Attachment D

Pipeline Risk Assessment and Environmental Consequence Analysis (Montana)





Keystone XL Project
Pipeline Risk Assessment and Environmental Consequence Analysis for Montana

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1.0 Project Overview

TransCanada Keystone Pipeline, L.P. (Keystone) is proposing to construct and operate a crude oil pipeline and related facilities from Hardisty, Alberta, Canada, to the Port Arthur and east Houston areas of Texas in the United States (US). The project, known as the Keystone XL Project (Project), will have a nominal capacity to deliver up to 900,000 barrels per day (bpd) of crude oil from an oil supply hub near Hardisty to existing terminals in Nederland near Port Arthur and the Houston Ship Channel in Houston, Texas. The project will consist of three new pipeline segments plus additional pumping capacity on the Cushing Extension Segment of the Keystone Pipeline Project (Keystone Cushing Extension). The Steele City Segment of the Project extends from Hardisty, Alberta southeast to Steele City, Nebraska. The Gulf Coast Segment extends from Cushing, Oklahoma south to Nederland, Texas. The Houston Lateral extends from the Gulf Coast Segment, in Liberty County, Texas southwest to Moore Junction, Harris County, Texas (**Figure 1.1-1**). In total, the Project will consist of approximately 1,702 miles of new, 36-inch-diameter pipeline, consisting of about 327 miles in Canada and 1,375 miles within the US. It will interconnect with the northern and southern termini of the previously approved 298-mile-long, 36-inch-diameter Keystone Cushing Extension. The Project is planned to be placed into service in phases. The Gulf Coast Segment and the Houston Lateral are planned to be in service in 2011 and the Steele City Segment is planned to be in service in 2012.

Figure 1.1-1 Keystone XL Project Route

1.1 Federal and Montana Permitting Processes

The Project will require the issuance of a Presidential Permit by the U.S. Department of State (DOS) to cross the US/Canada border. The proposed route also crosses federal lands managed by the Bureau of Land Management (BLM) that will require the issuance of a ROW grant. The issuance of the Presidential Permit and a ROW grant 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 § 4321 et seq.). The DOS has been designated as the lead federal agency for NEPA compliance, with the BLM participating as a cooperating agency.

In Montana the Project requires a certificate under the Montana Major Facilities Siting Act (MFSA), which includes environmental review under the Montana Environmental Policy Act (MEPA). The Montana Department of Environmental Quality has indicated that it will also use the NEPA review document and process to satisfy its environmental review requirement under MEPA.

Keystone is submitting a MFSA application to the MDEQ, which includes an objective disclosure of beneficial and adverse environmental impacts resulting from the Project, as well as a set of reasonable alternatives. This risk assessment supplements the information in the MFSA application, disclosing potential environmental consequences that might occur in the unlikely event of a crude oil release from the Project.

2.0 Introduction

This report represents Keystone's evaluation of the risk of a pipeline disruption and its potential environmental consequences to support the MEPA process. This report focuses on the potential for spills during operations and the subsequent potential effects on sensitive resources and humans associated with major spills. 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 Project's MFSA Application.

The purpose of this report is threefold. First, the report presents an assessment of potential effects resulting from the operation of the US portion of the Project that is sufficient for the purposes of MEPA. Second, the report provides a preliminary evaluation of potential risk for use during the pipeline's design phase, to facilitate the early selection of possible valve locations. Third, this report provides Keystone an initial basis for the development of emergency response planning and eventual incorporation of the Project into TransCanada's Integrity Management Program. Given these objectives, the analysis summarized within this report is intentionally conservative (i.e., overestimates risk). Keystone's expectation is that the spill frequencies and volumes 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 as well as allowing Keystone to prepare for the worst-case scenarios in its emergency response preparations.

This report presents the results of a pipeline incident frequency and spill volume analysis based on Keystone's design and operations criteria and applies the resulting risk probabilities to an environmental consequence analysis that incorporates project-specific environmental data. Specifically, this report evaluates the risk of crude oil spills during pipeline operations, including contribution of natural hazards to spill risk, and the subsequent potential effects on humans and other sensitive resources, particularly high consequence areas (HCAs), that include designated populated areas, drinking water areas, and/or ecologically sensitive areas.

3.0 Incident Frequency-Spill Volume Study

Keystone conducted a project-specific incident[1] frequency and spill volume analysis for the US portion of the Project. The analysis conservatively estimated the frequency and volume of releases for five distinct and independent failure causes. The study quantitatively assessed spill potential for the entire pipeline utilizing publicly available historical incident data collected from Pipeline and Hazardous Materials Safety Administration (PHMSA) incident reports.

3.1 Incident Frequency

Incident frequencies were estimated from publicly available historical data (PHMSA 2008) and modified by segment-specific adjustment factors for the Project. Based on the available information, the study produced a conservative incident frequency of 0.000119 incidents per mile per year, equivalent to no more than one spill in 30 years for the 282 miles of the Project in Montana. For any 1-mile segment, this probability is equivalent to 1 spill every 8,400 years.

While future events cannot be known with absolute certainty, incident frequencies can be used to estimate the number of events that might occur over a period of time. Actual frequency may differ from the predicted values of this analysis and Keystone believes that the actual number of incidents will be substantially lower than estimated for this report. In this regard, it should be noted that the number of spills on crude oil pipelines has substantially declined in recent years with the implementation of US Department of Transportation's (USDOT) Integrity Management Rule.

3.2 Spill Volume

For this analysis, maximum spill volumes were determined for a complete rupture of the Keystone XL pipeline, accounting for maximum throughput, time to isolate the leak (detection and system shutdown), and subsequent draindown from the affected pipeline segment. While Keystone has reported maximum spill volumes, actual incident data from the *Hazardous Liquid Pipeline Risk Assessment* (California State Fire Marshal 1993) indicate that spill volumes are significantly less than the maximum potential draindown volume. For example, in 50 percent of the cases, the actual spill volume represented less than 0.75 percent of the maximum potential draindown volume. In 75 percent of the cases, the actual spill volume represented less than 4.6 percent of the maximum draindown volume. Procedures to reduce spill volume, by reducing draindown and depressurizing, are not estimated or included in the analysis. If these procedures were included, they most likely would significantly reduce the predicted maximum spill volumes estimated for the Project, if a spill were to occur.

PHMSA's incident database (2008) demonstrates that Keystone's maximum spill volumes are highly conservative (i.e., overstate risk). Examination of the current PHMSA dataset (2002 to present) indicates that the vast majority of actual pipeline spills are relatively small, with 50 percent of the spills consisting of 3.0 barrels or less. In 85 percent of the cases, the spill volume was 100 barrels or less, and in over 95 percent of cases spill volumes were less than 1,000 barrels. Oil spills of 10,000 barrels or greater only occurred in 0.5 percent of cases. These data demonstrate that most pipeline spills are small and very large releases of 10,000 barrels or more are extremely uncommon.

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[1] An "incident" refers to a variety of abnormal pipeline events that are reportable to the PHMSA, including the release of oil greater than 5 gallons; a release resulting in an explosion or fire; and accident resulting in human injuries requiring hospitalization; fatality; or property damage (including operator costs, such as product loss, emergency response, and cleanup costs) in excess of $50,000.

Of the postulated maximum of one spill along the Project in Montana during a 30-year period, these PHMSA-derived spill volume statistics suggest that this one spill would have a 50 percent probability of being 3 barrels or less; 35 percent probability of being between 3 and 100 barrels; 10 percent probability of being between 100 and 1,000 barrels; 5 percent probability of being between 1,000 and 10,000 barrels; and a 0.5 percent probability of being more than 10,000 barrels[2].

[2] A barrel of oil equals 42 gallons.

4.0 Consequences of a Spill

4.1 Human Consequences

The risk associated with the operation of the Project can be compared with the general risks encountered in everyday life. Proposed actions that result in negligible additional risk from any cause are generally considered acceptable. The National Center for Health Statistics (Center for Disease Control 2003) overall average annual death rate for the general population in the US is approximately 830 per 100,000. The USDOT reports the historical average risk to the general population per year associated with all hazardous liquids transmission pipelines, such as the Project, is 0.004 in 100,000 (USDOT 2002). Therefore, the predicted risk of fatality to the public from incidents associated with the Project over and above the normal US death rate is negligible.

4.2 Environmental Consequences

The environmental risk posed by a crude oil pipeline 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 to the receptor. Based on spill probabilities and estimated spill volumes, this environmental assessment determines the probability of exposure to environmental receptors and the probable impacts based on a range of potential concentrations.

4.2.1 Environmental Fate of Crude Oil Spills

4.2.1.1 Crude Oil Composition

The composition of crude oil varies widely, depending on the source and processing. Crude oils are complex mixtures of hundreds of organic (and a few 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.

Crude oil expected to be transported by the Project is derived from the Alberta oil sands region in Canada. The oil extracted from the oil sands is called bitumen, which is highly viscous. In order for the bitumen to be transported by pipeline, it is either mixed with a diluent and is transported as diluted bitumen, or upgraded to synthetic crude oil before transportation. The precise composition of diluted bitumen and synthetic crude will vary by shipper and is considered proprietary information. Diluted bitumen is similar to other crude oils derived from various locations throughout the world, such as portions of California, Venezuela, Nigeria, and Russia. For the purposes of this analysis, transportation of two crude oil types will be assumed: diluted bitumen and synthetic crude. In general, the pipeline will contain segregated batches of these two products.

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., cyclyohexane); aromatics (e.g., benzene, toluene); cycloalkanes; and heavy aromatic hydrocarbons (e.g., polycyclic aromatic hydrocarbons [PAHs], asphaltines). Straight-chained alkanes are more easily degraded in the environment than branched alkanes. Cycloalkanes are extremely resistant to biodegradation. Aromatics (e.g., benzene, toluene, ethylbenzene, and xylenes [BTEX] compounds) pose the most potential for environmental concern. Because of their lower molecular weight, they are more soluble in water than alkanes and cycloalkanes.

4.2.1.2 Environmental Fate and Transport

Environmental processes that govern the fate of a crude oil spill include dispersion, evaporation, dissolution, sorption, photodegradation, and natural attenuation. Once released into the terrestrial environment, the crude oil will pool in low-lying areas. If left unattended, some lighter volatile constituents of the crude oil will evaporate into air over time, while other constituents will bind or leach into soils, or dissolve into water. Hydrocarbons that volatilize into the atmosphere are broken down by sunlight into smaller compounds. This process, referred to as photodegradation, occurs rapidly in air and the rate of photodegradation increases as molecular weight increases. If released onto soil, a portion of the crude oil will penetrate the soil as a result of the effects of gravity and capillary action. The rate of penetration will depend on the nature of the soil. Crude oil adheres to soil particles, limiting the spread of crude oil in soils. If released into water, crude oil will float to the water's surface. If crude oil is left on the water's surface over an extended period of time, some constituents within the oil will evaporate, other fractions will dissolve, and, eventually, some material may descend to the bottom as sedimentation.

Spreading of crude oil across soils is governed by slope, soil permeability, and, to a lesser extent, ambient temperature. Crude oil mobility in water increases with wind, stream velocity, and increasing temperature. Most crude oils spread across surface waters at a rate of 100 to 300 meters per hour. Surface ice will greatly reduce the spreading rate of oil across a waterbody. Spreading reduces the bulk quantity of crude oil present in the immediate vicinity of the spill but increases the spatial area within which adverse effects may occur. Thus crude oil in flowing, as opposed to contained, waterbodies will be less concentrated in any given location, but may cause impacts, albeit reduced in intensity, over a much larger area. Spreading and thinning of spilled crude oil also increases the surface area of the slick, thus enhancing surface dependent fate processes such as evaporation, degradation, and dissolution.

Dispersion of crude oil across water increases with increasing surface turbulence. The dispersion of crude oil into water may serve to increase the surface area of crude oil susceptible to dissolution and degradation processes and thereby limit the potential for physical impacts.

Over time, evaporation is the primary mechanism of loss for low molecular weight constituents and light oil products. As lighter components evaporate, remaining crude oil becomes denser and more viscous. Evaporation thus tends to reduce crude oil toxicity but enhances crude oil persistence. In field trials, bulk evaporation of Alberta 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.

Dissolution of crude oil in water is not a significant process controlling the crude oil's fate in the environment, since most components of oils are relatively insoluble (Neff and Anderson 1981). Moreover, overall solubility of crude oils tend to be less than their constituents 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 oil. Nevertheless, dissolution is one of the primary processes affecting the toxic effects of a spill, 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 crude oil in water.

In water, heavy molecular weight hydrocarbons will bind to suspended particulates, and 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.

Photodegradation of crude oil in terrestrial and aquatic systems increases with greater solar intensity. It can be a significant factor controlling the disappearance of a slick, especially of lighter oil constituents; but it will be less important during cloudy days and winter months. Photodegraded crude oil constituents tend to be more soluble and more toxic than parent compounds. Extensive photodegradation, like dissolution, may thus increase the biological impacts of a spill event.

In the immediate aftermath of a crude oil spill, natural biodegradation of crude oil will not tend to be a significant process controlling the fate of spilled crude oil in environments previously 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.

With time, however, microorganisms capable of consuming crude oil generally increase in number and the biodegradation process naturally remediates the previously contaminated soil. The biodegradation process is enhanced as the surface area of spilled oil increases (e.g., by dispersion or spreading). Biodegradation has been shown to be an effective method of remediating soils and sediments contaminated by crude oil.

Overall, the environmental fate of crude oil is controlled by many confounding factors and persistence is difficult to predict with great accuracy. Major factors affecting the environmental fate include spill volume, type of crude oil, dispersal rate of the crude oil, terrain, receiving media, and weather. Once released, the physical environment largely dictates the environmental persistence of the spilled material. Along the Project route, the primary aquatic habitats of concern include low gradient streams, rivers, and small intermittent ponds. Wetlands also occur along the proposed pipeline route. Estimates of the length of time materials could persist at potentially acute concentrations vary depending on the speed and success of emergency containment and cleanup, the size of spill, and environmental conditions. In warm summer months, the acutely toxic volatile components of crude oil will evaporate quickly, and a relatively small release into a high gradient stream would be expected to rapidly dissipate. In contrast, crude oil released into a small stream in winter could become trapped under pockets of ice and, thus, persist longer.

4.2.2 Environmental Impacts

An evaluation of the potential impacts resulting from the accidental release of crude oil into the environment is discussed by environmental resource below.

4.2.2.1 Soils

Because pipelines are buried, soil absorption of spilled crude oil could occur, thus impacting the soils. Subsurface releases to soil tend to disperse slowly and are generally 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 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 frequently 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 would likely become visible to aerial surveillance due to product on the soils surface or discoloration of nearby vegetation. If present, soil moisture and moisture from precipitation would increase the dispersion and migration of crude oil.

The vast majority of the Project is located in relatively flat or modestly rolling terrain. In these areas, the oil would generally begin dispersing horizontally within the pipeline trench, and with sufficient spill volume or flow, then the oil could move out of the trench onto the soils surface, generally moving towards and breaking the soil surface in low lying areas. If the spill were to occur on a steep slope where trench breakers had been installed during construction, then crude oil would pool primarily within the trench behind any trench breakers. If sufficient volume existed, the crude oil 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.

Both on the surface and in the subsurface, rapid attenuation of light, volatile constituents (due to volatilization) would quickly reduce the total volume of crude oil, 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 would generally 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/hour. Crude oil is more viscous than water, therefore permeability of crude oil would be slower than water.

In accordance with Federal and state regulations, Keystone would be responsible for cleanup of contaminated soils and would be required to meet applicable cleanup levels. In Montana, the soil cleanup level for benzene from petroleum hydrocarbon releases is 0.04 part per million (ppm).

It is difficult to 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).

4.2.2.2 Vegetation and Soil Ecosystems

Crude oil released to the soil's surface could potentially 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 U.S. Environmental Protection Agency (USEPA) ECOTOX database (USEPA 2001) was 18.2 ppm for benzene, higher than the 7.4 ppm threshold for aquatic species and the 0.005 ppm threshold for human drinking water. Similarly, available 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, crude oil in the root zone could harm individual plants and organisms.

Release of crude oil could result in the contamination of soils (see Section 4.2.2.1, Soils, above). Keystone 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.

4.2.2.3 Wildlife

Spilled crude oil can affect organisms directly and indirectly. Direct effects include physical processes, such as oiling of feathers and fur, 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 crude oil spilled, the species assemblage present, climate, and the spill response tactics employed.

Wildlife, especially birds and shoreline mammals, are typically among the most visibly affected organisms in any crude oil spill. Effects of crude oil 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).

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

Potential adverse effects could result from direct acute exposure. 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, and 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, unimpacted 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).

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.

4.2.2.4 Water Resources

Crude oil could be released to water resources if the pipeline is breached or leaks occur. As part of project planning and in recognition of the environmental sensitivity of waterbodies, the Project routing process attempted to minimize the number waterbodies crossed, including groundwater aquifers. Furthermore, valves have been strategically located along the Project route to help reduce the amount of crude oil that could potentially spill into waterbodies, if such an event were to occur. The location of valves, spill containment measures, and implementing actions in the Project Emergency Response Plan would mitigate adverse effects to both surface water and groundwater.

<u>Groundwater</u>

Multiple 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.

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, the PHMSA (in cooperation with the US Geological Service [USGS] and other agencies) has identified groundwater resources that are particularly vulnerable to contamination. These resources are designated by PHMSA as High Consequence Areas (HCAs; Section 4.3.2).

Depending on soil properties, the depth to groundwater, and the amount of crude oil in the unsaturated zone, localized groundwater contamination can result from the presence of free crude oil and the migration of its dissolved constituents. Crude oil is less dense than water and would tend to form a floating pool after reaching the groundwater surface. Movement of crude oil is generally quite limited due to adherence with soil particles, groundwater flow rates, and natural attenuation (i.e., microbial degradation) (Freeze and Cherry 1979; Fetter 1993). 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 constituent typically extends for greater distances than movement of pure crude oil in the subsurface, but is still relatively 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 aerial 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 at historical crude oil release sites indicate the migration of dissolved constituents typically stabilize within several hundred feet of the crude oil source area, depending on groundwater flow velocity and other site-specific hydrogeologic factors (USGS 1998; Charbeneau 2003). 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 crude oil constituents are not water soluble. For those constituents that are water soluble (e.g., benzene) the dissolved concentration is not controlled by the amount of oil in contact with the water, but by the concentration of the specific constituent in the oil (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., maximum contaminant levels [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, then regulatory standards, such as drinking water criteria (MCL) would mandate the scope of remedial actions, timeframe for remediation activities, and cleanup levels. The promulgated drinking water standards for humans vary by several orders of magnitude for crude oil constituents. For human health protection, the national MCL is an enforceable standard established by the USEPA and is designed to protect long-term human health. Of the various crude oil constituents, benzene has the lowest national MCL at 0.005 ppm[3] and, therefore, it was used to evaluate impacts on drinking water supplies, whether from surface water or groundwater.

However, response and remediation efforts have the potential for appreciable adverse effects from construction/cleanup equipment. If no active remediation activities were undertaken, natural biodegradation and attenuation ultimately would allow a return to preexisting conditions in both soil and groundwater.

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[3] Montana also uses the national MCL value of 0.005 ppm.

Depending on the amount of crude oil reaching the groundwater and natural attenuation rates, this would likely require up to tens of years. Keystone will utilize the most appropriate cleanup procedure as determined in cooperation with the applicable federal and state agencies.

Attenuation mechanisms that retard the movement of contaminants include dispersion, sorption, volatilization, abiotic chemical degradation, and biological degradation. The extent to which any of these mechanisms would retard contaminant movement at a given location depends upon site-specific conditions. In general, crude oil in groundwater tends to biodegrade as described for soil releases. Even in the case of large released volumes and floating free crude oil, dispersive forces become balanced with biodegradation and attenuation mechanisms, establishing degradation equilibrium. The typical result is a relatively limited zone of impact, typically 200 meters or less downgradient (USGS 1998). Over time, these natural degradation mechanisms, along with other natural attenuation mechanisms, including dispersion, result in the removal and/or destruction of crude oil materials; both in groundwater, and in overlying impacted soils. Observed degradation rates indicate this process would typically occur in timeframes measured in tens of years, depending on the concentration of crude oil in the groundwater.

<u>Flowing Surface Waters</u>

The PHMSA, in cooperation with various federal and state agencies, has identified surface water resources that are particularly vulnerable to contamination. These surface water resources are designated as HCAs (Section 4.3.2). Broadly, 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 4-1** summarizes the stream categories used for the assessment and identifies several representative streams within these categories.

Table 4-1 Stream Categories

	Streamflow (cubic feet per second; cfs)	Stream Width (feet)	Representative Streams
Low Flow Stream	10 – 100	<50	Many unnamed intermittent tributaries, Bear Creek
Lower Moderate Flow Stream	100 – 1,000	50 – 500	Upper Sevenmile Creek, Lone Tree Creek
Upper Moderate Flow Stream	1,000 – 10,000	500 – 1,000	Yellowstone River
High Flow Stream	>10,000	1,000 – 2,500	Missouri River

The following highly conservative assumptions were used for this analysis: 1) the entire volume of a spill was released directly into a waterbody; 2) complete, instantaneous mixing occurred; and 3) the entire benzene content was solubilized into the water column. While none of these assumptions would naturally occur, these were extremely conservative assumptions designed to over-estimate potential effects for planning purposes. It does not reflect Keystone's expectations of actual effects in the unlikely event of a spill.

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 4-2** and**4-3**). Based on these ultra-conservative assumptions, results suggest that most spills that enter a waterbody could result in exceedence of 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 spill to generic 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 Table 4-1 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 4-1**. The occurrence intervals shown on **Tables 4-2** and **4-3** 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 25,000 years for a large waterbody to over 900,000 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 3 barrels or less based on historical spill volumes.

In summary, while a release of crude oil directly into any given waterbody would likely cause an exceedence of drinking water standards, the frequency of such an event would be extremely low. Nevertheless, streams and rivers with downstream drinking water intakes represent sensitive environmental resources and could be temporarily impacted by a crude oil release. Keystone's Emergency Response Plan contains provisions for protecting and mitigating potential impacts to drinking water.

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 4-4** 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 were generally between 1 and 10 ppm, while LC_{50} values for anthracene were generally less than 1 ppm.

Table 4-4 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 molluscs.

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 toxicity to aquatic biota is relatively low. The toxicity of crude oil is dependent of the toxicity of its constituents. As an example, **Table 4-5** summarizes the toxicity of various crude oil hydrocarbons to the zooplankton, *Daphnia magna*. The relative toxicity of decane is much lower than for benzene or ethylbenzene 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 4-2 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Diluted Bitumen Spill

Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released							
			Very Small Spill: 3 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	**0.652**	**84,513**	**10.9**	**140,855**	**218**	**281,710**	**2175**	**939,033**
Lower Moderate Flow Stream	0.005	100	**0.065**	**59,159**	**1.09**	**98,598**	**21.8**	**197,197**	**218**	**657,323**
Upper Moderate Flow Stream	0.005	1,000	**0.007**	**44,369**	**0.109**	**73,949**	**2.18**	**147,898**	**21.8**	**492,992**
High Flow Stream	0.005	10,000	0.0007	25,354	**0.0109**	**42,256**	**0.218**	**84,513**	**2.18**	**281,710**

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.15 percent by weight benzene content of the transported material.
- 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 0.000119 incident/mile*year, 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 4-3 Comparison of Estimated Benzene Concentrations with the Benzene MCL Resulting from a Synthetic Crude Spill

Streamflow	Benzene MCL (ppm)	Stream Flow Rate (cfs)	Product Released							
			Small spill: 3 barrels		Moderate spill: 50 barrels		Large spill: 1,000 barrels		Very 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	**0.081**	**84,513**	**1.34**	**140,855**	**26.9**	**281,710**	**268.8**	**939,033**
Lower Moderate Flow Stream	0.005	100	**0.008**	**59,159**	**0.134**	**98,598**	**2.69**	**197,197**	**26.9**	**657,323**
Upper Moderate Flow Stream	0.005	1,000	0.0008	44,369	**0.0134**	**73,949**	**0.269**	**147,898**	**2.7**	**492,992**
High Flow Stream	0.005	10,000	0.00008	25,354	0.00134	42,256	**0.0269**	**84,513**	**0.3**	**281,710**

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated concentration is based on release of benzene into water over a 1-hour period with uniform mixing conditions.
- Concentrations are based on a 0.02 percent by weight benzene content of the transported material.
- Shading indicates estimated benzene concentrations that could exceed the MCL of 0.005 ppm.
- Occurrence intervals are based on an overall predicted incident frequency of 0.000119 incident/mile*year, 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 4-4 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 (*Kctalurus*)	---[1]	240	---	---	---
Clarias catfish (*Clarias* sp.)	425	26	---	---	---
Coho salmon (*Oncorhyncus kisutch*)	100	---	---	2.6	---
Fathead minnow (*Pimephales*)	---	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	---	---	---
Mosquitofish (*Gambusia affinis*)	---	1,200	---	150	---
Rainbow trout (*Oncorhyncus mykis)*	7.4	8.9	8.2	3.4	---
Zebrafish (*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	---
Zooplanton *(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 4-5 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
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 (e.g., 48 hours) (USEPA 2000).

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 crude oil 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 drive toxicity associated with potential crude oil spills.

Table 4-6 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 4-6 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 mortality unless denoted with an asterisk (*). The test endpoint for these 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 crude oil 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 2000). These toxicity threshold values are considered protective of acute and chronic effects to aquatic biota. Although trout are not found in many of the habitats crossed by the project, trout are among the most sensitive aquatic species and reliable acute and chronic trout toxicity data are available.

Tables 4-7 through **4-10** summarize the predicted acute and chronic toxicity to aquatic resources. Broadly, acute toxicity could potentially occur if substantial amounts of crude oil 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 could potentially 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 would likely be higher than in the mainstream of the river.

Table 4-7 Comparison of Estimated Benzene Concentrations Following a Diluted Bitumen Spill to the Acute Toxicity Thresholds for Aquatic Life (7.4 ppm) for Streams Crossed by the Project

	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 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	10	7.4	0.7	84,513	**10.9**	**140,855**	**217.5**	**281,710**	**2,175**	**939,033**
Lower Moderate Flow Stream	100	7.4	0.07	59,159	1.1	98,598	**21.7**	**197,197**	**217.5**	**657,323**
Upper Moderate Flow Stream	1,000	7.4	0.007	44,369	0.1	73,949	2.2	147,898	**21.7**	**492,992**
High Flow Stream	10,000	7.4	0.0007	25,354	0.01	42,256	0.2	84,513	2.2	281,710

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated proportion of benzene in the transported material is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of material released divided by 1 hour of stream flow volume. The model assumes uniform mixing conditions.
- Benzene concentrations are compared against the acute toxicity threshold for benzene.
- Shading indicates concentrations that could potentially cause acute toxicity to aquatic species. The darkest shading represents high probability of acute toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of acute toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of acute toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000119 incident/mile*year, 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 4-8 Comparison of Estimated Benzene Concentrations Following a Synthetic Crude Spill to the Acute Toxicity Thresholds for Aquatic Life (7.4 ppm) for Streams Crossed by the Project

	Stream Flow Rate (cfs)	Acute Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 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	10	7.4	0.09	84,513	1.3	140,855	**26.9**	**281,710**	**268.8**	**939,033**
Lower Moderate Flow Stream	100	7.4	0.009	59,159	0.1	98,598	2.7	197,197	**26.9**	**657,323**
Upper Moderate Flow Stream	1,000	7.4	0.0009	44,369	0.01	73,949	0.3	147,898	2.7	492,992
High Flow Stream	10,000	7.4	0.00009	25,354	0.001	42,256	0.03	84,513	0.3	281,710

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated proportion of benzene in the transported material is 0.02 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.02 percent of the total amount of material released divided by 1 hour of stream flow volume. The model assumes uniform mixing conditions.
- Benzene concentrations are compared against the acute toxicity threshold for benzene.
- Shading indicates concentrations that could potentially cause acute toxicity to aquatic species. The darkest shading represents high probability of acute toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of acute toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of acute toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000119 incident/mile*year, 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 4-9 Comparison of Estimated Diluted Bitumen Concentrations Following a Spill to the Chronic Toxicity Thresholds for Aquatic Life for Streams Crossed by the Project

	Stream Flow Rate (cfs)	Chronic Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 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	10	1.4	0.004	84,513	0.06	140,855	1.3	281,710	**12.9**	**939,033**
Lower Moderate Flow Stream	100	1.4	0.0004	59,159	0.006	98,598	0.13	197,197	1.3	657,323
Upper Moderate Flow Stream	1,000	1.4	0.00004	44,369	0.0006	73,949	0.013	147,898	0.13	492,992
High Flow Stream	10,000	1.4	0.000004	25,354	0.00006	42,256	0.0013	84,513	0.013	281,710

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated proportion of benzene in the transported material is 0.15 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.15 percent of the total amount of material released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions.
- The chronic toxicity value for benzene is based on a 7-day toxicity value of 1.4 ppm for trout.
- Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure.
- Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000119 incident/mile*year, 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 4-10 Comparison of Estimated Synthetic Crude Oil Concentrations Following a Spill to the Chronic Toxicity Thresholds for Aquatic Life for Streams Crossed by the Project

	Stream Flow Rate (cfs)	Chronic Toxicity Threshold (ppm)	Product Released							
			Very Small Spill: 3 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	10	1.4	0.0005	84,513	0.008	140,855	0.16	281,710	**1.6**	**939,033**
Lower Moderate Flow Stream	100	1.4	0.00005	59,159	0.0008	98,598	0.02	197,197	0.16	657,323
Upper Moderate Flow Stream	1,000	1.4	0.000005	44,369	0.00008	73,949	0.002	147,898	0.02	492,992
High Flow Stream	10,000	1.4	0.0000005	25,354	0.000008	42,256	0.0002	84,513	0.002	281,710

Notes:

- Historical data indicate that the most probable spill volume would be 3 barrels or less. However, this entire analysis is based on conservative incident frequencies and volumes calculated from worst-case spill volumes, which overestimates the proportion of larger spills. Consequently, the assessment is conservative in its evaluation on the magnitude of environmental consequences.
- Estimated proportion of benzene in the transported material is 0.02 percent, and is assumed to be entirely water solubilized in the event of a spill. The resulting concentration was calculated by multiplying 0.02 percent of the total amount of material released divided by 7 days of stream flow volume. The model assumes uniform mixing conditions.
- The chronic toxicity value for benzene is based on a 7-day toxicity value of 1.4 ppm for trout.
- Exposure concentrations were estimated over a 7-day period since the chronic toxicity value was based on a 7-day exposure.
- Shading indicates concentrations that could potentially cause chronic toxicity to aquatic species. The darkest shading represents high probability of chronic toxicity (>10 times the toxicity threshold); lighter shading represents moderate probability of chronic toxicity (1 to 10 times the toxicity threshold); and unshaded areas represent low probability of chronic toxicity (<toxicity threshold).
- Occurrence intervals are based on an overall predicted incident frequency of 0.000119 incident/mile*year, 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 is low, with an occurrence interval of once every 25,000 to 900,000 years (**Tables 4-7** through **4-10**). If any release did occur, it is likely that the total release volume of a spill likely would be 3 barrels or less based on historical spill volumes.

While a release of crude oil 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 crude oil release.

Wetlands/ Reservoirs/ Lakes

Although planning and routing efforts have reduced the overall number of wetlands and static waterbody environments crossed by the Project, wetlands and waterbodies with persistently saturated soils are present along and adjacent to the Project route. The effects of crude oil released into a wetland environment will 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 dissected 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 are generally low gradient with very slow unidirectional flow or no discernable flow. The presence of vegetation or narrow spits of dry land protruding into wetlands also may isolate parts of the wetland. Given these conditions, spilled materials may remain in restricted areas for longer periods than in river environments.

Crude oil released from a subsurface pipe within a wetland could reach the soil 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. Conversely, groundwater impacts within the 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 would likely require a timeframe on the order of tens of years. Keystone will utilize the most 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, the Project will cross 5.3 miles of wetlands in Montana. Of the estimated maximum of one spill postulated to occur during a 30-year period within Montana, there is a 1.9 percent probability that the spill would occur within wetland areas.

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 4-11 summarizes the amount of water necessary to dilute 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 benchmark for identifying areas of potential concern.

Table 4-11 Amount of Water Required to Dilute Crude Oil Spills Below Threshold Values

Barrels of Crude Oil	Volume of Water Required to Dilute Crude Oil Below Threshold (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)
Diluted Bitumen			
3	0.3	1.5	413
50	4.6	24.3	6,890
1,000	92.0	486.2	136,136
10,000	919.8	4,862.0	1,361,358
Synthetic Crude			
3	0.04	0.2	55
50	0.6	3.0	841
1,000	11.4	60.1	16,826
10,000	113.7	600.9	168,258

[1] Thresholds based on aquatic toxicity and drinking water thresholds established for benzene. The estimated benzene content of the diluted bitumen is 0.15 percent by weight. The synthetic crude oil is estimated to have a benzene content of 0.02 percent by weight.

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, above) also would not affect wetland plant species.

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.

4.3 Risk to Populated and 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, drinking water, and unusually sensitive ecologically resource areas (USAs) that could be damaged by a hazardous liquid pipeline release. **Table 4-12** identifies the types and lengths of HCAs crossed by the Project. Portions of the pipeline that could affect HCAs if a spill occurred (contributory pipeline segments [CPS]) are subject to higher levels of inspection, per 49 Code of Federal Regulations (CFR) Part 195. These data are compiled from a variety of data sources, including federal and state agencies (e.g., state drinking water agencies, the Environmental Protection Agency). The PHMSA acknowledges that spills within a sensitive area might not actually impact the sensitive resource and encourages operators to conduct detailed analysis, as needed. Keystone has conducted an evaluation of HCAs crossed or located downstream of the pipeline. Keystone has identified a total of 4.7 miles of pipeline in Montana (approximately 1.7 percent) that either crosses or has the potential to affect HCAs through downstream transport.

These CPS will be subject to higher levels of inspection, as required by 49 CFR Part 195. Furthermore, Keystone has subsequently evaluated the location of valves as a measure to reduce potential risk to HCAs. As a result of the HCA evaluation, Keystone moved some proposed valve locations and added valves in specific locations to protect HCAs in Montana.

Assuming that one spill occurred along the Project in a 30-year period, it is estimated that there is a 1 percent chance that the spill would occur within an HCA. Although the number of predicted spills in HCAs is very small, the potential impacts of these individual spills are expected to be greater than in other areas due to the environmental sensitivity within these areas. **Table 4-13** also shows the number of spills and their predicted sizes.

Table 4-12 Release and Spill Volume Occurrence Interval Associated with the Project

	Miles of Pipe[1]	Total Number of Predicted Spills	<3 barrels	3 to 50 barrels	50 to 1,000 barrels	1,000 to 10,000 barrels
Populated Areas	1.3	0.00015 (6,500 years)	0.00008 (12,900 years)	0.00005 (18,500 years)	0.00002 (64,600 years)	0.000007 (143,600 years)
Drinking Water Areas	0.9	0.0001 (9,300 years)	0.00005 (18,700 years)	0.00004 (26,700 years)	0.00001 (93,400 years)	0.000005 (207,500 years)
Ecologically Sensitive Areas	3.2	0.0004 (2,600 years)	0.0002 (5,300 years)	0.0001 (7,500 years)	0.00003 (26,300 years)	0.00002 (58,400 years)

[1] The amount of pipe that has the potential to affect an HCA in the unlikely event of a spill. Probability of a spill was based on the conservative incident frequency of 0.000119 incidents per mile per year. These areas overlap; the total length of pipeline that could affect HCAs in Montana is 4.7 miles.

4.3.1 Populated Areas

PHMSA defines populated area HCAs based on US Census data. While there are no populated area HCAs crossed by the Project in Montana (**Table 4-12**), Keystone has identified 1.3 miles of CPS where a crude oil spill from the pipeline could potentially be transported downstream to a populated HCA. CPS locations will be subject to higher levels of inspection, as required by 49 CFR Part 195, in order to reduce the chance of pipeline incident.

4.3.2 Drinking Water

PHMSA identifies certain surface water and groundwater resources as drinking water USAs (49 CFR Part 195.6 and 49 CFR 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. The groundwater USAs have buffers that vary in size. Source water protection areas in Montana are designated by the state and are 0.5 mile in diameter.

In Montana, there are no drinking water HCAs crossed by the Project (**Table 4-12**). Keystone has identified 0.9 mile of CPS where a crude oil spill from the pipeline could potentially be transported downstream to a populated HCA. CPS locations will be subject to higher levels of inspection, as per 49 CFR Part 195, in order to reduce the chance of pipeline incident.

4.3.3 Ecologically Sensitive Areas

Certain ecologically sensitive areas are classified as HCAs by PHMSA due to potential risks to ecologically sensitive resources. These areas focus on the characteristics of rarity, imperilment, or the potential for loss of large segments 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.

An isolated segment (0.4 miles in length) of the Project in Montana crosses an ecologically sensitive HCA (**Table 4-12**). Keystone has identified an additional 2.8 miles of CPS locations that have the potential to affect HCAs. All these areas will be subject to higher levels of inspection, as required by 49 CFR Part 195, in order to reduce the chance of pipeline incident.

4.3.4 Management of Risk Within HCAs

To protect particularly sensitive resources, portions of the pipeline that have the potential to affect an HCA 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. Keystone will develop management and analysis processes that integrate available integrity-related data and information and assess the risks associated with segments that can affect HCAs.

Due to Homeland Security concerns, the precise risk for specific locations of HCAs is highly confidential. Keystone will provide a confidential evaluation of site-specific risk to HCAs for federal agencies' review. As required by federal regulations (Integrity Management Rule, 49 CFR Part 195), the site-specific evaluation of risk is an ongoing process and is regulated by the PHMSA.

Based on Keystone's preliminary assessment of HCAs, some valve locations were moved from their initial locations and additional valves have been added to provide supplemental protection of HCAs, where warranted. In addition, Keystone will develop and implement a risk-based integrity management program (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.

5.0 Keystone's 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.

Historically, the most significant risk associated with operating a crude oil pipeline is the potential for third-party excavation damage. The pipeline will be built within an approved ROW and markers will be installed at all road, railway, and water crossings. The depth of cover required by federal regulations is 30 inches in most locations. In an effort to reduce excavation damage, Keystone has taken the proactive measure to increase the typical depth of cover to 4 feet (18 inches more cover than federal requirements). Keystone also will mitigate third-party excavation risk by implementing a comprehensive Integrated Public Awareness program focused on education and awareness in accordance with 49 CFR Part 195.440 and API RP1162. Further, Keystone's operating staff will complete regular visual inspections of the ROW (at least once every 3 weeks and a minimum of 26 times per year) as per 49 CFR Part 195.412 and monitor activity in the area to prevent unauthorized trespass or access.

Keystone will have a maintenance, inspection, and repair program that ensures the integrity of the pipeline. Keystone's annual Pipeline Maintenance Program (PMP) will be designed to maintain the safe operation of the pipeline. The PMP will include routine aerial patrol of the ROW, periodic inline inspections, and cathodic protection readings underpinned by a company-wide goal to ensure facilities are reliable and in service. Data collected in each year of the program will be fed back into the decision-making process for the development of the following year's program. In addition, the pipeline will be monitored 24 hours a day, 365 days a year from the oil control center using leak detection systems and supervisory control and data acquisition (SCADA). During operations, Keystone will have a Project Emergency Response Program in place to manage a variety of events.

6.0 Conclusion

In 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 Keystone's IMPs and Emergency Response Plan, as well as adherence to safety procedures will help to ensure long-term, environmentally sound, and safe operation of the pipeline.

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8.0 Glossary

Accidental Release

An accidental release is an unplanned occurrence that results in a release of oil from a pipeline.

Acute exposure

Exposure to a chemical or situation for a short period of time.

Acute toxicity

The ability of a substance to cause severe biological harm or death soon after a single exposure or dose.

Adverse effect

Any effect that causes harm to the normal functioning of plants or animals due to exposure to a substance (i.e., a chemical contaminant).

Algae

Chiefly aquatic, eukaryotic one-celled or multicellular plants without true stems, roots and leaves that are typically autotrophic, photosynthetic, and contain chlorophyll. They are food for fish and small aquatic animals.

Aquifer

An underground layer of water-bearing permeable rock, or unconsolidated materials (gravel, sand, silt or clay) from which groundwater can be usefully extracted using a water well.

Barrel

A barrel is a standard measure of a volume of oil and is equal to 42 gallons.

Bioavailability

How easily a plant or animal can absorb a particular contaminant from the environment.

Biodegradation

Biodegradation is the breakdown of organic contaminants by microbial organisms into smaller compounds. The microbial organisms transform the contaminants through metabolic or enzymatic processes. Biodegradation processes vary greatly, but frequently the final product of the degradation is carbon dioxide or methane.

BPD

Abbreviation for barrels per day

Cathodic Protection System

A technique to provide corrosion protection to a metal surface by making the surface of the metal object the cathode of an electrochemical cell. In the pipeline industry that is done using impressed current. Impressed current cathodic protection (ICCP) systems use an anode connected to a DC power source (a cathodic protection rectifier).

Chronic toxicity

The capacity of a substance to cause long-term poisonous health effects in humans, animals, fish, or other organisms. Biological tests use sublethal effects, such as abnormal development, growth, and reproduction, rather than mortality, as endpoints.

Contaminant

Any physical, chemical, biological, or radiological substance found in air, water, soil or biological matter that has a harmful effect on plants or animals; harmful or hazardous matter introduced into the environment.

Ecosystem

The sum of all the living plants and animals, their interactions, and the physical components in a particular area.

Exposure

How a biological system (i.e., ecosystem), plant, or animal comes in contact with a chemical.

Event

An event is a significant occurrence or happening. As applicable to pipeline safety, an event could be an accident, abnormal condition, incident, equipment failure, human failure, or release.

Facility

Any structure, underground or above, used to transmit a product.

Habitat

The place where a population of plants or animals and its surroundings are located, including both living and non-living components.

High Consequence Area (HCA)

A high consequence area is a location that is specially defined in PHMSA pipeline safety regulations as an area where pipeline releases could have greater consequences to health and safety or the environment. For oil pipelines, HCAs include high population areas, other population areas, commercially navigable waterways, and areas unusually sensitive to environmental damage, including certain ecologically sensitive areas and drinking water resources. Regulations require a pipeline operator to take specific steps to ensure the integrity of a pipeline for which a release could affect an HCA and, thereby, provide protection of the HCA.

High Population Area

A high population area is an urbanized area, as defined and delineated by the US Census Bureau, which contains 50,000 or more people and has a population density of at least 1,000 people per square mile. High population areas are considered HCAs.

Incident

As used in pipeline safety regulations, an incident is an event occurring on a pipeline for which the operator must make a report to the Office of Pipeline Safety. There are specific reporting criteria that define an incident that include the volume of the material released, monetary property damage, injuries, and fatalities (Reference 49 CFR 191.3, 49CFR 195.50).

Incident Frequency

Incident frequency is the rate at which failures are observed or are predicted to occur, expressed as events per given timeframe.

Integrity Management Program

An IMP is a documented set of policies, processes, and procedures that are implemented to ensure the integrity of a pipeline. An oil pipeline operator's IMP must comply with the federal regulations (i.e., the Integrity Management Rule, 49 CFR 195).

Integrity Management Rule

The Integrity Management Rule specifies regulations to assess, evaluate, repair, and validate the integrity of hazardous liquid pipelines that, in the event of a leak or failure, could affect HCAs.

Invertebrates

Animals without backbones: e.g., insects, spiders, crayfish, worms, snails, mussels, clams, etc.

LC_{50}

A concentration expected to be lethal to 50 percent of a group of test organisms.

Leak

A leak is a small opening, crack, or hole in a pipeline allowing a release of oil.

Likelihood

Likelihood refers to the probability that something possible may occur. The likelihood may be expressed as a frequency (e.g., events per year), a probability of occurrence during a time interval (e.g., annual probability), or a conditional probability (e.g., probability of occurrence, given that a precursor event has occurred).

Maximum Contaminant Level (MCL)

The maximum level of a contaminant allowed in drinking water by federal or state law and is based on the avoidance of health effects and currently available water treatment methods.

National Pipeline Mapping System (NPMS)

The National Pipeline Mapping System is a GIS database that contains the locations and selected attributes of natural gas transmission lines, hazardous liquid trunklines, and liquefied natural gas (LNG) facilities operating in onshore and offshore territories of the United States.

Operator

An operator is a person who owns or operates pipeline facilities (Reference 49 CFR 195.2).

Polycyclic Aromatic Hydrocarbons (PAHs)

Group of organic chemicals.

Pipeline

Used broadly, pipeline includes all parts of those physical facilities through which gas, hazardous liquid, or carbon dioxide moves in transportation. Pipeline includes but is not limited to: line pipe, valves and other appurtenances attached to the pipe, pumping/compressor units and associated fabricated units, metering, regulating, and delivery stations, and holders and fabricated assemblies located therein, and breakout tanks.

Receptor

The species, population, community, habitat, etc. that may be exposed to contaminants.

Risk

Risk is a measure of both the likelihood that an adverse event could occur and the magnitude of the expected consequences should it occur.

Sediment

The material of the bottom of a body of water (i.e., pond, river, stream, etc.).

Stressor

Any factor that may harm plants or animals; includes chemical (e.g., metals or organic compounds), physical (e.g., extreme temperatures, fire, storms, flooding, and construction/development) and biological (e.g., disease, parasites, depredation, and competition).

Supervisory Control and Data Acquisition System (SCADA)

A SCADA is a pipeline control system designed to gather information such as pipeline pressures and flow rates from remote locations and regularly transmit this information to a central control facility where the data can be monitored and analyzed.

Throughput

The volume of oil through a pipeline during a specified time (e.g., barrels per day).

Toxicity Threshold

Numerical values that represent concentrations of contaminants in abiotic media (sediments, water, soil) or tissues of plants and animals above which those contaminants are expected to cause harm.

Unusually Sensitive Areas (USAs)

USAs refers to certain drinking water and ecological resource areas that are unusually sensitive to environmental damage from a hazardous liquid pipeline release, as defined in 49 CFR 195.6.

Zooplankton

Small, usually microscopic animals (such as protozoans) found in lakes and reservoirs.