DAKOTA ACCESS, LLC

Energy Transfer Company

Dakota Access Pipeline Project

North Dakota Lake Oahe Crossing Spili Modei Discussion

WOOD GROUP MUSTANG

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TABLE OF CONTENTS

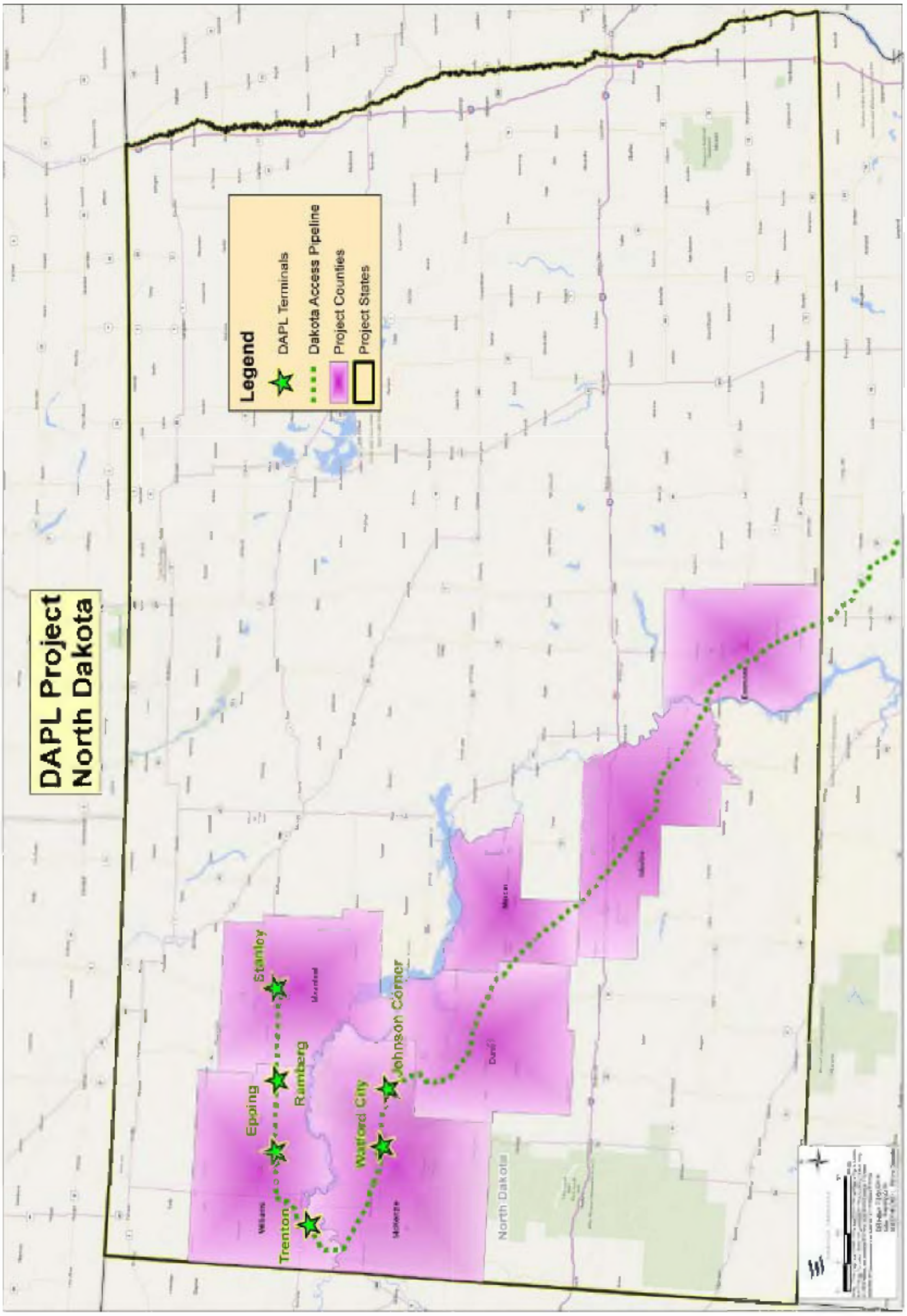
1.0 PROJECT DESCRIPTION

The overall project is comprised of two separate but interconnected pipeline systems – the Dakota Access Pipeline (DAPL) and the Energy Transfer Crude Oil Pipeline (ETCOP). Together, DAPL and ETCOP form an approximately 1,167-mile long cross-country pipeline that will initially transport 450,000 barrels per day (BPD) of crude oil commencing at Stanley, North Dakota and ending at the Trunkline Pipeline tie-in located near Johnsonville, Illinois.

Both the DAPL and ETCOP systems will be provided with pig launchers and receivers for pigging operations, mainline valves (emergency flow restricting devices), and a Supervisory Control and Data Acquisition system (SCADA) to control operations of the pipelines.

This report specifically discusses results of a spill model analysis as it pertains to the pipelines crossing of the Missouri River, Specifically Lake Oahe, within the state of North Dakota.

Maps of the DAPL system within North Dakota and a more detailed satellite view of the pipeline as it traverses, through the USACE jurisdictional area, have been provided on the next two pages.



DAPL Project
North Dakota
Legend
DAPL Terminals
Dakota Access Pipeline
Project Counties
Project States
Stanley
Epping
Ramberg
Trenton
Watford City
Johnson Corner
North Dakota

[redacted]

2.0 SPILL MODEL – PURPOSE AND OVERVIEW

For the purposes of determining the relative consequences associated with a spill occurring along the DAPL pipeline system, a US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA)–approved spill model was utilized.

This model uses hypothetical spill points, spaced at 200 foot intervals along the pipeline.

This approach complies with 49 CFR Section 194.105 which requires a pipeline company to determine the relative impact of a worse-case release in each of its emergency response zones. This determination is based on the following factors:

- Maximum pump shutdown response time
- Longest duration for a mainline valve closure
- Maximum flowrate in the pipeline
- Largest opening in the pipeline - assumes a full-diameter (guillotine) separation

Each simulated spills is then analyzed to determine which locations along the pipeline pose the greatest risk, thus allowing DAPL to mitigate potential risks in the design phase.

3.0 SPILL MODEL - TECHNICAL COMPONENTS

The PHMSA–approved spill model is based on the "OILMAP Land" computer software. This software generates hypothetical spill points along a pipeline, calculates the crude oil volume discharged at each point, and then models the pathways of the spills based on topographical data and site conditions.

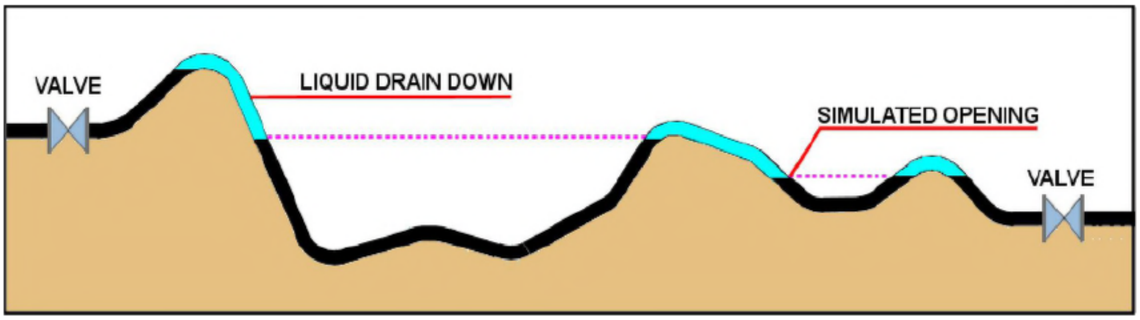
Volume Calculation

The spill model volumes are based on pipe diameter, flow rate, valve location, valve and pump shut down times, and the elevation profile along the pipeline.

When a pipeline break occurs, crude oil flows from the pipeline until the line is shut down and the valves are closed. To determine the maximum release volume, the model assumes a full diameter break (guillotine) in the pipeline.

In the first phase of the calculation, crude oil flows from the pipeline until the pumps are shut down.

In the second phase of the calculation, the pumps are no longer running, but some crude oil may continue to flow downhill out of the pipeline due to the effects of gravity. This volume is restricted to that amount of crude oil contained in the pipeline segment between closed valves and above the opening as indicated in the following diagram:



Pathway Determination

Land based spills travel down slope over land due to the effects of gravity.

The prediction of crude oil flow over land and across water requires utilizing the following two unique modeling approaches:

- Crude oil flow over land is governed by the characteristics and slope of the land surface. The land flow model takes into effect losses due to adhesion, the formation of small puddles, pooling in large depressions, and evaporation to the atmosphere.
- The water transport model moves oil on the water surface at a defined velocity and calculates oil lost to the shore from adhesion and oil evaporation to the atmosphere.

Effects of Adhesion

The amount of oil retained on the land surface as it flows down slope is determined by the nature of the land cover, e.g. dense vegetation is able to retain more oil than surface rock (ASCE 1969, Kouwen 2001, and Schwartz et al 2002).

Pooling on the land surface is the volume of oil retained within land depressions in the immediate area. The total oil lost to the ground is the sum of adhesion and pooling.

Effects of Evaporation

Oil evaporates as it spreads over land. The most volatile hydrocarbons (the light ends) evaporate rapidly - oftentimes in less than an hour (McAuliffe, 1989). The model uses a method called the Evaporative Exposure Model (Stiver and Mackay, 1984) which is used in most oil spill models to predict the evaporation rate.

In general, the rate of evaporation depends on surface area, composition of the crude oil, wind speed, and air and land temperature. The amount of oil evaporated is particularly sensitive to the surface area of the spreading oil and the time period over which evaporation is calculated.

The spill model software assumes evaporation ceases to occur once the total oil spill volume has been released. In reality, oil will continue to evaporate from the ground surface - increasing the total amount of oil evaporated and reducing the amount of oil available to spread along the ground.

The computer model's conservative calculation of evaporative loss is consistent with a worst-case scenario approach.

4.0 MODEL INPUT PARAMETERS

The following input data is utilized in the DAPL computer model:

Pipeline Segment	Diameter (inches)	Flow Rate (bbls/hour)	Detection and Shutdown*
[redacted]	12	4,833	12.9 minutes
[redacted]	20	13,170	12.9 minutes
[redacted]	24	18,880	12.9 minutes
[redacted]	30	18,880	12.9 minutes
[redacted]	30	25,000	12.9 minutes

* The mainline pumps are shutdown within 9 minutes of detection, and the adjacent block valves are completely closed within an additional 3.9 minutes.

The following crude oil properties are reflected in the DAPL model:

Property	Value
Density	50.2 lbs/ft^3
Temperature	64 °F
Boiling Point	331 °F
Specific Gravity	6.8 lbs/gal

The following operational parameters for North Dakota were used in the DAPL model:

Total Travel Time	6 hours	Time required for response equipment to arrive on site and for personnel to begin control and containment of the release.
Wind Speed	9 MPH	Constant wind speed used for evaporation calculation
Land Elevation	1,609' – 2,598'	10-meter resolution dataset provided by the United States Geological Survey (USGS)

DAPL Design Parameters	Parameter Value
Pipe Specifications	12-inch X-52 (0.375" WT) 20-inch X-70 (0.312" WT) 24-inch X-70 (0.375" WT) 30-inch X-70 (0.429" WT) 30-inch X-70 (0.625" WT)* * valve sites and road, rail, and river crossings
Coating	Fusion bond epoxy (FBE) coating.
Maximum Operating Pressure	1,440 psi
Depth of Cover	4' minimum - exceeds federal requirements
Above ground versus buried pipe	The pipeline shall be buried except at pump stations and valve sites.
Mainline Valve Operation	100% remotely controlled.
Pump Stations	6 pump stations in North Dakota

5.0 MODEL RESULTS

<u>Quantifying Risk</u>

The computer model outputs data about the potential volume of a worst-case release and the path that release will follow based on topography. By overlaying that data on a map that shows the location of High Consequence Areas (HCAs) - as identified by PHMSA and defined by 49 CFR section 195.450 - it is possible to identify oil plumes (if any) and their locations along the pipeline that pose the highest levels of risk.

A method to quantify risk, based on a text by Kent Muhlbauer, ("*Pipeline Risk Management Manual*", 2003) was used to allocate a risk score to each oil plume using the following formula:

Risk = (volume of the spill) x (area of the spill) x (number of HCA interactions).

The risk scores referenced in this report are relative to all of the modeled spills in the DAPL system.

Reducing Risk

Spill volumes are primarily controlled by mainline valve locations, the sensitivity of the DAPL leak-detection and notification system, and the valve closure rates. All of these factors are incorporated into the DAPL project design, and represent the primary defenses for reducing spill volumes. Reducing spill volume, by reducing drain down, is discussed further in Section 6.0. When combined, these components will significantly reduce the model's predicted maximum spill volume.

Clarification

It is important to note that predicted spills in a model do not correlate with the majority of spills seen in actual crude oil release. This is due to a number of factors such as:

- Most spills are not full ruptures of the line.
- Most spills do not suffer a full gravity drain down due to anti siphoning effects.
- Not all oil releases happen when the pipeline is exposed (un-buried). When a pipeline is buried, the backfill on top of the pipe restricts the area and volume the spill can effect.

This position is supported by actual incident data from the "*Hazardous Liquid Pipeline Risk Assessment*" (California State Fire Marshal, 1993). This report indicates that actual documented spill volumes are significantly less than the maximum theoretical volumes calculated by the computer models. For example, in 50% of all documented incidents, the actual release volume was less than 0.75% of what the computer models predicted. Further, in 75% of all documented incidents, the actual release volume was less than 4.6% of what the computer models predicted.

However, a worst case scenario, conservative analysis, is used in the spill model in accordance with PHMSA modeling requirements.

Risk-Ranked Spill Cases

The following graphs plot the Risk Score versus the pipeline Mile Posts and pipeline Elevations for the Lake Oahe Crossing. The computer-calculated spill volume is represented by the red line across the middle of the graph. The line at the bottom of the graph represents the risk score computed for a spill at any given location along the pipeline.

[redacted]

5.1 Lake Oahe in the DAPL Main Line

Below is a representation of the computer simulated oil plumes for the pipeline as it crosses Lake Oahe. Each simulated plume (one every 200 feet) is shown as a different color. The model assumes a worst case design and spill scenario where the pipeline is resting at grade (i.e. floating at the surface of the water) in accordance with PHMSA modeling protocol. However, please note that in reality the river crossing is achieved as a directional drill under the water. Since the pipeline is in a directional drill under the river, the behavior of a spill would be significantly different than the worst case shown in the model where the pipeline is assumed to be laying on top of grade. In a directional drill, any released crude oil will take the path of least resistance which is typically along the path of the original HDD bore. Therefore any modeled spills shown directly on top of the river are a worst case scenario to assist DAPL in mitigating any potential releases in this area

[redacted]

In this location at mile post 166 the model predicts a volume release of [redacted] bbls of crude, which can spread to cover approximately 50 acres.

The graph below shows the same location (at mile post 166) depicted on the map on the previous page. This graph shows the volume spilled in bbls as a black line running across the middle of the graph. Along the bottom of the graph a line showing the course of the pipelines elevation is depicted. The line at the bottom of the graph is also color coded to reference the risk score computed for a spill at any given location along the length of the pipeline. This line shows the risk level on a scale of 1-10 where a 1 is a minor risk, and a 10 is a major risk. The location of the Missouri River is shown as a highlighted bar.

[redacted]

The risk is relatively low at this location and has been assigned a risk rank of 3 (out of a possible 10). The risk rank of 3 is [redacted] The best way to reduce risk is to reduce the volume available during a potential spill.

DAPL has reduced the risk present in this location via the placement of valves to acting as EFRDs.

Prior to the completion of the Spill Model study, the original placement of MLV's was such that spill interaction with HCA's was 18% (other populated areas) and 79% (ecological). As a result of the Spill Model study, MLV locations were optimized and these interactions were reduced by approximately 45%.

MLV-ND-380 has been located as close to the west bank of the lake as possible considering the flood plain, and MLV-ND-390 is present approximately 280 yards from the pipelines east bank directional drill site.

6.0 CLARIFICATION OF RESULTS

In the unlikely event of a spill, the actual size is expected to be significantly smaller than that maximum volume predicted in the model. This is due to the way the model calculates releases as described earlier. In particular:

Guillotine Break

All PHMSA-approved spill models calculate the volume based on a full-diameter (guillotine) break on a pipeline. In reality, such full-diameter breaks are only likely to occur on small-diameter pipelines (< 16 inch). For larger diameter pipelines (> 20 inch) the most likely leak mechanism is due to punctures caused by augers or excavator bucket teeth.

Third-Party Contact

The most likely cause of damage to a pipeline is from contact during construction activities initiated by a third-party. In most cases this is due to the pipeline being struck by an auger or excavator. Specifically, the largest excavator built in the USA by Caterpillar can only generate 14,000 pounds of force at the end of the excavator bucket teeth. While this is enough force to create a small single-tooth puncture in a pipeline, it is not enough force to shear through the 30-inch diameter, 0.429-inch wall thickness pipeline, requiring 29,000 pounds of force. Note: The risk of construction equipment inadvertently contacting the pipeline is greatly reduced since a minimum of four feet of soil cover is being provided over the buried pipeline in most locations. Additionally, the risk of inadvertent contact is reduced through the following:

- Placement of yellow pipeline warning markers spaced at regular intervals according to PHMSA requirements.
- Accurate as-built information recorded with the county assessor.
- Participation in "One-Call" and "Before You Dig" notification systems.

Anti-Siphon Effects

Though the pipeline computer model calculates volume based on the entire release of oil between valves, it does this by assuming air can enter the pipeline through the opening and evacuate that entire section of pipeline. In reality, air does not completely evacuate the pipeline, but rather, only enters the immediate area of the pipeline adjacent to the opening. Beyond this localized area, anti-siphon effects take over and minimize any further release of oil from the pipeline.

7.0 PIPELINE DESIGN AND OPERATION PARAMETERS

The following DAPL design and operation standards will greatly reduce the threat of a crude oil release:

- Pipe specifications that meet or exceed applicable regulations, with a quality assurance program for pipe manufacturers
- Use of the highest quality external pipe coatings (fusion bond epoxy or FBE) to reduce the risk of corrosion, and stress corrosion cracking.
- Active Cathodic Protection applied to the pipeline and facilities
- Four feet of soil cover will be provided over the buried pipeline in most locations which exceeds federal standards.
- Pipeline system inspection and testing programs will be implemented prior to operation to ensure the pipeline is built in accordance with the standards and specifications.
- Non-destructive testing of 100 percent of girth welds
- Hydrostatic testing of the pipeline to 125% percent of the Maximum Operating Pressure (MOP).
- A continuous pipeline monitoring system (Supervisory Control and Data Acquisition [SCADA]) that remotely measures changes in pressure and volume on a continual basis. This measurement data is immediately analyzed to determine potential product releases anywhere on the pipeline system.
- Meter comparison system that continuously verifies meter flows match at multiple points along the pipeline in real-time.
- Periodic pipeline integrity inspection programs using internal inspection tools to detect pipeline diameter anomalies indicating excavation damage, and loss of wall thickness from corrosion.
- Periodic above-ground Close Interval Surveys (CIS) conducted along the pipeline.
- Aerial surveillance inspections will be conducted 26 times per year (not to exceed 3 weeks apart) to detect leaks and spills as early as possible, and to identify potential third-party activities that could damage the pipeline.
- Mainline valves are installed along the pipeline route to reduce or avoid spill effects to PHMSA-defined HCAs.
- In the unlikely event of a spill, the implementation of these measures, along with the leak detection program, will significantly reduce both the likelihood and impact of such an incident.

- Periodic landowner outreach and the implementation of a Public Awareness program
- Participation in "One-Call" and "Before You Dig" notification systems.

8.0 CONCLUSION

This report describes the results of a spill model analysis for the pipeline crossing of Lake Oahe. A PHMSA–approved spill model was utilized and the computer model outputs data about the potential volume of a worst-case release utilizing a worst case design (where the pipeline would be installed floating across the surface of the water) and worst case spill scenario using hypothetical spill points spaced at 200 foot intervals along the pipeline.

An analysis of the data shows that the Lake Oahe crossing is not considered a high risk. This crossing of the Missouri River crossing has been assigned a risk ranking between 2 and 3 (out of a possible 10).

In the unlikely event of a spill, the actual amount spilled is expected to be significantly smaller than that maximum volume predicted in the model due to the way the model calculates releases.

The Lake Oahe crossing is proposed to be directionally drilled which eliminate the possibility for inadvertent contact with the pipeline beneath the water bodies. Additionally, DAPL has strategically placed EFRD valves on both sides of the crossing to further minimize risk.