



THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable Bill Shuster
Chairman, Committee on Transportation
and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Enclosed is the report titled "A Study on Improving Damage Prevention Technology," as required by Section 8 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, Pub. L. No. 114-183 (June 22, 2016).

The Act directs the Secretary of Transportation, in consultation with stakeholders, to conduct a study on improving existing damage prevention programs through technological improvements in location, mapping, excavation, and communications practices to prevent excavation damage to a pipe or its coating, including considerations of technical, operational, and economic feasibility and existing damage prevention programs.

Similar letters have been sent to the Ranking Member of the House Committee on Transportation and Infrastructure; to the Chairman and Ranking Member of the House Committee on Energy and Commerce; and to the Chairman and Ranking Member of the Senate Committee on Commerce, Science, and Transportation.

Sincerely,

A handwritten signature in blue ink, reading "Elaine L. Chao", is positioned above the printed name.

Elaine L. Chao

Enclosure



THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable Peter A. DeFazio
Ranking Member
Committee on Transportation
and Infrastructure
U.S. House of Representatives
Washington, DC 20515

Dear Congressman DeFazio:

Enclosed is the report titled "A Study on Improving Damage Prevention Technology," as required by Section 8 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, Pub. L. No. 114-183 (June 22, 2016).

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THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable Greg Walden
Chairman, Committee on Energy
and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

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Similar letters have been sent to the Ranking Member of the House Committee on Energy and Commerce; the Chairman and Ranking Member of the House Committee on Transportation and Infrastructure; and to the Chairman and Ranking Member of the Senate Committee on Commerce, Science, and Transportation. I hope this information proves useful.

Sincerely,

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Elaine L. Chao

Enclosure



THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable Frank Pallone
Ranking Member
Committee on Energy and Commerce
U.S. House of Representatives
Washington, DC 20515

Dear Congressman Pallone:

Enclosed is the report titled "A Study on Improving Damage Prevention Technology," as required by Section 8 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, Pub. L. No. 114-183 (June 22, 2016).

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Elaine L. Chao

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THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable John Thune
Chairman, Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Mr. Chairman:

Enclosed is the report titled "A Study on Improving Damage Prevention Technology," as required by Section 8 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, Pub. L. No. 114-183 (June 22, 2016).

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Elaine L. Chao

Enclosure



THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

August 3, 2017

The Honorable Bill Nelson
Ranking Member
Committee on Commerce, Science,
and Transportation
United States Senate
Washington, DC 20510

Dear Senator Nelson:

Enclosed is the report titled "A Study on Improving Damage Prevention Technology," as required by Section 8 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016, Pub. L. No. 114-183 (June 22, 2016).

The Act directs the Secretary of Transportation, in consultation with stakeholders, to conduct a study on improving existing damage prevention programs through technological improvements in location, mapping, excavation, and communications practices to prevent excavation damage to a pipe or its coating, including considerations of technical, operational, and economic feasibility and existing damage prevention programs.

Similar letters have been sent to the Chairman of the Senate Committee on Commerce, Science, and Transportation; the Chairman and Ranking Member of the House Committee on Transportation and Infrastructure; and to the Chairman and Ranking Member of the House Committee on Energy and Commerce.

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Elaine L. Chao

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U.S. Department of Transportation

Pipeline and Hazardous Materials Safety Administration

A Study on Improving Damage Prevention Technology

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Executive Summary

The U.S. Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) is the Federal regulatory authority responsible for gas and hazardous liquid pipeline safety. The Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016 (Public Law 114-183, June 22, 2016), directed the Secretary of Transportation, in consultation with stakeholders, to conduct a study on improving existing damage prevention programs through technological improvements in location, mapping, excavation, and communications practices to prevent excavation damage to a pipe or its coating, including considerations of technical, operational, and economic feasibility and existing damage prevention programs.

This study includes (1) an identification of any methods to improve existing damage prevention programs through location and mapping practices or technologies in an effort to reduce releases caused by excavation; (2) an analysis of how increased use of global positioning system digital mapping technologies, predictive analytic tools, public awareness initiatives including one-call initiatives, the use of mobile devices, and other advanced technologies could supplement existing one-call notification and damage prevention programs to reduce the frequency and severity of incidents caused by excavation damage; (3) an identification of any methods to improve excavation practices or technologies in an effort to reduce pipeline damage; (4) an analysis of the feasibility of a national data repository for pipeline excavation accident data that creates standardized data models for storing and sharing pipeline accident information; and (5) an identification of opportunities for stakeholder engagement in preventing excavation damage.

PHMSA used existing data and information, and consulted with numerous key stakeholders for input. At PHMSA's bi-annual Research and Development (R&D) Forum held in November 2016, a working group focused heavily on the threat of excavation damage to pipeline safety and made several recommendations that PHMSA used to inform this study. PHMSA also consulted with key trade associations and the leading national damage prevention stakeholder organization. Many stakeholder organizations responded, and those responses included a wide variety of recommendations for methods to improve damage prevention technology, practices, and policies.

Regulatory requirements and market needs often drive damage prevention technology development and use, and PHMSA's R&D program also aids in the development of such technology. Stakeholder organizations continually develop and improve public awareness efforts and opportunities for stakeholder participation, and both PHMSA and stakeholders collect damage data in secure databases. PHMSA identified gaps and opportunities for improvement in the areas of data collection, technology development and application, and excavation damage prevention requirements. While PHMSA's recommendations do not reflect all stakeholder suggestions, the recommendations reflect common themes from all stakeholders. The full set of raw data showing stakeholder input is found in the appendices to this study.

Despite efforts by PHMSA and other stakeholder groups, such as pipeline operators, excavators, and trade associations, to improve the various practices and technologies associated with excavation damage prevention, excavation damage remains one of the leading causes of serious

pipeline accidents. Although data show a reduction in both the numbers and percentages of serious accidents caused by excavation damage,¹ more work is needed to further reduce threats to safety and security. Recommendations from this study include:

1. Develop collaboration/communication tools that foster better communication between the excavator and pipeline operator throughout the excavation process.
2. Evaluate and implement predictive analytic tools, which use data to identify and proactively address high-risk excavations.
3. Improve and implement GPS/GIS technologies in accurately locating and documenting the location of underground facilities.
4. Consider requiring operator damage data reporting.
5. Promote universal participation in the one-call process.
6. Consider the development of national standards for certain state one-call requirements.
7. Strengthen state damage prevention enforcement programs.
8. Pursue improvements in locating processes and technologies and right-of-way monitoring technologies.
9. Promote the continued identification and implementation of the Common Ground Alliance (CGA)² and other damage prevention best practices, and the education of stakeholders toward the benefits thereof.

Damage prevention is a shared responsibility. It is important that all affected parties are involved in the development and implementation of any of these recommendations or any other improvements to damage prevention programs.

¹ See PHMSA excavation damage data: <https://primis.phmsa.dot.gov/comm/DamagePrevention.htm?nocache=8655>

² The CGA is a nonprofit member-driven association dedicated to ensuring public safety, environmental protection, and the integrity of services by promoting effective practices for preventing excavation damage to underground utilities/facilities.

Introduction

The objective of this study is to address the five study requirements outlined in the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2016 (the Act).³

The Department of Transportation's Pipeline and Hazardous Materials Safety Administration (PHMSA) is the Federal regulatory authority for gas and hazardous liquid transportation pipeline safety. PHMSA's mission is to protect people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives.

Excavation damage is a leading cause of pipeline accidents resulting in fatalities and injuries. PHMSA addresses this threat to pipeline and public safety through a broad array of initiatives. PHMSA's efforts are guided by nine specific elements characteristic of strong state damage prevention programs. As cited by Congress in the 2006 Pipeline Inspection, Protection and Enforcement Act (the 2006 Act)⁴, those nine elements are:

- Element 1 - Enhanced Communication between Operators and Excavators
- Element 2 – Fostering Support and Partnership of all Stakeholders
- Element 3 – Operator's Use of Performance Measures for Locators
- Element 4 – Partnership in Employee Training
- Element 5 – Partnership in Public Education
- Element 6 – Enforcement Agencies' Role to Help Resolve Issues
- Element 7 – Fair and Consistent Enforcement of the Law
- Element 8 – Use of Technology to Improve the Locating Process
- Element 9 – Data Analysis to Continually Improve Program Effectiveness

Section 8 of the Act directed the Secretary of Transportation (the Secretary), in consultation with stakeholders, to conduct a study on improving existing damage prevention programs through technological improvements in location, mapping, excavation, and communications practices to prevent excavation damage to a pipe or its coating, including considerations of technical, operational, and economic feasibility and existing damage prevention programs. The Act specified that the study shall include:

- (1) an identification of any methods to improve existing damage prevention programs through location and mapping practices or technologies in an effort to reduce releases caused by excavation;
- (2) an analysis of how increased use of global positioning system digital mapping technologies, predictive analytic tools, public awareness initiatives including one-call initiatives, the use of mobile devices, and other advanced technologies could supplement existing one-call notification and damage prevention programs to reduce the frequency and severity of incidents caused by excavation damage;

³ Public Law No. 114-183 (6/22/2016).

⁴ See 2006 Pipeline Inspection, Protection and Enforcement Act: <https://www.gpo.gov/fdsys/pkg/PLAW-109publ468/pdf/PLAW-109publ468.pdf>.

- (3) an identification of any methods to improve excavation practices or technologies in an effort to reduce pipeline damage;
- (4) an analysis of the feasibility of a national data repository for pipeline excavation accident data that creates standardized data models for storing and sharing pipeline accident information; and
- (5) an identification of opportunities for stakeholder engagement in preventing excavation damage.

The Secretary is required to submit to the Senate Committee on Commerce, Science, and Transportation, the House Committee on Transportation and Infrastructure, and the House Committee on Energy and Commerce a report containing the results of the study, including recommendations, that include the consideration of technical, operational, and economic feasibility, on how to incorporate into existing damage prevention programs technological improvements and practices that help prevent excavation damage.

PHMSA determined that requirements 1 and 3 are similar, in that they both entail the identification of methods, and are addressed in one section of this report. PHMSA addressed study requirements 2, 4, and 5 separately. It is also important to note that all five study requirements may be inter-related. Therefore, the technologies and practices, in many cases, address more than one of the five requirements of the study. For example, the use of Global Positioning System (GPS) mapping technology to continually update records and the incorporation of those records into operator geographic information systems (GIS) benefits both locators and excavators (addressing requirements 1 and 3). Similarly, public awareness and education programs can address nearly any of the study requirements.

Section 1: Background

Nationwide data show that damage to an underground utility line occurs every six minutes because someone began digging without first determining if underground utilities exist in the digging area. Digging without knowing the location of existing underground utilities can result in damage to gas, hazardous liquid, electric, communication, water, and sewer lines. These damages can lead to service disruptions, costly repairs, and sometimes serious injury and death. “One-call” or “Call before you dig” systems and the technologies they use have evolved over the last 20 years to facilitate and encourage excavators to call and have existing underground utilities located and marked before they begin to dig. One-call system operators stand at the forefront in the promotion, development, and use of communication, mapping, and other technologies to prevent damage to underground utilities.

With the one-call process, individuals planning to dig can make a single call to provide information about the planned excavation project to one-call center representatives who, in turn, transmit the information to operators that may have underground facilities in the area of the project. The facility operators are responsible for locating their underground facilities and visibly marking the locations of the facilities to enable the excavator to know where existing underground facilities are located and avoid hitting them when digging.

In 2007, “811” was established as the nationwide one-call number. The 811 number enables an excavator to call from anywhere in the country to access the appropriate one-call center. Each state has its own 811 call center to help excavators avoid damaging underground utilities. Establishment of the toll-free 811 number was a result of the Pipeline Safety Improvement Act of 2002, with support from PHMSA and other stakeholders. More information about 811 is available at www.call811.com.

In some states, the facility location markings serve as notification to the excavator; in other states, the facility owner/operator may be required to provide a positive response back to the excavator. The locating, marking, and notification requirements vary by state, based on individual state one-call laws, but the process is generally required to be completed in two to three days. After underground facilities have been located and marked, excavation can proceed.

While this process seems straightforward, there are many variables that can impact the safety of a digging project, including the clarity and applicability of the state one-call law, the accuracy of the facility locating process, and the care taken by the excavator when digging around underground lines. Overall, the best way to prevent excavation damage to an underground facility and to protect safety is for excavators to make the initial call to 811. In 99 percent of the cases when this step is taken, no damage will occur.⁵

PHMSA has long been active in advancing excavation damage prevention programs. PHMSA’s pipeline safety regulations require pipeline operators to develop and implement damage prevention programs and to participate in qualified one-call systems; PHMSA’s Distribution Integrity Management Program (DIMP) requires gas distribution pipeline operators to take steps to address the threat of excavation damage to their pipeline systems; and PHMSA’s Public Awareness regulations require pipeline operators to develop and implement written continuing public education programs to stakeholder audiences. PHMSA couples these regulatory requirements with educational programs, data collection and analysis, stakeholder partnerships, grant programs and research and development programs — all addressing damage prevention. More recently, in states where enforcement of the state one-call law is deemed inadequate to protect safety, PHMSA now has authority to take federal enforcement actions against excavators who fail to comply with one-call requirements and damage a pipeline.⁶

Despite efforts by PHMSA and other stakeholder groups such as pipeline operators, excavators, and trade associations to improve the various practices and technologies associated with excavation damage prevention, excavation damage remains one of the leading causes of serious pipeline accidents. Although data show a reduction in both the numbers and percentages of serious accidents caused by excavation damage,⁷ more work is needed to eliminate this threat to safety and security.

⁵ Common Ground Alliance (CGA) voluntary Damage Information Reporting Tool (DIRT), Analysis & Recommendations, Vol. 10, 2013. The 2015 DIRT report estimates total damages to underground facilities in 2015 at 317,000.

⁶ See Pipeline Inspection, Protection, Enforcement and Safety (PIPES) Act of 2006 (the 2006 Act).

⁷ See PHMSA excavation damage data: <https://primis.phmsa.dot.gov/comm/DamagePrevention.htm?nocache=8655>.

In addition to the nine elements of effective damage prevention programs noted above, additional guidance for establishing strong damage prevention programs is found in the Common Ground Alliance (CGA)⁸ Best Practices Guide. These best practices are developed and updated by a CGA committee in consideration of input and consensus from a broad array of damage prevention stakeholders. They include practices for one-call centers, mapping, locating, excavating, compliance, reporting, public awareness, and other areas. PHMSA supports the development, publication, distribution, and incorporation of the CGA Best Practices into state damage prevention programs.

The five study requirements of the Act include technology-specific damage prevention elements as well as other related elements such as public awareness, damage data, and stakeholder engagement. This report and recommendations encompass those aspects to improve damage prevention.

Section 2: Methodology and Inputs

To develop this study, PHMSA used its own internal resources and sought and received comprehensive input from a variety of stakeholders. That stakeholder input addressed the use of technology in damage prevention recommendations for policy and regulatory changes, and suggestions for future research and development.

PHMSA gathered input and information from:

- PHMSA Research and Development (R&D) Programs
- PHMSA Grants and Enforcement Programs
- PHMSA State-specific Damage Prevention Information
- PHMSA Research and Development Forum
- The Common Ground Alliance
- Other Stakeholder Organizations

Stakeholder input and PHMSA's internal resources are further described in this section.

PHMSA Research and Development Programs

PHMSA conducts and supports research to support regulatory and enforcement activities and to provide the technical and analytical foundation necessary for planning, evaluating, and implementing the pipeline safety program. PHMSA sponsors R&D projects focused on providing near-term solutions that will increase the safety and reliability of our Nation's pipeline system and lead to the commercialization of new technologies. Several R&D projects address technological solutions to improving damage prevention. For example, in 2005, PHMSA, with support from other key stakeholders, initiated a pilot project in Virginia to enhance the one-call damage prevention process through the use of GPS technology. The project was undertaken as a 'proof-of-concept' project to research and implement new and existing technology to

⁸ CGA is a nonprofit dedicated to safety, environmental protection, and service integrity through implementation of effective excavation damage prevention practices. CGA continues the damage prevention efforts embodied by the 1999 Common Ground Study sponsored by PHMSA (www.commongroundalliance.com).

significantly enhance the development and communication of accurate information among stakeholders regarding the exact locations of planned excavations and of underground utilities. Phase I of the Virginia Pilot Project focused on technology that allowed the boundaries of one-call excavation tickets to be more accurately identified by excavators in the field using GPS-enabled mobile phones. Phase II of the Virginia Pilot Project applied GPS technology, along with enhanced software and locating equipment, to improve the underground facility locating process by improving the accuracy, amount, and functionality of data resulting from facility locates. Phase II resulted in the creation of geographically accurate “electronic ticket manifests” to provide an electronic graphical overview and utility mapping of an excavation site. Phase III of the Virginia Pilot Project demonstrated a GPS-based system that monitors excavation activity. The system provides a warning if excavation activity is occurring outside of a valid one-call ticket or in close proximity to underground facilities. PHMSA has also provided funding for R&D projects to improve acoustic-based locating technology, the development of detection technology that can be used on underground horizontal drill heads, and many other important damage prevention technological improvements.

In 2013, PHMSA implemented the Competitive Academic Agreement Program (CAAP)⁹ to further encourage innovation in pipeline safety research. The CAAP targets university students for the future pipeline safety workforce. The intent of the program is to spur innovation by enabling academic research focused on high risk and high pay-off solutions for wide-ranging pipeline safety challenges. The CAAP focuses on the delivery of desired solutions that can be handed-off to further investigations in CAAP or in PHMSA’s core research program, employing partnerships with a variety of public/private organizations. One goal in this strategy is to validate proof-of-concept of a thesis or theory, and potentially develop it all the way to commercial market penetration. Several projects funded under the CAAP address technological improvements in damage prevention. For example, CAAP awards address the challenge of improving methods to locate pipelines that are traditionally difficult to locate, using electromagnetic sensing, embedded passive radio frequency tags, or application of amorphous metals. From 2012 to 2016, PHMSA awarded over \$3.5 million in R&D and CAAP funding to improve damage prevention.

A summary of PHMSA R&D projects and posters describing the CAAP projects can be found in Appendix A. More information about PHMSA’s R&D programs can be found at <http://www.phmsa.dot.gov/pipeline/research-development>.

PHMSA Grants and Enforcement

PHMSA’s grant programs often serve as conduits for implementation of technology and/or practices to improve damage prevention. For example, in recent years, a large percentage of

⁹ The authority for PHMSA’s Pipeline Safety Research and Development Program, including the CAAP program, comes from the Pipeline Safety Improvement Act of 2002 (P. L. 107-355). Further, the authority to enter into cooperative agreements under the CAAP initiative is codified at 49 U.S.C. 60117(k).

PHMSA State Damage Prevention Grants and One-call Grants have funded costs associated with enforcement of state one-call laws, including personnel costs.

As the Act requires the identification of any methods to improve excavation practices or technologies to reduce pipeline damage, it is appropriate to note the importance of effective enforcement as a practice. Effective enforcement of state one-call laws is a priority for PHMSA. In states with adequate enforcement, excavation damage rates decrease and safety improves.¹⁰ Additionally, Congress prioritized state damage prevention enforcement in the 2006 Act by directing PHMSA to take enforcement actions against excavators who failed to comply with one-call requirements and damage a pipeline facility. While PHMSA's authority to take enforcement actions is limited to excavation activity occurring in states where state enforcement of the one-call law is deemed by PHMSA to be inadequate to protect safety, the intent of the enforcement program is to incentivize states to adequately enforce their state one-call laws. In recent years, many states have passed legislation, adopted regulations, or have made other improvements aimed at stronger, more effective damage prevention enforcement. Many have also used PHMSA State Damage Prevention and One-call grants, which are further described below, to implement those programs. Also provided are examples of implementation of programs related to the study requirements and links to more specific grant program information.

State Damage Prevention Grants

The State Damage Prevention (SDP) Grant Program awards funds of up to \$100,000.00 per year to fund state authorities to implement the nine elements of effective damage prevention programs, as outlined in the 2006 Act and discussed above. From 2012 to 2016, PHMSA awarded over \$1.7 million to state organizations to improve damage prevention technologies and practices relating to the study requirements.

Examples of past PHMSA State Damage Prevention grant-funded projects include:

- Implementation of a cloud and mobile-based geospatial solution with the ability to support processes to capture and store subsurface utility engineering data, which can be displayed visually on a Geographical Information System (GIS);
- Software to improve mapping data and programs;
- Portals for data collection and analysis;
- Development of mobile apps to enhance communication about excavation activity; and
- Stakeholder meetings and summits to provide opportunities for damage prevention stakeholder engagement.

More information about PHMSA's SDP Grant Program, including progress and final reports for each of the grant projects, can be found at <http://primis.phmsa.dot.gov/sdp/>.

¹⁰ Common Ground Alliance (CGA) Damage Information Reporting Tool (DIRT), Analysis & Recommendations, Vol. 11, 2014.

One-Call Grants

PHMSA's One-Call Grant Program provides funding to state agencies to promote damage prevention, including changes to their state underground damage prevention laws, related compliance activities, training, and public education. This grant program is for states that have a certification or agreement with PHMSA for the states to perform pipeline safety inspections¹¹. State agencies that participate in the pipeline safety program are eligible to apply for one-call grant funding on an annual basis, with a maximum request amount of \$45,000 per state. From 2012 to 2016, PHMSA funded over \$850,00 in One-Call Grants for damage prevention technologies and practices that align with the requirements of this study including:

- Technical training on locating underground facilities;
- Development, implementation, and administration of damage data collection tools and the analysis of data;
- Creation of interactive tools used to simulate line hits (used for training purposes); and
- Participation in damage prevention stakeholder meetings to develop damage prevention strategies.

More information on this grant program can be found under the "One-Call Grant" section at <http://primis.phmsa.dot.gov/comm/DamagePreventionGrantsToStates.htm>.

Technical Assistance Grants (TAG)

PHMSA's TAG Program was developed to offer new opportunities to strengthen the depth and quality of public participation in pipeline safety matters. Past TAGs awarded communities and groups of individuals funding for technical assistance in the form of engineering or other scientific analysis of pipeline safety issues, and to help promote public participation in official proceedings. PHMSA first awarded TAG funding for projects beginning in 2009, and the TAG program has funded numerous projects that address damage prevention technology, especially in the area of GIS. From 2012 to 2015, PHMSA awarded over \$1.7 million to communities for damage prevention technologies and practices that relate to the requirements of this study. More information on the TAG grant projects can be found at <http://primis.phmsa.dot.gov/tag>.

PHMSA State-specific Damage Prevention Information

There is considerable variability among state excavation damage prevention laws, regulations, and programs. PHMSA aggregates operator-reported pipeline incident, infrastructure, leak, and other safety-related data, along with state-specific data to develop information about state excavation damage prevention programs. Using this information helps PHMSA target limited resources to help address gaps in excavation damage prevention programs. PHMSA publishes online web pages that provide information about all state damage prevention programs.¹²

¹¹ More information on Federal and state authorities, including a link to lists of states participating in the Federal/State Cooperative Gas and Hazardous Liquid Pipeline Safety Programs is available at: <https://primis.phmsa.dot.gov/comm/Partnership.htm>.

¹² <https://primis.phmsa.dot.gov/comm/states.htm?nocache=6840>

Additional Input - External

Section 8(a) of the Act directed PHMSA to develop this study “in consultation with stakeholders.” Thus, in addition to incorporating information about PHMSA’s existing programs to inform this study, PHMSA sought external input from stakeholder organizations traditionally involved in damage prevention.

PHMSA R&D Forum

On November 16-17, 2016, PHMSA sponsored a Pipeline R&D Forum (Forum) in Cleveland, Ohio. The 2-day event is held bi-annually to generate a national research agenda that fosters solutions for the many challenges to pipeline safety and protecting the environment. The Forum allows public, government, and industry pipeline stakeholders to develop a consensus on the technical gaps and challenges for future research. It also reduces program duplication, factors ongoing research efforts, leverages resources, and broadens synergies. The national research agenda coming out of these events is aligned with the needs of PHMSA’s pipeline safety mission, makes use of the best available knowledge and expertise, and considers stakeholder perspectives. Specifically, the Forum:

1. Identified key pipeline technical challenges facing industry and government,
2. Disseminated information on current research efforts, and
3. Identified new research that could address known challenges.

During the Forum, five working groups addressed specific areas of focus for technology and research and development. The “Threat Prevention” working group focused on damage prevention technology and issues that aligned, to a large degree, with the study requirements in the Act. Topics included excavation damage, pipeline locating technology, rights-of-way monitoring, and other pipeline threats. The working group identified four primary gaps for consideration:

- Accurately locating and documenting the location of existing underground facilities,
- Continued development of predictive analytics to sort the major risks using multiple data sources,
- Adoption of best practices and education of public, and
- Broad use of GPS with accuracy standards.

These gaps address the foundations of strong damage prevention programs: operators having a comprehensive knowledge of their underground facility systems, the use of data to understand and address threats to pipeline systems, and shared responsibility in developing practices that are understood and used by all stakeholders. While much has been accomplished in these areas over the past several years, more work is needed to reduce the threat of excavation damage to pipeline facilities.

More information on the PHMSA 2016 R&D Forum, including presentations and report-outs, can be found at http://primis.phmsa.dot.gov/rd/mtg_111616.htm.

Common Ground Alliance

The CGA¹³ is a nonprofit member-driven association dedicated to ensuring public safety, environmental protection, and the integrity of services by promoting effective practices for preventing excavation damage to underground utilities/facilities. The CGA was established in 2000 in response to and in continuation of the damage prevention efforts embodied by the Department of Transportation's Common Ground Study,¹⁴ a collaborative effort of 160 industry professionals who identified best practices related to damage prevention.

A primary tenet of the CGA is that damage prevention is a shared responsibility of all stakeholders. Any damage prevention best practice or program endorsed by the CGA is supported by consensus from experts representing the following stakeholder groups:

- Excavators
- Locators
- Road Builders
- Electric Industry
- Telecommunications
- Pipelines (Hazardous Liquid, Gas Transmission, Gas Distribution, Gathering)
- Railroads
- One-call Organizations
- Public Works
- Public Safety Advocates
- Equipment Manufacturing
- State Regulators
- Insurance
- Emergency Responders
- Engineering/Design Organizations

PHMSA invited the CGA to provide input on any or all requirements of this study, as required by the Act. The CGA enlisted its Technology Committee to gather and provide information to PHMSA. The Technology Committee formed five task teams to align with each of the five specific deliverables required by the Act and used a survey to gain input from all interested CGA members and other stakeholders. The report and recommendations from the CGA are found in Appendix B; raw CGA survey responses are found in Appendix F.

The CGA recommendations include the following items:

CGA Recommendations for Requirement 1

1.a. Improve GPS Data Accuracy: The CGA recommends that all technologies focused on GPS data points deliver a final product that is at least within one meter of accuracy, which most

¹³ www.commongroundalliance.com

¹⁴ Common Ground Study of One Call Systems and Damage Prevention Best Practices. Sponsored by U.S. DOT Research and Special Programs Administration, Office of Pipeline Safety, as authorized by the Transportation Equity Act for the 21st Century. August 1999.

closely matches the locate mark parameters. All GPS data is not “good data.” The industry must guide everyone involved to provide accurate data to see a reduction in damages.

1.b. Verify Records Accuracy: The CGA recommends that there be a documented process to verify the accuracy of the records before a utility modifies or updates that data set.

1.c. Manufacturers’ Data Should Demonstrate Benefits: New technologies that have previously focused on accurate locating with the use of electromagnetic devices have demonstrated reduced risk associated with excavating. The CGA recommends that as a new technology becomes available, manufacturers capture and provide supporting data to demonstrate the overall benefit and their ability to provide measurable reductions in damages.

CGA Analysis and Recommendations for Requirement 2

2.a. Improve GPS Digital Mapping: Many aspects of the damage prevention process will benefit from a nationwide focus on improving the accuracy, quality, and consistency of geospatial information related to underground assets. This includes capturing or reporting geographic location in a common coordinate system, capturing accurate facility depth, and aligning facility records with a common land base. It also includes the ability to continuously improve geospatial data accuracy anytime underground facilities are located in the field (during the locate process, or any other activities that expose underground facilities such as repair, close interval surveys, in-line inspections, new installations, etc.). This will require significant investment to achieve.

2.b. Evaluate and Adopt Predictive Analytics: There are multiple opportunities throughout the damage prevention process to apply predictive analytic techniques (objective risk assessment) to more efficiently allocate limited resources to minimize the probability or consequences of excavation damage by using data to identify and proactively address high-risk excavations. This type of risk assessment would be most useful if it were to be made available as part of the locate notification sent from each one-call center to the underground facility owners. It should also be capable of incorporating data collected from all participants in the damage prevention process, including the locating personnel who mark the underground lines, and the underground facility owner.

2.c. Apply CGA Public Awareness and One-Call Center Best Practices: Experience shows that highly successful public awareness initiatives target specific audiences. High-impact target audiences include the agricultural community, excavators, landscapers, and homeowners. Proposed tactics to reach these audiences include 811 labeled excavation equipment (including rental equipment), 811 information at permitting offices, targeted 811 internet awareness campaigns, Spanish-language materials, and 811 information at do-it-yourself retail stores.

The CGA recommends the review and application of as many as practical of the One-call Center and Public Education and Awareness practices, contained in Chapter 3 and 8 of the CGA Best Practices, for each location.

2.d. Enable Use of Mobile Technology: Any technology investments that are being encouraged, mandated, or funded at the federal (or state) level should require or enable use of mobile technology wherever applicable, including “internet of things” concepts (mobile sensor technology).

CGA Analysis and Recommendations for Requirement 3

- 3.a. Ensure Accurate Communication: Accurate and effective communication between operators, locators, and excavators throughout the excavation cycle is imperative. The cycle starts with clearly defining the "dig area" or "work scope" and effectively communicating the information through the 811 Center to facility operators.
- 3.b. Hold Pre-Construction Meetings: Scheduling pre-construction meetings (see CGA Best Practice 5-4) with the excavators, operators, and locators on major or large projects offers an effective forum to discuss the flow of the job. These meetings open all lines of communication and enable the contractors involved to get the job done faster and safer, and more importantly reduces the likelihood of a damage occurring.
- 3.c. Monitor Excavations: Operator personnel monitoring excavation and backfill activities help to ensure that the job is completed consistent with the owner's requirements. In November 2016, the CGA Best Practices Committee approved a new practice titled "Facility Owner Provides a Monitor During Excavation."¹⁵
- 3.d. Record and Analyze Hits and Near Misses: Tracking, reporting, and related recordkeeping for all facility hits and near misses provides documentation of vital information enabling improvements by operators, locators, and excavators.
- 3.e. Evaluate and Adopt Technology Improvements: Technological developments, especially mobile devices, are constantly changing the game to the betterment of damage prevention. Excavation contractors are increasingly relying on mobile technologies that provide "real time," on-site data and information gathering and dissemination opportunities.

CGA Recommendation for Requirement 4

The CGA believes development of a national data repository for pipeline excavation accident data that creates standardized data models for storing and sharing pipeline accident information is feasible using the Damage Information Reporting Tool (DIRT). The CGA DIRT database serves as a national data repository and creates standardized data models, but its use is voluntary and, thus, not comprehensive to all pipeline excavation damage incidents.

CGA Recommendation for Requirement 5

- 5.a. PHMSA Review CGA Survey: The CGA recommends that PHMSA review each submission to the CGA survey, study the concepts and data presented, and seek further information as necessary.
- 5.b. Enhance Ownership of Damage Prevention: As public rights-of-way become even more congested with the introduction of new or the addition of "overbuild" utility lines, utility operators, locate technicians, and excavators are presented with new challenges and increasingly complex work sites, requiring better communication to work safely and efficiently. Effective damage prevention requires a proactive approach, a sense of ownership responsibility, and a genuine commitment on the part of everyone involved — excavator, locator, one-call center (811), and the utility operator. These stakeholders have a tradition of leadership in this area, through active participation in damage prevention processes, and through knowledge and use of

¹⁵ See Common Ground Alliance Best Practices 14.0, March 2017

CGA Best Practices. However, the excavation industry has an opportunity to further that commitment to safety and damage prevention.

5.c. Eliminate One-call Exemptions: The CGA recommends that each state review and eliminate as many exemptions as possible from their one-call laws (see Best Practice 5-1). The CGA DIRT Report for 2013 showed that 18 states with five or more exemptions had a reported rate of 7.32 damages per thousand one-call tickets, while 18 states with 4 or fewer exemptions had a reported rate of 3.5 damages per thousand tickets. New methods and technologies now being developed and deployed can improve the speed and accuracy of communication among all parties, lower participation costs, and improve safety. These data and improvements reduce the justification for exemptions.

Other Stakeholder Organizations

Many damage prevention stakeholder organizations and their members are also members of the CGA. However, PHMSA recognized that stakeholders with interest and knowledge of damage prevention technology may have additional specific inputs for this study. PHMSA invited participation in the study by contacting each of the following organizations and requesting voluntary input that addresses any or all of the study requirements found in the Act:

- American Gas Association (AGA)
- American Petroleum Institute (API)
- Association of Oil Pipelines (AOPL)
- American General Contractors (AGC)
- Distribution Contractors of America (DCA)
- National Utility Locating Contractors Association (NULCA)
- National Association of Pipeline Safety Representatives (NAPSR)
- Utility Workers Union of America (UWUA)

Three organizations provided input for the study: API/AOPL (combined), the DCA, and the UWUA. Their input focused on different topics. API/AOPL provided a variety of recommendations on the topics of technology, procedures and practices, communications, and public awareness. For example, API/AOPL suggested that PHMSA conduct R&D on technology to automatically and securely disseminate pipeline information to target audiences, such as emergency responders and public officials; the feasibility of national standards for certain one-call requirements; and public awareness methodologies, messaging and distribution. The UWUA input focused on stronger measures to improve digging practices around underground facilities that have been properly located and marked, including licensing requirements, enhanced training, and tracking of successor companies for records of unsafe digging or violations. The DCA strongly encouraged full participation by underground facility owners (i.e., no exemptions), including municipalities, in the one-call process, especially to avoid the threat of cross-bores, which are further described Section 3.

All stakeholder input was considered by PHMSA, and while the recommendations in this report do not incorporate all suggestions submitted, the stakeholders provided many additional recommendations that could be considered for ongoing discussions.

Section 3: Methods to Improve Mapping, Locating, and Excavation Practices and Technologies

This section of the report gives an overview of the identification of methods to improve locating, mapping, and excavation practices or technologies.

The ability to accurately and reliably locate, identify, and characterize buried pipelines before digging is critical to reducing incidents caused by hitting and/or damaging pipelines with mechanical equipment. A variety of technologies are both in use and in development to improve the capability and accuracy of locating underground pipelines and mapping their locations. Similarly, once underground lines have been located and marked, it is essential to ensure safe digging practices and technologies are in place to prevent damage.

PHMSA identified a wide variety of technologies and practices addressing the improvement of locating, mapping, and excavating. All of them, to varying degrees of success, have been implemented by some stakeholders to improve damage prevention. Most technologies and practices that are effective continue to be enhanced or further developed. As improvements are made, it is reasonable to expect that further implementation will improve damage prevention and pipeline safety. Some examples include:

- **Technologies to locate “un-locatable” plastic pipe.** In general, the most common method to determine the location of underground pipelines is to impress an electronic signal on the metallic pipe and use an above-ground receiver to identify and trace the location. New plastic pipe is often installed with metallic tracer wire to enable the electronic signal to be impressed and transmitted to the receiver. Though this method is generally acceptable, there are circumstances in which it is not always reliable. In addition, there is a substantial amount of installed plastic pipe that is un-locatable because there is no metallic path (or tracer wire) in place. It is important to develop reliable technology that provides ease of use and cost efficiencies for widespread use to locate these otherwise un-locatable facilities. Considerable efforts are underway for technologies to address this gap, including:
 - Acoustic locating technology
 - Line tracers - insertion of material into pipes to allow for temporary locating
 - Directional entry tools (providing access to the pipeline facility in tight bend, etc.)
 - Ground penetrating radar
 - Radio Frequency Identifying tags (RFIDs)
 - Marker balls
- **Rights-of-way (ROW) encroachment detection technologies.** PHMSA and other organizations have supported research and studies to develop monitoring technologies that can provide automatic notification of activity within a pipeline ROW. These include technologies such as aerial monitoring, acoustic signaling, and seismic monitoring.

- **Use of GPS.** Various technologies have been and are being developed to integrate GPS in locating and excavating activities, including the creation and use of digitized records, automated uploads of records, and map-based records. For example:
 - Geospatial and utility-attribute data for underground facilities is typically captured by locate/mapping technicians. The data is processed and subsequently posted to the facility owner/operator's mapping (GIS) database, allowing the operator to gather accurate location and attribute data for its new and legacy in-service facilities.
 - Digitized, map-based records that capture all information about locates are transmitted to excavators.
- **Trenchless excavation.** Improvements in trenchless excavation technologies and practices include, but are not limited to:
 - Exposure of the underground line through potholing, particularly where underground lines cross;
 - The use of sensors on drill heads to detect potential conflicts; and
 - Post-bore pull-back cameras, whereby upon completion of a pneumatic bore prior to installing a new gas service line, a camera is pulled back through the bore hole to verify there is no conflict with unmarked or unknown facilities.
- **Enhanced positive response.** After an underground facility locate has been completed, the excavator receives comprehensive information about the site, including the locate request information, facility maps, photos, and virtual manifests.
- **Soft excavation tools.** The use of soft excavation tools such as vacuum excavating and hydro-excavating have shown improvements in damage prevention, and their use is becoming more widespread.
- **As-built records.** Installation records of the location and configuration of underground facilities are verified during excavation activities, corrected as necessary, and incorporated into operator GIS on an ongoing basis.
- **Damage reporting.** Damages and near-misses are reported to a centralized database to include root cause. This is not consistent from state to state.
- **Training.** Excavator tailgate and pre-job meetings and training, and locator training can increase effectiveness of these tools.
- **Exemptions in state laws.** Removal of exemptions in state laws to require all facility owners to be members of one-call systems and to locate and mark their underground facilities. Such exemptions create gaps in safety. This is particularly true when there is a threat of a "cross-bore," which occurs when an existing underground utility or underground structure is intersected by a second utility. This can compromise the

integrity of either or both intersecting facilities, and has occurred numerous times during installations of gas distribution lines using trenchless technology.

Gas distribution lines have been installed through cross-bores that penetrated unmarked underground sewer lines. In these situations, the penetrating gas line can be compromised if a sewer line clog occurs and a “roto-rooter”-type machine is used to clear the clog. The gas line can be cut or completely severed, and the sewer line can provide a direct path for leaking natural gas to migrate into one or more homes or other structures. This can pose serious, life threatening consequences.

There are many programs and initiatives underway to address legacy cross-bore issues. However, some state one-call laws exempt municipalities (i.e., sewer line operators) from the requirements to mark/locate sewer lines. This can result in an increased possibility of sewer line cross-bores. Requiring full participation in one-call systems by all underground facility owners and operators so that they are responsible for locating and marking their facilities would significantly reduce the threat of any new cross-bores occurring. Additionally, requiring that all newly installed pipelines be locatable using electromagnetic equipment would further reduce the threat of pipeline damage resulting from cross-bores.

- **White-lining.** Standardize the requirement for and improving the methodology of “white lining” (pre-marking the proposed excavation site with white paint).
- **Mobile excavator app.** Creation of an “excavator app” populated with state requirements and other pertinent information.
- **Geo-fencing.** Development of geo-fencing programs to enable electronic equipment, including locating equipment, to automatically download secure one-call ticket and underground facility information.
- **Ticket renewal.** Automatic alerts when a one-call-notification ticket is expiring.
- **One-call laws.** National standards for one-call laws that address:
 - time requirements for providing excavation information on proposed projects;
 - one-call center emergency, short notice, and project design tickets;
 - notification criteria of changes to scope in excavation projects; and
 - length (life) of one-call tickets.

This is not a comprehensive list; the variety and number of technologies and practices available or under development to improve damage prevention continue to evolve and grow.

Section 4: Analysis of Increased Use of Technologies and Initiatives

The Act also required an analysis of how increased use of technologies and initiatives could supplement existing one-call notification and damage prevention.

With few exceptions, such as the use of electronic locating equipment and the practice/requirement to call before digging, there are no national or industry-wide implementations of single specific technologies, initiatives, or tools. The development of new programs or requirements is sometimes driven by state laws and regulations. State one-call laws and regulations, along with PHMSA's performance-based regulations such as DIMP, provide flexibility that supports the development of a variety of technological solutions to address common damage prevention challenges. Stakeholders also use the various products available to them to improve their internal processes and procedures. As a result, there are a variety of approaches to improving damage prevention programs through the use of technologies, tools, or methods. The decisions about which tools to use are driven by performance expectations of stakeholders and the market.

There are numerous examples of successful implementation of technologies, tools, and initiatives currently being used or under development. PHMSA grant programs have funded a number of technological and programmatic implementations to strengthen state and local damage prevention programs, including grants used to help communities implement GIS to map their underground infrastructure, to develop and distribute public awareness and training materials, to conduct stakeholder meetings for both locators and excavators, and to purchase mobile devices to allow state investigators access to one-call center ticket information.

PHMSA's R&D program includes new technologies for reducing the frequency and severity of incidents caused by excavation damage. For example, one past project to develop an acoustic-based technology to detect buried pipes resulted in an operational and commercially available device called Ultra-Trac® APL that successfully detects metallic and non-metallic pipes buried under concrete, asphalt, and grassy surfaces.

The following is a topic-by-topic discussion of products or initiatives related to items listed under the second requirement of the Act, based on general stakeholder input in each category.

Global Positioning Systems and Digital Mapping Technologies

It is common for pipeline operators to use GPS for locating and GIS for mapping. GPS has been used for electronically white lining the proposed area of excavation, for identifying the location of underground facilities within the proposed excavation area, and for monitoring excavation activity through the integration of GPS tools on excavation equipment. The challenges with the use of these technologies include the variability in the standards for GPS data, gaps in incorporating accurate or updated GPS data into operator GIS systems, the ease of use of GPS equipment, and the limitations of using GPS in certain geographic areas.

Predictive Analytic Tools

In recent years, stakeholders have turned to data to help determine high-risk excavation activity. Algorithms, fault-tree models, and other tools use historical damage information and other factors, such as pipe material and type of excavation, to help identify high-risk locate requests. In these cases, additional resources can be deployed to validate that the locating and marking was performed accurately, and to monitor the excavation activity if necessary. Users of predictive

analytic tools report a reduction in damage rates of 20-30 percent, according to the input provided by the CGA.

Enhanced Positive Response

Enhanced positive response allows for completed ticket information, including photos and manifests of the dig site, to be provided to the excavator in advance of the digging project. This is often provided through the one-call centers. According to information submitted to the CGA by Utiliquest,¹⁶ users of enhanced positive response report up to a 67 percent decrease in damage rates.

Public Awareness Initiatives Including One-Call Initiatives

PHMSA and a variety of stakeholders promote the national 811 “Call before you dig” message through efforts including collaborative advertising, CGA promotions, national trade association and individual facility operator organization promotions, and one-call center advertising. Additionally, natural gas and hazardous liquid pipeline operators are required to develop and implement public awareness programs that follow the guidance of the American Petroleum Institute’s (API) Recommended Practice (RP) 1162, codified at 49 CFR 192.616 and 49 CFR 195.440. These programs must educate the public, appropriate government organizations, and excavators about pipelines, including:

- (1) Use of a one-call notification system prior to excavation and other damage prevention activities (this could include educating excavators on the use of 811),
- (2) Possible hazards associated with unintended releases from a pipeline facility,
- (3) Physical indications that such a release may have occurred,
- (4) Steps that should be taken for public safety in the event of a pipeline release, and
- (5) Procedures for reporting such an event.

Operator public awareness programs must be measured for effectiveness. The methods of measurement vary, but 811 campaigns are generally measured to determine the number of 811 “impressions” reached, as well as increased traffic to 811 web sites.

The CGA annually conducts a national 811 awareness survey to measure the general public’s understanding and use of the 811 service. While the CGA surveys show growing public awareness of the 811 message, 40 percent of the CGA’s 2016 survey respondents indicated that they would NOT call 811 in advance of their planned digging project.

Other one-call initiatives for consideration include one-call-centered enhanced positive response (described above), potential national standardization of certain damage prevention requirements (such as ticket parameters and notification requirements), and map-based systems for capturing dig ticket information.

¹⁶ UtiliQuest, LLC (“UtiliQuest”) is a provider of damage prevention and infrastructure related services specializing in underground facility locating serving the telecommunications, gas, and electric industries.

Use of Mobile Devices

Most of the technologies already discussed, as well as those listed in the appendices, involve the use of mobile devices for capturing and relaying data directly to and from an excavation job site. The ability to transmit information from device to device is widely promoted and encouraged. Stakeholders generally recommended that future technology be developed to allow a variety of systems and equipment to work together to improve damage prevention programs.

Other Advanced Technologies

Stakeholders also expressed interest in other advanced technologies, including methods for automatically providing GPS information for pipelines and other safety information securely to key stakeholders; improvements for aerial patrols of pipeline ROW, to include unmanned aircraft systems; and the development of excavator applications that include state-specific requirements and information.

The use of advanced technologies and initiatives continues to grow, and stakeholder communities are using a broad array of methods to address gaps in damage prevention.

- Increased use and development of high-accuracy GPS and GIS systems will improve one of the foundations of damage prevention programs: complete and accurate maps.
- Enhanced positive response coordinated through one-call centers needs wider implementation; it can vastly improve communication among all involved in the digging process and has been shown to reduce damage rates.
- The use of predictive analytic tools is aligned with PHMSA's DIMP regulations and could assist pipeline operators in addressing one of the main threats to distribution facilities by identifying high-risk excavation activities.
- Public awareness efforts are critical to the safe digging process, because the first step in that process is to notify underground facility operators that an excavation is planned. More work is needed to gain public recognition and use of calling 811 before digging, perhaps through more centralized, coordinated national campaigns and through more precise measurement of 811 awareness and excavator behavior.
- The use of mobile devices continues to grow and as such, all new technologies should be developed to incorporate mobile features.
- Policy-makers should work to eliminate exemptions in state one-call requirements and consider the possibility of national standards for certain elements of one-call requirements currently found in state laws. Given that excavators often work across state lines, the wide variety of requirements from state to state for elements such as one-call notification requirements, ticket scope, and other parameters could increase the likelihood of one-call law violations and excavation damage.

Section 5: National Data Repository

This section addresses the fourth requirement of the study, to analyze the feasibility of a national data repository for pipeline excavation accident data that creates standardized data models for storing and sharing pipeline accident information.

Throughout the country most pipeline operators (or their contractors) develop, gather, and document damage investigation data. Many one-call centers collect and document data about excavation damages. Industry trade associations collect and analyze data and issue reports for their members. State pipeline safety regulators often require damage data reporting — in some cases comprehensive damage reporting, in others on a more limited basis. However, these separate efforts are not integrated and do not necessarily provide a national perspective of pipeline excavation damage.

There are currently two sources of information that can provide nationwide public insight to pipeline excavation damage; one is maintained by PHMSA and one is maintained by the CGA. PHMSA's databases contain data required of and reported by operators annually and following federally reportable pipeline incidents or accidents.¹⁷ Natural gas pipeline operators are required to report "incidents." An incident is defined as:

- (1) An event that involves a release of gas from a pipeline, gas from an underground natural gas storage facility, liquefied natural gas, liquefied petroleum gas, refrigerant gas, or gas from an LNG facility, and that results in one or more of the following consequences:
 - (i) A death, or personal injury necessitating in-patient hospitalization;
 - (ii) Estimated property damage of \$50,000 or more, including loss to the operator and others, or both, but excluding cost of gas lost; or
 - (iii) Unintentional estimated gas loss of three million cubic feet or more.
- (2) An event that results in an emergency shutdown of an LNG facility or an underground natural gas storage facility. Activation of an emergency shutdown system for reasons other than an actual emergency does not constitute an incident.
- (3) An event that is significant in the judgment of the operator, even though it did not meet the criteria of paragraph (1) or (2) of this definition.

Hazardous liquid pipeline operators are required to report accident reports for each failure in a pipeline system in which there is a release of the hazardous liquid or carbon dioxide transported resulting in any of the following:

- (a) Explosion or fire not intentionally set by the operator.

¹⁷ Requirements for annual and incident reports for gas pipeline systems are found in 49 CFR Part 191. Requirements for annual and accident reports for hazardous liquid pipelines are found in 49 CFR 195 Subpart B.

(b) Release of 5 gallons (19 liters) or more of hazardous liquid or carbon dioxide, except that no report is required for a release of less than 5 barrels (0.8 cubic meters) resulting from a pipeline maintenance activity if the release is:

- (1) Not otherwise reportable under this section;
 - (2) Not one described in §195.52(a)(4);
 - (3) Confined to company property or pipeline right-of-way; and
 - (4) Cleaned up promptly;
- (c) Death of any person;
- (d) Personal injury necessitating hospitalization;
- (e) Estimated property damage, including cost of clean-up and recovery, value of lost product, and damage to the property of the operator or others, or both, exceeding \$50,000.

The PHMSA incident and annual report forms include fields that provide details about the cause of the events. For events caused by excavation damage, the reports detail whether the damage was caused by a failure to call before digging, improper excavation techniques, or other causes and also provides specificity into the actions leading up to the events. PHMSA can use this information to understand if there are commonalities leading to these reportable events and build programs to address those risks.

Pipeline operators are also required to annually submit reports to PHMSA that include information such as pipeline mileage, materials, and decade of installation. For the gas distribution sector, additional information is collected on the annual report, including leaks by cause (excavation, corrosion, material failure, etc.), number of pipeline excavation damages including high-level root cause information (one-call error, locate and mark error, excavating error) and number of excavation notification received by the operator. These details are helpful because gas distribution operators experience damages at a higher rate than gas transmission or hazardous liquid operators. PHMSA can track trends within states and nationally to determine if damage rates are trending down. The annual report data does not include detailed root cause information but does provide valuable insight into excavation damage trends for each state. PHMSA uses this information to target education and outreach.

The CGA Damage Information Reporting Tool (DIRT) is a voluntary reporting tool that is available to stakeholders to submit underground damage and near-miss reports through a completely secure, private web application. The CGA DIRT database was established in 2003 and allows any damage prevention stakeholder to submit information about damages and near-misses to underground facilities (not limited to pipelines). Standardized, detailed data can be collected for the following fields: submitter information, date and location of event, affected facility information, excavation information, notification information, locating and marking information, excavator downtime, description of damages, and description of root causes. DIRT provides multiple drop-down options for each field and a free-form comments section.

Each year, the CGA's Data Reporting and Evaluation program publishes a report (the DIRT Report),¹⁸ analyzing the data submitted to DIRT for the previous year. The report uses information submitted through the tool each year, as well as pulling information from PHMSA's database. For incidents caused by excavation damage, the PHMSA reporting forms for incidents and accidents include fields that match the CGA DIRT fields. The PHMSA annual report forms, particularly for the gas distribution sector, provide some details about causes of damages, but the damage detail is not as comprehensive as the data that can be entered in the CGA DIRT database. Key findings of the DIRT Report in recent years include:

- If there is a call to 811 before digging, in 99 percent of cases, no damage will occur.
- In states where one-call law enforcement programs are in place at the state public utility commission or equivalent, damage rates are lower.
- States with five or more exemptions in the state one-call law have 108 percent average higher damage rates than states with fewer than five exemptions.
- Top causes of damages are insufficient excavation practices, insufficient notification practices, and insufficient locating practicing. These are further broken down in the DIRT program.

While the DIRT program and associated report provide useful insights to damage prevention trends, certain policies established when the DIRT program was first introduced are somewhat limiting when considering it as a potential national repository for damage incidents. For example, submitting data to DIRT is voluntary. Submission is also anonymous (with the exception of DIRT system developers and limited CGA staff, who have access to full information about DIRT submissions, and in cases where submitters have granted access to other organizations). Therefore, the data set is incomplete.

The CGA employs PhD-level statisticians to conduct the annual analysis of data, who extrapolate the data to determine the annual estimate of total damages. While this process is appropriate and is believed to accurately represent estimated damages, a full dataset including all damages to regulated pipeline facilities is needed to understand the true impact of excavation damages to pipeline safety. To validate that all damages to pipeline facilities are reported, the pipeline operators who submit cannot be anonymous. With these changes and enhanced promotion, the CGA DIRT database could be more fully utilized used as the national data repository for pipeline damage data. The CGA noted that the DIRT system is used by many pipeline operators, and welcomed "the opportunity to work with PHMSA to accomplish the objectives of the legislation through use of DIRT."

In addition to the CGA DIRT and the PHMSA databases, it is important to note that several states and trade associations have and continue to collect damage information through centralized reporting systems, but none include national data for all pipeline sectors.

¹⁸ - See more at: <http://commongroundalliance.com/programs/damage-information-reporting-tool-dirt#sthash.McFUpxuf.dpuf>

Section 6: Opportunities for Stakeholder Engagement

The fifth study requirement is an identification of opportunities for stakeholder engagement in preventing excavation damage.

Stakeholder engagement in damage prevention can be construed in many ways. A common tenet among damage prevention stakeholders is “Damage prevention is a shared responsibility.” PHMSA identified multiple opportunities for stakeholder engagement. The list is wide-ranging and includes communication methods, policy considerations, and public awareness programs. Opportunities for stakeholder engagement specifically relating to technology include, but are not limited to: automatic alerts of safety issues, expiring tickets, and enhanced positive response allowing for better communication among all stakeholders.

While there are many opportunities for stakeholder engagement, the first and most important opportunity is full participation in the call-before-you-dig process by all stakeholders. Virtually all states have exceptions or exemptions from the requirement to notify before digging in their state one-call laws. However, very few states have data relating to the impacts of these exemptions. For example, agricultural exemptions are common, but data indicating the number of damages caused by agricultural activity is not available. Similarly, nearly all states exempt certain facility operators from participating in one-call systems (such as state DOT), but data addressing the impact of those exemptions is generally lacking.¹⁹

Ideally, stakeholders should be engaged in efforts to prevent excavation damage, by participating as excavators and/or as facility owners. It should be noted that PHMSA regulations require all regulated pipeline operators to fully participate in state one-call programs. Damage prevention is truly a shared responsibility, and full stakeholder participation in the process is the first step in preventing damage to underground facilities.

Additionally, to ensure an effective one-call process, it is important that stakeholders are held accountable for creating unsafe conditions by violating the state one-call law. Enforcement of the law, including the use of civil penalties as appropriate, is a key incentive to ensure safety through regulatory compliance and can include many elements, such as education, certification and licensing conditions for excavators and contractors, performance improvement programs for violators, and other methods to gain compliance. States have opportunity to prevent human harm due to excavation damage by establishing and maintaining effective one-call enforcement programs. Input submitted by the CGA members, the DCA members (including multiple pipeline and excavator trade associations), and the UWUA support these concepts (see Appendices).

In addition to formally engaging in the damage prevention process by participating as excavators/locators/ facility owners, stakeholders can engage at the national, state, and local

¹⁹ As reported by PHMSA in its 2014 study to Congress addressing the impact of exemptions in state one call laws on pipeline safety, which fulfilled the requirements of Section 3 of the Pipeline Safety, Regulatory Certainty, and Job Creation Act of 2011 (Act). The report is available online at http://www.phmsa.dot.gov/staticfiles/PHMSA/DownloadableFiles/Congressional%20Reports/PHMSA_131203_001_F.pdf

level by participating in groups such as the Common Ground Alliance (national or regional), state damage prevention coalitions, summits and meetings, and local damage prevention councils or utility coordinating councils. These groups exist throughout the country and provide opportunities to identify and address gaps in damage prevention programs at the company, local, state, and national level.

Section 7: Conclusion and Recommendations

PHMSA plays a vital role in driving improvements in damage prevention through its regulatory, educational, grants, and R&D programs. Stakeholder needs and the market also drive the development and implementation of technologies and practices. A broad array of technologies and practices exist, are under development, or are recommended for consideration to improve damage prevention and public safety. All of the suggested tools used to inform this study have merit, and none of them should be eliminated when considering the path forward for improving damage prevention programs. PHMSA noted commonalities in the input provided for this study and accordingly, the following recommendations are offered for consideration.

Recommendations from this study address the gaps identified by the Threat Prevention working group during the 2016 PHMSA R&D Forum as well as other areas to improve damage prevention. As stated before, the identified gaps are:

- Accurately locating and documenting the location of existing underground facilities,
- Continued development of predictive analytics to sort the major risks using multiple data sources,
- Adoption of best practices and education of public, and
- Broad use of GPS with accuracy standards.

Most of these recommendations apply broadly to affected damage prevention stakeholders. One recommendation applies specifically to PHMSA, regarding the enforcement of damage prevention standards against excavators in states deemed to have inadequate damage prevention enforcement programs. The recommendations include:

1. Development of collaboration/communication tools that foster better communication between the excavator and pipeline operator throughout the excavation process.
2. Evaluation and implementation of predictive analytic tools to identify and address high-risk excavations.
3. Improvement and implementation of GPS/GIS technologies in accurately locating and documenting the location of underground facilities.
4. Require damage data reporting.
5. Promote universal participation in the one-call process.
6. Consider development of national standards for certain state one-call requirements.
7. Implementation of the program started by PHMSA in 2016 of evaluating state damage prevention enforcement programs.
8. Pursuit of improvements in locating processes, technologies, and right-of-way monitoring technologies.

9. Promote the continued identification and implementation of the CGA and other damage prevention best practices, including effective ways to communicate and reach out to the public, and the education of stakeholders toward the benefits thereof.

Expanding on the recommendations summary:

1. Collaboration/communication tools: Communicating complete and accurate information about the proposed excavation, the locate-and-mark process, and project status minimizes damage incidents. A critical element to a successful excavation project is full communication among involved parties; this is generally not a requirement in state one-call laws and is not available in all states, but should be considered for more widespread implementation. Technology affords several ways to facilitate stakeholder communication, such as enhanced positive response utilizing mobile devices.
2. Predictive analytic tools: These tools use data to identify and manage high-risk excavation tickets. These technologies have been implemented with success to reduce damage rates, and as such are considered technically, operationally, and economically feasible for at least some stakeholder groups. Additionally, these technologies could be enhanced by incorporation into one-call center processes.
3. GPS/GIS: All affected stakeholders should continue to strive for improvement and implementation of GPS/GIS technologies in accurately locating and documenting the location of underground facilities. While challenging to implement, accurate mapping is one of the cornerstones of damage prevention. Input to this study from the CGA noted the following:

“Many aspects of the damage prevention process will benefit from a nationwide focus on improving the accuracy, quality, and consistency of geospatial information related to underground assets. This includes capturing or reporting geographic location in a common coordinate system, capturing accurate facility depth, and aligning facility records with a common land base. It also includes the ability to continuously improve geospatial data accuracy anytime underground facilities are located in the field (during the locate process, or any other activities that expose underground facilities). This will require significant investment to achieve.”

PHMSA considers that the use of mobile devices should be an integral part of capturing and aligning GPS data. The CGA further recommends that any future technologies focused on GPS data points deliver a final product that is within one meter of accuracy, and PHMSA supports that minimum standard.

4. Damage Data Reporting: The CGA DIRT program is an existing national data repository that collects standardized damage and near-miss data. PHMSA recommends that steps be taken to adopt and require pipeline operators to use the CGA DIRT or an equivalent data reporting tool in the future. All pipeline operators should submit damage and near-miss data to DIRT or an equivalent database, and the DIRT tool (or equivalent database) should allow for analysis of all pipeline damage data on a state level. Regulators should

be able to verify operator submission to DIRT. Other stakeholders, such as excavators, should also be encouraged to report damage and near-miss data, and regulators should be able to have access to those reports by stakeholder group on a state level. Since the reporting system already exists, PHMSA considers these proposals to be technically, operationally, and economically feasible. PHMSA notes that, in developing a requirement for submission to a national database such as DIRT, it is important to consider existing reporting efforts of pipeline operators through DIRT and other databases (such as state databases).

5. Participation in the one-call process: Exemptions from participation in the one-call process for excavators and for facility owners/operators should be eliminated if possible. Alternatively, data should be collected by states to understand the impact of exemptions in state laws.
6. National standards for certain state one-call requirements: Consideration should be given to establishing national standards for state one-call laws with respect to notification requirements, ticket scope, emergency tickets, design/project tickets, or other requirements. Consistency in these requirements for each state could reduce the likelihood of damages by eliminating confusion between state requirements and establishing a baseline by which state performance could be measured. The technical, operational, and economic feasibility of these proposals is not fully understood and would require additional study. For most proposed changes, legislative changes would be required at the state or federal level.
7. Implementation of the program started by PHMSA in 2016 of evaluating state damage prevention enforcement programs: The 2006 Act gave PHMSA new enforcement authority over excavators who damage pipelines in States with inadequate excavation damage prevention law enforcement programs. Prerequisite to excavator enforcement is PHMSA's determination of the states' enforcement program adequacy. In 2016, PHMSA conducted meetings with state pipeline safety and damage prevention stakeholders to discuss and evaluate each state's program. These interactions served to raise the awareness of the participating stakeholders. PHMSA should continue these interactions through outreach and support to states seeking to strengthen enforcement of their one-call laws and raise awareness for excavators.
8. Locating processes, technologies, and right-of-way monitoring technologies: Advances made in developing technology improve efficiency and accuracy in the facility locating process. However, more work is needed, for example, to include technology to address pipelines currently un-locatable through existing technology. The use of RFID, in combination with GIS, shows promise to address the issue of un-locatable pipe. Other technologies such as ground penetrating radar are in use, and improvements in such technologies will assist in difficult-to-locate circumstances. Similarly, rights-of-way monitoring systems that detect movement on or around pipeline rights-of-way show promise. PHMSA recommends the continued use of and further development of these

tools and considers that existing R&D programs and stakeholder/market needs will drive such development.

9. Best practices. All stakeholders should promote the continued identification and implementation of damage prevention best practices, including effective ways to communicate and educate the public. The CGA and other industry best practices will yield the best benefits in improving damage prevention. All stakeholders should continue to promote and participate in sharing best practice information and promoting education about and implementation of those best practices.

Damage prevention is truly a shared responsibility. It is important that all affected parties are involved in the development and implementation of any of these recommendations or any other improvements to damage prevention programs. The threat of excavation damage to pipeline facilities remains a safety concern and addressing this threat is a top priority for PHMSA. PHMSA looks forward to continuing collaborative efforts to improve damage prevention through not only technological improvements, but also enhanced data collection and analysis and improved programmatic elements such as education and enforcement, throughout the nation.