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DEPARTMENT OF TRANSPORTATION

Pipeline and Hazardous Materials Safety Administration

[Docket No. PHMSA-2022-0063]

Pipeline Safety: Pipeline Safety: Potential for Damage to Pipeline Facilities Caused by Earth Movement and Other Geological Hazards.

AGENCY: Pipeline and Hazardous Materials Safety Administration (PHMSA), DOT.

ACTION: Notice; issuance of updated advisory bulletin.

SUMMARY: PHMSA is issuing this updated advisory bulletin to remind owners and operators of gas and hazardous liquid pipelines, including supercritical carbon dioxide pipelines, of the potential for damage to those pipeline facilities caused by earth movement in variable, steep, and rugged terrain and terrain with varied or changing subsurface geological conditions. Additionally, changing weather patterns due to climate change, including increased rainfall and higher temperatures, may impact soil stability in areas that have historically been stable. These phenomena can pose a threat to the integrity of pipeline facilities if those threats are not identified and mitigated. Owners and operators should consider monitoring geological and environmental conditions, including changing weather patterns, in proximity to their facilities.

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I. BACKGROUND

The purpose of this updated advisory bulletin is to remind owners and operators of gas and hazardous liquid pipelines, particularly those with facilities located onshore or in inland waters, about the serious safety-related issues that can result from earth movement and other geological hazards. Additionally, changing weather patterns due to climate change may result in heavier than normal rainfall and increased temperatures causing soil saturation and flooding or soil erosion. Either phenomenon may adversely impact the stability of soil surrounding or supporting nearby pipeline facilities. The United States Geological Survey (USGS) is a resource for pipeline owners and operators in evaluating earth movement vulnerabilities of pipeline facilities.

Gas and hazardous liquid pipelines are required to be designed to withstand external loads including those that may be imposed by geological forces. Specifically, gas pipelines must be designed in accordance with 49 CFR 192.103 and hazardous liquid pipelines must be designed in accordance with 49 CFR 195.110. To comply with these regulations, the design of new pipelines, including repairs or replacement, must consider the load that may be imposed by geological forces.

Once operational, § 192.317(a) states that for gas transmission and part 192-regulated gathering pipelines "[t]he operator must take all practicable steps to protect each transmission line or main from washouts, floods, unstable soil, landslides, or other hazards that may cause the pipeline to move or to sustain abnormal loads. In addition, the operator must take all practicable steps to protect offshore pipelines from damage by mud slides, water currents, hurricanes, ship anchors, and fishing operations." This advisory bulletin addresses those protective requirements associated with damage caused by geological factors.

In addition, § 192.705 requires operators of gas transmission lines, and applicable gas gathering lines, to have a patrol program to observe surface conditions on and adjacent to the pipeline right-of-way for indications of leaks, construction activity, and other factors affecting safety and operation. The frequency of these patrols must be based upon the size of the line, operating pressures, class locations, terrain, seasonal weather conditions, and other relevant factors. One of the primary reasons for this patrol requirement is to monitor geological movement, both slowly occurring and acute changes, which may affect the current or future safe operation of the pipeline.

Furthermore, for applicable gas pipelines § 192.613(a) states that "each operator shall have a procedure for continuing surveillance of its facilities to determine and take appropriate action concerning changes in class location, failures, leakage history, corrosion, substantial changes in cathodic protection requirements, and other unusual operating and maintenance conditions." Section 192.613(b) further states that "[i]f a segment of pipeline is determined to be in unsatisfactory condition but no immediate hazard exists, the operator shall initiate a program to recondition or phase out the segment involved, or, if the segment cannot be reconditioned or phased out, reduce the maximum allowable operating pressure in accordance with § 192.619(a) and (b)."

For hazardous liquid pipelines, § 195.401(b)(1) states that "[w]henever an operator discovers any condition that could adversely affect the safe operation of its pipeline system, it must correct the condition within a reasonable time. However, if the condition is of such a nature that it presents an immediate hazard to persons or property, the operator may not operate the affected part of the system until it has corrected the unsafe condition." Section 195.401(b)(2) further states that "[w]hen an operator discovers a condition on a pipeline covered under [the integrity management requirements in] § 195.452, the operator must correct the condition as prescribed in § 195.452(h)." Land movement, soil instability due to saturation, severe flooding, river scour, and river channel migration are the types of conditions that can adversely affect the safe operation of a pipeline and require corrective action under §§ 192.613(a) and 195.401(b). Additional guidance for identifying risk factors and mitigating natural force hazards on pipeline segments that could affect high consequence areas, are outlined in Appendix C, section I, subsection B, to part 195.

PHMSA integrity management regulations require operators to take additional preventative and mitigative measures to prevent, and to mitigate the consequences of, failures on gas transmission lines in high consequence areas (§ 192.935) and hazardous liquid pipelines that are in or which could affect a high consequence area (§ 195.452(i)). An operator must base the additional measures on the threats the operator has identified for each pipeline segment. If an operator determines there is a threat to the pipeline, such as outside force damage (e.g., earth movement or floods), the operator must take steps to prevent a failure and to minimize the consequences of a failure under these regulations.

PHMSA is aware of recent earth movement and other geological-related incidents and accidents and safety-related conditions throughout the country. Some of the more notable events, including those discussed in a prior advisory bulletin (ADB-2019-02; 84 FR 18919, 05/02/2019) are briefly described below:

- On March 11, 2022, a 22-inch hazardous liquid pipeline spilled 3,900 barrels of crude oil adjacent to the Cahokia Creek approximately 15 miles east of St. Louis, Missouri. Preliminary information indicates land movement may have contributed to this failure. The National Transportation Safety Board (NTSB) investigation into the cause continues as of the date of this notice.

- On May 30, 2021, a hazardous liquid pipeline spilled 640 barrels of gasoline in Greens Bayou affecting high consequence areas near Houston, Texas. The operator's reported cause indicated earth movement/progressive ground movement over time on a bayou bank.

- On February 19, 2021, 22,318 one thousand cubic feet[1] (Mcf) of natural gas was released from a Type A gathering pipeline system in Belmont, Ohio. A third-party subject matter expert determined the proximate cause of this incident was land movement, or slip, that exerted force on the pipe causing a circumferential crack in an area where evidence of stress corrosion cracking and general corrosion were found.

[1] Mcf stands for one thousand cubic feet. The "M" is representative of the roman numeral for one thousand.

- On December 23, 2020, 4,450 Mcf natural gas was released from a gas distribution main line in the City of Newport News, Virginia. The operator report indicated that the apparent cause was pipe stress created by ground settlement which caused misalignment of a flange resulting in a pinhole leak on gasket.

- On November 19, 2020, a pipeline spilled 17.50 barrels of crude oil east of I-5 in Kern, California during routine start-up. A metallurgical analysis determined the root cause to be related to external factors (i.e., historical land movement, terrain, and cyclic weather patterns around this pipeline segment). There is a history of land movement in the area, all of which contributed to unintentional bending of the pipeline causing the circumferential cracking found at the leak site.

- On October 4, 2020, an intrastate gas transmission pipeline in Goodrich, Texas released 118,724 Mcf of natural gas below the Trinity River. While no definitive root cause was determined, the operator used the geological, meteorological, site-gathered information and historical data in its computer modeling and identified earth movement of the soil surrounding the pipe as the most plausible cause of the rupture. Circumferential stress corrosion cracking may have been a contributing factor to the failure.

- On May 19, 2020, 447 Mcf was released from a gas distribution main pipeline in Edenville Township, Michigan due to heavy rain fall. An investigation confirmed a 4-

inch steel pipeline was severed when significant flooding in the area caused a road washout/scouring.

- On May 4, 2020, a 30-inch natural gas pipeline ruptured and ignited near Hillsboro, Kentucky. Preliminary information indicates land movement may have contributed to this failure. The NTSB investigation into the cause continues as of the date of this notice.

- On February 22, 2020, a carbon dioxide pipeline failed approximately one mile southeast of Satartia, Mississippi, releasing approximately 30,000 barrels of liquid carbon dioxide that immediately began to vaporize at atmospheric conditions. The pipeline failed on a steep embankment which had subsided adjacent to a local highway. Heavy rains are believed to have triggered a landslide, which created axial strain on the pipeline and resulted in a full circumferential girth weld failure.

- On January 29, 2019, a pipeline ruptured near the town of Lumberport in Harrison County, West Virginia. The rupture was located at a girth weld of an elbow on the 12-inch interstate pipeline. The root cause investigation concluded that a landslide about 150 yards from the rupture moved the pipeline approximately 10 feet from its original location causing excessive stress on the pipe resulting in the rupture.

- On January 21, 2019, a 30-inch natural gas pipeline ruptured and ignited near Summerfield, Ohio. A metallurgical analysis indicates a girth weld failed due to ductile overload from a longitudinal tensile or bending force, likely from land movement.

- On June 7, 2018, a 36-inch pipeline ruptured in a rural, mountainous area near Moundsville, West Virginia, resulting in the release of approximately 165,000 Mcf of natural gas. According to a metallurgical analysis, the rupture was caused by earth movement on the right-of-way due to a single overload event. Overloading of the pipeline likely resulted from a series of lateral displacements with accompanying bending.

- On April 30, 2018, an 8-inch intrastate pipeline failed in a remote mountainous region of Marshall County, West Virginia resulting in the release of 2,658 barrels of propane. The failure was caused by lateral movement of the pipeline due to earth movement along the right-of-way.

- On January 31, 2018, a 24-inch interstate pipeline ruptured near the city of Summerfield, Ohio releasing approximately 23,500 Mcf of natural gas in a rural forested area. A root cause analysis concluded that the girth weld failure was caused by axial stress due to movement of the pipe that exceeded the cross-sectional tensile strength of the net section weld zone surrounding the crack initiation location.

- On January 9, 2018, a 22-inch transmission pipeline failed in Montecito, California. The incident resulted in a fire and explosion and the release of an estimated 12,000 Mcf of natural gas. Heavy rains and localized flooding contributed to the pipe failure.

- On December 5, 2016, approximately 14,400 barrels of crude oil were spilled into an unnamed tributary to Ash Coulee Creek, Ash Coulee Creek itself, the Little Missouri River, and their adjoining shorelines in Billings County, North Dakota. The metallurgical and root cause failure analysis indicated the failure was caused by compressive and bending forces due to a landslide impacting the pipeline. The landslide was the result of excessive moisture within the hillside creating unstable soil conditions.

- On October 21, 2016, a pipeline release of over 1,238 barrels of gasoline spilled into the Loyalsock Creek in Lycoming County, Pennsylvania. The release was caused by extreme localized flooding and soil erosion.

Within its rulemaking entitled "Safety of Gas Transmission Pipelines: Repair Criteria, Integrity Management Improvements, Cathodic Protection, Management of Change, and Other Related Amendments" (RIN 2137-AF39), PHMSA notes that it is considering adopting revisions to § 192.613 that would oblige operators of gas transmission pipelines to conduct inspections on their facilities following an extreme weather event to ensure timely identification and remediation of damage to those facilities. In addition, the Council on Environmental Quality (CEQ) recently issued interim guidance underscoring the importance of the evaluation of, and emergency planning for, geohazards for safe operation of carbon dioxide and other pipeline facilities.[2]

II. Advisory Bulletin (ADB-2022-01)

Advisory: All owners and operators of gas and hazardous liquid pipelines, including supercritical carbon dioxide pipelines, are reminded that earth movement, particularly in variable, steep, and rugged terrain and terrain with varied or changing subsurface geological conditions, can pose a threat to the integrity of a pipeline if those threats are not identified and mitigated. Additionally, changing weather patterns due to climate change may result in heavier than normal rainfall and higher temperatures, resulting in soil saturation and flooding or soil erosion, each of which may adversely impact soil stability surrounding or supporting nearby pipeline facilities.

Pipeline operators should consider taking the following actions to ensure pipeline safety:

1. Identify areas surrounding the pipeline that may be prone to large earth movement, including but not limited to slope instability, subsidence, frost heave, soil settlement, erosion, earthquakes, and other dynamic geologic conditions that may pose a safety risk.

2. Use geotechnical engineers during the design, construction, and ongoing operation of a pipeline system to ensure that sufficient information is available to avoid or minimize the impact of earth movement on the integrity of the pipeline system. At a minimum, operators should

[2] CEQ, "Carbon Capture, Utilization, and Sequestration Guidance," 87 FR 8808, 8810 (Feb. 16, 2022).

consider soil strength characteristics, ground and surface water conditions, propensity for erosion or scour of underlying soils, and the propensity of earthquakes or frost heave.

3. Develop design, construction, and monitoring plans and procedures for each identified location, based on the site-specific hazards identified. When constructing new pipelines, develop and implement procedures for pipe and girth weld designs to increase their effectiveness for taking loads, either stresses or strains, exerted from pipe movement in areas where geological subsurface conditions and movement are a hazard to pipeline integrity.

4. Monitoring plans may include provisions related to the following:

- Ensuring during construction of new pipelines that excavators do not steepen, load (including changing the groundwater levels) or undercut slopes which may cause excessive ground movement during construction or after operations commence.
- Conducting periodic visits and site inspections. Increased patrolling may be necessary due to potential hazards identified and existing/pending weather conditions. Right-of-way patrol staff must be trained on how to detect and report conditions that may lead to or exhibit ground movement to appropriate staff.
- Identifying geodetic monitoring points (i.e., survey benchmarks) to track potential ground movement.
- Installing slope inclinometers to track ground movement at depth which may otherwise not be detectable during right-of-way patrols.

- Installing standpipe piezometers to track changes in groundwater conditions that may affect slope stability.
- Evaluating the accumulation of strain on the pipeline by installing strain gauges.
- Conducting stress/strain analysis utilizing in-line inspection tools equipped with inertia mapping unit technology and high resolution deformation in-line inspection for pipe bending and denting from movement.
- Utilizing aerial mapping light detection and ranging or other technology to track changes in ground conditions.

5. Develop mitigation measures to remediate the identified locations.

6. Monitor environmental conditions and changing weather patterns in proximity to their facilities and evaluate soil stability that may have been adversely impacted.

- The National Oceanic and Atmospheric Administration's National Centers for Environmental Information has excellent information publicly available. For example, see the National Temperature and Precipitation Maps at the National Centers for Environmental Information (https://www.ncdc.noaa.gov/temp-and-precip/us-maps/)

7. Use available data and information resources to assess pipeline facility vulnerability relative to landslides and other types of earth movement.

- The USGS has excellent information publicly available regarding land movement. For example, see the Landslide Hazards Maps at the USGS website (https://www.usgs.gov/programs/landslide-hazards/maps).

8. Consider the findings and recommendations of pertinent research projects, studies, and reports on the impact of changing weather patterns on soil stability.[3] PHMSA also notes that industry and academic materials could be informative regarding relevant considerations and strategies for ensuring pipeline integrity in areas of land movement or soil subsidence.

9. Mitigation measures should be based on site-specific conditions and may include:

- Re-routing the pipeline right-of-way prior to construction to avoid areas prone to large ground movement such as unstable slope areas, earthquake fault zones, permafrost movement, or scour.
- Utilize properly designed horizontal directional drilling to go below areas of potential land movement.
- Installation of drainage measures in the trench to mitigate subsurface flows and enhance surface water draining at the site including streams, creeks, runs, gullies, or other sources of surface run-off that may be contributing surface water to the site or changing groundwater levels that may exacerbate earth movement.

[3] For example, PHMSA has funded the following research and development projects on the impact of soil movement and pipeline monitoring: *Pipeline Integrity Management for Ground Movement Hazards* (https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=202); *Combined Vibration, Ground Movement, and Pipe Current Detector* (https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=655); *Definition of Geotechnical and Operational Load Effects on Pipeline Anomalies* (https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=561); and *Fiber Optic Sensors for Direct Pipeline Monitoring Under Geohazard Conditions* (https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=889).

- Reducing the steepness of potentially unstable slopes, including installing retaining walls, soldier piles, sheet piles, wire mesh systems, mechanically stabilized earth systems and other mechanical structures.
- Installing trench breakers and slope breakers to mitigate trench seepage and divert trench flows along the surface to safe discharge points off the site or right-of-way.
- Building retaining walls and/or installing steel piling or concrete caissons to stabilize steep slope areas as long as the corrosion control systems are not compromised.
- Reducing the loading on the site by removing and/or reducing the excess backfill materials to off-site locations. Soil placement should be carefully planned to avoid triggering earth movement in other locations.
- Compacting backfill materials at the site to increase strength, reduce water infiltration, and achieve optimal moisture content.
- Drying the soil using special additives such as lime-kiln dust or cement-kiln to allow the materials to be re-used and worked at the site. Over-saturated materials may require an extensive amount of time and space to dry.
- Regrading the pipeline right-of-way to minimize scour and erosion.
- Bringing the pipeline above ground and placing it on supports that can accommodate large ground movements (e.g., transitions across earthquake fault zones or unstable slopes, without putting excessive stress or strain on the pipeline).

- Reducing the operating pressure temporarily or shutting-in the affected pipeline segment completely.
- Re-routing the pipeline when other appropriate mitigation measures cannot be effectively implemented to maintain safety.

Pipeline safety regulations require reporting of certain conditions that impair the serviceability of a pipeline, as noted in §§ 191.23 and 195.55.

PHMSA encourages pipeline operators to enhance their preparations and procedures beyond the minimum Federal standards and to address the unique threats, vulnerabilities, and challenges of each individual pipeline facility. Pipeline operators, Federal and state regulators, and the public have a common goal of no damage and no releases from pipeline infrastructure. Working together will better achieve our goal of zero incidents and releases.

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Associate Administrator for Pipeline Safety.