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Fatalities in the U.S. Oil and Gas Extraction Industry: Recent Trends and New Details

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Introduction[i]

The U.S. oil and gas extraction industry is a high-risk industry. An analysis of oil and gas extraction worker fatalities for 2003-2006 found that workers were killed on-the-job at a rate seven times greater than the rate among all U.S. workers.[1] Research also identified a positive correlation between the industry's fatality rate and industry activity (number of drilling rigs).[1] During 2003-2013, the number of active drilling rigs in this industry increased by 71%, resulting in a two-fold increase in the number of workers employed in the industry.[2,3] The boom in activity and employment resulted in an increase in worker deaths as well. Within the industry, elevated fatality rates have been identified among contractors, workers in small companies, and workers new to the industry.[4] The largest portion of fatalities is a result of transportation incidents, the majority of which are motor vehicle crashes.[5] The leading cause of death for workers on-site is being struck by, crushed, or caught in equipment.[3,4]

Research

The National Institute for Occupational Safety and Health (NIOSH) began conducting research focused on the U.S. oil and gas extraction industry in response to an increase in the number and rate of fatal injuries in the industry in 2004. As a result, NIOSH created an Oil and Gas Safety

[i] The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health.

and Health Program, which focused its initial research activities on learning about the industry and collecting and analyzing data to describe the most frequent fatal events, the groups of workers most at risk, and associated risk factors. Early NIOSH research projects targeted specific types of fatal events, such as motor vehicle crashes, workers struck by objects, falls, and fires and explosions. The results and recommendations generated by these projects were published in scientific and trade journals, presented at professional conferences and meetings, and included in a series of training videos targeting specific risk factors and high-risk operations.[6]

Partnerships

A number of collaborative efforts to improve safety and health for oil and gas extraction workers began during the last decade. In 2003, the Service, Transmission, Exploration & Production Safety (STEPS) Network was founded in South Texas by the Occupational Safety and Health Administration (OSHA) and industry to share best practices in oil and gas safety and health. Since then, the National STEPS Network and 22 independent STEPS groups serving 15 oil and gas producing states have also formed. In 2008, the National Occupational Research Agenda (NORA) Oil and Gas Extraction Sector Council was created by NIOSH as a partnership program to stimulate occupational safety and health research in the U.S. oil and gas extraction industry (website: www.cdc.gov/niosh/nora/councils/oilgas/). Since then, the NORA Council has identified priority research activities and created several safety products targeting high-risk workers and activities.[7] Regional groups have formed as well. The Texas Oil and Gas Association joined Texas Mutual Insurance to create the Texas Oil and Gas Safety Roundtable (http://texasoilandgassafety.com/) whose mission is to collaborate with stakeholders to develop and disseminate best safety practices that address common industry hazards. Another regional group, the Appalachian Shale Transportation Safety Workgroup, was formed to identify and share best practices in transportation safety in the Marcellus Shale Play.

The purpose of this article is to examine trends during 2003-2013 to determine if these research and partnership efforts may have had an impact in reducing the number and rate of fatal injuries in the oil and gas extraction industry. Secondly, the authors will provide an overview of a new NIOSH oil and gas fatality database and present preliminary results. The *Fatalities in Oil and Gas Extraction* or "FOG" database was created in 2014 in response to the need for more detailed and timely information about oilfield fatalities. The goal of the FOG database is to increase the availability of important information about fatalities in the oil and gas extraction industry for use by health and safety professionals and others to develop targeted interventions that prevent future loss of life.

Recent Trends in Fatality Rates

Methods

NIOSH analyzed publicly available data from the Bureau of Labor Statistics (BLS) Census of Fatal Occupational Injuries (CFOI) to identify the number and type of fatalities that occurred to workers during 2003-2013. The North American Industrial Classification System (NAICS) identifies three types of companies in the oil and gas extraction industry and assigns a unique code to each: oil and gas operators who own or lease the rights to extract crude oil and natural gas (211), drilling contractors who drill the well (213111), and well servicing companies who perform a number of support operations, including stimulating and completing the well (213112). The CFOI includes a NAICS variable allowing for the identification of fatalities by company type. Fatality rates were calculated using worker estimates from the BLS Quarterly Census of

Employment and Wages (QCEW). Trends in fatality rates were calculated for the industry as a whole by company type and by the leading causes of death. Negative binomial regression was used to estimate rates.

Results

There were 1,183 workers who died during 2003-2013 while working in the U.S. oil and gas extraction industry. Table 1 shows the most frequent fatal events for workers, with transportation incidents accounting for 40% of all fatalities.

The rate of fatalities for the industry as a whole decreased significantly during 2003-2013 ($p<.001$), with an average annual reduction of 4%. While the number of fatalities increased during this time period, the number of workers increased at a greater pace, resulting in decreasing fatality rates. The overall fatality rate was approximately six times that of all U.S. workers.

Event Type	**Number of Deaths (%)**
Transportation	479 (40.3)
Contact injuries	308 (25.9%)
Fires/Explosions	170 (14.3%)
Exposure to Harmful Environments	105 (8.8%)
Falls	97 (8.2%)
Other	30 (2.5%)
Total	1189

Table 1. These are the most frequent fatal events in the U.S. oil and gas extraction industry during 2003-2013.[1] (N=1,189)[2]

[1] 2013 data is preliminary

[2] Data Source: U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries

All three company types experienced a decrease in fatality rates; however, only operators and well servicing companies were found to have statistically significant reductions ($p<.05$). Fatality rates due to transportation incidents and contact with objects/equipment declined significantly during the time period examined. Contact injuries experienced the greatest decrease, with an average annual reduction of 9%.

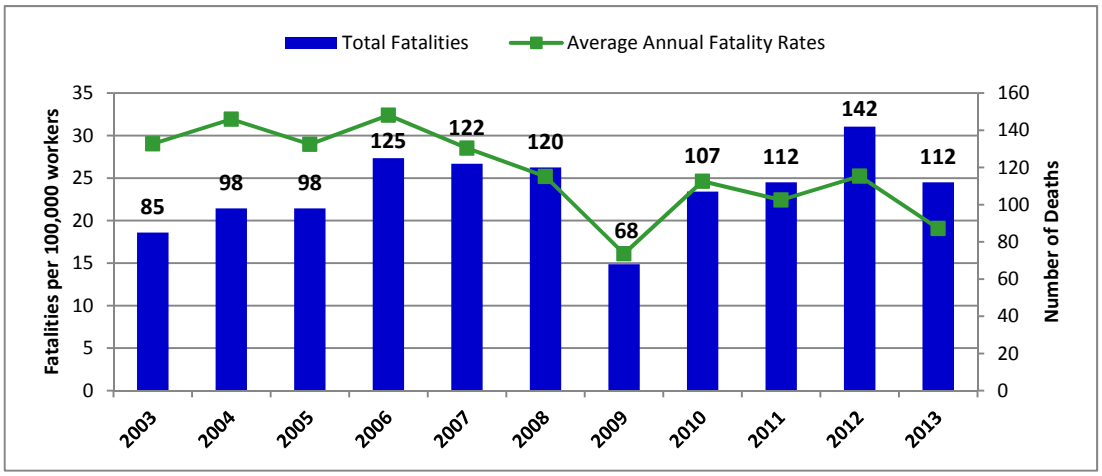


Exhibit 1. This chart contains the number and rate of fatal injuries by year for the U.S. oil and gas extraction industry during 2003-2013.[1,2] (N=1,189)

[1] 2013 data is preliminary

[2] Data Sources: U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries (2003-2013). U.S. Department of Labor, Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2003-2013).

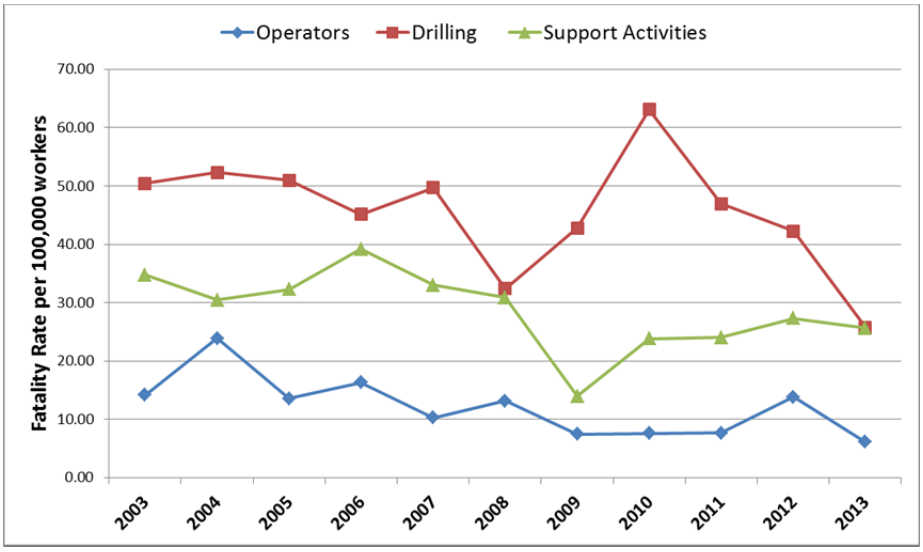


Exhibit 2. This chart contains worker fatality rates by company type and year for the U.S. oil and gas extraction industry during 2003-2013.[1] (N=1,189)

[1]Data Sources: U.S. Department of Labor, Bureau of Labor Statistics, Census of Fatal Occupational Injuries (2003-2013). U.S. Department of Labor, Bureau of Labor Statistics, Quarterly Census of Employment and Wages (2003-2013).

Development of a New Fatality Database for Oil and Gas Extraction

The NIOSH Oil and Gas Safety and Health Program developed a database in 2014 to collect detailed information on fatalities in the U.S. land-based and offshore oil and gas extraction industry. The goal of the FOG database is to increase the availability of information about contributing factors leading to fatal events in the oilfield. This system will be used to identify common themes and emerging issues that might not be identified through existing surveillance systems. All fatalities that occur to oil and gas extraction workers are included and those currently in the database are described in more detail below. The outputs created from this database will include information and tools for safety and health professionals to train workers and focus workplace initiatives.

Case Definition

The FOG database includes information on all fatal events determined to be related to the U.S. oil and gas extraction industry. While most of the fatalities in the industry occur to workers employed by a company assigned to one of the three NAICS described above (211, 213111, and 213112), FOG also seeks to identify fatalities to workers conducting work related to oil and gas, but coded to another industry. Table 2 shows the industries (and NAICS codes) that conduct most oil and gas-related work and are included in FOG. In addition, most occupational surveillance systems do not collect information about injuries and fatalities that occur during commuting because they are not considered work-related. Because well sites are often located in rural areas, many oil and gas extraction workers drive long distances to report to work. For these reasons, FOG collects data on long distance commutes.

NAICS Code	Description
211, 213111, 213112	Workers involved in the exploration for crude petroleum and natural gas; drilling, completing and equipping wells; operating separators, emulsion breakers, desilting equipment, and field gathering lines for crude petroleum and natural gas; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property. This includes workers paid on a contract or fee basis.
238910	Workers involved in site preparation and related construction activities for oil and gas wells.
484220, 484230	Workers involved in specialized freight trucking, local and long distance, that includes hauling of materials for oil and gas extraction activities.
541360	Workers involved in performing geophysical surveying and mapping services for oil and gas on a contract or fee basis.
N/A	Workers who meet one of the above conditions and who are fatally injured in motor vehicle crashes that occur during non-traditional commutes (i.e., long distance commutes) to the worksite or to temporary lodging camps.
N/A	Other workers involved in oil and gas extraction activities, irrespective of the NAICS code.

Table 2. Industry Sectors Included in the Fatalities in Oil and Gas Extraction Database (FOG)

Data Sources and Limitations

Data sources for FOG include: 1) OSHA preliminary descriptions, citations, and closed investigations, 2) media reports, 3) formal investigations from federal, state, and local agencies, 4) crash reports from the Department of Transportation and local police, 5) emergency responder and police reports, 6) coroner and medical examiner reports, 7) death certificates, and 8) Bureau of Safety and Environmental Enforcement (BSEE) investigation reports (offshore).

FOG does not currently capture all fatalities in this industry. Since the primary data sources for FOG are OSHA (land-based) and BSEE (offshore), events outside the scope of these agencies (e.g., highway crashes) will be underrepresented. In addition, FOG does not include fatalities that occur related to oil and gas pipelines (midstream) or refineries (downstream). FOG also does not collect data on non-fatal injuries and illnesses.

Results from the FOG Database

The NIOSH Oil and Gas Program will use FOG data to publish annual reports. These reports will include preliminary descriptions of incidents by operation type, fatality characteristics, and industry activity. Maps of fatality sites will also be included. Examples of information that will be in the reports are shown below. In addition to the annual NIOSH publications, FOG will be used to respond to specific requests for information by health and safety professionals, researchers, and others. Table 3 shows the operation types that were most frequently reported in the first half of 2014. The greatest number of fatal incidents occurred during the rig up/rig down process. Table 3 shows the preliminary descriptions of the fatalities that occurred during rig up/rig down with all identifying information removed. Exhibit 3 shows the number of fatalities by month and the average number of rotary rigs by month. Fatalities spiked in April with 11 deaths. Exhibit 4 (at end of report) includes a map of the fatality sites by industry sector.

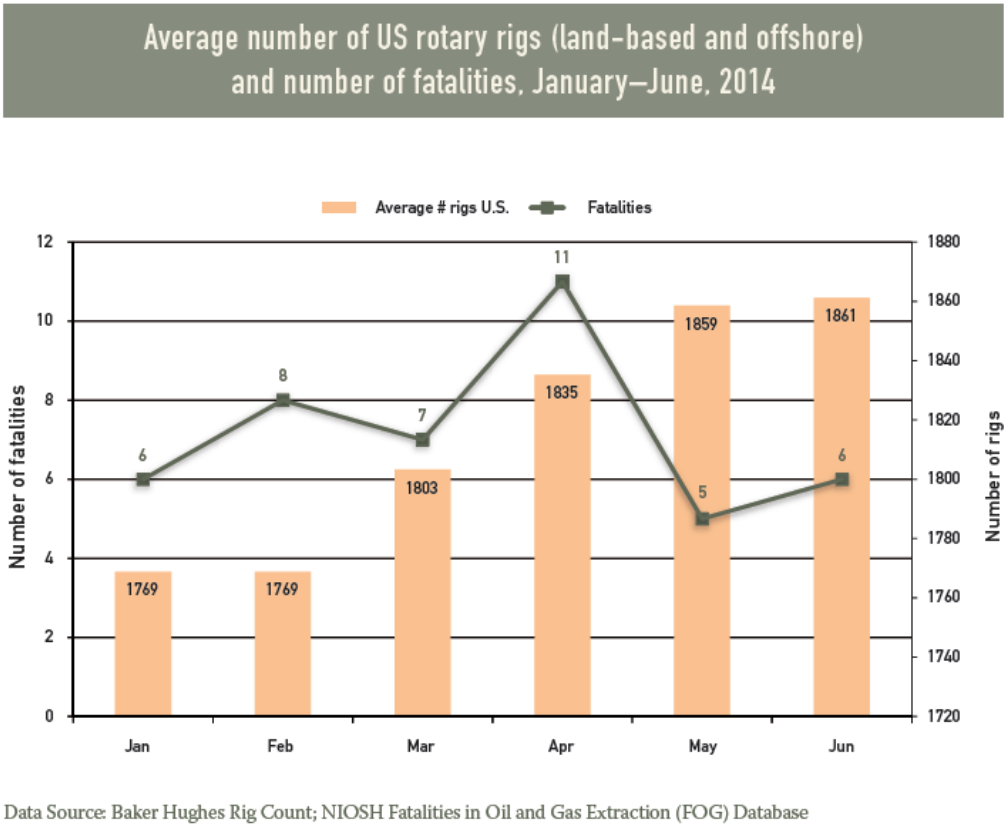
Operation	Number of Fatalities
Rigging Up/Down	6
Unknown Operations	5
Commuting	4
Material Handling: Crane, Forklift, Winchtruck	4
General Well Servicing	4
Rig Equipment Repair/Maintenance	3
Welding	2
Flowback Operations	2

Table 3. This table contains the most frequent types of fatalities by oil and gas operation during January to June, 2014.

Event Type	Preliminary Description
Crushed	The employee was involved in the rig up operation of the substructure (derrick tower), and before the incident occurred, the employee was trying to scope out the derrick. The decedent was directed to knock some pins out of a section of the derrick. The employee used a 12 pound sledge hammer to

	remove the 8 inch x 3 inch diameter pin from the left crown support bracket. When the pin was removed, the right crown support bracket gave way and broke. The middle section of the derrick dropped approximately 16 inches, crushing the employee to death between the section of derrick and the fifth wheel.
Fall	A Roustabout (E1) suffered injuries from a fall off a platform which resulted in his death. E1 had been working directly for the employer for approximately three years, performing duties of a roustabout, working primarily on a production rig. The day of the accident, E1 had been working with a floor hand (E2) and the field manager (E3) on the production rig performing well service. They had completed the well service and were in the process of rigging down the production rig when E1 fell. The production rig is a single hoist style. At the time of the accident, E1 had climbed onto a platform at the base of the derrick located over the cab of the rig. The platform was approximately 7 feet 7 inches from the ground. E3 had lowered the traveling block and manually pushed it over towards the platform and held it so that E1 could attach it to the derrick with a hook and sling. The hook was attached to the block then E3 let go of the block. E1 then fell, head first, to the ground below from the platform. E1 was pronounced dead at the scene. The cause of death was blunt injuries to the head and neck from the fall. The definite cause of the fall is unknown.
Pedestrian Struck by Motor Vehicle	During the rigging up process, the victim went to the tool trailer to get bolts needed to install a floor plate. He was struck by a tractor being used as a forklift. The tractor was backing up, turning to the driver's right. The left front tire hit the victim and knocked him down. He was caught under the forks and was dragged approximately 20 ft.
Struck by	Employee was removing the monkey board from the derrick by means of removing a pin. The monkey board shifted and struck the decedent between the derrick and the monkey board, resulting in fatal injuries.
Struck by Falling Object	Employee was struck by a service rig hinged working floor when the cable bridle broke while being winched up, allowing the floor to fall, striking the employee who had stepped under the fall line.
Electrocution	The crew was rigging down; they just finished cleaning the mud tanks. First responders were told that employee stepped on an electrical cable and was electrocuted.

Table 4. This list contains unedited descriptions of the rig up and down fatalities during January to June, 2014.



Data Source: Baker Hughes Rig Count; NIOSH Fatalities in Oil and Gas Extraction (FOG) Database

Exhibit 3. This chart contains the average number of U.S. rotary rigs (land-based and offshore) and number of fatalities during January to June, 2014.

Tank Gauging/Sampling - An Area of Concern

In 2014, NIOSH learned about several worker fatalities associated with tank gauging in the Williston Basin (North Dakota and Montana) that appeared to have been the result of acute chemical exposures. This information came from media reports, OSHA officials, and members of the academic community.[9] NIOSH reviewed data contained in the FOG database to determine if other similar fatalities had occurred. Fatalities due to confirmed hydrogen sulfide (H_2S), fires/explosions, and confined spaces were excluded. The review of FOG data revealed 11 fatalities potentially associated with acute inhalation of gaseous and volatile organic compounds (VOCs) and possible oxygen deficiency during 2010-2014 to workers who were gauging tanks, collecting samples, and/or transferring fluids to trucks. A summary of these fatalities is below:

- Of the 11 worker fatalities, seven occurred in 2014, one in 2013, two in 2012, and one in 2010.
- Four fatalities occurred in North Dakota, three in Colorado, two in Texas, one in Oklahoma, and one in Montana.
- Nine of the fatalities occurred on crude oil (production) tanks. One fatality occurred on a produced water (flowback) tank. One fatality occurred on a salt water tank.
- Five of the fatalities occurred during tank gauging. The other six fatalities occurred during sampling/fluid transfer by pumpers/truckers.
- While several cases remain open, available data indicate the primary cause of death in six fatalities was some type of cardiac event. The inhalation of lower molecular weight gaseous

hydrocarbons and VOCs was ruled as the primary cause of death in one fatality and a contributory factor in two other deaths (where a cardiac event was the primary cause). The cause of death is still undetermined/not available in four cases.
- At least 10 of the fatalities occurred among employees who were working alone or not being observed.
- In at least one case, the victim had sought medical evaluation for health effects (dizziness, disorientation, etc.) experienced during prior gauging activities.

NIOSH is working closely with OSHA to collect further details surrounding these deaths. However, there is evidence to substantiate that manual gauging by unprotected workers poses significant hazards. These hazards include potential for inhalation of VOCs and oxygen deficiency hazards that could result in impaired judgment, disorientation, sudden death, and risks for explosive/flammable conditions.[10] Collection and analysis of a limited number of personal breathing zone and area air samples taken above open "thief hatches" during gauging activities have indicated concentrations of VOCs (including benzene) in excess of occupational exposure limits and, in some cases, at levels immediately dangerous to life and health (IDLH).[11] Characterization of emissions using forward looking infrared radiometer (FLIR) Infrared Imaging technology has also shown that there are significant emissions of hydrocarbons released from thief hatches on production and flowback tanks.[12] Additionally, concentrations approaching 50% of the lower explosive limit were measured, indicating a flammable/explosion risk may also be present.

Recommendations to keep workers safe while working around open thief hatches on production and flowback tanks have previously been outlined.[10,11] These recommendations include: 1) develop alternative tank gauging procedures so workers do not have to routinely open hatches on the tops of the tanks and manually gauge the level of liquid, 2) provide hazard awareness training so workers understand the potential hazards for volatile chemical exposures from open tanks, 3) monitor workers for their exposure to volatile hydrocarbons, 4) ensure workers do not work alone, 5) use appropriate respiratory protection, 6) wear calibrated, real-time personnel monitors that can detect oxygen deficiency and explosive limits, and 6) establish emergency procedures.

The use of FOG to explore these fatalities has highlighted the importance of such a system in targeting specific hazards in the oil and gas extraction industry.

Conclusions

The oil and gas extraction industry has made progress in reducing the fatality rate among its workforce. Still, oil and gas extraction workers continue to die in large numbers and remain more at risk of dying on the job than most other American workers. Efforts to reduce hazards will need to focus on implementing effective interventions that target high-risk operations and groups of workers within the industry. The systematic collection of detailed information about worker fatalities will help to guide these efforts.

NIOSH continues to develop relationships with State agencies and OSHA regional and area offices to enhance the collection and dissemination of information on oilfield fatalities. Increased access to State source documents will allow for validation of existing information, identification of additional motor vehicle fatalities, and provision of more robust information overall.

Partnerships with states may also allow for joint reports to be produced containing specific information on an individual state's oilfield fatalities.

The authors would like to acknowledge the extraordinary contributions of the NORA Oil and Gas Sector Council, who helped develop the FOG database. This database would not have been possible without their expert guidance.

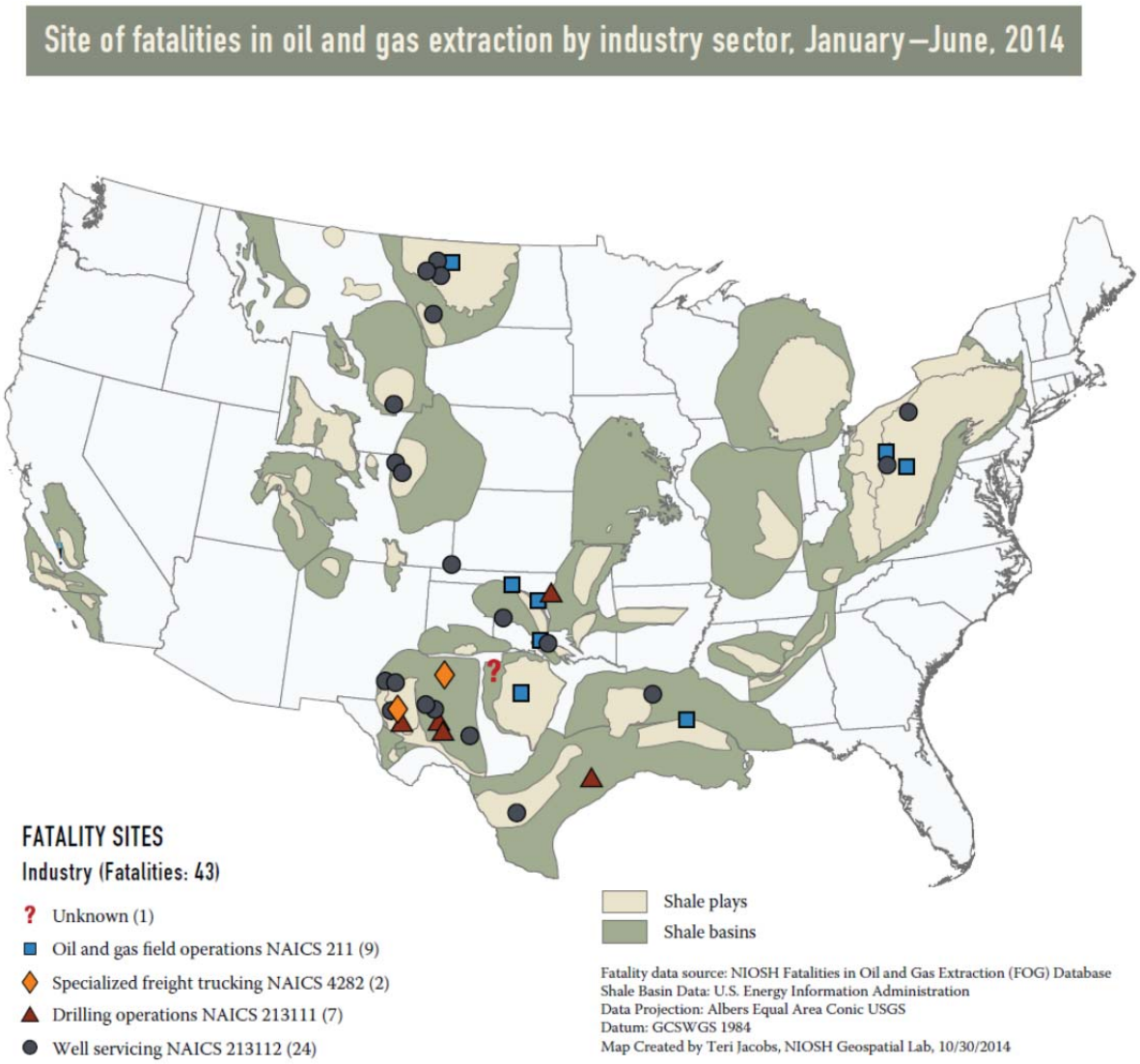


Exhibit 4. This map contains the sites of fatalities in the oil and gas extraction industry by industry sector during January-June 2014.

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