Pipeline Risk Assessment and Environmental Consequence Analysis for the Hess Hawkeye Pipeline System Project

Stantec

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EXHIBIT
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Sign-off Sheet

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ACRONYMS AND ABBREVIATIONS

API	American Petroleum Institute
ASTM	American Standard for Testing and Materials
bpd	barrels per day
BLM	Bureau of Land Management
bmp	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
CPM	computational pipeline monitoring
CWA	Clean Water Act
EA	environmental assessment
ERW	electronic resistance welding
FBE	fusion bond epoxy
HCA	high consequence area
Hess	Hess Corporation
IMP	Integrity Management Plan
MAOP	maximum allowable operating pressure
MCL	maximum contaminant level
mmscfd	million standard cubic feet per day
MOP	maximum operating pressure
NEPA	National Environmental Policy Act
NGL	natural gas liquids
NPDES	National Pollutant Discharge Elimination System
OCC	Operations Control Center

OD	outside diameter
PAH	polycyclic aromatic hydrocarbon
PHMSA	Pipeline and Hazardous Materials Safety Administration
ppb	parts per billion
ppm	parts per million
Project	Hawkeye Pipeline System Project
PSC	Public Service Commission
psig	pounds-force per square inch gauge
ROW	right-of-way
SCADA	Supervisory Control and Data Acquisition
SPCC Plan	Spill Prevention, Control and Countermeasures Plan
SWPPP	Storm Water Pollution Prevention Plan
U.S.	United States
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USDOT	United States Department of Transportation
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USA	unusually sensitive area
USGS	United States Geological Survey
WT	wall thickness

1.0 Project Overview

Hess Corporation (Hess) has filed a Right-of-Way (ROW) Grant application with the Bureau of Land Management (BLM) to construct, operate, and maintain the proposed Hawkeye Pipeline System Project (Project) in McKenzie and Williams counties, North Dakota, as shown in **Figure 1-1**. Hess proposes to construct an approximately 26-mile-long pipeline system connecting Bakken production fields south of Lake Sakakawea to existing processing facilities north of the lake. The projected in-service date for the Project is October 2015. The Project would remain in operation for approximately 30 years.

The Project would transport crude oil from the proposed Hawkeye Oil Facility near Keene, North Dakota, and natural gas and natural gas liquids (NGL) from the existing Hawkeye Compressor Station near Charlson, North Dakota, to the existing Ramberg Truck Facility (crude oil) and existing Silurian Compressor Station (natural gas and NGL) near Tioga, North Dakota (**Figure 1-1**). The Project would include:

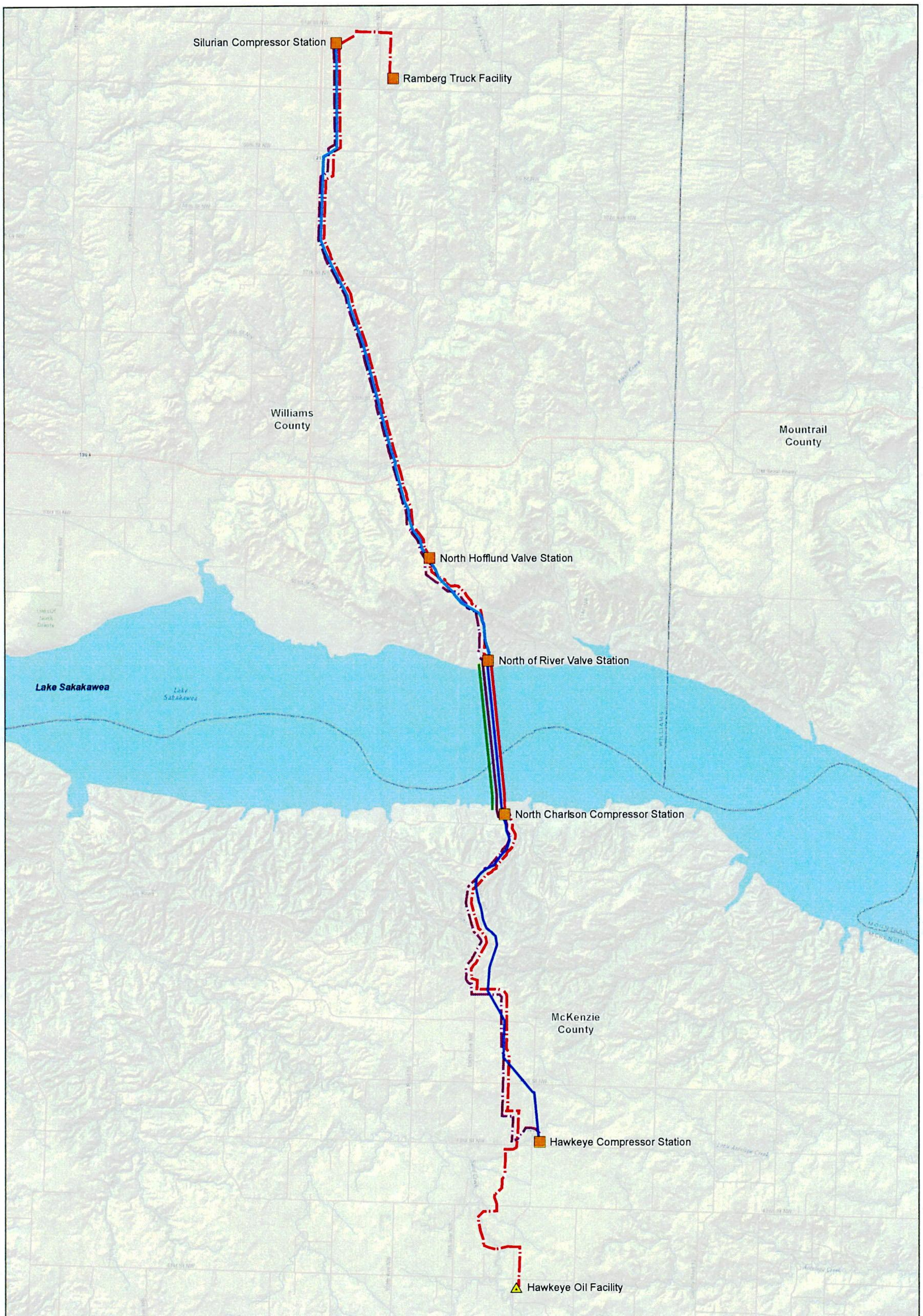
- Construction of 22.9 miles of new 12-inch-diameter crude oil pipeline, which would initiate at the Hawkeye Oil Facility, tie-in to 2.4 miles of existing 8-inch pipeline to cross Lake Sakakawea, and terminate at the Ramberg Truck Facility north of Lake Sakakawea.
- Construction of 18.2 miles of new 12-inch diameter natural gas pipeline, which would initiate at the Hawkeye Compressor Station, tie-in to 2.4 miles of existing 8-inch diameter pipeline to cross Lake Sakakawea, and terminate at the Silurian Compressor Station.
- Repurposing of 19.2 miles of existing 8-inch- and 10-inch-diameter pipeline to a NGL pipeline, which would initiate at the Hawkeye Compressor Station, tie in to 2.4 miles of existing pipeline to cross Lake Sakakawea, and terminate at the Silurian Compressor Station.
- Construction of 24-strand fiber optic lines. The fiber optic lines would be encased in one of the other existing pipelines across Lake Sakakawea, but placed in the trench alongside the new crude oil and natural gas pipelines outside of the lake crossing. From the Hawkeye Oil Facility to the Hawkeye Compressor Station, there would be one 24-strand fiber optic line; from the Hawkeye Compressor Station to the Ramberg Truck Facility, there would be two 24-strand fiber optic lines; and from the Ramberg Truck Facility to the Silurian Compressor Station, there would be one 24-strand fiber optic line. The fiber optic lines would be used for communications for monitoring and controlling the pipelines.
- Construction of eight pig launchers (3 crude oil, 3 natural gas, and 2 NGL). All eight pig launchers would be constructed within existing Hess-owned facilities.
- Construction of eight pig receivers (3 crude oil, 3 natural gas, and 2 NGL). All eight pig receivers would be constructed within existing Hess-owned facilities.
- Construction of the Hawkeye Oil Facility, including permanent surface disturbance of approximately 79.7 acres.
- Placement, setting, and construction of 4 mainline valves and 12 emergency shutdown valves would be constructed within existing Hess-owned facilities.

The Project would cross approximately 2.6 miles of United States (U.S.) Department of Agriculture Forest Service (USFS) lands, 2.9 miles of U.S. Army Corps of Engineers (USACE) lands, 1.2 miles of North Dakota state-owned property, and 19.2 miles of private land. The two proposed pipelines would be buried (in the same trench) and collocated with existing Hess pipeline easements to the extent practicable and would utilize existing pipeline infrastructure at the Lake Sakakawea crossing (four 8-inch-diameter pipelines that currently cross the lake; one each for the NGL, natural gas, crude oil, and the fiber optic cables [both of which would be strung through one of the 8-inch-diameter pipes]).

1.1 FEDERAL PERMITTING PROCESS

The proposed Project requires the issuance of a ROW grant by the BLM to cross federal lands. The proposed route crosses federal lands managed by the USFS and USACE, which would require ROW easements, special use permits, and other applicable permits. The issuance of the ROW grant and easement across federal lands are considered federal actions and, therefore, the Project is subject to environmental review pursuant to the National Environmental Policy Act (NEPA) (42 United States Code [U.S.C.] § 4321 et seq.). Per Section 28 of the Mineral Leasing Act of 1920, as amended (30 U.S.C. 185), the BLM is the lead federal agency for NEPA compliance (i.e., preparation of an Environmental Assessment [EA] for the Project) and the USFS and USACE are participating as cooperating agencies.

Hess submitted a Standard Form 299 application to the BLM North Dakota Field Office on May 25, 2012, requesting a new ROW grant to cross USACE and USFS lands in North Dakota. The proposed Project would not cross BLM-administered lands. Consultation with the BLM indicated that an EA would be needed to fulfill NEPA requirements. The EA provides an objective disclosure of beneficial and adverse environmental impacts resulting from the Project, as well as a set of reasonable alternatives and mitigation measures. This risk assessment provides part of the technical basis for the EA, disclosing potential environmental consequences that might occur in the unlikely event of a release from the Project.



Legend

- Proposed Facility
- Existing Facility
- Repurposed 8-inch-diameter NGL Pipeline
- Repurposed 10-inch-diameter NGL Pipeline
- Repurposed 8-inch-diameter Natural Gas Pipeline
- Proposed 12-inch-diameter Natural Gas Pipeline (Including 2 Fiber Optic Cables)
- Repurposed 8-inch-diameter Crude Oil Pipeline
- Proposed 12-inch-diameter Crude Oil Pipeline (Including 2 Fiber Optic Cables)
- Repurposed Pipeline with 4 24-strand Fiber Optic Cables

Source: Hess 2014.

Hawkeye Pipeline System Project

Figure 1-1

Overview Map of Hess Hawkeye Pipeline System Project

0 0.5 1 2
Miles

2.0 Introduction

This risk assessment presents the results of a pipeline incident frequency analysis based on the Project's design and operations criteria and applies the resulting risk probabilities to an environmental consequence analysis that incorporates Project-specific environmental data. Specifically, this risk assessment evaluates the risk of crude oil, NGL, and natural gas releases during pipeline operations, including probable spill volumes and contribution of natural hazards to spill risk and the subsequent potential effects on humans and other sensitive resources, particularly in areas of high environmental sensitivity, including federally designated high consequence areas (HCAs) (e.g., certain populated areas, designated zones around public drinking water intakes, and/or ecologically sensitive areas).

Based on agency scoping comments, this risk assessment focuses particular attention to potential impacts to Lake Sakakawea and associated resources. Additional effects on public health and safety that could occur during project construction are discussed under other resource sections (e.g., air quality, water resources, transportation, land use, and aesthetics) within the EA.

The purpose of this risk assessment is to provide a conservative range of anticipated effects from the operation of the Project that is sufficient for the purposes of NEPA. Given this objective, the analysis summarized within this risk assessment is intentionally conservative (i.e., overestimates risk). The expectation is that the spill frequencies presented in this analysis are not likely to occur, but are provided as a conservative framework to ensure agency decisions are based on knowledge of the potential range of effects.

3.0 Pipeline Design Features

3.1 PIPELINE DESIGN SPECIFICATIONS

3.1.1 Overview of Pipeline Segments

3.1.1.1 Crude Oil Pipeline

Hess proposes to install 22.9 miles of new pipeline and repurpose 2.4 miles of an existing pipeline that crosses Lake Sakakawea. South of Lake Sakakawea, the project consists of approximately 10.1 miles of new 12-inch-diameter crude oil pipeline and two associated 24-strand fiber optic cables in a single trench from the proposed Hawkeye Oil Facility to the existing North Charlson Compressor Station. From the existing North Charlson Compressor Station to the existing North of River Valve Station, Hess proposes to repurpose approximately 2.4 miles of an existing 8-inch-diameter pipeline across Lake Sakakawea to crude oil service. North of Lake Sakakawea from the existing North of River Valve Station to the existing Ramberg Truck Facility, Hess proposes to install approximately 12.8 miles of new 12-inch-diameter crude oil pipeline and two associated 24-strand fiber optic cables in a single trench.

All pipeline components must meet federal pipeline safety standards (49 Code of Federal Regulations [CFR] 195).The existing pipeline proposed for crude oil service was constructed in 1992 and its serviceability was confirmed in 2013 by hydrostatic testing per pipeline safety requirements (49 CFR 195 Subpart E Pressure Testing) and through use of in-line inspection tools. New pipe and pipeline components also must be tested prior to service to demonstrate the pipeline is fit for service.

The crude oil pipeline is designed for an initial flow rate of 60,000 barrels per day (bpd) and a maximum design flow rate of the crude oil pipeline is 76,000 bpd. The crude oil pipeline would be buried a minimum of 5 feet underground, a depth that exceeds federal pipeline safety requirements (49 CFR 195.248). This additional depth helps protect the pipeline from outside force damage, such as excavation damage and stream scour. Since excavation damage is a major cause of pipeline releases, this additional depth of cover is a supplemental mitigation measure Hess is employing to reduce the probability of pipeline incidents. The pipe is designed for a maximum operating pressure (MOP) of 1,000 pounds-force per square inch gauge (psig). The crude oil pipeline would consist of American Petroleum Institute (API) 5L–X52 steel pipe with a 12-inch outside diameter (OD) and a0.375-inch wall thickness (WT), for the majority of the Project route except for at boring locations that would be 0.500-inch WT, and at the Lake Sakakawea crossing where the existing pipe consists of an 8-inch OD pipe with a 0.500-inch WT.

3.1.1.2 Natural Gas Pipeline

Hess proposes to install 18.2 miles of new pipeline and repurpose 2.4 miles of an existing pipeline that crosses Lake Sakakawea. South of Lake Sakakawea, from the existing Hawkeye Compressor Station to the existing North Charlson Compressor Station, Hess proposes to install approximately 7.2 miles of new 12-inch-diameter natural gas pipeline and two associated fiber optic cables in the same trench with the proposed crude oil pipeline. Between the existing North Charlson Compressor Station and existing North of River Valve Station, Hess proposes to repurpose approximately 2.4 miles of an existing 8-inch-diameter residue line to natural gas service. On the north side of Lake Sakakawea, from the existing North of River Valve Station to the existing Silurian Compressor Station, Hess proposes to install approximately 11.0 miles of new 12-inch-diameter natural gas pipeline and two associated 24-strand fiber optic cables in the same trench as the proposed crude oil pipeline.

All pipeline components must meet federal pipeline safety standards (49 CFR 192). The existing pipeline was constructed in 1956. Serviceability of the existing pipe was confirmed in 2013 by hydrostatic testing per pipeline safety requirements (49 CFR 192 Subpart J Test Requirements) and through use of in-line inspection tools. New pipe and pipeline components also must be tested prior to service to demonstrate the pipeline is fit for service.

The natural gas pipeline is designed for an initial flow rate of 70 million standard cubic feet per day (mmscfd) and a maximum design flow rate of 100 mmscfd. The natural gas pipeline would be buried a minimum of 5 feet underground, exceeding depth of cover requirements and thus providing supplemental mitigation to reduce the risk of outside force damage. The pipe is designed for a maximum allowable operating pressure (MAOP) of 1,250 psig. Typically, the natural gas pipeline would consist of API 5L –X52 steel pipe with a 12-inch OD and 0.375-inch WT except at boring locations that would be 0.500-inch WT, and at the Lake Sakakawea crossing where the existing pipe consists of a 8-inch OD with 0.500-inch WT.

3.1.1.3 Natural Gas Liquids Pipeline

Hess proposes to install 19.2 miles of new pipeline and repurpose 2.4 miles of an existing pipeline that crosses Lake Sakakawea. South of Lake Sakakawea between the existing Hawkeye Compressor Station and existing North Hofflund Valve Station, approximately 10.5 miles of an existing 8-inch-diameter natural gas pipeline would be repurposed to NGL service. North of Lake Sakakawea from the existing North Hofflund Valve Station to the existing Silurian Compressor Station, approximately 8.7 miles of an existing 10-inch natural gas pipeline would be repurposed to NGL service.

The 8- and 10-inch existing pipelines proposed for NGL service were both constructed in 1978 with the river crossing constructed in 1992. Serviceability of these pipelines was confirmed in 2013 by hydrostatic testing per pipeline safety requirements (49 CFR 195 Subpart E Pressure Testing) and through use of in-line inspection tools. New pipe and pipeline components also must be tested prior to service to demonstrate the pipeline is fit for service.

The NGL pipeline is designed for an initial flow rate of 13,000 bpd. The maximum design flow rate of the NGL pipeline is 30,000 bpd. The NGL pipeline would maintain a minimum burial depth of 5 feet underground, exceeding depth of cover requirements and thus providing supplemental mitigation to reduce the risk of outside force damage. The pipe is designed for a MOP of 1,250 psig. The NGL pipeline would utilize existing API 5L Grade B steel pipe with an 8-inch OD and 0.250-inch WT or 10-inch OD with 0.279-inch WT, except at the Lake Sakakawea crossing where the existing pipe has a 8-inch OD and a 0.500-inch WT.

3.1.1.4 Receipt Facilities

Seven receipt facilities would be associated with the Project, six of which are existing Hess facilities (i.e., Hawkeye Compressor Station, North Charlson Compressor Station, North of River Valve Station, North Hofflund Valve Station, Silurian Compressor Station, and Ramberg Truck Facility). The proposed Hawkeye Oil Facility would be the only receipt facility constructed as part of the Project.

3.1.2 Project Design Parameters

The Project would be designed, constructed, and operated in compliance with applicable portions of the U.S. Department of Transportation (USDOT) pipeline safety regulations as set forth for natural gas and liquid pipelines (49 CFR 192 and 195, respectively). These regulations encompass general requirements, accident reporting and safety-related condition reporting, design requirements, construction, pressure testing, operation and maintenance, qualification of pipeline personnel, and corrosion control. Relevant industry standards are incorporated into these regulations by reference, including those of the API, American Society of Mechanical Engineers, the American Standard for Testing and Materials (ASTM), and others. Key project design parameters are identified in **Table 3-1**.

3.2 MAINLINE VALVE ASSEMBLIES

Mainline valve assemblies would be spaced along the pipeline to meet the federal pipeline safety requirements. Valve spacing for natural gas is based on a prescribed distance according to population density. In contrast, valve spacing for liquid pipelines is based on proximity to areas that potentially could be affected by a release, such as municipal drinking water supplies. The route has been evaluated to confirm the proposed valve placement is appropriate and assessed to determine whether additional valves or location adjustments are warranted to further reduce potential environmental impacts. Additionally, the Pipeline and Hazardous Materials Safety Administration (PHMSA) will review valve placement for the proposed Project to ensure the Project complies with federal requirements.

Table 3-1 Pipeline Specifications

Parameter	Crude Oil Pipeline	NGL Pipeline	Natural Gas Pipeline
New Pipe Specifications	Above ground (within facilities): A333,Gr 6 Below ground (along route): API 5L, X-52	Above ground (within facilities): A333,Gr 6 Below ground (existing pipeline): API 5L GrB	Above ground (within facilities): A333,Gr 6 Below ground (along route): API 5L, X-52
	River Crossing API 5L Grade B	River Crossing API 5L Grade B	River Crossing API 5L Grade B
Coating	Fusion bond epoxy (FBE) coating	FBE coating	FBE coating
	River Crossing Fusion bond epoxy (FBE) coating	River Crossing Fusion bond epoxy (FBE) coating	River Crossing Coal tar wrap 1" concrete over coating
MAOP	1,250 psig	1,250 psig	1,250 psig
Maximum Throughput	• 60,000 barrels per day (bpd) base flow rate • 76,000 bpd maximum flow rate	• 13,000 bpd base flow rate • 30,000 bpd maximum flow rate	• 70 mmscfd base flow rate • 100 mmscfd maximum flow rate
Depth of Cover	Minimum 5 feet River Crossing approximately 6 feet	Minimum 5 feet River Crossing approximately 6 feet	Minimum 5 feet River Crossing approximately 6 feet
Aboveground versus Belowground Piping	Pipe will be belowground except within supply and receipt facilities.	Pipe will be belowground except within supply and receipt facilities.	Pipe will be belowground except within supply and receipt facilities.
Pipe Wall Thickness	Trenched pipeline - 12.75" OD, 0.375" WT Bored pipeline – 12.75" OD, 0.500" WT	Trenched pipeline - 10.75" OD, 0.279" WT & 8.625" OD, 0.250" and 0.500" WT	Trenched pipeline - 12.75" OD, 0.375" WT Bored pipeline – 12.75" OD, 0.500" WT
	Above ground piping (within facilities) 12" piping, Sch 80, 0.688" WT 16" piping, Sch 80, 0.844" WT	Above ground piping (within facilities) 8" piping, Sch 80, 0.500" WT 10" piping, Sch 80, 0.594" WT	Above ground piping (within facilities) 12" piping, Sch 80, 0.688" WT 16" piping, Sch 80, 0.844" WT
	River crossing 8.625" OD pipe: 0.500" WT, GrB	River crossing 8.625 " OD pipe: 0.500" WT, GrB	River crossing 8.625" OD pipe: 0.500" WT, GrB
Pump Stations	No intermediate pump stations required	No intermediate pump stations required	No intermediate compressor stations required
Leak Prevention Program	Multiple overlapping and redundant systems, including: • FBE or other protective pipeline coating • Cathodic protection • Non-destructive testing of the girth welds per 49 CFR 195.234	Multiple overlapping and redundant systems, including: • FBE or other protective pipeline coating • Cathodic protection • Non-destructive testing of the girth welds per 49 CFR 195.234	Multiple overlapping and redundant systems, including: • FBE or other protective pipeline coating • Coal tar wrap, 1" concrete coating at river crossing • Cathodic protection • Non-destructive testing of the girth welds per 49 CFR 192

Table 3-1 Pipeline Specifications

Parameter	Crude Oil Pipeline	NGL Pipeline	Natural Gas Pipeline
Leak Prevention Program (Continued)	• Hydrostatic testing to 125% of the MOP (49 CFR 195 Subpart E) • Periodic in-line inspection	• Hydrostatic testing to 125% of the MOP (49 CFR 195 Subpart E) • Periodic in-line inspection	• Hydrostatic testing to 125% of the MAOP (49 CFR 192 Subpart J) • Periodic in-line inspection
	• Depth of cover meeting or exceeding federal standards • Periodic aerial surveillance in accordance with federal requirements • Supervisory Control and Data Acquisition (SCADA) system • Operations Control Center (OCC) providing continuous monitoring of the pipeline, 24 hours a day, every day of the year	• Depth of cover meeting or exceeding federal standards • Periodic aerial surveillance in accordance with federal requirements • SCADA system • OCC providing continuous monitoring of the pipeline, 24 hours a day, every day of the year	• Depth of cover meeting or exceeding federal standards • Periodic aerial surveillance in accordance with federal requirements • SCADA system • OCC providing continuous monitoring of the pipeline, 24 hours a day, every day of the year
Leak Detection Systems	• Remote Monitoring with SCADA • Computational pipeline monitoring (CPM) per 49 CFR 195.444 • Aerial or foot patrols 26 times per year, not to exceed 3-week interval • Public awareness program	• Remote Monitoring with SCADA • CPM per 49 CFR 195.444 • Aerial or foot patrols 26 times per year, not to exceed 3-week interval • Public awareness program	• Remote Monitoring with SCADA • CPM per 49 CFR 192 • Aerial or foot patrols 26 times per year, not to exceed 3-week interval • Public awareness program

4.0 Incident Frequency Analysis

Because the Project has not yet been constructed, it does not have an operational history from which to derive incident frequency rates. Consequently, a conservative approach was taken by first determining the baseline incident frequencies from industry data (i.e., PHMSA data).

Baseline incident frequencies are derived from historical national pipeline incident data for both hazardous liquid and natural gas transmission (PHSMA 2013). Because the majority of pipelines in the U.S. were constructed in the "pre-modern" era (i.e., the 1970s or earlier), these baseline frequencies reflect incident rates associated with earlier pipeline design and construction methods that often do not meet the current regulatory requirements or best management practices (BMPs). Further, these historical data do not account for supplemental protective measures that Hess would implement.

Although Hess proposes to repurpose existing pipelines for portions of the Project, the majority of the pipelines were built during the late 1970s, or after, using modern technologies and materials, including high performance coatings, high frequency electric resistance welding, and high strength pipe. Additionally, after the 1970s, in-line inspection tools evolved substantially, allowing the integrity of pipelines to be monitored through the use of high-resolution smart pigs, crack detection tools, and ultrasonic tools (Kiefner and Trench 2001). Furthermore, pipelines reach a state of equilibrium in which random accidents (e.g., those caused by third-party damage and natural hazards) maintain a constant low frequency (Muhlbauer 2004). Because Hess has confirmed the integrity of the pipelines proposed for repurposing through the use of in-line inspection and hydrostatic testing, it can be concluded that these pipelines currently are in the constant low failure zone.

Hess will implement a number of protective measures to decrease the probability of an incident occurring at the tie-in between the existing 8-inch lines and the proposed 12-inch lines. For instance, the crude oil line will utilize a number of valves at the North Charlson Compressor Station and North of River Valve Station to allow for isolation of the segments. These include block valves on the 12-inch lines and block and check valves on the 8-inch line. All pipeline and facility equipment welds will use a system that has been previously designed and destructively tested under laboratory conditions, with all welds to be non-destructively tested upon completion using x-ray radiography. Thus, it is anticipated that the incident frequencies presented in this section are applicable to both new pipeline and repurposed pipeline, including the interface between the two segments.

4.1 HAZARDOUS LIQUIDS

The baseline incident frequencies for hazardous liquids identified in **Table 4-1** were generated from the PHMSA incident database (PHMSA 2014) and are expressed as per mile of pipeline per year (/mile·year).

Table 4-1 Baseline Incident Frequency for Hazardous Liquids Pipelines[1]

Threat Name	Incident Frequency/mile-yr[2]	Occurrence Interval (years/mile[3])
Corrosion	5.31E-04	1,882
Excavation Damage	1.67E-04	6,000
Incorrect Operation	3.01E-04	3,319
Material/Weld/Equip. Failure	7.76E-04	1,288
Natural Force Damage	1.12E-05	8,942
Other Outside Force Damage	4.32E-05	23,171
All Other Causes	1.30E-04	7,714
Total All Causes	**2.11E-03**	**473**

[1] Baseline statistics based on PHMSA hazardous liquid incident database (2014), excluding offshore data.
[2] Incident frequencies are expressed in scientific notation. A value of 2.9E-04 incidents/mile•-year is equivalent to 0.00029 incident/mile•-year, which is approximately equivalent to one incident every 3,400 years.
[3] Occurrence intervals are the inverse of the incident frequency (i.e., years between events per mile of pipeline). This is similar in concept to flood frequencies (e.g., 100-year flood event).

The overall incident frequency was calculated by summing the likelihood of each individual root cause.

$$f_{total} = f_{co} + f_{ex} + f_{md} + f_{hy} + f_{gm} + f_{wo}$$

Where:

f_{total} = total leak frequency
f_{co} = leak frequency from corrosion
f_{ex} = leak frequency from excavation
f_{md} = leak frequency from material defects or construction deficiency
f_{hy} = leak frequency from a hydraulic event
f_{gm} = leak frequency from ground movement
f_{wo} = leak frequency from washout event

The resultant incident frequency is 2.11E-03 incidents/mile·year, equivalent to 1 incident in 473 years per mile of pipe.[1] While future events cannot be known with absolute certainty, historic incident frequencies can be used to estimate the number of events that might occur over a period of time. Based on this spill frequency and a total of 43.2 miles of pipeline (crude oil and natural gas liquid total mileage), this analysis estimates that there would be 0.913 spills during a 10-year period.

Utilizing nationwide spill data results in a significantly more statistically robust and conservative analysis than utilizing only data from North Dakota. For example, the nationwide PHMSA database contains data on approximately 185,000 miles of hazardous liquid pipelines; North Dakota has data for only 2,900 miles of hazardous liquid pipelines. Additionally, incident reports indicate that the state-specific incident frequency is approximately 0.00165 incidents/mile·year (equivalent to 0.577 spills during a 10-year period), substantially lower than the nationwide statistic of 0.00211 incidents/mile·year (PHMSA 2014).

[1] This value is an estimate based on historical statistics; actual values may differ from these estimates. Incident frequencies are expected to be applicable to new pipeline and repurposed pipeline.

Thus, utilizing the nationwide data overestimates spill frequency by approximately 30 percent as compared with state-specific data.

Additionally, this spill frequency does not account for project- and site-specific conditions, including improved technologies and practices that are used on a newly constructed pipeline and currently are not reflected in the historical PHMSA incident frequency data. Consequently, the spill frequency is considered extremely conservative and overestimates the probability of a spill.

This is important as many of the recent, high profile liquid pipeline spills that have occurred have involved pre-modern pipe. For instance, the Enbridge Line 6b spill in Marshall, Michigan, and the ExxonMobil spill in Mayflower, Arkansas, involved pre-1970s pipe. Both of these ruptures involved longitudinal seam failure, a prominent failure mode in pre-modern pipe due to the method of low frequency electronic resistance welding (ERW) that was utilized at the time of manufacturing. Additionally, this older pipe typically incorporates suboptimal corrosion resistant coatings (e.g., coal tar or asphalt). Modern pipelines, on the other hand, have significantly more robust longitudinal seams due to improved high frequency ERW techniques. Modern pipelines also are coated in a highly corrosion-resistant FBE coating, which significantly reduces the probability of external corrosion. These factors, and other improved technologies, contribute to the improved safety record of the modern liquids pipeline (including the new pipeline and repurposed pipeline) that will be utilized for this Project. Consequently, the spill frequency is considered extremely conservative and over-estimates the probability of a spill.

In 2002, PHMSA instituted a 5-gallon reporting limit. Prior to this action, only spills over 50 barrels (1,575 gallons) were reported. This change has resulted in a significant increase in the calculated baseline incident frequency. The calculated incident frequency using earlier data (from 1993 to 2011) is 0.000883 incidents/mile·year. The calculated incident frequency using data obtained after the updated reporting limit (2002 to 2011) is 0.00211 incidents/mile·year, a substantial increase in incident frequency. However, it should be noted that this increase is attributable to different reporting requirements and not an actual increase in spills.

In fact, PHMSA data show that the number of spills on crude oil pipelines has substantially declined with the implementation of USDOT's Integrity Management Rule. Moreover, federal pipeline safety standards continue to evolve, and operators are required to comply with these standards. Implementation of current industry standards and compliance with federal regulatory standards ensures that the likelihood of spills to occur would be very small, and that the volume released, in the unlikely event of a spill, would be very small. For these reasons, it is expected that the actual number of incidents would be substantially lower than those estimated in this analysis.

4.1.1 Spill Volume

Examination of the current PHMSA dataset (2002 to 2014)[2] indicates that the majority of actual liquid pipeline spills are relatively small. Fifty percent of the spills consist of 4 barrels or less. In 84 percent of the cases, the spill volume was 100 barrels or less. In 95 percent of the incidents, spill volumes were less than 1,000 barrels. Oil spills of 10,000 barrels or larger occurred in 0.5 percent of cases. These data demonstrate that most pipeline spills are small and larger releases of 10,000 barrels or more are

[2] Incidents associated with offshore facilities and refining facilities were excluded from the analysis.

extremely uncommon. **Table 4-2** illustrates the frequencies of different spill volumes conservatively predicted to occur for both liquid pipelines over a 10-year interval.

Table 4-2 Approximate Occurrence Intervals by Spill Volume for Both Liquid Pipelines over 10 Years

Spill Volume	Conservative Number of Spills per 10 years
Spill volume 4 barrels or less	0.534
Spill volume between 4 barrels and 50 barrels	0.210
Spill volume between 50 barrels and 100 barrels	0.039
Spill volume between 100 barrels and 1,000 barrels	0.090
Spill volume between 1,000 barrels and 10,000 barrels	0.036
Spill volume greater than 10,000 barrels	0.004
Total Spills	**0.913**

Based on a number of factors including pipeline properties, terrain, and pipeline shutdown times, the worst case discharge, a measure of the largest volume spill that could credibly arise from the pipeline, was calculated for the Project.[3] Although this information is considered sensitive due to Homeland Security concerns, it should be noted that 10,000 barrels, the largest volume included in this assessment, is inclusive of the Project's worst case discharge. Thus, this assessment overestimates potential effects to the natural and human environment as it considers spill volumes larger than the worst case discharge.

4.2 NATURAL GAS

Natural gas is a naturally occurring hydrocarbon gas mixture consisting primarily of methane, a lightweight hydrocarbon (U.S. Environmental Protection Agency [USEPA] 2013) that is transported as a high pressure, liquefied gas. The Project would transport unprocessed natural gas from Hawkeye Oil Facility to the Silurian Compressor Station. Hess indicates that their unprocessed natural gas consists of 85 percent methane and can contain significant amounts of ethane, propane, butane, and pentane.

Like liquid pipelines, the probability of a natural gas pipeline rupture is very low. The baseline incident frequency for natural gas lines from all causes is 3.88E-04 incidents/mile·year. Thus, the probability of an incident occurring on any 1-mile stretch of the pipeline is approximately once in 2,580 years. For the entire natural gas pipeline, this translates to approximately once in 125 years.

Impacts from a natural gas release generally are associated with fire and explosions because natural gas poses little toxicological threat in rural environments[4]. Because the probability of a spill is very low, potential toxicological impacts to the environment are negligible, and the probability of a release resulting in fire or explosion in an area where people reside is very low, so the risk posed by the natural gas pipeline

[3] The method used to calculate worst case discharge is consistent with 49 CFR 194.105.

[4] Natural gas can cause asphyxiation in enclosed spaces due to its ability to displace air. Because of the rural nature of the Project, this hazard is considered to be negligible.

is extremely low. Risk from the natural gas pipeline is not discussed in further detail, but is examined as part of the overall cumulative risk associated with the Project.

4.3 CUMULATIVE

Because the Project involves two liquid pipelines and one natural gas pipeline, the cumulative failure frequency must be calculated in order to fully characterize the risk of the system as a whole. Given the hazardous liquid pipeline incident frequency of 2.11E-03 incidents/mile·year and the combined 43.2 miles of liquid line (24.0 miles of crude oil pipeline and 19.2 miles of NGL pipeline), the predicted occurrence interval for the hazardous liquids portion of the Project is approximately 1 spill in 11 years. When the natural gas incident frequency (Section 4.2, Natural Gas) is incorporated into the analysis, the predicted occurrence interval for the Project as a whole is calculated to be approximately equivalent to 1 spill in 10.1 years. The cumulative incident frequency for any 1 mile of the Project is 217 years.

Because this analysis utilizes the PHMSA database, which includes pre-modern pipe, and because of the modern materials, spill prevention techniques, and leak detection capabilities of the proposed Project, this cumulative incident frequency can be considered conservative.

5.0 Spill Consequences

5.1 HUMAN CONSEQUENCES

The risk associated with the operation of the Project can be compared with the general risks encountered in everyday life. The National Center for Health Statistics reports that in 2011, the age-adjusted death rate for the general population in the U.S. was approximately 740.6 per 100,000 (Center for Disease Control 2011). The risk of fatality from a natural gas pipeline release or a hazardous liquid pipeline release, as presented in the following sections, are insignificant in comparison to the age-adjusted death rate for the general population.

5.1.1 Hazardous Liquids

The USDOT reports that the average number of fatalities per year in the general population associated with hazardous liquids pipelines from 2002 to 2012 was 2.0 (PHMSA 2014). Based on U.S. Census Population Data and an average incident frequency of 2.0 fatalities/year, the risk to the general population per year associated with all hazardous liquids transmission pipelines is 0.0007 per 100,000 (U.S. Census Bureau 2010, 2000; PHMSA 2014). In comparison, the overall average annual death rate for the general population in the US is 740.6 per 100,000 people (Center for Disease Control 2011). Therefore, the predicted risk of fatality to the public from incidents associated with the Project over the normal U.S. death rate is very low.

5.1.2 Natural Gas

The primary concern regarding a natural gas transmission pipeline release is the possibility of explosion after a release. The risk to the general population is a function of the probability of a pipeline release and the proximity of populated areas. PHMSA reports that the average number of fatalities associated with natural gas transmission pipelines per year from 2002 to 2013 was 1.4. Based on U.S. Census population data and an average incident frequency of 1.4 fatalities/year, the average risk to the general population per year associated with all natural gas transmission pipelines is 0.0005 in 100,000. In comparison, the overall average annual death rate for the general population in the U.S. is 740.6 per 100,000 people (Center for Disease Control 2011). Therefore, the predicted risk of fatality to the public from natural gas pipeline incidents over the normal U.S. death rate is very low.

5.2 ENVIRONMENTAL CONSEQUENCES OF LIQUID PETROLEUM PRODUCTS

The environmental risk posed by crude oil and natural gas liquid pipelines is a function of: 1) the probability of an accidental release; 2) the probability of a release reaching an environmental receptor (e.g., waterbody, fish); 3) the concentration of the contamination once it reaches the receptor; and 4) the hazard posed by that concentration of crude oil and natural gas liquid to the receptor. Based on spill probabilities and estimated spill volumes, this risk assessment determines the probability of exposure to environmental receptors and the probable impacts based on a range of potential concentrations.

5.2.1 Composition

The composition of crude oil varies widely, depending on the source and processing. Crude oils are complex mixtures of hundreds of organic (and inorganic) compounds. These compounds differ in their solubility, toxicity, persistence, and other properties that profoundly affect their impact on the environment. The effects of a specific crude oil cannot be thoroughly understood without taking its composition into account.

The system would transport light sweet crude, derived from production in the middle Bakken and upper Three Forks formations (Bakken). Representative chemical assay data are presented in **Table 5-1**. The primary classes of compounds found in crude oil are alkanes (hydrocarbon chains), cycloalkanes (hydrocarbons containing saturated carbon rings), and aromatics (hydrocarbons with unsaturated carbon rings). Most crude oils are more than 95 percent carbon and hydrogen, with small amounts of sulfur, nitrogen, oxygen, and traces of other elements. Crude oils contain lightweight straight-chained alkanes (e.g., hexane, heptane); cycloalkanes (e.g., cyclohexane); aromatics (e.g., benzene, toluene); and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltenes). Straight-chained alkanes are more easily degraded in the environment than branched alkanes. Cycloalkanes are extremely resistant to biodegradation. Aromatics pose the most potential for environmental concern. PAHs are persistent in the environment and can cause adverse impacts. However, they do not significantly bioaccumulate (increasing concentration within food chains) and are not highly water soluble. Studies of 69 crude oils found that benzene was the only aromatic or PAH compound tested that is capable of exceeding groundwater protection values for drinking water (i.e., maximum contaminant levels [MCLs] or Water Health Based Limits) (Kerr et al. 1999 as cited in O'Reilly et al. 2001). Lightweight aromatics (e.g., benzene, toluene, ethyl benzene, xylenes) tend to be highly water soluble compared to other hydrocarbons because of their lower molecular weight while having low toxicity thresholds.

Table 5-1 Chemical Composition of Crude Oil and NGL Proposed for Transport

Constituent	Chemical Notation	Crude Oil % by weight	NGL % by weight
Nitrogen	N2	0.027	---
Methane	C1	0.001	2.593
Carbon dioxide	CO_2	0.000	---
Ethane	C2	0.105	4.905
Propane	C3	1.026	8.271
Iso-butane	i-C4	0.498	2.383
N-butane	n-C4	2.210	8.900
Iso-pentane	i-C5	1.262	4.564
N-pentane	n-C5	2.350	8.398
Hexanes	C_6H_{14}	2.105	7.508
N-hexane	n-C6	2.132	
2,2,4-Trimethylpentane	C_8H_{18}	0.501	---
Benzene	Benzene	0.239	0.810
Heptanes	C7	5.267	5.296
Toluene	Toluene	1.403	1.605
Octanes	C8	4.896	2.807

Table 5-1 Chemical Composition of Crude Oil and NGL Proposed for Transport

Constituent	Chemical Notation	Crude Oil % by weight	NGL % by weight
Ethyl benzene	Ethyl benzene	0.485	0.216
Xylenes	m-, o-, p-xylenes	2.427	1.866
Nonanes	C9	2.407	0.990
Decanes plus	C10 +	70.661	1.36
Specific Gravity		0.76741 g/ml	<0.7 g/ml[1]
API Gravity		52.9	>65[1]

[1] Estimate based on general NGL gravities

Source: SGS 2013.

5.2.2 Environmental Fate and Transport

Overall, the environmental fate of liquid petroleum products (e.g., crude oil, NGL) is controlled by many factors and persistence is difficult to predict with great accuracy. The speed and efficiency of emergency response containment and cleanup largely dictates the fate and extent of transport within the environment. This section, however, discusses environmental fate and transport of petroleum products without accounting for the benefits of emergency response. Major factors affecting the environmental fate include spill volume, type of product, dispersal rate of the product, terrain, receiving media, and weather. Once released, the physical environment largely dictates the environmental persistence of the spilled material. Fate and transport of released petroleum products are discussed by environmental medium and the primary degradation processes associated with each medium.

Soils

If released in soil at pipeline depth, the released petroleum products can volatilize, sorb to soil particles, dissolve into the groundwater, or remain in residual form (Spence et al. 2001). The movement of crude oil or NGL and the physical and chemical transformations of their constituents are influenced by a variety of factors and processes discussed below.

- Physical Factors. The movement of petroleum products across the soil surface is governed by slope, soil permeability, and, to a lesser extent, ambient temperature. Spreading across environmental surfaces reduces the bulk quantity of crude oil and NGLs present in the immediate vicinity of the spill but increases the spatial area within which adverse effects may occur. Spreading and thinning of spilled product in soils or water also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.
- Evaporation. Evaporation is the primary fate process governing the loss of NGL and crude oil released into the environment. This process is referred to as weathering. The majority of the volatile hydrocarbon fractions will evaporate quickly from pooled oil on the soil surface. Extremely volatile compounds in crude oil and NGL, such as ethane, propane, and butane, will immediately gasify once released into the environment. The vast majority of highly volatile compounds, such as benzene and toluene, will evaporate within the first several hours following a release, depending on environmental conditions. Whereas the majority of NGL will evaporate, weathered crude oil will contain an increasing fraction of higher molecular weight compounds that are less susceptible to

evaporation. Crude oil and NGL that infiltrate into the soil profile will evaporate more slowly due to a decrease in oil surface area exposed to the air, and the presence of other binding forces (see sorption). The rates of evaporation primarily are controlled by soil porosity and soil temperature.

- Sorption. Sorption is negligible for NGL since its constituents do not bind to soil particles. In contrast, crude oil dispersed in soil will bind (adhere) to soil particles. Crude oil will bind most strongly with soil particles in organic soils and less strongly with soil particles in sandy soils.
- Photodegradation. Photodegradation (breakdown of hydrocarbon molecules under exposure to sunlight) is an important process for soils directly exposed to sunlight at the soil surface. Products that have penetrated deeper into the soil profile are not affected by this process.
- Biodegradation. With time, soil microorganisms capable of consuming petroleum hydrocarbons generally increase in number and the biodegradation process naturally remediates previously contaminated soil. The biodegradation process is enhanced as the surface area of spilled product increases (e.g., by dispersion or spreading). Biodegradation has been shown to be an effective method of remediating soils and sediments contaminated by petroleum products.

Water

If released into water, crude oil and NGL will float to the water's surface[5]. NGL will float on the water surface and quickly evaporate. If crude oil is allowed to weather on the water's surface over an extended period of time (i.e., no cleanup), the majority of lightweight volatile constituents within the oil will evaporate, while other fractions will dissolve, and eventually, some material may descend to the bottom as sediment. The following is a summary of the major processes that occur during crude oil dispersion and degradation.

- Physical Factors. The mobility of petroleum hydrocarbons in water increases with wind, stream velocity, and increasing temperature. Most products move across surface waters at a rate of 100 to 300 meters per hour, with NGLs spreading more quickly than crude oil due to their lower viscosity. Surface ice will greatly reduce the spreading rate of product across a waterbody due to the presence of under-ice depressions, which collect oil and limit the area affected by a release, facilitating cleanup actions (Dickens 2011). Petroleum hydrocarbons in flowing, as opposed to contained, waterbodies may cause transitory impacts. Although reduced in intensity, a petroleum product spill into flowing waters tends to move over a much larger area. Spreading and thinning of spilled product in water also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.
- Dissolution. Dissolution of crude oil and NGL constituents in water is not a significant process controlling the products' fate in the environment because most components of oils are relatively insoluble (Neff and Anderson 1981). Evaporation tends to dominate the reduction of crude oil, with dissolution slowly occurring with time. Overall solubility of crude oils and NGL tend to be less than their individual constituents' optimal solubilities since solubility is limited to the partitioning between oil and water interface and individual compounds are often more soluble in oil than in water, thus they tend to remain in the product. Nevertheless, dissolution is one of the primary

[5] The API Gravity of a representative Hess crude oil is 52.9. An API Gravity of 10 or more indicates that the oil would float on water. Thus, light crude oils from the Bakken Formation are very light and would float on the water's surface.

processes affecting water quality, especially in confined waterbodies. Dissolution increases with decreasing molecular weight, increasing temperature, decreasing salinity, and increasing concentrations of dissolved organic matter. Greater photodegradation also tends to enhance the solubility of product in water.

- Sorption. Lightweight volatile hydrocarbons have low sorption potential, whereas heavy molecular weight hydrocarbons, such as those that occur in crude oil, will bind to suspended particulates. This process can be significant in highly turbid or eutrophic waters. Organic particles (e.g., biogenic material) in soils or suspended in water tend to be more effective at sorbing oils than inorganic particles (e.g., clays). Sorption processes and sedimentation reduce the quantity of heavy hydrocarbons present in the water column and available to aquatic organisms. However, these processes also render hydrocarbons less susceptible to degradation. Sedimented oil tends to be highly persistent and can cause shoreline impacts.
- Evaporation. Over time, evaporation is the primary mechanism of loss of low molecular weight constituents and light products, such as NGL. As lighter components evaporate in crude oil, the remaining oil becomes denser and more viscous. Evaporation tends to reduce crude oil toxicity but enhances crude oil persistence. In field trials, bulk evaporation of crude oil accounted for an almost 50 percent reduction in volume over a 12-day period, while the remaining oil was still sufficiently buoyant to float on the water's surface (Shiu et al. 1988). Evaporation increases with increased spreading of a slick, increased temperature, and increased wind and wave action. Ice cover will prevent the volatilization of lighter constituents within crude oil, increasing the probability that they will solubilize into the water in the absence of emergency response actions. NGLs, which have a significantly higher proportion of light, volatile constituents, evaporate more completely. The National Oceanic and Atmospheric Administration's ADIOS model predicts that more than 95 percent of NGLs will evaporate within approximately 2 days.
- Photodegradation. Photodegradation of crude oil and NGL in aquatic systems increases with greater solar intensity. It can be a significant factor controlling the reduction of a slick, especially of lighter oil constituents and NGL, but it will be less important during cloudy days and winter months. Photodegraded constituents can be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, may thus increase the biological impacts of a spill event.
- Biodegradation. In the immediate aftermath of a product spill, natural biodegradation of petroleum hydrocarbons will not tend to be a significant process controlling the fate of spilled hydrocarbons in environments that previously were unexposed to oil. Microbial populations must become established before biodegradation can proceed at any appreciable rate. Also, prior to weathering (i.e., evaporation and dissolution of light-end constituents), oils may be toxic to the very organisms responsible for biodegradation and high molecular weight constituents tend to be resistant to biodegradation. Biodegradation is nutrient and oxygen demanding and may be precluded in nutrient-poor aquatic systems. It also may deplete oxygen reserves in closed waterbodies, causing adverse secondary effects to aquatic organisms.

5.2.2.1 Dispersion of Crude Oil

Crude oil does not dissolve in water the same way that, for example, salt or ethanol dissolves in water. If released into turbulent water, small droplets of the oil may be driven into the water column.[6] Experimental data suggest that the maximum size of these droplets is approximately 70 microns. If the crude oil is positively buoyant, then larger droplets will resurface, while small droplets may remain in suspension due to the natural turbulence in the water, just as turbulence in the air keeps small dust particles afloat. This process is called dispersion. Environmental conditions dictate the importance of dispersion. For oil spills during storm events that cause significant wave action, dispersion is an important and significant removal mechanism of the slick. For spills under calm weather conditions, evaporation is more significant, but dispersion still can occur.

Chemically induced dispersion may be considered an appropriate method to clean up high volume crude oil spills, particularly those that occur in large bodies of water. The argument in favor of dispersion is that spreading the oil into the water column facilitates natural weathering processes such as biodegradation and oxidation, thus reducing exposure of aquatic organisms to elevated oil concentrations. The decision to use chemical dispersants must be coordinated with federal and state agencies, such as the USEPA. In some areas, regional contingency plans may prohibit the use of chemical dispersants and this would be incorporated into Hess's Emergency Response Plan (ERP).

5.2.2.2 Submersion of Crude Oil

All crude oils weather (i.e., light end hydrocarbons evaporate over time) when exposed to the environment. With time, the remaining crude oil becomes denser as the proportion of light hydrocarbons decreases. Eventually, this process, particularly when combined with turbulent water, can result in remaining weathered oil sinking below the water's surface.[7] While this weathering process occurs with all types of crude oils, light crude oils will contain a smaller fraction of high molecular weight compounds that will resist weathering and eventually can sink if not cleaned up in a timely manner. The crude oil proposed for transport by Hess has a very high API gravity and is expected to float on the surface of water for an extended period, allowing emergency responders time for containment and cleanup.

Recent spills involving submerged crude oils, such as the 2010 Enbridge Kalamazoo River spill, have given emergency response teams the opportunity to test and refine sunken and submerged oil recovery techniques. Many conventional and unconventional techniques have proven to be quite effective, including:

Nets: specialized nets can be utilized to contain submerged globules of weathered crude oil as they migrate downstream or with a current.

Bottom booms: bottom booms have a heavy ballast to create a seal against the bottom of a waterbody and a float chamber that extends toward the surface of the water. These booms have the potential to be very effective in containing submerged oil.

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[6] Dispersion is not a significant fate process for NGL.
[7] Sedimentation is not a significant fate process for NGL.

Dams: watergates, underflow weir dams, and other dams can be set up on the bottom of a waterbody to contain oil as it migrates downstream or with a current. Underflow weir dams can be built using standard spill response equipment (i.e., sandbags, shovels, polyvinyl chloride piping, etc.).

Dredging: well established dredging techniques can be extremely effective in recovering sunken and submerged oils and have been used effectively following spills of high density crude oils.

Manual Recovery: sunken oil has the tendency to collect in depressions and areas of low flow, where it often can be manually recovered. Techniques for manual recovery (e.g., vacuuming) are well established and can be executed using only standard spill response materials.

Air Injection: submerged oil can be floated and recovered using injection of air similar to soil vapor extraction techniques used in remediation of contaminated soil.

5.2.3 Environmental Impacts

An evaluation of the potential impacts resulting from the accidental release of petroleum product into the environment according to environmental resource is discussed below.

5.2.3.1 Soils

Because pipelines are buried, soil absorption of spilled product can occur, thus impacting the soils. Subsurface releases to soil tend to disperse slowly and generally are located within a contiguous and discrete area, often limited to the less consolidated soils (lower soil bulk density) within the pipeline trench. Effects to soils can be quite slow to develop, allowing time for emergency response and cleanup actions to mitigate effects to potential receptors.

In the event of a spill, a portion of the released materials would enter the surrounding soil and disperse both vertically and horizontally in the soil. The extent of dispersal would depend on a number of factors, including speed and success of emergency containment and cleanup, size and rate of release, topography of the release site, vegetative cover, soil moisture, bulk density, product viscosity, and soil porosity. High rates of release from the buried pipeline would result in a greater likelihood that released materials would escape the trench and reach the ground surface.

If a release were to occur in sandy soils encountered along the Project route, it is likely that the horizontal and vertical extent of the contamination would be greater than in areas containing more organic soils. Crude oil released into sandy soils likely would become visible to aerial surveillance due to product on the soils surface or discoloration of nearby vegetation, which will facilitate emergency response and soil remediation efforts. If present, soil moisture and moisture from precipitation would increase the dispersion and migration of crude oil and NGL.

The majority of the Project is located in relatively flat or moderately rolling terrain. In these areas, the oil generally would begin dispersing horizontally within the pipeline trench, and with sufficient spill volume or flow, the product could move out of the trench onto the soils surface, generally moving toward low lying areas. If the spill were to occur on a steep slope where trench breakers had been installed during construction, then product would pool primarily within the trench behind any trench breakers. If sufficient volume existed, the product would breach the soil's surface as it extended over the top of the trench breaker. In either case, once on the soil's surface, the release would be more apparent to leak surveillance patrols, facilitating emergency response and remediation.

Both on the surface and in the subsurface, rapid attenuation of light, volatile constituents (due to evaporation) would quickly reduce the total volume of product, while heavier constituents would be more persistent. Except in rare cases of high rate and high total volume releases with environmental settings characterized by steep topography or karst terrain, soil impacts would be confined to a relatively small, contiguous, and easily defined area, facilitating cleanup and remediation. Within a relatively short time, lateral migration generally would stabilize. Downward vertical migration would begin at the onset of a spill, with rates governed by soil permeability. For example, in soils with moderately high permeability, water may penetrate 2.5 inches per hour, while penetration rates for soils of low permeability may occur at 0.05 inch per hour. Crude oil is more viscous than water; therefore, permeability of crude oil would be slower. Modeling indicates that the penetration of crude oils into soils, even sandy soils, is limited in the vadose zone to a few feet. NGL would have greater vertical mobility in highly permeable soils than crude oil.

In accordance with federal and state regulations, Hess would be responsible for cleanup of contaminated soils and would be required to meet applicable cleanup levels. In North Dakota, soil cleanup levels are determined on a risk-based analysis, designed to protect human health and the environment. For most areas, benchmark soil cleanup levels from petroleum hydrocarbon releases are 100 part per billion [ppb] of total petroleum hydrocarbons and 5 ppb benzene (North Dakota Department of Health 2006). Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts would be expected.

It is difficult to precisely estimate the volume of soil that might be contaminated in the event of a spill. Site-specific environmental conditions (e.g., soil type, weather conditions) and release dynamics (e.g., leak rate, leak duration) would result in substantially different surface spreading and infiltration rates, which in turn, affect the final volume of affected soil to be remediated. Based on historical data (PHMSA 2008), soil remediation involved 100 cubic yards of soil or less at the majority of spill sites where soil contamination occurred, and only 3 percent of the spill sites required remediation of 10,000 cubic yards or more (PHMSA 2008).

5.2.3.2 Vegetation and Soil Ecosystems

Crude oil and NGL released to the soils surface potentially could produce localized effects on plant populations. Terrestrial plants are much less sensitive to crude oil than aquatic species. The lowest toxicity threshold for terrestrial plants found in the USEPA ECOTOX database (USEPA 2001) is 18.2 parts per million (ppm) for benzene, which is higher than the 7.4 ppm threshold for aquatic species and the 0.005 ppm threshold for human drinking water. Similarly, data from the USEPA database indicate that earthworms also are less sensitive than aquatic species (toxicity threshold was greater than 1,000 ppm). If concentrations were sufficiently high, however, product in the root zone could harm respiration and nutrient uptake by individual plants and organisms.

While a release of petroleum hydrocarbons could result in the contamination of soils (see Section 5.2.3.1, Soils), Hess would be responsible for cleanup of contaminated soils. Once remedial cleanup levels were achieved in the soils, no adverse or long-term impacts to vegetation would be expected.

5.2.3.3 Wildlife

Spilled petroleum hydrocarbons can affect organisms directly and indirectly. Direct effects include physical processes[8] such as oiling of feathers, fur, and eggs, and toxicological effects, which can cause sickness or mortality. Indirect effects are less conspicuous and include habitat impacts, nutrient cycling disruptions, and alterations in ecosystem relationships. The magnitude of effects varies with multiple factors, the most significant of which include the amount of material released, the size of the spill dispersal area, the type of product spilled, the species assemblage present, climate, and the spill response tactics employed.

Wildlife, especially birds and shoreline mammals, typically are among the most visibly affected organisms in petroleum product spills. Impacts can be differentiated into physical (mechanical) and toxicological (chemical) effects. Physical effects result from the actual coating of animals with crude oil, causing reductions in thermal insulative capacity and buoyancy of plumage (feathers) and pelage (fur). Nesting birds that come into contact with a slick can bring product back to the nest, covering eggs with oil. Because respiration occurs through the eggshell and constituents can harm developing embryos, oiling of eggs can cause mortality.

Crude oil and NGL released to the environment may cause adverse biological effects on birds and mammals via inhalation or ingestion exposure. Ingestion of petroleum hydrocarbons may occur when animals consume contaminated food, drink contaminated water, or orally consume petroleum products during preening and grooming behaviors.

Potential adverse effects could result from direct acute exposure. Potential toxicological effects of petroleum products on waterbirds include the destruction of red blood cells, alterations of liver metabolism, adrenal tissue damage, pneumonia, intestinal damage, reduction in the number of eggs laid, decreased fertility of eggs, and reduced reproduction ability (Australian Maritime Safety Authority 2013). Additional acute toxic effects include drying of the skin, irritation of mucous membranes, diarrhea, narcotic effects, and possible mortality. While releases of crude oil may have an immediate and direct effect on wildlife populations, the potential for physical and toxicological effects attenuates with time as the volume of material diminishes, leaving behind more persistent, less volatile, and less water-soluble compounds. Although many of these remaining compounds are toxic and potentially carcinogenic, they do not readily disperse in the environment and their bioavailability is low; therefore, the potential for impacts is low.

Unlike aquatic organisms that frequently cannot avoid spills in their habitats, the behavioral responses of terrestrial wildlife may help reduce potential adverse effects. Many birds and mammals are mobile and generally will avoid oil-impacted areas and contaminated food (Sharp 1990; Stubblefield et al. 1995). In a few cases, such as cave-dwelling species, organisms that are obligate users of contaminated habitat may be exposed. However, most terrestrial species have alternative, non-impacted habitat available, as will often be the case with localized spills (in contrast to large-scale oil spills in marine systems); therefore, mortality of these species would be limited (Stubblefield et al. 1995).

[8] Due to the high volatility and low viscosity of NGLs, physical impacts would be less prevalent than for crude oil.

Indirect environmental effects of spills can include reduction of suitable habitat or food supply. Primary producers (e.g., algae and plants) may experience an initial decrease in primary productivity due to physical effects and acute toxicity of the spill. However, these effects tend to be short-lived and a decreased food supply is not considered to be a major chronic stressor to herbivorous organisms after a spill. If mortality occurs to local invertebrate and wildlife populations, the ability of the population to recover will depend upon the size of the impact area and the ability of surrounding populations to repopulate the area.

5.2.3.4 Water Resources

Crude oil and NGL could be released to water resources if one of the pipelines was breached or leaks occur. Federal regulations (49 CFR 195.260) require valves to be placed strategically along the Project route to help reduce spill volumes into sensitive areas, such as waterbodies. Spill containment measures and implementing actions would be identified in the Project's ERP, as required by federal regulation and would help mitigate adverse effects to both surface water and groundwater.

Groundwater

Groundwater aquifers underlie the proposed Project. Vulnerability of these aquifers is a function of the depth to groundwater and the permeability of the overlying soils. While routine operation of the Project would not affect groundwater, there is the possibility that a release could migrate through the overlying surface materials and enter a groundwater system.[9]

In general, the potential for groundwater contamination following a spill would be more probable in locations where a release into or on the surface of soils has occurred:

- Where a relatively shallow water table is present (as opposed to locations where a deeper, confined aquifer system is present);
- Where soils with high permeability are present throughout the unsaturated zone; and
- Where, in cooperation with federal and state agencies, PHMSA (in cooperation with the U.S. Geological Survey [USGS] and other federal and state agencies) has identified specific groundwater resources that are particularly vulnerable to contamination. These resources are designated by PHMSA as HCAs (see Section 5.4, Risk to High Consequence Areas).

Depending on soil properties, the depth to groundwater, and the amount of petroleum product in the unsaturated zone, localized groundwater contamination can result from the presence of free petroleum product and the migration of its dissolved constituents. Crude oil and NGL are less dense than water and would tend to form a floating pool after reaching the groundwater surface. Movement of petroleum products generally is quite limited due to adherence with soil particles, groundwater flow rates, and natural attenuation (i.e., microbial degradation) (Fetter 1993; Freeze and Cherry 1979). Those compounds in the crude oil that are soluble in water will form a larger, dissolved "plume." This plume would tend to migrate laterally in the direction of groundwater flow. Movement of dissolved constituents typically extends for greater distances than movement of pure crude oil in the subsurface, but is still relatively

[9] There are no municipal groundwater intakes in the vicinity of the pipeline.

limited. The flow velocity of dissolved constituents would be a function of the groundwater flow rate and natural attenuation, with the dissolved constituents migrating more slowly than groundwater.

Unlike chemicals with high environmental persistence (e.g., trichloroethylene, pesticides), the areal extent of the dissolved constituents will stabilize over time due to natural attenuation processes. Natural biodegradation through metabolism by naturally occurring microorganisms is often an effective mechanism for reducing the volume of crude oil and its constituents. Natural attenuation will reduce most toxic compounds into non-toxic metabolic byproducts, typically carbon dioxide and water (Minnesota Pollution Control Agency 2005). Field investigations of more than 600 historical petroleum hydrocarbon release sites indicate the migration of dissolved constituents typically stabilize within several hundred feet of the crude oil source area (Newell and Conner 1998; USGS 1998; Ruiz-Aguilar et al. 2003; Shih et al. 2004; Kamath et al., in press). Over a longer period, the area of the contaminant plume may begin to reduce due to natural biodegradation. Removal of crude oil contamination will eliminate the source of dissolved constituents impacting the groundwater.

Most petroleum product constituents are not very soluble in water. The dissolved concentration of water soluble compounds (e.g., benzene) is not controlled by the amount of product in contact with the water, but by the concentration of the specific constituent in the product (Charbeneau et al. 2000; Charbeneau 2003; Freeze and Cherry 1979). Studies of 69 crude oils found that benzene was the only aromatic or PAH compound tested that is capable of exceeding groundwater protection values for drinking water (i.e., MCLs or Water Health Based Limits) (Kerr et al. 1999 as cited in O'Reilly et al. 2001).

If exposure to humans or other important resources would be possible from a release into groundwater, regulatory standards, such as drinking water criteria (MCL) would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. For human health protection, the national MCL is an enforceable standard established by the USEPA and is designed to protect long-term human health. The promulgated drinking water standards for humans vary by several orders of magnitude for crude oil constituents. Of the various crude oil constituents, benzene has the lowest national MCL at 0.005 ppm; therefore, it was used to evaluate impacts on drinking water supplies.

If no active remediation activities were undertaken, natural biodegradation and attenuation ultimately would allow a return to preexisting conditions in both soil and groundwater. Depending on the amount of crude oil reaching the groundwater and natural attenuation rates, this likely would require up to tens of years. Hess would utilize the appropriate cleanup procedures as determined in cooperation with the applicable federal and state agencies.

Flowing Surface Waters

This report evaluated impacts to downstream drinking water sources by comparing projected surface water benzene concentrations with the national MCL for benzene. Like other pipelines already in existence, the Project will cross hundreds of perennial, intermittent, and ephemeral streams. Rather than evaluate the risk to each waterbody crossed by the Project, this risk assessment evaluated categories of streams, based on the magnitude of streamflow and stream width. **Table 5-2** summarizes the stream categories used for the assessment and identifies several representative streams within these categories.

Table 5-2 Stream Categories

	Streamflow (cubic feet per second [cfs])	Top of Bank Stream Width (feet)	Representative Streams
Low Flow Stream	10 – 100	<50	Unnamed intermittent tributaries
Lower Moderate Flow Stream	100 – 1,000	50 – 500	Little Missouri River, Green River, Heart River
Upper Moderate Flow Stream	1,000 – 10,000	500 – 1,000	Missouri River, Heart River (peak flow), Little Missouri River (peak flow)
High Flow Stream	>10,000	1,000 – 2,500	Missouri River (peak flow)

The following extremely conservative assumptions were developed to overestimate potential spill effects for planning purposes.

- The entire volume of a spill was released directly into a waterbody;
- Complete, instantaneous mixing occurred; and
- The entire benzene content of the crude oil was solubilized into the water column.

Under the actual conditions of a crude oil release, the spill and mixing events outlined by these assumptions are not expected to occur at the very high levels described.

A 1-hour release period for the entire spill volume was assumed in order to maximize the product concentration in water. The estimated benzene concentrations were then compared with the human health drinking water MCL for benzene (**Tables 5-3**). Based on these ultra-conservative assumptions, results suggest that most spills that enter the waterbody could lead to benzene levels that exceed the national MCL for benzene. Although the assumptions used are highly conservative and, thus, overestimate potential benzene water concentrations, the analysis indicates the need for rapid notification of managers of municipal water intakes downstream of a spill so that any potentially affected drinking water intakes could be closed to bypass river water containing crude oil.

In addition to evaluating a general-case spill to flowing water, the potential for impacts to any specific waterbody also were evaluated. To do this, the occurrence interval for a spill at any one representative stream within one of the four stream categories reflected in **Tables 5-3** and **5-4** was calculated based on spill probabilities generated from the PHMSA database. To be conservative, a 500-foot buffer on either side of the river was added to the crossing widths identified in **Table 5-2**. The occurrence intervals shown on **Tables 5-3** and **5-4** indicate the chance of a spill occurring at any specific waterbody is very low. Conservative occurrence intervals for a spill at any representative stream within any of the stream categories ranged from about 1,397 years for a large waterbody to 4,656 years for a small waterbody (less likely to occur in any single small waterbody than any single large waterbody). If any release did occur, it is likely that the total release volume of a spill likely would be 4 barrels or less based on PHMSA data for historical spill volumes.

Table 5-3 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Bakken Crude Oil Spill

Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released: Very Small Spill: 4 barrels — Benzene Conc. (ppm)	Very Small Spill: 4 barrels — Occurrence Interval (years)	Small Spill: 50 barrels — Benzene Conc. (ppm)	Small Spill: 50 barrels — Occurrence Interval (years)	Moderate Spill: 1,000 barrels — Benzene Conc. (ppm)	Moderate Spill: 1,000 barrels — Occurrence Interval (years)	Large Spill: 10,000 barrels — Benzene Conc. (ppm)	Large Spill: 10,000 barrels — Occurrence Interval (years)
Low Flow Stream	0.005	10	1.5	4,766	18.5	11,916	369	47,664	3,693	476,642
Lower Moderate Flow Stream	0.005	100	0.2	3,336	1.8	8,341	36.9	33,365	369	333,649
Upper Moderate Flow Stream	0.005	1,000	0.02	2,502	0.2	6,256	3.7	25,024	36.9	250,237
High Flow Stream	0.005	10,000	0.002	1,430	0.02	3,575	0.4	14,299	3.7	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.27 percent by volume benzene content of the transported material (Hawkeye Central Bakken Oil).
- Shading indicates estimated benzene concentrations that could exceed the benzene MCL of 0.005 ppm.
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 5-4 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a NGL Spill

Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released							
			Very Small Spill: 4 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	0.005	10	3.1	4,766	38.2	11,916	764	47,664	7,646	476,642
Lower Moderate Flow Stream	0.005	100	0.3	3,336	3.8	8,341	76.4	33,365	764	333,649
Upper Moderate Flow Stream	0.005	1,000	0.03	2,502	0.4	6,256	7.6	25,024	76.4	250,237
High Flow Stream	0.005	10,000	0.003	1,430	0.04	3,575	0.8	14,299	7.6	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.559 percent by volume benzene content of the transported material (Hawkeye Central NGL).
- Shading indicates estimated benzene concentrations that could exceed the benzene MCL of 0.005 ppm.
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

In summary, while a release of crude oil directly into any given waterbody likely would cause the water to exceed drinking water standards under the conservative assumptions used in this analysis, the frequency of such an event would be very low. Nevertheless, streams and rivers with downstream drinking water intakes represent sensitive environmental resources and could be temporarily impacted by a crude oil release. Hess's ERP would contain provisions for protecting and mitigating potential impacts to drinking water.[10]

Aquatic Organisms

The concentration of crude oil constituents in an actual spill would vary both temporally and spatially in surface water; however, localized toxicity could occur from virtually any size of crude oil spill. **Table 5-5** summarizes the acute toxicity values (USEPA 2000) of various crude oil hydrocarbons to a broad range of freshwater species. Acute toxicity refers to the death or complete immobility of an organism within a short period of exposure. The LC_{50} is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms. For aquatic biota, most acute LC_{50} for monoaromatics range between 10 and 100 ppm. LC_{50} for the polyaromatic naphthalene generally were between 1 and 10 ppm, while LC_{50} values for anthracene generally were less than 1 ppm.

Table 5-5 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms

Species	Toxicity Values (ppm)				
	Benzene	**Toluene**	**Xylenes**	**Naphthalene**	**Anthracene**
Carp (*Cyprinus carpio*)	40.4	---	780	---	---
Channel catfish (*Ictalurus* sp.)	---[1]	240	---	---	---
Clarias catfish (*Clarias* sp.)	425	26	---	---	---
Coho salmon (*Oncorhyncus kisutch*)	100	---	---	2.6	---
Fathead minnow (*Pimephales promelas*)	---	36	25	4.9	25
Goldfish (*Carassius auratus*)	34.4	23	24	---	---
Guppy (*Poecilia reticulate*)	56.8	41	---	---	---
Largemouth bass (*Micropterus*)	---	---	---	0.59	---
Medaka (*Oryzias* sp.)	82.3	54	---	---	---
Mosquito fish (*Gambusia affinis*)	---	1,200	---	150	---
Rainbow trout (*Oncorhyncus mykis*)	7.4	8.9	8.2	3.4	---
Zebra fish (*Therapon iarbua*)	---	25	20	---	---
Rotifer (*Brachionus calyciflorus*)	>1,000	110	250	---	---
Midge (*Chironomus attenuatus*)	---	---	---	15	---
Midge (*Chironomus tentans*)	---	---	---	2.8	---
Zooplankton (*Daphnia magna*)	30	41	---	6.3	0.43
Zooplankton (*Daphnia pulex*)	111	---	---	9.2	---

[10] An in-depth site-specific assessment for Lake Sakakawea is provided in **Attachment A**.

Table 5-5 Acute Toxicity of Aromatic Hydrocarbons to Freshwater Organisms

Species	Toxicity Values (ppm)				
	Benzene	Toluene	Xylenes	Naphthalene	Anthracene
Zooplankton *(Diaptomus forbesi)*	---	450	100	68	---
Amphipod *(Gammarus lacustris)*	---	---	0.35	---	---
Amphipod *(Gammarus minus)*	---	---	---	3.9	---
Snail *(Physa gyrina)*	---	---	---	5.0	---
Insect *(Somatochloa cingulata)*	---	---	---	1.0	---
Chlorella vulgaris	---	230	---	25	---
Microcystis aeruginosa	---	---	---	0.85	---
Nitzschia palea	---	---	---	2.8	---
Scenedesmus subspicatus	---	130	---	---	---
Selenastrum capricornutum	70	25	72	7.5	---

[1] Indicates no value was available in the database.

Note: Data summarize conventional acute toxicity endpoints from USEPA's ECOTOX database. When several results were available for a given species, the geometric mean of the reported LC_{50} values was calculated.

Table 5-5 shows fish are among the most sensitive aquatic biota, while aquatic invertebrates generally have intermediate sensitivities, and algae and bacteria tend to be the least sensitive. Nevertheless, even when major fish kills have occurred as a result of oil spills, population recovery has been observed and long-term changes in fish abundance have not been reported. Benthic (bottom-dwelling) aquatic invertebrates tend to be more sensitive than algae, but are equally or less sensitive than fish. Planktonic (floating) species tend to be more sensitive than most benthic insects, crustaceans, and mollusks.

In aquatic environments, toxicity is a function of the concentration of a compound necessary to cause toxic effects combined with the compound's water solubility. For example, a compound may be highly toxic, but if it is not very soluble in water then its relative toxicity to aquatic biota is relatively low. The toxicity of crude oil is dependent of the toxicity of its constituents. As an example, **Table 5-6** summarizes the toxicity of various crude oil hydrocarbons to the water flea, *Daphnia magna*. This species of water flea is used as a standard test organism to determine acute and chronic responses to toxicants. The relative toxicity of decane is much lower than for benzene or ethyl benzene because of the comparatively low solubility of decane. Most investigators have concluded that the acute toxicity of crude oil is related to the concentrations of relatively lightweight aromatic constituents, particularly benzene.

Table 5-6 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC_{50} (ppm)	Optimum Solubility (ppm)	Relative Toxicity
Hexane	3.9	9.5	2.4
Octane	0.37	0.66	1.8
Decane	0.028	0.052	1.9

Table 5-6 Acute Toxicity of Crude Oil Hydrocarbons to *Daphnia magna*

Compound	48-hr LC_{50} (ppm)	Optimum Solubility (ppm)	Relative Toxicity
Cyclohexane	3.8	55	14.5
methyl cyclohexane	1.5	14	9.3
Benzene	9.2	1,800	195.6
Toluene	11.5	515	44.8
Ethylbenzene	2.1	152	72.4
p-xylene	8.5	185	21.8
m-xylene	9.6	162	16.9
o-xylene	3.2	175	54.7
1,2,4-trimethylbenzene	3.6	57	15.8
1,3,5-trimethylbenzene	6	97	16.2
Cumene	0.6	50	83.3
1,2,4,5-tetramethylbenzene	0.47	3.5	7.4
1-methylnaphthalene	1.4	28	20.0
2-methylnaphthalene	1.8	32	17.8
Biphenyl	3.1	21	6.8
Phenanthrene	1.2	6.6	5.5
Anthracene	3	5.9	2.0
9-methylanthracene	0.44	0.88	2.0
Pyrene	1.8	2.8	1.6

Note: The LC_{50} is the concentration of a compound necessary to cause 50 percent mortality in laboratory test organisms within a predetermined time period (i.e., 48 hours) (USEPA 2013).

Relative toxicity = optimum solubility/LC_{50}.

While lightweight aromatics such as benzene tend to be water soluble and relatively toxic, they also are highly volatile. Thus, most or all of the lightweight hydrocarbons accidentally released into the environment evaporate, and the environmental persistence of this crude oil fraction tends to be low. High molecular weight aromatic compounds, including PAHs, are not very water-soluble and have a high affinity for organic material. Consequently, these compounds, if present, have limited bioavailability, which render them substantially less toxic than more water-soluble compounds (Neff 1979). Additionally, these compounds generally do not accumulate to any great extent because these compounds are rapidly metabolized (Lawrence and Weber 1984; West et al.1984). There are some indications, however, that prolonged exposure to elevated concentrations of these compounds may result in a higher incidence of growth abnormalities and hyperplastic diseases in aquatic organisms (Couch and Harshbarger 1985).

Significantly, some constituents in crude oil may have greater environmental persistence than lightweight compounds (e.g., benzene), but their limited bioavailability renders them substantially less toxic than other more soluble compounds. For example, aromatics with four or more rings are not acutely toxic at their limits of solubility (Muller 1987). Based on the combination of toxicity, solubility, and bioavailability, benzene was determined to dominate toxicity associated with potential crude oil spills.

Table 5-7 summarizes chronic toxicity values (most frequently measured as reduced reproduction, growth, or weight) of benzene to freshwater biota. Chronic toxicity from other oil constituents may occur, however, if sufficient quantities of crude oil are continually released into the water to maintain elevated concentrations.

Table 5-7 Chronic Toxicity of Benzene to Freshwater Biota

Taxa	Test Species	Chronic Value (ppm)
Fish	Fathead minnow (*Pimephales promelas*)	17.2 *
	Guppy (*Poecilia reticulata*)	63
	Coho salmon (*Oncorhynchus kitsutch*)	1.4
Amphibian	Leopard frog (*Rana pipens*)	3.7
Invertebrate	Zooplankton (*Daphnia* spp.)	>98
Algae	Green algae (*Selenastrum capricornutum*)	4.8 *

Note: Test endpoint was reproduction for those denoted with an asterisk (*). The test endpoint for other studies was growth.

The potential impacts to aquatic organisms of various-sized spills to waterbodies were modeled assuming the benzene content within each type of petroleum product completely dissolved in the water. The benzene concentration was predicted based on amount of crude oil spilled and streamflow. The estimated benzene concentrations were compared to conservative acute and chronic toxicity values for protection of aquatic organisms. For aquatic biota, the lowest acute and chronic toxicity thresholds for benzene are 7.4 ppm and 1.4 ppm, respectively, based on standardized trout toxicity tests (USEPA 2001). These toxicity threshold values are considered protective of acute and chronic effects to aquatic biota. Although trout are not found in any of the habitats crossed by the Project, trout are among the most sensitive aquatic species for which reliable acute and chronic trout toxicity data are available. Using trout toxicity thresholds, therefore, provides a conservative benchmark to screen for the potential for toxicity.

Tables 5-8 through **5-11** summarize the screening-level assessment of acute and chronic toxicity, respectively, to aquatic resources. Broadly, acute toxicity potentially could occur if substantial amounts of product were to enter rivers and streams. If such an event were to occur within a small stream, aquatic species in the immediate vicinity and downstream of the rupture could be killed or injured. Chronic toxicity also potentially could occur in small and moderate sized streams and rivers. However, emergency response, containment, and cleanup efforts would help reduce the concentrations and minimize the potential for chronic toxicity. In comparison, relatively small spills (less than 50 barrels) into moderate and large rivers would not pose a major toxicological threat. In small to moderate sized streams and rivers, some toxicity might occur in localized areas, such as backwaters where concentrations likely would be higher than in the mainstream of the river.

Table 5-8 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Acute Toxicity Threshold for Aquatic Life (1.4 ppm) for Streams Crossed by the Project

Streamflow	Acute Toxicity Threshold (ppm)	Stream Flow Rate (cfs)	Product Released							
			Very Small Spill: 4 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	7.4	10	1.5	4,766	**18.5**	**11,916**	**369**	**47,664**	**3,693**	**476,642**
Lower Moderate Flow Stream	7.4	100	0.2	3,336	1.8	8,341	**36.9**	**33,365**	**369**	**333,649**
Upper Moderate Flow Stream	7.4	1,000	0.02	2,502	0.2	6,256	3.7	25,024	**36.9**	**250,237**
High Flow Stream	7.4	10,000	0.002	1,430	0.02	3,575	0.4	14,299	**3.7**	**142,993**

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. Additionally, 10,000 barrels, the largest spill analyzed, is higher than the worst case discharge. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.27 percent by volume benzene content of the transported material (Hawkeye Central Bakken Oil).
- Shading indicates estimated benzene concentrations that could exceed the acute aquatic toxicity threshold for benzene (7.4 ppm).
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 5-9 Comparison of Estimated Benzene Concentrations Following a NGL Spill to the Acute Toxicity Threshold for Aquatic Life (7.4 ppm) for Streams Crossed by the Project

			Product Released							
			Very Small Spill: 4 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
Streamflow	Acute Toxicity Threshold (ppm)	Stream Flow Rate (cfs)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	7.4	10	3.1	4,766	38.2	11,916	764	47,664	7,646	476,642
Lower Moderate Flow Stream	7.4	100	0.3	3,336	3.8	8,341	76.4	33,365	764	333,649
Upper Moderate Flow Stream	7.4	1,000	0.03	2,502	0.4	6,256	7.6	25,024	76.4	250,237
High Flow Stream	7.4	10,000	0.003	1,430	0.04	3,575	0.8	14,299	7.6	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. Additionally, 10,000 barrels, the largest spill analyzed, is higher than the worst case discharge. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.559 percent by volume benzene content of the transported material (Hawkeye Central NGL).
- Shading indicates estimated benzene concentrations that could exceed the acute aquatic toxicity threshold for benzene (7.4 ppm).
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 5-10 Comparison of Estimated Benzene Concentrations Following a Bakken Crude Oil Spill to the Chronic Toxicity Threshold for Aquatic Life (1.4 ppm) for Streams Crossed by the Project

Streamflow	Chronic Toxicity Threshold (ppm)	Stream Flow Rate (cfs)	Product Released: Very Small Spill: 4 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
			Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	1.4	10	0.009	4,766	0.1	11,916	**2.2**	**47,664**	**22.0**	**476,642**
Lower Moderate Flow Stream	1.4	100	0.0009	3,336	0.01	8,341	0.2	33,365	**2.2**	**333,649**
Upper Moderate Flow Stream	1.4	1,000	0.00009	2,502	0.001	6,256	0.02	25,024	0.2	250,237
High Flow Stream	1.4	10,000	0.000009	1,430	0.0001	3,575	0.002	14,299	0.02	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. Additionally, 10,000 barrels, the largest spill analyzed, is higher than the worst case discharge. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 7-day period with uniform mixing conditions.
- Concentrations are based on a 0.27 percent by volume benzene content of the transported material (Hawkeye Central Bakken Oil).
- Shading indicates estimated benzene concentrations that could exceed the chronic aquatic toxicity threshold for benzene (1.4 ppm).
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

Table 5-11 Comparison of Estimated Benzene Concentrations Following a NGL Spill to the Chronic Toxicity Threshold for Aquatic Life (1.4 ppm) for Streams Crossed by the Project

			Product Released							
			Very Small Spill: 4 barrels		Small Spill: 50 barrels		Moderate Spill: 1,000 barrels		Large Spill: 10,000 barrels	
Streamflow	Chronic Toxicity Threshold (ppm)	Stream Flow Rate (cfs)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)	Benzene Conc. (ppm)	Occurrence Interval (years)
Low Flow Stream	1.4	10	0.02	4,766	0.2	11,916	4.6	47,664	45.5	476,642
Lower Moderate Flow Stream	1.4	100	0.002	3,336	0.02	8,341	0.5	33,365	4.6	333,649
Upper Moderate Flow Stream	1.4	1,000	0.0002	2,502	0.002	6,256	0.05	25,024	0.5	250,237
High Flow Stream	1.4	10,000	0.00002	1,430	0.0002	3,575	0.005	14,299	0.05	142,993

Notes:

- Historical data indicate that the most probable spill volume would be 4 barrels or less. Additionally, 10,000 barrels, the largest spill analyzed, is higher than the worst case discharge. However, this entire analysis is based on conservative incident frequencies and a range of spill volumes, to provide a range of the magnitude of potential effects for the NEPA analysis.
- Estimated concentration is based on release of benzene into water over a 7-day period with uniform mixing conditions.
- Concentrations are based on a 0.559 percent by volume benzene content of the transported material (Hawkeye Central NGL).
- Shading indicates estimated benzene concentrations that could exceed the chronic aquatic toxicity threshold for benzene (1.4 ppm).
- Occurrence intervals are based on an overall predicted incident frequency of 0.00211 incident/mile*year (Section 4.1), projected frequencies of each spill volume, and estimated stream widths. Widths of higher flow streams are greater than widths of lower flow streams, with more distance where an incident might occur. This results in a greater predicted frequency for high flow streams and a corresponding lower occurrence interval.

The likelihood of a release into any single waterbody would be low, with a predicted occurrence interval of no more than once every 1,430 to 476,642 years (**Tables 5-8** through **5-11**). If any release did occur, it is likely that the total release volume of a spill would be 4 barrels or less based on historical spill volumes.

While a release of product into any given waterbody might cause immediate localized toxicity to aquatic biota, particularly in smaller streams and rivers, the frequency of such an event would be very low. Nevertheless, streams and rivers with aquatic biota represent the sensitive environmental resources that could be temporarily impacted by a release.

Wetlands/Reservoirs/Lakes

Wetlands and waterbodies with persistently saturated soils are present along and adjacent to the proposed Project route. The effects of crude oil released into a wetland environment would depend not only upon the quantity of oil released, but also on the physical conditions of the wetland at the time of the release. Wetlands include a wide range of environmental conditions. Wetlands can consist of many acres of standing water bisected with ponds and channels, or they may simply be areas of saturated soil with no open water. A single wetland can even vary between these two extremes as seasonal precipitation varies. Wetland surfaces generally are low gradient with very slow unidirectional flow or no discernible flow. The presence of vegetation or narrow spits of dry land protruding into wetlands also could isolate parts of the wetland. Given these conditions, spilled materials could remain in restricted areas for longer periods than in river environments.

Crude oil released from a subsurface pipe within a wetland could reach the soils surface. If the water table reaches the surface, the release would manifest as floating crude oil. The general lack of surface flow within a wetland would restrict crude oil movement. Where surface water is present within a wetland, the spill would spread laterally across the water's surface and be readily visible during routine ROW surveillance. The depth of soil impacts likely would be minimal, due to shallow (or emergent) groundwater conditions. Groundwater impacts within a wetland are likely to be confined to the near-surface, enhancing the potential for biodegradation. If humans or other important resource exposures were to occur in proximity to the wetland, then regulatory drivers would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. However, response and remediation efforts in a wetland have the potential for appreciable adverse effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation would ultimately allow a return to preexisting conditions in both soil and groundwater. This likely would require a timeframe on the order of tens of years. In the unlikely event of a spill, Hess would utilize appropriate cleanup procedures as determined in coordination with the applicable federal and state agencies.

The chance of a spill occurring at any specific wetland along the pipeline is very low. Based on survey data and aerial interpretation, wetlands comprise 0.27 miles of the entire Project. Therefore, although it is conservatively estimated that 1 spill could occur in 10.7 years to either of the liquid pipelines, it is unlikely that a spill would occur in a wetland (approximately equivalent to 1 spill in 860 years).

Based on a review of publicly available toxicity literature for wetland plant groups (i.e., algae, annual macrophytes, and perennial macrophytes), crude oil is toxic to aquatic plants but at higher concentrations than observed for fish and invertebrates. Therefore, spill concentrations that are less than toxic effect levels for fish and invertebrates (see Aquatic Organisms) also would not affect wetland plant species.

The predicted effects of a spill reaching standing water (e.g., reservoirs, lakes) would depend largely upon the volume of crude oil entering the waterbody and the volume of water within the waterbody. **Table 5-12** summarizes the amount of water necessary to dilute crude oil spill volumes below aquatic toxicity and drinking water thresholds. While this preliminary approach does not account for fate and transport mechanisms, mixing zones, environmental factors, and emergency response capabilities, it does provide an initial screening benchmark for identifying areas of potential concern.

Table 5-12 Volume of Water Required to Dilute Benzene in Bakken Crude Oil Spills Below Benchmark Values

Barrels of Crude Oil	Volume of Water Required to Dilute Benzene in Crude Oil Below Benchmark (acre-feet)[1]		
	Acute Toxicity Threshold (7.4 milligrams per liter [mg/L])	Chronic Toxicity Threshold (1.4 mg/L)	Drinking Water MCL (0.005 mg/L)
4	0.17	0.88	250
50	2.06	10.9	3,100
1,000	41.2	218	61,000
10,000	412	2,180	610,000

1 Benchmarks based on aquatic toxicity and drinking water thresholds established for benzene. The estimated benzene content of the Hawkeye Central Bakken crude oil is 0.27 percent by volume.

2 10,000 barrels is larger than the Project's worst case discharge. Thus, a spill of this size is not anticipated.

Table 5-13 summarizes the amount of water necessary to dilute NGL spill volumes below aquatic toxicity and drinking water thresholds.

Table 5-13 Volume of Water Required to Dilute Benzene in NGL Spills Below Benchmark Values

Barrels of Crude Oil	Volume of Water Required to Dilute Benzene in Crude Oil Below Benchmark (acre-feet)[1]		
	Acute Toxicity Threshold (7.4 mg/L)	Chronic Toxicity Threshold (1.4 mg/L)	Drinking Water MCL (0.005 mg/L)
4	0.34	1.8	510
50	4.27	22.6	6,320
1,000	85.4	451	127,000
10,000[2]	854	4,510	1,270,000

1 Benchmarks based on aquatic toxicity and drinking water thresholds established for benzene. The estimated benzene content of the Hawkeye Central NGL is 0.559 percent by volume.

2 10,000 barrels is larger than the Project's worst case discharge. Thus, a spill of this size is not anticipated.

5.3 LAKE SAKAKAWEA

Lake Sakakawea is a reservoir crossed by the pipeline. Its normal volume is 12,800,000 acre-feet, with a maximum capacity of 23,800,000 acre-feet (USACE 2007). The lake is used for drinking water, recreational activities, flood control, hydroelectric power, navigation, and irrigation. It also supports a coldwater fishery. Lake Sakakawea offers a wide range of water-based recreational activities (USACE 2012). The lake offers swimming, boating, sailing, camping, and fishing. There also are camp grounds and a park located nearby. According to the Garrison Dam/Lake Sakakawea master plan prepared by the USACE (2007), Lake Sakakawea and the surrounding areas comprise a wide variety of habitats suitable for many different types of species. Garrison Dam National Fish Hatchery adds volume to some of the naturally reproducing fish populations.

5.3.1 Wildlife

According to the Garrison Dam/Lake Sakakawea master plan prepared by the USACE (2007), Lake Sakakawea and the surrounding areas comprise a wide variety of habitats suitable for many different types of species. Garrison Dam National Fish Hatchery adds volume to the naturally reproducing fish population. Several cold water fish species including rainbow smelt (*Osmerus mordax*) and Chinook salmon (*Oncorhynchus tshawytscha*) thrive near the riverine end of the lake. Warmer water species such as shovelnose and pallid sturgeon (*Scaphirhynchus platorynchusm* and *S. albus*), paddlefish (S. platorynchus), walleye (*Sander vitreus*), sauger (*Sander canadense*), northern pike (*Exos lucius*), and common carp (*Cyprinus carpio*) are found inhabiting the delta at the north end of the lake.

Large mammals including white-tailed deer (*Odocoileus virginianus*), mule deer (*O. hemionus*), mountain lions (*Puma concolor*), and pronghorn (*Antilocapra americana*) are common in the area. Smaller mammals such as cottontail rabbit (*Sylvilagus floridanus*), many different species of bats, squirrels, shrews, and mice, and black-tailed prairie dogs (*Cynomys ludovicianus*) also are present. Species of birds that may be present near the crossing at Lake Sakakawea include the least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), and whooping crane (*Grus americana*). However, it should be noted that over 365 bird species have been known to occur in the area.

According to the U.S. Fish and Wildlife Service (USFWS), eight species occurring in the Lake Sakakawea area are federally-listed or proposed to be federally-listed threatened and endangered species. The black-footed ferret (*Mustela nigripes*), whooping crane (*Grus americana*), gray wolf (*Canis lupus*), interior least tern (*Sternula antillarum*), and pallid sturgeon (*Scaphirhynchus albus*) are listed as endangered, while the piping plover (*Charadrius melodus*) and the rufa red knot (*Calidris canutus rufa*) are listed as threatened (USACE 2007; USFWS 2014). The northern long-eared bat (*Myotis septentrionalis*) is proposed for listing as endangered.

As proposed, no new pipeline installation across the lake would be required. The existing pipelines have been trenched across the bottom of the reservoir, so if a spill were to occur in Lake Sakakawea, the oil would immediately rise to the surface. Once at the water's surface, the oils would spread laterally, creating an oil slick. Lateral spread rates would be significantly reduced by the presence of ice. Emergency response teams would be dispatched and the oil would be contained and removed, even if ice is present. The magnitude of potential impacts would depend on the amount of oil released, where the oil spread prior to containment, and the amount of time prior to removal of the oil. If a spill were to occur, it is possible that there may be localized impacts to water quality and possible toxic effects to aquatic biota. Impacts to aquatic invertebrates and young fish may occur along shorelines and backwater areas where oil may be in contact with relatively small volumes of water. But impacts to fish in the main portion of the reservoir are expected to be minimal. Additionally, effects to demersal species, including pallid sturgeon, would be limited due to the low density and high volatility of Bakken crude oil and NGLs. These characteristics decrease the chances of the products sinking and contaminating sediments. Given the crude oil's buoyancy and low viscosity, a spill event would be likely to create a slick extending to the shoreline. Thus, birds that use open water and shorelines for foraging or nesting may be affected by oil spills near the shore.

It is highly unlikely that a spill would impact drinking water, given the location of the drinking water intake and the distance (and associated time) from the pipeline. In summary, while a release of crude oil into wetland and static waterbodies has the potential to cause temporary environmental impacts, the frequency of such an event would be very low. An in-depth, site-specific risk assessment for Lake Sakakawea is provided in **Attachment A**.

5.4 RISK TO HIGH CONSEQUENCE AREAS

Consequences of inadvertent releases from pipelines can vary greatly, depending on where the release occurs. Pipeline safety regulations use the concept of HCAs to identify specific locales and areas where a release could have the most significant adverse consequences. HCAs include populated areas, designated zones around public drinking water intakes, and unusually sensitive ecological resource areas.[11] Segments of the pipeline that potentially could affect HCAs would be subject to higher levels of inspection, as per 49 CFR 195.

5.4.1 Populated Areas

PHMSA-defined populated areas, including highly populated areas and other populated areas, are not crossed by the Project.

5.4.2 Drinking Water

PHMSA identifies certain surface water and groundwater resources as drinking water USAs (49 CFR 195.6 and 195.450). Surface water USAs include intakes for community water systems and non-transient non-community water systems that do not have an adequate alternative drinking water source. Groundwater USAs include the source water protection area for community water systems and non-transient non-community water systems that obtain their water supply from a Class I or Class IIA aquifer and do not have an adequate alternative drinking water source. If the source water protection area has not been established by the state, the wellhead protection area becomes the USA.

Surface water USAs identified for their potential as a drinking water resource have a 5-mile buffer placed around their intake location. Groundwater USAs have buffers that vary in size. These buffers are designated by the state's source water protection program or their wellhead protection program and the buffer sizes vary from state to state.

[11] A sole source municipal drinking water intake or an ecological resource that is particularly sensitive to environmental damage from a hazardous liquid pipeline release are referred to as Unusually Sensitive Areas (USAs), as defined in 49 CFR 195.6.

PHMSA-defined drinking water USAs are not crossed by the Project.

5.4.3 Ecologically Sensitive Areas

Certain ecologically sensitive areas are classified as HCAs by PHMSA due to potential risks to unusually sensitive ecological resources. These areas focus on the characteristics of rarity, imperilment, or the potential for loss of large portions of an abundant population during periods of migratory concentration. These include:

- Critically imperiled and imperiled species and/or ecological communities;
- Threatened and endangered species (or multi-species assemblages where three or more different candidate resources co-occur);
- Migratory waterbird concentrations;
- Areas containing candidate species or ecological communities identified as excellent or good quality; and
- Areas containing aquatic or terrestrial candidate species and ecological communities that are limited in range.

5.4.4 Management of Risk within HCAs

To protect particularly sensitive resources, HCAs would be subject to a higher level of inspection per USDOT regulations. Federal regulations require periodic assessment of the pipe condition and timely correction of identified anomalies within HCAs. Under federal pipeline regulations, Hess would be required to develop management and analysis processes that integrate available integrity-related data and information and assess the risks associated with segments that can affect HCAs.

Hess also would be required to conduct routine surveys to locate HCA changes along the pipeline system. If portions of the pipeline become populated area HCAs during the operational pipeline life, Hess would be required to integrate the information into their Integrity Management Plan (IMP), which is audited by PHMSA.

For Homeland Security reasons, the specific locations of HCAs are highly confidential. Therefore, additional information on risk to HCAs is provided to federal and state regulatory agencies, if requested, as a confidential appendix. Per federal regulations (Integrity Management Rule, 49 CFR 195), the site-specific evaluation of risk is an ongoing process and is regulated by PHMSA. As part of the compliance process, Hess would need to develop and implement a risk-based IMP. The IMP will use state-of-practice technologies applied within a comprehensive risk-based methodology to assess and mitigate risk associated with all pipeline segments including HCAs.

6.0 Impacts from Construction of the Project

6.1 SOILS

Soils in the Project area vary depending on the topography, slope orientation, and parent material from which the soil is derived. The Project area is located toward the center of the Williston Basin. The Greenhorn Formation, which consists of thin limestone and dark gray to black organic-rich shale, is found from the surface to a depth of approximately 4,000 feet. The Greenhorn is subdivided into lower and upper intervals of limestone and calcareous shale with a middle interval of shale. Near-surface sediment is of Recent, Pleistocene, or Tertiary age, and includes Sauk, Tippecanoe, Kaskaskia, Absaroka, Zuni, and Tejas sequences. Thirty-four soil types are found throughout the Project area. Each individual soil series may exist individually within the Project area or in combination with other soil types.

No permanent impacts to the soils in the Project area are anticipated as a result of pipeline installation or operation, except at those locations where new aboveground facilities are constructed, mainline valve sites are located, or pig receivers are placed. The majority of the soil disturbance along the proposed route would be limited to the construction ROW, but temporary access, staging areas, and additional temporary workspaces may be needed at select locations.

In order to prevent effects on the soil due to compaction by construction operations, topsoil stripping, and/or soil decompaction techniques would be used during clearing, grading, and restoration activities.

Topsoil stripping would occur in the Project ROW above both the trench and the spoil side of the trench within the Project ROW along the entire length of the new pipeline segments, except across USFS land. Across USFS land, topsoil would be stripped above the entire Project ROW (i.e., spoil, trench, and working side). In locations where topsoil is not stripped, but significant compaction occurs, decompaction measures would be taken. Decompaction measures are further described in the Construction, Mitigation, and Reclamation Plan.

Soil impacts may occur due to wind and water erosion on areas that are disturbed during construction. Wind erosion would be more of a hazard in those portions with coarse-textured soils. Erosion potential can be influenced by the size of area being disturbed at any given time. Because the length of the pipeline would be disturbed in segments during the construction phase, erosion potential would be minimized. Grading may be required in some places to ensure safe working platforms for equipment, as well as to improve access roads. Generally, these areas would be on steep slopes that are not agriculturally productive. Dust control measures also would be taken to minimize wind erosion.

Soils crossed by the Project would be susceptible to contamination from spills or leaks of liquids used during construction. Hess has developed a Spill Prevention, Control, and Countermeasures Plan (SPCC Plan) that would outline methods to reduce spills or leaks. Any contaminated soils would be excavated and removed from the Project area, and the appropriate agencies would be notified as required. Procedures for handling contaminated soil are further described in the SPCC Plan.

During construction, soil erosion will be minimized by implementing procedures described in BMPs, the Storm Water Pollution Prevention Plan (SWPPP), and the Reclamation Plan. Also, topsoil and subsoil will be segregated; the topsoil will be stripped and stored separately from the subsoil and replaced with minimum handling. In rocky areas, an assessment of the soil handling requirements will be made by Hess. On agricultural land, subsoil will be chisel-plowed, rock-picked, and leveled prior to the replacement of topsoil.

6.2 VEGETATION AND SOIL ECOSYSTEMS

The proposed Project area occurs in the Northwestern Great Plains (ecoregion III) (USGS 2012), which is a western mixed-grass and short-grass prairie ecosystem (Bryce et al. 1998). Native grasses include blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), green needlegrass (*Nassella viridula*), prairie sandreed (*Calamovilfa longifolia*), and buffalograss (*Bouteloua dactyloides*). Common wetland vegetation includes various species of sedge (*Carex* spp.), bulrush (*Scirpus* spp.), and cattails (*Typha* spp.). Common plant species found in woody draws, coulees, and drainages include Juniper (*Juniperus* spp.), silver buffaloberry (*Shepherdia argentea*), and western snowberry (*Symphoricarpos occidentalis*).

The habitat types identified during the field surveys include mixed grass prairie, woodland, shrubland, wetlands, and agricultural fields. Northern mixed grass prairie can include wetlands, native grassland, and grass-shrub habitats, with riparian and floodplain forests along major drainages.

Temporary impacts would occur along the route and where access is needed for Project construction activities. Woodlands within the Project ROW primarily are associated with streams and wind breaks found near current or former homesteads. Any trees along the route would be protected to the extent practicable and in a manner compatible with safe operation, maintenance, and inspection of the pipeline.

Existing agricultural and grazing practices along the route have substantially altered the original vegetative landscape. Minimal impacts are expected to occur to native plant communities. Permanent vegetative impacts from pipeline construction are not anticipated. Temporarily disturbed areas that are normally cultivated would be available after Project construction. Areas not currently in agricultural use would be seeded with native seed mixes per USFS, USFWS, and Natural Resources Conservation Service recommendations, or as otherwise negotiated with private landowners.

Hess would work closely with landowners to minimize adverse impacts to vegetation associated with construction of the pipeline. A survey would be conducted to document tree species and numbers that would be impacted by Project construction. Trees and shrubs would be replaced in accordance with the Public Service Commission's (PSC's) tree and shrub mitigation specifications; and as required by other governing agencies. Generally, Hess would conduct an inventory of trees and shrubs that would be removed during construction of the pipeline. Trees and shrubs would be replaced by the same species or similar species suitable for North Dakota growing conditions at a 2:1 replacement ratio. The replacement location(s) would be coordinated with the landowner(s). Documentation identifying the number, variety, type, location, and date of the replacement plantings would be filed with the PSC. Monitoring of the survival rate and overall condition of the plantings would be conducted for 3 years. If the survival rate is 75 percent or less, the PSC may require additional plantings.

Following construction, trees and shrubs will be replaced in accordance with the PSC's tree and shrub mitigation specifications. Hess will coordinate with appropriate agencies to identify efficient restoration and mitigation measures following construction. ROW monitoring of reclamation will be conducted for the first growing season following reclamation and every other year, for 5 years thereafter. Reclamation success will be based on revegetation to 70 percent of the background cover as stipulated in the SWPPP. The Reclamation Plan will outline the procedures to be followed to return the land to pre-existing vegetative cover and land uses.

6.3 WILDLIFE

Potential impacts to wildlife include the temporary (short-term and long-term) reduction or loss of habitat. Short-term impacts arise from habitat removal and disturbance; these impacts would cease upon construction completion and completion of successful reclamation. Long-term impacts consist of changes to habitats and the wildlife populations that depend on those habitats, irrespective of reclamation success.

Direct impacts to wildlife populations may include limited direct mortalities from pipeline construction, habitat loss or alteration, incremental habitat fragmentation, and animal displacement. Indirect impacts could include increased noise, additional human presence, and the potential for increased vehicle-related mortalities. The degree of the impacts on terrestrial wildlife species and their upland habitats would depend on factors such as the sensitivity of the species, seasonal use patterns, type and timing of project activity, and physical parameters (e.g., topography, cover, forage, and climate).

To protect species protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act, a presence/absence survey for active nests would be conducted prior to construction. To minimize impacts, migratory birds and nests would be avoided during construction and operation of the pipeline. Any wildlife encountered during work activities would be avoided to the extent possible. Mowing, clearing, and grubbing of the Project ROW would occur in the fall or early spring to discourage bird nesting. In the event clearing and grubbing of the ROW is not possible prior to the nesting season, nesting surveys for migratory birds would be conducted where suitable nesting habitat exists prior to construction. If active nests are encountered on the ROW, the USFWS would be consulted for instructions on avoidance and/or mitigation measures. Consultation with the USFWS regarding nesting avian species would be continued during construction activities.

Adverse impacts to special status species (i.e., federally-listed, proposed, or USFS sensitive) are not anticipated. If, during construction, special status species are encountered, construction would be halted and the USFS and USFWS would be notified and consulted for additional information on how to proceed. The proposed Project ROW does not include any areas designated as Wildlife Management Areas (North Dakota Game and Fish Department 2014) or USFWS Waterfowl Production Areas.

6.4 GROUNDWATER

Aquifers in the Project area include, from deepest to shallowest, the Cretaceous Fox Hills and Hell Creek formations and the Tertiary Ludlow, Tongue River, and Sentinel Butte formations. Several shallow aquifers related to post-glacial outwash composed of till, silt, sand, and gravel are located in Dunn County. However, none are within the proposed Project area. Since none of the proposed Project area lies within the boundaries of the post-glacial outwash aquifers, low porosity bedrock near the Project wells would act as confining layers to prevent impacts to groundwater resources. Additionally, well completion methods would prevent cross contamination between aquifers or the introduction of hazardous materials into aquifers.

The shallow Sentinel Butte Formation, commonly used for domestic supply in the area, outcrops in Dunn and McKenzie counties. This aquifer meets the water quality standards of the North Dakota Department of Health (Croft 1985). Detailed analyses are available from the North Dakota Geological Survey, Bulletin 68, Part III, 1976. Review of electronic records of the North Dakota State Water Commission revealed 81 existing water wells within an approximate 5-mile boundary of the proposed Project area. The existing water wells include 7 domestic wells, 7 industrial wells, 1 industrial well-plugged, 1 irrigation well, 18 observation wells, 3 observation wells-plugged, 6 stock wells, 1 surface water monitoring site, 22 test holes, and 15 wells of an unknown type. Eleven of the existing wells are within 1 mile of the proposed Hawkeye Pipeline Project.

Some dewatering of construction areas and the pipeline trench may occur; however, relatively small volumes are expected and effects on the overall groundwater system would be small and temporary. Potential impacts on the groundwater would include minor fluctuations in groundwater levels and/or increased turbidity within the aquifer adjacent to the activity. Because of the relatively small amount of water removed, the short duration of the activity, and the local discharge of the water, groundwater levels would quickly recover after pumping stops.

The greatest risk for impacts to groundwater would result from the accidental release of a hazardous substance during construction or from a release during operations of the pipeline. Hess has developed a SPCC Plan and a SWPPP to address preventive and mitigation measures that would be used to avoid or minimize the potential impact of hazardous material spills during construction. The Project would be monitored through a fiber optic cable control system, which would alert operations personnel to any potential leaks. Additionally, communications equipment would be installed allowing valves to be operated remotely to minimize any potential impacts of a spill. Expected actuator locations include both sides of the Lake Sakakawea crossing; however, additional locations are pending consultation with the PHMSA.

6.5 FLOWING SURFACE WATERS

During construction of the Project, the SWPPP and BMPs will be implemented to minimize storm water transport of sediment from disturbed areas to streams and wetlands. All Project-related storm water and hydrostatic test water discharges will be in compliance with a National Pollutant Discharge Elimination System (NPDES) permit. Persons familiar with wetland and riparian identification will post signs at the edges of the wetland/waterbody features prior to construction. No aboveground facilities or staging areas will be constructed within wetland, riparian areas, or other waters of the U.S. Additional temporary workspace will be located a minimum of 50 feet outside wetland boundaries. BMPs will be utilized at all wetland and waterbody crossings to minimize sedimentation. For areas where additional setbacks are deemed necessary to protect the resource, the applicability of the appropriate setback will be determined in consultation with agencies on a site-specific basis.

The surface water resources in the Project area would be managed and protected according to existing federal laws and policies regarding the use, storage, and disposal of the resource during the construction and operation of the Project. Surface water resource use and protection is administered under the following federal laws:

- Clean Water Act of 1972 (CWA), as amended (33 U.S.C. 1251 et seq.);
- Federal Land Policy and Management Act of 1976 (43 U.S.C. 1711–1712);
- NEPA (42 U.S.C. 4321); and
- Safe Drinking Water Act of 1974, as amended (42 U.S.C. 300 et seq.).

Water quality is protected under the Federal Water Pollution Control Act (as amended), otherwise known as the CWA. The CWA has developed rules for regulating discharges of pollutants into waters of the U.S. and also regulates water quality standards for surface waters. The CWA also has made it unlawful to discharge any pollutant from a point source into any navigable waters of the U.S., unless a permit has been obtained from the NPDES program.

The Project would be designed and constructed so it would not impede the flow of any waterway. Pipeline crossings would be scheduled at times when there is as little rainfall as possible to minimize the risks of debris, stockpiled soil, and other sources of sediment from being washed into water bodies or wetlands. Temporary erosion and sediment control BMPs would be installed across the entire width of the construction ROW, upslope of and on both sides of each waterbody crossing, after clearing, and before ground surface disturbance. No silt-laden/turbid discharge water from trench dewatering operations would be allowed to enter any waterbody or wetland. The pipeline would be installed below the bed of the waterway, at a level so the channel bed gradient does not change.

6.6 WETLANDS/RESERVOIRS/LAKES

On-the-ground wetland and waterbody delineations were conducted in October 2012, and in May and July 2013, within a 200-foot-wide survey corridor centered along the Project route. Subsequent wetland and waterbody delineations were conducted in October 2013; and in August and October 2014 within a 200-foot-wide survey corridor centered along segments of the Project route that were realigned. In total, the following wetland and waterbody features were identified along the Project route: 20 palustrine emergent wetland complexes (totaling 6.74 acres), and 2 intermittent waterbody crossings (Stantec 2014). The associated Natural Resources Report (Stantec 2014) summarizes the scope of work, methodology, and survey results including figures, data forms, and photographs of the aforementioned features. Fifteen wetlands are anticipated to be temporarily affected by the proposed Project.

The pipeline would be routed to avoid most wetland crossings. Wetlands that cannot be avoided would be crossed using open cut methods and mitigation measures. Standard wetland construction mitigation measures would include reducing construction ROW to 50 feet and limiting equipment working in wetlands to that essential for clearing the ROW, excavating the trench, fabricating and installing the pipeline, backfilling the trench, and restoring the ROW. In areas where access to the ROW is only available through the wetland area, non-essential equipment would be allowed to travel through wetlands only if the ground is firm enough, or has been stabilized, to avoid rutting. If rutting is anticipated, non-essential equipment would be allowed to travel through the wetlands only once, and essential equipment would need to be stabilized with prefabricated mats or terra mats. Areas that would be disturbed by excavation, grading, and construction traffic may increase sedimentation into a wetland area. Reasonable efforts would be employed to limit any sediment movement within the Project area. Following completion of pipeline installation, it is anticipated that there would be no additional impacts on wetlands or water quality. Permanent impacts are not anticipated.

Industry BMPs would be used during construction to avoid contamination of wetlands, reservoirs, and lakes from fuel spills. These include:

- Utilizing a 100-foot setback distance between wetlands and hazardous materials storage areas (e.g., fueling areas, overnight vehicle storage);
- Use of appropriate secondary containment structures around hazardous materials storage areas; and
- Ensuring construction crews have appropriate spill response materials and training to respond to spills and contamination.

Erosion and sediment control BMPs would be used during construction, operation, and maintenance of the pipeline to protect topsoil and minimize soil erosion into adjacent wetlands. Vegetation clearing would be limited to trees and shrubs, and excavation would be limited to the pipeline trench only. During clearing activities, sediment barriers would be installed and maintained adjacent to wetland areas and within temporary extra workspaces, as necessary, to minimize the potential for sediment runoff.

A qualified wetland specialist will mark the boundary of all wetlands and waterbodies within the construction ROW no more than 5 days before the commencement of construction activities. The wetland specialist will use either pink wetland delineation tape or pin flags to demarcate these boundaries. No construction activities will occur within the demarcated wetland or waterbody boundaries.

Two intermittent waterbody crossings were identified during the field survey. Each intermittent and perennial waterbody is considered to be jurisdictional due to the presence of an ordinary high water mark. No hydrophytic vegetation was noted within the delineated streams. Hess is proposing to use an open-cut crossing method for installing the pipeline through perennial and intermittent streams. If it is flowing, Hess will flume the stream crossing to allow water to flow continuously during construction to eliminate the impoundment of each stream.

7.0 Hess Pipeline Safety Program

Pipelines are one of the safest forms of crude oil transportation and provide a cost-effective and safe mode of transportation for oil on land. Overland transportation of oil by truck or rail produces higher risk of injury to the general public than the proposed pipeline (USDOT 2002). The Project will be designed, constructed, and maintained in a manner that meets or exceeds industry standards.

Safeguards have been implemented during design and will be implemented during construction and operations of the pipeline. Historically, one of the most significant risks associated with operating a crude oil pipeline is the potential for third-party excavation damage. To minimize the risk of third-party damage, the pipeline will be built within an approved ROW and markers will be installed at all road, railway, and water crossings.

The entire length of the three product pipelines would be hydrostatically tested per USDOT regulations at 49 CFR 195 and 192 before being placed into service. The existing pipes to be used to convey crude oil, natural gas, and NGL across Lake Sakakawea will be hydrostatically tested and Hess plans to dispose of all hydrostatic test water via a contracted trucking company, which will haul the water to a wastewater treatment facility for treatment prior to being discharged.

Per federal regulations, Hess would have a maintenance, inspection, and repair program that ensures the integrity of the pipeline during operations. Hess's pipeline maintenance program would be designed to maintain the safe and reliable operation of the pipeline. Data collected during maintenance would be fed back into the decision-making process for the development of the ongoing maintenance program.

Hess also would mitigate third-party excavation risk by implementing comprehensive Public Awareness and Damage Prevention programs focused on education and awareness in accordance with 49 CFR 195.440 and API Recommended Practice 1162. Further, Hess would complete regular visual inspections (ground or aerial) of the ROW as per 49 CFR 195.412 and monitor activity in the area to prevent unauthorized trespass or access.

To mitigate the effects of corrosion on the pipeline, Hess would apply a FBE or other type of protective pipeline coating to the external surface of the pipe to prevent corrosion. A cathodic protection system would be installed, comprised of engineered metal alloys or anodes, which would be connected to the pipeline. A low voltage direct current would be applied to the pipeline; the process corrodes the anodes rather than the pipeline. During operations, the pipeline would be routinely cleaned. The pipeline would be inspected with a smart in-line inspection tool, which measures and records internal and external metal loss, thereby allowing Hess the ability to proactively detect corrosion.

In addition, the pipeline would be monitored 24 hours a day, 365 days a year from the OCC using a sophisticated SCADA system. Hess would implement multiple leak detection methods and systems that are overlapping in nature and progress through a series of leak detection thresholds. The leak detection methods are as follows:

- Remote monitoring performed by the OCC operator, which would consist of monitoring pressure and flow data received from pump stations and valve sites fed back to the OCC by the Hess SCADA system. Remote monitoring typically is able to detect leaks down to approximately 25 to 30 percent of the pipeline flow rate.
- Software-based volume balance systems that would monitor receipt and delivery volumes. These systems typically are able to detect leaks down to approximately 5 percent of the pipeline flow rate.
- CPM or model-based leak detection systems that would break the pipeline into smaller segments and monitor each of these segments on a mass balance basis. These systems typically are capable of detecting leaks down to a level of approximately 1.5 to 2 percent of pipeline flow rate.
- ATMOS Wave, a system that gathers all of the pressure data collected and sends it back to the central SCADA system for detailed filtering and analysis. ATMOS Wave uses pressure data to examine all aspects of a potential negative pressure wave front and its propagation through the pipeline to 3-dimensionally map time, distance, and wave intensity. This allows the system to accurately detect true leak events from the pressure changes caused by transient operation. If a leak occurs, the system generates an alarm within 2 to 5 minutes and allows location of the leak within 1 to 2 percent of the distance between pressure sensors (ATMOS Wave 2012).
- Computer-based, non-real time accumulated gain/loss volume trending that would assist in identifying low rate or seepage releases below the 1.5 to 2 percent by volume detection thresholds.
- Direct observation methods, which include aerial patrols, ground patrols, and public and landowner awareness programs that would be designed to encourage and facilitate the reporting of suspected leaks and events that may suggest a threat to the integrity of the pipeline.

The leak detection system would be configured in a manner capable of alarming the OCC operators through the SCADA system and also would provide the OCC operators with a comprehensive assortment of display screens for incident analysis and investigation. In addition, there would be a redundant, stand-by OCC to be used in case of emergency.

The Project will be located a minimum distance of 500 feet from residences to minimize hazard to human health and safety. Also, isolation valves will be installed along the pipeline in accordance with federal regulations to isolate the pipeline during a leak to minimize the release. Equipment will be maintained on-site to contain, capture, and clean up any accidental release of harmful chemicals, pollutants, or other materials into the environment. Spills will be cleaned up immediately and spills on water will be removed by vacuum pumping. Land spills shall be cleaned up using an absorbent material and the contaminated material either drummed in marked 55-gallon drums or hauled to an authorized disposal area.

7.1 EMERGENCY RESPONSE

After contracts are awarded, a Project Safety Plan and Procedures document would be developed with the Contractor. All work would be conducted in compliance with the Safety Plan and Procedures. A copy of the Safety Plan would be maintained on site at all times during work. During construction planning, emergency egress and nearest urgent care facilities would be identified and used in the Safety Plan.

The Contractor would provide an emergency conveyance vehicle (a Suburban equivalent) for transportation of an injured worker. At a minimum, this vehicle would be equipped with stretcher/cot and basic first aid supplies. Hess would require the construction crew involved in a serious or critical incident injury to worker(s) and crews with similar work operations to stand down from work until an investigation is completed and mitigations put in place to minimize the risk of the incident occurring again.

Lastly, Hess would have an ERP in place to respond to incidents. The ERP would contain comprehensive manuals, detailed training plans, equipment requirements, resources plans, auditing, change management and continuous improvement processes. The Integrity Management Program (49 CFR 195) and ERP would ensure Hess operates the pipeline in an environmentally responsible manner.

8.0 Summary

This conservative analysis of the proposed Project shows that the predicted frequency of incidents is very low, the probability of a large spill occurring is very low, and, consequently, risk of environmental impacts is minimal. Compliance with regulations, application of Hess's IMPs and ERP, as well as adherence to federal safety regulations would help to ensure long-term environmentally responsible and safe operation of the Project.

9.0 References

ATMOS Wave Pipeline Leak Detection and Location Software. October 2012.

Australian Maritime Safety Authority. 2013. The effects of maritime oil spills on wildlife including non-avian marine life. Australian Government Internet website: http://www.amsa.gov.au/environment/maritime-environmental-emergencies/national-plan/General-Information/oiled-wildlife/marine-life/index.asp

Bryce, S. A., J. M. Omernik, D. E. Pater, M. Ulmer, J. Schaar, J. Freeouf, R. Johnson, P. Kuck, and S. H. Azevedo. 1998. Ecoregions of North Dakota and South Dakota (map poster). U.S. Geological Survey, Reston, Virginia. Scale 1:1,500,000.

Center for Disease Control. 2011. National Center for Health Statistics for 2011. Online data summary. Internet website: http:// www.cdc.gov/nchs/data/databriefs/db115.htm

Charbeneau, R. J. 2003. Models for Design of Free-Product Recovery Systems for Petroleum Hydrocarbon Liquids. American Petroleum Institute, Publication 4729. Washington, D.C. August 2003.

Charbeneau, R. J., R. T. Johns, L. W. Lake, and M. McAdams. 2000. Free-product recovery of petroleum liquid hydrocarbon liquids. Ground Water Monitoring and Remediation 20(3):147-158. Summer 2000.

Couch, J. A. and J. C. Harshbarger. 1985. Effects of carcinogenic agents on aquatic animals: an environmental and experimental overview. J. Environ. Sci. Health, Part C, Environ. Carcin. Rev. 3:63-105.

Croft, M. G. 1985. Ground-water resources of McKenzie County, North Dakota: North Dakota Geological Survey, Bulletin 80, North Dakota State Water Commission, County Groundwater Studies 37, Part III, 57 p.

Dickins, D. 2011. Behavior of Oil Spills in Ice and Implications for Arctic Spill Response. Offshore Technology Conference.

Fetter, C. W. 1993. Applied Hydrology, Second Edition. Merrill Publishing Company, Columbus, Ohio. 458 pp.

Freeze, R. A. and J. A. Cherry. 1979. Groundwater. Prentice Hall, Inc. Englewood Cliffs, New Jersey/ 604 pp.

Kamath, R., J. A. Connor, T. E. McHugh, A. Nemir, M. P. Le, and A. J. Ryan. In press. Use of long-term monitoring data to evaluate benzene, MTBE and TBA plume behavior in groundwater at retail gasoline sites. Accepted by Journal of Environmental Engineering.

Kiefner, J. F. and C. J. Trench. 2001. Oil Pipeline Characteristics and Risk Factors: Illustrations from the Decade of Construction. American Petroleum Institute.

Kerr, J. M., H. R. Melton, S. J. McMillen, R. I. Magaw, and G. Naughton. 1999. Polyaromatic hydrocarbon content of crude oils around the world. In: SPE/EPS Exploration and Production Environmental Conference, SPE 52724 as cited in O'Reilly et al. 2001.

Lawrence, J. F. and D. F. Weber. 1984. Determination of polycyclic aromatic hydrocarbons in some Canadian commercial fish, shellfish, and meat products by liquid chromatography with confirmation by capillary gas chromatography with fluorescence detection. J. Agric. Food Chem. 32:794-797.

Minnesota Pollution Control Agency. 2005. Assessment of Natural Attenuation at Petroleum Release Sites. Guidance Document c-prp4-03, Petroleum Remediation Program, Minnesota Pollution Control Agency. April 2005. 11pp.

Muhlbauer, W.K. 2004. "Risk: Theory and Application." *Pipeline Risk Management Manual.* 3rd ed. Burlington, MA. Gulf Professional Publishing.

Muller, H. 1987. Hydrocarbons in the freshwater environment. A Literature Review. Arch. Hydrobiol. Beih. Ergebn. Limnol 24:1-69.

Neff, J. M. 1979. Polycyclic aromatic hydrocarbons in the aquatic environment. Applied Science publ. Ltd., London. 262 pp.

Neff, J. M. and J. W. Anderson. 1981. Response of Marine Animals to Petroleum and Specific Hydrocarbons. Applied Science Publishers, London. 177 pp.

Newell, C. J. and J. A. Connor. 1998. Characteristics of Dissolved Petroleum Hydrocarbon Plumes: Results from Four Studies. American Petroleum Institute Soil/Groundwater Technical Task Force. December 1998.

North Dakota Department of Health. 2006. UST Information: Cleanup Action Levels for Gasoline and Other Petroleum Hydrocarbons. Division of Waste Management – Underground Storage Tank Program. Internet website: www.ndhealth.gov/wm.

North Dakota Game and Fish Department (NDGFD). 2014. Wildlife Management Area Guide. Internet website: gf.nd.gov/hunting/wildlife.html. Accessed February 10, 2014.

Pipeline and Hazardous Materials Safety Administration (PHMSA). 2014. Significant Pipeline Incidents. http://primis.phmsa.dot.gov/comm/reports/safety/sigpsi.html.

_____. 2013. (Page 4.1)

_____. 2008. PHMSA Pipeline Incident Statistics January 2002 to Dec 2009. Internet website: http://primis.phmsa.dot.gov/comm/reports/safety/PSI.html.

Ruiz-Aguilar, G.M.L., K. O'Reilly, and P.J.J. Alvarez. 2003. A comparison of benzene and toluene plume lengths for sites contaminated with regular vs. ethanol-amended gasoline. Ground Water Monitor. Remed. 23(1):4853.

SGS. 2013. Certificate of Analysis: DP13-07032.003.

Sharp, B. 1990. Black oystercatchers in Prince William Sound: oil spill effects on reproduction and behavior in 1989. Exxon Valdez Trustees' Study-Bird Study Number 12. US Fish and Wildlife Service, Portland, Oregon.

Shih, T., Y. Rong, T. Harmon, and M. Suffet. 2004. Evaluation of the impact of fuel hydrocarbons and oxygenates on groundwater resources. Environment Science and Technology 38(1):42–48.

Shiu, W. Y. A. Maijanen, A. L. Y. Ng, and D. Mackay. 1988. Preparation of aqueous solutions of sparingly soluble organic substances: II. Multicomponent systems – hydrocarbon mixtures and petroleum products. Environ. Toxicol. Chem. 7:125-137.

Spence, L. R., K. T. O'Reilly, R. I. Maagaw, and W. G. Rixey. 2001. Chapter 6 - Predicting the fate and transport of hydrocarbons in soil and groundwater. in: risk-based decision-making or assessing petroleum impacts at exploration and production sites. Edited by S McMillen, R. Magaw, R. Carovillano, Petroleum Environmental Research Forum and US Department of Energy.

Stantec Consulting Services Inc. (Stantec). 2014. Natural Resources Report. Hess Hawkeye Pipeline System Project, Williams and McKenzie Counties, North Dakota. Prepared for Hess Corporation. November 2014.

Stubblefield, W. A., G. A. Hancock, W. H. Ford, H. H. Prince, and R. K. Ringer. 1995. Evaluation of toxic properties of naturally weathered Exxon Valdez crude oil to surrogate wildlife species. Pp. 665 692. In: P. G. Wells, H. N. Butler, and J. S. Hughes (eds.). Exxon Valdez Oil Spill: Fate and Effects in Alaskan Waters, ASTM STP 1219. American Society for Testing and Materials, Philadelphia, Pennsylvania.

United States Army Corps of Engineers (USACE). 2012. Garrison and Lake Sakakawea. Omaha District. Internet website: http://www.nwo.usace.army.mil/Missions/DamandLakeProjects/MissouriRiverDams/Garrison.aspx.

_____. 2007. Garrison Dam/Lake Sakakawea Master Plan with Integrated Programmatic Environmental Assessment: Missouri River, North Dakota: Update of Design Memorandum MGR-107D. Omaha District. 817 pp.

United States Census Bureau. 2010. 2010 Interactive Population Map. Internet website: http://www.census.gov/2010census/popmap/

_____. 2000. Census 2000 Gateway. Internet website: http://www.census.gov/main/www/cen2000.html.

United States Department of Transportation (USDOT). 2002. Office of Pipeline Safety Pipeline Statistics. Internet website: http://ops.dot.gov/stats/stats.htm.

United States Environmental Protection Agency (USEPA. 2013. Natural gas. Internet website: http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html. Accessed April 30, 2013.

_____. 2001. ECOTOX database. Internet database for aquatic and terrestrial toxicity data. http://www.epa.gov/ecotox/2000. AQUIRE ECOTOX database. Internet database for aquatic toxicity data. http://www.epa.gov/ ecotox/.

_____. 2000. (Page 5.15)

United States Fish and Wildlife Service (USFWS). 2014. (Page 5.25)

United States Geological Survey (USGS). 2012. Contemporary Land Coverage Change in the Northwestern Great Plains Ecoregion. Internet website: http://landcovertrends.usgs.gov/gp/eco43Report.html

_____. 1998. Groundwater Contamination by Crude Oil near Bemidji, Minnesota. US Geological Survey Fact Sheet 084-98, September 1998.

West, W. R., P. A. Smith, P. W. Stoker, G. M. Booth, T. Smith-Oliver, B. E. Butterworth, and M. L. Lee. 1984. Analysis and genotoxicity of a PAC-polluted river sediment. Pages 1395-1411 In: M. Cooke and A. J. Dennis (eds.). Polynuclear aromatic hydrocarbons: mechanisms, methods, and metabolism. Battelle Press, Columbus, Ohio.

Attachment A

Lake Sakakawea Site-specific Risk Assessment

CONFIDENTIAL DATA

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