United States Government Accountability Office

Report to Congressional Requesters

July 2021

PIPELINE SAFETY

Information on Keystone Accidents and DOT Oversight

GAO@100
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GAO-21-588

GAO@100 Highlights

Highlights of GAO-21-588, a report to congressional requesters

July 2021

PIPELINE SAFETY

Information on Keystone Accidents and DOT Oversight

Why GAO Did This Study

Since it began operating in 2010, Keystone has transported over 3 billion barrels of crude oil from Canada to refineries in Illinois, Oklahoma, and Texas, according to its operator, TC Energy. Prior to construction, TC Energy requested and obtained a special permit from PHMSA to operate certain portions of the pipeline at a higher stress level than is allowed under PHMSA's regulations. Since TC Energy was the first and remains the only hazardous liquid pipeline operator to request a waiver of this particular regulation, the Keystone special permit is unique.

GAO was asked to review PHMSA's oversight of the Keystone Pipeline. This report discusses: (1) PHMSA's actions to approve the Keystone special permit and allow the pipeline to operate at a higher stress level, (2) how Keystone accidents compare to accidents on all U.S. crude oil pipelines since 2010, and (3) PHMSA's actions in response to Keystone safety issues.

GAO reviewed applicable statutes and regulations, the special permit, and PHMSA enforcement actions. It also analyzed PHMSA's pipeline accident data from 2010 to 2020 to describe Keystone's accidents and compare TC Energy to PHMSA's performance measures. GAO also interviewed TC Energy representatives, PHMSA officials, and 17 stakeholders selected to provide a range of perspectives representing industry associations; pipeline safety and technical stakeholders; and environmental, tribal, and state organizations.

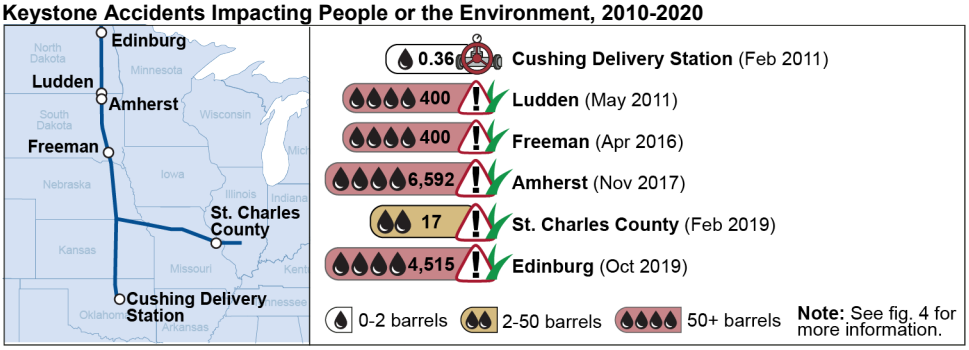
View GAO-21-588. For more information, contact Heather Krause at (202) 512-2834 or KrauseH@gao.gov.

What GAO Found

The Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) required TC Energy to take additional safety measures specified in a special permit as conditions of allowing certain portions of the Keystone Pipeline (Keystone) to operate at a higher stress level than allowed by regulation. PHMSA reviewed technical information and drew on its experience granting similar permits to natural gas pipelines to develop 51 conditions with which TC Energy must comply. Most pipeline safety and technical stakeholders GAO interviewed agreed the conditions offset the risks of operating at a higher stress level. However, PHMSA did not allow TC Energy to fully operate Keystone at this higher stress level until 2017, after TC Energy replaced pipe affected by industry-wide pipeline quality issues.

Keystone's accident history has been similar to other crude oil pipelines since 2010, but the severity of spills has worsened in recent years. Similar to crude oil pipelines nationwide, most of Keystone's 22 accidents from 2010 through 2020 released fewer than 50 barrels of oil and were contained on operator-controlled property such as a pump station. The two largest spills in Keystone's history in 2017 and 2019 were among the six accidents that met PHMSA's criteria for accidents "impacting people or the environment." According to PHMSA's measures for these more severe types of accidents, from 2010 to 2020 TC Energy performed better than nationwide averages, but worse in the past five years due to the 2017 and 2019 spills.

Keystone Accidents Impacting People or the Environment, 2010-2020



Source: PHMSA data and Map Resources. | GAO-21-588

In response to each of Keystone's four largest spills, PHMSA issued Corrective Action Orders requiring TC Energy to investigate the accidents' root causes and take necessary corrective actions. These investigations found that the four accidents were caused by issues related to the original design, manufacturing of the pipe, or construction of the pipeline. PHMSA also issued other enforcement actions and assessed civil penalties to TC Energy for deficiencies found during inspections, such as inadequate corrosion prevention and missing pipeline markers. Based in part on its experience overseeing Keystone, PHMSA officials said they have increased resources to conduct inspections during construction of other pipelines and are establishing a more formal process to document and track the compliance of all special permits, including Keystone's permit.

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Abbreviations

PHMSA	Pipeline and Hazardous Materials Safety Administration
SMYS	specified minimum yield strength

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July 22, 2021

The Honorable Frank Pallone, Jr.
Chairman
Committee on Energy and Commerce
House of Representatives

The Honorable Peter A. DeFazio
Chairman
Committee on Transportation and Infrastructure
House of Representatives

The Honorable Bobby L. Rush
Chairman
Subcommittee on Energy
Committee on Energy and Commerce
House of Representatives

The Honorable Donald M. Payne, Jr.
Chairman
Subcommittee on Railroads, Pipelines, and Hazardous Materials
Committee on Transportation and Infrastructure
House of Representatives

About 84,000 miles of pipelines transported crude oil from production areas to refineries in the United States as of 2020. Although pipelines are relatively safe when compared to transportation alternatives such as truck and rail, pipeline accidents can release large amounts of crude oil into the environment, damaging natural resources and wildlife. Within the U.S. Department of Transportation, the Pipeline and Hazardous Materials Safety Administration (PHMSA) oversees safety for pipelines carrying oil, natural gas, and other products.[1] PHMSA's oversight includes setting and enforcing the federal minimum pipeline safety standards for the construction, operation, maintenance, and inspection of interstate pipelines. Operators may apply for—and PHMSA has the authority to issue—special permits that waive compliance with one or more pipeline

[1]PHMSA's general authority is under the Pipeline Safety Laws codified at 49 U.S.C. § 60101 et seq.

safety regulations if PHMSA determines that the permit is not inconsistent with pipeline safety.[2]

The Keystone pipeline runs 2,687 miles from Canada into the United States and according to the operator has transported over 3 billion barrels of crude oil since it began operating in 2010. The oil it transports from Canada to refineries in Illinois, Oklahoma, and Texas is a dense and highly viscous form of crude oil derived from oil sands, called "bitumen." Prior to Keystone's construction, the pipeline's operator, TransCanada (now TC Energy), requested and was granted a special permit from PHMSA that allowed the company to use pipe made of higher grade steel in order to operate some sections of the pipeline at a higher stress level than would otherwise be allowed under regulation.[3]

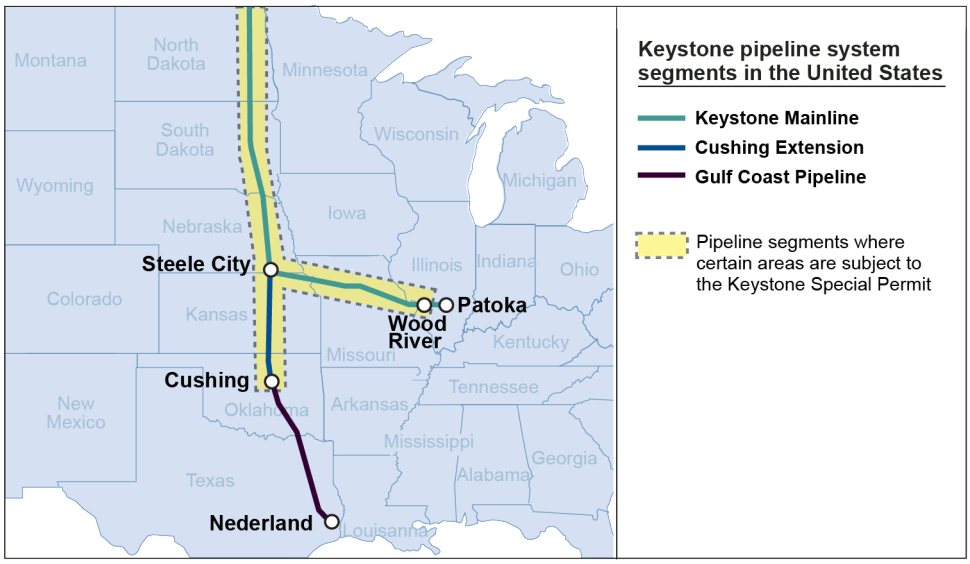
The Keystone special permit applies to certain portions of two pipeline segments, and in this report, we refer collectively to those segments as "Keystone." The first segment is the 1,025-mile, 30-inch diameter pipeline referred to as the Mainline from the Canadian border at North Dakota, to Wood River, Illinois. The second segment is the 291-mile, 36-inch diameter pipeline referred to as the Cushing Extension from Steele City, Nebraska, to Cushing, Oklahoma. See figure 1. This report focuses on these segments and does not include the Gulf Coast Pipeline or Keystone XL. The Keystone XL pipeline was originally proposed in 2008 and was intended to cross the U.S.-Canada border in Montana and travel through South Dakota and Nebraska before joining the existing Keystone pipeline at Steele City, Nebraska. On June 9, 2021, TC Energy announced that it had terminated Keystone XL, after the project's presidential permit was revoked in January 2021.[4]

[2]49 U.S.C. § 60118(c); 49 C.F.R. § 190.341.

[3]PHMSA, Grant of Special Permit to TransCanada Keystone Pipeline, Docket No. PHMSA-2006-26617 (Apr. 30, 2007).

[4]Presidential permits are distinct from special permits issued by PHMSA. The Secretary of State has the authority to receive applications for presidential permits for the construction, connection, operation, or maintenance of pipelines and other physical infrastructure at the borders of the United States. The process involves consulting relevant federal agencies, determining whether the application meets the standards for granting a presidential permit, and if so, issuing the permit. Exec. Order No. 11423, § 1 (Aug. 16, 1968), as amended. The presidential permit to construct Keystone XL, issued under the Trump administration in 2019, was revoked by a January 20, 2021 Executive Order under the Biden administration. TC Energy was previously denied a presidential permit for the pipeline under the Obama administration in 2015.

Figure 1: Map of TC Energy Keystone Pipeline System in the United States



Sources: PHMSA and TC Energy data and Map Resources. | GAO-21-588

A number of accidents have occurred on Keystone, including an October 2019 rupture near Edinburg, North Dakota which released more than 4,500 barrels of oil. You asked us to review Keystone accidents and PHMSA's oversight of this pipeline. This report examines (1) PHMSA's actions to approve the Keystone special permit and allow the pipeline to operate at a higher stress level, (2) how Keystone accidents compare to accidents on all U.S. crude oil pipelines since 2010, and (3) PHMSA's actions in response to Keystone safety issues.

To describe the actions that PHMSA took to approve the Keystone special permit and allow the pipeline to operate at a higher stress level, we reviewed applicable statutes and regulations, the 2007 special permit, and related PHMSA and TC Energy documentation. These documents included: TC Energy's application and additional documents the company provided in response to PHMSA requests; a PHMSA-commissioned technical report; PHMSA advisory meeting proceedings; and public comments submitted in response to PHMSA's notice and request for comments on TC Energy's application. We also conducted semi-structured interviews with 17 stakeholders to gain their perspectives on

PHMSA's approval of the special permit.[5] The stakeholders were selected to capture a range of known interests (industry, safety, environmental, state, and tribal interests). These stakeholders were identified by reviewing documentation such as the PHMSA advisory meeting noted above and a National Academies report on the safety of crude oil pipelines, as well as by asking for recommendations in interviews. Stakeholder views cannot be generalized to represent the views of all Keystone stakeholders.

To compare Keystone accidents to all U.S. crude oil pipeline accidents, we analyzed PHMSA accident data. We used these data to describe Keystone accidents from 2010 through 2020 in terms of the amount of oil released, the accident location and cause, and whether the accident met PHMSA's definition for an accident impacting people or the environment.[6] For purposes of this report, we characterize such accidents as "more severe" than those that did not meet PHMSA's definition for impacting people or the environment. We compared the averages of these more severe accidents for Keystone's operator, TC Energy, to national averages for operators of pipelines transporting crude oil, refined petroleum products, and biofuel from 2010 (the first year of Keystone operations) through 2020 (the latest full year of PHMSA data available). Specifically, we used PHMSA's performance measures—accidents impacting people or the environment per 1,000 miles of pipeline and barrels of oil spilled per billion barrel-miles—to compare TC Energy to 3-, 5-, and 11-year averages across pipeline operators nationwide. We assessed the reliability of these data by (1) performing manual testing, (2)

[5]These stakeholders were: representatives from three industry associations (Association of Oil Pipelines, American Petroleum Institute, and Interstate Natural Gas Association of America); seven pipeline technical and safety stakeholders (National Transportation Safety Board's Pipeline and Hazardous Materials Division; Pipeline Safety Trust; Kiefner and Associates; Accufacts, Inc.; Kent Muhlbauer; Evan Vokes; and Jeff Wiese); and representatives from seven environmental, state, and tribal organizations (Dakota Rural Action; Bold Nebraska; Paul Blackburn, Environmental Attorney; Natural Resources Defense Council; South Dakota Public Utilities Commission and South Dakota Department of Environment and Natural Resources, North Dakota Department of Environmental Quality; and Great Plains Tribal Chairmen's Association).

[6]PHMSA defines an accident as impacting people or the environment if it meets one of two criteria: (1) regardless of the accident's location, any of the following occur: a fatality, injury requiring in-patient hospitalization, ignition, explosion, evacuation, wildlife impact, contamination of specific water sources, or damage to public or private, non-operator property or (2) where the accident's location is not totally contained on operator-controlled property, any of the following occur: an unintentional release equal to or greater than 5 gallons in a high consequence area, an unintentional release of 5 barrels or more outside of a high consequence area, surface water contamination, or soil contamination.

reviewing documentation about the data and the system that produced them, and (3) interviewing PHMSA officials and TC Energy representatives. We determined these data were sufficiently reliable for these purposes. To gain their perspectives on Keystone accidents, we interviewed PHMSA officials, TC Energy representatives, and the 17 stakeholders described above.

To identify actions PHMSA has taken in response to Keystone's safety issues, we reviewed PHMSA enforcement actions for Keystone from 2010 through 2020 and TC Energy's responses to these actions. PHMSA's enforcement actions included Warning Letters, Notices of Probable Violations, and Corrective Action Orders. TC Energy's responses to PHMSA's enforcement actions include Root Cause Failure Analysis reports of accidents.[7] We analyzed the enforcement actions against TC Energy to identify the most common issues, such as repeated noncompliance with the same regulations or special permit conditions. To further describe PHMSA's enforcement actions and the actions TC Energy took in response, we interviewed PHMSA officials, TC Energy representatives, and the 17 stakeholders described above for their perspectives.

We conducted this performance audit from April 2020 to July 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

The U.S. energy pipeline network includes about 530,000 miles of pipelines transporting hazardous liquids and natural gas over long distances to users. As of 2020, about 228,000 miles of these pipelines carried hazardous liquids such as crude oil, refined oil products, or other liquids such as anhydrous ammonia. Slightly more than one-third of these

[7]We report on the findings of the Root Cause Failure Analyses but did not independently review or evaluate the methodology used in these reports.

hazardous liquid pipelines (about 84,000 miles) transported crude oil to refineries for processing into petroleum products, similar to Keystone.[8]

Pipeline accidents can occur from a variety of causes, including construction damage, corrosion, mechanical failure, control system failure, and operator error. Natural forces, such as floods and earthquakes, can also damage pipelines. Although relatively few people have been injured or killed due to pipeline accidents, a single accident can have catastrophic consequences for public safety and the environment. For example, in July 2010, a pipeline operated by Enbridge ruptured near Marshall, Michigan, releasing an estimated 19,500 barrels of crude oil into a creek, wetlands, and the Kalamazoo River.

PHMSA's Roles and Responsibilities

PHMSA is responsible for setting and enforcing the federal minimum safety standards for the design, construction, operation, maintenance, and inspection of interstate hazardous liquid and natural gas pipelines.[9] These standards include technical requirements such as:

- **Maximum operating pressure as a percentage of Specified Minimum Yield Strength (SMYS).** PHMSA regulations specify that the maximum operating pressure for hazardous liquid pipelines is 72 percent of a pipeline's SMYS.[10] SMYS represents the stress level at which a steel pipeline will begin to deform. It can vary depending on the grade (strength) of steel used to manufacture the pipe, so maximum operating pressure is defined as a percentage of SMYS. For example, higher grade steel allows for thinner but stronger pipeline walls, which in turn allows for operation at a higher percentage of SMYS. Pipelines manufactured using lower-grade steel would need thicker walls to withstand the same pressure as pipelines

[8]In addition to the 530,000 miles of hazardous liquid and natural gas transmission pipelines, the nation's 2.8 million miles of pipeline also includes 2.3 million miles of natural gas distribution pipelines that deliver gas to end users, such as businesses and homes, and about 21,000 miles of regulated gathering pipelines that carry natural gas and hazardous liquids from production areas and wells to processing plants.

[9]PHMSA also has the authority to set the minimum safety standards for intrastate pipelines. However, states may assume some regulatory, inspection, and enforcement responsibilities for those pipelines after certifying to PHMSA that they have adopted and are enforcing the federal minimum safety standards. States with certifications may adopt additional or more stringent safety standards as long as they are compatible with federal standards.

[10]*See* 49 C.F.R. §§ 195.106, 195.406(a). PHMSA's hazardous liquid pipeline safety regulations are located in 49 C.F.R. Part 195.

designed with stronger steel. Operating at a higher SMYS allows operators to reduce overall steel material expense since higher grade steel pipelines have thinner walls.

- **Corrosion prevention technologies.** PHMSA regulations include specifications to protect pipelines from corrosion. For example, PHMSA generally requires pipelines to have external coatings and cathodic protection systems. External coatings are protective layers of plastic material or other chemical compounds that are bonded to the metallic surface of a pipe to protect it from outside elements. Cathodic protection systems help prevent or mitigate external corrosion by applying an electrical current onto a buried pipeline.[11] Corrosion prevention is particularly important for pipelines operating at a higher SMYS using thinner but higher grade steel, as the thinner pipeline walls may have less corrosion allowance—that is, the amount of material that may corrode without affecting the integrity of the pipeline.

In addition, since 2000, PHMSA has required certain pipeline operators to develop and maintain integrity management programs to systematically manage risks in areas where accidents would have the most severe consequences, called high consequence areas.[12] For example, operators must periodically assess the integrity of pipelines in these areas through various methods, including by inserting electronic in-line inspection devices into the pipeline to identify potential risks such as corrosion or other damage.[13]

PHMSA officials periodically inspect pipelines to oversee operators' compliance with federal requirements and may issue enforcement actions when an inspector identifies probable violations of pipeline safety laws, regulations, or a PHMSA order, such as the conditions of a special

[11]Corrosion is an electro-chemical reaction that causes metal loss from a pipe that is in contact with the ground. Cathodic protection provides a substitute electro-chemical reaction to minimize corrosion. Specifically, cathodic protection involves voltage transformers, called rectifiers, and groundbeds that contain anodes, which are highly active metals that "sacrifice" by corroding rather than having the corrosion occur on the pipeline.

[12]High consequence areas generally include high population areas, other populated areas, certain navigable waterways, and areas unusually sensitive to environmental damage. 49 C.F.R. § 195.450.

[13]In 2019, PHMSA issued a final rule requiring hazardous liquid pipeline operators to also conduct these integrity assessments on pipeline segments outside of high consequence areas. Pipeline Safety: Safety of Hazardous Liquid Pipelines, 84 Fed. Reg. 52,260, 52,269 (Oct. 1, 2019).

permit.[14] PHMSA may also issue enforcement actions in the course of investigating an identified safety condition or a pipeline accident. According to officials, PHMSA's Office of Pipeline Safety has 124 authorized inspector positions whose responsibilities include inspecting 555 companies that operate about 530,000 miles of interstate pipelines. PHMSA has broad discretion in deciding what enforcement action, if any, to take against a particular operator to ensure compliance, and the enforcement actions range in severity:[15]

- *Warning Letters* notify operators when PHMSA inspections or other oversight activities reveal less serious violations or program deficiencies. Warning Letters direct the operator to correct the issues or be subject to potential, future enforcement actions.
- *Notices of Amendment* identify alleged inadequacies in the operator's plans and procedures to ensure safe operation of the pipeline, propose revisions to the plans or procedures, and instruct the operator as to how to respond to the allegations.
- *Notices of Probable Violation* allege the existence of one or more probable violations of pipeline safety laws, regulations, or related orders. These notices are accompanied by either a proposed compliance order identifying the remedial actions the operator is required to take, proposed civil monetary penalties, or both.[16] This is the only type of enforcement action that may include proposed civil monetary penalties. If PHMSA finds that a violation was committed, then it issues a final order, which includes the compliance order, the assessment of civil monetary penalties, or both, as applicable.

[14]The pipeline safety laws are codified at 49 U.S.C. § 60101 et seq., and the pipeline safety regulations are located in 49 C.F.R. Parts 190-199. PHMSA's regulations governing its enforcement of pipeline safety are located in 49 C.F.R. Part 190.

[15]PHMSA officials note that in addition to those listed, there is another enforcement tool that PHMSA can issue but has not issued to TC Energy for Keystone. Specifically, a Notice of Proposed Safety Order alleges that a particular pipeline facility has a condition or conditions that pose a pipeline integrity risk to the public safety, property, or the environment, and proposes requiring the operator to take necessary corrective action. If after issuing such a notice, PHMSA finds that such an integrity risk exists, PHMSA may issue a Safety Order.

[16]These enforcement actions must contain the options available to the operator for responding to the notice. The options include but are not limited to submitting written responses contesting the allegations, requesting mitigation or elimination of the proposed civil penalty, objecting to the compliance order, or requesting a hearing. Failure to respond constitutes a waiver of a right to contest the allegations.

- *Corrective Action Orders* direct an operator to take immediate corrective actions to ensure safe pipeline operation. PHMSA may issue a corrective action order if it finds that the pipeline or pipeline facility is or would be hazardous to life, property, or the environment, such as after an accident occurs. These orders do not allege probable violations.

PHMSA also collects and shares pipeline-related data, including data on accidents. For example, for each accident that releases over 5 gallons of product, PHMSA requires hazardous liquid pipeline operators to submit a report that includes information such as amount, location, timing, impacts, and cause of the release. To provide transparency into pipeline operators' safety records, PHMSA publishes information on its website on pipeline accidents by operator. This information covers each operator's network of pipelines carrying crude oil or refined petroleum products. PHMSA also reports nationwide averages for accidents—such as the average number of accidents and average amount of product spilled per billion barrel transported—which enables comparisons between an individual operator and the industry as a whole.

Keystone Special Permit

PHMSA issued the Keystone special permit in April 2007 after TC Energy applied for a waiver of the regulatory requirement for hazardous liquid pipelines to operate at a maximum stress level of 72 percent of SMYS for certain segments of the pipeline. The special permit allows TC Energy to construct the pipeline using higher-grade steel in order to operate at 80 percent of SMYS along the Keystone Mainline and Cushing Extension. Except for this waived requirement, all other pipeline safety regulations apply to the segments covered by the special permit. Certain portions within those segments are not covered by the special permit, such as those operating in high consequence areas and within pump stations.[17] In those pipeline portions, Keystone remains wholly subject to PHMSA's hazardous liquid pipeline safety regulations. The special permit is in effect for the life of the pipeline, although PHMSA has the authority to modify, suspend, or revoke the permit in certain circumstances designated in regulations.

[17]Pump stations are located at regular intervals along the pipeline to boost pressure to desired levels. Without these pumps, pipelines experience pressure losses over the length of the pipeline. Many pump stations are unstaffed and located in sparsely populated areas.

To grant a special permit, PHMSA must determine that the requested waiver is not inconsistent with safety,[18] which PHMSA officials interpret to mean that the waiver provides a level of safety equal to or greater than that which would be provided if the pipeline were operated under existing regulations. When approving a special permit, PHMSA can also impose conditions to offset the safety risks posed by waiving the operator's compliance with a regulation. Between 2000 and 2020, PHMSA granted 99 special permits: 94 for natural gas pipelines and five for hazardous liquid pipelines. Keystone's special permit is the only one PHMSA has granted that allows a hazardous liquid pipeline to be designed and operated at 80 percent of SMYS. No other hazardous liquid pipeline operator has requested a special permit to waive the same regulation. According to PHMSA officials, during inspections of the Keystone pipeline, the agency evaluates the operator's overall performance data, as well as compliance with the terms of the special permit.

PHMSA Developed Conditions to Offset Safety Risks and Required TC Energy to Replace Low-Quality Pipe

Technical Information and PHMSA's Experience Informed Special Permit Conditions

PHMSA gathered technical information from TC Energy related to the potential operation of the Keystone pipeline at 80 percent of SMYS. PHMSA's regulations require special permit applications to include information spanning 12 categories, including, for example, pipeline design and construction and how proposed safety measures would mitigate safety or environmental risks. TC Energy included this information in its November 2006 application. PHMSA then requested, and TC Energy provided, 22 additional items, such as the pipe's predicted fatigue life at 80 percent of SMYS and the reason TC Energy sought the special permit. TC Energy stated that the special permit would reduce steel costs by approximately 10 percent while still maintaining high standards of safety. TC Energy also proposed additional actions, such as

[18]49 U.S.C. § 60118(c); 49 C.F.R. § 190.341.

more frequent assessments of the pipeline using in-line inspection tools, to help ensure safety.

PHMSA also requested and incorporated input from a technical advisory committee, an engineering consultant, pipeline safety experts, and the public regarding the technical aspects of the special permit request. For example, it solicited comments from an external technical advisory committee containing members from industry, federal and state government, and pipeline safety groups. It also commissioned a study that analyzed and made recommendations regarding the potential fatigue and fracture of a pipeline operating at 80 percent of SMYS. For example, the study recommended requiring the operator to perform a full in-line inspection within 3 years of the pipeline starting operations, a stipulation that PHMSA later made a condition of the special permit. In addition, according to the special permit, PHMSA requested and incorporated input from experts in areas such as steel fracture mechanics and leak detection. Finally, in response to publishing TC Energy's special permit request in the *Federal Register* in February 2007, PHMSA received two comments. One comment was from a pipeline safety expert who supported the application and recommended a number of conditions, such as quality control practices during pipeline installation, which PHMSA incorporated into the special permit.[19]

In reviewing the Keystone special permit application, PHMSA officials said they also drew on their experience with granting similar special permits for natural gas pipelines, as well as on the experiences of other countries regulating crude oil pipelines operating at a higher stress level. In 2005, PHMSA started receiving requests for special permits that would allow operators to increase the maximum allowable operating pressure to 80 percent of SMYS for certain natural gas pipeline segments. PHMSA evaluated these special permit applications against safety criteria such as pipe design, construction, operations and maintenance, integrity management, and reporting requirements. PHMSA would later require TC Energy to submit information across similar categories. A PHMSA official also said that the Keystone special permit conditions were similar to those the agency included in natural gas special permits, such as addressing risks from corrosion and cracking. In addition, according to officials, PHMSA considered how regulatory agencies in Europe and Australia oversaw crude oil pipelines operating at 80 percent of SMYS. As PHMSA

[19]As PHMSA notes in the Keystone special permit, the other commenter did not provide substantive comments relevant to the special permit request.

noted in Keystone's 2007 special permit, Canadian safety standards already allowed operators there to design and operate hazardous liquid pipelines at 80 percent of SMYS, which TC Energy had been doing since 2004 in Canada.

Based on the technical information and its experience with the natural gas pipeline industry, PHMSA issued the special permit with 51 conditions that the agency determined would offset the risks of operating the relevant Keystone segments at 80 percent of SMYS in non-high consequence areas. The special permit conditions are in effect for the entire lifecycle of the pipeline, from design and construction to ongoing maintenance and reporting. Three quarters (38) of the conditions relate to constructing, operating, and maintaining the pipeline to ensure safety, including three conditions requiring periodic in-line inspections to proactively identify issues such as corrosion and cracking. See Table 1 for a summary of the 51 special permit conditions.

Table 1: Keystone Special Permit Conditions the Pipeline and Hazardous Materials Safety Administration (PHMSA) Developed to Provide for Safe Operation at 80 Percent of Specified Minimum Yield Strength

Condition number	Pipeline lifecycle stage	Description
1 – 10	Planning and Design	Pipe Manufacturing, Coating, Transportation, and Mill Testing Requirements to ensure that the pipe is adequately manufactured, protected, delivered, and inspected before it goes into the ground.
11 – 24	Construction	Field Coating, Fittings, Design, Corrosion, and Construction Requirements to ensure that the pipe is adequately welded and coated in the field, operates at a safe pressure rating for its installation location, and is modified to mitigate potential corrosion issues. In addition, the operator must create a quality assurance plan for the pipe's installation, as construction defects could lead to material failure during operation.
25 – 48	Operations and Maintenance	Operations and Maintenance Requirements to ensure that the pipeline is maintained properly through measures including the installation of a control room system that detects leaks so trained operators can provide remote monitoring and control of the pipeline. The pipeline must also be appropriately marked, inspected, evaluated, and repaired.
49 – 51	Reporting	Reporting and Records Retention Requirements to ensure that the operator submits immediate reports to PHMSA for any leak in the special permit area, as well as longer term reports, such as annual reports addressing 12 specific areas. These areas include inspection results and internal programs for corrosion management and damage prevention.

Source: PHMSA Keystone special permit information. | GAO-21-588

Most safety and technical stakeholders we interviewed regarded the terms of the Keystone special permit as offsetting the risks of operating the pipeline under a higher stress level. All seven of the safety and

technical stakeholders we interviewed acknowledged that operating at 80 percent of SMYS poses risks. For example, one noted that the thinner-walled pipe used for Keystone—albeit made of higher-grade steel—could be less resistant to outside forces, cracking, and corrosion than pipe made with thicker walls. However, five of the seven stakeholders generally agreed that PHMSA designed the Keystone special permit conditions in a way that required TC Energy to offset those risks. For example, three noted that the Keystone special permit conditions require TC Energy to conduct more frequent in-line inspections using more advanced technologies. In addition, one industry association stakeholder we interviewed said that the percentage of SMYS is just one of many factors engineers consider to ensure safety. All four environmental stakeholders we interviewed said that although they have safety concerns with Keystone, they could not comment on approval of the special permit because they were not involved during PHMSA's development of the conditions in 2006-2007. For example, one environmental stakeholder said that his organization was more involved with the Keystone XL pipeline, which TC Energy proposed after the Keystone special permit was approved by PHMSA.

One industry stakeholder noted that his organization would prefer PHMSA update the hazardous liquid pipeline regulations to allow all pipelines that meet the conditions to operate at increased SMYS, but PHMSA officials stated they do not intend to take this action. Due to the experience PHMSA gained from natural gas pipeline special permits, the agency amended its regulations in 2008 to allow certain natural gas pipeline segments to operate at 80 percent of SMYS if operators met specific requirements. However, since Keystone's special permit is the only one of its kind, PHMSA has less experience overseeing hazardous liquid pipelines operating above 72 percent of SMYS. PHMSA officials said that because there is low demand from industry for special permits waiving this regulation, they have not sought to amend their regulations to generally allow hazardous liquid pipelines to operate at a higher stress level. These officials speculated the low demand from industry for special permits waiving the regulation was in part because operators do not want to be subject to additional conditions that are more onerous than the safety regulations that would have otherwise applied.

PHMSA Required TC Energy to Replace Low-Quality Pipe before Operating Keystone at a Higher Stress Level

After issuing the special permit in 2007, PHMSA identified industrywide pipeline quality issues and as a result initially prohibited the operation of any Keystone segment at 80 percent of SMYS. Through inspections of new construction in 2008, PHMSA identified pipe manufacturing quality issues across the pipeline industry, including one or more manufacturers that had supplied pipe used to construct Keystone. Specifically, some pipe mills had manufactured pipe that failed to meet strength specifications required by regulations, which could cause the steel to deform at pressures lower than intended and the pipeline to expand as a result. To address these issues, in 2009 PHMSA issued an Advisory Bulletin and accompanying guidance, directing operators to use in-line inspection tools to identify pipeline segments with steel that had expanded. The same year PHMSA required TC Energy, which had started Keystone construction in June 2008, to conduct inspections along its entire U.S. pipeline to identify and replace any affected pipeline sections prior to operating the pipeline at the higher SMYS allowed under the special permit. As a result, Keystone began operating in June 2010 at 72 percent of SMYS.

PHMSA allowed TC Energy to gradually phase in Keystone operations at 80 percent of SMYS as inspections and repairs were completed. More specifically, in 2015, TC Energy completed its inspections to detect areas with the expanded pipe, and began excavating and replacing 32 affected pipeline joints in 2016.[20] PHMSA conducted inspections to verify TC Energy's process for identifying the expanded pipe and conducting the repair work. For segments that TC Energy found unaffected by pipeline quality issues, PHMSA allowed the company to operate Keystone at 80 percent of SMYS beginning in 2016. For segments where TC Energy found expanded pipe, PHMSA approved a phased increase in operating pressure up to 80 percent of SMYS after TC Energy completed the replacements. By 2017, all sections of the pipeline subject to the special permit were operating at 80 percent of SMYS.

[20]According to TC Energy officials, a joint is a segment of the pipe that is welded together in the field to form the pipeline and is typically 40 feet but can be 80 feet depending on the type of pipe.

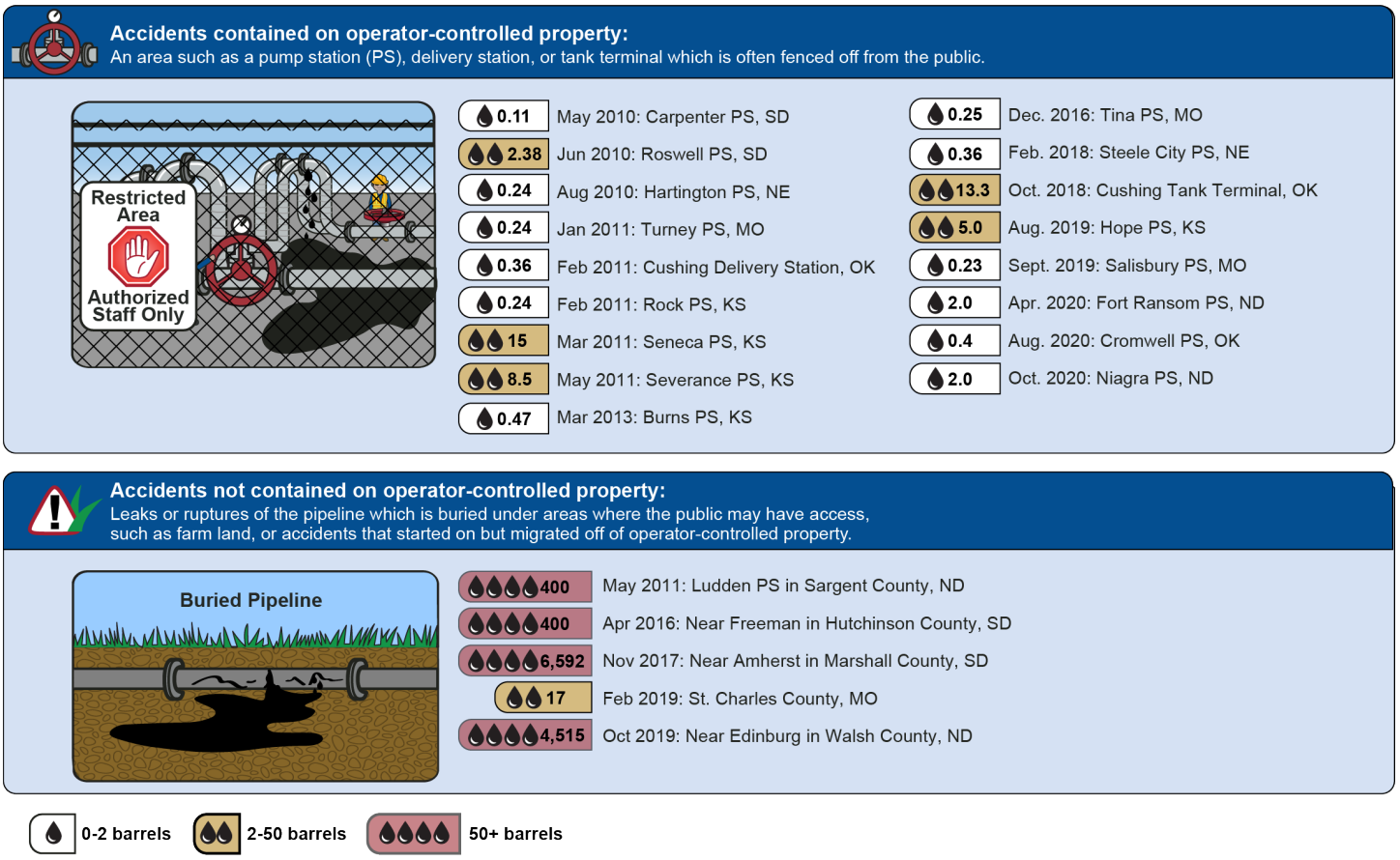
Keystone's Accident History Is Similar to Other Pipelines since 2010, but Severity of Spills Has Worsened in Recent Years

Keystone's 22 Accidents Are Similar in Volume Released and Location to All Crude Oil Pipeline Accidents

Since 2010, when it began operating, through December 31, 2020, Keystone has had 22 accidents (see figure 2).[21] About half (12 of 22) of these accidents released 2 or fewer barrels (a barrel is 42 gallons, about the same volume as a typical bathtub) and 82 percent (18 of 22) released fewer than 50 barrels of crude oil.

[21]These 22 accidents occurred along the pipeline segments subject to the special permit—the Keystone Mainline and Cushing Extension—including at pump stations which, as noted earlier, are not covered by the special permit.

Figure 2: Keystone Pipeline Accidents, 2010–2020



Source: GAO analysis of PHMSA data. | GAO-21-588

Keystone's accidents follow the pattern of crude oil pipeline accidents nationwide, with respect to the amount of oil spilled and where the spill occurred. The percentage of accidents releasing fewer than 50 barrels is the same for Keystone as all crude oil pipeline accidents over the past decade (82 percent). The location of the Keystone accidents is also comparable to industry averages. Seventy-seven percent (17 of 22) of Keystone accidents were contained on property that TC Energy controls, such as one of the company's pump stations. Similarly, over the past decade, 74 percent of all crude oil pipeline accidents were contained on operator-controlled property.

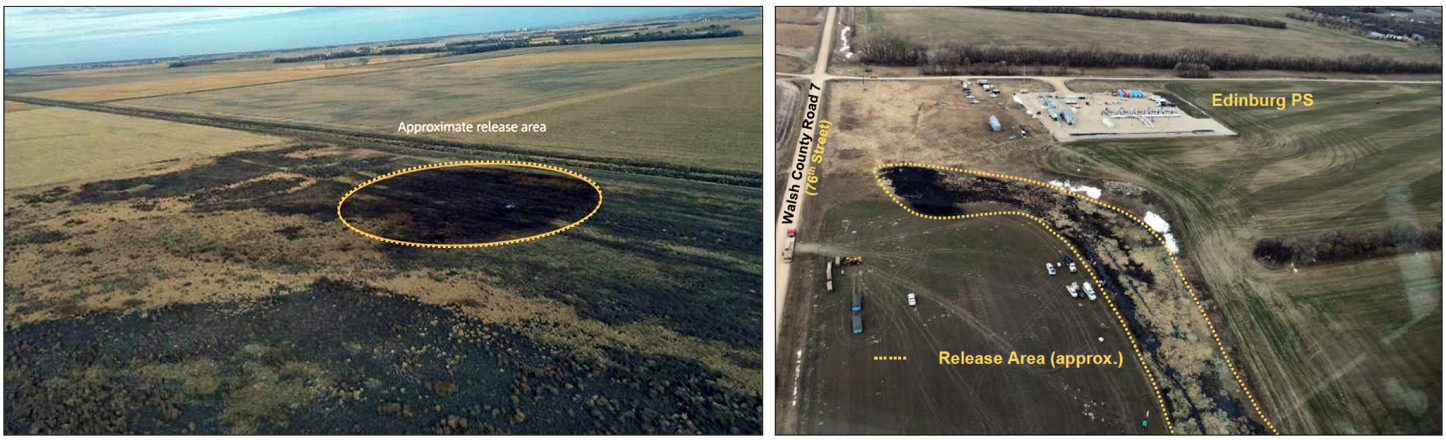
The four largest Keystone accidents each released more than 50 barrels of oil, but did not occur in areas that met the regulatory definition for a high consequence area, such as areas that are highly populated or unusually sensitive to environmental damage:

- Two accidents—one in southeastern North Dakota in May 2011 and the other in southeastern South Dakota in April 2016—each spilled 400 barrels of crude oil. The 2011 accident, which was identified by TC Energy's pipeline control system as well as a local landowner, occurred at a pump station but also released crude oil that affected areas outside of the operator-controlled property. The 2016 accident, also reported by a local landowner, stemmed from a pipeline leak and affected an agricultural area.
- Two more recent accidents account for about 93 percent of the total 11,975 barrels of oil released from Keystone since 2010. Both accidents—one in northeastern South Dakota near Amherst, in November 2017 spilled 6,592 barrels, and another in northeastern North Dakota, near Edinburg, in October 2019 spilled 4,515 barrels—occurred on the pipeline right-of-way.[22] Specifically, the Amherst spill occurred on land reserved for wildlife and public use, while the Edinburg accident occurred approximately 585 feet from a pump station and affected a nearby culvert and surrounding area. See figure 3. For both ruptures, investigations conducted by PHMSA-approved third parties found that TC Energy shut down the pipeline and isolated the failure locations by closing remotely operated valves within 15 minutes.[23] South and North Dakota state environmental agency officials we interviewed noted that TC Energy promptly addressed and remediated both spills, which involved excavating and disposing of contaminated material. According to the South Dakota Department of Environment and Natural Resources, TC Energy's remediation included removing more than 112,000 tons of oil-contaminated soil from the site.

[22]A right-of-way is a defined strip of land on which an operator has the rights to construct, operate, and maintain a pipeline. Pipeline operators often enter into a contract with a property owner for these rights.

[23]On February 6, 2020, PHMSA proposed to amend its regulations to require operators of certain pipeline segments, after identifying a rupture, to close valves and isolate the ruptured segment within 40 minutes. Pipeline Safety: Valve Installation and Minimum Rupture Detection Standards, 85 Fed. Reg. 7162, 7171. This Notice of Proposed Rulemaking was published partially in response to recommendations made by GAO in 2013. See GAO, *Pipeline Safety: Better Data and Guidance Needed to Improve Pipeline Operator Incident Response,* GAO-13-168 (Washington, D.C.: Jan. 23, 2013).

Figure 3: Two Largest Keystone spills—Near Amherst, SD (left) in 2017 and Near Edinburg, ND in 2019 (right)



Sources: NTSB (left) and PHMSA/ TC Energy (right). | GAO-21-588

Five safety and technical stakeholders and one state environmental agency official told us that the overall number and severity of accidents in Keystone's history does not cause them concern about the overall safety of the pipeline.[24] For example, one safety stakeholder noted that in regard to accidents, Keystone was "in the middle of the pack" compared to other pipelines.

When asked about the number and severity of Keystone accidents, representatives from four tribal and environmental organizations and one safety and technical stakeholder told us that they encountered difficulty accessing information from PHMSA such as on Keystone's oil spills. For example, one environmental group noted that although PHMSA provides a lot of information on its website, it is not easy to navigate and it is difficult for a lay person, such as a local landowner, to link together the location of a pipeline with what company operates it and to retrieve details on accidents that have occurred. PHMSA officials noted that the agency is working to increase transparency of industry performance measures, such as accident and enforcement data, by making it easier for the public to access, view, and understand the data. For example, these officials noted that each webpage includes a link to "ask a question" to which PHMSA typically responds within 24 hours, and the agency is engaging

[24]We also asked the other two safety and technical stakeholders about the number and severity of Keystone accidents. One expressed concern that underlying issues could result in future accidents, while the other noted they do not track pipeline accident trends.

stakeholders to improve access to public information. PHMSA has also established on its website a repository that includes all of its enforcement data, which is accessible to the public.

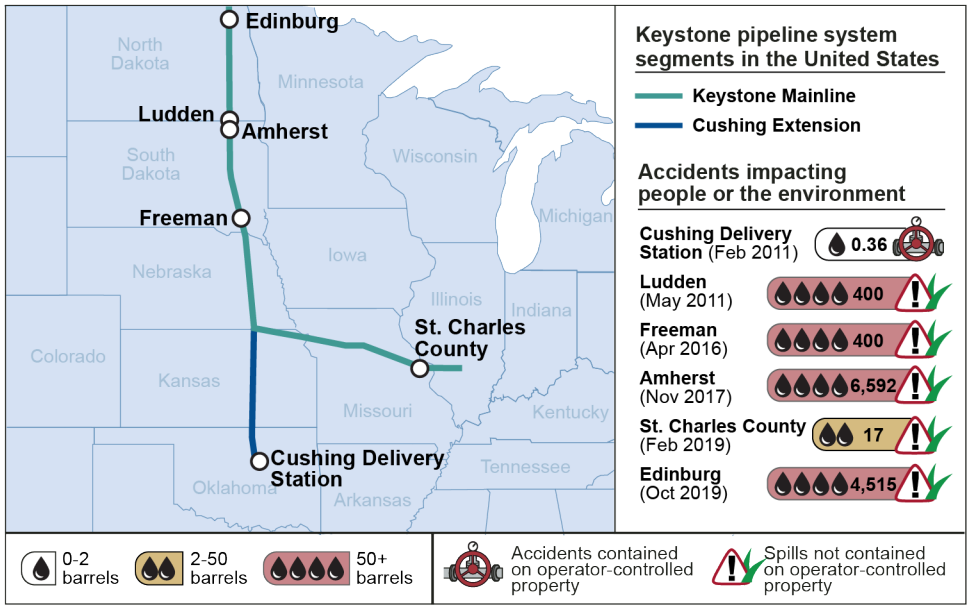
PHMSA Measures Show TC Energy Performance was Better than National Averages since 2010 but Declined in Recent Years

About 27 percent (six of 22) of Keystone's accidents over the past decade met PHMSA's definition of those impacting people or the environment.[25] Five of Keystone's accidents met the definition because they were not entirely contained on operator-controlled property and each released more than 5 barrels of oil outside of a high consequence area. The sixth accident met the definition because, although it released less than 1 barrel of oil on operator-controlled property, the oil ignited.[26] Specifically, the accident occurred during the commissioning of the pipeline when an in-line inspection device was being removed, and a flare used to control vapors ignited overflowing crude oil. See figure 4 for a map of these accidents.

[25]PHMSA officials stated that it developed the definition for accidents impacting people or the environment in collaboration with industry and safety stakeholders to gauge overall safety performance for pipeline systems transporting crude oil, refined petroleum, and biofuel. These commodities tend to remain liquid upon release, unlike highly volatile liquids and carbon dioxide, which vaporize upon release and are excluded from the performance measures.

[26]This accident along with the May 2011 accident in Ludden, North Dakota, originated on portions of Keystone that are not covered by the special permit (i.e., pump stations).

Figure 4: Location of Keystone Accidents Impacting People or the Environment, 2010-2020



Source: PHMSA data and Map Resources. | GAO-21-588

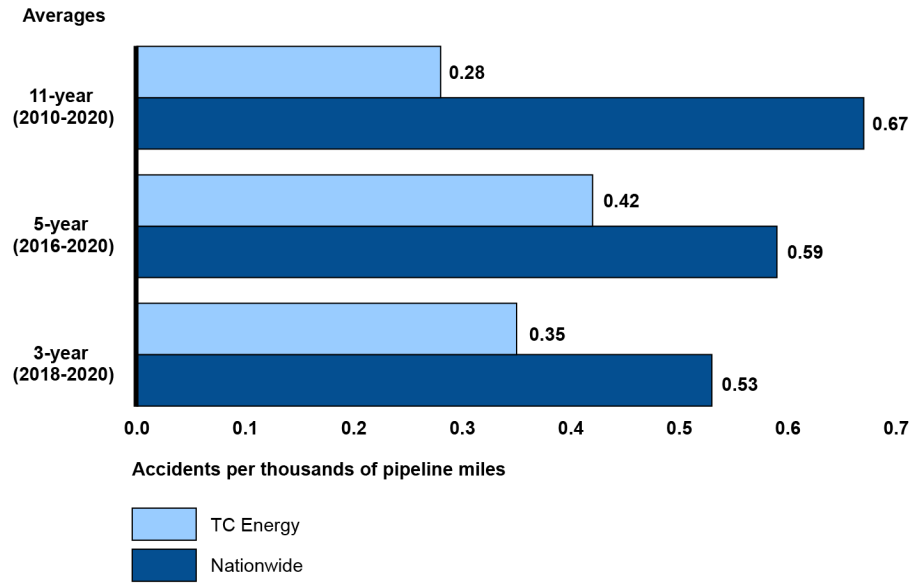
Note: PHMSA defines an accident as impacting people or the environment if it meets one of two criteria: (1) Regardless of the accident's location, any of the following occur: a fatality, injury requiring in-patient hospitalization, ignition, explosion, evacuation, wildlife impact, contamination of specific water sources, or damage to public or private, non-operator property; or (2) Where the accident's location is not totally contained on operator-controlled property, any of the following occur: an unintentional release equal to or greater than 5 gallons in a high consequence area, an unintentional release of 5 barrels or more outside of a high consequence area, surface water contamination, or soil contamination.

Using PHMSA's performance measure for the number of accidents impacting people or the environment per total miles of pipeline owned by an operator, Keystone's six such accidents put TC Energy consistently better than the nationwide average, though less so in recent years.[27] PHMSA developed performance measures to provide public transparency, improve industry performance, and to identify safety trends. It reports 3-year and 5-year averages nationwide and for each operator that has 300 or more miles of pipeline carrying crude oil, refined petroleum products, and biofuels, but does not identify specific targets for

[27]Since PHMSA performance measures are calculated by operator, the denominator includes all pipeline TC Energy operates in the United States, including both Keystone and the Gulf Coast Pipeline. However, the accidents impacting people or the environment in the numerator occurred along the pipeline segments subject to the special permit—Keystone Mainline and Cushing Extension.

these performance metrics. According to PHMSA's reported 3- and 5-year averages, as well as a 11-year average we calculated using PHMSA data, TC Energy was consistently below the nationwide average of accidents impacting people or the environment per pipeline mile, although less so for the most recent 3- and 5-year averages (see fig. 5). PHMSA reports that when ranking operators' 5-year averages from lowest to highest, TC Energy ranked 43rd out of 80 operators.

Figure 5: Comparison of the Keystone Pipeline's Operator, TC Energy, to Nationwide Performance Measure of Accidents Impacting People or the Environment per Thousands of Pipeline Miles



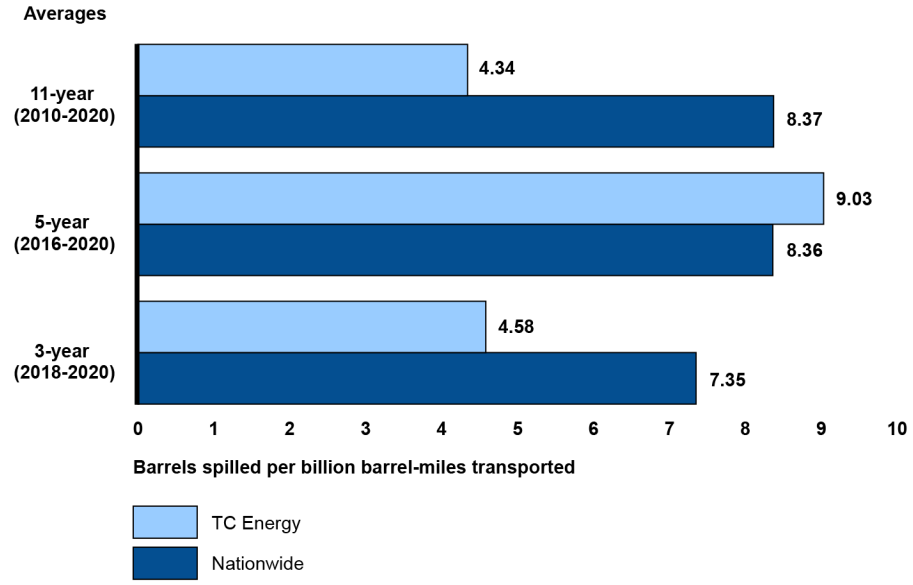
Source: PHMSA. | GAO-21-588

Note: PHMSA defines an accident as impacting people or the environment if it meets one of two criteria: (1) Regardless of the accident's location, any of the following occur: a fatality, injury requiring in-patient hospitalization, ignition, explosion, evacuation, wildlife impact, contamination of specific water sources, or damage to public or private, non-operator property; or (2) Where the accident's location is not totally contained on operator-controlled property, any of the following occur: an unintentional release equal to or greater than 5 gallons in a high consequence area, an unintentional release of 5 barrels or more outside of a high consequence area, surface water contamination, or soil contamination.

According to PHMSA's other performance measure—the volume of oil spilled per billion barrel-mile transported—despite being better than the national average over the past decade, Keystone's pipeline ruptures in 2017 and 2019 put TC Energy worse than the nationwide average over

the past 5 years (2016-2020).[28] According to PHMSA officials, this measure takes into account the total amount of oil released by accidents impacting people or the environment relative to the amount of oil transported by the operator. Although TC Energy was better than the national average over the decade and for the 3-year average (2018-2020) for this measure, it was worse for the 5-year national average (see fig. 6). PHMSA reports that when ranking operators' 5-year averages from lowest to highest, TC Energy ranked 57th out of the 80 pipeline operators with 300 or more miles of pipeline carrying crude oil, refined oil products, or biofuels. TC Energy's 5-year average ranking reflects the fact that the two largest oil spills in Keystone's history occurred in 2017 and 2019.

Figure 6: Comparison of the Keystone Pipeline's Operator, TC Energy, to Nationwide Performance Measure of Barrels Spilled per Billion Barrel-Miles Transported



Source: PHMSA. | GAO-21-588

[28]Barrel-miles are the total of the number of barrels transported multiplied by the distance in miles they were moved. Given this results in a very large number, PHMSA reports this in billions.

PHMSA Required TC Energy to Address Construction and Other Issues, and Used Lessons Learned to Improve Oversight Nationwide

PHMSA Issued Corrective Action Orders in Response to Keystone's Largest Accidents

In response to each of Keystone's four largest spills, PHMSA issued Corrective Action Orders requiring TC Energy to take several actions, including engaging a PHMSA-approved independent consultant to conduct a Root Cause Failure Analysis which found the accidents stemmed from construction issues.[29] For each such order—which PHMSA may issue when the agency determines that a pipeline is or would be hazardous to life, property, or the environment—PHMSA required TC Energy to shut down the pipeline and obtain PHMSA approval to restart the pipeline. The Root Cause Failure Analysis, conducted by a third party, indicated that the four accidents were caused by issues related to the original design, manufacturing of the pipe, or construction of the pipeline that are distinct from the issue with low-quality pipe that delayed Keystone from operating at 80 percent SMYS. Table 2 provides a summary of the reports' causation findings, as well as actions TC Energy took in response to the Corrective Action Orders. Examples of TC Energy actions include conducting inspections across the pipeline to detect similar issues and replacing components if needed. In addition, TC Energy representatives note that they have been working to evolve and improve the company's in-line inspection tools in order to detect pipeline flaws before they become accidents.

[29]Three of the four Corrective Action Order cases have been closed by PHMSA, meaning that TC Energy complied with the terms. While PHMSA has not yet closed the Order most recently issued in November 2019, according to TC Energy representatives, PHMSA has removed a temporary pressure restriction and TC Energy has complied with the relevant terms.

Table 2: The Causes of Keystone Accidents Resulting in PHMSA Issuing Corrective Action Orders and TC Energy Actions in Response to the Orders

Accident date and location	Barrels released	Causes according to Root Cause Failure Analysis	TC Energy Actions in response to the PHMSA Corrective Action Orders
May 2011- Ludden Pump Station, North Dakota and Severance Pump Station, Kansas	408.5	Design of the pipeline system did not adequately take into account the vibrations that occurs at pump stations, so pump station components failed as a result.	Between May 2011 and March 2012, replaced damaged components, inspected connections to determine risk areas, modified connections that posed a risk, and conducted verification testing to ensure effectiveness at pump stations.
April 2016- Near Freeman, South Dakota	400	The weld (called a girth weld) joining two pipe segments of differing thicknesses failed and caused a leak.	Conducted in-line inspection to detect defects on similar girth welds across the affected segment by June 2016. No other similar weld defects were detected.
Nov. 2017- Near Amherst, South Dakota	6,592	A fatigue crack, likely originating from mechanical damage to the pipe exterior by a vehicle during installation that grew to a critical size.	Used technology to detect cracks on the affected segment and excavated several anomalies by September 2018 but did not find issues similar to the flaw that caused the accident.
Oct. 2019- Near Edinburg, North Dakota	4,515	The pipe was manufactured with an atypical seam weld geometry severe enough to initiate a fatigue crack.	Launched a crack in-line inspection program with a new technology platform across the system to detect similar cracks. This work is ongoing.

Source: GAO analysis of PHMSA and TC Energy information. | GAO-21-588

Although the relevant pipeline segments were operating at a stress level greater than 72 percent of SMYS at the time of Keystone's two largest accidents, PHMSA officials stated that this did not cause the ruptures. As noted previously, PHMSA did not allow Keystone to operate at 80 percent of SMYS until TC Energy identified and replaced 32 pipe joints that contained low strength steel. For the segment of the pipeline where the two largest spills occurred, TC Energy did not identify any affected pipe joints requiring replacement, and began operating this segment at 80 percent of SMYS in 2016. PHMSA officials stated that based on their review of the Root Cause Failure Analysis reports, they not believe that the operating stress level of the pipeline would have had an effect, as both accidents were caused by a fatigue failure related to pre-existing flaws or defects.

PHMSA's accident data suggest that construction issues may be a more frequent contributor to Keystone's accidents impacting people or the environment when compared to causes for such accidents for pipelines nationwide. PHMSA reports that from 2010 to 2020, 12 percent of all accidents impacting people or the environment (119 of 981) on pipelines carrying crude oil, refined oil products, or biofuels were caused by a material failure of the pipe or weld, such as defects in the steel material or welds used in manufacturing the pipe or joining pipe during construction.

By comparison, half (3 of 6) of Keystone's accidents impacting people or the environment were caused by material failure of pipe or weld. Specifically, the two accidents in South Dakota in 2016 and in 2017 were caused by issues in the construction, installation, or fabrication of the pipeline, while the 2019 North Dakota accident was caused by defects in the original pipe manufacturing.

In contrast to Keystone, PHMSA reports that the leading cause of accidents impacting people or the environment on pipelines carrying crude oil, refined oil products, or biofuels from 2010 to 2020 was corrosion, accounting for 30 percent of such accidents.[30] On Keystone, none of these more severe accidents have been caused by corrosion. However, according to PHMSA officials and TC Energy representatives, a February 2019 Keystone accident in St. Charles County, Missouri, which released 17 barrels, was caused by the failure of a pipeline wrap that was applied in 2012 to address previous corrosion issues.[31]

PHMSA Issued Additional Enforcement Actions for TC Energy to Address Deficiencies in Corrosion Prevention and Other Areas

In addition to the Corrective Action Orders, PHMSA also issued enforcement actions regarding corrosion prevention and other deficiencies discovered during inspections. See table 3.

Table 3: Enforcement Actions PHMSA Issued to TC Energy for Keystone Deficiencies Identified during Inspections

Date enforcement action issued	Type of enforcement action	Topics of Deficiencies Found	Civil monetary penalty assessed
Jan. 13, 2012	Warning Letter	Pipeline markers Cathodic protection	N/A
Aug. 28, 2013	Notice of Amendment	Public awareness program	N/A
Nov. 20, 2015	Notice of Probable Violation	Cathodic protection	$135,400[a]

[30]In addition to corrosion (30 percent) and material failure of pipe or weld (12 percent) mentioned above, the other causes nationally were: equipment failure (23 percent), incorrect operation (12 percent), excavation damage (11 percent), natural force damage and other outside force damage (9 percent), and other causes (3 percent).

[31]The cause for this accident according to PHMSA data was "incorrect operation- wrong equipment specified or installed." Furthermore, the causes for the other two Keystone accidents IPE were: "equipment failure- threaded connection or coupling failure" (for the 2011 release of 400 barrels at Ludden Pump Station in North Dakota) and "incorrect operation- tank or vessel overfill or overflow" (for the 2011 leak of 0.36 barrels at the Cushing Delivery Station in Oklahoma).

Date enforcement action issued	Type of enforcement action	Topics of Deficiencies Found	Civil monetary penalty assessed
June 13, 2019	Notice of Probable Violation	Atmospheric corrosion	N/A
March 11, 2020	Notice of Probable Violation	Pipeline markers	$170,300[b]

Source: PHMSA. | GAO-21-588

[a]This penalty was assessed in a Final Order on May 31, 2017. The proposed amount in the 2015 Notice was $187,200.

[b]This penalty was assessed in a Final Order on November 6, 2020.

Corrosion Prevention

During a 2011 PHMSA inspection in North and South Dakota, PHMSA noted that TC Energy was unable to demonstrate that it had complied with one of the conditions of the special permit. That condition requires TC Energy to conduct a test to find stray currents, such as from nearby power lines or pipelines, which could interfere with the cathodic protection system for the pipeline. As a result of this inspection, PHMSA issued a Warning Letter to TC Energy in January 2012. A couple of months later, in March 2012, TC Energy provided the stray current test results to PHMSA as required by this condition of the special permit and a proposed mitigation plan, such as installing additional groundbed facilities.

Issues with Keystone's cathodic protection culminated months later when thinned pipe was discovered that according to PHMSA came extremely close to causing a pipeline failure that could have impacted a high consequence area. Specifically, during an October 2012 in-line inspection, TC Energy discovered significantly thinned pipe due to accelerated corrosion in four locations along the mainline segment between Salisbury, Missouri and Patoka, Illinois. TC Energy reported that it immediately depressurized the pipeline, isolated the affected section, notified PHMSA, and completed appropriate repairs. In all four locations, the amount of metal loss (i.e., corrosion) was over 60 percent deep. In one location, 97 percent of the metal had corroded, leaving a remaining pipeline wall thickness of 0.0120 inch—less than half the thickness of a dime.

As a result of these issues, PHMSA issued a Notice of Probable Violation and a Final Order determining that TC Energy had committed violations of the regulations and assessing civil monetary penalties of $135,400. A subsequent TC Energy report found the primary cause for the metal loss anomalies was the inadequacy of the original cathodic protection design and electrical current interference from nearby pipelines. PHMSA found

that TC Energy began taking corrective measures to address these deficiencies in 2012, and completed this work in 2013. This work included installing 13 additional impressed current systems on the pipeline and adding six groundbeds at pump stations, among other things. TC Energy reported that its repair timeframes were due to factors outside of its control, such as acquiring land access permission and environmental permitting. Representatives from TC Energy acknowledge that the original cathodic protection had problems and noted that their design philosophy has changed since then, a change that has benefitted other pipelines operated by the company.

Other Areas

In addition to the issues with cathodic protection, PHMSA also issued enforcement actions related to additional deficiencies found during inspections.

- **Public awareness program:** PHMSA identified inadequacies with TC Energy's public awareness program and plan during a 2011 inspection and issued a Notice of Amendment in 2013. PHMSA found, among other things, that TC Energy's public awareness plan did not include a written process for conducting an annual implementation review, as required by regulation. Based on feedback the PHMSA inspector provided during the 2011 inspection, TC Energy updated its program in 2012 before the Notice of Amendment was issued. PHMSA closed the case in 2015.
- **Coatings:** PHMSA issued a 2019 Notice of Probable Violation in response to deficiencies PHMSA found in a 2018 inspection of coatings applied to pipe to prevent atmospheric corrosion on above ground pipeline sections, such as at pump stations. In its 2019 response, TC Energy said it began remediating the issue in 2018 and would complete the work in 2019. PHMSA closed the case in September 2020, noting the TC Energy had complied with the terms.
- **Markers:** PHMSA has twice found that TC Energy had not placed all required visual markers along the pipeline.[32] First, in the 2012 Warning Letter, PHMSA found TC Energy had not placed line markers at all road crossings. PHMSA cited condition #40 of the special permit, which requires line-of-sight pipeline markings except in areas

[32]Markers warn that a transmission pipeline is located in the area, identify the product transported in the line, and provide the name of the pipeline operator and a telephone to call in the event of an emergency.

where it is impractical.[33] Second, in a 2020 Notice of Probable Violation, PHMSA alleged 20 instances of missing markers in the special permit area that it observed during a 2018 inspection, which would be a violation of condition #40. It also proposed a civil penalty of $170,300. PHMSA issued a final order in November 2020 finding that TC Energy had committed this violation and assessed a civil penalty of $170,300.[34]

PHMSA Applied Lessons Learned from Keystone to Improve Pipeline Construction and Special Permit Oversight Nationwide

PHMSA officials told us that they have applied "lessons learned" since the time that Keystone was built by increasing the amount of staff resources it devotes to inspecting pipelines under construction. According to PHMSA officials, PHMSA inspectors spent 351 inspection days on site during Keystone's construction, from June 2008 to November 2010.[35] PHMSA did not issue any formal enforcement actions to TC Energy during construction, but PHMSA officials told us that inspectors brought up issues that were addressed at the construction site, such as improper welds and weld inspections. To address common issues such as poor quality control for welding and inadequate construction practices that PHMSA identified across 35 pipeline construction projects in the 2008 construction season, PHMSA held a workshop in April 2009 to alert the industry to construction issues that could affect pipeline integrity. Since then, the agency has placed increased focus on inspections during construction to improve oversight of additional pipelines. Specifically, PHMSA officials said that the agency now expects each of their inspectors to spend 20 to 25 percent of their time on construction inspections. Further, according to these officials, the number of days inspectors have spent on construction inspections has approximately doubled since 2010.

[33]Line-of-sight refers to being able to stand at one marker and see the next marker in order to determine the path of the pipe below. The special permit is more stringent than 49 CFR § 195.410, which requires pipeline markers at all road crossings but does not require that operators maintain the line-of-sight spacing.

[34]PHMSA closed the enforcement action in January 2021, as it had determined that TC Energy had complied with the terms of the final order and paid the civil penalty amount.

[35]We have previously reported that, given the size of PHMSA's inspection staff relative to the federally regulated pipeline network, PHMSA uses a risk-based inspection approach that allows it to allocate inspection resources to pipelines considered higher risk. GAO, *Pipeline Safety: Additional Actions Could Improve Federal Use of Data on Pipeline Materials and Corrosion,* GAO-17-639 (Washington, D.C.: Aug. 3, 2017).

PHMSA developed additional conditions as a result of "lessons learned" from construction and operation of the original Keystone pipeline, which it planned to apply to the construction of Keystone XL. Examples of these conditions include: (1) implementing a construction Quality Management System to ensure that the pipeline is built to the highest standards by TC Energy personnel and its contractors; and (2) hiring an independent third party inspector to monitor construction.[36] TC Energy previously agreed to these and other conditions that were developed in consultation with PHMSA as part of the State Department's presidential permit process. TC Energy announced that it terminated the Keystone XL project in June 2021, after the presidential permit for the pipeline was revoked in January 2021.

PHMSA officials noted that they will continue to monitor Keystone and are establishing a process to more formally document and track the safety and compliance of all special permits. Officials told us that, during its inspections of the Keystone pipeline, PHMSA monitors and evaluates TC Energy's compliance with the terms of the Keystone special permit and the operator's overall performance data. Officials also told us that PHMSA's regional and headquarters staff review TC Energy's annual reports on Keystone for compliance with the special permit. PHMSA officials said they plan to continue this process for all special permits, but is taking steps to more formally record and track these reviews, including developing a database by the end of 2021 to record the reviews and any actions resulting from the reviews.

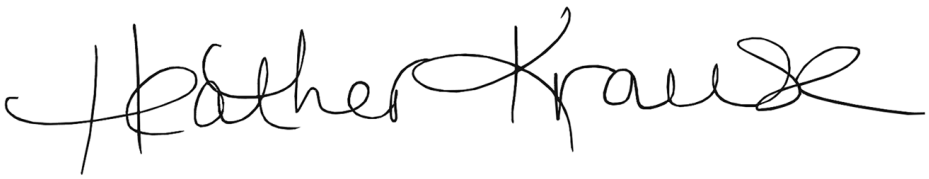
Agency Comments, Third Party Views, and Our Evaluation

We provided a draft of this report to the Department of Transportation and TC Energy for review and comment. In its comments, reproduced in appendix I, TC Energy generally agreed with the report and its findings. The Department of Transportation provided technical comments which we incorporated as appropriate.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Secretary of Transportation, and other interested parties. In addition, the report will be available at no charge on the GAO website at https://www.gao.gov.

[36]Department of State, *Final Supplemental Environmental Impact Statement for the Keystone XL Project,* Appendix Z: Compiled Mitigation Measures, (Washington, D.C.: January 2014).

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or KrauseH@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix I.



Heather Krause
Director, Physical Infrastructure

Appendix I: Comments from TC Energy

TC Energy
450 - 1 Street S.W. Calgary, AB
Canada, T2P 5H1

June 25, 2021

Ms. Emily Larson
Senior Analyst
U.S. Government Accountability Office
441 G Street, NW
Washington, D.C., 20548

RE: TC Energy Response to draft report GAO-21-588, "Information on Keystone Accidents and DOT Oversight"

Dear Ms. Larson,

Thank you for the opportunity to comment on this draft report. We appreciate the work of the Government Accountability Office (GAO) and the Pipeline and Hazardous Materials Safety Administration (PHMSA) and share their interest and commitment to the safe operation of our pipeline systems.

At TC Energy, nothing matters more to us than safety. Safety is a core value and embedded in everything we do. Our employees live and work in the communities where we operate, and every one of us takes seriously our responsibility to protect people, communities, and the environment. While our safety record is strong, we recognize we must continuously strive to do better. To that end, we have taken decisive action over the last several years to implement measures to strengthen our approach to safety and the integrity of the Keystone System with a laser-focus on incident prevention.

Meaningful Actions Have Been Taken to Improve Safety

Our actions to achieve a higher level of safety performance have included a comprehensive third-party review of our pipeline integrity program to capture and incorporate independent recommendations designed to improve our safety programs and processes. We have also leaned heavily into the development and utilization of new technology. For example, our engineering team helped develop an advanced inspection validation tool and next-generation crack detection technology that expands our ability to detect minute pipeline imperfections. By year-end, we will have conducted internal pipeline inspections using this and other state-of-the-art technologies through the entirety of the Keystone System.

These actions have contributed to a significant improvement in our safety performance, with zero high-impact incidents occurring in the past 18 months. Our team is working hard every day to extend this success well into the future.

The Keystone Special Permit Was Rigorously Reviewed and Not Connected to Pipeline Incidents

We agree with the report's acknowledgment of the rigorous approach PHMSA took to review the Keystone special permit application. As noted in the report, PHMSA requested and incorporated the input of pipeline safety experts, federal and state government officials, the Oak Ridge National Laboratory, and the public into the safety-related aspects of the permit. We agree with the safety and technical stakeholders who were interviewed for the report that the safety conditions included in the special permit offset any potential risk associated with operating at a higher stress level. We also agree with the report's acknowledgment that based on independent root cause

failure analyses, neither of the significant historical incidents that occurred on the Keystone System were causally related to the operation of our system under the terms of the special permit issued by PHMSA.

As noted in the report, TC Energy is not unique in its operation of our pipeline under a special permit, and PHMSA has issued similar permits to other pipeline operators. The Keystone System continues to operate well within the allowable engineering and design limits for safety and in compliance with additional requirements imposed by PHMSA, and we are confident it can continue to do so. We understand that PHMSA is preparing to more formally document and track compliance of all special permits. We wholeheartedly support them in this effort and stand ready to assist in any way possible.

TC Energy Has a Strong Safety and Sustainability Culture

At TC Energy, no safety incident will ever be acceptable to us. Our goal remains focused on reaching a zero-incident operating record. We believe this is achievable through a multi-layered approach to safety that includes a strong internal safety culture, industry-leading technology, a commitment to continuous improvement, and shared best practices and learnings across industry.

An equally broad approach is being taken toward the development of new initiatives that promote environmental sustainability and long-term economic opportunities for Indigenous groups in the U.S. and Canada. We are actively pursuing new renewable electricity projects to power pipeline operations with clean zero-carbon energy. When fully implemented, this initiative would reduce GHG emissions by two million metric tonnes annually. We are also exploring opportunities for Tribal Nations to own an equity stake in our North American energy assets, which would provide meaningful long-term financial benefits for those who participate.

The Keystone System is North America's critical energy transportation linkage between responsibly developed energy supplies in western Canada and some of the world's most sophisticated refining facilities in the U.S. Midwest and Gulf Coast. By safely and reliably connecting these endpoints, the Keystone pipeline provides enhanced economic and energy security for North America and the communities within its operational footprint.

We are committed to continuing to identify opportunities to apply this level of ingenuity across our business going forward, whether it's in safety innovation, environmental improvements, or economic development for North America.

Thank you again for the opportunity to comment on this draft report.

Sincerely,

Leslie Kass
Executive Vice-President, Technical Centre

Appendix II: GAO Contact and Staff Acknowledgments

GAO Contacts

Heather Krause, (202) 512-2834 or KrauseH@gao.gov

Staff Acknowledgments

In addition to the contact named above, Sara Vermillion (Assistant Director), Emily Larson (Analyst in Charge), Nirmal Chaudhary, Gary Guggolz, Georgeann Higgins, Delwen Jones, Andrea Levine, Mary-Catherine P. Overcash, Madhav Panwar, Malika Rice, and Kelly Rubin made key contributions to this report.

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