria, and limestone. This formation is as much as 300 feet thick and was deposited in lakes and rivers during the Paleocene Epoch.

3 Desktop Review

The first phase of the geohazard investigation was a desktop review along the existing and proposed pipelines in Montrail and Ward Counties using ESRI's ArcMap GIS software. Geographical data included the U.S. Fish & Wildlife National Wetlands Inventory (NWI) and U.S. Geological Survey (USGS) National Hydrography Dataset data for streams and ponds, NRCS soils data, and available geohazard data from the NDGS. These data were overlain on ESRI World Imagery to create maps of the Study Area. Elevation and topography were created from USGS Earth Explorer Digital Elevation Model to show contours. The 1-mile-wide Study Area (0.5-mile on either side of the centerlines for both pipelines) and pertinent geohazard features are shown in the Avoidance Areas map sheets found in **Appendix A**. Google Earth aerial imagery was also examined for evidence of possible geohazards in proximity to the pipeline. Google Earth imagery from August 2013 to June 2024 is of high quality for the Study Area.

Arcadis considered the following items during the desktop study:

- Previously determined geohazards from the NDGS;
- General terrain and site conditions in the vicinity of the pipeline corridor;
- Surface and soil drainage conditions;
- General flow pattern and channel conditions;
- Vegetative indicators for high moisture, erosion, or slope movement; and
- Signs of instability.

Based on this initial assessment, Arcadis identified areas that pose a potential threat to the pipelines and may require additional investigation. Geohazards in proximity of the pipeline (as shown on the GIS maps) were inventoried for the field study. These consisted of historical mines, gravel pits, potential landslide areas, ponds, and water crossings. Additional features that could impact the pipeline that were identified in the Google Earth imagery were added to the inventory, such as roadside and farm drainage ditches.

The Study Area used for the desktop analysis for both the proposed pipeline and the existing pipeline is 1-mile wide (0.5 mile on either side of the pipeline centerlines). The Field Survey Area (project corridor) for the geohazard study was a 50-foot-wide project corridor (25 feet on either side of the pipeline centerline) for the existing pipeline and a 200-foot-wide project corridor (100 feet on either side of the pipeline centerline) for the proposed pipeline.

4 Field Evaluation

For the second phase of the geohazard investigation, personnel traveled to the project and performed a field evaluation of the features identified in the desktop review. A complete table of geohazards and their attributes can be found in the Geohazard Feature Inventory Table in **Appendix B**. Each feature was visually observed and documented. The photolog showing all potential geohazard features is provided in **Appendix C**. Attributes noted during the fieldwork include slope height, slope angle, amount of vegetative cover, and the presence of soil cracks or erosion. The fieldwork was executed from August 5 - 7, 2024. Vegetative cover identified within the project corridors included cultivated crops (primarily wheat, pea, and canola), pasture, and wetland grasses as shown in the photograph log provided in **Appendix C**.

Slope failure involves sliding and/or movement of a portion of an embankment relative to the adjacent mass. The slope movement has potential to act upon buried pipeline and/or increase the unsupported span length of a pipeline across the waterway. The assessment can be broken into two parts: 1) the stability of the slope; and 2) the vulnerability of the pipeline. The stability of the slope is related to the likelihood that the bank will experience a failure. Taller banks, steeper slopes, and banks suffering erosion are generally more prone to fail.

If the slopes lack vegetation and root structure, they are more susceptible to erosion. Continuous erosion of the slopes over time can lead to ongoing bank instability that would exert additional soil forces on the pipeline and threaten its integrity. Waterways, ponds, and ditches have potential for erosion and steepening of the slopes from flowing water. During field evaluation, if the crossing did not appear to have any signs of potential instability, or if the banks were less than 5 feet tall and/or the bank slope was less than 15 degrees (about 3.5H:1V), the bank was classified as “likely stable” which means slope failure is unlikely. Fortunately, the study area is well vegetated with tall grasses and crops.

Arcadis surveyed the larger water crossings and ponds and used the data to create drawings of their profiles. The Arcadis Scour Screening and Erosion Tool (ASSET) was utilized to further assess the hydrotechnical threat to the pipeline at select waterways. Hydrotechnical threats posed by waterways to pipelines include channel bed scour, bank erosion and channel migration, and channel avulsion. The results of the ASSET analysis are discussed in Section 4.2 *Water Crossings* and reported in **Appendix D**. Cross section drawings are included in **Appendix E**. The surveys allowed determination of bank heights and slopes for preliminary assessment of scour potential and slope stability. Pipeline DOC was also measured at the water crossings and many of the ponds and ditches.

4.1 Potential Landslides

Pipelines are often threatened by impact and displacement from landslides. Landslides can pose a significant threat to buried pipelines due to their potential to disrupt the integrity and stability of the ground above. When a landslide occurs, the movement of soil and rock can exert immense pressure on buried pipelines, causing them to shift, bend, or even break. The sudden movement and shifting of the ground can lead to deformation or rupture of the pipelines, resulting in leaks or breaks along the pipeline corridor.

Landslides can also displace the soil around the pipelines, leaving them exposed to erosion or impact from debris. This can compromise the protective coatings of the pipelines, making them more vulnerable to corrosion and abrasion. Most landslides are shallow and above the pipe; thus, assessment is focused on documenting and analyzing the hazards posed by the various types of deep-seated landslides that penetrate to pipeline-burial depths.

Changes to the environment such as intense precipitation events, earthquakes, undercutting and erosion by streams, and/or activities of humans can initiate or trigger landslides. Landslides are often a function of hydrological conditions within the hill, rock slope, or bank, as increased saturation adversely affects slope stability. Landslides may occur in hillsides, rock slopes, or along the banks of waterways. Landslides in the banks of waterways may be impacted by riverine scour at the toe of the slope, as well.

There were three areas of potential slope instability noted by the NDGS data, labeled S1, S2, and S3 as shown on the Avoidance Areas map sheets in **Appendix A** and survey figures in **Appendix E**. Features S1 and S2 were confirmed to be active landslides with displacement; however, these features are outside of the 50-foot-wide project corridor for the existing pipeline. Arcadis observed erosion on the slopes near feature S3 but could not confirm the presence of an active slide. All three NDGS locations are far enough from the pipelines to not be a threat, but their presence indicates that slopes in those areas may be unstable and require monitoring.

Two additional potential landslide features were added during the field work, noted as area of concern (AOC) AOC2 and AOC3. Feature AOC2 is a 21-foot tall, steeper slope (18.4°) along the south side of the pipeline that presently does not exhibit signs of instability but should be monitored for changes over time. AOC1 is an 80-foot long area along the pipeline that lacks vegetation and may be susceptible to erosion. AOC1 should also be monitored but the area currently has adequate pipeline DOC. AOC3 drew attention due to its steeper slope in between farm fields and was surveyed. No signs of instability were observed during the survey of AOC3. Potential landslide areas are summarized in **Table 1**. All potential landslides are located along the existing pipeline. The photograph numbers listed in **Table 1** are referencing the photolog provided in **Appendix C**.

Table 1 Potential Landslides

Feature ID	Distance from Pipeline	Description	Photo Number(s) Appendix C
S1	870 feet from existing pipeline	Scarp at top of slope; rotational slide with displaced material downslope; tension cracks around slide; unstable.	90-93
S2	350 feet existing pipeline	Existing landslide. Two scarps located about 4 ft above bottom of slope, likely will progress upslope; unstable.	100-103
S3	1,200 feet from existing pipeline	No obvious signs of instability observed; appears to be erosion near base of slopes and erosion rills downslope to unnamed stream; **l**ikely stable.	123-128
AOC1	15 feet from existing pipeline	Area along pipeline shows disturbance and lack of vegetation on crest (80 feet long, visible in aerial imagery); likely stable. See Figure 1 in **Appendix E**.	139
AOC2	25 feet from existing pipeline	Steeper 21-foot tall slope (18.4°) located 25 feet south of pipeline; slope is well vegetated but top along pipeline lacks vegetation and is vulnerable to erosion (AOC1); conditionally stable. See Figure 1 in **Appendix E**.	140-142
AOC3	0 foot from existing pipeline	Steep slope (9.9°; 5.65H:1V) along the pipeline between farm fields that warranted inspection; no signs of instability were observed; likely stable.	87-89

4.2 Water Crossings

Pipeline water crossings are considered a threat to pipeline integrity. Although pipelines may be buried under a streambed, phenomena such as floods and heavy rains can lead to scour (i.e., erosion of the riverbed and riverbanks) leaving the pipeline exposed. Once exposed, the primary threat to pipeline integrity is the oscillation produced by vortex-induced vibrations (VIVs). Additionally, if the pipelines are exposed, they could also be susceptible to unsupported spans due to erosion of soil beneath the pipeline. Unnoticed, it can result in a rupture, and if the transported product is liquid, the damage caused could lead to water pollution. Adequate pipeline setback and depth of cover (DOC) are essential to preventing impacts from bank stability and scour.

The route for the existing pipeline crosses the Little Knife River, Shell Creek, and several unnamed streams or drainages. Based on field surveys, none of the existing pipeline water crossings are believed to have been installed using horizontal direction drilling methods.

The proposed pipeline route crosses the East Fork of Shell Creek, an intermittent unnamed stream, and several wetlands. Shell creek flows to the southwest before connecting with Lake Sakakawea. Two surface drains, Taylor Slough Drain and Wild Willow Drain, were identified within the 1-mile Study Area (0.5-mile on either side of the centerlines for the proposed pipelines; however, these surface drains are not in the 200-foot-wide project corridor and will not be crossed by the pipeline route.

There were nine defined water crossings that required evaluation in the field, most of them small unnamed streams. The seven largest crossings were surveyed as outlined in Section 6, *Surveys*, and drawings including the cross sections and plan views were developed. The two largest waterways underwent ASSET analysis to assesses scour, erosion, and avulsion estimates at select crossings and predict actual magnitude and frequency of potential pipeline impacts, if any, due to varying flood related forces. The results of the ASSET analyses are provided in **Appendix D**. Shell Creek was the waterway with the highest drainage area and the lowest measured DOC of any of the waterways within the 50-foot-wide project corridor of the existing pipeline. The ASSET analysis of Shell Creek, feature W11, estimates a maximum scour during a 100-year flood event of 0.7 foot, which is not predicted to expose the pipeline. The ASSET analysis for this waterway calculated an Annual Exceedance Probability (AEP) of less than 1%. The AEP is the predicted likelihood of a pipeline becoming damaged due to VIVs or exceedance of the maximum allowable unsupported span length. Qualitatively, an AEP of less than 1% implies that a water crossing poses little hydrotechnical threat to the pipeline. Analyses of the largest waterways indicating an AEP of less than 1% implies that all the water crossings within the project extents pose little hydrotechnical threat to the pipeline. As with all hydrological predictive analyses, the findings of the ASSET analyses reported herein should be considered a snapshot in time based on the conditions at the crossings at the time of the survey. Successive and/or extreme flood events have the potential to modify pipeline vulnerability over time.

Survey drawings can be found in **Appendix E**. Water crossings are summarized in **Table 2** and shown on the Avoidance Areas map sheets in **Appendix A**. The photograph numbers listed in **Table 2** are referencing the photolog provided in **Appendix C**. All water crossing banks that were inspected and evaluated were classified as “likely stable” which means slope failure is unlikely.

Table 2 Water Crossings

Feature ID	Description	Survey	Photo Numbers in Appendix C
W1	Branch of Little Knife River with surveyed cross section (existing pipeline)	**Appendix E**, Figure 2	1-3
W2	Little Knife River with surveyed cross section (existing pipeline)	**Appendix E**, Figure 2	4-20
W5	Unnamed stream with surveyed cross section (existing pipeline)	**Appendix E**, Figure 3	54-60
W7	Unnamed stream with surveyed cross section, slopes less than 3 feet tall (existing pipeline)	**Appendix E**, Figure 4	65-73
W9	Unnamed stream with surveyed cross section (existing pipeline)	**Appendix E**, Figure 5	94-99
W11	Shell Creek with surveyed cross section (existing pipeline)	**Appendix E**, Figure 6	108-119
W13	Unnamed stream with surveyed cross section, banks less than 3 feet tall; tallest slope beyond bank on east side is 31 feet tall with a slope of 8.2° (existing pipeline)	**Appendix E**, Figure 7	129-138
W14	East Fork Shell Creek with surveyed cross section, banks less than 3 feet tall (proposed pipeline)	**Appendix E**, Figure 8	179-188
W15	Unnamed stream or drainage that passes through culvert under railroad and crosses pipeline (proposed pipeline)	Not surveyed	204-205

4.3 Pond Crossings

Ponds can endanger buried pipelines in various ways. Ponds are considered a geohazard due to their ability to create soil instability around pipelines. Saturated soil due to ponding can shift and settle, potentially applying pressure on the pipeline. Additionally, fluctuating water levels and inflow may cause erosion of the surrounding soil, exposing the pipeline to external elements and increasing vulnerability to damage. Similar to water crossings, adequate pipeline DOC is critical at pond locations. Also, ponds may collect corrosive chemicals or minerals such as salts that accelerate the deterioration of the pipeline walls. Some ponds and lakes in the area that are at lower elevations are brackish due to naturally occurring sodium sulfate.

Crossings of areas classified as ponds by the NWI were inspected during the fieldwork. These areas typically hold water year-round and are considered a water body crossing. Areas designated as wetlands were not included in the field evaluation due to their shallow water and intermittent nature. All ponds were surrounded by tall cattails and wetland grasses, had silty soils, and were lined with a layer of peat. Banks typically had flat slopes with a gentle transition to lower, water filled elevations. Pond water was not tested for salinity. All pond crossing banks that were inspected and evaluated were classified as “stable”. Pond crossings are summarized in Table 3 and shown on the Avoidance Areas map sheets in **Appendix A**. All pond features are located along the existing pipeline. The photograph numbers listed in Table 3 are referencing the photolog provided in **Appendix C**.

Table 3 Pond Crossings

Feature ID	Description	Survey	Photo Number(s) Appendix C
P2	180-foot diameter (existing pipeline)	Not surveyed	31-33
P5	400-foot x 200-foot dimensions (existing pipeline)	Not surveyed	34-35
P6	450-foot diameter; survey shows bank slopes 4 feet vertical over 100-foot distance (existing pipeline)	Surveyed transect to measure slopes	38-40
P8	800-foot x 550-foot dimensions; survey shows bank slopes 5 feet vertical over 80-foot distance (existing pipeline)	Surveyed transect at steepest side over pipeline centerline	43-45
P9	250-foot diameter; survey shows bank slopes 5 feet vertical over 50-foot distance (existing pipeline)	Surveyed transect at steepest side over pipeline centerline	46-47
P10	400-foot x 300-foot dimensions (existing pipeline)	Not surveyed	48
P12	120-foot x 70-foot dimensions; pipeline does not cross P12, located greater than 200 feet from existing pipeline	Not surveyed	106-107
P13	730-foot x 250-foot dimensions (existing pipeline)	Not surveyed	156
P14	400-foot x 85-foot dimensions; pipeline does not cross P14, located greater than 100 feet from existing pipeline	Not surveyed	163

4.4 Open Pits

Gravel and lignite were mined in the vicinity of the Study Area using open pit excavation. Most of the abandoned lignite mines in Montrail County are small surface pits that were used as local sources of household fuel. The North Dakota Geological Survey (NDGS) data indicated several pits in proximity to the pipeline; however, these pits are outside the project corridor of the existing pipeline. Open pit surface mine hazards include corrosive water and soils from mine spoils that can accelerate deterioration and corrosion of pipelines. As a geohazard, pits may experience ground subsidence where backfilled and can change drainage patterns.

Open pits were included in the desktop NDGS data and were observed in the field. Three locations that were in the closest proximity of the pipeline were investigated. Pits were found to be relatively shallow with spoil piles surrounding them. They do not represent a potential threat to the pipeline due to their depth and distance from the pipeline. Open pits are summarized in **Table 4** and shown as O1, O2, and O3 on the Avoidance Areas map sheets in **Appendix A** and Figure 1 **in Appendix E**. The photograph numbers listed in **Table 4** are referencing the photolog provided in **Appendix C**.

Table 4 Open Pits

Feature ID	Distance from Pipeline	Description	Photo Number(s) Appendix C
O1	2,000 feet from existing pipeline	Vegetated and tree filled pit, about 4 feet deep (existing pipeline)	149-150
O2	1,700 feet from existing pipeline	Pit has steep 12-foot tall, partially vegetated slopes (existing pipeline)	154-155
O3	1,800 feet from proposed pipeline	Pit is about 6 feet deep with multiple spoil piles; area is well vegetated (proposed pipeline)	192

4.5 Abandoned Mines

Abandoned underground mines can pose serious hazards to buried pipelines due to various factors. Structural instability caused by eroding pillars or shoring can lead to ground subsidence or collapse. As the mine shafts and tunnels deteriorate over time, the surrounding land may sink or shift unpredictably, putting pressure on buried pipelines. This movement can result in bending and crushing, possibly rupturing the pipeline. Abandoned mines often contain residual chemicals, heavy metals, or other hazardous substances that can seep into the surrounding soil and water.

Most of the older commercial mines in the vicinity of the Study Area were underground and were entered through sides of river bluffs or vertical mine shafts. Strip mines replaced underground mines in the 1940s. Thick overburden in most areas prevents mining from being economical in the region. The largest mines in Mountrail County are located about a mile east of New Town and a mile south of Parshall, southwest and outside of the Study Area.

Abandoned mines were included in the desktop NDGS data. The location and size of the underground mines are uncertain; thus, it is unknown whether they extend below the pipeline. Aerial imagery and field observations indicate the lack of subsidence in the areas of the mines; however, the 30-foot-wide permanent right-of-way (ROW) of the existing pipeline in proximity to the mine locations should be monitored. Three mine locations that were closest to the pipeline were investigated. The provided coordinates for M1 and M2 are less than 100 feet apart. It is likely that feature M3 is the same as open pit feature O1, since M3 is noted as a surface mine. Abandoned mines are summarized in **Table 5** and shown on the Avoidance Areas map sheets in **Appendix A**. All mines fell along the existing pipeline. The coordinates provided by NDGS for the abandoned mines indicated that the mines are approximately 450 feet from centerline of the existing pipeline; however, the extent of the underground workings are unknown. The photograph numbers listed in **Table 5** are referencing the photolog provided in **Appendix C**.

Table 5 Abandoned Mines

Feature ID	Distance from Pipeline	Description	Photo Number(s) Appendix C
M1	450 feet (existing pipeline)	Speigel Coal Mine, aka Smith coal mine; unknown quantity mined; likely closed in 1940	78-82
M2	450 feet (existing pipeline)	Mormon Coal Mine; 2,500 tons mined; likely closed in 1935	78-82
M3	2,200 feet (existing pipeline)	Unknown surface mine; may be same NDGS feature as O1	143

4.6 Roadway and Farm Ditches

Roadway drainage ditches can impact buried pipelines that cross their paths in several ways. Drainage ditches can alter the natural water flow patterns in the vicinity of buried pipelines. Poorly designed or maintained ditches may result in water pooling near the pipelines, increasing the risk of corrosion. Larger ditches can present hazards similar to water crossings as they are susceptible to landslides, erosion, and scour.

The construction and maintenance of drainage ditches alongside roadways can increase the risk of accidental damage to buried pipelines. During excavation or cleaning activities related to the ditches, there is a possibility of machinery or equipment coming into contact with the pipelines, leading to potential punctures, dents, or other mechanical damage. These incidents can compromise the structural integrity of the pipelines, making them more susceptible to leaks or failures.

The desktop study identified numerous roadway and farm ditches crossed by the existing and proposed pipelines. Ditches represent areas of decreased DOC with potential for instability and erosion. Farmland areas typically have a series of drainage ditches between fields to prevent flooding during rain events, but field observations indicate that the rolling topography and well drained soils negate the need for ditches. Thus, most of the farm ditches identified from Google Earth imagery did not exist in the field. Photographs were taken as evidence of the lack of a defined ditch between fields.

The roadway ditches in the Study Area are typically shallow (less than 5 feet deep) and without a defined channel, likely due to the well-drained soils and gravel surfaced roads. The paved state highways have more defined ditches. No potential for instability was observed due to the ditches being well vegetated and having conservatively designed and constructed slopes. DOC was checked at several of the ditches to confirm the pipeline was protected. All ditch slopes were classified as “likely stable”. Roadway and farm ditches are summarized in **Table 6** and shown on the Avoidance Areas map sheets in **Appendix A.** The photograph numbers listed in **Table 6** are referencing the photolog provided in **Appendix C**.

Table 6 Roadway and Farm Ditches (From North to South)

Feature ID	Description	Photo Number(s) Appendix C
RD1A	North road ditch at 61st St NW (existing pipeline)	21
RD1B	South road ditch at 61st St NW (existing pipeline)	22
RD2A	North road ditch at 60th St NW (existing pipeline)	23
RD2B	South road ditch at 60th St NW (existing pipeline)	24
RD3B	West road ditch at 79th Ave NW (existing pipeline)	25
RD3A	East road ditch at 79th Ave NW (Existing Mile Marker #2)	26
F1	No apparent farm ditch between fields (existing pipeline)	27
RD4A	North road ditch at 59th St NW (existing pipeline)	28
RD4B	South road ditch at 59th St NW (Existing Mile Marker #4)	29-30
RD25A	North road ditch at 58th St NW (existing pipeline)	36
RD25B	South road ditch at 58th St NW (Existing Mile Marker #5)	37
RD5A	East road ditch at 76th Ave NW (Existing Mile Marker #7)	41
RD5B	West road ditch at 76th Ave NW (existing pipeline)	42
F2	No apparent farm ditch between fields (existing pipeline)	49
RD6A	East road ditch at 74th Ave NW (Hwy 3) (existing pipeline)	50
RD6B	West road ditch at 74th Ave NW (Hwy 3) (existing pipeline)	51
RD26A	North road ditch at 55th St NW / Palermo Rd (existing pipeline)	52
RD26B	South road ditch at 55th St NW / Palermo Rd, (Existing Mile Marker #10)	53
RD7A	East road ditch at 46th St NW (existing pipeline)	61
RD7B	West road ditch at 46th St NW (existing pipeline)	62
RD8B	South road ditch at 53rd St NW (Existing Mile Marker #13)	63
RD8A	North road ditch at 53rd St NW (existing pipeline)	64
RD9B	West road ditch at 71st Ave NW (Existing Mile Marker #14)	74
RD9A	East road ditch at 71st Ave NW (existing pipeline)	75
RD10A	North road ditch at 52nd St NW (existing pipeline)	76
RD10B	South road ditch at 52nd St NW (existing pipeline)	77
RD11A	North road ditch at 51st St NW (existing pipeline)	83
RD11B	South road ditch at 51st St NW (Existing Mile Marker #15)	84
RD12A	East road ditch at 70th Ave NW (existing pipeline)	85
RD12B	West road ditch at 70th Ave NW (existing pipeline)	86
RD13A	North road ditch at 49th St NW (existing pipeline)	104
RD13B	South road ditch at 49th St NW (Existing Mile Marker #18)	105
RD14A	East road ditch at 67th Ave NW (Existing Mile Marker #20)	120
RD14B	West road ditch at 67th Ave NW (existing pipeline)	121
F6	No apparent farm ditch between fields (existing pipeline)	143

Table 6 Roadway and Farm Ditches (From North to South)

Feature ID	Description	Photo Number(s) Appendix C
F7	No apparent farm ditch between fields (existing pipeline)	144
RD15A	East road ditch at 65th Ave NW (Existing Mile Marker #23)	145
RD15B	West road ditch at 65th Ave NW (existing pipeline)	146
RD16B	South road ditch at 45th St NW (existing pipeline)	151
RD16A	North road ditch at 45th St NW (existing pipeline)	152
RD17B	West road ditch at 63rd Ave NW (existing pipeline)	157
RD17A	East road ditch at 63rd Ave NW (Existing Mile Marker #26)	158
RD18A	East road ditch at 62nd Ave NW (Existing Mile Marker #26)	160
RD18B	West road ditch at 62nd Ave NW, surveyed: 6ft deep with 14.8° slope. DOC is 68-inches at bottom of ditch. (existing pipeline)	162
RD19A	North road ditch at 43rd St NW (existing pipeline)	164
RD19B	South road ditch at 43rd St NW (Existing Mile Marker #26)	165
RD27B	West road ditch at 61st St Ave NW (existing pipeline)	166
RD27A	East road ditch at 61st St Ave NW (existing pipeline)	167
RD20A	North road ditch at 42nd St NW (existing pipeline)	168
RD20B	South road ditch at 42nd St NW (existing pipeline)	169
F8	No apparent farm ditch between fields (existing pipeline)	170
RD21A	East road ditch at 62nd Ave NW (Existing Mile Marker #30). Note that two parallel GAP Midstream LLC pipelines cross here.	171-172
RD21B	West road ditch at 62nd Ave NW (existing pipeline)	173
RD22A	North road ditch at 41 St NW. No visible Ditch (proposed pipeline)	175
RD22B	South road ditch 41 St NW. No visible Ditch. (proposed pipeline)	176
F9	No apparent farm ditch between fields; near East Fork Shell Creek (proposed pipeline)	178
F10	No apparent farm ditch between fields; near East Fork Shell Creek (proposed pipeline)	189
RD23B	West road ditch at 66th St NW (proposed pipeline)	197
RD23A	East road ditch at 66th St NW (proposed pipeline)	198
RD24B	South road ditch at 247th Ave SW (proposed pipeline)	207
RD24A	North road ditch at 247th Ave SW (proposed pipeline)	208

4.7 Railroad Area

A portion of the proposed pipeline in Ward County is collocated with railroad ROW and runs along the ditch below the embankment. The proposed pipeline crosses railroad tracks at one location. There are three culverts that pass under the tracks that allow flow to continue from farm ditches or small streams. The pipeline crosses these areas and flows from the culverts have the potential to erode pipeline backfill. There were no visible stability or

erosion issues at the railroad features. The railroad companies typically construct and maintain their ROW to strict standards. Potential geohazards in the area of the railroad are summarized in **Table 7** and shown on the Avoidance Areas map sheets in **Appendix A**. The photograph numbers listed in **Table 7** are referencing the photolog provided in **Appendix C**. The slope near RR1 that rises above the proposed pipeline was measured and is 13 feet tall at an 18.4° slope. The slope is taller and steeper than most along the project and should be monitored. It appears that the slope was created during construction of the railroad.

Table 7 Railroad Area (From North to South)

Feature ID	Description	Photo Number(s) Appendix C
RR1	Start of ditch along railroad where proposed pipeline is parallel with slope rising above it to the north	190-191
RR XING	Proposed pipeline crossing under railroad	194-196
F11	Farm ditch where metal culvert passes under railroad; riprap at outlet	199-201
F12	Farm ditch where metal culvert passes under railroad; riprap at outlet	202-203
W15	Stream where concrete culvert passes under railroad; no riprap present	204-205
RR2	End of proposed pipeline in railroad ditch as it turns south	206

5 Surveys

The inspection and survey aimed to gather accurate information regarding the pipeline location and elevation relative to the surrounding ground elevations and topography. Survey equipment included a Trimble R12i Global Positioning System (GPS) receiver utilizing Trimble's Real Time eXtended (RTX) correction service to collect accurate georeferenced elevation data. All surveys were captured in the horizontal datum North America Datum of 1983 (2011), in the vertical datum North America Vertical Datum of 1988 using the GEOID18 (CONUS) geoid model, and in the zone North Dakota North (ND N-3301). Elevation data collected included existing grade, top of pipeline location and elevation, and points of inflection within a minimum of 25 feet upstream and downstream of the pipeline and at least 50 feet from the top of the high banks of sufficient resolution to accurately capture slopes and geohazard form. DOC measurements were obtained using a Radio Detection 8200 locator and were recorded using the Trimble R12i GPS receiver.

6 Conclusions and Recommendations

Geohazard-related risk can be mitigated by avoidance of geohazards by either modifying the geohazard to decrease the likelihood of occurrence or reducing the vulnerability of the pipeline. Arcadis has created an inventory of geohazards within the project corridors for both the proposed and existing pipelines that could potentially impact pipeline integrity. It is recommended that the inventory be supported by a GIS-based component that is maintained and enhanced throughout the life of the asset. Monitoring is recommended, especially in the areas of the potential landslides (features S1, S2, AOC1, and AOC2), and underground mines (features M1 and M2) as shown on the Avoidance Areas map sheets in **Appendix A**. Features AOC1, and AOC2 are also shown on the survey figures in **Appendix E.** Monitoring should minimally consist of a desktop review every 5 to 10 years. If instability is observed in the future, field inspections and more frequent monitoring should be implemented for those locations.

The potential geohazards within the project corridors for both the existing pipeline and the proposed pipeline were evaluated and the results are summarized in the table provided in **Appendix B**. Based on the desktop review, GIS data, aerial imagery, and the field survey, there are no “geologically unstable” areas that presently exhibit signs of instability within the 50-foot-wide project corridor for the existing pipeline or within the 200-foot-wide project corridor for the proposed pipeline. Features considered as avoidance areas due to their unknown extents are the active landslides S1 and S2, and the underground mines M1 and M2; however, these features appear to be outside of the project corridors.

7 Limitations of Assessment

This report has been prepared by Arcadis for Thunder Butte Pipeline, LLC to present the observations and findings of the desktop review and site surveillance/field assessments conducted August 5th through 7th, 2024. This report is not intended for use by others and is not applicable to other sites. The reader is cautioned that conditions between and/or outside observation points may vary considerably.

8 References Cited and GIS Resources

Anderson, F. 2016. North Dakota Earthquake Catalog (1870 to 2015). Miscellaneous Series No. 93. North Dakota Geological Survey.

Clayton, L. 1972. Geology of Montrail County North Dakota. North Dakota Geological Survey Bulletin 55-IV. North Dakota State Water Commission County Groundwater Study 14-IV.

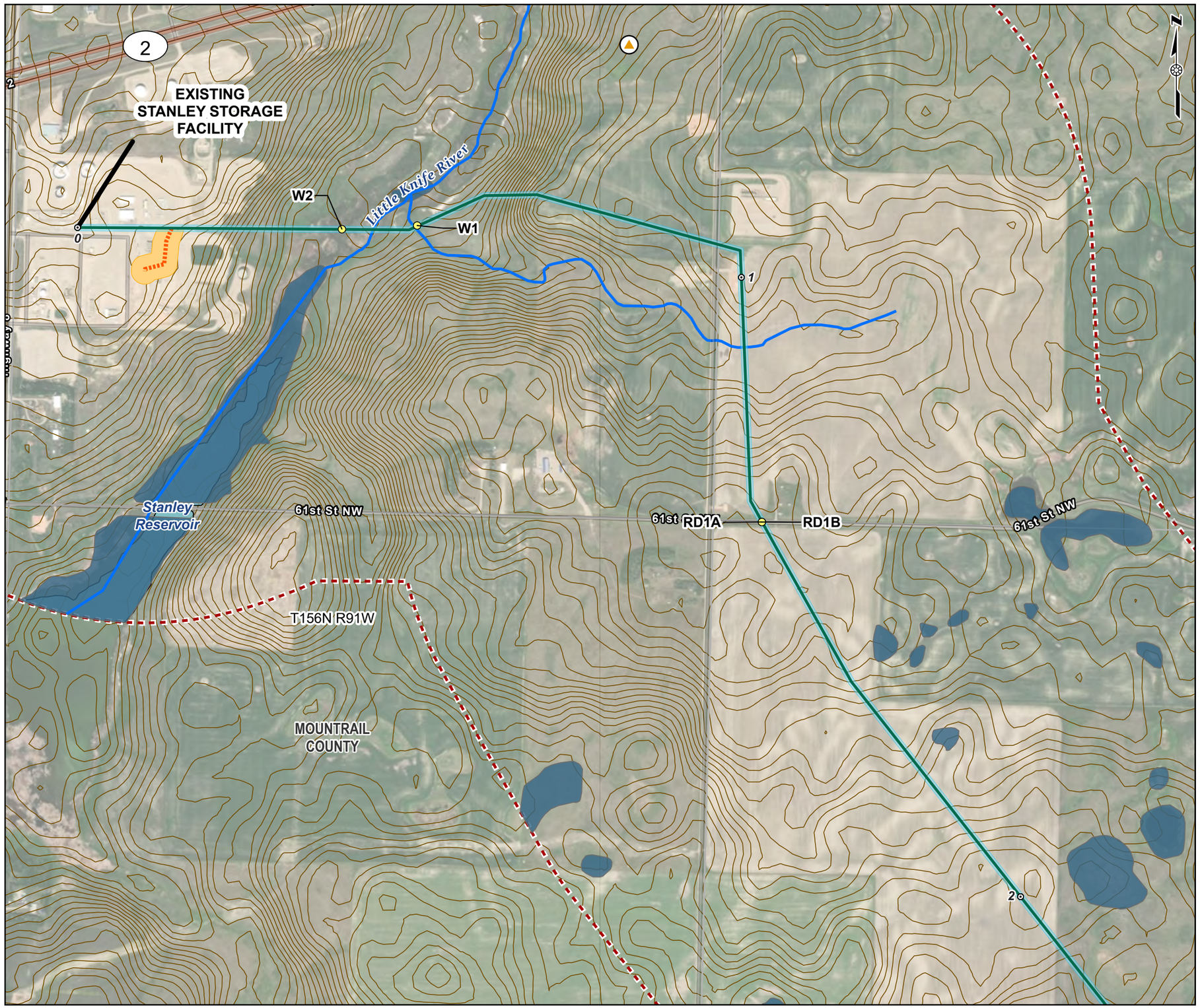
Natural Resources Conservation Service (NRCS). 2023. Web Soil Survey – Custom Soil Resource Report for Montrail and Ward Counties, North Dakota. Available at https://websoilsurvey.sc.egov.usda.gov /App/WebSoilSurvey.aspx. Accessed: August 2024.

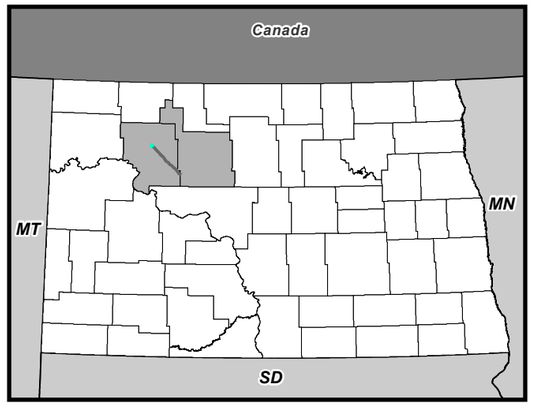
GIS Data Resources

1. National Wetlands Inventory (NWI) Wetland Data is obtained from the U.S. Fish & Wildlife Service at: www.fws.gov.
2. National Hydrography Dataset (NHD) is obtained from the U.S. Geological Survey at: https://nhd.usgs.gov.
3. North Dakota Department of Transportation (NDDOT) Landmarks (e.g., occupied residence, barn, railways, sand and gravel sites, etc.) is obtained from NDDOT at: https://www.gis.nd.gov/data.
4. Oil and Gas Well Information is obtained from the Department of Mineral Resources (DMR) Oil and Gas Division at: https://gis.dmr.nd.gov/gisdownload.asp.
5. PLOTS land is obtained from North Dakota Game and Fish (NDGF) at: https://gf.nd.gov/maps/data.
6. Surface Tracks Lands (i.e., school lands) is obtained from North Dakota Department of Trust Lands at: https://www.land.nd.gov/.
7. Landslide Data is obtained from the North Dakota Geological Survey (NDGS) at: https://www.dmr.nd.gov/ndgs/landslides/counties/.
8. Bureau of Indian Affairs (BIA) Land Area Representation (LAR) of Federally-Recognized Tribes is obtained from U.S. Domestic Sovereign Nations: https://bia-geospatial-internal.geoplatform.gov/indianlands/.
9. Digital Elevation Models (DEMs) from Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global are obtained from the U.S. Department of the Interior U.S. Geological Survey at: https://www.usgs.gov/tools/earthexplorer.
10. Abandoned Mines Data is obtained from the Abandoned Mine Lands Division from the North Dakota Public Service Commission at: https://www.psc.nd.gov/jurisdiction/aml/index.php.

Appendix A

Avoidance Area Map Sheets with Geohazards





Legend

- Milepost
- Geohazard Survey Location
- Gravel Pit
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)
- 200-foot Project Corridor (100 feet on either side of the pipeline centerline)

ID	Description
W1	Stream crossing No. 1, branch of Little Knife River
W2	Stream crossing No. 2 at Little Knife River
RD1A	North road ditch at 61st St NW
RD1B	South road ditch at 61st St NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

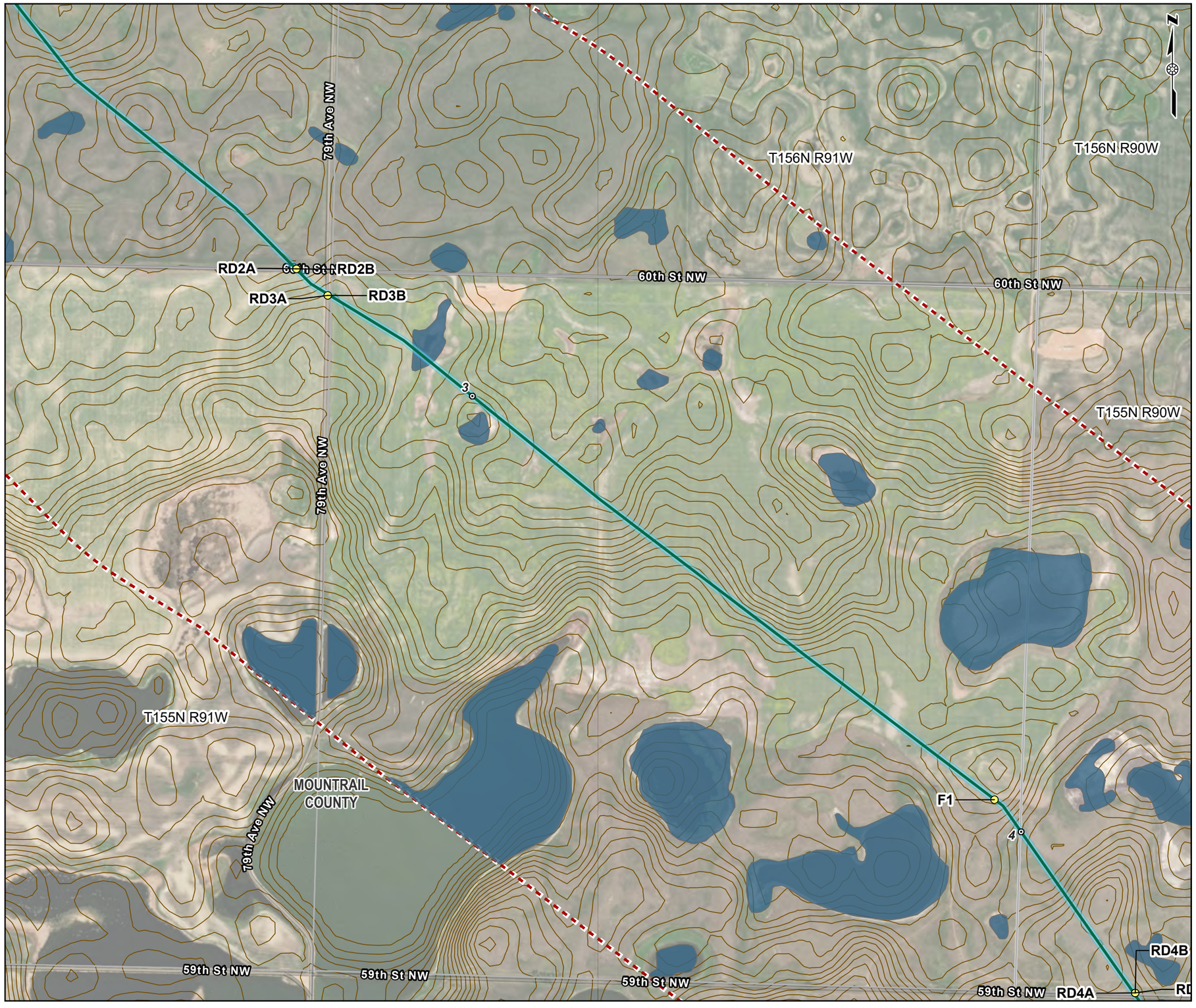
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

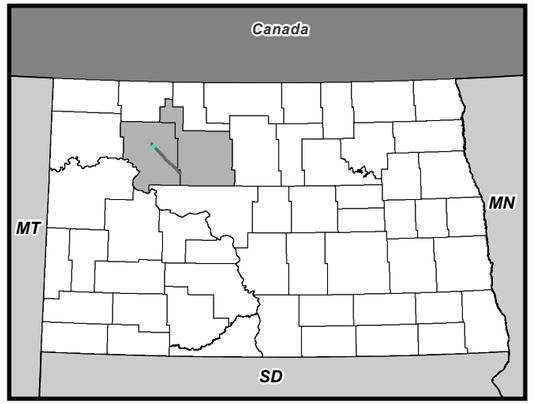
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 1 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD2A	North road ditch at 60th St NW
RD2B	South road ditch at 60th St NW
RD3B	West road ditch at 79th Ave NW
RD3A	East road ditch at 79th Ave NW
F1	No apparent farm ditch between fields
RD4A	North road ditch at 59th St NW
RD4B	South road ditch at 59th St NW
RD4B	Upslope of south road ditch at 59th St NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

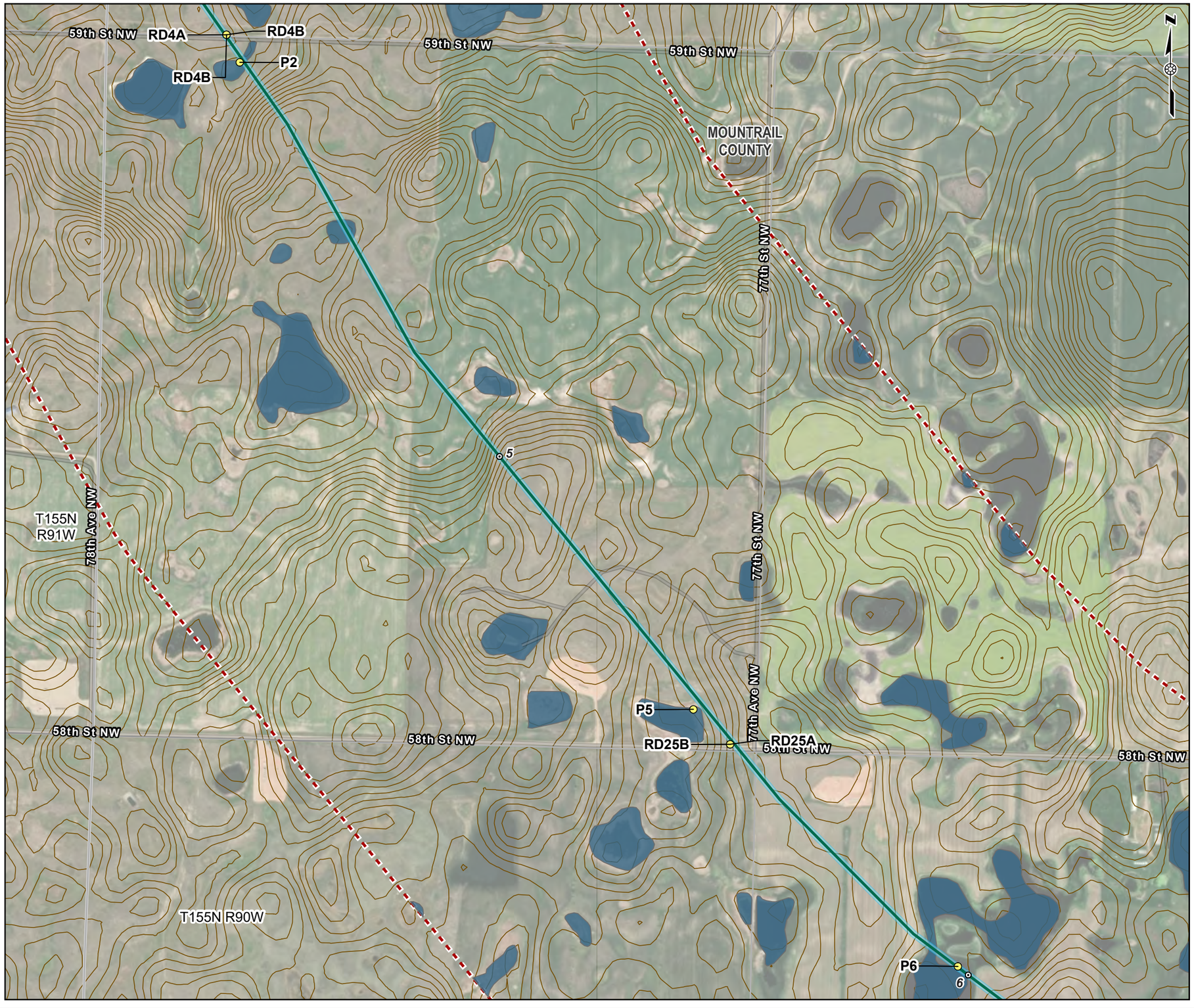
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 2 OF 19

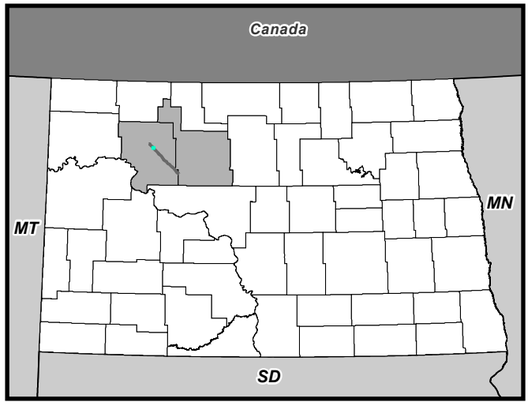
PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD4A	North road ditch at 59th St NW
RD4B	South road ditch at 59th St NW
RD4B	Upslope of south road ditch at 59th St NW
P2	NWI Pond No. 2
P5	NWI Pond No. 5
RD25A	North road ditch at 58th St NW
RD25B	South road ditch at 58th St NW
P6	NWI Pond No. 6

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

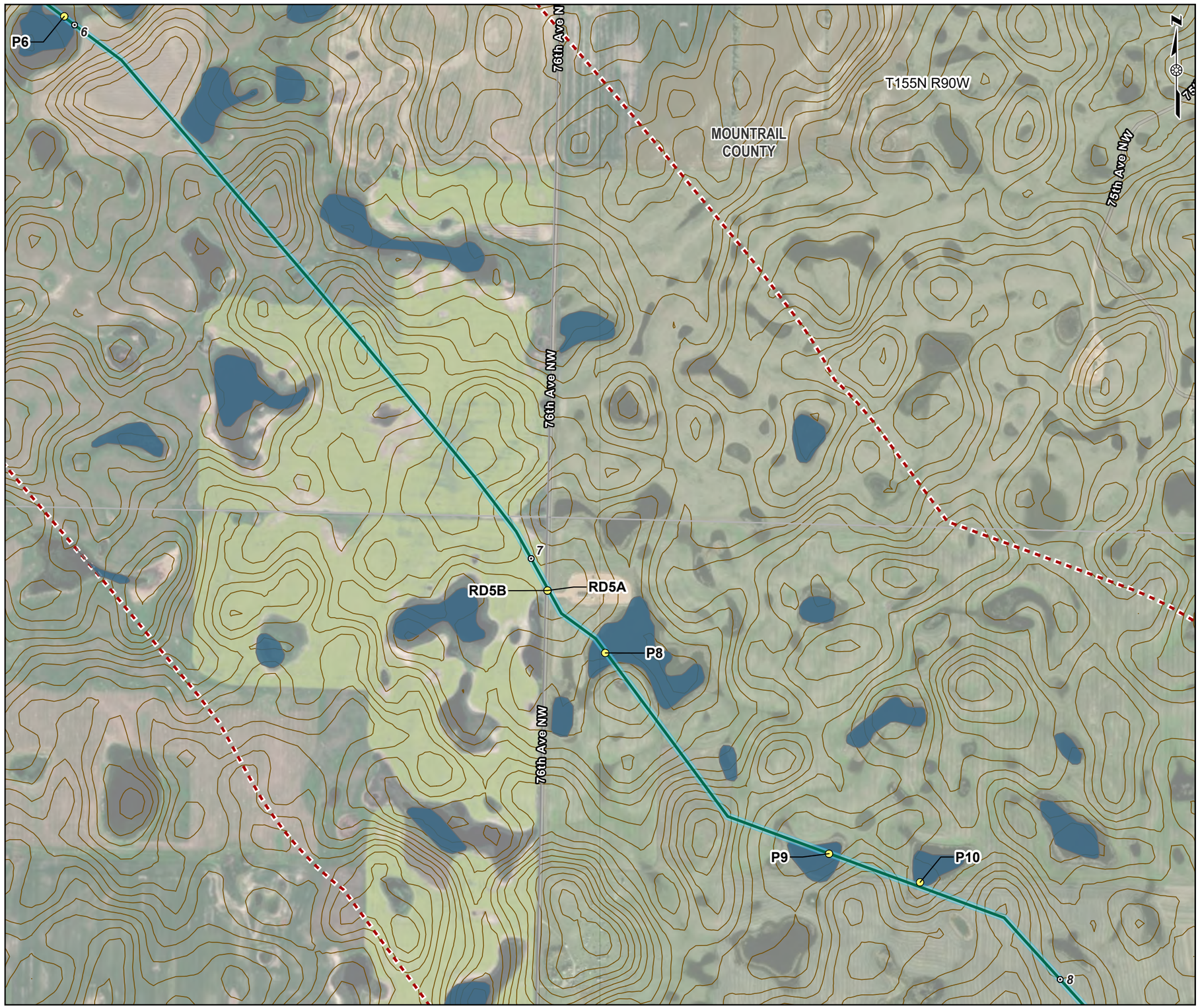
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

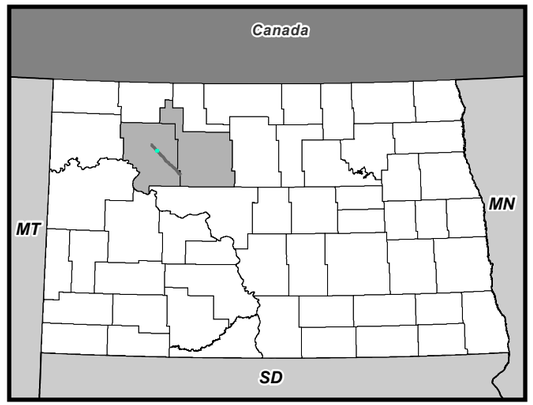
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 3 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
P6	NWI Pond No. 6
RD5A	East road ditch at 76th Ave NW
RD5B	West road ditch at 76th Ave NW
P8	NWI Pond No. 8
P9	NWI Pond No. 9
P10	NWI Pond No. 10

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

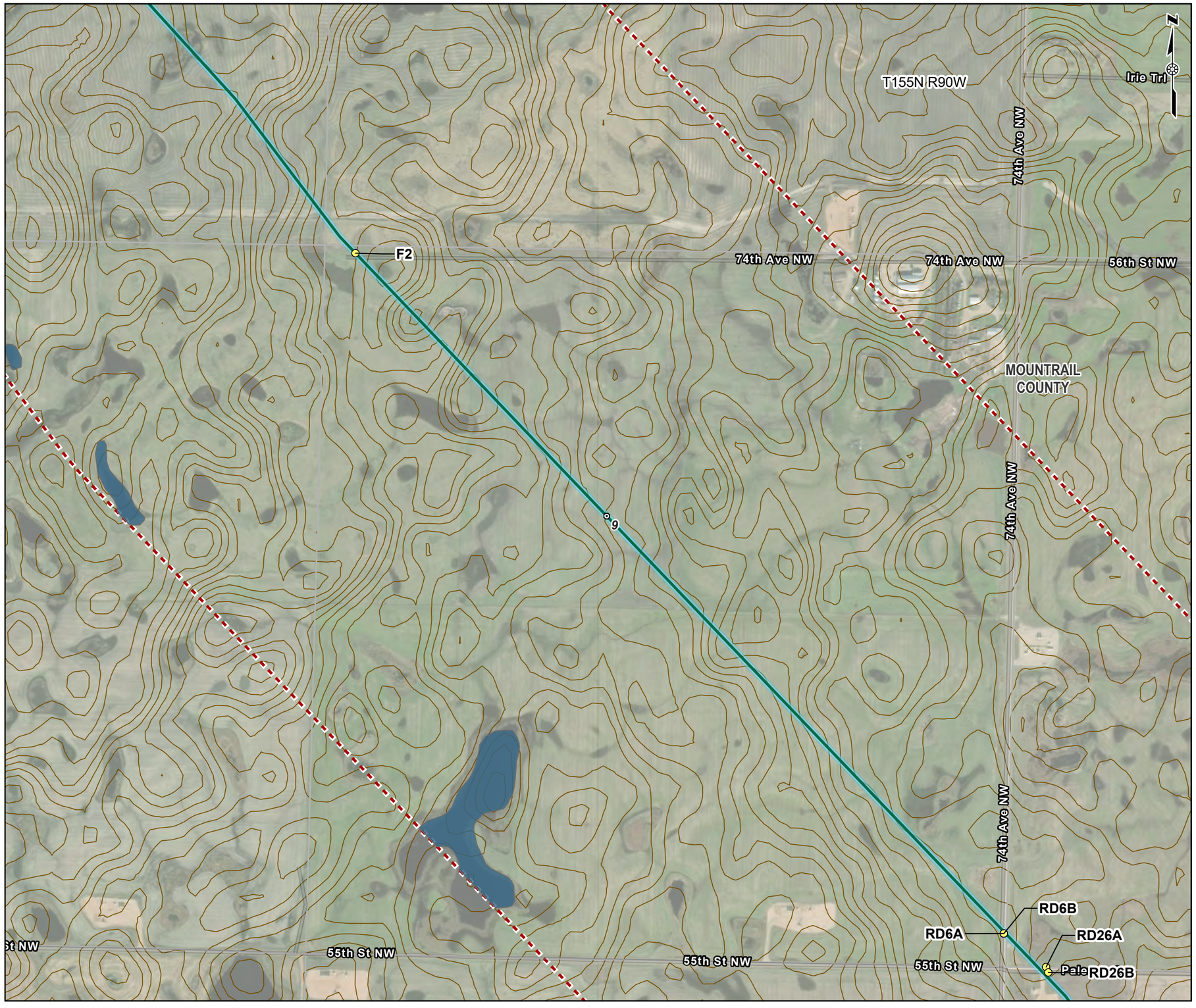
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 4 OF 19

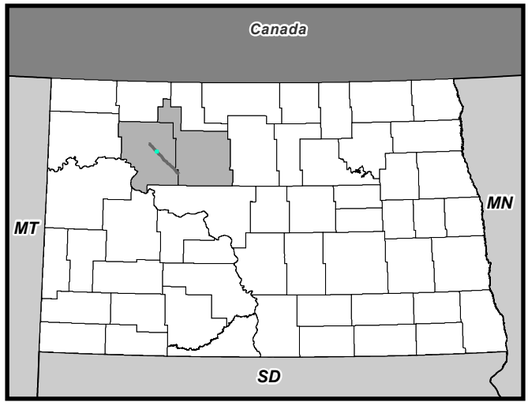
PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
F2	No apparent farm ditch between fields
RD6A	East road ditch at 74th Ave NW (Hwy 3)
RD6B	West road ditch at 74th Ave NW (Hwy 3)
RD26A	North road ditch at 55th St NW / Palermo Rd
RD26B	South road ditch at 55th St NW / Palermo Rd

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

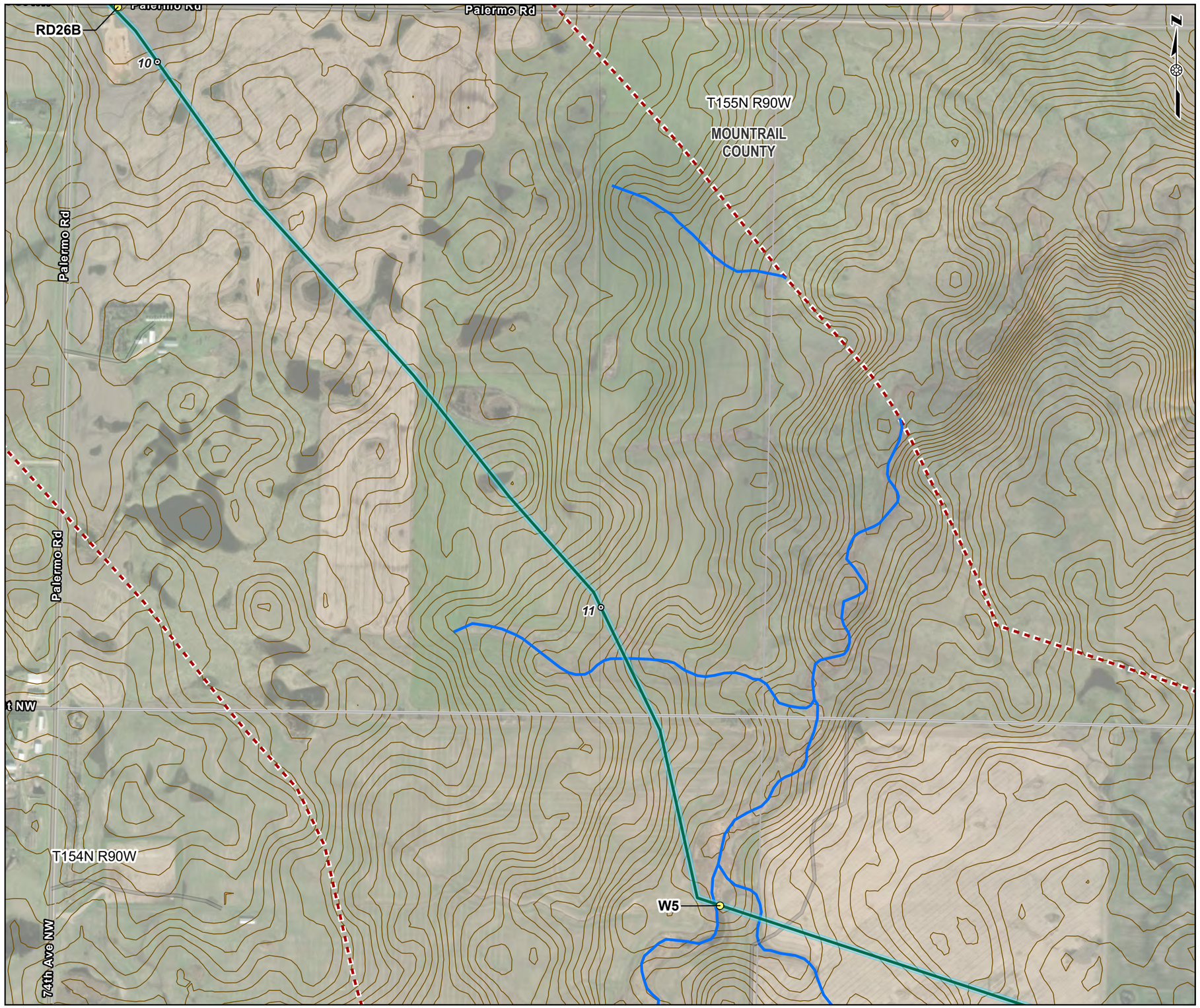
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

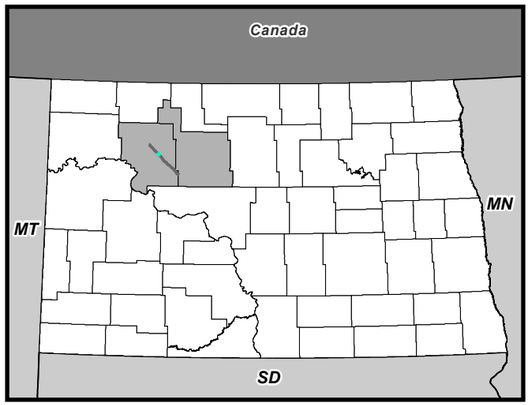
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 5 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD26A	North road ditch at 55th St NW / Palermo Rd
RD26B	South road ditch at 55th St NW / Palermo Rd
W5	Waterway No. 5

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

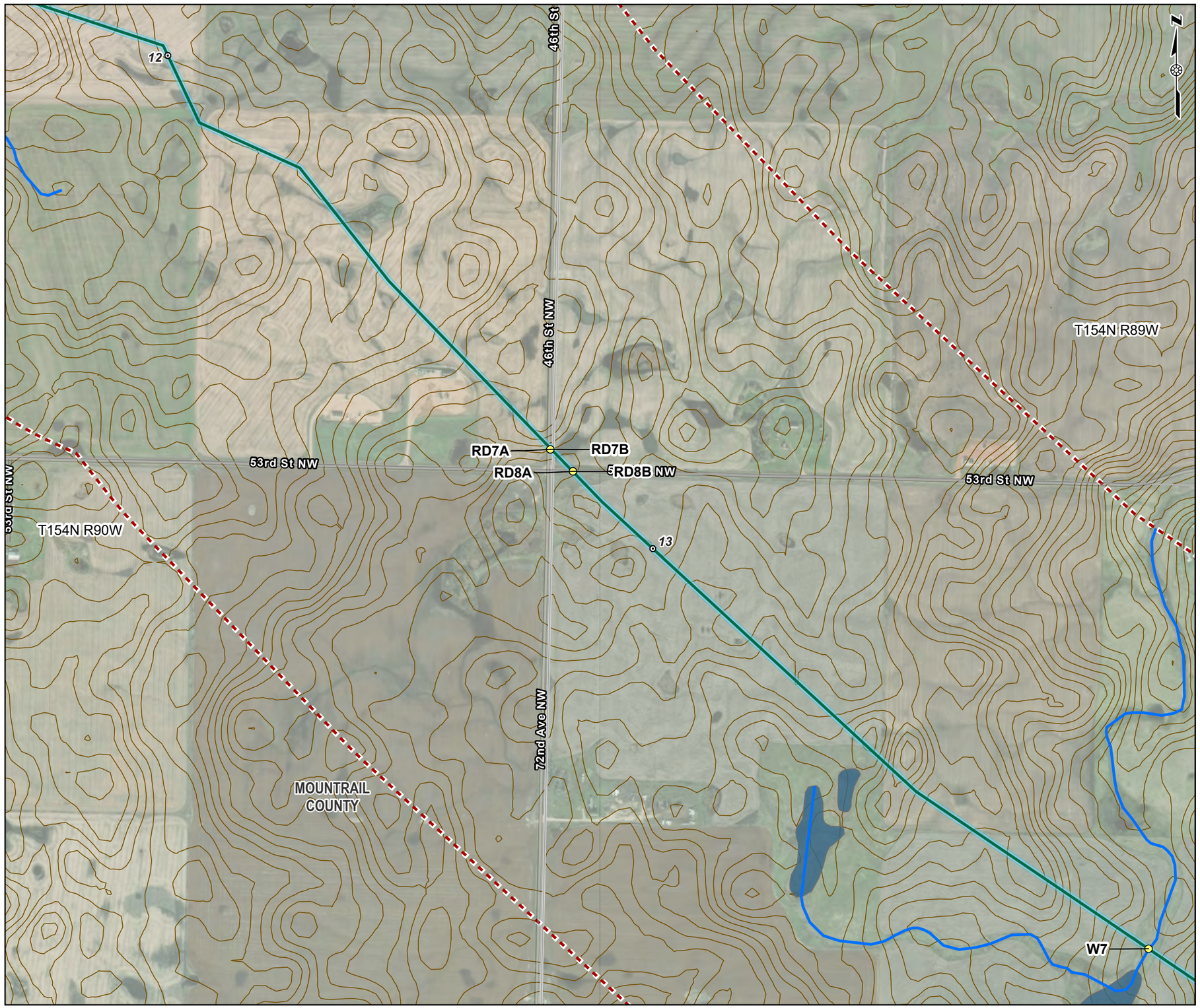
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

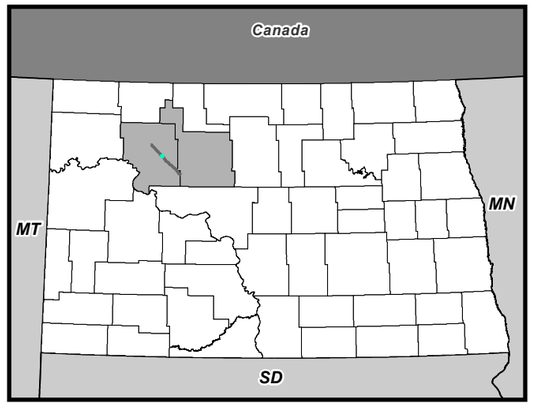
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 6 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD7A	East road ditch at 46th St NW
RD7B	West road ditch at 46th St NW
RD8B	South road ditch at 53rd St NW
RD8A	North road ditch at 53rd St NW
W7	Stream crossing No. 7 at unnamed stream

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

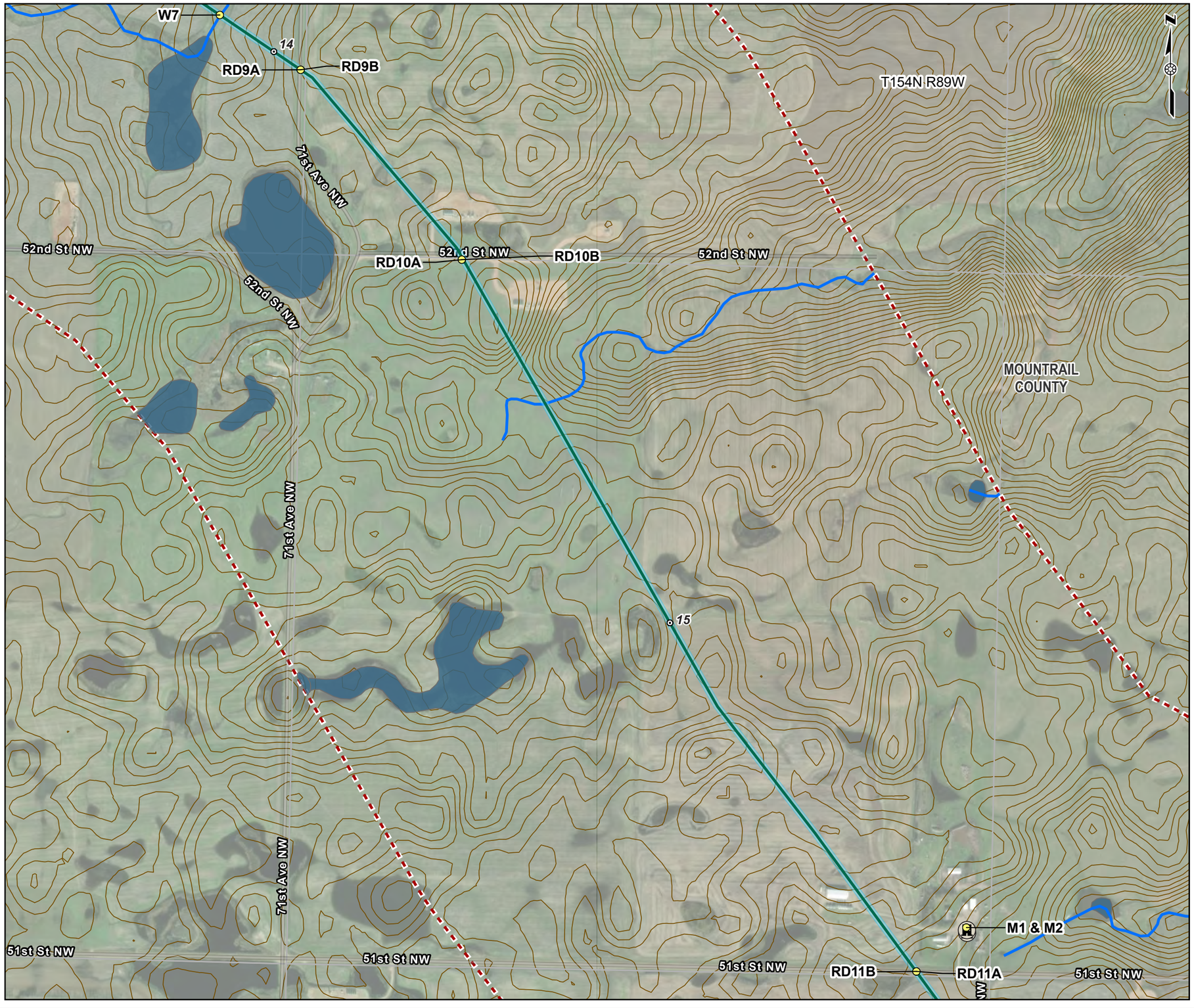
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

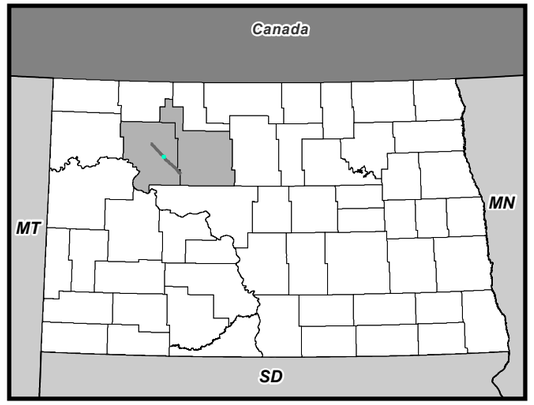
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 7 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Abandoned Coal Mine
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
W7	Stream crossing No. 7 at unnamed stream
RD9B	West road ditch at 71st Ave NW
RD9A	East road ditch at 71st Ave NWeast
RD10A	North road ditch at 52nd St NW
RD10B	South road ditch at 52nd St NW
M1 & M2	NDGS Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine
RD11A	North road ditch at 51st St NW
RD11B	South road ditch at 51st St NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

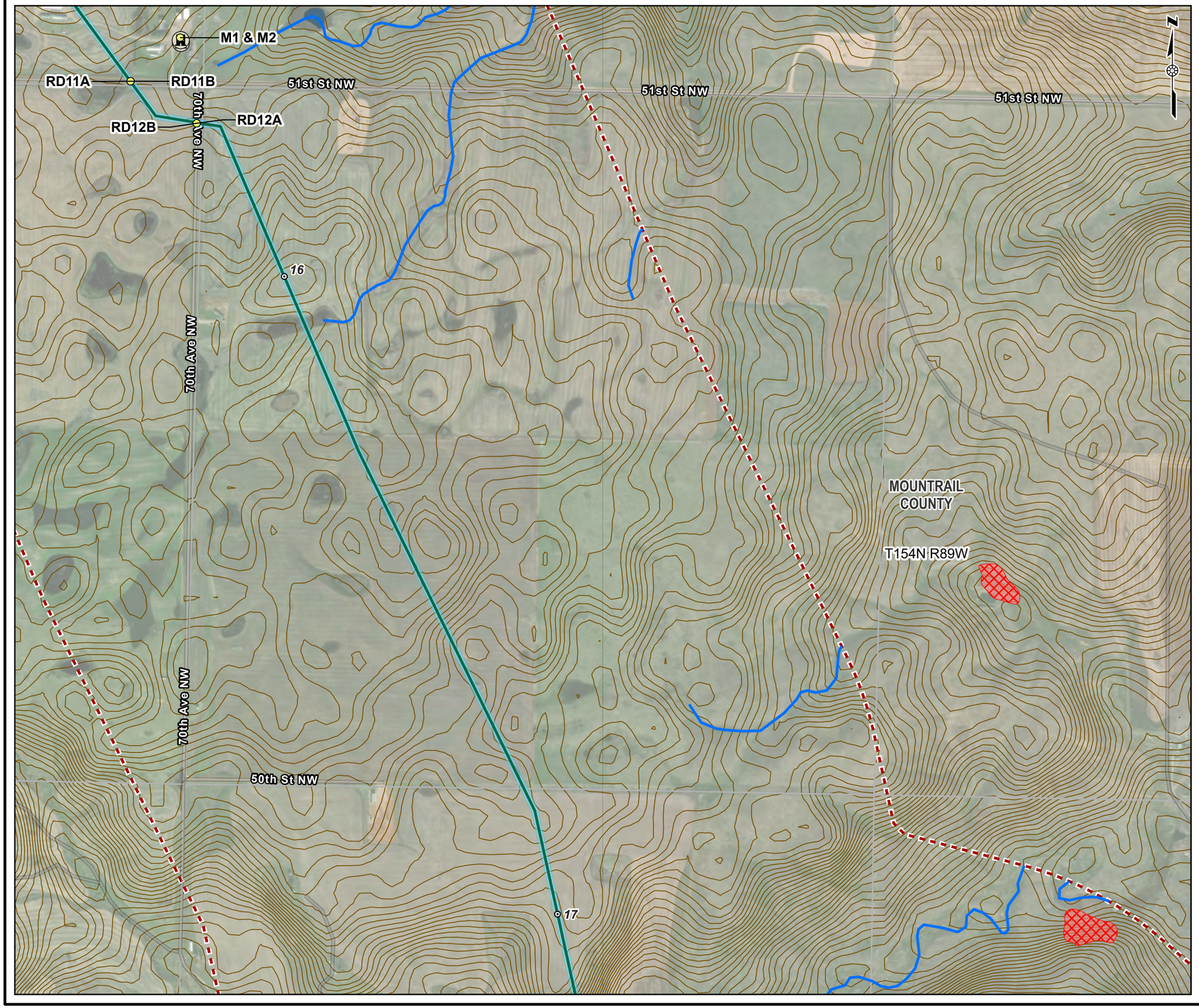
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

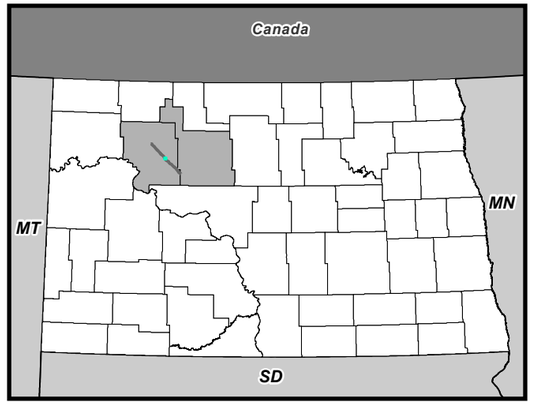
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 8 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Abandoned Coal Mine
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
M1 & M2	NDGS Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine
RD11A	North road ditch at 51st St NW
RD11B	South road ditch at 51st St NW
RD12A	East road ditch at 70th Ave NW
RD12B	West road ditch at 70th Ave NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

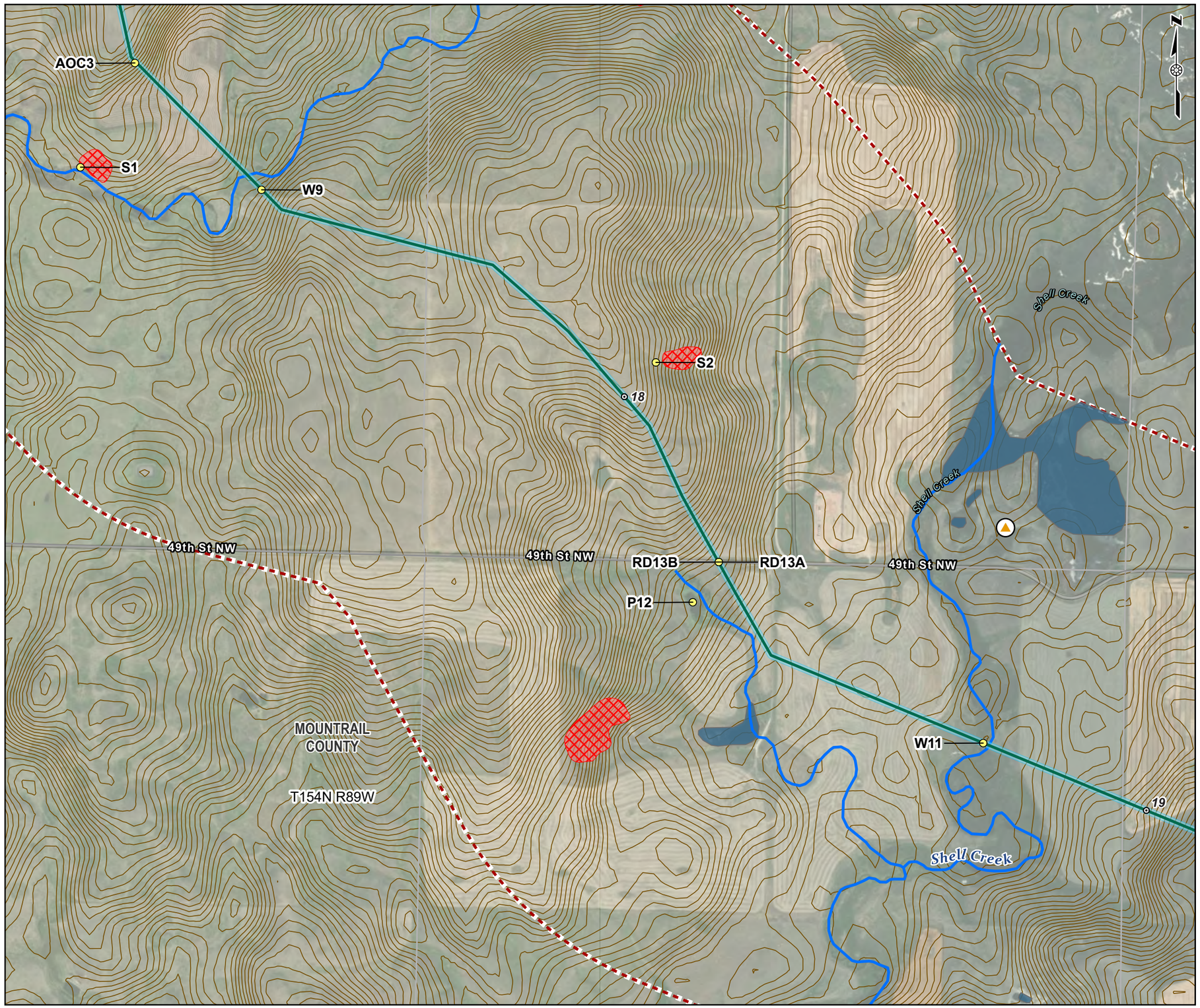
NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

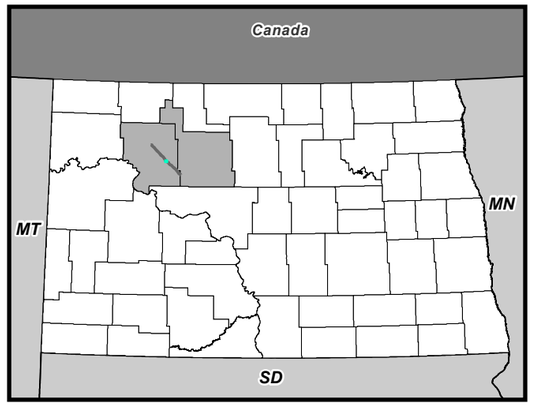
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 9 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Gravel Pit
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
AOC3	Area of concern. Steep 16:1 slope along pipeline
S1	NDGS Slide No. 1
W9	Stream crossing No. 9 at unnamed stream
S2	NDGS Slide No. 2
RD13A	North road ditch at 49th St NWwest
RD13B	South road ditch at 49th St NW
P12	NWI Pond No. 12
W11	Shell Creek crossing

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

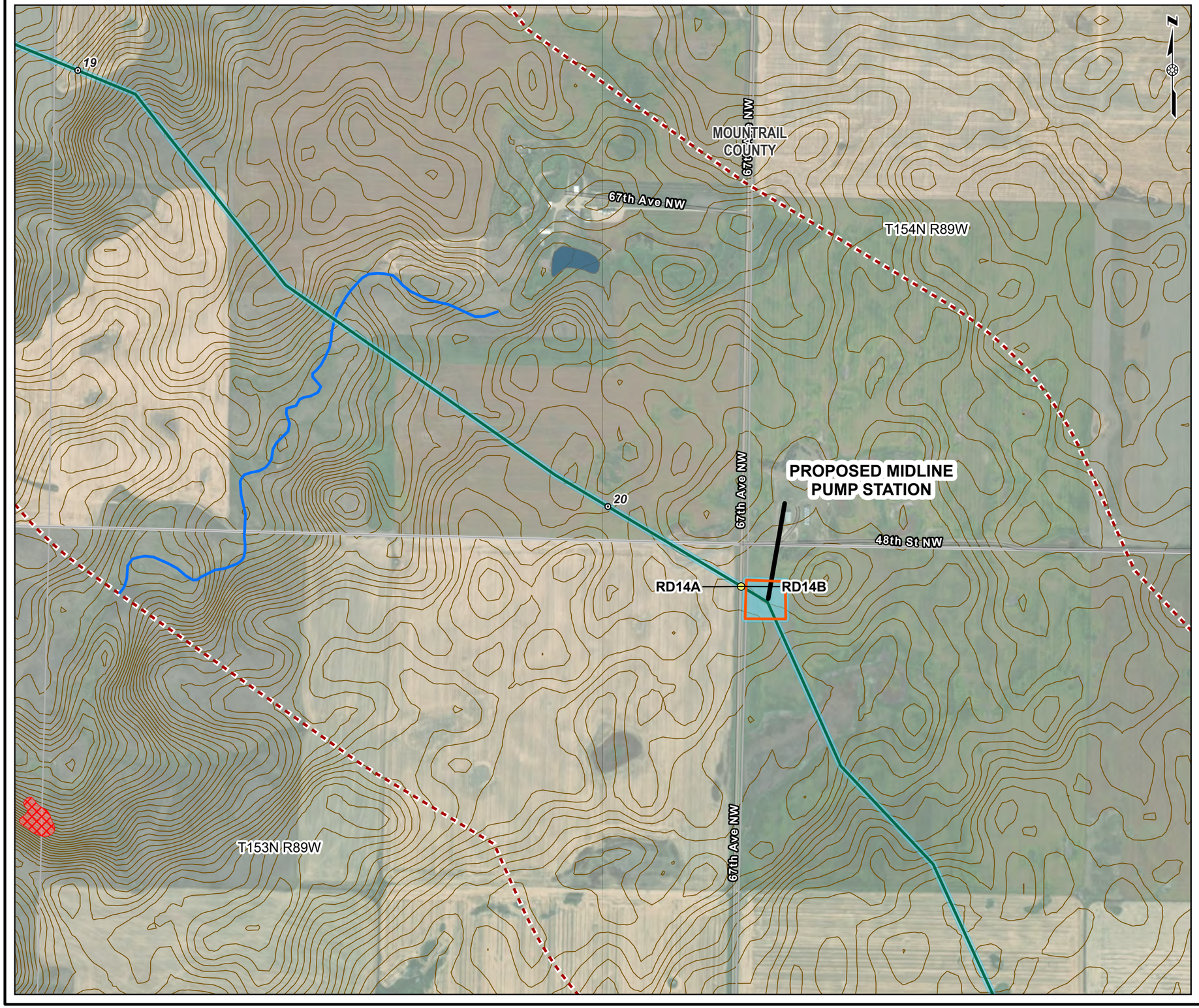
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 10 OF 19

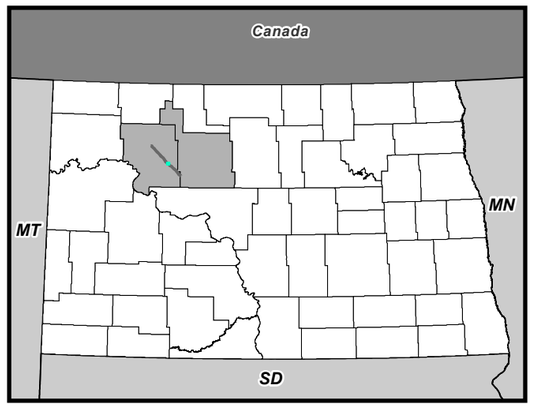
PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- Proposed Midline Pump Station - 2.0 acres
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD14A	East road ditch at 67th Ave NW
RD14B	West road ditch at 67th Ave NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

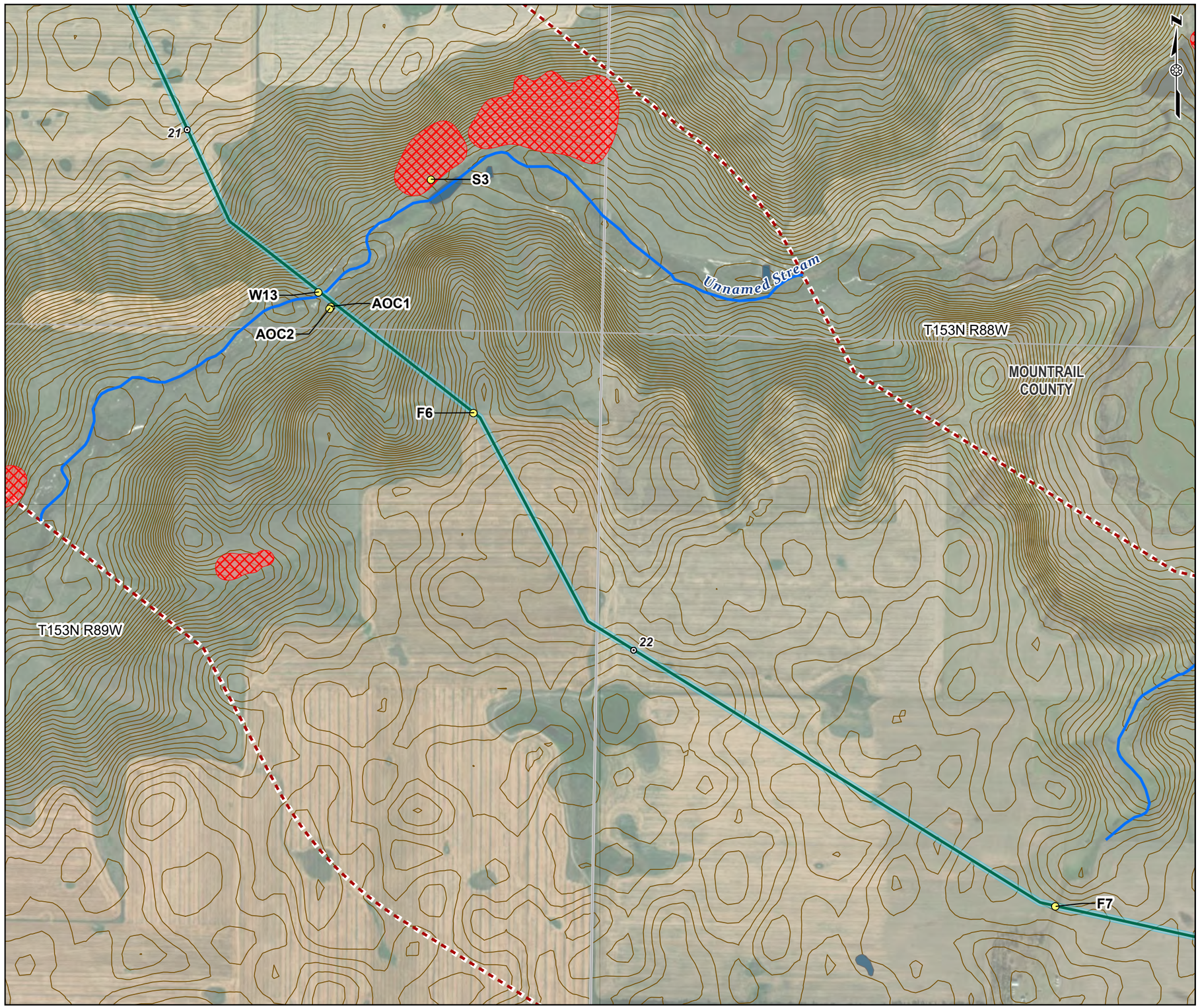
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

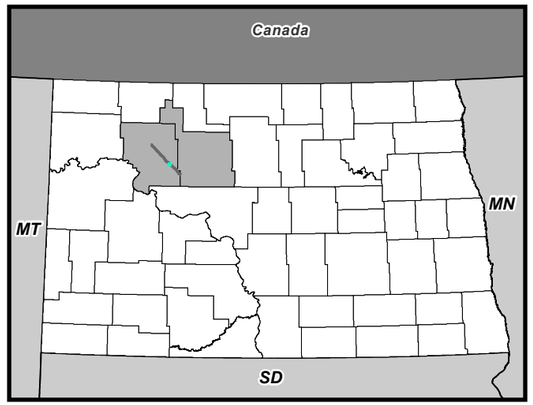
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 11 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
S3	NDGS Slide No. 3 along unnamed stream
W13	Stream crossing No. 13
AOC1	Area of concern. Area along pipeline shows disturbance, likely from construction and grass didn't establish.
AOC2	Area of concern. Steep slope on south side of W13 located 15 ft south of pipeline
F6	No apparent farm ditch between fields
F7	No apparent farm ditch between fields

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 12 OF 19

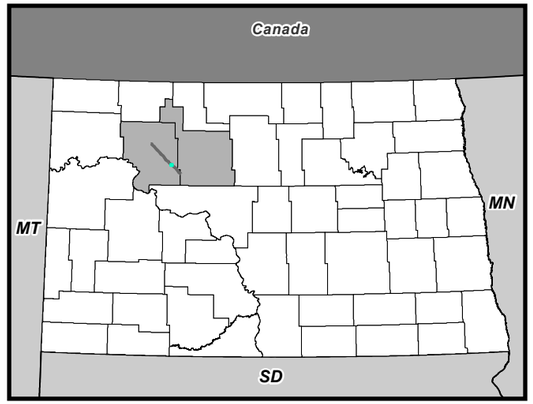
PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx

F7
RD15B
23
RD15A
65th Ave NW
46th St NW
46th St NW
46th St NW
64th Ave NW
24
MOUNTRAIL COUNTY
65th Ave NW
64th Ave NW
T153N R88W
45th St NW
65th Ave NW
45th St NW
45th St NW
64th Ave NW
45th St NW



Legend
- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
F7	No apparent farm ditch between fields
RD15A	East road ditch at 65th Ave NW
RD15B	West road ditch at 65th Ave NW

0 500 1,000 1,500 2,000 Feet
GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

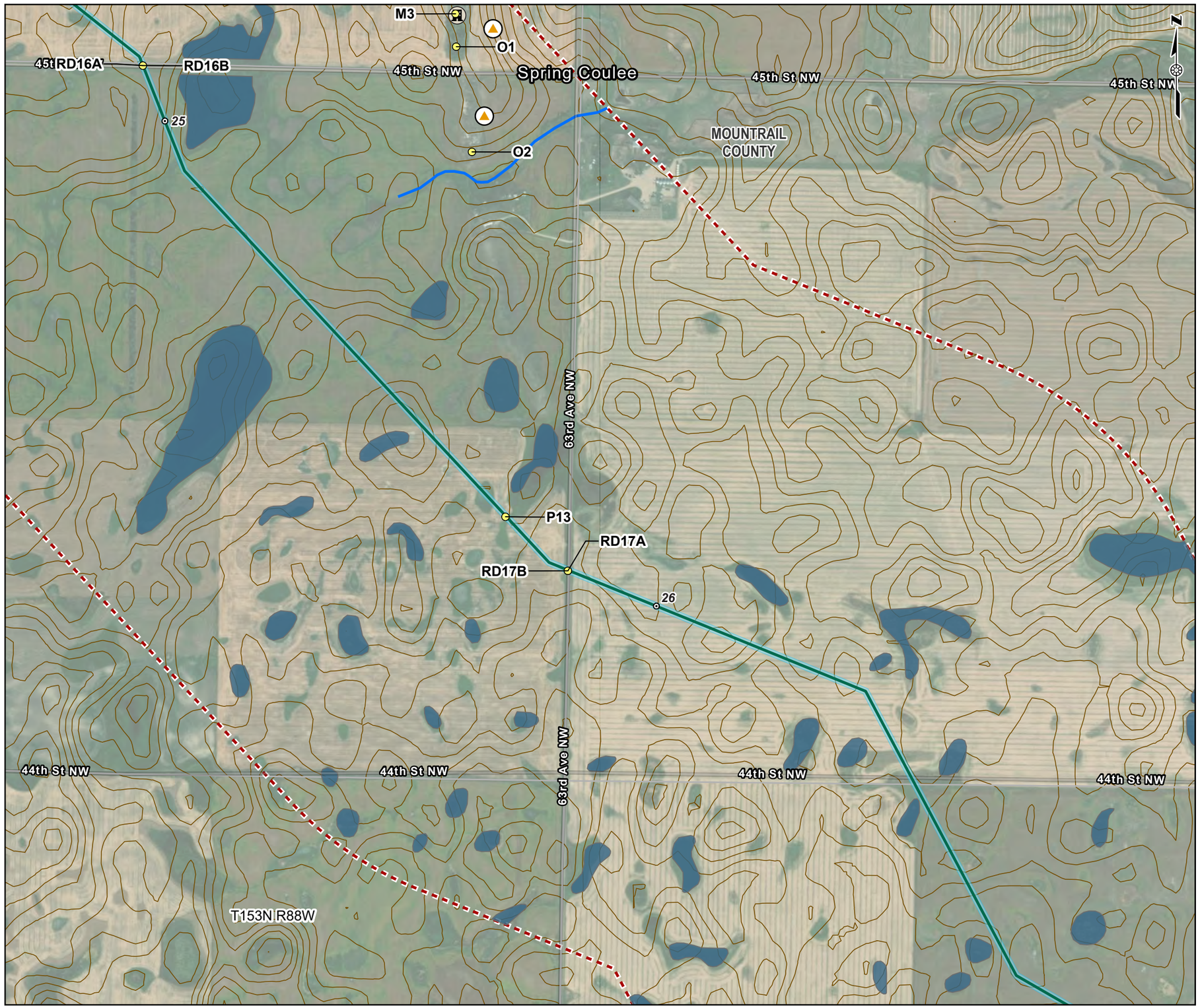
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

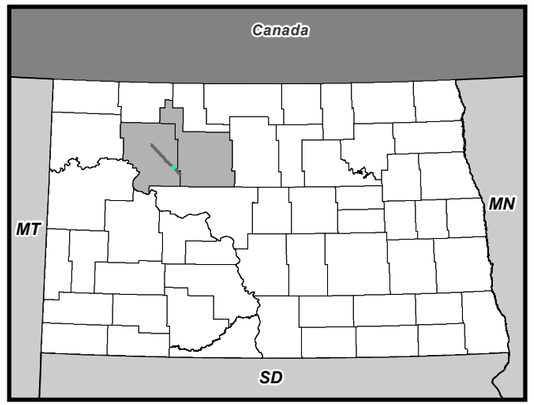
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 13 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Abandoned Coal Mine
- Gravel Pit
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
M3	NDGS Mine No. 3, surface mine (unknown)
O1	NDGS Gravel open pit No. 1
RD16B	South road ditch at 45th St NW
RD16A	North road ditch at 45th St NW
O2	NDGS Gravel open pit No. 2
P13	NWI Pond No. 13
RD17B	West road ditch at 63rd Ave NW
RD17A	East road ditch at 63rd Ave NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

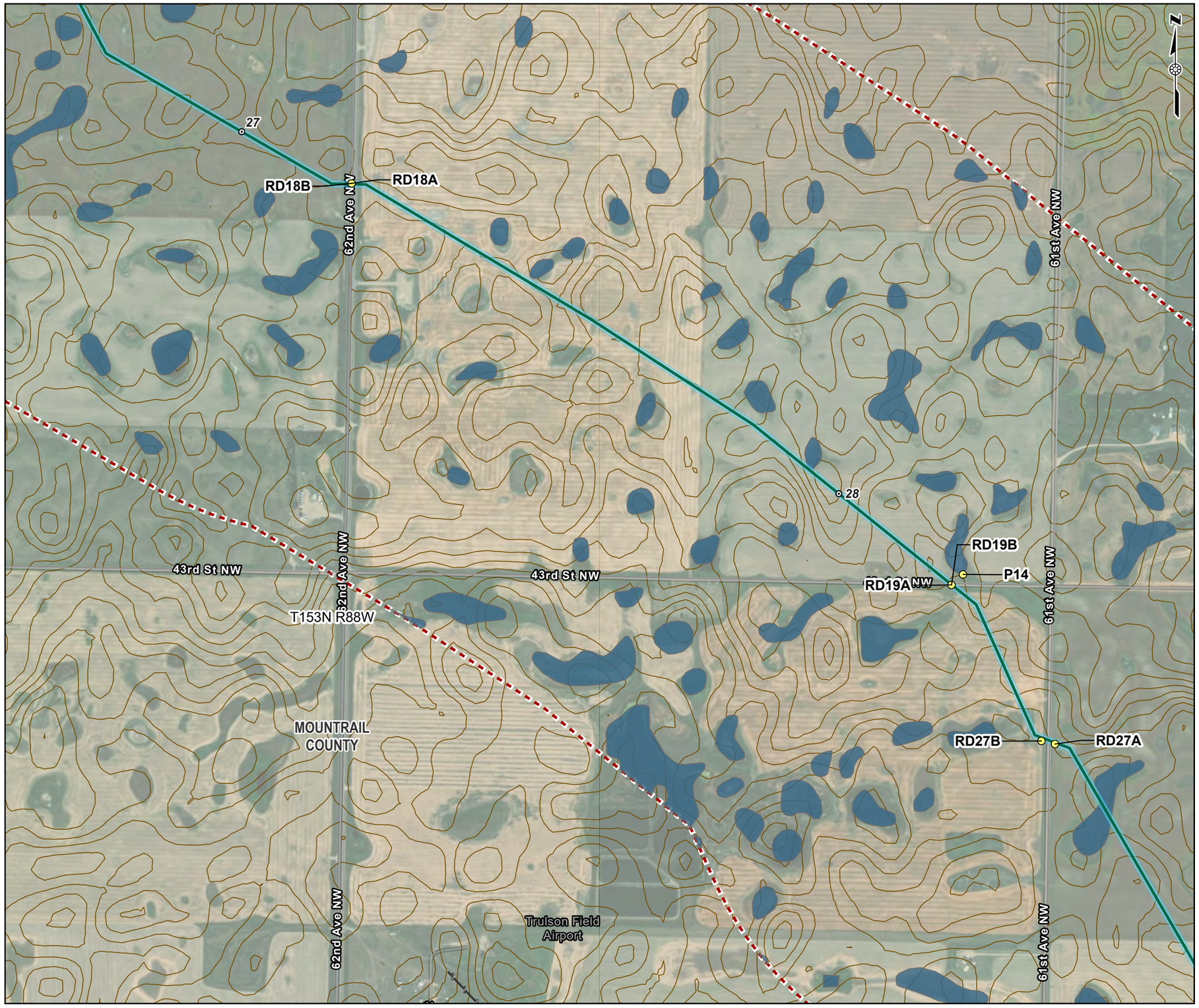
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

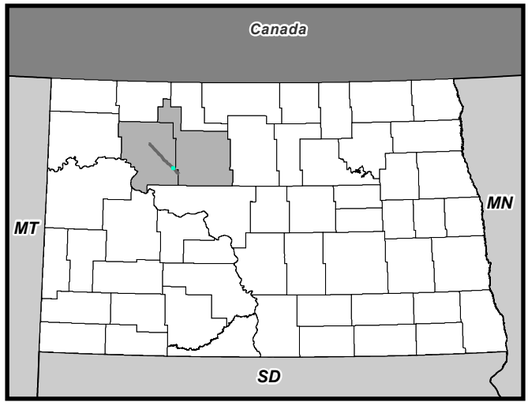
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 14 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)

ID	Description
RD18A	East road ditch at 62nd Ave NW
RD18B	West road ditch at 62nd Ave NW
P14	NWI Pond No. 14
RD19A	North road ditch at 43rd St NW
RD19B	South road ditch at 43rd St NW
RD27B	West road ditch at 61st St Ave NW
RD27A	East road ditch at 61st St Ave NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

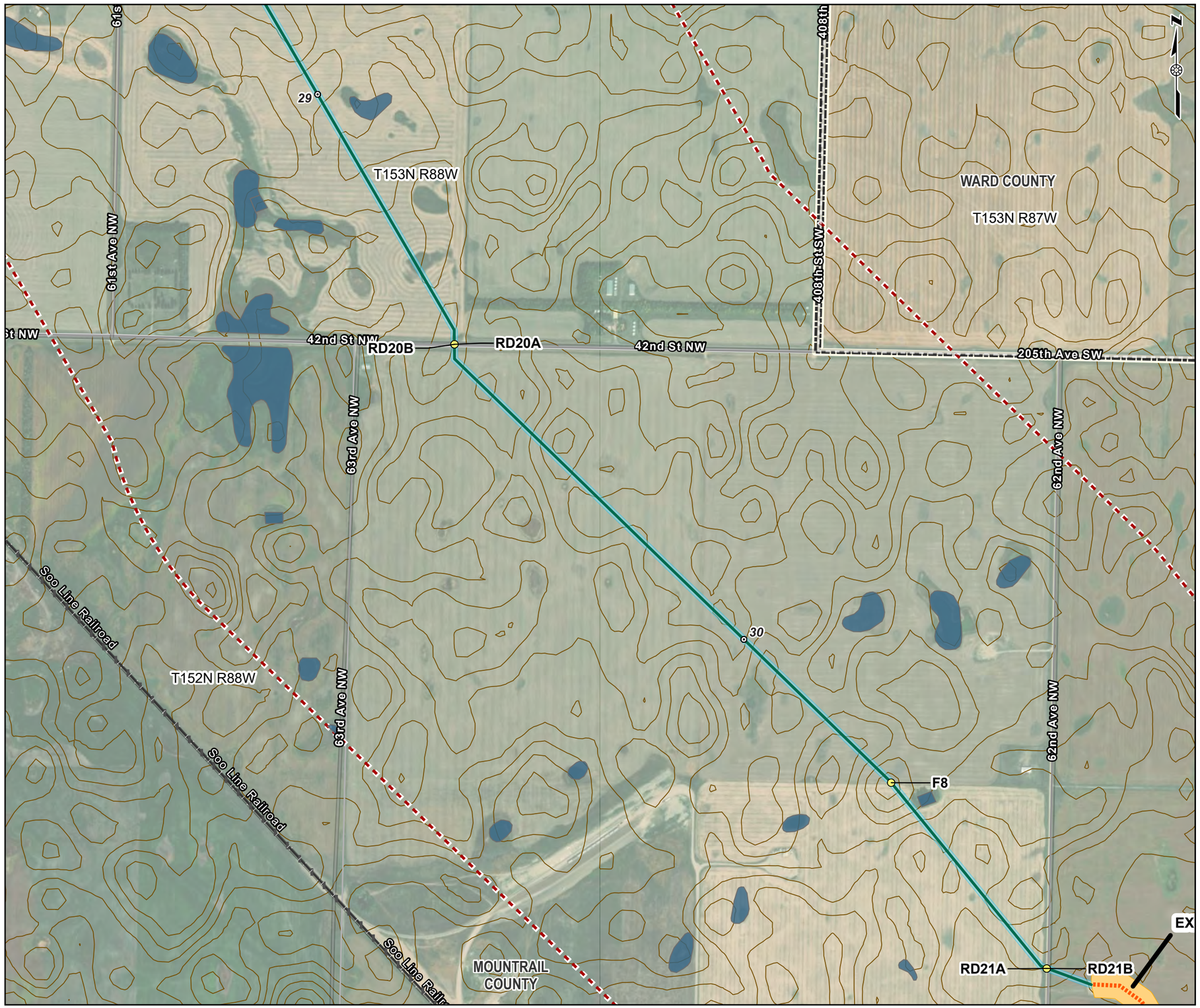
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

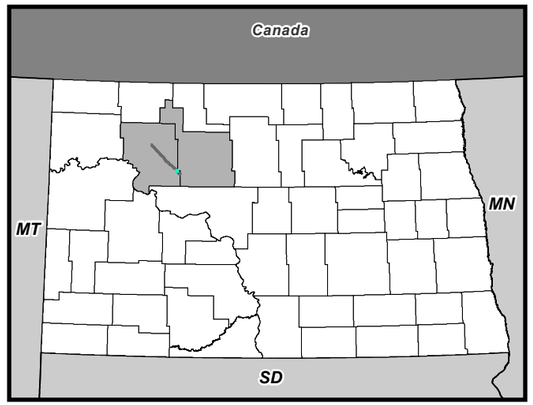
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 15 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)
- 200-foot Project Corridor (100 feet on either side of the pipeline centerline)

ID	Description
RD20A	North road ditch at 42nd St NW
RD20B	South road ditch at 42nd St NW
F8	No apparent farm ditch between fields
RD21A	East road ditch at 62nd Ave NW (near existing Mile Marker #30). Two parallel GAP pipelines cross here
RD21B	West road ditch at 62nd Ave NW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL AND WARD COUNTY, NORTH DAKOTA

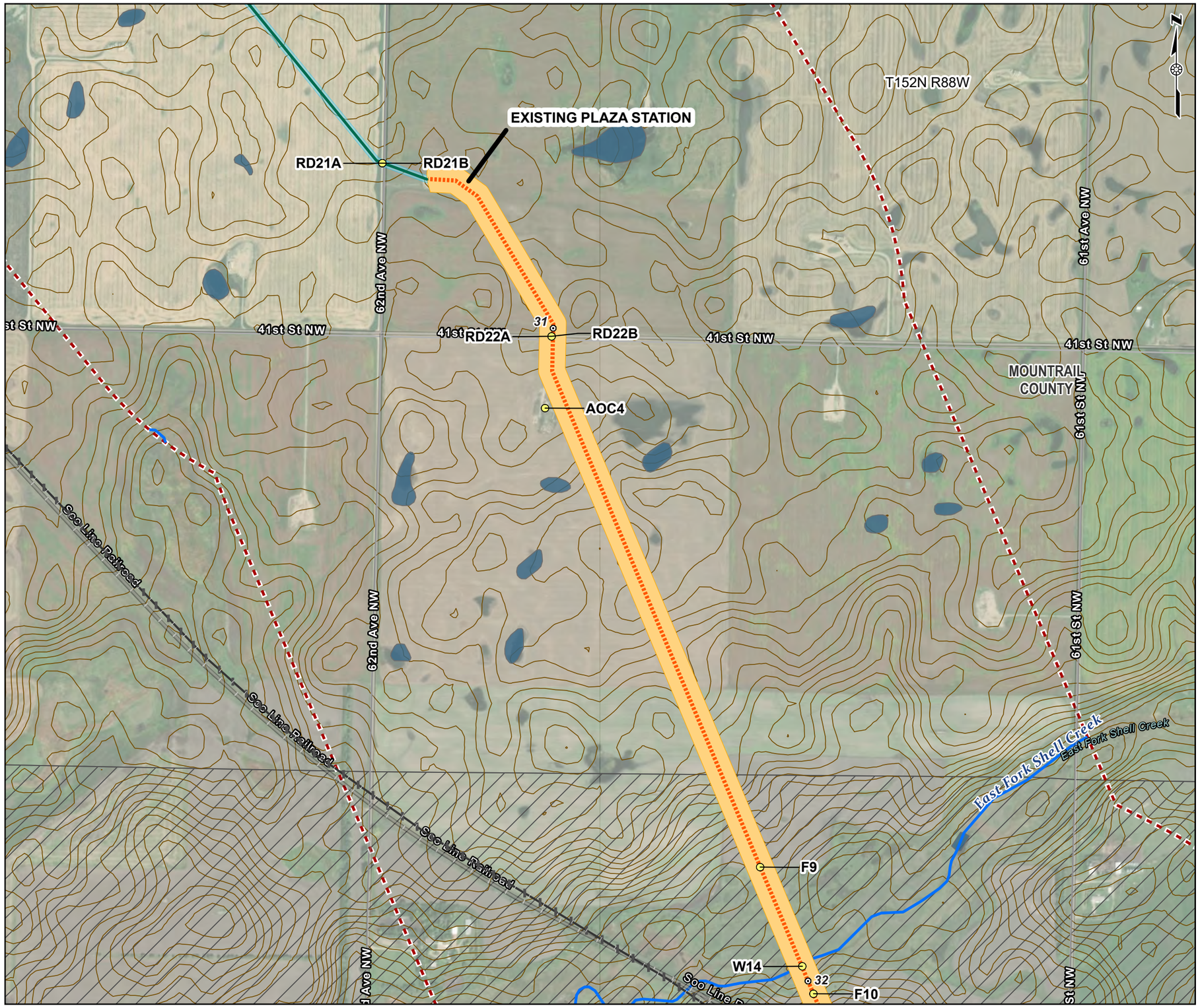
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 16 OF 19

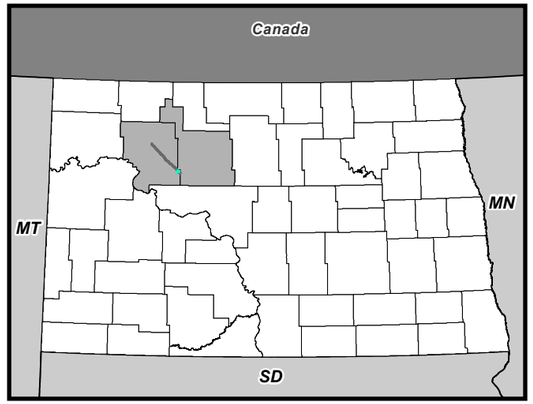
PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 50-foot Project Corridor (25 feet on either side of the pipeline centerline)
- 200-foot Project Corridor (100 feet on either side of the pipeline centerline)

ID	Description
RD21A	East road ditch at 62nd Ave NW (near existing Mile Marker #30). Two parallel GAP pipelines cross here
RD21B	West road ditch at 62nd Ave NW
RD22A	North road ditch at 41 St NW. No visible ditch
RD22B	South road ditch 41 St NW. No visible ditch
AOC4	Cleared area with spoil piles, no visual excavation to the southeast
F9	No apparent farm ditch between fields, by East Fork Shell Creek
W14	Stream crossing No. W14 at East Fork Shell Creek
F10	No apparent farm ditch between fields, by East Fork Shell Creek

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

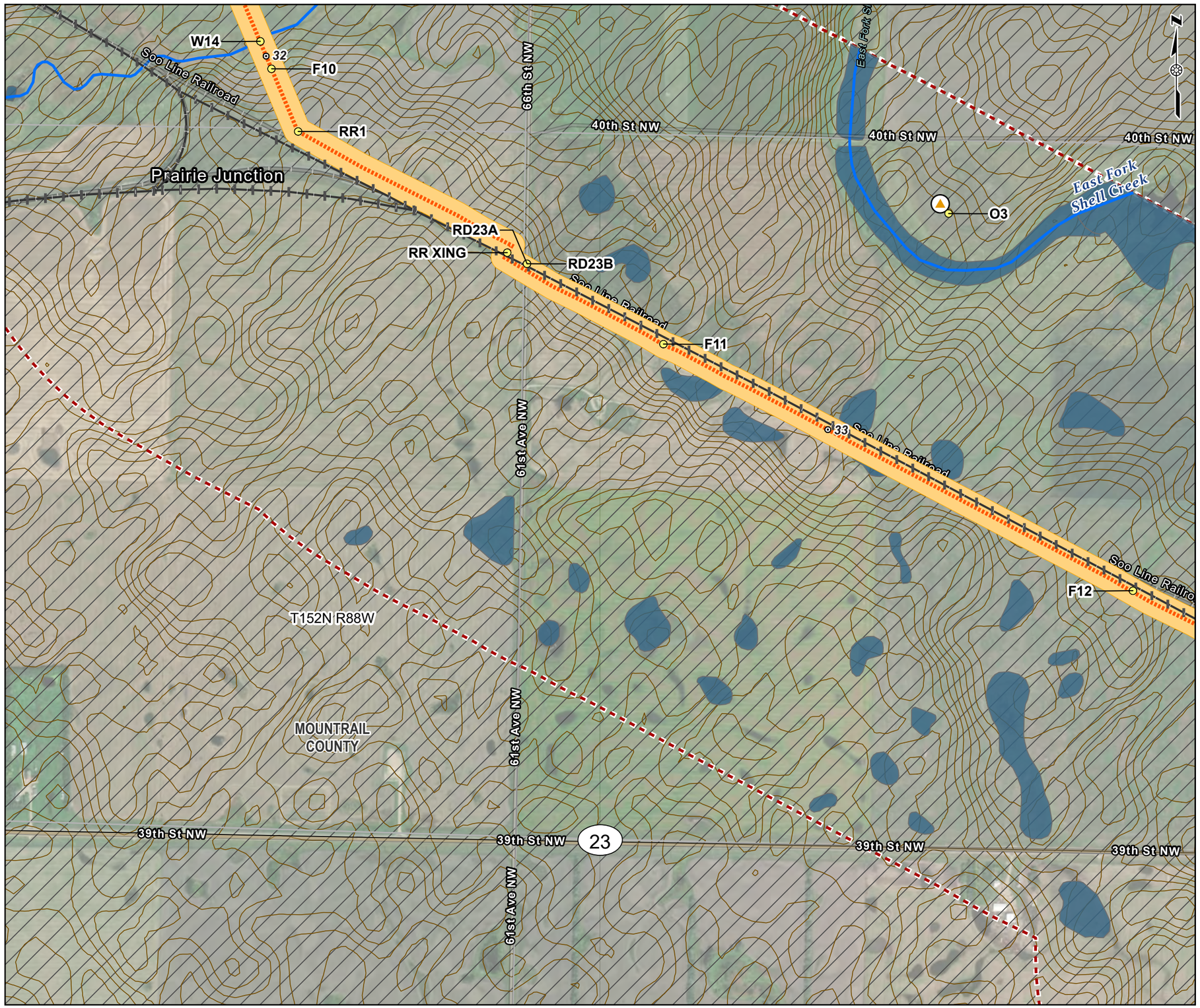
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL COUNTY, NORTH DAKOTA

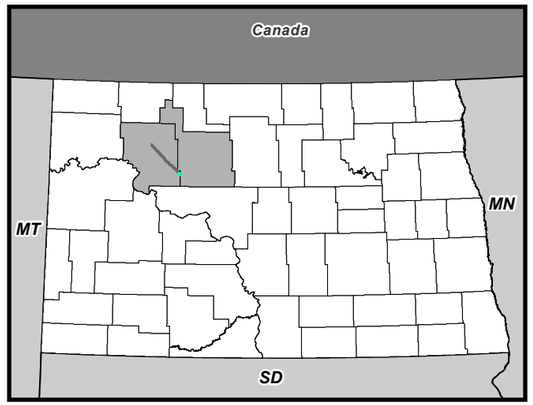
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 17 OF 19

PN:CO002338.0001
Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx





Legend

- Milepost
- Geohazard Survey Location
- Gravel Pit
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 200-foot Project Corridor (100 feet on either side of the pipeline centerline)

ID	Description
W14	Stream crossing No. W14 at East Fork Shell Creek
F10	No apparent farm ditch between fields, by East Fork Shell Creek
RR1	Start of ditch along railroad where planned pipeline is parallel
O3	Gravel pit No. 3
RR XING	Planned pipeline crossing under railroad
RD23B	West road ditch at 66th St NW
RD23A	East road ditch at 66th St NW
F11	Farm ditch where metal culvert passes under RR
F12	Farm ditch where metal culvert passes under RR

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

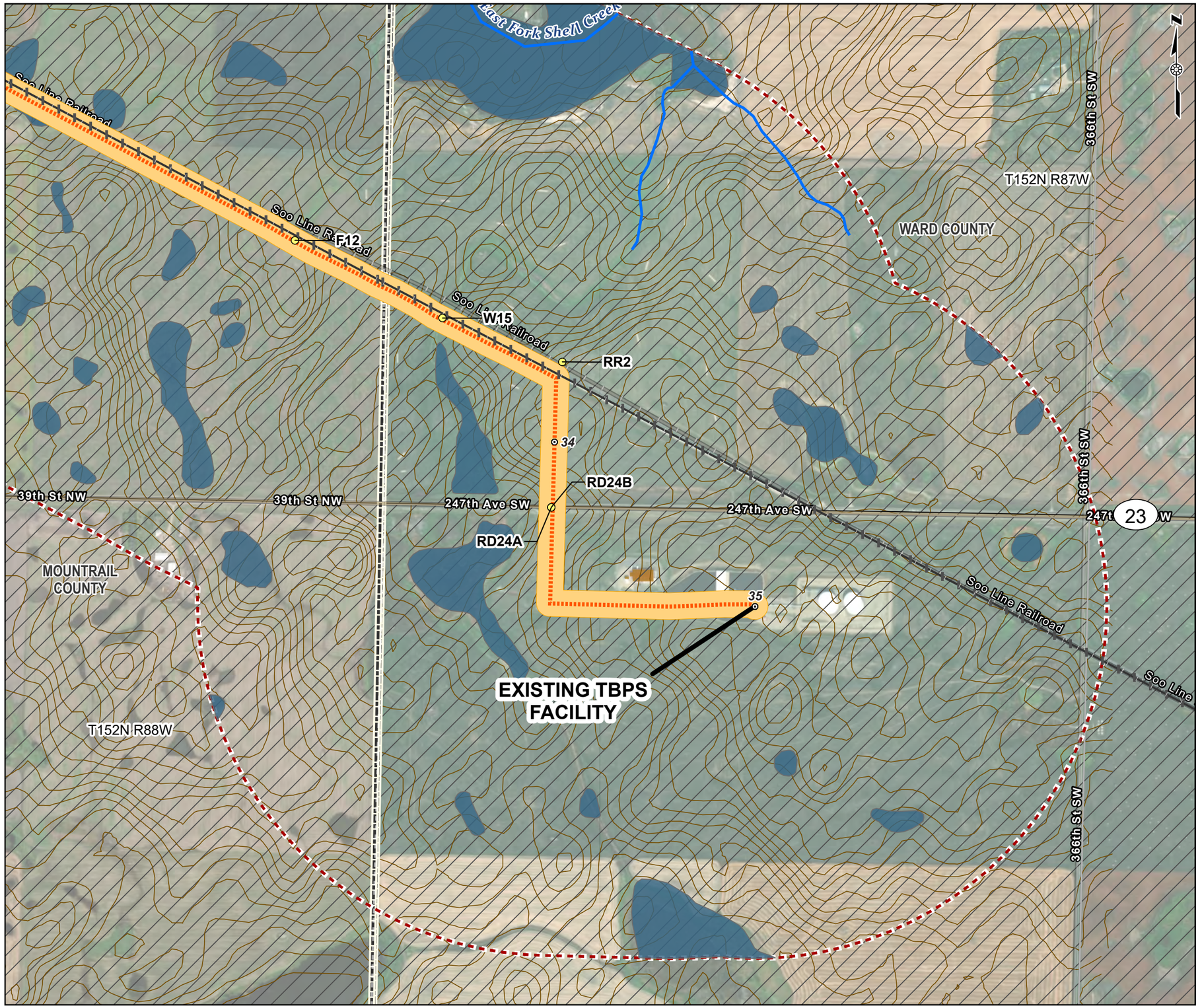
THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL AND WARD COUNTY, NORTH DAKOTA

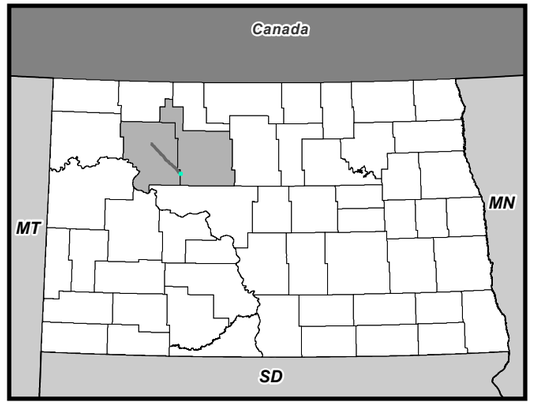
APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 18 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS





Legend

- Milepost
- Geohazard Survey Location
- Contour (3-ft Interval)
- Existing Pipeline Route (30-foot permanent ROW)
- Proposed Pipeline Route (30-foot permanent ROW)
- NDGS Landslide Areas
- Geohazard Study Area (1 mile)
- 200-foot Project Corridor (100 feet on either side of the pipeline centerline)

ID	Description
F12	Farm ditch where metal culvert passes under RR
W15	Stream where concrete culvert passes under RR
RR2	End of planned pipeline in RR ditch as it turns south
RD24B	South road ditch at 247th Ave SW
RD24A	North road ditch at 247th Ave SW

0 500 1,000 1,500 2,000 Feet

GRAPHIC SCALE

NOTES:
1. LANDSLIDE AREAS ARE DERIVED FROM THE ND GEOLOGICAL SURVEY AT: HTTPS://WWW.DMR.ND.GOV/NDGS/LANDSLIDES/.
2. PROJECTION IS NAD 1983 STATE PLANE NORTH DAKOTA N FIPS 3301 (US FEET). THE SCALE IS: 1:9,000.

THUNDER BUTTE PIPELINE PROJECT
MOUNTRAIL AND WARD COUNTY, NORTH DAKOTA

APPENDIX A
GEOHAZARD AVOIDANCE AREAS
DETAIL SHEET 19 OF 19

PN:CO002338.0001

Date: 8/30/2024

ARCADIS

Date: 8/30/2024 Document Path: T:_EPP\Makoti_pipeline\pro\Makoti_Pipeline\Makoti_Pipeline_Rev.aprx

Appendix B

Geohazard Feature Inventory Table

Thunder Butte Pipeline Project - Geohazard Feature Inventory

Inspection ID	Latitude	Longitude	Description	Notes	USCS Soil Class* Top layer (6-in), 2nd layer	Photolog Numbers	Screening Outcome
AOC1	48.0962	-102.0600	Area of concern due to lack of vegetation	Area of concern. Area along existing pipeline shows disturbance and lack of vegetation on crest (80 ft long, visible in aerial imagery). Located south of W13.	ML,CH	139	Likely Stable
AOC2	48.0961	-102.0601	Area of concern. Steeper side slope	Steeper 21-foot-tall slope (18.4°) located 25 ft south of existing pipeline, slope is well vegetated but top along pipeline lacks vegetation and is vulnerable to erosion (AOC1). Located south of W13 crossing	ML,CH	140-142	Conditionally Stable
AOC3	48.1345	-102.1258	Area of concern. Steeper 9.9 degree slope along pipeline	Steeper slope (9.9 degrees (5.65H:1V)) along existing pipeline between farm fields that warranted inspection, no signs of instability were observed.	CL,CL	87-89	Likely Stable
AOC4	48.0056	-101.9096	Cleared area with spoil piles, no visual excavation, looking southeast	Area required observation to verify not a potential hazard. Near proposed pipeline.	ML,CL	174, 177	Likely Stable
F1	48.2732	-102.3108	No apparent farm ditch between fields	Existing pipeline.	CL,SC-SM	27	Stable
F2	48.2258	-102.2449	No apparent farm ditch between fields	Existing pipeline.	CL/ML,CL	49	Stable
F6	48.0940	-102.0556	No apparent farm ditch between fields	Existing pipeline.	ML,CL	143	Likely Stable
F7	48.0841	-102.0374	No apparent farm ditch between fields	Existing pipeline.	ML,CL	144	Likely Stable
F8	48.0143	-101.9196	No apparent farm ditch between fields	Existing pipeline.	ML,CL	170	Stable
F9	47.9962	-101.9028	No apparent farm ditch between fields	Near East Fork Shell Creek. Proposed pipeline.	CL/ML,CL	178	Stable
F10	47.9936	-101.9011	No apparent farm ditch between fields	Near East Fork Shell Creek. Proposed pipeline.	CL,SC-SM	189	Stable
F11	47.9881	-101.8889	Farm ditch where metal culvert passes under RR	Railroad Area; Proposed pipeline.	ML,CL	199-201	Likely Stable
F12	47.9832	-101.8744	Farm ditch where metal culvert passes under RR	Railroad Area; Proposed pipeline.	CL/ML,CL	202-203	Likely Stable
M1	48.1543	-102.1388	Speigel Coal Mine	Speigel Coal Mine aka Smith coal mine, unknown quantity mined, likely closed in 1940. Located 450 ft from pipeline	ML,CL	78-82	Unknown
M2	48.1540	-102.1388	Mormon Coal Mine (Underground)	Located 450 ft from pipeline. Estimated 2,500 tons mined, likely closed in 1935	ML,CL	78-82	Unknown
M3	48.0678	-101.9907	NDGS Mine No. 3, surface mine (unknown)	2,200 ft from existing pipeline, may be same NDGS feature as O1	SC/SC-SM,SC/SC-SM	143	Likely Stable
O1	48.0671	-101.9907	NDGS Gravel open pit No. 1	Vegetated and tree filled pit, about 4 feet deep. Existing pipeline.	SC/SC-SM,SC/SC-SM	149-150	Unknown
O2	48.0650	-101.9901	NDGS Gravel open pit No. 2	Pit has steep 12 foot tall, partially vegetated slopes. Existing pipeline.	SC/SC-SM,SC/SC-SM	154-155	Unknown
O3	47.9909	-101.8803	Gravel pit No. 3	Pit is about 6 feet deep with multiple spoil piles, area is well vegetated. Proposed pipeline.	GM/GW-GM/SW/SW-SM	192	Unknown
P2	48.2687	-102.3059	NWI Pond No. 2	180 ft diameter; Existing pipeline.	MH,MH	31-33	Stable
P5	48.2556	-102.2914	NWI Pond No. 5	400 ft x 200 ft dimensions; Existing pipeline.	MH,MH	34-35	Stable
P6	48.2504	-102.2831	NWI Pond No. 6	450 ft diameter, survey shows bank slopes 4 ft vertical over 100 ft distance. Average depth of cover was measured to be 49 inches. Existing pipeline.	MH,MH	38-40	Stable
P8	48.2376	-102.2660	NWI Pond No. 8	800 ft x 550 ft dimensions, survey shows bank slopes 5 ft vertical over 80 ft distance. Average depth of cover was measured to be 50 inches. Existing pipeline.	MH,MH	43-45	Stable
P9	48.2335	-102.2589	NWI Pond No. 9	250 ft diameter, survey shows bank slopes 5 ft vertical over 50 ft distance. Average depth of cover was measured to be 47 inches. Existing pipeline.	MH,MH	46-47	Stable
P10	48.2330	-102.2561	NWI Pond No. 10	400 ft x 300 ft dimensions	MH,MH	48	Stable
P12	48.1236	-102.1083	NWI Pond No. 12	120 ft x 70 ft dimensions, pipeline does not cross P12, located >200 ft from existing pipeline	ML,CL	106-107	Stable
P13	48.0575	-101.9889	NWI Pond No. 13	730 ft x 250 ft dimensions; Existing pipeline.	OH,MH	156	Stable
P14	48.0379	-101.9464	NWI Pond No. 14	400 ft x 85 ft dimensions, pipeline does not cross P14, located >100 ft from existing pipeline	MH,MH	163	Stable
RD1A	48.2982	-102.3518	North road ditch at 61st St NW	Existing pipeline.	ML,CL	21	Likely Stable
RD1B	48.2982	-102.3518	South road ditch at 61st St NW	Existing pipeline.	ML,CL	22	Likely Stable
RD2A	48.2838	-102.3328	North road ditch at 60th St NW	Existing pipeline.	CL,CL	23	Likely Stable
RD2B	48.2838	-102.3328	South road ditch at 60th St NW	Existing pipeline.	CL,CL	24	Likely Stable
RD3A	48.2833	-102.3318	East road ditch at 79th Ave NW (Existing Mile Marker #2)	Existing pipeline.	CL,CL	26	Likely Stable
RD3B	48.2833	-102.3318	West road ditch at 79th Ave NW	Existing pipeline.	CL,CL	25	Likely Stable
RD4A	48.2693	-102.3063	North road ditch at 59th St NW	Existing pipeline.	CL/ML,CL	28	Likely Stable

* Soil class form NRCS Soil Survey. CL=Low Plasticity Clay; CH=High Plasticity Clay; ML=Low Plasticity Silt; MH=High Plasticity Silt; SC=Clayey Sand; SM = Silty Sand; OH = Plastic Organics; GM = Silty Gravel; GW=Well Graded Gravel

Thunder Butte Pipeline Project - Geohazard Feature Inventory

Inspection ID	Latitude	Longitude	Description	Notes	USCS Soil Class* Top layer (6-in), 2nd layer	Photolog Numbers	Screening Outcome
RD4B	48.2693	-102.3063	South road ditch at 59th St NW (Existing Mile Marker #4)	Existing pipeline.	CL/ML,CL	29-30	Likely Stable
RD5A	48.2388	-102.2678	East road ditch at 76th Ave NW (Existing Mile Marker #7)	Existing pipeline.	CL/ML,CL	41	Likely Stable
RD5B	48.2388	-102.2678	West road ditch at 76th Ave NW	Existing pipeline.	CL/ML,CL	42	Likely Stable
RD6A	48.2121	-102.2244	East road ditch at 74th Ave NW (Hwy 3)	Existing pipeline.	CL/ML,CL	50	Likely Stable
RD6B	48.2121	-102.2244	West road ditch at 74th Ave NW (Hwy 3)	Existing pipeline.	CL/ML,CL	51	Likely Stable
RD7A	48.1828	-102.1811	East road ditch at 46th St NW	Existing pipeline.	ML,CL	61	Likely Stable
RD7B	48.1828	-102.1811	West road ditch at 46th St NW	Existing pipeline.	ML,CL	62	Likely Stable
RD8A	48.1824	-102.1804	North road ditch at 53rd St NW	Existing pipeline.	ML,CL	64	Likely Stable
RD8B	48.1824	-102.1804	South road ditch at 53rd St NW (Existing Mile Marker #13)	Existing pipeline.	ML,CL	63	Likely Stable
RD9A	48.1717	-102.1599	East road ditch at 71st Ave NW	Existing pipeline.	ML,CL	75	Likely Stable
RD9B	48.1717	-102.1599	West road ditch at 71st Ave NW (Existing Mile Marker #14)	Existing pipeline.	ML,CL	74	Likely Stable
RD10A	48.1679	-102.1548	North road ditch at 52nd St NW	Existing pipeline.	ML,CL	76	Likely Stable
RD10B	48.1679	-102.1548	South road ditch at 52nd St NW	Existing pipeline.	ML,CL	77	Likely Stable
RD11A	48.1534	-102.1403	North road ditch at 51st St NW	Existing pipeline.	ML,CL	83	Likely Stable
RD11B	48.1534	-102.1403	South road ditch at 51st St NW (Existing Mile Marker #15)	Existing pipeline.	ML,CL	84	Likely Stable
RD12A	48.1526	-102.1382	East road ditch at 70th Ave NW	Existing pipeline.	ML,CL	85	Likely Stable
RD12B	48.1526	-102.1382	West road ditch at 70th Ave NW	Existing pipeline.	ML,CL	86	Likely Stable
RD13A	48.1245	-102.1075	North road ditch at 49th St NW	Existing pipeline.	CL/ML,CL	104	Likely Stable
RD13B	48.1245	-102.1075	South road ditch at 49th St NW (Existing Mile Marker #18)	Existing pipeline.	CL/ML,CL	105	Likely Stable
RD14A	48.1091	-102.0733	East road ditch at 67th Ave NW (Existing Mile Marker #20)	Existing pipeline.	CL/ML,CL	120	Likely Stable
RD14B	48.1091	-102.0733	West road ditch at 67th Ave NW	Existing pipeline.	CL/ML,CL	121	Likely Stable
RD15A	48.0830	-102.0302	East road ditch at 65th Ave NW (Existing Mile Marker #23)	Existing pipeline.	ML,ML	145	Likely Stable
RD15B	48.0830	-102.0302	West road ditch at 65th Ave NW	Existing pipeline.	ML,ML	146	Likely Stable
RD16A	48.0666	-102.0003	North road ditch at 45th St NW	Existing pipeline.	CL/ML,CL	152	Likely Stable
RD16B	48.0666	-102.0003	South road ditch at 45th St NW	Existing pipeline.	CL/ML,CL	151	Likely Stable
RD17A	48.0564	-101.9870	East road ditch at 63rd Ave NW (Existing Mile Marker #26)	Existing pipeline.	CL/ML,CL	158	Likely Stable
RD17B	48.0564	-101.9870	West road ditch at 63rd Ave NW	Existing pipeline.	CL/ML,CL	157	Likely Stable
RD18A	48.0457	-101.9654	East road ditch at 62nd Ave NW (Existing Mile Marker #26)	Existing pipeline.	ML,CL	160	Likely Stable
RD18B	48.0457	-101.9654	West road ditch at 62nd Ave NW	West road ditch at 62nd Ave NW, surveyed: 6ft deep with 14.8° slope. DOC is 68-inches at bottom of ditch. Existing pipeline.	ML,CL	162	Likely Stable
RD19A	48.0377	-101.9468	North road ditch at 43rd St NW	Existing pipeline.	CL/ML,CL	164	Likely Stable
RD19B	48.0377	-101.9468	South road ditch at 43rd St NW (Existing Mile Marker #26)	Existing pipeline.	CL/ML,CL	165	Likely Stable
RD20A	48.0232	-101.9332	North road ditch at 42nd St NW	Existing pipeline.	CL/ML,CL	168	Likely Stable
RD20B	48.0232	-101.9332	South road ditch at 42nd St NW	Existing pipeline.	CL/ML,CL	169	Likely Stable
RD21A	48.0106	-101.9147	East road ditch at 62nd Ave NW (Existing Mile Marker #30) Two parallel GAP pipelines cross here	Existing pipeline.	MH,CL	171-172	Likely Stable
RD21B	48.0106	-101.9147	West road ditch at 62nd Ave NW	Existing pipeline.	MH,CL	173	Likely Stable
RD22A	48.0071	-101.9094	North road ditch at 41 St NW. No visible Ditch	Proposed pipeline.	CH/CL,CH/MH	175	Likely Stable
RD22B	48.0071	-101.9094	South road ditch 41 St NW. No visible Ditch	Proposed pipeline.	CH/CL,CH/MH	176	Likely Stable
RD23A	47.9897	-101.8931	East road ditch at 66th St NW	Proposed pipeline.	ML,CL	198	Likely Stable

* Soil class form NRCS Soil Survey. CL=Low Plasticity Clay; CH=High Plasticity Clay; ML=Low Plasticity Silt; MH=High Plasticity Silt; SC=Clayey Sand; SM = Silty Sand; OH = Plastic Organics; GM = Silty Gravel; GW=Well Graded Gravel

Thunder Butte Pipeline Project - Geohazard Feature Inventory

Inspection ID	Latitude	Longitude	Description	Notes	USCS Soil Class* Top layer (6-in), 2nd layer	Photolog Numbers	Screening Outcome
RD23B	47.9897	-101.8931	West road ditch at 66th St NW	Proposed pipeline.	ML,CL	197	Likely Stable
RD24A	47.9779	-101.8664	North road ditch at 247th Ave SW	Proposed pipeline.	CL/ML,CL	208	Likely Stable
RD24B	47.9779	-101.8664	South road ditch at 247th Ave SW	Proposed pipeline.	CL/ML,CL	207	Likely Stable
RD25A	48.2549	-102.2903	North road ditch at 58th St NW	Existing pipeline.	CL,CL	36	Likely Stable
RD25B	48.2549	-102.2903	South road ditch at 58th St NW (Existing Mile Marker #5)	Existing pipeline.	CL,CL	37	Likely Stable
RD26A	48.2114	-102.2231	North road ditch at 55th St NW / Palermo Rd	Existing pipeline.	CL,CL	52	Likely Stable
RD26B	48.2113	-102.2230	South road ditch at 55th St NW / Palermo Rd, (Existing Mile Marker #10)	Existing pipeline.	CL,CL	53	Likely Stable
RD27A	48.0344	-101.9435	East road ditch at 61st St Ave NW	Existing pipeline.	ML,CL	167	Likely Stable
RD27B	48.0345	-101.9439	West road ditch at 61st St Ave NW	Existing pipeline.	ML,CL	166	Likely Stable
RR XING	47.9900	-101.8937	Planned pipeline crossing under railroad	Railroad Area; proposed pipeline	ML,CL	194-196	Likely Stable
RR1	47.9924	-101.9002	Start of ditch along railroad where proposed pipeline is parallel	Railroad Area; proposed pipeline	SC/SC-SM,SC/SC-SM	190-191	Likely Stable
RR2	47.9808	-101.8662	End of planned pipeline in RR ditch as it turns south	Railroad Area; proposed pipeline	CL/ML,CL	206	Likely Stable
S1	48.1323	-102.1274	NDGS Slide No. 1	Existing landslide. Scarp at top of slope, rotational slide with displaced material downslope, tension cracks around slide, unstable. Existing pipeline.	CL/ML,CL (sandy soil in field)	90-93	Unstable
S2	48.1285	-102.1096	NDGS Slide No. 2	Existing landslide. Two scarps located about 4 ft above bottom of slope, likely will progress upslope, unstable. Existing pipeline.	ML,CL (sandy soil in field)	100-103	Unstable
S3	48.0988	-102.0570	NDGS Slide No. 3 along unnamed stream	No obvious signs of instability observed, appears to be erosion near base of slopes and erosion rills downslope to the unnamed stream. Existing pipeline.	CL,CH (sandy soil in field)	123-128	Likely Stable
W1	48.3041	-102.3626	Stream crossing No. 1, branch of Little Knife River	Branch of Little Knife River with surveyed cross section. Existing pipeline.	ML,CL	1-3	Likely Stable
W2	48.3040	-102.3649	Stream crossing No. 2 at Little Knife River	Little Knife River with surveyed cross section. Existing pipeline.	ML,CL	4-20	Likely Stable
W5	48.1931	-102.2039	Waterway No. 5, unnamed stream	Existing pipeline	CL,CL	54-60	Likely Stable
W7	48.1728	-102.1624	Stream crossing No. 7 at unnamed stream	Unnamed stream with surveyed cross section, slopes < 3 ft tall. Existing pipeline.	ML,CL	65-73	Likely Stable
W9	48.1319	-102.1218	Stream crossing No. 9 at unnamed stream	Unnamed stream with surveyed cross section. Existing pipeline.	ML,CL	94-99	Likely Stable
W11	48.1208	-102.0993	Shell Creek crossing	Shell Creek with surveyed cross section. Existing pipeline.	CL,CH	108-119	Likely Stable
W13	48.0964	-102.0604	Stream crossing No. 13	Unnamed stream with surveyed cross section, banks less than 3 ft tall, tallest slope beyond bank on east side is 31 ft tall with a slope of 8.2°. Existing pipeline.	CL,CH	129-138	Likely Stable
W14	47.9942	-101.9014	Stream crossing No. W14 at East Fork Shell Creek	East Fork Shell Creek with surveyed cross section, banks less than 3 ft tall. Proposed pipeline.	ML,CL	179-188	Likely Stable
W15	47.9817	-101.8698	Stream where concrete culvert passes under RR	Unnamed stream or drainage that passes through culvert under railroad and crosses pipeline. Proposed pipeline.	CL/ML,CL	204-205	Likely Stable

* Soil class form NRCS Soil Survey. CL=Low Plasticity Clay; CH=High Plasticity Clay; ML=Low Plasticity Silt; MH=High Plasticity Silt; SC=Clayey Sand; SM = Silty Sand; OH = Plastic Organics; GM = Silty Gravel; GW=Well Graded Gravel

Appendix C

Photolog

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 1

Location ID: W1

Description: Stream crossing No. 1, branch of Little Knife River looking east into valley forming waterway

Date: 8/7/2024

Latitude, Longitude: 48.3041327, -102.3625887

Photograph: 2

Location ID: W1

Description: Stream crossing No. 1, branch of Little Knife River looking northeast into valley forming waterway

Date: 8/7/2024

Latitude, Longitude: 48.3041327, -102.3625887

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 3

Location ID: W1

Description: Stream crossing No. 1, branch of Little Knife River standing at flowline looking northeast into valley forming waterway

Date: 8/7/2024

Latitude, Longitude: 48.3041327, -102.3625887

Photograph: 4

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, top of slope looking east

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 5

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, looking east along pipeline

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 6

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, looking west at west bank

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 7

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, west edge of cattails

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 8

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River. Bank soils

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 9

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, stream and east bank

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 10

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River, peat bottom

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 11

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River in middle of channel looking east

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 12

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River in middle of channel looking downstream

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 13

Location ID: W2

Description:
Stream crossing No. 2 at Little Knife River in middle of channel looking upstream

Date: 8/7/2024

Latitude, Longitude:
48.3040193, -102.3649006

Photograph: 14

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River standing at flowline of crossing No. 2 looking west towards channel

Date: 8/7/2024

Latitude, Longitude:
48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 15

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River in left floodplain looking northeast

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 16

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River in left floodplain looking southwest

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 17

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River in left floodplain looking west

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 18

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River looking west at channel

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 19

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River standing at cattail interface looking northeast along right of way

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph: 20

Location ID: W2

Description: Stream crossing No. 2 at Little Knife River channel bottom

Date: 8/7/2024

Latitude, Longitude: 48.3040193, -102.3649006

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 21

Location ID: RD1A

Description: North road ditch at 61st St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.2982117, -102.3517553

Photograph: 22

Location ID: RD1B

Description: South road ditch at 61st St NW, looking south

Date: 8/5/2024

Latitude, Longitude: 48.2982117, -102.3517553

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 23

Location ID: RD2A

Description: North road ditch at 60th St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.2837836, -102.3327577

Photograph: 24

Location ID: RD2B

Description: South road ditch at 60th St NW, looking south

Date: 8/5/2024

Latitude, Longitude: 48.2837836, -102.3327577

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 25

Location ID: RD3B

Description: West road ditch at 79th Ave NW, looking west

Date: 8/5/2024

Latitude, Longitude: 48.2832528, -102.3317727

Photograph: 26

Location ID: RD3A

Description: East road ditch at 79th Ave NW (Existing Mile Marker #2), looking east

Date: 8/5/2024

Latitude, Longitude: 48.2832528, -102.3317727

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 27

Location ID: F1

Description: No apparent farm ditch between fields, looking west

Date: 8/5/2024

Latitude, Longitude: 48.2731835, -102.3108208

Photograph: 28

Location ID: RD4A

Description: North road ditch at 59th St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.269267, -102.306336

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 29

Location ID: RD4B

Description: South road ditch at 59th St NW (Existing Mile Marker #4), looking southwest

Date: 8/5/2024

Latitude, Longitude: 48.269267, -102.306336

Photograph: 30

Location ID: RD4B

Description: Upslope of south road ditch at 59th St NW, looking east

Date: 8/5/2024

Latitude, Longitude: 48.269267, -102.306336

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 31

Location ID: P2

Description: NWI Pond No. 2 within the cattails, looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.2687041, -102.3059057

Photograph: 32

Location ID: P2

Description: NWI Pond No. 2 has peat soils

Date: 8/5/2024

Latitude, Longitude: 48.2687041, -102.3059057

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 33

Location ID: P2

Description: Distance between pipeline (orange marker) and NWI Pond No. 2 (tall grass on right), looking south

Date: 8/5/2024

Latitude, Longitude: 48.2687041, -102.3059057

Photograph: 34

Location ID: P5

Description: NWI Pond No. 5, looking west

Date: 8/5/2024

Latitude, Longitude: 48.2555672, -102.2914149

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 35

Location ID: P5

Description: Distance between pipeline (orange marker) and pond (tall grass on left), looking west

Date: 8/5/2024

Latitude, Longitude: 48.2555672, -102.2914149

Photograph: 36

Location ID: RD25A

Description: North road ditch at 58th St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.2548642, -102.2902539

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 37

Location ID: RD25B

Description: South road ditch at 58th St NW (Existing Mile Marker #5), looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.2548642, -102.2902539

Photograph: 38

Location ID: P6

Description: NWI Pond No. 6 in farm field, looking southeast along pipeline towards pond

Date: 8/7/2024

Latitude, Longitude: 48.2503882, -102.2830546

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 39

Location ID: P6

Description: NWI Pond No. 6, looking east along pipeline, surveyor on pipeline. DOC is about 6.25 ft near center and 4.25 ft at west edge. Pond bottom consists of peat, sand and gravel

Date: 8/7/2024

Latitude, Longitude: 48.2503882, -102.2830546

Photograph: 40

Location ID: P6

Description: NWI Pond No. 6, looking west at entire pond

Date: 8/7/2024

Latitude, Longitude: 48.2503882, -102.2830546

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 41

Location ID: RD5A

Description: East road ditch at 76th Ave NW (Existing Mile Marker #7), pipeline has 6.8 ft DOC at ditch bottom, looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.2388194, -102.2677869

Photograph: 42

Location ID: RD5B

Description: West road ditch at 76th Ave NW, looking west

Date: 8/5/2024

Latitude, Longitude: 48.2388194, -102.2677869

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 43

Location ID: P8

Description: NWI Pond No. 8 looking at north edge.

Date: 8/7/2024

Latitude, Longitude: 48.2375647, -102.2659685

Photograph: 44

Location ID: P8

Description: NWI Pond No. 8, looking south, pipeline crosses near with rock on opposite bank. DOC in pond is about 6.8 ft

Date: 8/7/2024

Latitude, Longitude: 48.2375647, -102.2659685

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 45

Location ID: P8

Description: NWI Pond No. 8, looking south, pipeline crosses near with rock on opposite bank

Date: 8/7/2024

Latitude, Longitude: 48.2375647, -102.2659685

Photograph: 46

Location ID: P9

Description: NWI Pond No. 9 from above, looking east

Date: 8/7/2024

Latitude, Longitude: 48.2335441, -102.258946

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 47

Location ID: P9

Description: NWI Pond No. 9

Date: 8/7/2024

Latitude, Longitude: 48.2335441, -102.258946

Photograph: 48

Location ID: P10

Description: NWI Pond No. 10 looking east, pipeline at water / cattail interface on right side of photo

Date: 8/7/2024

Latitude, Longitude: 48.2329999, -102.2561285

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 49

Location ID: F2

Description: No apparent farm ditch between fields (Looking east)

Date: 8/5/2024

Latitude, Longitude: 48.2258136, -102.2449054

Photograph: 50

Location ID: RD6A

Description: East road ditch at 74th Ave NW (Hwy 3), pipeline has 7 ft DOC at ditch bottom (Looking north)

Date: 8/5/2024

Latitude, Longitude: 48.2120907, -102.2244374

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 51

Location ID: RD6B

Description: West road ditch at 74th Ave NW (Hwy 3), pipeline has 6 ft DOC at ditch bottom (Looking south)

Date: 8/5/2024

Latitude, Longitude: 48.2120907, -102.2244374

Photograph: 52

Location ID: RD26A

Description: North road ditch at 55th St NW / Palermo Rd, looking west

Date: 8/5/2024

Latitude, Longitude: 48.211419, -102.223111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 53

Location ID: RD26B

Description: South road ditch at 55th St NW / Palermo Rd, (Existing Mile Marker #10)

Date: 8/5/2024

Latitude, Longitude: 48.211308, -102.223039

Photograph: 54

Location ID: W5

Description: Waterway No. 5 looking at right floodplain

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 55

Location ID: W5

Description: Waterway No. 5 looking at waterway

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph: 56

Location ID: W5

Description: Waterway No. 5 looking south towards upstream

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 57

Location ID: W5

Description: Waterway No. 5 looking north towards downstream

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph: 58

Location ID: W5

Description: Waterway No. 5 from left floodplain looking towards channel

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 59

Location ID: W5

Description: Waterway No. 5 from left floodplain looking towards channel

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph: 60

Location ID: W5

Description: Waterway No. 5 looking upstream standing upstream of crossing

Date: 8/7/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 61

Location ID: RD7A

Description: East road ditch at 46th St NW, looking northeast, pipeline has 6.5 ft DOC at ditch bottom

Date: 8/5/2024

Latitude, Longitude: 48.1828353, -102.1811381

Photograph: 62

Location ID: RD7B

Description: West road ditch at 46th St NW, looking west, pipeline has 4.8 ft DOC at ditch bottom

Date: 8/5/2024

Latitude, Longitude: 48.1828353, -102.1811381

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 63

Location ID: RD8B

Description: South road ditch at 53rd St NW, (Existing Mile Marker #13) looking southwest, pipeline has 5.9 ft DOC at ditch bottom

Date: 8/5/2024

Latitude, Longitude: 48.1823952, -102.1804293

Photograph: 64

Location ID: RD8A

Description: North road ditch at 53rd St NW, looking northeast, pipeline has 5.9 ft DOC at ditch bottom

Date: 8/5/2024

Latitude, Longitude: 48.1823952, -102.1804293

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 65

Location ID: W7

Description: Stream crossing No. 7 at unnamed stream

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph: 66

Location ID: W7

Description: Stream crossing No. 7 at unnamed stream

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 67

Location ID: W7

Description: Stream crossing No. 7 standing at left cattail interface looking towards left floodplain

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph: 68

Location ID: W7

Description: Stream crossing No. 7 standing at left cattail interface looking towards right floodplain

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 69

Location ID: W7

Description: Stream crossing No. 7 standing in middle of channel looking downstream

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph: 70

Location ID: W7

Description: Stream crossing No. 7 standing in middle of channel looking upstream

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 71

Location ID: W7

Description: Stream crossing No. 7 standing in right floodplain looking towards channel

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph: 72

Location ID: W7

Description: Stream crossing No. 7 standing in right floodplain looking towards right floodplain

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 73

Location ID: W7

Description: Stream crossing No. 7 showing channel bottom material

Date: 8/5/2024

Latitude, Longitude: 48.1728417, -102.1624325

Photograph: 74

Location ID: RD9B

Description: West road ditch at 71st Ave NW (Existing Mile Marker #14), looking northwest

Date: 8/5/2024

Latitude, Longitude: 48.1717468, -102.1599023

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 75

Location ID: RD9A

Description: East road ditch at 71st Ave NW, looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.1717468, -102.1599023

Photograph: 76

Location ID: RD10A

Description: North road ditch at 52nd St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.1678993, -102.1548031

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 77

Location ID: RD10B

Description: South road ditch at 52nd St NW, looking south

Date: 8/5/2024

Latitude, Longitude: 48.1678993, -102.1548031

Photograph: 78

Location ID: M1 AND M2

Description: Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine, looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.154336, -102.1387947

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 79

Location ID: M1 AND M2

Description: Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine, looking north

Date: 8/5/2024

Latitude, Longitude: 48.1931149, -102.2039271

Photograph: 80

Location ID: M1 AND M2

Description: Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine, looking south

Date: 8/5/2024

Latitude, Longitude: 48.154336, -102.1387947

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 81

Location ID: M1 AND M2

Description: Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine, looking north

Date: 8/5/2024

Latitude, Longitude: 48.154336, -102.1387947

Photograph: 82

Location ID: M1 AND M2

Description: Mines No. 1 and 2: Mormon Coal Mine and Speigel Coal Mine, looking southwest

Date: 8/5/2024

Latitude, Longitude: 48.154336, -102.1387947

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 83

Location ID: RD11A

Description: North road ditch at 51st St NW, looking north

Date: 8/5/2024

Latitude, Longitude: 48.1534068, -102.1403069

Photograph: 84

Location ID: RD11B

Description: South road ditch at 51st St NW (Existing Mile Marker #15), looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.1534068, -102.1403069

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 85

Location ID: RD12A

Description: East road ditch at 70th Ave NW, facing east

Date: 8/5/2024

Latitude, Longitude: 48.1525616, -102.1382263

Photograph: 86

Location ID: RD12B

Description: West road ditch at 70th Ave NW, facing west

Date: 8/5/2024

Latitude, Longitude: 48.1525616, -102.1382263

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 87

Location ID: AOC3

Description: Steep 16:1 slope, looking downslope / southeast, located north of Slide No. 1

Date: 8/7/2024

Latitude, Longitude: 48.134458, -102.125764

Photograph: 88

Location ID: AOC3

Description: Steep 16:1 slope, looking upslope / northwest, located north of Slide No. 1

Date: 8/7/2024

Latitude, Longitude: 48.134458, -102.125764

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 89

Location ID: AOC3

Description: Soil on slope is sand

Date: 8/7/2024

Latitude, Longitude: 48.134458, -102.125764

Photograph: 90

Location ID: S1

Description: NDGS Slide No. 1, looking east

Date: 8/5/2024

Latitude, Longitude: 48.1322922, -102.12737

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 91

Location ID: S1

Description: NDGS Slide No. 1, sand soils

Date: 8/5/2024

Latitude, Longitude: 48.1322922, -102.12737

Photograph: 92

Location ID: S1

Description: NDGS Slide No. 1, looking downslope / south

Date: 8/5/2024

Latitude, Longitude: 48.1322922, -102.12737

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 93

Location ID: S1

Description: NDGS Slide No. 1, looking west

Date: 8/5/2024

Latitude, Longitude: 48.1322922, -102.12737

Photograph: 94

Location ID: W9

Description: Stream crossing No. 9 at unnamed stream, facing southeast

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 95

Location ID: W9

Description: Stream crossing No. 9 at unnamed stream, south bank

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph: 96

Location ID: W9

Description: Stream crossing No. 9 at unnamed stream, looking southwest

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 97

Location ID: W9

Description: Stream crossing No. 9 at unnamed stream, looking east

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph: 98

Location ID: W9

Description: Stream crossing No. 9 at unnamed stream, looking east, 5 ft erosion on right bank along bottom 1/4 slope, located >100 ft from pipeline

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 99

Location ID: W5

Description: Stream crossing No. 9 at unnamed stream, looking east, flood plain of left bank

Date: 8/5/2024

Latitude, Longitude: 48.1319075, -102.1217975

Photograph: 100

Location ID: S2

Description: NDGS Slide No. 2, looking south

Date: 8/5/2024

Latitude, Longitude: 48.1285306, -102.1095871

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 101

Location ID: S2

Description: NDGS Slide No. 2, looking southeast

Date: 8/5/2024

Latitude, Longitude: 48.1285306, -102.1095871

Photograph: 102

Location ID: S2

Description: NDGS Slide No. 2, sandy soil

Date: 8/5/2024

Latitude, Longitude: 48.1285306, -102.1095871

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 103

Location ID: S2

Description: NDGS Slide No. 2, scarp, looking south

Date: 8/5/2024

Latitude, Longitude: 48.1285306, -102.1095871

Photograph: 104

Location ID: RD13A

Description: North road ditch at 49th St NW, looking northwest

Date: 8/5/2024

Latitude, Longitude: 48.1244562, -102.1075279

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 105

Location ID: RD13B

Description: South road ditch at 49th St NW (Existing Mile Marker #18), looking south

Date: 8/5/2024

Latitude, Longitude: 48.1244562, -102.1075279

Photograph: 106

Location ID: P12

Description: NWI Pond No. 12, looking northeast, > 100 ft from pipeline

Date: 8/5/2024

Latitude, Longitude: 48.1236181, -102.1083004

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 107

Location ID: P12

Description: NWI Pond No. 12, looking north, > 100 ft from pipeline

Date: 8/5/2024

Latitude, Longitude: 48.1236181, -102.1083004

Photograph: 108

Location ID: W11

Description: Shell Creek crossing, facing west

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 109

Location ID: W11

Description: Shell Creek, looking west

Date: 8/5/2024

Latitude, Longitude: 48.1208484, 102.0992996

Photograph: 110

Location ID: W11

Description: Shell Creek bank soils

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 111

Location ID: W11

Description: Shell Creek crossing from left floodplain looking towards channel

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph: 112

Location ID: W11

Description: Shell Creek crossing from right bank looking downstream

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 113

Location ID: W11

Description: Shell Creek crossing from right bank looking towards left bank

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph: 114

Location ID: W11

Description: Shell Creek crossing from middle of channel downstream looking upstream

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 115

Location ID: W11

Description: Shell Creek crossing showing channel bottom material

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph: 116

Location ID: W11

Description: Shell Creek crossing from left bank looking towards left floodplain

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 117

Location ID: W11

Description: Shell Creek crossing from left bank looking towards right bank

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph: 118

Location ID: W11

Description: Shell Creek crossing from left floodplain looking downstream

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 119

Location ID: W11

Description: Shell Creek crossing from left floodplain looking upstream

Date: 8/5/2024

Latitude, Longitude: 48.1208484, -102.0992996

Photograph: 120

Location ID: RD14A

Description: East road ditch at 67th Ave NW (Existing Mile Marker #20), looking east

Date: 8/5/2024

Latitude, Longitude: 48.1090952, -102.073335

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 121

Location ID: RD14B

Description: West road ditch at 67th Ave NW, looking west

Date: 8/5/2024

Latitude, Longitude: 48.1090952, -102.073335

Photograph: 122

Location ID: PUMP STA

Description: Area of planned pump station, looking east

Date: 8/6/2024

Latitude, Longitude: 48.1087879, -102.0725312

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 123

Location ID: S3

Description: NDGS Slide No. 3, photo taken from S3 coordinate, looking southwest along unnamed stream

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph: 124

Location ID: S3

Description: NDGS Slide No. 3, photo taken from S3 coordinate, looking downslope (southeast) toward unnamed stream

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 125

Location ID: S3

Description: Slide No. 3, slope above floodplain, looking north, some disturbance near base of slope

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph: 126

Location ID: S3

Description: Slopes along NDGS Slide No. 3, looking northeast

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 127

Location ID: S3

Description: Slopes east of NDGS Slide No. 3, looking east

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph: 128

Location ID: S3

Description: NDGS Slide No. 3, surface soils are silty fine sand

Date: 8/6/2024

Latitude, Longitude: 48.0988124, -102.0570465

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 129

Location ID: W13

Description: Stream crossing No. 13 standing on left bank looking towards right floodplain

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph: 130

Location ID: W13

Description: Stream crossing No. 13 standing on left bank looking at channel

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 131

Location ID: W13

Description: Stream crossing No. 13 standing on left bank looking downstream

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph: 132

Location ID: W13

Description: Stream crossing No. 13 standing on left bank looking upstream

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 133

Location ID: W13

Description: Stream crossing No. 13 standing downstream on right bank looking downstream

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph: 134

Location ID: W13

Description: Stream crossing No. 13 standing on right bank looking towards left floodplain

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 135

Location ID: W13

Description: Stream crossing No. 13 standing on right bank looking towards right floodplain

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph: 136

Location ID: W13

Description: Stream crossing No. 13 channel bottom material

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 137

Location ID: W13

Description: Stream crossing No. 13 standing in left floodplain looking towards channel

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph: 138

Location ID: W13

Description: Stream crossing No. 13 standing in left floodplain looking towards left floodplain

Date: 8/6/2024

Latitude, Longitude: 48.0964497, -102.0604311

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 139

Location ID: AOC1

Description: Area along pipeline shows disturbance, likely from construction and grass didn't establish. DOC is 36 in. Area susceptible to erosion. (located south of W13)

Date: 8/6/2024

Latitude, Longitude: 48.096158, -102.060039

Photograph: 140

Location ID: AOC2

Description: Steep slope on south side of W13 located 25 ft south of pipeline, looking southeast

Date: 8/6/2024

Latitude, Longitude: 48.096117, -102.060078

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 141

Location ID: AOC2

Description: Steep slope on south side of W13 located 25 ft south of pipeline, looking north towards W13 (at forefront)

Date: 8/6/2024

Latitude, Longitude: 48.096117, -102.060078

Photograph: 142

Location ID: AOC2

Description: Steep slope on south side of W13 located 25 ft south of pipeline, looking north towards W13

Date: 8/6/2024

Latitude, Longitude: 48.096117, -102.060078

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 143

Location ID: F6

Description: No apparent farm ditch between fields

Date: 8/6/2024

Latitude, Longitude: 48.0940329, -102.0555992

Photograph: 144

Location ID: F7

Description: No apparent farm ditch between fields, orange marker on left fence is pipeline

Date: 8/6/2024

Latitude, Longitude: 48.0841304, -102.0374441

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 145

Location ID: RD15A

Description: East road ditch at 65th Ave NW (Existing Mile Marker #23), looking east

Date: 8/6/2024

Latitude, Longitude: 48.0830125, -102.030236

Photograph: 146

Location ID: RD15B

Description: West road ditch at 65th Ave NW, looking west

Date: 8/6/2024

Latitude, Longitude: 48.0830125, -102.030236

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 147

Location ID: RD15B

Description: West road ditch at 65th Ave NW, looking north

Date: 8/6/2024

Latitude, Longitude: 48.0830125, -102.030236

Photograph: 148

Location ID: M3

Description: NDGS Mine No. 3, surface mine (unknown), looking east

Date: 8/6/2024

Latitude, Longitude: 48.0678017, -101.9907341

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 149

Location ID: O1

Description: NDGS Open pit No. 1, looking north

Date: 8/6/2024

Latitude, Longitude: 48.0671252, -101.9906927

Photograph: 150

Location ID: O1

Description: NDGS Open pit No. 1, looking north

Date: 8/6/2024

Latitude, Longitude: 48.0671252, -101.9906927

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 151

Location ID: RD16B

Description: South road ditch at 45th St NW, looking south

Date: 8/6/2024

Latitude, Longitude: 48.0666111, -102.0002848

Photograph: 152

Location ID: RD16A

Description: North road ditch at 45th St NW, looking north. Many rodent holes near pipeline in ditch. DOC ranges from 6.8 ft to 8 ft

Date: 8/6/2024

Latitude, Longitude: 48.0666111, -102.0002848

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 153
Location ID: RD16A

Description: North road ditch at 45th St NW, looking north. Rodent holes range for, 4 to 10 inches diameter

Date: 8/6/2024

Latitude, Longitude:
48.0666111, -102.0002848

Photograph: 154

Location ID: O2

Description: NDGS Open pit No. 2, looking south

Date: 8/6/2024

Latitude, Longitude:
48.0649697, -101.9901487

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 155

Location ID: O2

Description: NDGS Open pit No. 2, looking south

Date: 8/6/2024

Latitude, Longitude: 48.0649697, -101.9901487

Photograph: 156

Location ID: P13

Description: NWI Pond No. 13, looking south

Date: 8/6/2024

Latitude, Longitude: 48.0574843, -101.9889052

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 157

Location ID: RD17B

Description: West road ditch at 63rd Ave NW, looking west, DOC at ditch bottom is 5 ft

Date: 8/6/2024

Latitude, Longitude: 48.0563997, -101.9869604

Photograph: 158

Location ID: RD17B

Description: West road ditch at 63rd Ave NW, looking south along ditch

Date: 8/6/2024

Latitude, Longitude: 48.0563997, -101.9869604

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 159

Location ID: RD17A

Description: East road ditch at 63rd Ave NW (Existing Mile Marker #26), looking east, DOC at ditch bottom is 5 ft. 10" rodent hole in bottom of ditch

Date: 8/6/2024

Latitude, Longitude: 48.0563997, -101.9869604

Photograph: 160

Location ID: RD18A

Description: East road ditch at 62nd Ave NW (Existing Mile Marker #26), looking east

Date: 8/6/2024

Latitude, Longitude: 48.045682, -101.9653799

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 161

Location ID: RD18A

Description: East road ditch at 62nd Ave NW (Existing Mile Marker #26), looking north along ditch

Date: 8/6/2024

Latitude, Longitude: 48.045682, -101.9653799

Photograph: 162

Location ID: RD18B

Description: West road ditch at 62nd Ave NW, looking west. Survey results indicate 6ft depth with 18.5° slope. DOC is 68-inches at bottom of ditch.

Date: 8/6/2024

Latitude, Longitude: 48.045682, -101.9653799

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 163

Location ID: P14

Description: NWI Pond No. 14, looking north, does not encroach on pipeline

Date: 8/6/2024

Latitude, Longitude: 48.0378798, -101.9464097

Photograph: 164

Location ID: RD19A

Description: North road ditch at 43rd St NW, looking north

Date: 8/6/2024

Latitude, Longitude: 48.0376582, -101.9467566

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 165

Location ID: RD19B

Description: South road ditch at 43rd St NW (Existing Mile Marker #26), looking south

Date: 8/6/2024

Latitude, Longitude: 48.0376582, -101.9467566

Photograph: 166

Location ID: RD27B

Description: West road ditch at 61st St Ave NW, looking west

Date: 8/6/2024

Latitude, Longitude: 48.034486, -101.943911

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 167

Location ID: RD27A

Description: East road ditch at 61st St Ave NW, looking east

Date: 8/6/2024

Latitude, Longitude: 48.034428, -101.943492

Photograph: 168

Location ID: RD20A

Description: North road ditch at 42nd St NW, looking north

Date: 8/6/2024

Latitude, Longitude: 48.0231574, -101.9332

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 169

Location ID: RD20B

Description: South road ditch at 42nd St NW, looking south

Date: 8/6/2024

Latitude, Longitude: 48.0231574, -101.9332

Photograph: 170

Location ID: F8

Description: No apparent farm ditch between fields

Date: 8/6/2024

Latitude, Longitude: 48.0143158, -101.9195814

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 171

Location ID: RD21A

Description: East road ditch at 62nd Ave NW (Existing Mile Marker #30), looking east

Date: 8/6/2024

Latitude, Longitude: 48.0105555, -101.9147143

Photograph: 172

Location ID: RD21A

Description: East road ditch at 62nd Ave NW looking west across road along pipeline

Date: 8/6/2024

Latitude, Longitude: 48.0105555, -101.9147143

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 173

Location ID: RD21B

Description: West road ditch at 62nd Ave NW, looking west

Date: 8/6/2024

Latitude, Longitude: 48.0105555, -101.9147143

Photograph: 174

Location ID: AOC4

Description: 41 St NW, looking south at cleared area with spoil piles. No excavated pits observed

Date: 8/6/2024

Latitude, Longitude: 48.0070596, -101.9094366

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 175

Location ID: RD22A

Description: North road ditch at 41 St NW, looking north. No visible Ditch

Date: 8/6/2024

Latitude, Longitude: 48.0070596, -101.9094366

Photograph: 176

Location ID: RD22B

Description: South road ditch 41 St NW, looking south. No visible Ditch

Date: 8/6/2024

Latitude, Longitude: 48.0070596, -101.9094366

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 177

Location ID: AOC4

Description: Cleared area with spoil piles and no visual evidence of excavation pit, looking southeast

Date: 8/6/2024

Latitude, Longitude: 48.005583, -101.909597

Photograph: 178

Location ID: F9

Description: No apparent farm ditch between fields, by East Fork Shell Creek

Date: 8/6/2024

Latitude, Longitude: 47.9962316, -101.9027565

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 179

Location ID: W14

Description: Stream crossing No. W14 at East Fork Shell Creek, looking north. Antenna is at pipeline

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph: 180

Location ID: W14

Description: Stream crossing No. W14 at East Fork Shell Creek, looking south. Shallow water and peat soils

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 181

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek in left floodplain looking south

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph: 182

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek in left floodplain looking north toward channel

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 183

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek in right floodplain looking south toward channel

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph: 184

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek in right floodplain looking north

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 185

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek from right edge of cattails looking towards channel

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph: 186

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek from right edge of cattails looking downstream

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 187

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek from right edge of cattails looking upstream

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph: 188

Location ID: W14

Description: Stream crossing No. 14 at East Fork Shell Creek, channel bottom soils are peat

Date: 8/6/2024

Latitude, Longitude: 47.994209, -101.9014111

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 189

Location ID: F10

Description: No apparent farm ditch between fields, by East Fork Shell Creek

Date: 8/6/2024

Latitude, Longitude: 47.9936487, -101.9010553

Photograph: 190

Location ID: RR1

Description: Start of ditch along railroad where planned pipeline is parallel, facing southeast. Slope is 13 ft tall with a 18° slope.

Date: 8/6/2024

Latitude, Longitude: 47.9923713, -101.9002043

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 191

Location ID: RR

Description: RR Ditch along planned pipeline at switch, looking southeast

Date: 8/6/2024

Latitude, Longitude: 47.9923713, -101.9002043

Photograph: 192

Location ID: O3

Description: Open pit No. 2, looking south

Date: 8/6/2024

Latitude, Longitude: 47.990926, -101.8802539

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 193

Location ID: RR

Description: RR Ditch along planned pipeline at switch, looking southeast

Date: 8/6/2024

Latitude, Longitude: 47.990917, -101.89635

Photograph: 194

Location ID: RR XING

Description: Planned pipeline crossing under railroad, looking south

Date: 8/6/2024

Latitude, Longitude: 47.98995909, -101.8937389

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 195

Location ID: RR XING

Description: Planned pipeline crossing under railroad, looking north

Date: 8/6/2024

Latitude, Longitude: 47.98995909, -101.8937389

Photograph: 196

Location ID: RR XING

Description: Planned pipeline crossing under railroad, looking east

Date: 8/6/2024

Latitude, Longitude: 47.98995909, -101.8937389

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 197

Location ID: RD23B

Description: West road ditch at 66th St NW, looking east
Date: 8/6/2024

Latitude, Longitude:
47.9897378, -101.8931279

Photograph: 198

Location ID: RD23A

Description: East road ditch at 66th St NW, looking west

Date: 8/6/2024

Latitude, Longitude:
47.9897378, -101.8931279

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 199

Location ID: F11

Description: Farm ditch where culvert passes under RR

Date: 8/6/2024

Latitude, Longitude: 47.9881374, -101.8889086

Photograph: 200

Location ID: F11

Description: Farm ditch where metal culvert passes under RR, facing northeast

Date: 8/6/2024

Latitude, Longitude: 47.9881374, -101.8889086

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 201

Location ID: F11

Description: Farm ditch where culvert passes under RR, looking northwest from metal culvert where pipeline is planned

Date: 8/6/2024

Latitude, Longitude: 47.9881374, -101.8889086

Photograph: 202

Location ID: F12

Description: Farm ditch where metal culvert passes under RR, facing northeast

Date: 8/6/2024

Latitude, Longitude: 47.983242, -101.874406

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 203

Location ID: F12

Description: Farm ditch where metal culvert passes under RR, facing northeast

Date: 8/6/2024

Latitude, Longitude: 47.983242, -101.874406

Photograph: 204

Location ID: W15

Description: Stream where concrete culvert passes under RR, facing northeast

Date: 8/6/2024

Latitude, Longitude: 47.9817022, -101.8698489

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 205

Location ID: W15

Description: Stream where culvert passes under RR, no riprap, facing northeast

Date: 8/6/2024

Latitude, Longitude: 47.9817022, -101.8698489

Photograph: 206

Location ID: RR2

Description: End of planned pipeline in RR ditch as it turns south. Planned pipeline is parallel to RR. Looking northwest towards RR1

Date: 8/6/2024

Latitude, Longitude: 47.9808441, -101.8661596

Photograph Log

Thunder Butte Petroleum Services Clean Fuels Refinery
Geological Hazard Investigation

Photograph: 207

Location ID: RD24B

Description: South road ditch at 247th Ave SW, looking east

Date: 8/6/2024

Latitude, Longitude: 47.9778535, -101.8664165

Photograph: 208

Location ID: RD24A

Description: North road ditch at 247th Ave SW, looking north

Date: 8/6/2024

Latitude, Longitude: 47.9778535, -101.8664165

Appendix D

ASSET Packets

ARCADIS

ASSET - Version 7.0 - Updated 5/23/2022 - For Gap Midstream

Waterway Name:	Shell Creek
Water Crossing ID:	W11
Pipeline Description:	Thunder Butte Pipeline
Latitude:	48.1208484
Longitude:	-102.0992996
Water Crossing Drafter:	Tim Webb-Horvath
Water Crossing Reviewer:	Aaron Dayton
Date of Assessment:	8/15/2024
Date of Crossing Survey:	8/6/2024
Annual Exceedance Probability (VIV)[1]:	<1%
Annual Exceedance Probability (Bending)[1]:	<1%
Prioritization:	Low

[1] Based on site visit measurements and subsequent ASSET analysis noted in this summary packet

Reinspection Interval	
Duration Based:	Every 10 Years
Date:	2034
Event Based:	25-year Flood

Summary

The channel substrate was mostly sand with sand. The longitudinal water surface slope was determined to be 0.001 ft/ft. Maximum Allowable Unsuppoted Span Lengths (MAUSL) based on Vortex-induced Vibrations (VIV) and Bending Stress (without debris) are not expected to exceed predicted unsupported span lengths through the 100-year return period flood event. The MAUSL calculations assumes end fixity coefficients for bending and VIV to be 8 and 1.57, respectively. Bank Erosion is a calculated predicted rate based on current conditions.

Additional Notes

Assessment Inputs	
Pipe Diameter (inches):	6.625
Wall Thickness (inches):	0.25
SMYS (psi):	25,764
MOP (psi):	1,400
Specific Gravity of Product:	0.8
Design Factor:	0.8

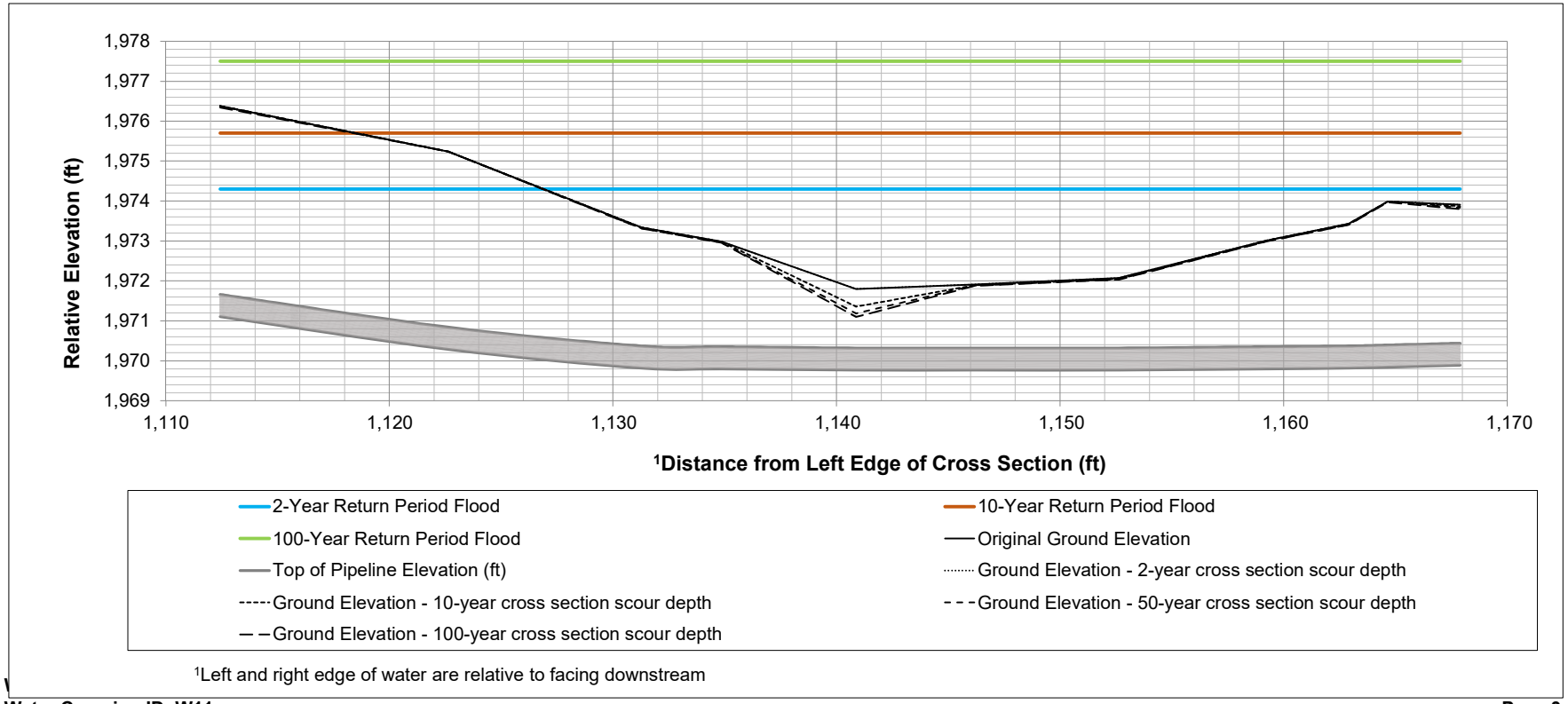
Disclaimer

A variety of methods are available for estimating channel bed scour, bank erosion, channel migration and avulsion potential. These channel processes are complex and predicting the magnitude and frequency of these events is difficult and often imprecise, reliant upon available data, and professional judgment. The tool and results provided here are based on a single cross section and largely driven by flow hydraulics from the Manning's Equation and a variety of channel stability, scour equations, migration and bank erosion equations. A number of simplifying assumptions and professional judgment were necessary to produce this screening tool. Results should be considered screening level and not appropriate for design and/or construction.

Pipeline Scour Assessment Results (Maximum Scour Depth)

Flood Event (Year Return Period Flood)	Discharge (cfs)	Minimum Pipeline Burial Depth in Channel (ft)	Maximum General Scour Depth (ft)	Maximum Dune Scour Depth (ft)	Maximum Cross Section Scour Depth (ft) (general + dune)	Maximum Pier or Obstruction Scour Depth (ft)	Maximum Bendway Scour Depth (ft)	Maximum Spur Dike or Bank Structure Scour Depth (ft)	Total Maximum Potential Scour Depth (ft) (sum of all scour components)
2	99	1.5	0.0	0.0	0.0	0	0.0	0	0.0
5	270	1.5	0.0	0.0	0.0	0	0.0	0	0.0
10	459	1.5	0.0	0.0	0.0	0	0.4	0	0.4
25	828	1.5	0.0	0.0	0.0	0	0.5	0	0.5
50	1,232	1.5	0.0	0.0	0.0	0	0.6	0	0.6
100	1,788	1.5	0.0	0.0	0.0	0	0.7	0	0.7

Cross Section Plot at Pipeline Crossing and Channel Scour

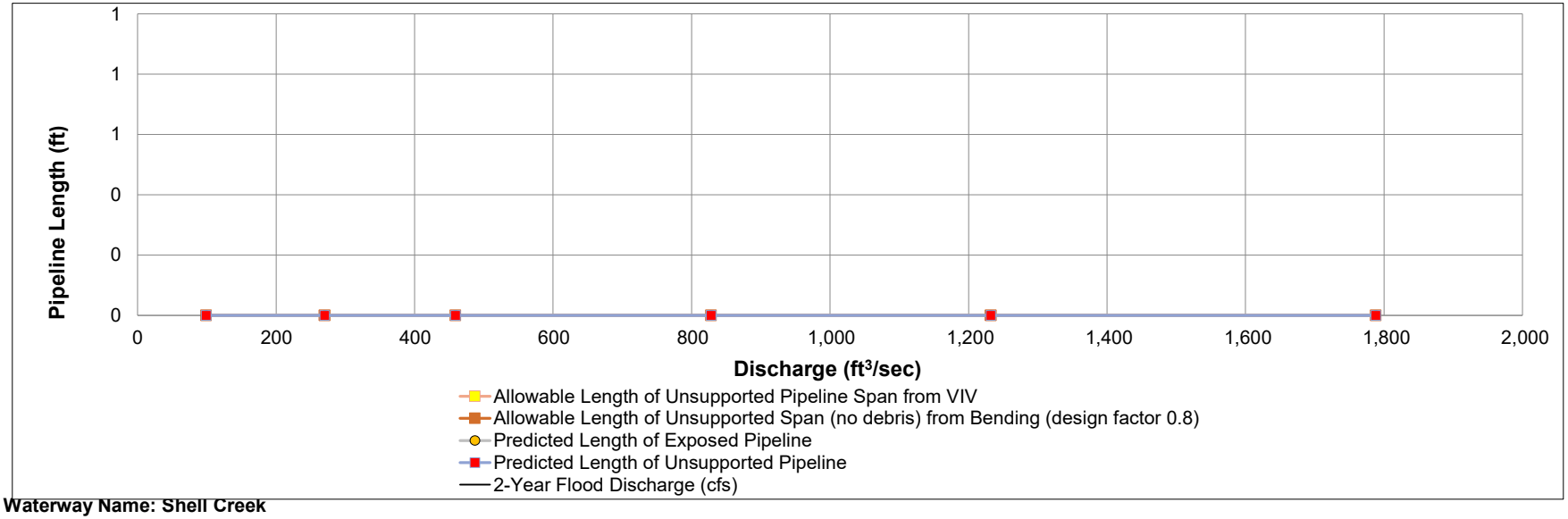


[1]Left and right edge of water are relative to facing downstream

Pipeline Exposure and Suspension Results (no debris)

Flood Event (Year Return Period Flood)	Discharge (cfs)	Predicted Length of Pipeline Exposure (ft)	Predicted Length of Pipeline Suspension (ft)	Maximum Water Velocity Acting on Top of Pipeline (ft/sec)	Horizontal Drag Force Acting on Pipeline (no debris) (lbs/ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 0.54) (ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 0.8) (ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 1.0) (ft)	Maximum Allowable Unsupported Pipeline Span Length from VIV (ft)
2	99	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
5	270	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
10	459	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
25	828	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
50	1,232	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
100	1,788	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A

Discharge vs Predicted and Allowed Unsupported Span Lengths



Waterway Name: Shell Creek
Water Crossing ID: W11

Avulsion Potential Assessment

Flood Event (Year Return Period Flood)	Discharge (cfs)	Radius of Curvature / Top Width (if value <6 check for Avulsion Risk)	Maximum Depth of Water on Left Floodplain (ft)	Maximum Depth of Water on Right Floodplain (ft)	Maximum Water Velocity on Left Floodplain (ft/sec)	Maximum Water Velocity on Right Floodplain (ft/sec)	Maximum Left Floodplain Scour Depth Potential (ft) (assumed sand sediments)	Maximum Left Floodplain Scour Depth Potential (ft) (assumed sand sediments)	Ratio of Maximum Left Floodplain Scour Depth to Left Bank Height	Ratio of Maximum Right Floodplain Scour Depth to Right Bank Height	Potential for Floodplain Erosion Induced Avulsion (assumes scour depth of 20% bank height represents increased avulsion risk)
2	99	3.8	0	0.4	0	0.7	0	0	0	0	No
5	270	3.8	0	1.2	0	1.5	0	0	0	0	No
10	459	3.8	0	1.8	0	2	0	0	0	0	No
25	828	3.8	0	2.4	0	2.4	0	0	0	0	No
50	1,232	3.8	0.5	3	1	2.8	0	0.1	0	0.1	No
100	1,788	3.8	1.1	3.6	1.7	3.2	0	0.5	0	0.3	Yes

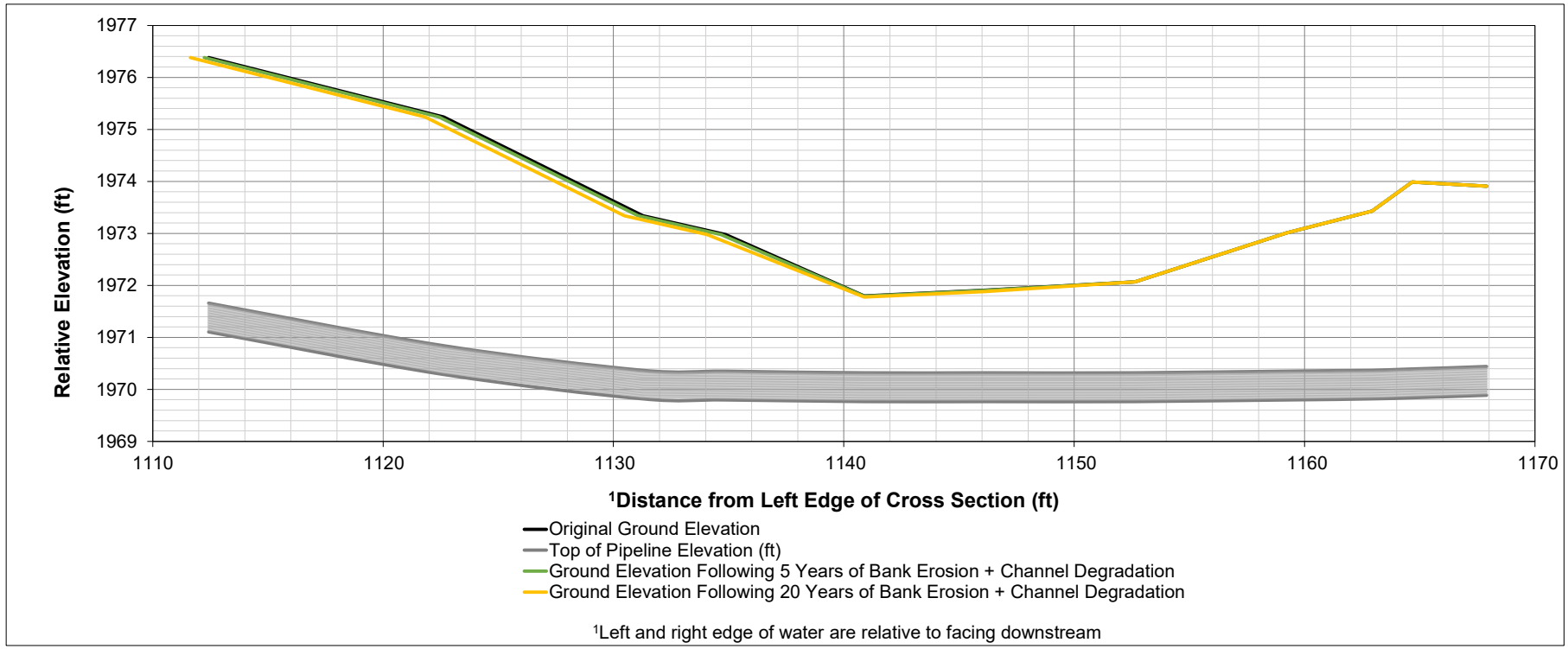
Estimate of Potential Bank Erosion

Bank	Potential Bank Erosion / Channel Migration Rate (ft/year)
Right Bank	Bank Located on Inside of Channel Bend and Not Expected to Erode - Continue to Monitor
Left Bank	0.04 ft/year - Compare to Pipeline Bank Setback Distance

Estimate of Potential Channel Degradation

Degradation Rate (ft/year)	0.001

Cross Section Plot Following 5 and 20 Years of Bank Erosion + Channel Degradation



Waterway Name: Shell Creek
Water Crossing ID: W11

ARCADIS

ASSET - Version 7.0 - Updated 5/23/2022 - For Gap Midstream

Waterway Name:	Unnamed Stream
Water Crossing ID:	W13
Pipeline Description:	Thunder Butte Pipeline
Latitude:	48.0964497
Longitude:	-102.0604311
Water Crossing Drafter:	Tim Webb-Horvath
Water Crossing Reviewer:	Aaron Dayton
Date of Assessment:	8/15/2024
Date of Crossing Survey:	8/6/2024
Annual Exceedance Probability (VIV)[1]:	<1%
Annual Exceedance Probability (Bending)[1]:	<1%
Prioritization:	Low

[1] Based on site visit measurements and subsequent ASSET analysis noted in this summary packet

Reinspection Interval	
Duration Based:	Every 10 Years
Date:	2034
Event Based:	25-year Flood

Summary

The channel substrate was mostly gravel with sand. The longitudinal water surface slope was determined to be 0.003317 ft/ft. Maximum Allowable Unsuppoted Span Lengths (MAUSL) based on Vortex-induced Vibrations (VIV) and Bending Stress (without debris) are not expected to exceed predicted unsupported span lengths through the 100-year return period flood event. The MAUSL calculations assumes end fixity coefficients for bending and VIV to be 8 and 1.57, respectively. Bank Erosion is a calculated predicted rate based on current conditions.

Additional Notes

Assessment Inputs	
Pipe Diameter (inches):	6.625
Wall Thickness (inches):	0.25
SMYS (psi):	25,764
MOP (psi):	1,400
Specific Gravity of Product:	0.8
Design Factor:	0.8

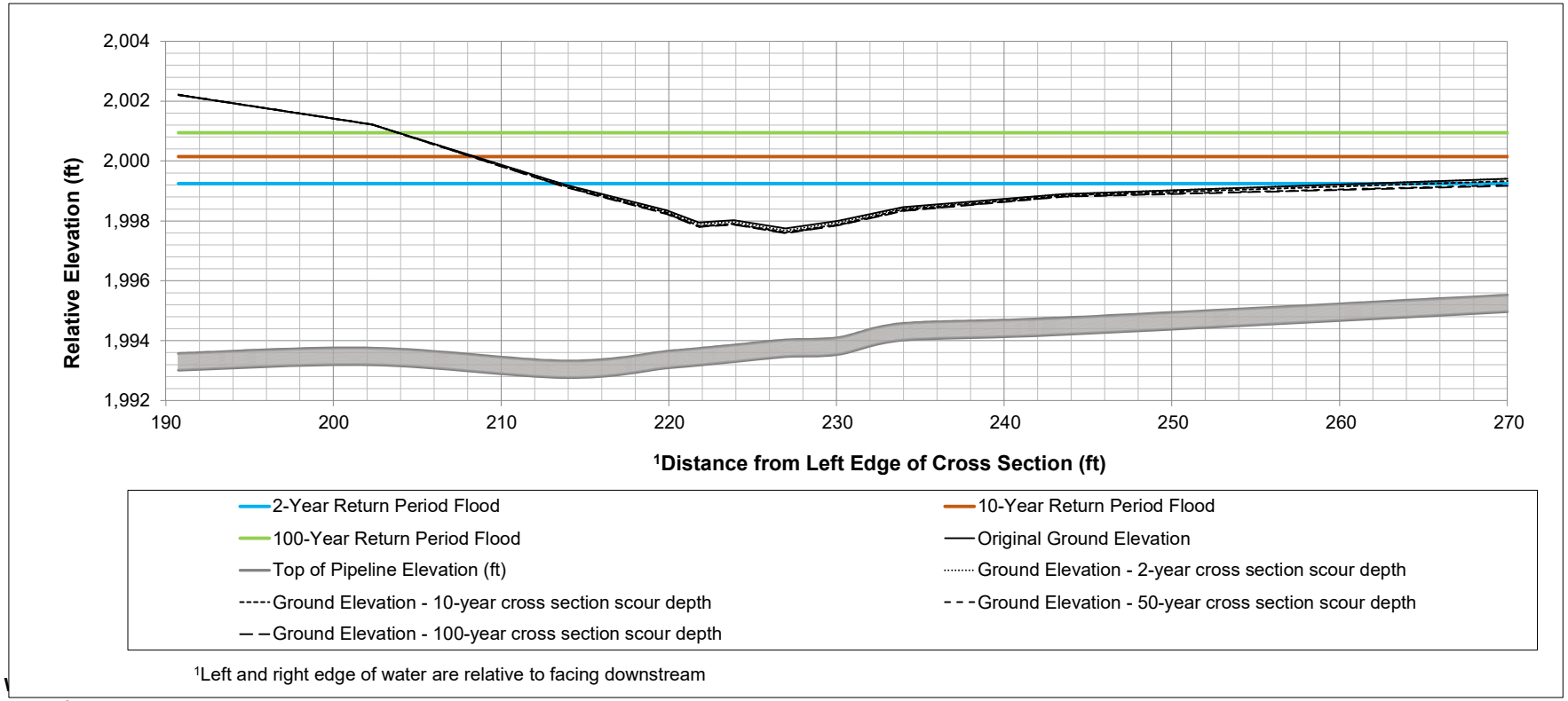
Disclaimer

A variety of methods are available for estimating channel bed scour, bank erosion, channel migration and avulsion potential. These channel processes are complex and predicting the magnitude and frequency of these events is difficult and often imprecise, reliant upon available data, and professional judgment. The tool and results provided here are based on a single cross section and largely driven by flow hydraulics from the Manning's Equation and a variety of channel stability, scour equations, migration and bank erosion equations. A number of simplifying assumptions and professional judgment were necessary to produce this screening tool. Results should be considered screening level and not appropriate for design and/or construction.

Pipeline Scour Assessment Results (Maximum Scour Depth)

Flood Event (Year Return Period Flood)	Discharge (cfs)	Minimum Pipeline Burial Depth in Channel (ft)	Maximum General Scour Depth (ft)	Maximum Dune Scour Depth (ft)	Maximum Cross Section Scour Depth (ft) (general + dune)	Maximum Pier or Obstruction Scour Depth (ft)	Maximum Bendway Scour Depth (ft)	Maximum Spur Dike or Bank Structure Scour Depth (ft)	Total Maximum Potential Scour Depth (ft) (sum of all scour components)
2	55	3.7	0.1	0.0	0.1	0	0.0	0	0.1
5	155	3.7	0.1	0.0	0.1	0	0.0	0	0.1
10	241	3.7	0.1	0.0	0.1	0	0.0	0	0.1
25	370	3.7	0.1	0.0	0.1	0	0.0	0	0.1
50	472	3.7	0.2	0.0	0.2	0	0.0	0	0.2
100	581	3.7	0.2	0.0	0.2	0	0.0	0	0.2

Cross Section Plot at Pipeline Crossing and Channel Scour

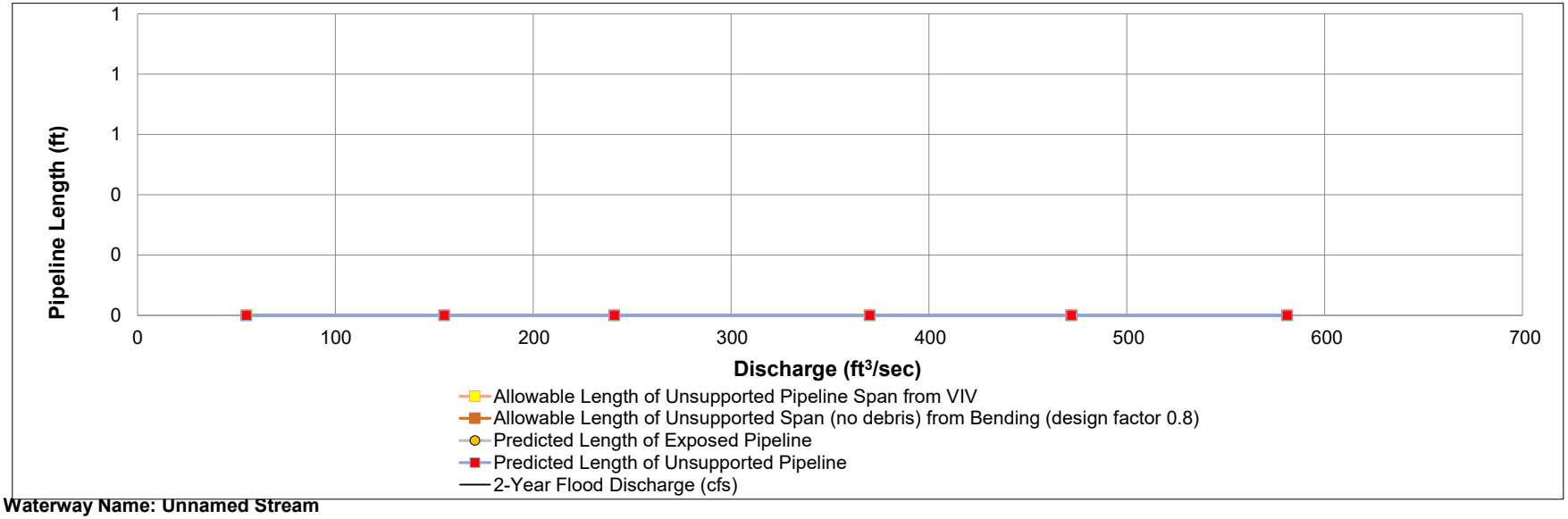


[1]Left and right edge of water are relative to facing downstream

Pipeline Exposure and Suspension Results (no debris)

Flood Event (Year Return Period Flood)	Discharge (cfs)	Predicted Length of Pipeline Exposure (ft)	Predicted Length of Pipeline Suspension (ft)	Maximum Water Velocity Acting on Top of Pipeline (ft/sec)	Horizontal Drag Force Acting on Pipeline (no debris) (lbs/ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 0.54) (ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 0.8) (ft)	Maximum Allowable Unsupported Pipeline Span Length from Bending (design factor 1.0) (ft)	Maximum Allowable Unsupported Pipeline Span Length from VIV (ft)
2	55	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
5	155	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
10	241	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
25	370	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
50	472	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A
100	581	0.0	0.0	Pipeline Not Exposed	0	N/A	N/A	N/A	N/A

Discharge vs Predicted and Allowed Unsupported Span Lengths



Waterway Name: Unnamed Stream
Water Crossing ID: W13

Avulsion Potential Assessment

Flood Event (Year Return Period Flood)	Discharge (cfs)	Radius of Curvature / Top Width (if value <6 check for Avulsion Risk)	Maximum Depth of Water on Left Floodplain (ft)	Maximum Depth of Water on Right Floodplain (ft)	Maximum Water Velocity on Left Floodplain (ft/sec)	Maximum Water Velocity on Right Floodplain (ft/sec)	Maximum Left Floodplain Scour Depth Potential (ft) (assumed sand sediments)	Maximum Left Floodplain Scour Depth Potential (ft) (assumed sand sediments)	Ratio of Maximum Left Floodplain Scour Depth to Left Bank Height	Ratio of Maximum Right Floodplain Scour Depth to Right Bank Height	Potential for Floodplain Erosion Induced Avulsion (assumes scour depth of 20% bank height represents increased avulsion risk)
2	55	6.0	0	0	0	0	0	0	0	0	No
5	155	6.0	0	0.4	0	1.4	0	0	0	0	No
10	241	6.0	0	0.7	0	2	0	0	0	0	No
25	370	6.0	0	1	0	2.5	0	0	0	0	No
50	472	6.0	0	1.3	0	3	0	0	0	0	No
100	581	6.0	0	1.5	0	3.3	0	0	0	0	No

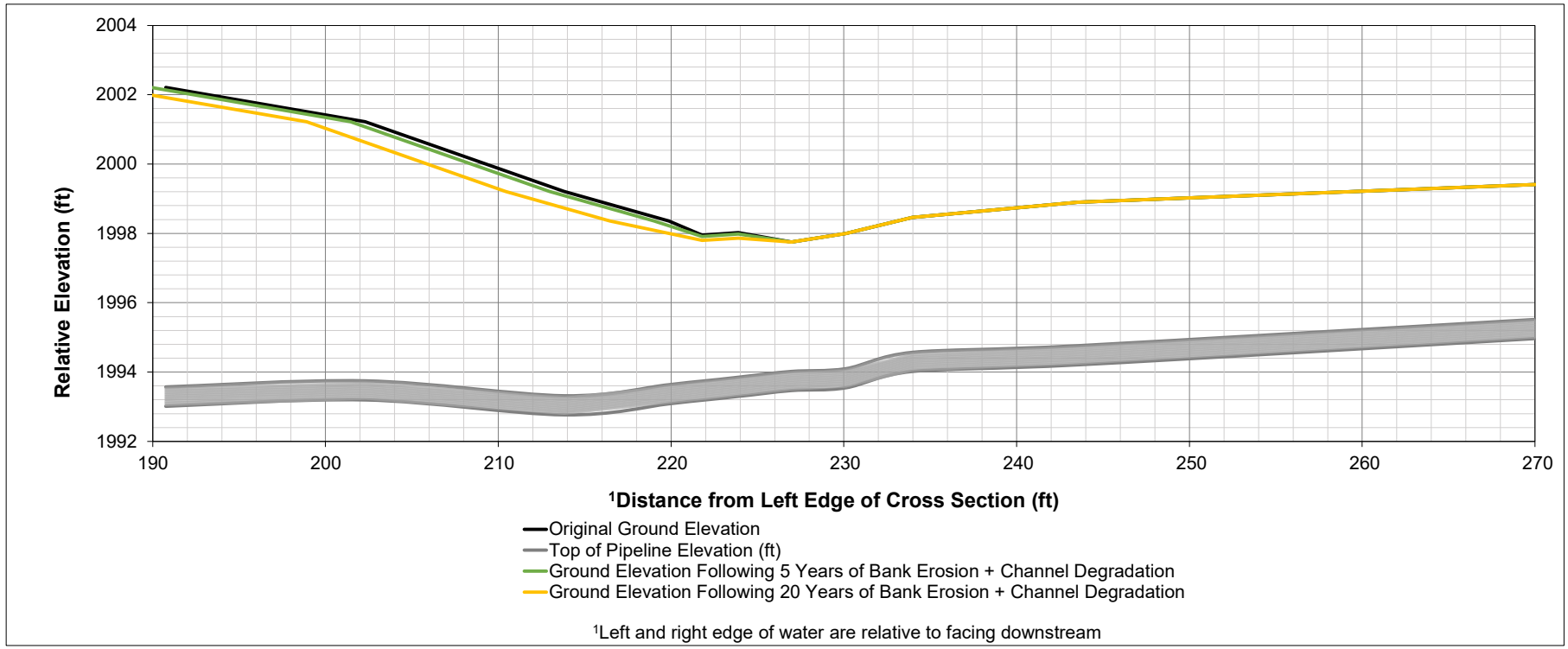
Estimate of Potential Bank Erosion

Bank	Potential Bank Erosion / Channel Migration Rate (ft/year)
Right Bank	Bank Located on Inside of Channel Bend and Not Expected to Erode - Continue to Monitor
Left Bank	0.17 ft/year - Compare to Pipeline Bank Setback Distance

Estimate of Potential Channel Degradation

Degradation Rate (ft/year)	0.008

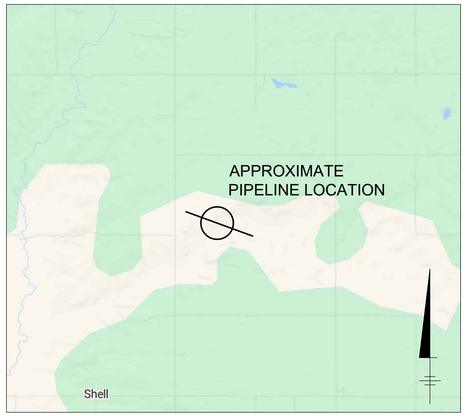
Cross Section Plot Following 5 and 20 Years of Bank Erosion + Channel Degradation



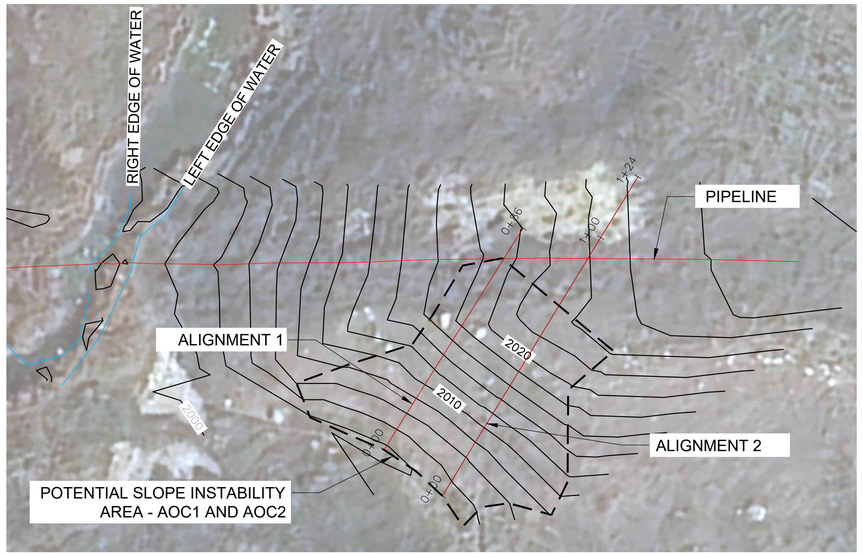
Waterway Name: Unnamed Stream
Water Crossing ID: W13

Appendix E

Survey Figures



LOCATION MAP
SCALE: 1" = 5,000'
HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF



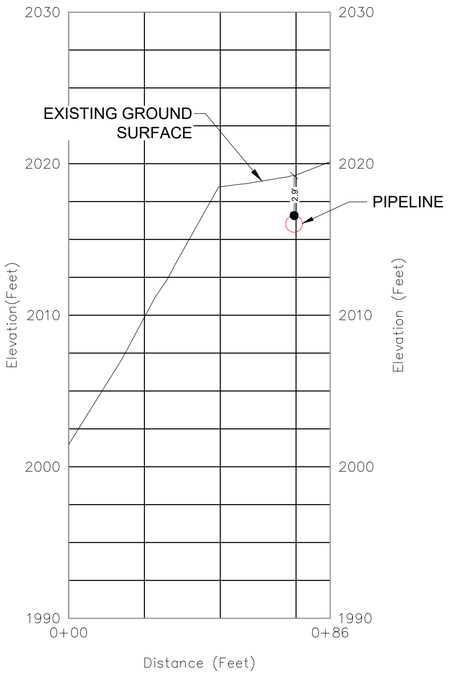
PLAN VIEW
SCALE: 1" = 25'

LEGEND:

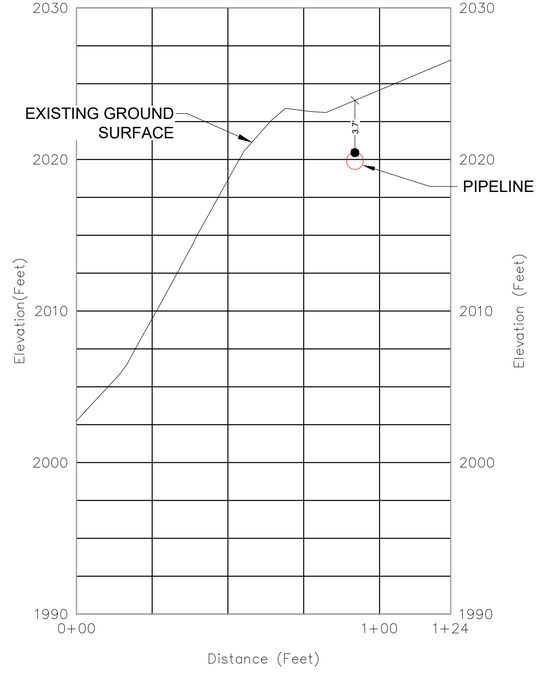
- PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT

ABBREVIATIONS:
AOC = AREA OF CONCERN

NOTE:
1. WATERWAY LOCATED BETWEEN MILE POST 21 AND MILE POST 22.



ALIGNMENT 1



ALIGNMENT 2

PROFILE VIEW
HORIZONTAL SCALE= 1" = 25'
VERTICAL SCALE= 1" = 5'

0 25' 50'
SCALE IN FEET
1" = 25' HORIZONTAL

0 5' 10'
SCALE IN FEET
1" = 5' VERTICAL

AOC1 & AOC2
MOUNTRAIL COUNTY, NORTH DAKOTA

AOC1 & AOC2 SURVEY

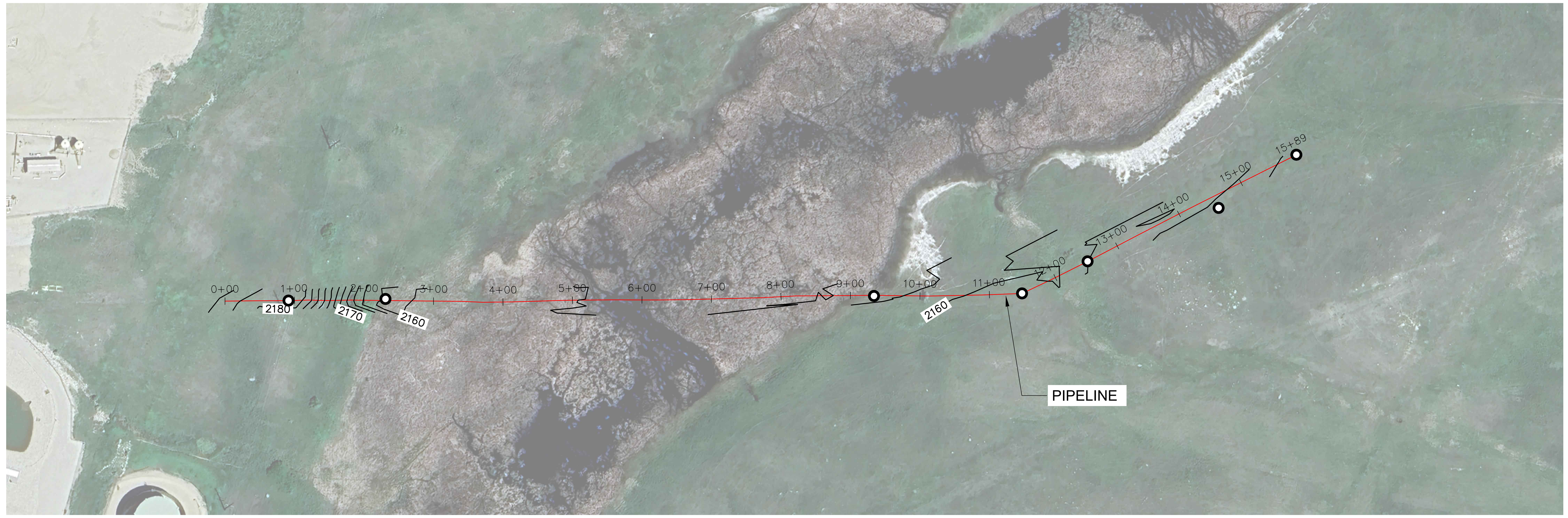
ARCADIS

FIGURE
1

LOCATION MAP

SCALE: 1" = 4,000'

HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF



PLAN VIEW

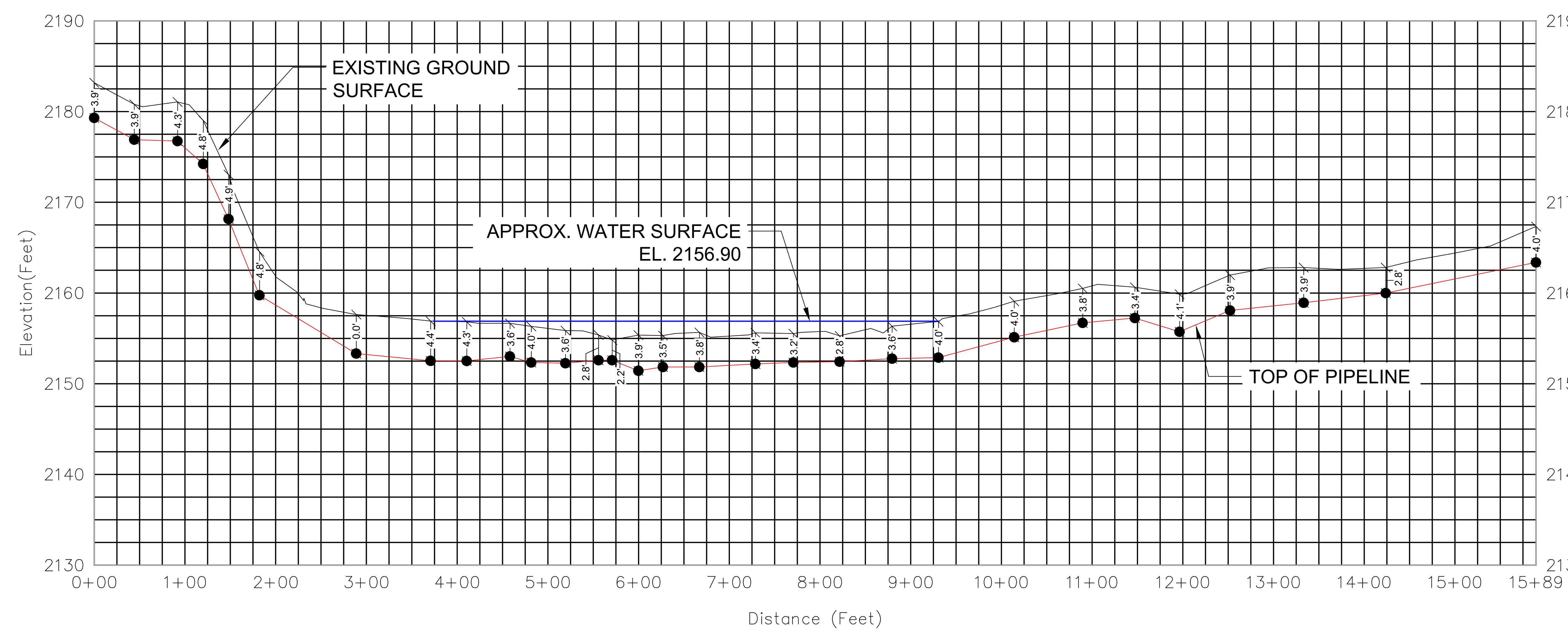
SCALE: 1" = 100'

LEGEND:

- PIPELINE MARKER
- PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT

NOTE:

1. WATERWAYs LOCATED BETWEEN MILE POST 0 AND MILE POST 1.



PROFILE VIEW

HORIZONTAL SCALE= 1" = 100'

VERTICAL SCALE= 1" = 10'

SCALE IN FEET 1" = 100' HORIZONTAL

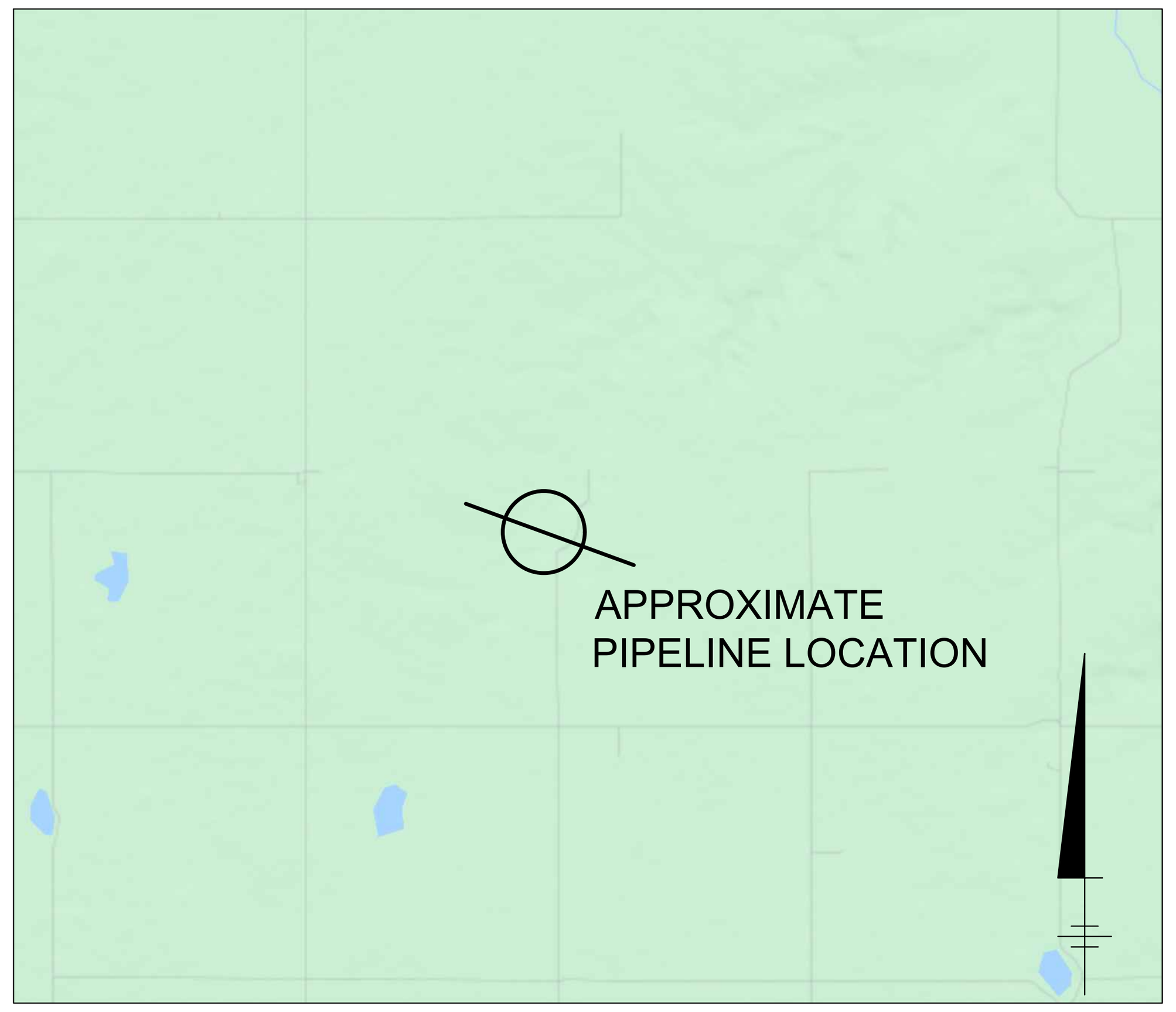
SCALE IN FEET 1" = 10' VERTICAL

W1, W2
MOUNTRAIL COUNTY, NORTH DAKOTA

W1, W2 SURVEY

ARCADIS

FIGURE 2



LOCATION MAP

SCALE: 1" = 4,000'

HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF

PLAN VIEW

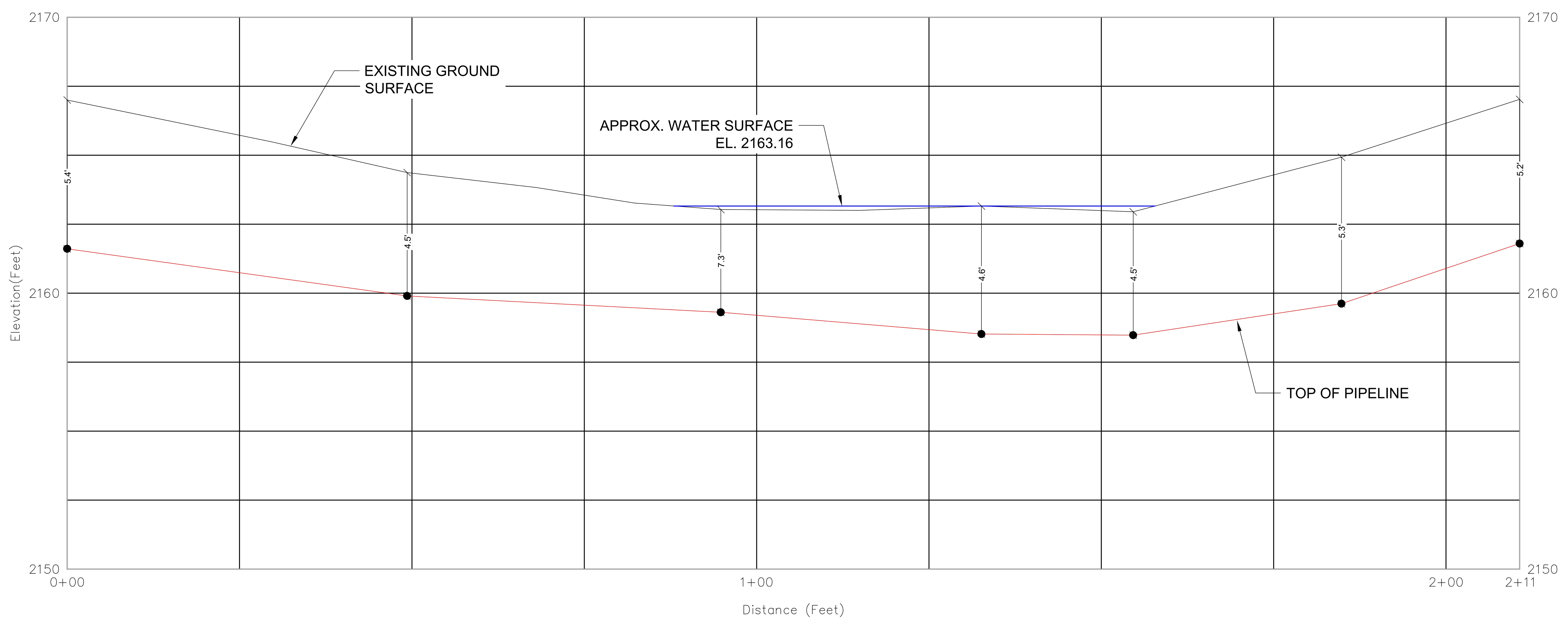
SCALE: 1" = 10'

LEGEND:

- ● PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT

NOTE:

1. WATERWAY LOCATED BETWEEN MILE POST 11 AND MILE POST 12.



PROFILE VIEW

HORIZONTAL SCALE= 1" = 10'
VERTICAL SCALE= 1" = 2.5'

0 10' 20'
SCALE IN FEET
1" = 10' HORIZONTAL

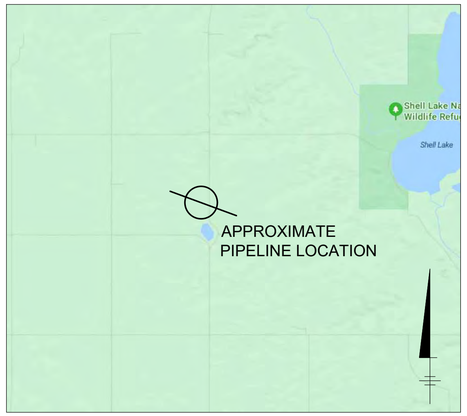
0 10' 20'
SCALE IN FEET
1" = 2.5' VERTICAL

W5
MOUNTRAIL COUNTY, NORTH DAKOTA

W5 SURVEY

ARCADIS

FIGURE
3



LOCATION MAP
SCALE: 1" = 4,000'
HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF

PLAN VIEW
SCALE: 1" = 10'

LEGEND:

- PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT

NOTE:
1. WATERWAY LOCATED BETWEEN MILE POST 13 AND MILE POST 14, NEAR MILE POST 14.

PROFILE VIEW
HORIZONTAL SCALE= 1" = 10'
VERTICAL SCALE= 1" = 5'

0 10' 20'
SCALE IN FEET
1" = 10' HORIZONTAL

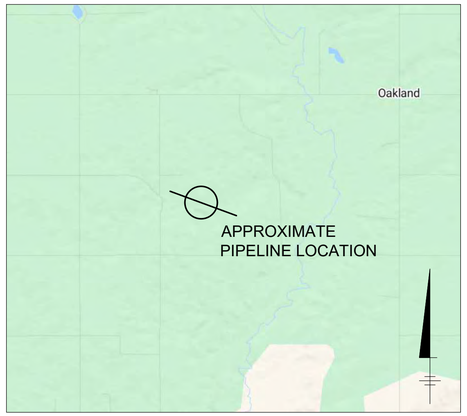
0 5' 10'
SCALE IN FEET
1" = 5' VERTICAL

W7
MOUNTRAIL COUNTY, NORTH DAKOTA

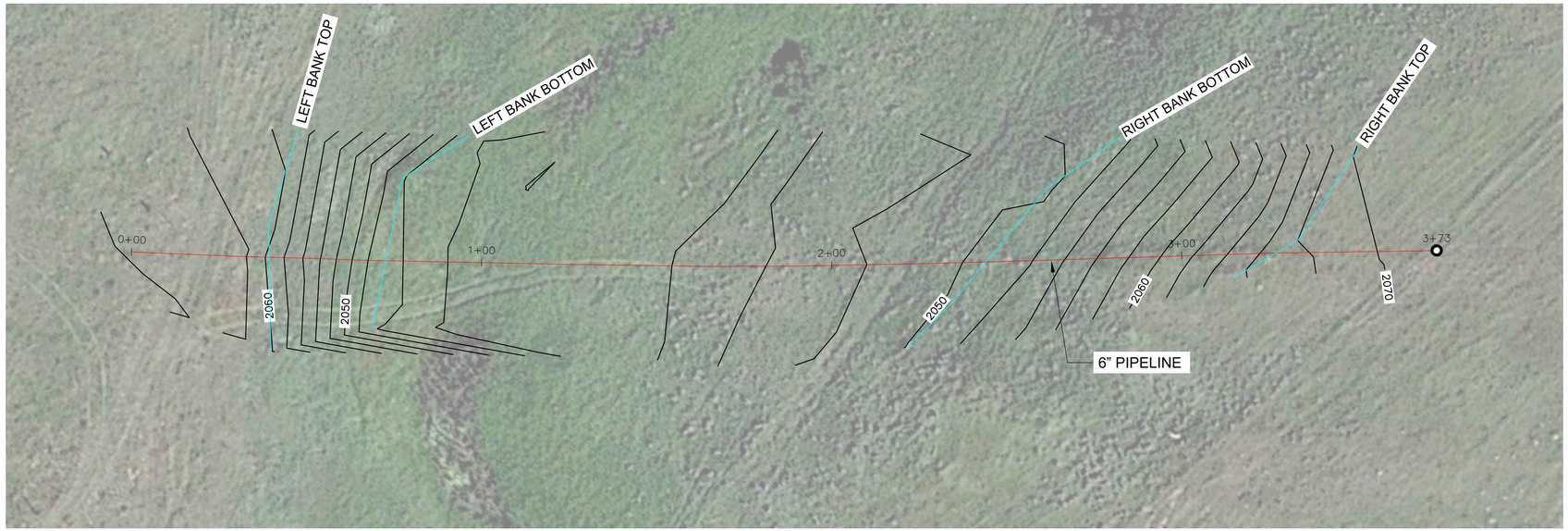
W7 SURVEY

ARCADIS

FIGURE
4



LOCATION MAP
SCALE: 1" = 5,000'
HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF



PLAN VIEW
SCALE: 1" = 20'

LEGEND:

- ● PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT
- O PIPELINE MARKER

NOTE:
1. WATERWAY LOCATED BETWEEN MILE POST 17 AND MILE POST 18.

PROFILE VIEW
HORIZONTAL SCALE= 1" = 20'
VERTICAL SCALE= 1" = 10'

0 20' 40'
SCALE IN FEET
1" = 20' HORIZONTAL

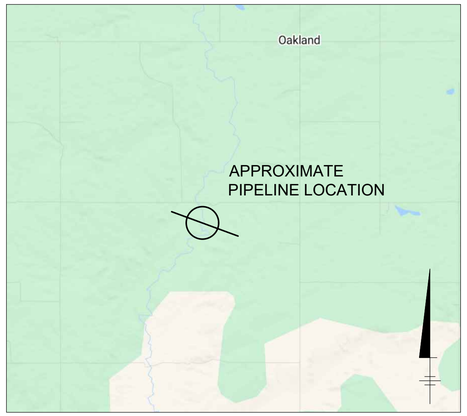
0 10' 20'
SCALE IN FEET
1" = 10' VERTICAL

W9
MOUNTRAIL COUNTY, NORTH DAKOTA

W9 SURVEY

ARCADIS

FIGURE
5



LOCATION MAP
SCALE: 1" = 5,000'
HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF

PLAN VIEW
SCALE: 1" = 10'

LEGEND:

- ● PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT
- O PIPELINE MARKER

NOTE:
1. WATERWAY LOCATED BETWEEN MILE POST 18 AND MILE POST 19.

PROFILE VIEW
HORIZONTAL SCALE= 1" = 10'
VERTICAL SCALE= 1" = 5'

0 10' 20'
SCALE IN FEET
1" = 10' HORIZONTAL

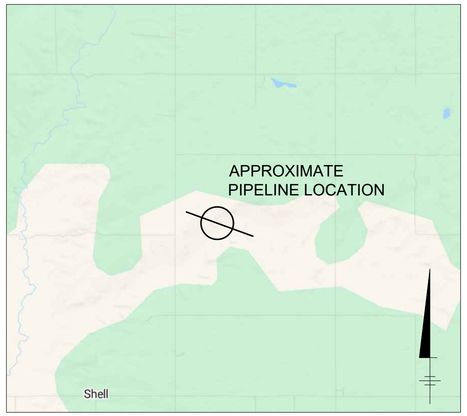
0 5' 10'
SCALE IN FEET
1" = 5' VERTICAL

W11
MOUNTRAIL COUNTY, NORTH DAKOTA

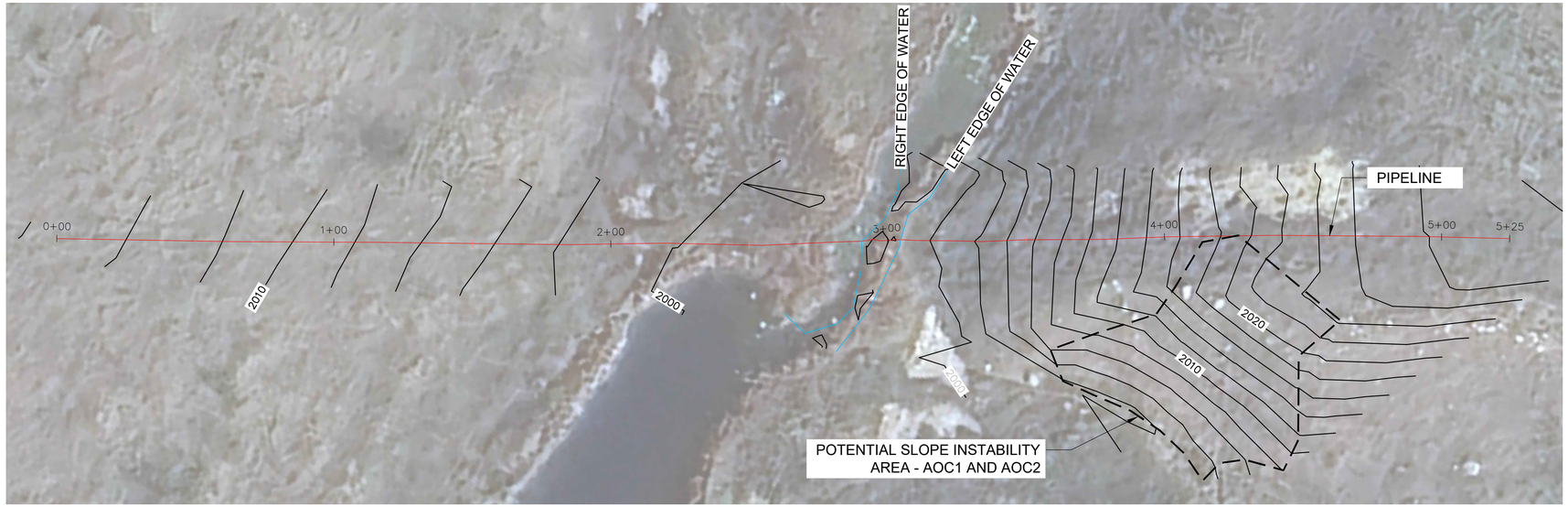
W11 SURVEY

ARCADIS

FIGURE
6



LOCATION MAP
SCALE: 1" = 5,000'
HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF



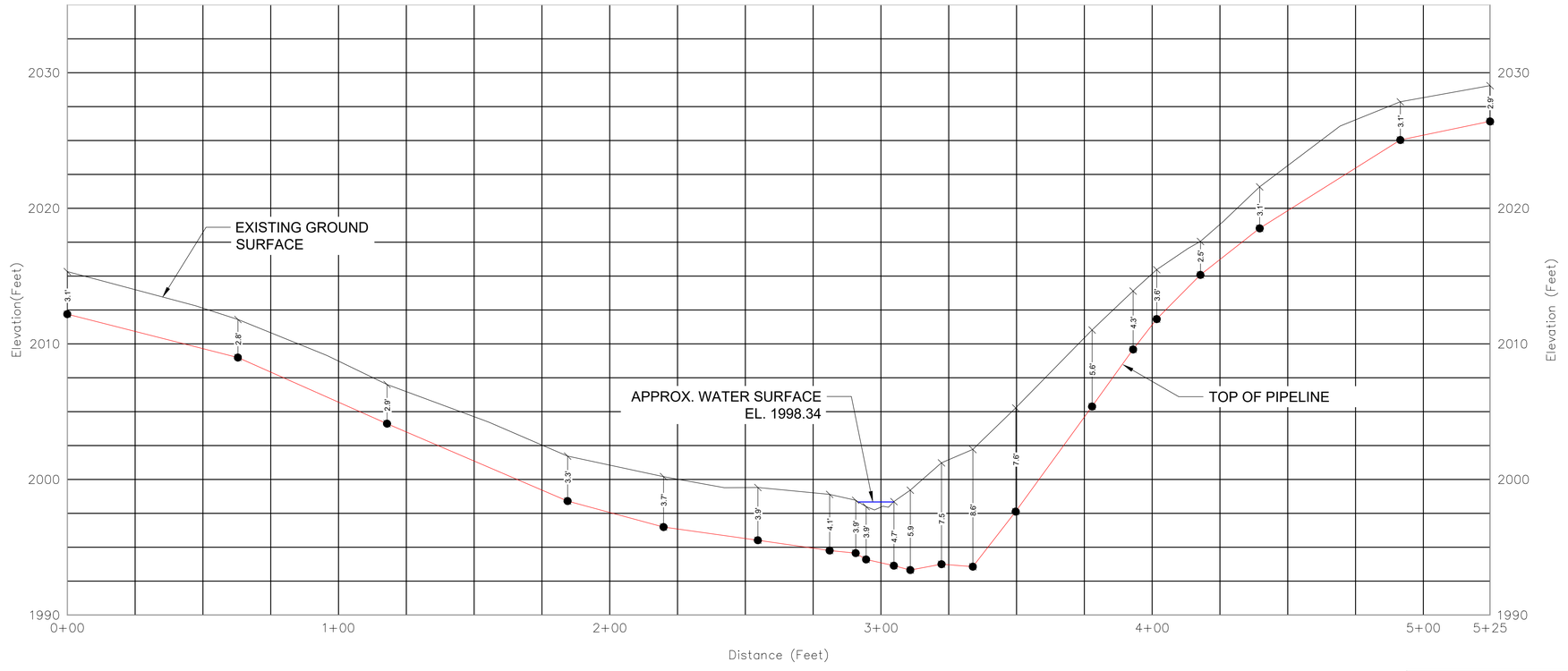
PLAN VIEW
SCALE: 1" = 25'

LEGEND:

- PIPE DEPTH FIELD VERIFIED BY ELETROMAGNETIC LOCATING EQUIPMENT

ABBREVIATIONS:
AOC = AREA OF CONCERN

NOTE:
1. WATERWAY LOCATED BETWEEN MILE POST 21 AND MILE POST 22.



PROFILE VIEW
HORIZONTAL SCALE= 1" = 25'
VERTICAL SCALE= 1" = 5'

0 25' 50'
SCALE IN FEET
1" = 25' HORIZONTAL

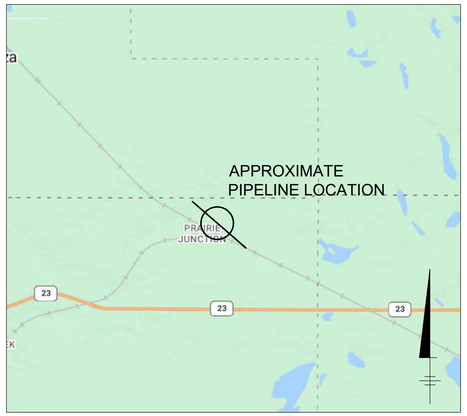
0 5' 10'
SCALE IN FEET
1" = 5' VERTICAL

W13
MOUNTRAIL COUNTY, NORTH DAKOTA

W13 SURVEY

ARCADIS

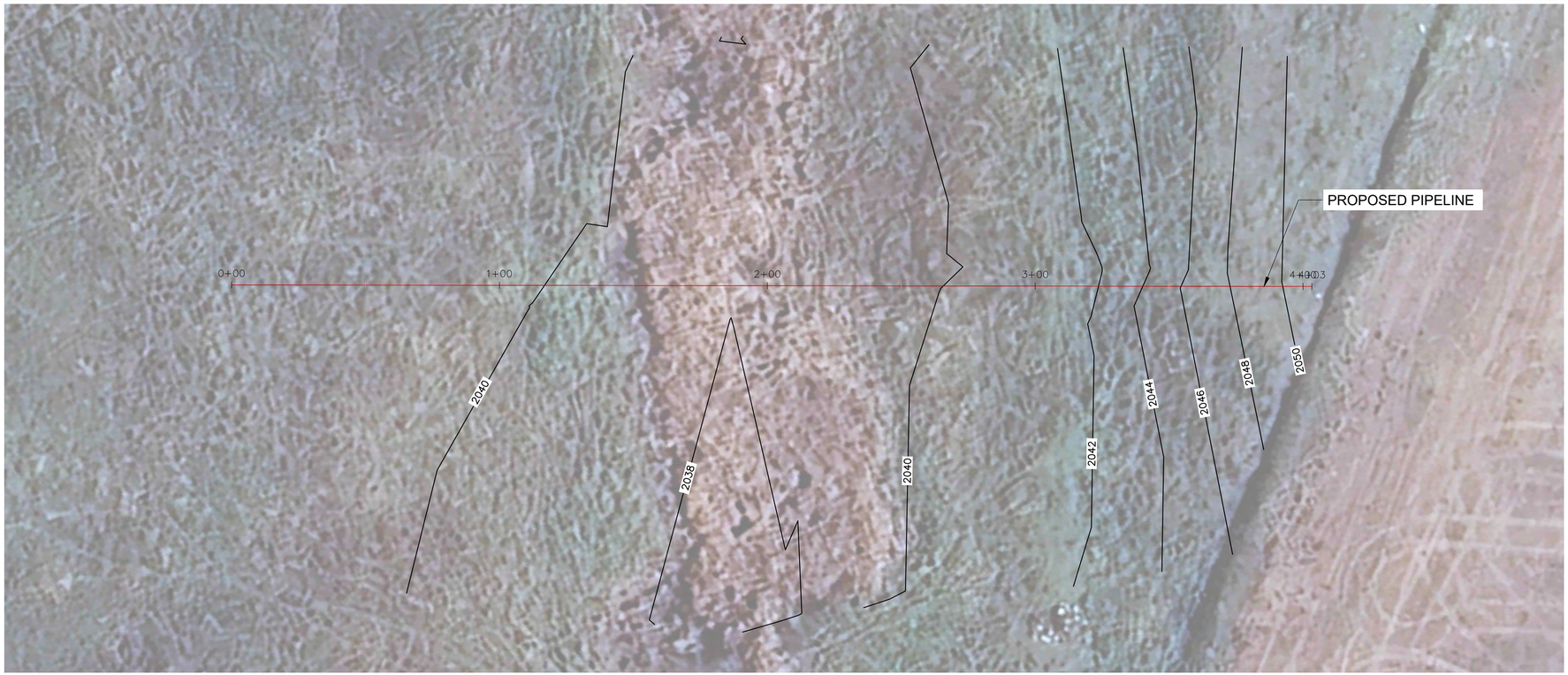
FIGURE
7



LOCATION MAP

SCALE: 1" = 5,000'

HORZ: NAD83 NORTH DAKOTA STATE PLANE, ZONE, US FOOT, ND83-NF

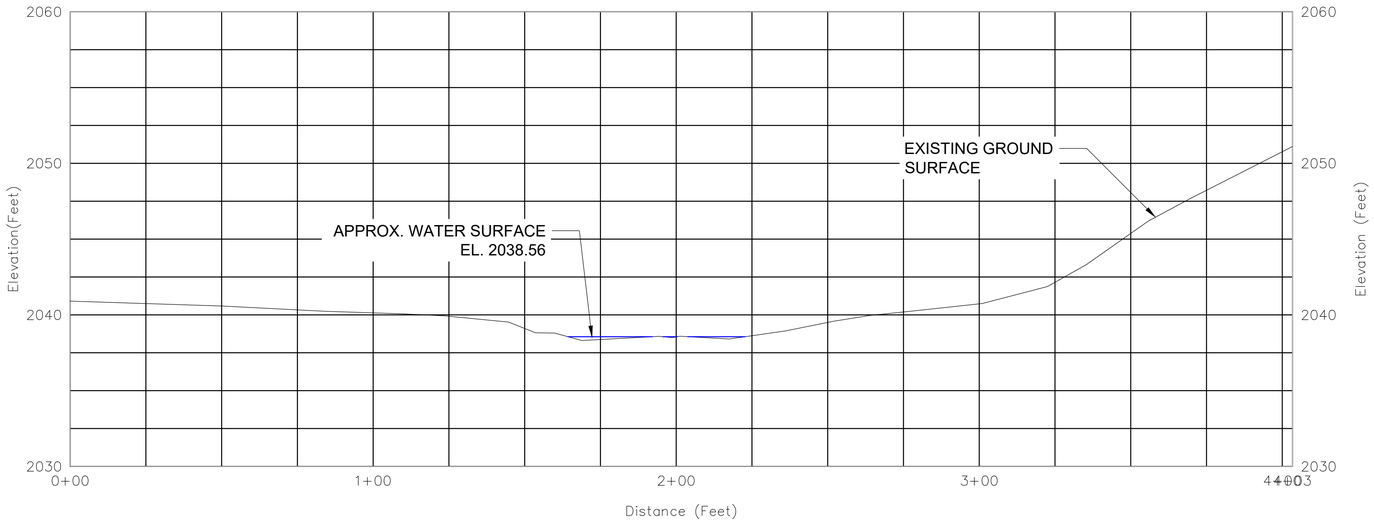


PLAN VIEW

SCALE: 1" = 25'

NOTE:

1. WATERWAY LOCATED A MILE POST 32.



PROFILE VIEW

HORIZONTAL SCALE= 1" = 25'

VERTICAL SCALE= 1" = 5'

0 25' 50'
SCALE IN FEET
1" = 25' HORIZONTAL

0 5' 10'
SCALE IN FEET
1" = 5' VERTICAL

W14
MOUNTRAIL COUNTY, NORTH DAKOTA

W14 SURVEY

ARCADIS

FIGURE
8

Arcadis U.S., Inc.
630 Plaza Drive, Suite 200
Highlands Ranch
Colorado 80129
Phone: 720 344 3500
Fax: 720 344 3535
www.arcadis.com