

STAKEHOLDER AND POLICY ANALYSIS OF HYDRAULIC FRACTURING IN  
CALIFORNIA

By

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## **ABSTRACT**

### **STAKEHOLDER AND POLICY ANALYSIS OF HYDRAULIC FRACTURING IN CALIFORNIA**

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Hydraulic fracturing of underground oil- and gas-bearing formations is a well stimulation treatment (WST) process used to form fissures in rock formations to improve oil and gas recovery. California's recent and most prominent bill to regulate hydraulic fracturing, Senate Bill 4 (SB 4), represents the state's first bill to provide a comprehensive statutory framework for WST regulation in California. New advancements in horizontal drilling and complex chemical compositions have made WST more effective and economical, but, simultaneously, they have made oil and gas exploration and production more controversial due to potential for environmental and public health risks. SB 4 is commended for taking initiative to regulate WST activities; however, some stakeholders question the efficacy of SB 4 and have remaining concerns regarding hydraulic fracturing in California.

In this thesis, I present a stakeholder and policy analysis of hydraulic fracturing in California to gain insight regarding diverse perspectives on the state's current oil and gas developments. I developed and distributed a research survey to gauge stakeholders' knowledge, attitudes, and perceptions of SB 4, as well as perceived benefits and concerns

of hydraulic fracturing in California. According to the survey results, economic growth, including jobs, is the primary perceived benefit of hydraulic fracturing in California. The foremost concerns are water and air quality. Informed by stakeholder feedback and policy analysis, recommendations are proposed for appropriate policy measures and best practices. It is hoped that the potential influential factors and observations resulting in this thesis will serve as a foundation of inquiry for prospective WSTs.

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## CHAPTER 1. INTRODUCTION

Hydraulic fracturing of underground oil- and gas-bearing formations is a well stimulation treatment that is used to create or enhance cracks in the rock formation in order to improve oil and gas production. California's recent and most prominent bill to regulate hydraulic fracturing, Senate Bill 4 (SB 4), defines a "well stimulation treatment" (WST) to mean "any treatment of a well designed to enhance oil and gas production or recovery by increasing the permeability of the formation. Well stimulation treatments include, but are not limited to, hydraulic fracturing treatments and acid well stimulation treatments" (Pavley, 2013). Recent advances in the practices of hydraulic fracturing have made the development of previously uneconomic oil and gas reservoirs financially feasible and have contributed to drilling and production booms in many areas across the United States. The extensive use of hydraulic fracturing and other WSTs is of increasing public concern due to the potential risks to human and environmental health. In particular, California uses a WST called acidization, which raises similar concerns and may present risks equally worthy of attention. The development of California's hydrocarbon reserves may depend upon hydraulic fracturing, acidization, and other forms of WSTs, yet they appear to be largely outside the current regulatory framework (Pavley, 2013).

The past decade has marked a shift of focus in the oil and gas industry. Conventional sources of energy are on the wane, but with population growth continually

rising and society's energy-rich lifestyle becoming ever more dependent, global demand for energy concurrently increases. Offshore drilling for underground energy resources, such as oil and natural gas, has great potential to be lucrative but has proven to be a risky venture. Unconventional onshore WSTs offer a solution to precarious offshore drilling and declining conventional drilling. While oil and gas operators have traditionally focused on economical, vertical wells and shallow pools of oil and gas, future economic success will likely require new expensive resource extraction techniques for unconventional sources of energy.

In this thesis, I present a stakeholder and policy analysis of hydraulic fracturing in California to gain insight regarding the diverse perspectives on the state's current oil and gas developments. A list of recommendations for appropriate policy measures and best practices is developed. The recommendations are informed by stakeholder feedback and a policy analysis. This thesis is divided into chapters that focus on specific aspects of hydraulic fracturing and other WSTs related to California. The Background Chapter thoroughly describes the hydraulic fracturing process, including each crucial step in the Technical Overview section. The Technical Overview also covers acidizing, which is a WST predominantly used in California and is becoming an increasingly relevant technology used to develop the Monterey Shale. The Review of Literature Chapter assesses the politics and current regulatory context associated with unconventional hydraulic fracturing at the federal, state, and local levels of governance. The Methods Chapter outlines the methodology used to conduct the research for this thesis. The Results Chapter reveals the outcomes garnered from surveys, interviews, and formal

documents associated with stakeholder feedback and relevant policy in California. The Discussion chapter critically examines the findings by drawing upon feedback collected from the research survey, interviews, and formal documents. The Discussion Chapter interprets what the findings may portend, and offers additional points reflecting specific stakeholder perspectives. Policy recommendations and best practices are presented in the Discussion Chapter. These policy recommendations and best practices are based on the stakeholder feedback and policy analysis in order to identify and address the foremost expressed concerns associated with hydraulic fracturing and other relevant WSTs used in California to extract unconventional shale resources. Finally, the Conclusion Chapter draws conclusions from the interpreted and analyzed results, and also suggests ways in which the study can be improved. Ultimately, the objective of this thesis is to conduct a stakeholder and policy analysis with the goal to gauge stakeholders' knowledge, attitudes, and perceptions of SB 4 and hydraulic fracturing in California, as well as to gauge the efficacy of SB 4.

## **CHAPTER 2. BACKGROUND**

A comprehensive understanding regarding the history, technology, and current legislation associated with hydraulic fracturing is necessary to conduct a thorough stakeholder and policy analysis. The Background Chapter reviews the history of oil production in California in order to illustrate the progression of oil production that has evolved to present operations. A technical overview is also provided in this chapter that explains technology advances that have made modern practices more effective at accessing and extracting oil and gas. The technical overview also describes the process of hydraulic fracturing, including each step from establishing a well pad to recovering the oil and gas at the well site. Water is a huge component in the hydraulic fracturing process; therefore, the water cycle is outlined to clarify the involvement and importance of water in the unconventional oil and gas operations. Lastly, the Background Chapter will summarize applicable WSTs particular to the state of California.

### **2.1 History of Oil Production in California**

The discovery of California's bountiful oil supply dates back centuries to a time when Native Americans in Northern California utilized asphalt oil seeps for binding tools, coating baskets, and other domestic needs (Rintoul, 1990). An oil seep is a naturally occurring upwelling of liquid or gaseous hydrocarbons that leaks up through the ground

(Cleveland, 2010). These seeps result from natural underground accumulations of abundant oil and natural gas. Inevitably, the oil seeps attracted the attention of pursuers of the westward frontier as early as the mid-19<sup>th</sup> century. These new California settlers were eager to make commercial use of the copious petroleum resource (Rintoul, 1990).

In 1861, the first oil well in California was drilled in Humboldt County, but much like other wells in the area of that time, the well resulted in minimal success (Stalder, 1941). By 1876, the first truly commercial well, Pico No. 4, was established in Pico Canyon (Rintoul, 1990). Pico Canyon is located in the Santa Susana Mountains approximately seven miles west of Santa Clarita in Southern California. A photograph of Pico No. 4 in the 1870s is provided in Figure 1.



**Figure 1: Pico No. 4. The figure above is a photo of California's first truly commercially successful oil well, Pico No. 4. This well was drilled in Pico Canyon in Southern California and became the state's pioneering commercial well in 1876.**

Pico No. 4 produced 30 barrels a day from a depth of 300 feet (DOC, 2013).

Similarly to Pico No. 4, the pioneering state oil wells were derricks built with wooden

frames that drilled a vertical depth of a few hundred feet to reach sizeable oil pockets. The discovery of the Midway-Sunset field in 1894 became California's largest oil field, in terms of expected total oil production (CCST, 2014). Southern California proved to be an oil apex with the Los Angeles fields producing 750,000 barrels of oil and accounting for over half of the state's 1.2 million barrels of production in 1895 (Rintoul, 1990). Oil production continued to steadily rise, and California became the nation's top oil-producing state with an output of over 24,000,000 barrels in 1903.

The State Mining Bureau was the appointed regulatory agency that oversaw the state's oil production, and the agency's primary duty consisted of gathering and publishing information in regard to various state mineral resources (Rintoul, 1990). California's oil industry went largely unregulated until 1915 when a mining engineer, Roy McLaughlin, introduced a bill to "protect oil lands menaced by water" (Rintoul, 1990). California exemplified a unique problem in that extremely saline water intruded into oil wells. The saline water intrusion would convert initially producible oil into a "wet" well that would no longer be commercial. The bill passed and went into affect in 1915. The law established the Department of Petroleum and Gas of the State Mining Bureau, and McLaughlin was appointed as the first State Oil and Gas Supervisor (Rintoul, 1990). The Department's new regulatory role was supervising drilling operations and monitoring well activity. The law also established a "Notice of Intention to Drill", that required the well operator to notify the Department of intended and actual drilling activities, including precise well location, the derrick floor elevation, and depths to which the well was estimated to be drilled (Rintoul, 1990). State oil production steadily grew with the

advancement of technology and enhanced industry practices. Eventually new management regimes and regulations emerged coinciding with the development of California's oil, which is discussed in further detail in Chapter 2.2, Review of Literature.

By 1975, the Division of Oil, Gas and Geothermal Resources (DOGGR) identified 45 onshore and partially onshore oil fields in California as "giant" fields. "Giant" fields are more than 16 million cubic meters or 1000 million barrels of expected total oil production (DOGGR, 2010). The volume of oil produced in California peaked in the mid-1980s, and California has had the third largest oil production among U.S. states since the 1980s (CCST, 2014). State oil production has declined since peak production in the mid-1980s. With recently enhanced technology that makes extraction of shale oil economically and technically feasible, California has experienced a recent increase in oil production during in the past decade. With the new accessibility of shale oil resources, California was the third largest oil producing state in 2013, behind Texas and North Dakota (CCST, 2014). Figure 2 is a map outlining the array of various shale plays in the United States. A play can be described as a set of recognized or postulated oil or gas deposits that reflect alike geologic, geographic, and temporal characteristics (Klett et al., 2005).

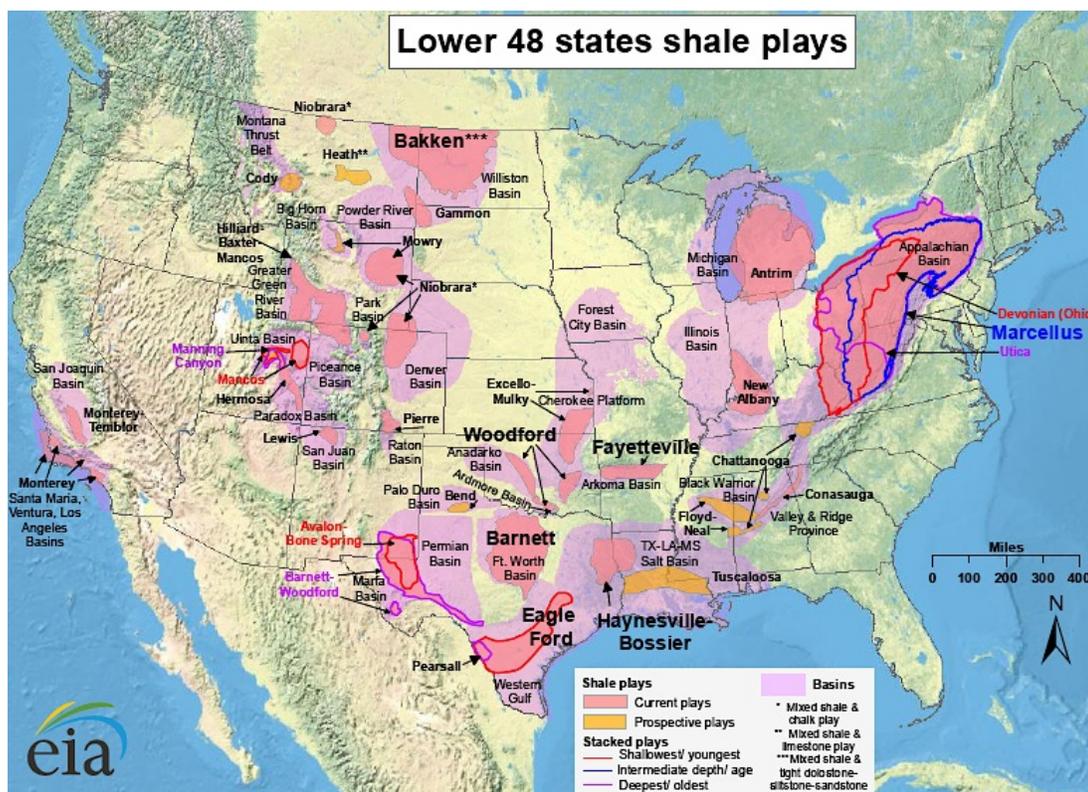


Figure 2: Oil and gas shale plays in the lower 48 states. Current shale plays that are being actively pursued are highlighted in pink. The Energy Information Administration based on data from various published studies provides this map. The map reflects data from 2011 (EIA, 2011).

The majority of shale plays are located in the central United States, with significant oil production activity in North Dakota, Wyoming, and Texas. California is the only oil producing state on the West Coast. The Monterey shale formation is the most prominent shale play in California. The Santos shale formation is another significant shale play in the state. The Monterey and Santos oil formations include the Lower Monterey and Santos shale and are situated in the San Joaquin and Los Angeles Basins in California, respectively (EIA, 2011). The Monterey shale formation is primarily located in the San Joaquin Basin, and Kern County serves as the epicenter for oil and gas exploration and production. The Santos shale is situated in the Los Angeles Basin with exploration activities onshore and offshore. Table 1

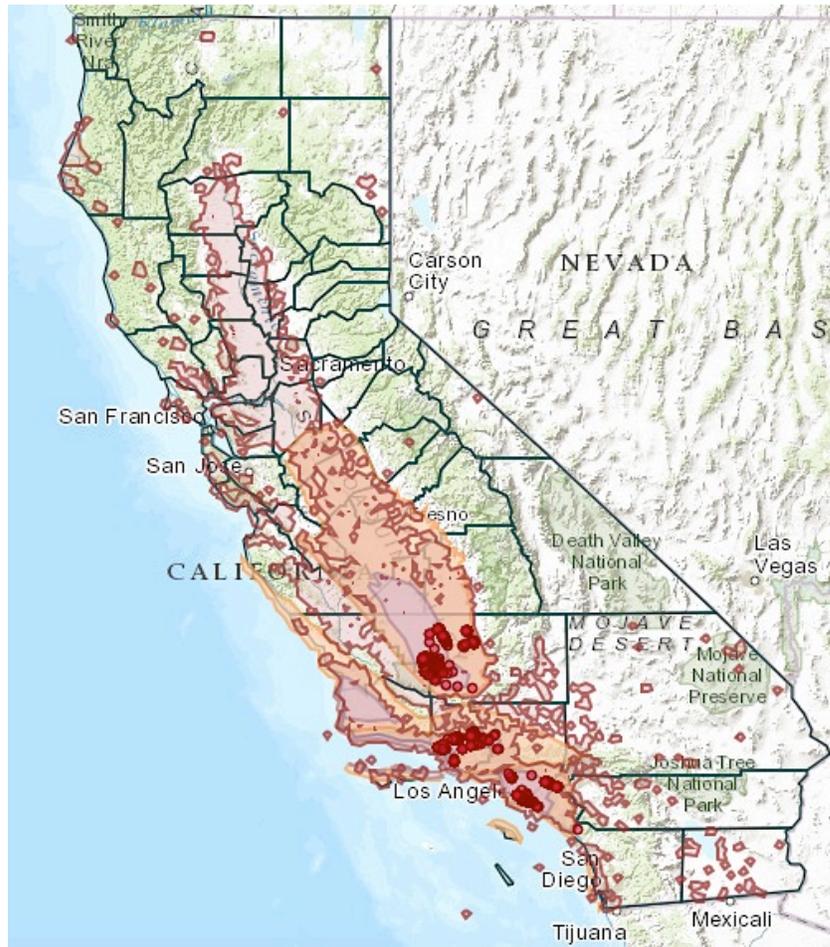
depicts the top five oil producing counties in California as of 2012.

**Table 1: Top five oil-producing counties in California in 2012. Oil production is represented in barrels of oil. Table 1 also shows the number of active well and inactive wells in each county as of 2012 (DOGGR, 2012b).**

County	Oil Production (bbl)	Active Wells	Inactive Wells
Kern	141,481,290	42,875	15,803
Los Angeles	24,130,729	3,690	1,552
Ventura	8,977,459	1,743	1,263
Monterey	7,433,840	657	562
Fresno	5,992,763	1,946	1,571

The well count includes wells associated with oil and gas, dry gas, and gas storage.

As seen in Table 1, the top oil producing area in California is Kern County with 141,481,290 barrels of oil and nearly 43,000 active wells in 2012 (DOGGR, 2012b). All of the top five oil producing counties are located in Southern California, the San Joaquin Valley, or Los Angeles Basin. Figure 3 depicts the location of shale plays and stimulated oil and gas wells in California as of 2014.



**Figure 3: Shale Play and Oil and Gas Wells in California. The red dots indicate stimulated oil and gas wells, including hydraulically fractured well stimulations. The orange shaded area indicates the location of the sedimentary basin. The purple shaded areas indicate where the Monterey and Santos Shale Play is located (FracTracker, 2014).**

The active area for the Monterey and Santos shale play is approximately 1,750 square miles in the San Joaquin and Los Angeles Basin (EIA, 2011). The depth of the shale ranges from 8,000 to 14,000 feet deep and has a thickness of 1,000 to 3,000 feet thick (EIA, 2011). Given the active tectonic regime in which it was deposited, the Monterey and Santos shale are exceptionally complex, both stratigraphically and structurally (Hughes, 2013). The underground layers of shale are not flat, and, instead, the layers resemble a folded and faulted configuration. The unusual geologic complexity of California's shale makes for

arduous resource exploration and production as the shale is difficult to access and extract.

Though immense shale oil resources may be present in California, the actual recoverable reserves may project a much lower number than the total resource volume. For example, in 2011, the Energy Information Administration (EIA), published a report by INTEK Inc. estimating the Monterey and Santos plays to contain 15.4 billion barrels of technically recoverable oil, or shale oil (EIA, 2011). This volume equates to 64% of the total shale oil resources in the United States. However, in May 2014, EIA reevaluated the total recoverable reserves in the Monterey shale and drastically cut the 2011 estimate by nearly 96%. The EIA reported a new estimate of 600 million barrels of oil that can be extracted using existing technology. The geologic character of the shale deposits in California is the main factor to amend the projected technically recoverable reserves. Though the EIA revision predicts that less oil can be recovered from the Monterey and Santos shale plays, some stakeholders are optimistic that advancements in technology will be able to further access the vast shale oil resource. For example, President of the Western States Petroleum Association, Catherine Reheis-Boyd, states that the amended recoverable reserve estimate “indicates the need to continue to invest in research and exploration...to adapt technologies that have proved successful at producing oil from shale resources elsewhere to California’s unique geology” (Reheis-Boyd, 2014). An overview of well stimulation treatment technology is provided in Section 2.2, Technical Overview. The Technical Overview section reviews hydraulic fracturing applications used for oil and gas extraction in the United States and covers specific well stimulation treatment technologies employed in California.

## **2.2 Technical Overview**

This section reviews technical aspects of hydraulic fracturing associated with unconventional oil and gas recovery. Conventional oil and gas are found in permeable formations, often sandstone or limestone, and are relatively easy to extract. Conversely, unconventional oil and gas are situated in rock formations characterized by exceptionally low permeability, such as shale, which makes extraction challenging. Unconventional hydraulic fracturing is composed of novel technologies and enhanced applications of existing techniques that make unconventional resource extraction achievable. A fundamental technical understanding of hydraulic fracturing by policymakers and the public is essential to developing effective regulation. The technical overview section will review the following: (1) unconventional hydraulic fracturing technology, (2) hydraulic fracturing process, and (3) hydraulic fracturing water cycle.

### **2.2.1 Unconventional hydraulic fracturing technology**

Oil and gas producers have used hydraulic fracturing for decades, but what is new and prompts concern are projections of dramatically increased unconventional hydraulic fracturing activity in California coupled with the potential for environmental and public health issues (Kiparsky & Hein, 2013). Recent hydraulic fracturing is the result of unconventional resource recovery practices that differ considerably from conventional

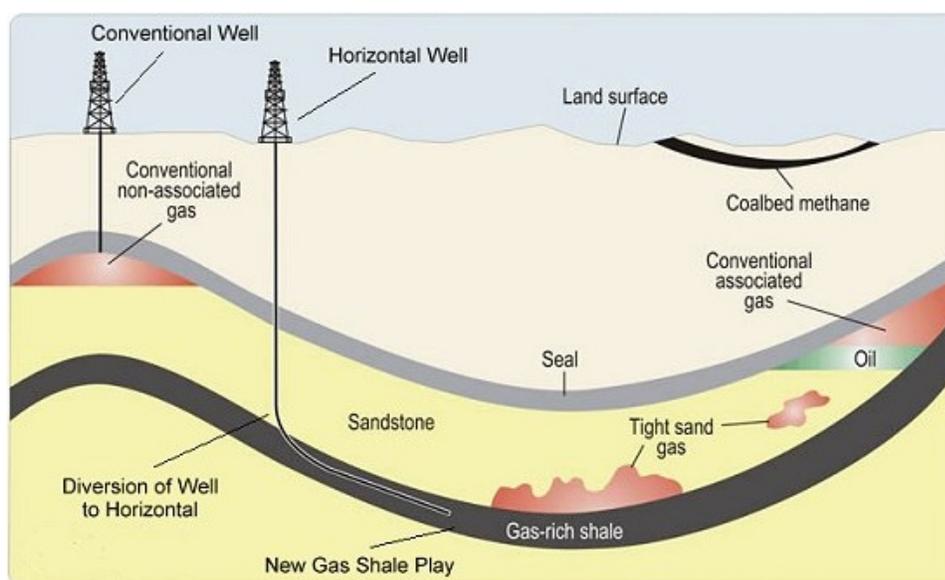
methods (Roundtree et al., 2010). Unconventional hydraulic fracturing consists of pioneering technology and innovative practices that allow maximized exposure to shale reserves. For example, unconventional techniques include advances in technology that enable horizontal drilling, which allows the wellbore to follow the geology of the hydrocarbon bearing rock (Andrews et al., 2009). Traditionally, conventional practices employed technology that only allowed for vertical drilling. Unconventional technology has the ability to rotate the direction of a proposed well from a vertical course to a horizontal course, which substantially elongates the well into the reservoir formation (Andrews et al., 2009). Correspondingly, a greater volume of fracturing mixture, including ample chemical additives, is required to perform the hydraulic fracturing job. Unconventional hydraulic fracturing is becoming a more prominently used practice because it maximizes exposure to hydrocarbons, which greatly increases recovery and makes the extraction economically viable. The enhanced economics of oil and gas extraction through unconventional recovery techniques has intensified production across the United States and could enable immense prospective growth in California. The accelerated practice of unconventional hydraulic fracturing, coupled with increased use of chemical additives pumped underground, raises environmental and public health concerns (Kiparsky & Hein, 2013). Such concerns stem from the possibility of associated chemicals coming in contact with and contaminating groundwater used for drinking water and agriculture.

Unconventional oil and gas resource recovery diverges from conventional practices primarily due to four technologies that have only recently been used in

combination to make oil and gas production from shale formations technically and economically feasible (DEC, 2011). The four technologies that make up unconventional hydraulic fracturing are: (1) horizontal drilling, (2) multi-well pads, (3) high volume fracturing fluid, and (4) slick-water. Each of these four terms will be defined and further explained in the following subsections. These unconventional technologies differ drastically from the fundamental methods used in the mid- to late 1900s, and the following sections describe each technology in detail.

**2.2.1.1 Horizontal drilling.** Horizontal drilling is a technology that enables the drill to deviate in any direction to follow the geology of the oil or gas bearing rock. Horizontal wells were first tested between 1980 and 1983, and the results indicated that commercial horizontal drilling was efficacious (EIA, 1993). Taking a cue from initial successes, there were nearly 1,000 horizontal wells drilled worldwide in 1990, and since then more operators have undertaken horizontal drilling with increasing frequency (EIA, 1993). The ability to devise a wellbore to follow the geologic patterns provides operators with greater access to and retrieval of oil and gas reserves (Andrews et al., 2009). Conversely, vertical drilling is characteristic of conventional hydraulic fracturing and, in effect, is inefficient due to the natural geology of shale formations. Shale formations are often found at depths of 6,000 feet to 10,000 feet below ground and range from only five feet to a few hundred feet in thickness (MCOR, 2010). Natural gas and oil are relatively uniformly distributed in tiny existing fissures throughout the entire shale layer that can extend horizontally for miles. Conventional vertical drilling bores down to reach an

accumulation of an oil or gas pocket that allows access to only a few hundred feet of the reserve (MCOR, 2010). In contrast, horizontal drilling technology allows boring to curve laterally in any direction of the rock formation in order to follow the thin shale layer as illustrated in Figure 4 (Zoback et al., 2010).



**Figure 4. Schematic diagram depicting the way that vertical and horizontal drilling approaches can be used to reach various fossil fuel resources (EIA, 2010).**

A conventional vertical well typically extends from 5,000 feet to 9,000 feet depending on the depth and thickness of the resource reservoir. Alternatively, an unconventional horizontal well diverts its pathway at the depth of the resource play and will follow the geology for another 3,000 feet to 10,000 feet (MCOR, 2010). For example, in the Marcellus Shale in Pennsylvania, a typical vertical well may be exposed to as little as 50 feet of the reservoir while a horizontal well may have exposure to 2,000 to 6,000 feet of the shale layer (Arthur & Cornue, 2010). Though current horizontal

drilling in the U.S. typically extends from one to three miles, this technology has potential to greatly lengthen its horizontal leg. For example, operations located offshore of Qatar involve a well with a horizontal length set at 35,770 feet, or just under seven miles (JPT, 2009). Unconventional oil and gas operations use horizontal drilling to increase exposure to the shale layer, which simultaneously increases exposure to the oil and gas inventory. Overall, horizontal drilling is a technological advance that greatly increases oil and natural gas recovery.

**2.2.1.2 Multi-well pads.** The second of the four unconventional hydraulic fracturing techniques is the use of multi-well pads. Multi-well pads enable drilling of multiple wells on a single pad (GOGA, 2012; Merrill & Schizer, 2013). Therefore, several wells can be drilled from a solitary well pad while congregating in a single location at the surface level. Conventional hydraulic fracturing, on the other hand, typically holds one well per pad (Arthur & Cornue, 2010). In large U.S. shale energy developments, operations require a large number of sizeable multi-well pads and significant auxiliary infrastructure. Well pads are large and spatially intense areas. Several acres of land are cleared for one hydraulic fracturing site in order to set up the pad, road access, and additional auxiliary infrastructure (Lee et al., 2011; Rodgers et al., 2009). Figure 5 demonstrates the number of wells per “vertical pad” versus the number of wells per “horizontal pad”. Multi-well pads are more economically appealing than conventional vertical well pads because more wells will come into contact with the energy-rich geology.

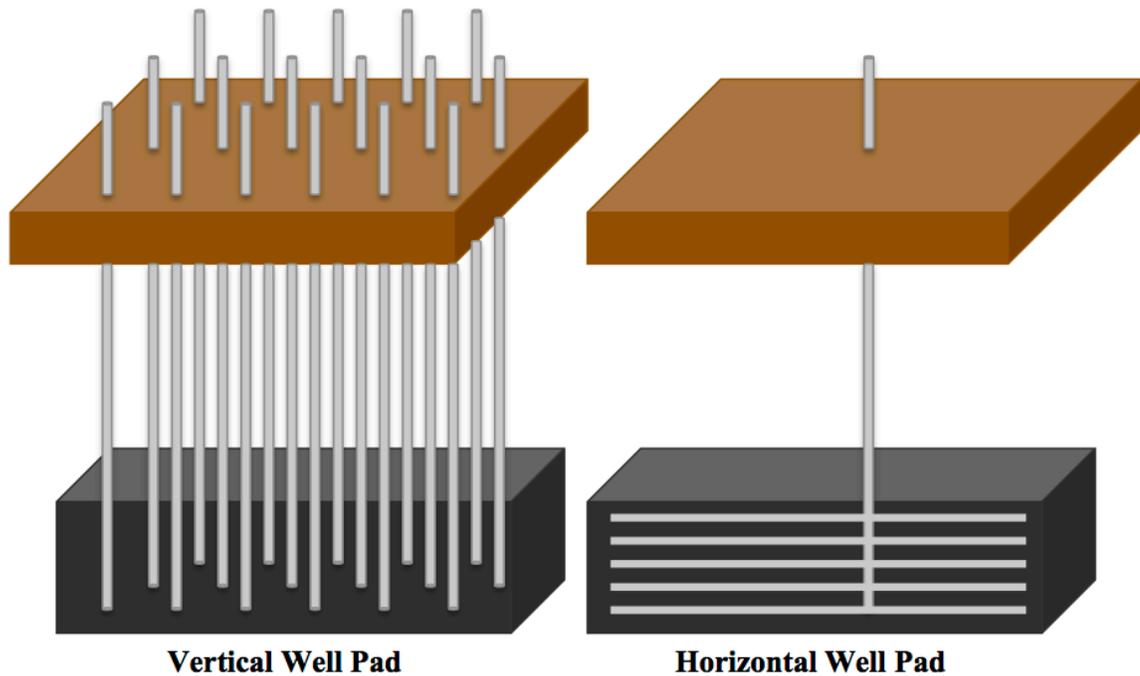


Figure 5: Vertical Well Pad vs. Horizontal Well Pad.

**2.2.1.3 High volume fracturing fluid.** High volume fracturing fluid is the third component of unconventional hydraulic fracturing practices. This technique is critical for stimulating oil and gas release from many existing fractures in the shale rock. Hydraulic fracturing is a water-intensive process that requires between two to eight million gallons per well fractured (API, 2010). For example, a typical horizontal well in the Marcellus Shale requires between one and five million gallons of water to perform a hydraulic fracturing job (Rodgers et al., 2009). Conventional vertical wells typically require less than 100,000 gallons of fracturing fluid and employ 1% to 2% of the volume of water used in unconventional hydraulic fracturing (Williams, 2012). An exact definition of “high volume fluid” in the context of hydraulic fracturing is contingent on each state’s

regulations. According to the Michigan Department of Environmental Quality, a “*high volume hydraulic fracturing well completion* means a well completion operation that is intended to use a total of more than 100,000 gallons of hydraulic fracturing fluid” (Fitch, 2011). Typically, a single unconventional shale well requires millions of gallons of fracturing fluid (API, 2010).

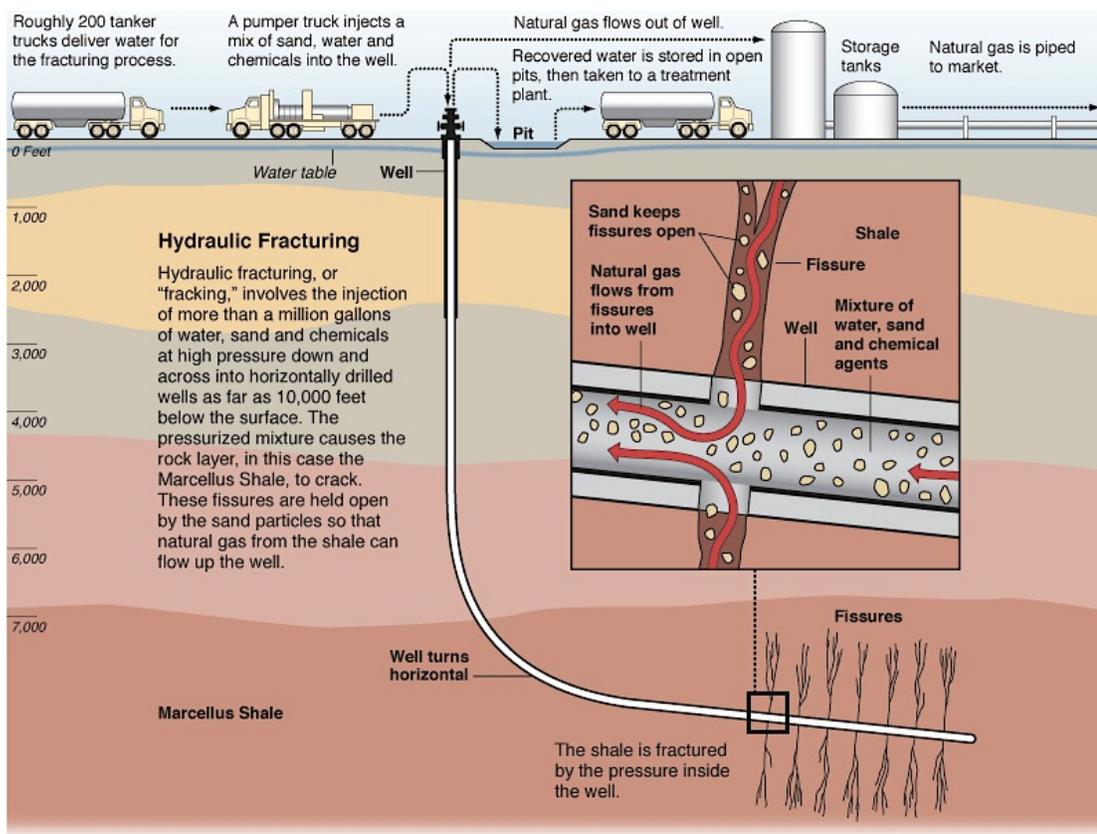
The purpose of hydraulic fracturing is to induce new fissures and augment existing fractures in the shale rock in which the oil or gas resides (Arthur et al., 2008). Vast quantities of fluid are required because horizontal drilling elongates the wellbore length and, in turn, increases exposure to the shale rock. High volume fracturing fluid opens up clefts and exposes the shale gas spanning the lateral well section in the shale layer (Arthur et al., 2008). These fluids are highly pressurized in order to compensate for pressure lost to friction as the fluid travels to the foot of the well. Depending on the geology and wellbore length, the required well head pressure to force millions of gallons of fluid through a small diameter pipe over two miles can be 5,000 to 8,000 pounds-per-square-inch (Ramudo & Murphy, 2010). The size of the well leg that reaches the hydrocarbon-bearing zone is small; approximately eight inches in diameter, and can extend 5,000 to 10,000 feet in length (COGA, 2011). These dimensions of a typical wellbore require a substantial quantity of fluid to effectively hydraulically fracture a well.

**2.2.1.4 Slick-water.** The final aspect that differentiates unconventional hydraulic fracturing from conventional oil and gas recovery practices is the use of “slick-water.” Slick-water is the fracturing fluid used in unconventional hydraulic fracturing, which is

composed of water, chemical additives, and proppants (Zoback et al., 2010). The propping agent is commonly sand that is used to hold open fractures in the shale rock created by the high volume fracturing fluid (EPA, 2012a). The combination of water and chemicals acts as a lubricant to mitigate high friction experienced as high volumes of fracturing fluid flow down the wellbore at high pressures and over long distances of piping. The water mixture used in unconventional hydraulic fracturing is described in more detail in Section 3, Hydraulic fracturing Water Cycle.

### **2.2.2 Unconventional Hydraulic fracturing process**

Unconventional oil and gas recovery is a process composed of multiple stages that can be categorized into upstream and downstream elements. Upstream procedures take place at the well site while the downstream refers to offsite processes. This section will elaborate on the upstream activities that occur at the well site in which the hydraulic fracturing process occurs. Figure 6 illustrates the various steps in the onsite process. The steps that comprise the unconventional hydraulic fracturing process are: (1) drilling and casing, (2) perforation, (3) hydraulic fracturing, and (4) the flowback period.

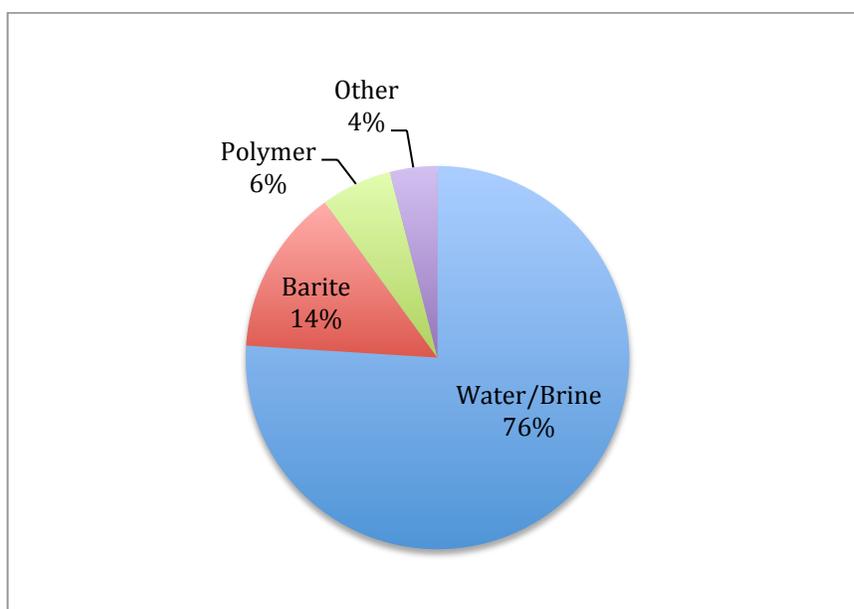


Graphic by AI Granberg

Figure 6: Typical components of a hydraulically fractured well (ProPublica, 2013).

**2.2.2.1 Drilling and casing.** Set up begins with clearing several acres for the well pad, establishing roads for heavy truck transit, and setting up the drill rig and auxiliary equipment (Lee et al., 2011; Rodgers et al., 2009). Drilling operations can then commence, which is done with a drill bit mounted on the end of a drill pipe that grinds through subsurface rock, soils, and other material. Air and drilling muds are commonly used to help facilitate the boring. Air can be pumped down the hole to flush rock cuttings and lift excess rock and other subsequent subsurface material to the surface. Drilling muds are also used to lift rock cuttings to the surface, manage subsurface pressures, and lubricate the drill bit (Harto, 2000; Ramudo & Murphy, 2010). Drilling muds are

typically composed of a water-based fluid. A mixture of salts is combined with the water base to produce specific brine phase properties (IPIECA & OGP, 2009). Other components in the drilling muds may be barite, polymer, and other chemicals to facilitate the drilling. The International Association of Oil and Gas Producers provide the information in Figure 7, and this chart depicts the general proportions of a water-based fluid drilling mud as a percentage by weight.

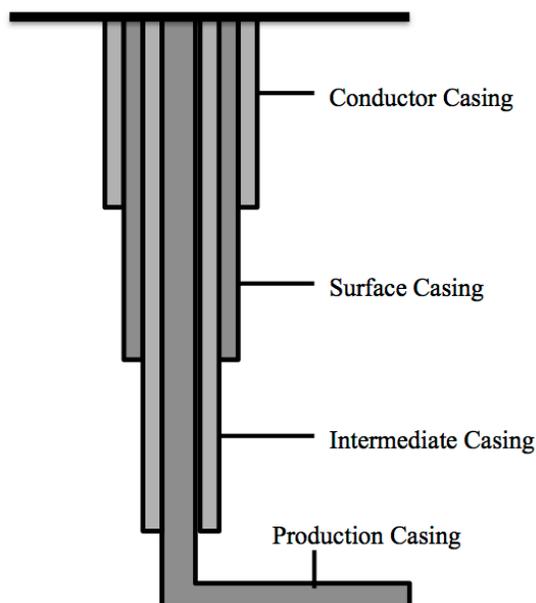


**Figure 7: Water-based drilling fluids. The chart depicts the chemical composition of water-based drilling fluids represented as a percentage by weight. The majority of water-based drilling fluids are composed of a water or brine solution (IPIECA & OGP, 2009).**

As seen in Figure 7, the brine water mixture is the primary component in the water-based drilling fluid. Barite is the second largest component in water-based drilling fluid. Another type of drilling fluid is a non-aqueous fluid. The non-aqueous fluids are generally composed of oils, barite, brine, emulsifiers, and gellants (IPIECA & OGP, 2009). Non-aqueous fluid encompasses components such as crude oil, diesel oil,

conventional mineral oil, and highly processed mineral oil. According to the International Petroleum Industry Environmental Conservation Association and the International Association of Oil and Gas Producers (2009), water-based fluids are typically used in the upper hole sections of the well, and non-aqueous fluids are used for the more technically demanding deep section of the well.

Groundwater contamination is initially possible if the well drilling intersects an existing aquifer and the groundwater is exposed to drilling muds. The drilling muds are pumped down the hole to cool the drill bit, control pressure, and transport drilled rock cuttings to the surface (Ogbonna, 2013). It is crucial to be mindful of groundwater contamination prevention during the early stages of resource recovery operations. Vertical drilling continues until the drill bit is approximately 500 feet above the shale rock formation (Hanna, 2012). This depth is referred to as the “kick-off” point, which is when the well diverges from a vertical path and continues horizontally along the length of the shale formation. The EPA states “wells may extend to depths greater than 8,000 feet or less than 1,000 feet, and horizontal sections of the well may extend several thousands of feet away from the production pad on the surface” (EPA, 2010b). Once the target distance is reached, the drill bit and drill pipe are removed. Various steel and cement casings are established throughout the drilling stage to ensure well integrity and to isolate the wellbore. Figure 8 depicts the multiple layers of casing used in wellbore construction.



**Figure 8: Typical hydraulic fracturing well casing used for unconventional shale oil and natural gas extraction. The well will generally have multiple well casing layers. The outermost and most shallow layer is the conductor casing. The second outermost layer is the surface casing. The intermediate casing is the second innermost layer that typically extends the length of the vertical portion of the well. The innermost layer is the production casing, which usually extends the entire length of the well bore.**

Proper wellbore construction is essential to directing the fracturing fluid and protecting drinking water sources. Layers of steel pipe casing and cement casing enforce the wellbore. The well's design and unique subsurface features determine the number of casings required. Typical well construction is made up of conductor, surface, intermediate and production casings, with larger diameter well casings installed first. The first and outmost casing layer is called the conductor casing. Conductor casing is a steel pipe that is cemented into place during the initial stages of drilling and extends between 80 to 150 feet below ground (Encana, 2014). Conductor casing is used during the early stages of drilling to restrain unconsolidated surface material from the hole and to isolate shallow groundwater. Once the conductor casing is established, the surface

casing is inserted and cemented into place. The surface casing extends nearly 2,000 feet with the purpose of preventing groundwater contamination from drilling fluids, hydrocarbons, or water mixtures associated with production activities (Encana, 2014). After the surface casing is installed and cemented, the intermediate casing is inserted. The intermediate casing isolates and stabilizes the well (Burton, 2011). Production casing is the final pipe use in wellbore construction. Production casing typically extends the total length of the well in order to seclude the fracturing fluid and extracted hydrocarbons from any other subsurface materials.

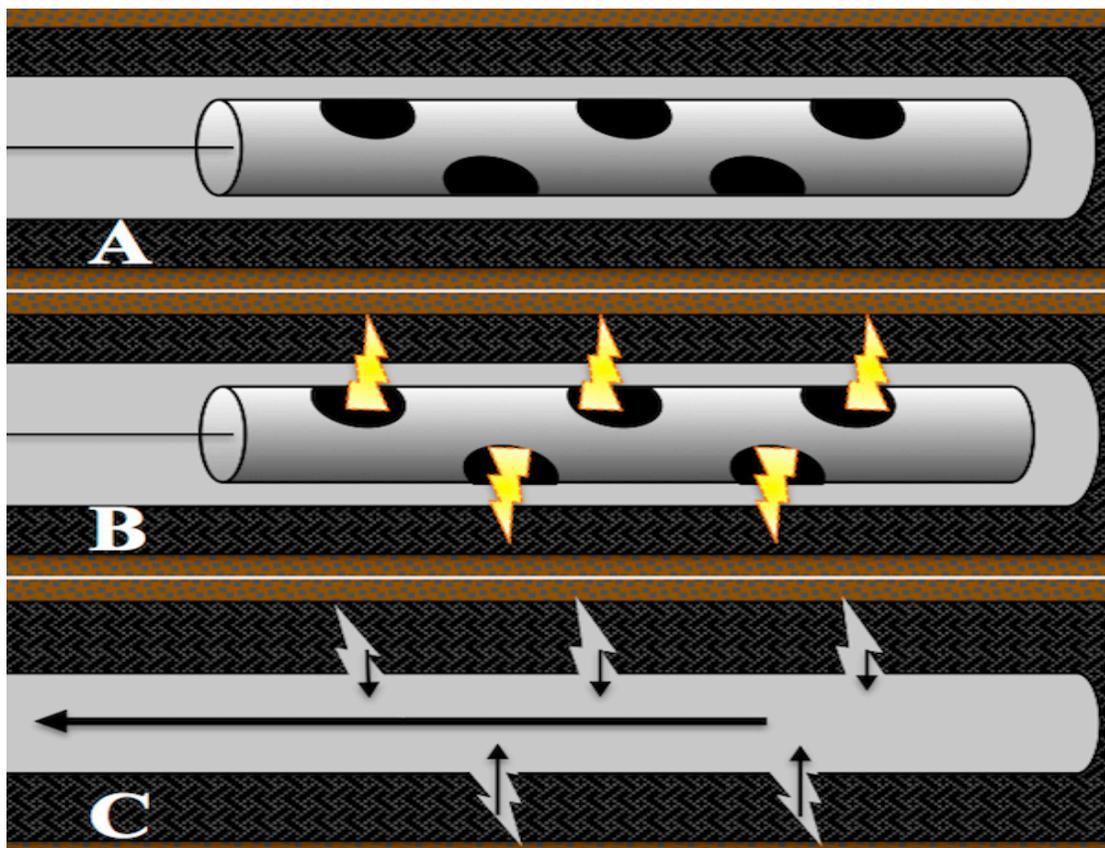
Proper wellbore construction is essential in protecting groundwater because there is a potential for contamination due to well casing failure. While traveling to the surface, oil and gas can intersect an underground source of drinking water as a result of well casing failures. Hydraulic fracturing fluid also has the potential to migrate from the initial point of the shale rock fracture to contaminate groundwater through breaks and cracks in the well casing. Exposure to deep underground soils can result in the fracturing fluid coming in contact with varying concentrations of subsurface organic matter, salts, metals, and naturally occurring radioactive materials (Warner et al., 2013). Due to faulty wells, fracturing fluid can infiltrate freshwater aquifers used for drinking water by humans and animals.

Additionally, partly because of very high pressures, unconventional hydraulic fracturing generates greater risk for well integrity failure than conventional extraction practices (Watson & Bachu, 2009). For example, Watson and Bachu (2009) conducted a study of wellbore gas leakage data from over 315,000 oil, gas, and injection wells. The

results from the study conclude that unconventional horizontal wells have a higher leakage rate than that of conventional wells, and the integrity of the well casing substantially decreases as the well ages (Watson & Bachu, 2009). Therefore, there is an indication that the unconventional techniques used to access and retrieve shale oil and gas are more prone to leaking than conventional wells. Also, the possibility for water contamination is not only present during the initial processes of production, but there are also potential long-term effects as well. Though the immediate impacts of hydraulic fracturing are highlighted, the full lifecycle of the well should also be considered.

After the initial hole is drilled, the well is assessed for the presence of an abundant oil or natural gas reservoir (Devold, 2013). If commercially viable quantities of hydrocarbons are confirmed, subsequent steps are taken to complete the well. These next steps are considered “completion steps”. Completion steps typically involve perforation, hydraulic fracturing, and the flowback period.

**2.2.2.2 Perforation.** Perforation is initiated once the well casing is established with the primary objective to create effective flow transfer between the wellbore and a productive reservoir (Hansen, 2011). Perforation involves a perforating gun that is lowered to the target zone in the well. A target zone is the desired section of the horizontal leg of the wellbore where a productive reservoir is present. Figure 9 demonstrates the perforating step.



**Figure 9. Perforation step used in hydraulic fracturing well stimulation. The figure above illustrates the perforation process used in the hydraulic fracturing process to extract oil and natural gas. Step A shows the perforating gun positioned in the target zone. Step B shows the blasts from the perforating gun in order to create or augment fissures in the rock formation. Step C shows the direction that the oil and natural gas will eventually flow when the resource is ready for extraction.**

Step A in Figure 9 shows the perforating gun located in the target zone of the wellbore. Once the gun is positioned properly, an electrical charge is sent by wire to detonate an explosion (Step B). The explosion blasts small holes through the casing and cement into the shale (Estrada, 2013). This step forms the initial small rock fissures (Step C), and is typically completed in subsets throughout the well's horizontal leg. The purpose of the holes created by the perforating gun is to provide access for the fracturing fluids to enter the target zone and subsequently allows the oil or gas to enter the wellbore

(Chabot, 2013). Once the perforation step is complete, the perforating gun is removed and the well is ready to be hydraulically fractured.

**2.2.2.3 Hydraulic fracturing.** The American Petroleum Institute (2010) defines hydraulic fracturing as a WST “intended to increase the exposed flow area of the productive formation and to connect this area to the well by creating a highly conductive path extending a carefully planned distance outward from the wellbore into the targeted hydrocarbon-bearing formation, so that hydrocarbons can flow easily to the well.” The actual hydraulic fracturing step represents a considerable process modification between conventional and unconventional oil and gas recovery, as described in Section 2.2.1. Unconventional hydraulic fracturing requires ample quantities of fracturing fluid, allowing for significantly increased exposure to hydrocarbons from otherwise impermeable shale formations (API, 2010). Under high pressures ranging from 5,000 to 8,000 pounds-per-square-inch, the fracturing fluid is pumped down the wellbore, exits through the perforations of the horizontal leg, and fractures the shale rock (Ramudo & Murphy, 2010). As a result, the induced fissures created during the perforation process are augmented. The proppant is embedded into these fissures during the hydraulic fracturing step and keeps the fissures from closing during the extraction process (API, 2010).

Hydraulic fracturing can be completed multiple times in subsets to cover the horizontal length of the wellbore (Seale, 2007). A well plug is used to isolate each subset of the horizontal leg (Blevins, 2011). The plug intensifies applied subsurface pressure on

controlled areas of the well to maximize the extent of fissures. These induced fractures free trapped oil and gas, which can then drift into the well and up to the surface (API, 2010). The resultant oil, gas or oil/gas mixture is collected onsite and then shipped (or piped) to market or storage. Before the hydrocarbons are collected, however, operations cease for a short period to allow fracturing fluid to return to the surface (Kurth et al., 2010). This stage of the process is known as the flowback period.

**2.2.2.4 Flowback period.** The flowback period occurs after well stimulation is complete and associated fluids return to the surface (Zoback et al., 2010). Returning fluids are the flowback and produced water, collectively referred to as hydraulic fracturing wastewater (EPA, 2012d). EPA considers flowback to be any fluids returned to the surface after hydraulic fracturing has occurred, but before the well is put into production. Any hydrocarbon that emerges during the flowback period remains unprocessed. According to the EPA (2012), produced water is considered to be the surfacing fluid after the well has been placed into production. Hydraulic fracturing wastewater may contain dissolved constituents from the formation itself along with some of the fracturing fluid constituents initially pumped into the well. According to the American Petroleum Institute (2010), the flowback period can last seven to fourteen days or longer. The American Petroleum Institute (2010) states that the “volume of initial flow back water recovered during the first 30 days following the completion of hydraulic fracturing operations may account for less than 10% to more than 70% of the original fracture fluid volume.” Similarly, the EPA (2010) estimates that approximately 15% to

80% of the original fracturing fluid is recovered depending on the site. The flowback period ends once the well is put into production and the hydrocarbons are scheduled for extraction and processing.

### **2.2.3 Hydraulic fracturing water cycle**

The stages in the hydraulic fracturing water cycle are important to understand as water plays a vital role in the entire resource recovery process. The EPA remarks that, “as the use of hydraulic fracturing has increased, so have concerns about its potential human health and environmental impacts, especially for drinking” (EPA, 2012d). Therefore, an understanding of the hydraulic fracturing water cycle educates interest groups and provides policymakers at all levels with knowledge that allows for intelligent decision-making and management. The stages of the hydraulic fracturing water cycle are illustrated in Figure 10 and include (1) water acquisition, (2) chemical mixing, (3) well injection, (4) flowback, and (5) wastewater treatment and disposal.

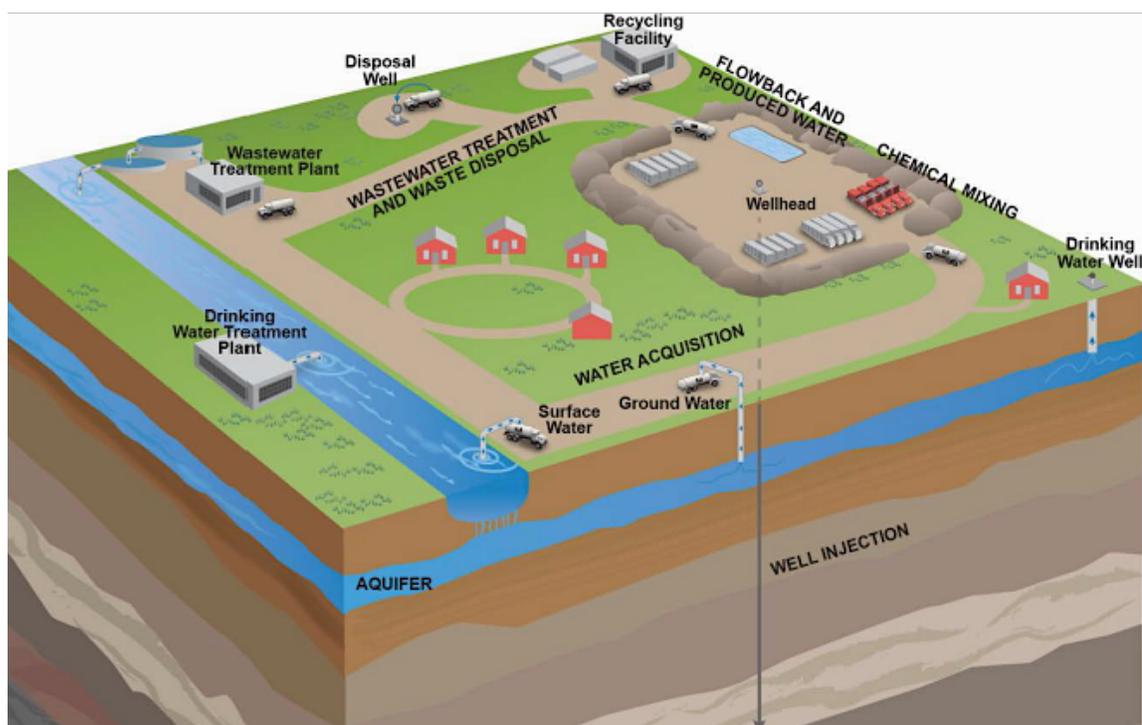


Figure 10: Hydraulic fracturing water cycle stages (EPA, 2012d).

**2.2.3.1 Water acquisition.** The hydraulic fracturing water lifecycle begins with water acquisition. The water acquired before the chemical mixing phase is called “source water” and is used as the base of the fracturing fluid. Source water is commonly retrieved from surface water, groundwater, or municipal water suppliers in the form of treated wastewater (EPA, 2012d). Surface water sources are typically lakes and rivers. Groundwater is used where there are sufficient quantities. Industry trends reflect a recent shift in favor of treating and recycling wastewater to use as base fluid in hydraulic fracturing operations (EPA, 2012; Rodgers et al., 2009). The order of ideal source water varies depending on local water availability and project parameters. The amount of water that is used for the fracturing job typically varies according to factors such as water quantity and quality requirements, regulatory restraints, competing uses, and

characteristics of the formation to be fractured (Sullivan et al., 2013). For example, the water usage in an unconventional shale resource play requires approximately two to eight million gallons of water to hydraulically fracture a single well (API, 2010). The amount of water used for hydraulic fracturing raises concerns regarding short- and long-term effects resulting from sizable water withdrawals from local areas. Substantial withdrawals from local groundwater can detract from the public's water supply. Secondary questions emerge as to the possible impacts of water withdrawals on local water quality (EPA, 2012d). The U.S. Environmental Protection Agency is currently researching how water withdrawals potentially impact local drinking water quality and availability. Redistribution of freshwater for hydraulic fracturing (that would otherwise be used for residential, commercial, or agriculturally uses) may have detrimental impacts on other users and the environment. For example, water availability and distribution in California has been a topic of immense debate for decades (Reisner, 1986). Central California is fiercely dependent on water intensive agriculture, yet the availability of local water is scarce and water is typically transported from Northern California by aqueducts. With hydraulic fracturing operations increasing in the state, energy companies are beginning to outbid agriculture water districts for freshwater (Aiello, 2013). Therefore, conflict emerges over competing users and the availability and quality of water.

**2.2.3.2 Chemical mixing.** Once onsite, the source water is combined with chemical additives and proppant to render the hydraulic fracturing fluid. The addition of

chemicals to the water base modifies properties (e.g. viscosity, pH) to optimize the performance of the fluid (EPA, 2012d). The hydraulic fracturing fluid performs two primary purposes: to generate pressure to propagate fractures or augment existing fractures in the formation and to transport proppant into the fractures (EPA, 2012d). The types and concentrations of chemical additives and proppants vary from well to well. Fracturing fluid is tailored to the properties and parameters of the resource formation and the provisions of the project.

Water is the primary component for most hydraulic fracture jobs and chemicals make up a very small portion of the total volume of fracturing fluid. Chemical additives make up roughly 1% of hydraulic fracturing fluid, which is equivalent to 50,000 gallons for a shale gas well that uses 5 million gallons of fracturing fluid (EPA, 2012d). According to the American Petroleum Institute (2010) and Chesapeake Energy (2014), chemicals may consist of acids, surfactants, biocides, bactericides, pH stabilizers, gel breakers, and other additives. Table 2 is replicated from publically available information provided by Chesapeake Energy that depicts the typical fracture fluid composition for hydraulic fracturing.

**Table 2: Chemical additives frequently used in unconventional hydraulic fracturing fluid. The chemical additives are sorted by product, purpose, and downhole result. Approximately 98% of the hydraulic fracturing fluid is made up of water and sand. The sand is often referred to as the “proppant” or “propping agent.” Approximately 2% of the remaining hydraulic fracturing fluid is made up of various chemicals. Though the specific chemical names are not presented in Table 2, the name of each component is exhibited under the “product” column. The downhole objective of each chemical product is described under the “purpose” column and the effect of each product is explained under the “downhole result” column (Chesapeake Energy, 2014).**

Product	Purpose	Downhole Result
<b>Water and Sand: ~ 98%</b>		
Water	Expand the fracture and deliver sand	Some stays in formation while remainder returns with natural formation water as “produced water” (actual amounts returned vary from well to well)
Sand (Proppant)	Allows the fractures to remain open so that the natural gas and oil can escape	Stays in formation, embedded in fractures (used to “prop” fracture open)
<b>Other Additives: ~ 2%</b>		
Acid	Helps dissolve minerals and initiate cracks in the rock	Reacts with minerals present in the formation to create salts, water, and carbon dioxide (neutralized)
Anti-Bacterial Agent	Eliminates bacteria in the water that produces corrosive byproducts	Reacts with micro-organisms that may be present in the treatment fluid and formation; these micro-organisms break down the product with a small amount of the product returning in produced water
Breaker	Allows a delayed breakdown of the gel	Reacts with the crosslinker and gel once in the formation making it easier for the fluid to flow to the borehole; this reaction produces ammonia and sulfate salts, which are returned to the surface in produced water
Clay Stabilizer	Prevents formation clay from swelling	Reacts with clays in the formation through a sodium-potassium ion exchange; this reaction results in sodium chloride (table salt), which is returned to the surface in produced water
Corrosion Inhibitor	Prevents corrosion of the pipe	Bonds to metal surfaces, such as pipe, downhole; any remaining product not bonded is broken down by micro-organisms and consumed or returned to the surface in produced water
Crosslinker	Maintains fluid viscosity as temperature increases	Combines with the breaker in the formation to create salts that are returned to the surface in produced water
Friction Reducer	“Slicks” the water to minimize friction	Remains in the formation where temperature and exposure to the breaker allow it to be broken down and consumed by naturally occurring micro-organisms; a small amount returns to the surface with the produced water
Gelling Agent	Thickens the water in order to suspend the sand	Combines with the breaker in the formation thus making it easier for the fluid to flow to the borehole and return to the surface with the produced water
Iron Control	Prevents precipitation of metal in the pipe	Reacts with minerals in the formation to create simple salts, carbon dioxide and water, all of which are returned to the surface in the produced water

Product	Purpose	Downhole Result
pH Adjusting Agent	Maintain the effectiveness of other components, such as crosslinkers	Reacts with acidic agents in the treatment fluid to maintain a neutral (non-acidic, non-alkaline) pH; this reaction results in mineral salts, water and carbon dioxide; a portion of each is returned to the surface in produced water
Scale Inhibitor	Prevents scale deposits downhole and in surface equipment	Breaks down and consumes microorganisms throughout the hydraulic fracturing fluid and naturally occurring water in the producing formation
Surfactant	Used to increase the viscosity of the fracture fluid	Generally returned to the surface with the produced water, but in some formations it may enter the natural gas stream in the produced natural gas

Table 2 provides an example of fracturing fluid composition, product purpose, and resulting effects. The composition of the fracturing fluid varies with each well depending on the design of the well and the formation of the resource play. Situation-specific endeavors that must be addressed include scale buildup, bacteria growth, proppant transport, and iron content, along with fluid stability and breakdown requirements (API, 2010). Addressing each of the criteria may necessitate specific additives to achieve the desired well performance. Since each well will reflect varying characteristics, not all wells require each category of additives. The American Petroleum Institute (2010) states that while there are many different formulas for each type of additive, a typical fracture fluid will contain four to six additives.

Concerns over hydraulic fracturing rise over the possibility that some chemicals are harmful if exposed to groundwater used for agricultural and domestic uses. The American Petroleum Institute (2010) discloses that a small number of potential fracture fluid additives (such as benzene, ethylene glycol, and naphthalene) have been linked to negative environment and human health affects at certain exposure levels. Once the

proppant and chemical additives are combined with the source water, the fracture fluid is then prepared for well injection.

**2.2.3.3 Well injection.** The hydraulic fracturing fluid is injected into the well under immense pressure ranging from 5,000 to 8,000 pounds-per-square-inch (Ramudo & Murphy, 2010). The injection of the fluid will act to create cracks and augment existing fissures in the geologic formation in order to allow oil or gas to escape through the well and collect at the surface (Chabot, 2013). The wells can be hydraulically fractured in a single stage or multiply stages, as determined by the total length of the injection zone (Seale, 2007). The actual fracturing process within each stage consists of a series of injections using different volumes and compositions of fracturing fluids. In the first stage of a fracture job, the hydraulic fracturing fluid is injected down the well at high pressures to initiate the fracture at the targeted zone underground. Additional fracturing fluid is then injected, often in stages of varying sizes, concentrations, and pressures (EPA, 2011). Once the fluid is injected into the targeted zones and the hydraulic fracturing stage is complete, water is circulated to flush the fluid from the well (Arthur et al., 2008). The flowback period can begin to allow the fluid to return to the surface before putting the well into production.

**2.2.3.4 Flowback.** Once the injection phase is complete, the water is ready for the flowback period. The operator can recover the injected fluid by releasing the pressure of the well, thus reversing the direction of the fluid flow. The mixture of returning fluid is

initially called “flowback” (EPA, 2012d). The flowback fluid refers to the fluid that returns to the surface after a fracturing job, but before the well is put into production. The flowback fluid is made up of the original fracturing fluid, but also can contain naturally occurring substances and total dissolved solids as a result of unintentional contact and integration during the hydraulic fracturing stage. Estimates of the amount of fracturing fluid recovered as flowback in shale resource operations vary from 15% to 80% depending on the project and geologic formation (EPA, 2010b). Kurth et al. (2010) estimate that approximately 20% to 40% of the fluid is expected to return after the hydraulic fracture step is performed. The term “produced water” is used to define the fluid that returns to the surface after the well is put into production. The flowback fluid and the produced water are collectively called “hydraulic fracturing wastewater” (EPA, 2012d). The wastewater is typically stored in open pits or storage tanks before treatment and disposal. Open pits used in hydraulic fracturing operations commonly have the capacity to hold one to 16 million gallons of fluid (Atkinson & King, 2012). A single hydraulic fracturing site can have one or multiple synthetic pits according to the size of the project. Pits are typically reinforced with a heavy-duty liner, such as polypropylene. Polypropylene is a flexible plastic liner material to prevent possible fluid leakage and seepage into the surrounding soils and farmland (Western Environmental Liner, 2009).

The failure of pits or tanks can result in the release of wastewater into surface water or shallow groundwater. For example, a 2007 Californian case, *Starrh and Starrh Cotton Growers v. Aera Energy*, found that Aera Energy contaminated the local groundwater due to pit failure, causing millions of dollars’ worth of damaged agriculture.

Fred Starrh proved that the company's produced water contained extremely high concentrations of boron and chloride along with detectable radiation, which seeped into his groundwater and led to the loss of almonds trees (Starrh v. Aera Energy, 2007). Greater oversight and adequate policy decisions could be beneficial to mitigate any future impacts such as the Starrh case. Once the well is ready for production, the flowback period ends and the flowback water must either be treated or disposed of.

**2.2.3.5 Wastewater treatment and disposal.** Wastewater is handled in one of several ways, including but not limited to: disposal by underground injection wells, treatment at municipal waste water facilities, treatment followed by disposal to surface water bodies, or recycled for use in future hydraulic fracturing operations (EPA, 2014e). Disposal options are dependent on a variety of factors, including the availability of suitable injection zones and the possibility of obtaining permits for injection (API, 2010). The EPA (2012) states that wastewater is usually managed through disposal into deep underground injection control wells, treatment followed by discharge to surface water, or treatment followed by reuse in closed-loop systems. Proper management and understanding of the disposal and treatment of hydraulic fracturing wastewater is important. For example, contaminants present in wastewater may be inadequately treated at publically owned treatment works and subsequently discharged to downstream bodies of water used for drinking water intake (EPA, 2012d). Sufficient management and regulation over the wastewater treatment and disposal stage in the water cycle can reinforce safe fluid handling practices and avoid drinking water contamination.

#### **2.2.4. Well stimulation technology in California**

Well stimulation techniques in California differ considerably from those employed in other regions of the United States. In most of the United States, WSTs, such as hydraulic fracturing, are primarily used to extract natural gas from deep below the ground (EIA, 2011). California is an uncommon case in that the underground energy resource is primarily oil rather than natural gas. Most of that resource is found in the San Joaquin and Los Angeles Basins. Also, due to California's complex geology, different well stimulation treatments are used to extract the state's viscous oil compared to techniques used in other states. According to the California Council on Science and Technology (CCST), "the vast majority of California hydraulic fractures are conducted in shallower wells that tend to be vertical rather than horizontal, and use a relatively small amount of water that is more highly concentrated in chemicals in geologic settings that differ significantly from those in other states" (CCST, 2014). The CCST is an independent non-partisan scientific group instituted by the California Legislature that was chartered by the BLM to perform a study on WSTs and oil production in California. California's oil production and oil resource extraction technologies differ from other parts of the U.S. because the subsurface geological layers in other states are relatively flat while California's geology is structurally and stratigraphically complex. Therefore, California's resources bearing underground layers are highly variable compared to other oil-rich formations such as the Bakken in North Dakota and Eagle Ford in Texas

(Dobson, 2014). Due to California's frequent tectonic activity, the underground layers of shale within the Monterey and Santos formations do not reflect a uniform thickness on a horizontal layer. Instead, the layers resemble a folded and faulted configuration. Therefore, well operators have difficulty drilling horizontally at a long range from the vertical well column without encountering a variant subsurface geological non-shale layer. As a result, well operators are likely to use alternative WSTs that are designed to address California's geologic characterization in order to access and extract underground resources. Such well stimulation treatments include: matrix acidization, acid fracturing, and steam injection.

Matrix acidizing is the process of injecting strong corrosive acids into the rock formation surrounding a well at pressures lower than the fracturing pressure point of the rock in order to dissolve the adjacent rock and increase near-well permeability (CCST, 2014). Unlike hydraulic fracturing, matrix acidizing does not create fracture in the target zone rock formation. Matrix acidizing is best suited for carbonate and sandstone hydrocarbon bearing rock formations. The most common acid systems used are hydrochloric acid in carbonate formations and hydrofluoric/hydrochloric acid mixtures in sandstone formations (CCST, 2014). By comparison, however, the penetration into the formation of enhanced permeability caused by matrix acidizing is not typically as extensive as it is after hydraulic fracturing with proppant or acid. Matrix acidizing is not commonly used as a WST for shale formations. Shale rock has a low permeability that requires excessively high pressure in order to successfully penetrate and stimulate the

rock layer. Therefore, matrix acidizing is an ineffective technique to stimulate shale driven wells.

Acid fracturing is a technique that combines hydraulic fracturing and matrix acidization. Acid fracturing uses high pressure to create fissures in the target formation while also using acid to dissolve the adjacent rock. Instead of a propping agent, such as sand used in hydraulic fracturing, hydrochloric acid is injected at immense pressure to break up the near-well material (CCST, 2014). Acid fracturing is most applicable for carbonate reservoir rock formations. Similarly to hydraulic fracturing, acid fracturing also uses immense volumes of water (CCST, 2014). Unlike hydraulic fracturing, however, acid fracturing generally results in relatively condensed fractures (Economides et al., 2013). The CCST report found that acid fracturing is not excessively used in California. The report indicates that since acid fracturing is most commonly used in carbonate reservoirs, the only applicable locations to use this well stimulation treatment are in the Santa Maria Basin and Los Angeles Basin. The national hydraulic fracturing disclosure registry website, FracFocus, reveals that the highest concentration levels of hydrochloric acid and hydrofluoric acid are too low to be considered an acid fracturing operation in California. The CCST report concludes that both matrix acidizing and acid fracturing are infrequently used in California, and these technologies are not anticipated to generate substantial increases in oil development in the state.

Steam injection is a WST for the purpose of oil recovery in California that began in the mid-1960s (CCST, 2014). Steam injection pumps high temperature steam, water, or other fluids into an oil reservoir. The injection of steam heats highly viscous oil in

order to stimulate the oil flow toward the production wells. Steam injection became one of the more successful well stimulation treatments in California. By the late 1980s, steam injection techniques contributed to the majority of state oil production (Schenk, 1991). In 2009, 72% of techniques used for oil recovery were attributed to steam injection, making this technology the steady primary contributor to enhanced oil recovery projects in California (DOGGR, 2010).

## **CHAPTER 3. REGULATORY CONTEXT AND REVIEW OF LITERATURE**

This chapter draws on peer-reviewed and grey literature to summarize and elucidate the current understanding of topics relevant to hydraulic fracturing policy and decision-making. This is not a review on the technical or physical aspects of hydraulic fracturing, but rather a review on relevant regulation and policymaking. Existing federal and state regulations are reviewed to provide a background in the current framework of hydraulic fracturing policy at various levels of regulatory oversight. This investigation begins from a macro-level perspective with a review of federal laws that set the stage for state and local governing over oil and gas productions. California is used as a case example, and I outline the current regulatory environment of hydraulic fracturing operations in the state. I then conclude with a micro-level perspective focusing on Senate Bill 4 because that legislation currently provides the most relevant and comprehensive set of WST regulations in California.

### **3.1 Federal Law Sets the Stage for State and Local Regulatory Context**

This section includes a review of the politics and current regulatory perspective associated with unconventional hydraulic fracturing at the federal, state, and local levels of governance. The federal government began to take natural energy resources and environmental issues into more serious consideration in the 1970s, and thus began a new

era for natural resource directive and control. During this time, the federal government enacted a succession of statutes that adopted the political management approach called cooperative federalism (Kramer, 2012). Cooperative federalism refers to a concept in which local governments, state governments, and the federal government try to collectively collaborate and share responsibilities to resolve common problems. In order to troubleshoot emerging concerns and create effective policy measures, responsibilities are balanced and distributed at the various levels of government. In the United States, cooperative federalism is exercised to manage oil and gas activities, including hydraulic fracturing and other WSTs. Responsibility for regulating the facets of oil and gas production involving hydraulic fracturing is divided among federal and state agencies (Kiparsky & Hein, 2013).

The federal government has broad regulatory authority over oil and gas production that uses hydraulic fracturing, and the role of the federal government shapes the context for state regulation (Richardson et al., 2013). The primary regulatory bodies at the federal level include the U.S. Environmental Protection Agency (EPA) and the Federal Bureau of Land Management (BLM) (Kiparsky & Hein, 2013; Kramer, 2012). The EPA states that its role is to provide oversight, guidance, and rulemaking with the objective to safeguard air, water, and land (EPA, 2014d). The Federal BLM is responsible for leasing oil and gas resources on all federally owned lands (BLM, 1983). Governance over oil and gas operations is generalized among a few key federal laws, in which the federal government's role is limited under current law. The most relevant federal laws that affect oil and gas production involving hydraulic fracturing are the

following: (1) Safe Drinking Water Act, (2) Emergency Planning and Community Right-to-Know Act, and (3) Resource Conservation and Recovery Act. These federal laws preceded unconventional hydraulic fracturing; therefore, the provisions do not directly address current issues resultant from recent oil and gas exploration. The variety of existing laws governing oil and gas operations, including hydraulic fracturing operations, along with the multitude of federal, state, and local agencies that enforce them, is complex and multifaceted. The following sections review the most relevant federal laws that create the context for state and local regulation over oil and gas operations, including hydraulic fracturing and other WSTs.

### **3.1.1 Safe Drinking Water Act**

The Safe Drinking Water Act (SDWA) was established in 1974 to protect the quality of drinking water sources in the United States (EPW, 2002). The regulation emphasizes all waters actually or potentially designed for consumption, whether from surface or underground sources (EPA, 2013). A key objective of the SDWA is to hold EPA accountable for developing national primary drinking water regulations to address contaminants that may pose public health issues and that are likely to be present in public water sources (Tiemann, 2014). Under the SDWA, EPA is the responsible agency for the preservation of source water quality, including groundwater, through its Underground Injection Control (UIC) program (Kiparsky & Hein, 2013).

The UIC program establishes regulatory supervision of underground injection of fluids whose injection may cause contamination of groundwater (EPW, 2002). According to the SDWA “underground injection” is defined as the “subsurface emplacement of fluid by well injection” (EPW, 2002). Injection wells related to enhanced oil recovery or disposal of wastewater associated with oil and gas activities are categorized as “Class II” wells (Howard, 2013). The EPA does not classify oil and gas wastewater as “hazardous”; therefore, these fluids are not subject to the more rigorous “Class I” well standards. The UIC program functions as the cornerstone of the SDWA and is directly related to hydraulic fracturing operations as it regulates disposal of water and by-products associated with oil and gas production (EPW, 2002; Kramer, 2012). There has been much contention over the SDWA program’s ability to effectively regulate oil and gas production employing hydraulic fracturing technology, especially as the program relates to groundwater, due to exemptions imposed by the Energy Policy Act of 2005 (Deweese, 2010; Kurth et al., 2010).

The Energy Policy Act of 2005 was established under the George W. Bush administration, and the act implemented a number of energy management objectives but also amended and mitigated some existing regulations, such as the SDWA (Kramer, 2012). One amendment to the SDWA put forth by the Energy Policy Act of 2005 essentially exempts hydraulic fracturing from any EPA regulatory authority under the UIC program (Tiemann, 2014). The Energy Policy Act of 2005 amended the SDWA to exclude from the definition of underground injection “the underground injection of fluids or propping agents (other than diesel fuels) pursuant to hydraulic fracturing operations

relating to oil, gas, or geothermal activities” (U.S. G.P.O., 2005). As such, hydraulically fractured wells are not considered Class II wells due to the exemption in the SDWA (Howard, 2013). Thus, the UIC program under SDWA does not currently impose direct federal regulation over the use of injection of hydraulic fracturing fluids.

Under the SDWA, the UIC program employs the basic principles of cooperative federalism; governance is shared at the federal and state levels. Since federal regulation under the SDWA remains broad and does not directly address hydraulic fracturing activities, states have the option to retain primacy over their own UIC program (Kurth et al., 2010). In order to retain state primacy, the state must submit its own UIC program to the EPA for approval. The proposed UIC program will be approved if the state demonstrates that the program is “at least as stringent as federal standards” and upholds the SDWA’s criteria (EPA, 2012; Tiemann, 2014). If approved, the state retains primacy and holds responsibility for program execution and regulation enforcement (Kurth et al., 2010). As of 2012, the EPA has granted primacy to 33 states and shares responsibility over the UIC program with seven states, including California (EPA, 2012c).

### **3.1.2. Emergency Planning and Community Right-to-Know Act**

The Emergency Planning and Community Right-to-Know-Act (EPCRA) was enacted in 1986 with the primary purpose to inform local officials, local fire departments, and citizens of chemical hazards in local areas (EPA, 2010a; Ground Water Protection Council & ALL Consulting, 2009). The EPA (2012) states that the objective of EPCRA

is to: (1) allow state and local planning for chemical emergencies, (2) provide for notification of emergency releases of chemicals, and (3) address communities' right-to-know about toxic and hazardous chemicals. Through EPCRA, the EPA allocates responsibility to states, tribes, and local governments for developing and administering emergency response efforts associated with hazardous chemicals. Section 313 of EPCRA requires the EPA and the states to collect and disclose known toxic chemical data from specified industrial sectors on an annual basis (EPA, 2014b). The collected data are available to the public through the Toxics Release Inventory (TRI) Program. The TRI acts as a reporting database devised to provide information on chemical uses and potential releases into the environment (Ground Water Protection Council & ALL Consulting, 2009). The TRI program is designed to minimize health and safety threats to employees or other parties who may have access to the workplace or are in close proximity (EPA, 2002a). The public can take information provided by TRI and hold companies and local governments accountable for proper management over hazardous chemicals.

The TRI Program covers industries such as mining, utilities, manufacturing, merchant wholesalers, and hazardous waste facilities (EPA, 2014c). Oil and gas extraction, however, is not included under the list of industries obligated to submit a toxic chemical release inventory form for the TRI Program. EPCRA excludes oil and gas exploration and production from the requirement to disclose information related to locations and quantities of chemicals stored, used, or released. Interestingly, the exclusion of oil and gas extraction from the industry list is not considered an exemption

but rather a decision made by EPA asserting this industry as low priority for TRI reporting (Ground Water Protection Council & ALL Consulting, 2009).

Cooperative federalism is evident under the EPCRA, as several levels of government from federal to local agencies share responsibility and management over certain facets of the EPCRA law. State and local governments collectively cooperate with the federal EPA to execute the EPCRA and TRI programs. Section 1101 of the EPCRA assigns responsibility to the state to establish a state emergency response commission, emergency planning districts, and local emergency planning committees (EPA, 2010a). The local committees are valuable because the personnel on the committee ideally have intimate knowledge regarding the local region, including industrial activities. The local emergency planning committee establishes procedures for receiving and processing requests from the public for toxic chemical data. The local committee is also responsible for making emergency response plans and toxic chemical information available to the general public (EPA, 2010a).

### **3.1.3. Resource Conservation and Recovery Act**

Finally, the Resource Conservation and Recovery Act (RCRA) is a federal act intended to govern the collection, storage, and disposal of hazardous waste materials. Hazardous waste is defined as a liquid, solid, gas, or sludge waste that contains properties known to be dangerous or potentially harmful to human health and the environment (EPA, 2014f). The EPA prepared hazardous waste management standards, in which

certain specified large volume wastes are subject to less stringent regulation. One of the specified waste categories is “special wastes.” EPA considers particular large volume special wastes to be lower in toxicity than other large volume wastes regulated as hazardous waste under RCRA (EPA, 2002b). EPA categorizes wastes generated during the exploration, development, and production of crude oil and natural gas as special wastes. As such, oil and gas special wastes are considered exempt from federal hazardous waste regulations under Subtitle C of the RCRA (EPA, 2014a). Therefore, drilling fluids, produced water, and other wastes associated with the exploration and production of oil and gas are exempt from federal hazardous waste regulations (EPA, 2012b). EPA admits that some exempt oil and gas exploration and production wastes “might be harmful to human health and the environment, and many non-exempt wastes might not be as harmful” (EPA, 2002b).

Similarly to the SDWA and EPCRA, RCRA is administered and enforced by the various levels of federal and state government. The EPA encourages the states to assume principal responsibility for employing a hazardous waste program through state adoption, authorization, and implementation of the regulations (EPA, 2014f). The American Petroleum Institute acknowledges that hydraulic fracturing flow back fluids still need to be addressed at the state level in spite of the federal RCRA exemption (API, 2010). Many different federal laws (such as SDWA, EPCRA, and RCRA) have set up the context for state and local agencies to govern oil and gas exploration according to industry operations at the time of enactment. These agencies still function under the same laws, though industry practices and technologies have advanced and transformed considerably

in recent years. Some state and local agencies are taking initiative to implement more appropriate regulations for region-specific industry activities to address unconventional oil and gas extraction techniques.

### **3.2 State Regulation**

Due to the context of the federal laws and regulations, many states are left with weak, minimal, and disordered management of hydraulic fracturing operations (Finkel et al., 2013). Deficiency of proper regulation, effective management, implementation, and lack of shared knowledge causes regulatory challenges and public skepticism. The inability to influence and properly regulate oil and gas exploration at the local level can create the perception of regulatory ineptness and can contribute to increased concern about hydraulic fracturing activities among public interest organizations. For example, Adrienne Alvord, Western States Director of Union of Concerned Scientists, commented that, “the safety, public health, and environmental impacts of fracking have been difficult to answer in many cases because limited information is available in the public domain due to a combination of trade secret protections and uneven, weak, or nonexistent regulations” (Union of Concerned Scientists, 2013).

An existing debate persists over whether the precedent for hydraulic fracturing operations should be held by the federal or state government (Williams, 2012). Some arguments in favor of federal oversight defer to dependency on oil and gas industry to bolster state and local economies, and therefore, states may be disinclined to enact more

rigorous regulation on the industry. However, there is also consensus among politicians, activists, and the industry that the most effective method of regulating oil and gas exploration involving hydraulic fracturing is at state and local levels (Pavley, 2013; Quast, 2013; Reheis-Boyd, 2014). John Graves, author of Fracking: America's Alternative Energy Revolution, claims that state application of regulatory oversight is far more effective and efficient compared to federal jurisdiction because local regulators have accrued experience and knowledge of a particular geographic area and the subsurface formation. Furthermore, a report prepared for the U.S. Department of Energy explains that nation-wide regulations may not always be the most applicable approach to each state's unique oil and gas exploration conditions; therefore, many federal laws have provisions for granting state primacy (Ground Water Protection Council & ALL Consulting, 2009). Brady and Crannell (2012) imply that, despite Congress's power to regulate hydraulic fracturing activities under the Commerce Clause of the U.S. Constitution, governance over the oil and gas industry is largely bestowed to the states. With federal oversight, state agencies are permitted to implement programs to more effectively address the state- and regional-specific character of oil and gas activities. States have developed regulatory and management schemes of varying effectiveness and complexity. Some states enforce provisions related specifically to hydraulic fracturing, while other states regulate operations exclusively under broad oil and gas permitting requirements (Brady & Crannell, 2012).

### **3.2.1. California**

California is an example of a state that has recently been taking a strong position to regulate state oil and gas exploration, and some California communities are taking a step further to implement region-specific requirements. California holds substantial petroleum reserves in the Monterey Shale Formation, which the industry is eager to extract, but current state regulatory agencies do not employ systems to effectively provide oversight of operations involving recent novel technological advances to recover shale oil. Many state agencies in California share responsibility to oversee varying aspects of oil exploration and production. These agencies include the California Division of Oil, Gas & Geothermal Resources, the State Water Resources Control Board, and the Regional Water Resources Control Boards.

California's Division of Oil, Gas & Geothermal Resources (DOGGR) was formed in 1915 with the purpose of regulating statewide oil and gas activities to meet the needs of the industry as well as the state and local governments (DOGGR, 2013b). DOGGR is the agency with primary responsibility for oil exploration and production activities in the state. The agency supervises the drilling, operation, maintenance, plugging and abandonment of onshore and offshore oil, gas, and geothermal wells (DOGGR, 2013b). Until recently, however, DOGGR had not specifically addressed hydraulic fracturing, acidization, or other WSTs. As described in Section 2.2.4, acidization is the WST application of pumping acid down a well to dissolve hydrocarbon bearing rock in order to extract the residual oil and gas. As the prospect of enhanced resource recovery

becomes more prevalent in other states across the country, California's Monterey Shale is developing into a topic of heavy controversy. Industries, such as Venoco, Occidental Petroleum, and Plains Exploration and Production, are eager to accelerate extraction of the Monterey shale oil (Krishnamsetty, 2013). However, despite the widespread use of hydraulic fracturing and acidization in California, DOGGR admits that the agency has minimal information available regarding these WSTs.

Formerly, California's regulations do not require oil and gas operators to notify DOGGR when hydraulic fracturing occurs (DOGGR, 2014). In 2011, the then State Oil and Gas Supervisor, Elena Miller, responded to a request from Senator Fran Pavley to provide information regarding hydraulic fracturing in California. Miller revealed in the response letter that DOGGR is "unable to identify where and how often hydraulic fracturing occurs within the state" because there are no reporting requirements or regulatory parameters of when, how, and what needs to be reported when acquiring drilling permits (Miller, 2011). Miller further discloses that although DOGGR has statutory authority to regulate hydraulic fracturing under Section 3106 of the Public Resources Code, no regulatory measures have been conceived to address any hydraulic fracturing activity. The correspondence between Pavley and Miller in 2011 also revealed an evident lack of reporting and permitting requirements that would otherwise inform DOGGR of industry activity such as the quantity of energy produced attributable to hydraulic fracturing and the quantity of water involved in the hydraulic fracturing process. This exchange indicates that there are significant gaps in the degree of regulatory oversight for hydraulic fracturing activities in California. As of 2014, DOGGR's

hydraulic fracturing in California informational website acknowledges a remaining gap between the “requirements placed on oil and gas operators to safely construct and maintain their wells, and the information [the operators] provide [DOGGR] about hydraulic fracturing operations and steps taken to protect resources and the environment” (DOGGR, 2014).

In March 2012, in response to legislative pressure, DOGGR requested state oil and gas operators to voluntarily disclose hydraulic fracturing activity. This notice strongly encouraged California oil and gas operators to disclose information through FracFocus regarding well location, well depth, chemicals, fluids, and proppants used for hydraulic fracturing (Kustic, 2012). FracFocus is a national hydraulic fracturing disclosure registry website managed by the Ground Water Protection Council and Interstate Oil and Gas Compact Commission that was created to provide public access to region-specific hydraulic fracturing information (GWPC & IOGCC, 2014). DOGGR released a “discussion draft” of proposed hydraulic fracturing regulations in December 2012. The “discussion draft” is an improvement made by DOGGR to address provisions for pre-fracturing well testing, advance notification, monitoring during and after fracturing operations, disclosure of materials used in fracturing fluid, trade secrets, and storage and handling of hydraulic fracturing fluids (DOGGR, 2012a). Though DOGGR is the primary regulatory agency for hydraulic fracturing and other WSTs in California, responsibilities are also shared with the State Water Resources Control Board.

The State Water Resources Control Board (SWRCB) and DOGGR have overlapping statutory obligations for safeguarding the state’s water resources, and each

agency performs specific duties in regulating activities and potential consequences from oil and gas operations (Howard, 2013; Senate Rules Committee, 2013). For example, DOGGR has received primacy from the EPA to regulate Class II injection wells in California, and the SWRCB collaborates with DOGGR in this responsibility (Howard, 2013). In 1988, the SWRCB and the DOGGR entered into a Memorandum of Agreement (MOA) to collectively address discharges produced by oil and gas operations and streamline reporting and permitting for Class II wells (DOG, 1988). However, as discussed in Section 3.1.1 (Safe Drinking Water Act), hydraulically fractured wells are not considered Class II wells due to the exemption provided in the SDWA by the Energy Policy Act of 2005. When the Executive Director of SWRCB, Thomas Howard, was asked if the agency will consider amending the 1988 MOA, Howard responded that there are no formal plans for revisions. Howard views the existing statutory authorities and regulations as “sufficient to minimize potential risks to water quality related to hydraulic fracturing activities” and further states that the SWRCB considers hydraulic fracturing as a low threat to groundwater (Howard, 2013). In 2010, the EPA requested a review of DOGGR’s Class II UIC program. The review found that existing DOGGR practices may not adequately prevent groundwater contamination from Class II wells and that former projects do not always reflect present requirements (Walker, 2011). DOGGR acknowledges on its website that the agency needs to revisit its regulatory programs and there is an existing “gap between the requirements placed on oil and gas operators to safely construct and maintain their wells, and the information they provide to [DOGGR] about hydraulic fracturing operations and steps taken to protect resources and the

environment” (DOGGR, 2014). There is need for DOGGR and the SWRCB to improve their collaboration efforts in order to sufficiently oversee industry activities involving oil and gas, as well as the associated waste materials and wastewater. There is further need to more effectively monitor regional activities with the assistance of the Regional Water Resources Control Boards.

The State Water Resources Control Board (SWRCB) and the nine Regional Water Resources Control Boards (hereinafter referred to as regional boards) in California enforce the Porter-Cologne Water Quality Control Act, which establishes the state’s primary water quality regulations (SWRCB, 2014). The SWRCB and regional boards also share responsibility to issue permits for discharge to surface, coastal, and ground waters (SWRCB, 2011). The regional boards issue waste discharge requirement permits, take enforcement action against dischargers who violate permits or harm water quality, and monitor waterways (SWRCB & Regional Boards, 2010). The regional boards are divided in nine water quality control boards that exercise rulemaking and regulatory activities in their respective watershed basins. Therefore, each board has a specific knowledge of the local region, including industrial activities and environmental factors. The regional boards are currently in the process of creating model criteria for groundwater monitoring related to oil and gas wells subject to WSTS, as specified in Senate Bill 4 (Button, 2014).

**3.2.1.1 Senate Bill 4 (SB 4)**. In response to increasing concerns and lack of existing suitable policy, Governor Brown signed into law the first piece of legislation in

California to regulate well stimulation treatments, including hydraulic fracturing and acidizing. SB 4, Oil and Gas: Well Stimulation, was signed on September 20, 2013 and went into effect January 1, 2014. SB 4 represents California's first and only bill to provide a comprehensive statutory framework for hydraulic fracturing as part of a general well stimulation regulation in California. Sponsored by California State Senator Fran Pavley, SB 4 was enacted in response to increased interest to pursue unconventional resources in the Monterey Shale Formation, perceived weak regulatory oversight, insufficient government and industry transparency, and an information gap between government agencies, the industry, and the public (Murza, 2014). SB 4 imposes the following requirements: a new permitting system for oil and gas well operators, groundwater testing before and after well stimulation, notification to inhabitants in proximity of operations, and disclosure of chemicals used in the process (Pavley, 2013). Broadly, the following is performed as specified under SB 4:

- (1) The Division of Oil, Gas, and Geothermal Resources (DOGGR) is appointed as the primary responsible government agency to undertake and enforce SB 4. Furthermore, DOGGR must collaborate and consult with multiple state government agencies to apportion responsibilities among each public entity.
- (2) By January 1, 2015, the Secretary of the Natural Resources Agency must conduct and complete an independent scientific study on well stimulation, including hydraulic fracturing and acid well stimulation treatments. The scientific study shall evaluate the potential environmental, occupational, and public risks posed by well stimulation treatments.

- (3) An oil or gas operator must apply for a permit before performing a well stimulation treatment. The permit application includes, but is not limited to, information such as well location, planned date for well stimulation, a water management plan, and a complete list of each chemical constituent of the well stimulation treatment fluids.
- (4) Oil and gas operators must provide full disclosure of the composition and disposition of well stimulation treatment fluids, including, but not limited to, hydraulic fracturing fluids, acid stimulation fluids, and flowback fluids.
- (5) A person who violates certain statutes or regulations relating to oil and gas well operations is subject to a civil penalty of no less than \$10,000 and not to exceed \$25,000 per day per violation.

One of the most significant provisions of SB 4 is the mandate for an independent scientific study to be conducted to evaluate hazards and risks of oil and gas exploration, including hydraulic fracturing and acid well stimulation treatments (Pavley, 2013). This study should ultimately highlight genuine existing and potential risks caused by WST, but should also suppress concerns found to be irrelevant in association with California oil and gas operations. The study must consider evaluating factors such as, but not limited to, potential impacts on wildlife and habitat, potential noise pollution, induced seismicity, potential water and surface contamination, and disposition of WST fluids (Pavley, 2013).

Furthermore, under Public Resources Code section 3160(e), the Secretary of the Natural Resources Agency must provide progress reports regarding the development, timeline, and formation of the scientific study. The first progress report was required to

be provided to the California Legislator by April 1, 2014 (Pavley, 2013). This report was sent to the Joint Legislative Budget Committee, Natural Resources Committee, and Environmental Quality Committee and is publically available online. The initial progress report serves to inform these entities of the “organization and scope of the study and the expected timeline for the conduct and completion of the study” (Powell & Gomez, 2014).

The study will be divided into three separate volumes. The first volume will review the factual basis describing the technology and practice of WSTs in California. Volume I will also trace where previous and present WSTs occur in the state. Volume II will evaluate the conceivable impacts of well stimulation treatments with respect to water and air quality, induced seismicity, ecosystems, road traffic, and noise. Lastly, Volume III of the scientific study will yield case studies to gauge environmental concerns and qualitative hazards for particular geographic regions, based on results in Volume I and II. To date, a peer reviewed version of Volume I is expected to be published by January 2, 2015. Subsequently, the current timeline sets publication of Volumes II and III for July 1, 2015 (Powell & Gomez, 2014). Since there has been no statewide, comprehensive research evaluation of WSTs, including hydraulic fracturing, the independent scientific study will prove to be an essential component to the stated objective and overall success of SB 4 (Murza, 2014).

Another significant and highly debated provision of SB 4 is the full disclosure of well stimulation fluids, including hydraulic fracturing and acid well stimulation fluids. Perhaps the most notable criticism regarding hydraulic fracturing is that chemicals and fluids involved in the well stimulation process are generally company proprietary and

currently not publically accessible. SB 4 seeks to address such concerns by requiring public disclosure of each chemical present throughout every step of the oil and gas extraction process. Section 3160(b)(2) sets forth the disclosure requirements in the Public Resources Code. The requirements cover disclosure of the composition and disposition of well stimulation fluids, total volume of base fluid, complete list of chemical names, source and volume of source water, and name and concentration of each additive (Pavley, 2013). Section 3160(j)(2) explicitly declares that, notwithstanding any other law or regulation, none of the following shall be protected as a trade secret:

- (1) The identities of the chemical constituents of additives.
- (2) The concentrations of the additives in the well stimulation treatment fluids.
- (3) Any air or other pollution monitoring data.
- (4) Health and safety data associated with well stimulation treatment fluids.
- (5) The chemical composition of the flowback fluid.

Generally, the supplier of the chemicals, not the oil and gas operator, will be most impacted by the disclosure provision set forth by SB 4. The supplier is usually referred to as the entity that supplies an additive or proppant to the operator for the use in a WST. However, chemical disclosure is not absolute under the legislation and is subject to some limited trade secret protections. Under SB 4, the supplier is given the opportunity to substantiate a trade secret claim. In order to do so, the supplier must provide information to DOGGR for review. In order to substantiate a trade secret claim, the supplier must provide the following information to DOGGR:

- (1) The extent to which the trade secret information is known by the supplier's employees, other involved in the supplier's business and outside the supplier's business.
- (2) The measures taken by the supplier to guard the secrecy of the trade secret information.
- (3) The value of the trade secret information to the supplier and its competitors.
- (4) The amount of effort or money the supplier expended developing the trade secret information and the ease or difficulty with which the trade secret information could be acquired or duplicated by others.

Regardless of some residual trade secret protections, SB 4 specifies that DOGGR can release trade secret information under unique circumstances to select individuals. Such circumstances are detailed under Section 3160(j)(10), and identifies individuals such as specified government employees and health professionals in an emergency event (Pavley, 2013). DOGGR created a page on its website titled "Well Stimulation Treatment Disclosure." The page provides a link to the "Well Stimulation Treatment Disclosure Index", which provides specific information as stipulated in SB 4. The index includes details regarding WST fluid information, location of treatment, identification of all water, volume of recovered fluid, identification of other fluids, and radiological components. The information provided in the index is publically accessible through the DOGGR "Well Stimulation Treatment Disclosure" webpage. The next chapter will describe the methodological approach used to conduct the stakeholder and policy analysis and will outline the intended goals of the thesis research.

## CHAPTER 4. METHODS

The primary methodological approaches used for this thesis research are a stakeholder analysis and a policy analysis. A stakeholder analysis is the process of distinguishing individuals or organizations that are expected to influence or be influenced by a projected action and arranging them according to their effect on the action and the effect the action will have on them. A policy analysis is used to thoroughly evaluate a policy measure, in which the problem, goal, and implementation of a specific policy are outlined and analyzed. Specific methods to conduct the stakeholder and policy analysis, and the intended goals for each method, are described in this section.

This thesis uses a stakeholder analysis to demonstrate the attitudes and perceptions towards SB 4 and WSTs, including hydraulic fracturing, in California. Using a stakeholder analysis as a methodical approach helps to facilitate this thesis research in determining the efficacy of SB 4 and potential future WST policy reform. A stakeholder is considered to be a person or organization that can be positively or negatively impacted by a certain course of action. The stakeholder analysis performed in this thesis is used to clarify the diverse attitudes towards SB 4 and hydraulic fracturing operations in California. My thesis research presents a stakeholder analysis that qualitatively reflects data on stakeholders understanding, position, influence, and interest in policy reform and general hydraulic fracturing developments in California. The stakeholder analysis also elucidates conflicting standpoints towards impending reforms and the power struggles among stakeholder groups.

Simply, a stakeholder is any entity with an established or feasible interest or investment in a policy reform. This thesis identifies key stakeholders who are ultimately affected by oil and gas production, have significant importance within the policymaking process, or project influence on the involvement and outcome of WST operations in California. The key stakeholders identified in this thesis research fall into the categories of political actors, public sector agencies, interest groups, commercial organizations, nonprofit organizations, and concerned citizens. Key stakeholders were selected based on the following four major attributes in regards to hydraulic fracturing operations and policy decision-making in California: the stakeholder's stance, the level of influence, the level of interest, and the stakeholders' organizational association.

Specific individuals from oil and gas groups, environmental organizations, governmental agencies, research laboratories, and academia were asked to participate as key stakeholders for this thesis research. The prospective participants were carefully selected based on the criteria previously described regarding the four major attributes in key stakeholder selection. The prospective participants were invited to participate in this thesis research based on previous and current involvement, interest, and influence in the formation of SB 4. For example, several individuals and groups published public comments, articles, and documents regarding SB 4. Such publications reflected either a supportive or opposing stance or analysis of the bill during and after the policy decision-making process. Therefore, the stakeholders selected for this thesis should have a thorough working knowledge of SB 4 and a perspective concerning WST developments in California.

Approximately 70 individuals who are considered to be key stakeholders were initially invited to participate in this thesis research. Of the initial outreach, 17 individuals, or 24% of the initial prospective stakeholders, agreed to participate. As previously mentioned, this research aims to represent diverse affiliations such as industry groups, environmental organizations, government agencies, and academia.

For example, oil and gas industry-affiliated individuals were initially invited to participate from groups such as Western States Petroleum Association (WSPA), California Independent Petroleum Association (CIPA), Chevron, Halliburton, and Energy In Depth. Outreach to industry stakeholders resulted in two individuals who agreed to participate in this thesis research. One participant is Suzanne Noble, Vice President at WSPA. WSPA was founded in 1907 and is the oldest petroleum trade association in the United States, representing companies of petroleum exploration and production in Arizona, California, Nevada, Oregon, and Washington (WSPA, 2013b). The second participant from the industry stakeholder group is a representative of CIPA, but this individual requested to remain anonymous. CIPA is a non-profit, non-partisan trade association representing approximately 500 independent crude oil and natural gas producers and service and supply companies operating in California (CIPA, 2014). Overall, despite several outreach attempts, industry affiliated stakeholders yielded a low participation rate. A few individuals either provided a response to the initial research invitation, but did not participate, or provided reasons for declining the invitation. For example, a public relations representative from Halliburton responded by referring me to Halliburton's website and corresponding hydraulic fracturing microsite. I was told that

information provided on the webpages would answer my questions, including information about the company's "Frac of the Future technologies, which are reducing our environmental footprint." The e-mail also referred me to three other web sources, including Energy in Depth, Energy from Shale, and American's Natural Gas Alliance, in order to answer more industry-level questions. Outreach was also made to these sources, but these efforts did not produce any responses. Though this thesis research and stakeholder results represent two participants from the industry stakeholder group, it is important to note that WSPA and CIPA collectively represent hundreds of oil and gas companies. Therefore, the perspectives and feedback collected from WSPA and CIPA may be considered to reflect the outlook of many businesses and organizations in the oil and gas industry.

The environmental stakeholder group represented the highest participation in this thesis research. Initial participation outreach was made to individuals affiliated with groups such as (but not limited to) 350.org, California Food and Water Watch, Frack-Free Butte County, Global Exchange, Center for Biological Diversity, Natural Resources Defense Council, Environmental Working Group, and Sierra Club. Many of these participants provided permission to use their name and direct quotes for the use of this thesis research. More detailed information regarding these stakeholders and their feedback is provided in the Results Chapter.

Individuals from governmental agencies who were involved in the creation of SB 4, or who are affected by parameters in SB 4, were invited to participate in this thesis research. Prospective government stakeholders who received an invitation are affiliated

with DOGGR, the California State Water Board, the EPA, the Water Replenishment District of Southern California, and various counties in Southern California. Only one individual agreed to participate from the government stakeholder group. However, this stakeholder preferred that his/her information remain confidential. Similarly to the industry group, the prospective government stakeholder group also received a low participation rate. One EPA representative declined to participate due to unfamiliarity with California's regulations and policies associated with hydraulic fracturing. The EPA representative referred me to EPA's research on the potential impacts of hydraulic fracturing on drinking water resources. I was also encouraged to explore EPA's programs related to hydraulic fracturing. Another response example is from a representative of the California Department of Natural Resources who kindly regretted that he or she had to decline my invitation to participate in the research because the representative did not want personal feedback to be perceived as related to California policy.

Lastly, individuals from academia, research laboratories, and legal service providers who publically published articles and reports regarding SB 4 and hydraulic fracturing developments in California were also invited to participate in this thesis research. People were contacted from organizations including, but not limited to, the following: the University of Southern California School of Public Policy, University of California Davis, University of California Berkeley Law, Lawrence Berkeley Laboratory, Luna and Glushon, and Mayer Brown. From this particular outreach, four willing participants represent the academia group and one individual agreed to participate from the private legal service sector.

For the purpose of organization and conveying results, stakeholders are arranged into three primary groups. The first group consists of the individuals from WSPA and CIPA and is referred to as the industry stakeholder group. The second group is comprised of the participants from various environmental and advocacy organizations and is referenced as the environmental stakeholder group. The third group encompasses the remaining six individuals from the governmental, academia, and legal service provider sector. The third group is referred to as the academia and governmental stakeholder group in this thesis.

I used a survey and follow up interviews in the context of the stakeholder analysis. Stakeholders were initially presented with the opportunity to participate in the study through an invitation to complete the survey. Upon initial contact, the stakeholders were informed that the researcher did not anticipate any risks or benefits for participation in the study. Any participant identified in this thesis agreed to provide consent to participate according to the terms outlined in Appendix A. These terms included that the participant understands partaking is entirely voluntary and he/she may withdraw from the study at any time without jeopardy. The participants were given the option to indicate a preferred level of participation. The three levels of participation offered included: permission to be quoted *with* use of name, permission to be quoted *without* use of name, or deny permission to be directly quoted. Of the 17 total participants, 47% preferred to be directly quoted with *use* of their name and 35% of the participants preferred to be directly quoted *without* use of their name. Only 18% of participants preferred to not be directly quoted. The survey was created using Google Forms, and submitted survey responses

were stored on the researcher's personal Google account. Outreach efforts and data collection took place during the spring and summer of 2014.

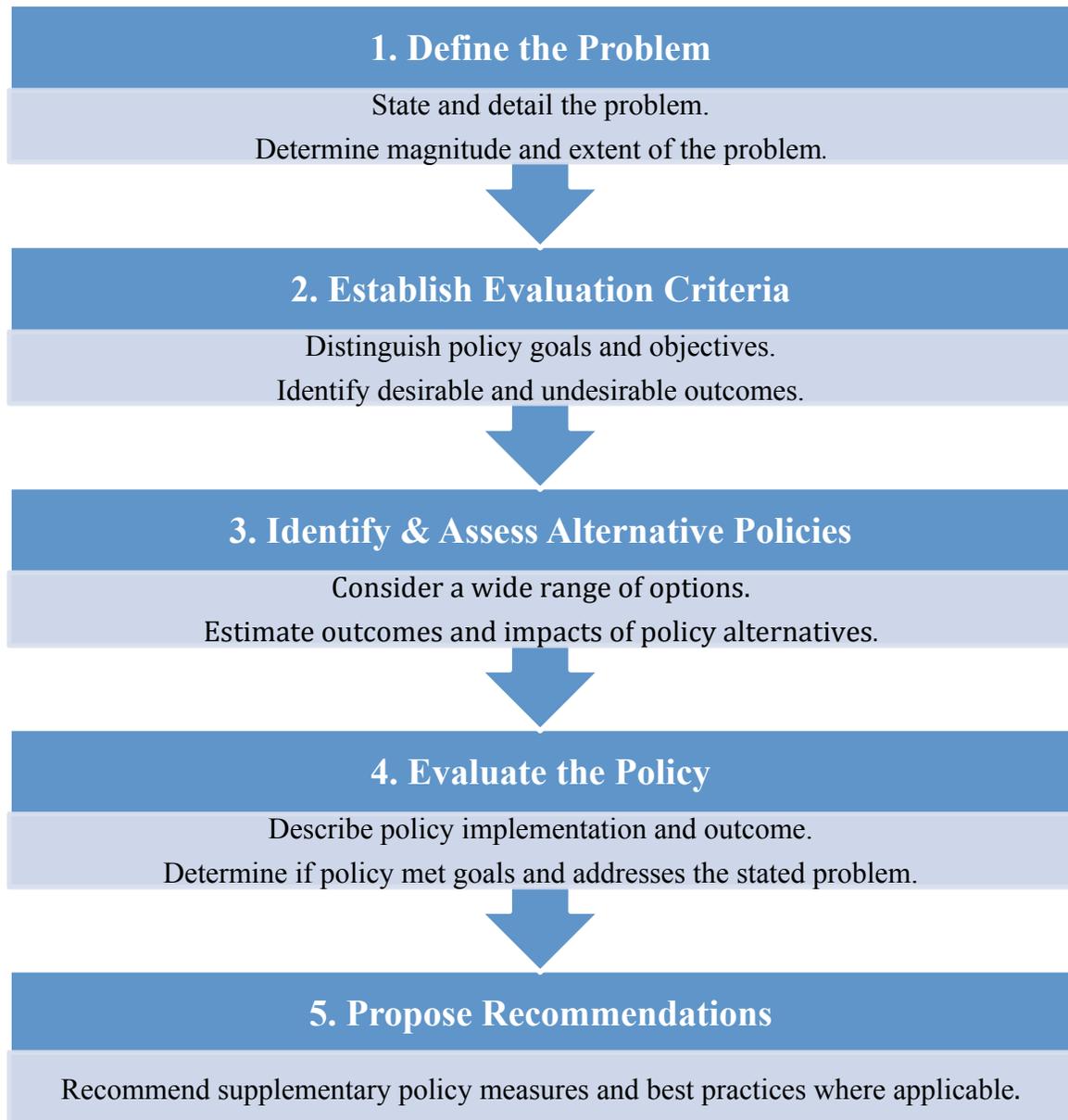
An online survey was used as the principal method to facilitate the stakeholder analysis. The survey was created with the objective of gauging stakeholders' knowledge, attitudes, and perceptions of SB 4, as well as perceived benefits of and concerns with hydraulic fracturing in California. Google Forms served as the medium to create and administer this survey. The participant was required to provide a consent form before submitting the survey. The consent form was positioned in the beginning of the survey, in which the decision to provide or deny consent was required. The survey was voluntary and each participant had the right to withdraw at anytime during the research project. The survey consisted of approximately ten questions and was estimated to take roughly five to ten minutes to complete. Language used in the survey was configured to avoid producing biased responses, and questions were clearly and succinctly presented. The participants were given identical surveys with the same questions and formatting. Questions pertained to stakeholder perspectives of perceived benefits and concerns with oil and gas extraction, the efficacy of SB 4, and recommendations for policy measures or regulations in California. The full survey and consent form, including instructions and survey questions, are provided in Appendix A.

Semi-structured open-ended interviews served as the secondary method to help facilitate the stakeholder analysis. Interviews were used as a follow up approach after a survey was submitted. Helen Newing et al. (2010) explains that interviews are an essential qualitative tool that differ from surveys in that interviews are a two-way

conversation with discussion and follow-up questions. This form of data collection is highly valuable in obtaining more nuanced feedback and supplementary information that may have gone unobserved through the survey responses. The final survey question asks participants if the researcher can contact her/ him with additional questions. If the participant provides this permission, then she/he was asked to partake in an interview to add depth to survey responses. The form of the interviews was semi-structured and open-ended, and was pre-arranged with the willing participant.

The Humboldt State University Institutional Review Board (IRB) formally reviewed the supplementary methods used to conduct the stakeholder analysis for the Protection of Human Subjects. The IRB categorized my proposed research methods as exempt by Federal Regulation 45 CFR 46.101(b). The exempt designation for my research proposal expires on March 9, 2015. My IRB reference number is 13-126.

A policy analysis is the additional primary methodological approach used in this research. I used a policy analysis to clarify the complex policy challenge, analyze relevant information and the context, outline implications of proposed actions, and rationalize proposed recommendations. A five-step method was used to conduct the policy analysis. The five basic steps to facilitate the policy analysis were the following: (1) define the problem, (2) establish evaluation criteria, (3) identify alternative policies, (4) assess and evaluate the policy, and (5) propose recommendations if applicable (Adugba, 2011; Saint-Germain, 1998). The chart below illustrates the policy analysis process, including the sequence of steps, and objective of each of the five steps.



The objective of a policy analysis for this thesis research is to evaluate SB 4. This study aims to address relevant questions associated with each of the five steps in the policy analysis process. These questions are outlined below in sequence of each step.

- *Step 1. Define the Problem:* What is the problem that SB 4 proposes to address? What was the event or series of events that was a catalyst for the creation of SB 4? Does the problem demand immediate attention? What interests are at stake for key stakeholders?
- *Step 2. Establish Evaluation Criteria:* How does SB 4 translate the problem into a specific set of goals? What is the relationship between those goals and the problem that was identified? What government organizations were involved in the creation and administration of SB 4?
- *Step 3. Identify and Assess Alternative Policies:* What other alternative policy options were considered to address the original problem? What was the outcome of alternative policies? Why were the other alternatives rejected?
- *Step 4. Evaluate the Policy:* Did SB 4 achieve its goals and intended effects? Did SB 4 solve the original problem?
- *Step 5. Propose Recommendations:* Are there recommendations that can help SB 4 achieve its goals? What can be recommended to further address the original problem?

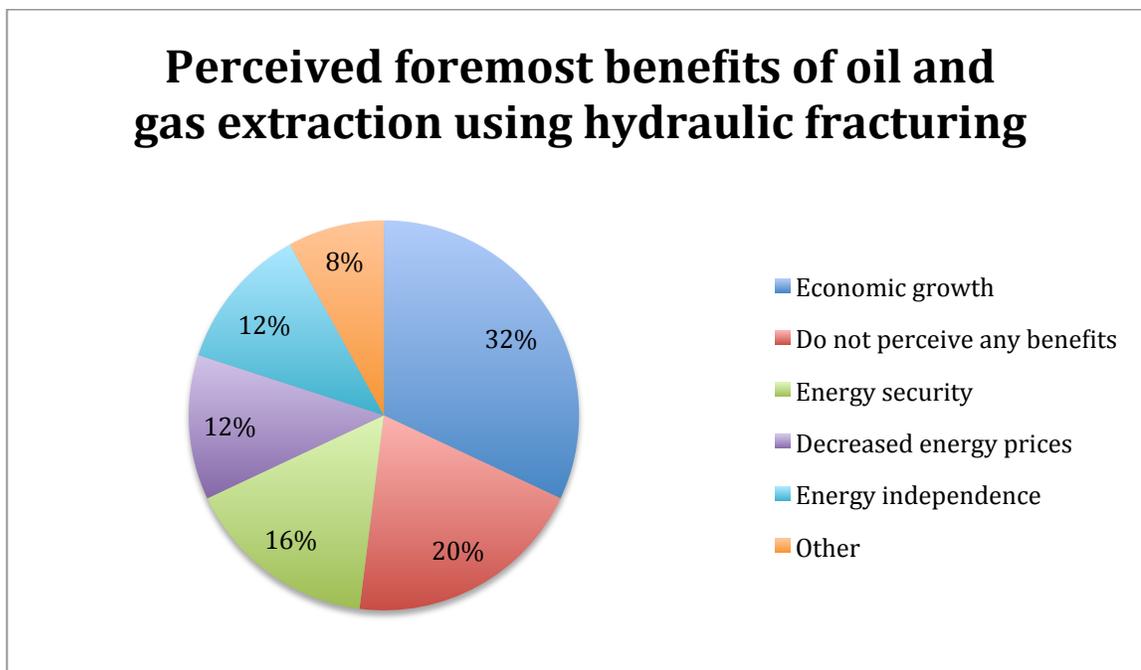
The results of the aforementioned analysis are considered and discussed further in the Discussion Chapter. The information provided for the policy analysis reflects the most accurate and complete material available during the time of this thesis research. The next chapter will disclose and review the results of the stakeholder analysis and policy analysis.

## CHAPTER 5. RESULTS

The following chapter reflects data that are primarily collected from the stakeholder analysis. The policy analysis also produced tangible findings, which are discussed in depth in the Discussion Chapter. The stakeholder responses and feedback that the research study received provides insightful perspectives on the current developments of hydraulic fracturing technology and policy in California. The Results Chapter primarily reflects the results of the interviews as part of the stakeholder analysis. The nuanced feedback collected from the interviews is discussed in further detail in the Discussion Chapter. The stakeholder analysis results are presented in the same sequence as the research questions appeared in the research survey. Results from the survey questions are generally written according stakeholder group feedback. As described in the Methods Chapter, participants are arranged by key stakeholder affiliation and categorized into the following groups: industry group, environmental group, and academia and governmental group. The results for the stakeholder analysis are provided below.

One of the first survey questions asked, “In California, what do you perceive as the foremost *benefits* of oil and gas extraction using hydraulic fracturing?” The participants were provided six different checkboxes, in which he/she could check one or multiple answers of their choosing. The checkbox choices were; energy security, energy independence, economic growth (including jobs), and decreased energy prices. There was also an option to check “I do not perceive any benefits of oil/gas extraction using

hydraulic fracturing.” The last checkbox provided for this question was an “other” option, in which participants were able to provide a variant answer or expand on a selected response. The total percentage reflecting all the participants for each answer for this survey question is provided in Figure 11 below.

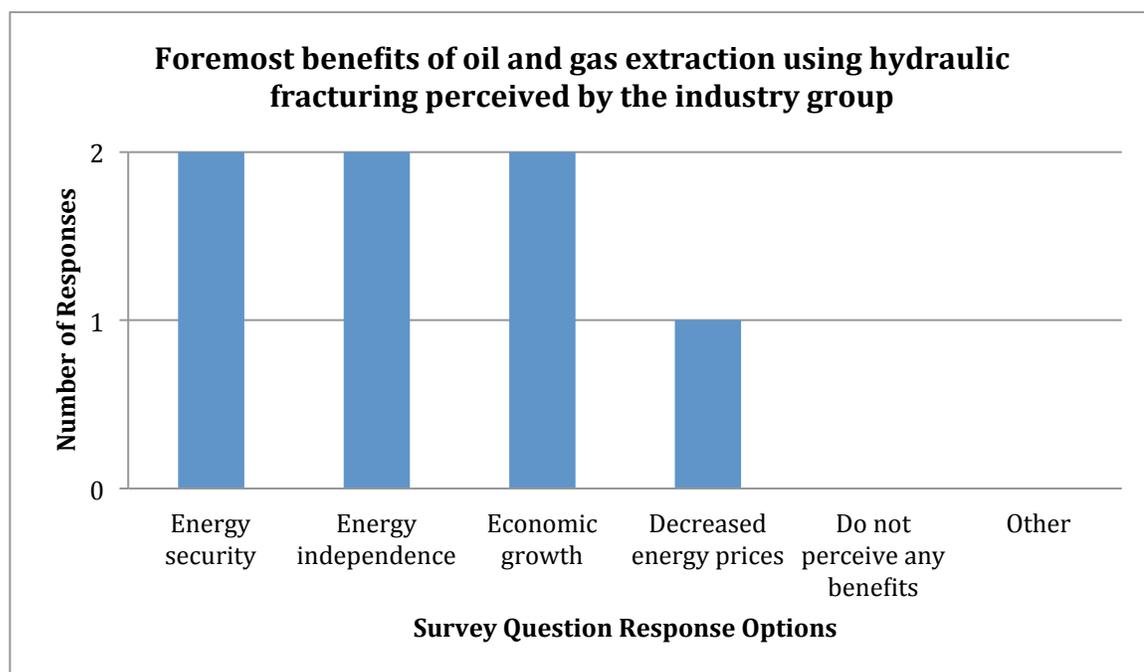


**Figure 11: Perceived foremost benefits of oil and gas extraction using hydraulic fracturing.** The chart above reflects the survey results for foremost benefits of oil and gas extraction using hydraulic fracturing in California as perceived by stakeholders. The majority of stakeholders responded that economic growth, including jobs, is the upmost benefit of hydraulic fracturing.

Of the 17 total participants, 16 stakeholders answered this survey question.

Among all the stakeholders, the answers that received the highest response rate were “economic growth (including jobs)” and “I do not perceive any benefits of oil/gas extraction using hydraulic fracturing.” Combined, 52% of participants selected one of these options. Overall, stakeholders perceived economic growth, including, jobs as the foremost benefit of hydraulic fracturing in California. The options with the lowest

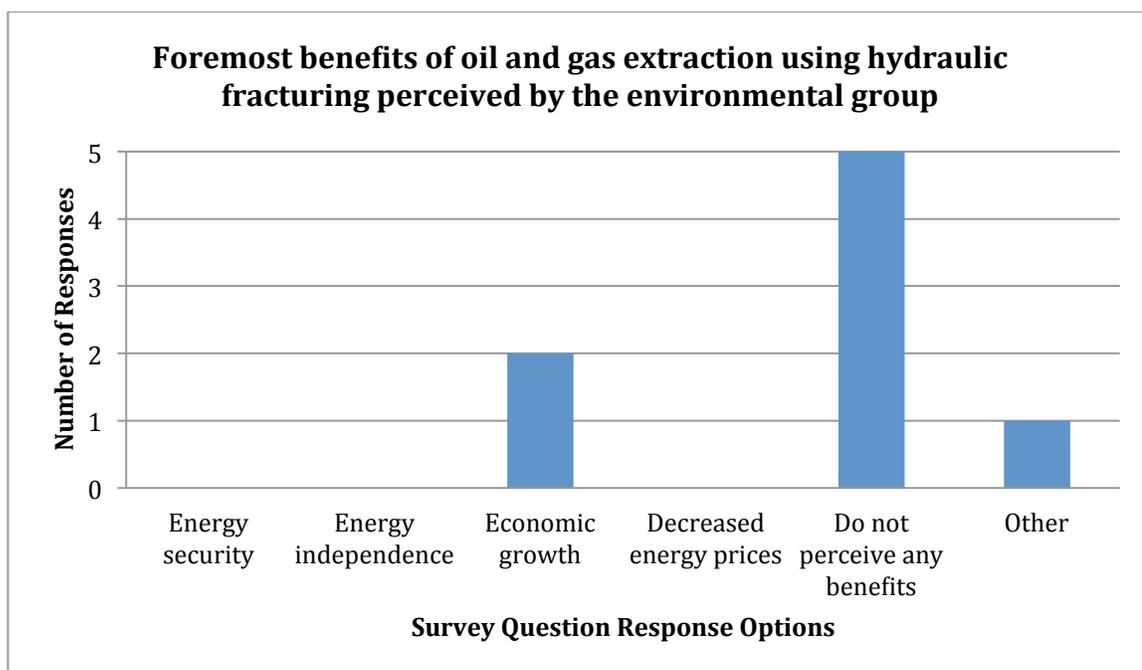
response rate were “energy independence” and “decreased energy prices,” with only 12% each. Two participants chose the “other” option. One participant wrote “increased profits for exploration and production companies.” The other participant perceived that energy resources would be more abundant for a limited time with the use of hydraulic fracturing, but there is no promise of definite security or independence. Results are also presented by key stakeholder group in order to provide a clearer picture of the perspectives of the various stakeholder groups. Figure 12 reflects the foremost benefits of hydraulic fracturing in California as perceived by the industry stakeholder group.



**Figure 12: Foremost benefits of oil and gas extraction using hydraulic fracturing as perceived by the industry stakeholder group. The results reflect that industry stakeholder consider economic growth, energy independence, and energy security as upmost benefits of hydraulic fracturing in California.**

The results specifically from the industry stakeholder group indicate that the perceived foremost benefits of hydraulic fracturing in California are economic growth (including jobs), energy independence, and energy security. Both of the industry

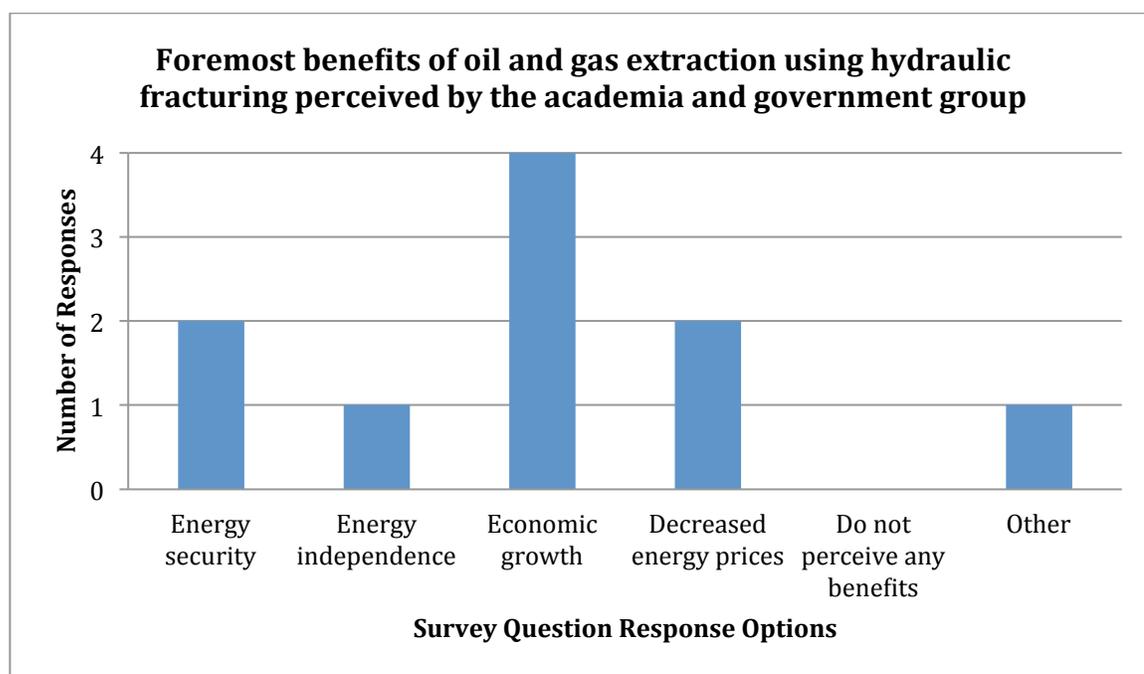
stakeholders chose these three responses. One industry stakeholder indicated decreased energy prices as a benefit resulting from hydraulic fracturing in California. No one from the industry stakeholder group selected “do not perceive any benefits” as a response for this survey question. Figure 13 provides the results of foremost benefits of hydraulic fracturing in California as perceived by the environmental stakeholder group.



**Figure 13: Foremost benefits of oil and gas extraction using hydraulic fracturing as perceived by the environmental stakeholder group. The results reflect that environmental stakeholder group largely does not perceive any benefits of hydraulic fracturing in California.**

The results in Figure 13 indicate that the environmental stakeholder group principally does not perceive any benefits of oil and gas extraction using hydraulic fracturing in California. Five of the eight environmental stakeholders who responded to this survey question perceive no benefits of hydraulic fracturing. Economic growth, including jobs, received the second highest response rate from the environmental group with two environmental stakeholders selecting this option. One environmental

stakeholder, Dr. Clyde Thomas Williams, member of the Water Committee with the Sierra Club, selected the “other” option and noted that “increased profits for exploration and production companies” are foreseen benefits of hydraulic fracturing in California. No one from the environmental stakeholder group selected energy security, decreased energy prices, or energy independence as a response for this survey question. Figure 14 provides the results of foremost benefits of hydraulic fracturing in California as perceived by the academia and government stakeholder group.

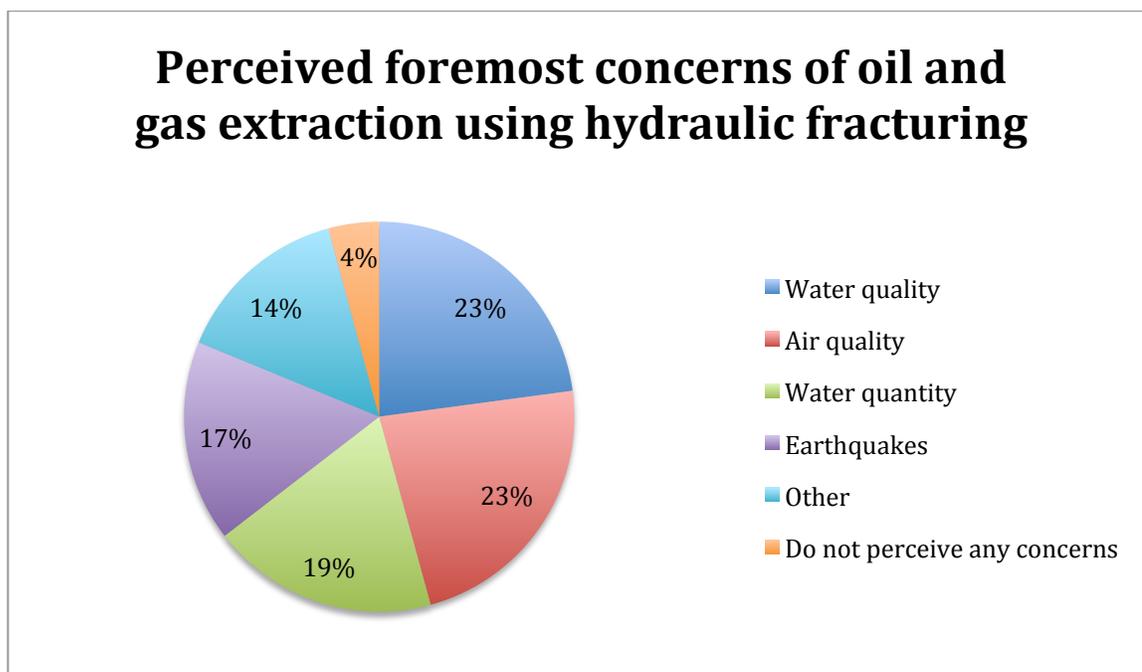


**Figure 14: Foremost benefits of oil and gas extraction using hydraulic fracturing as perceived by the academia and government stakeholder group. The results reflect that the academia and government stakeholder group perceive economic growth, followed by energy security and decreased energy prices, as benefits of hydraulic fracturing in California.**

The results in Figure 14 indicate that the academia and government stakeholder group perceive economic growth as the foremost benefit of oil and gas extraction using hydraulic fracturing in California. Four of the six academic and government stakeholders

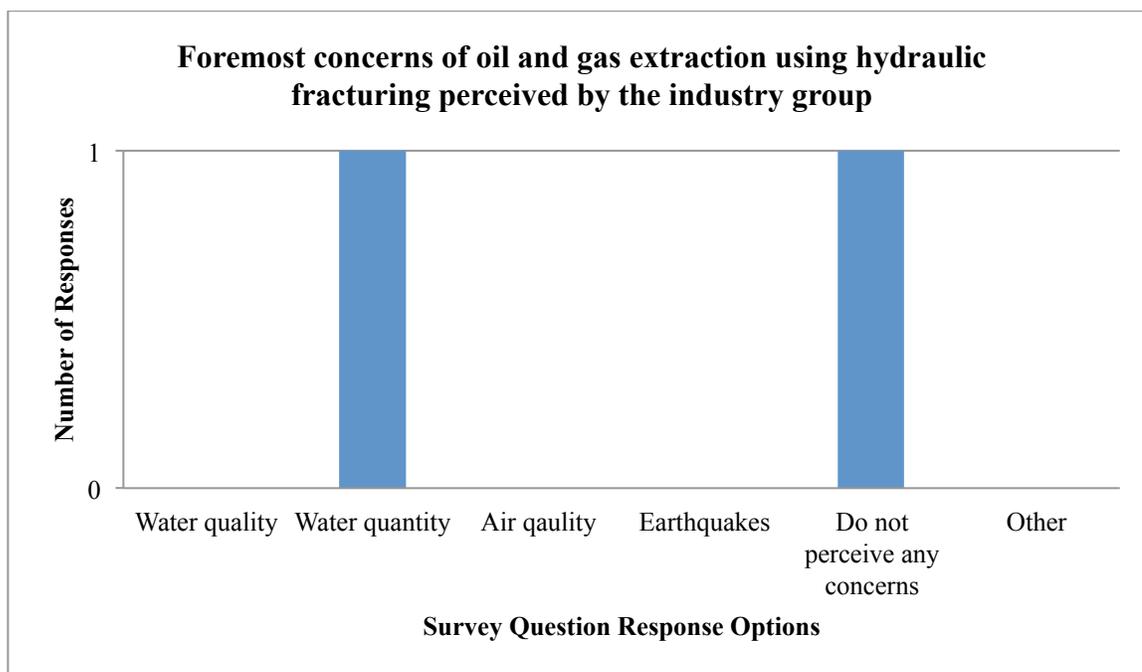
who responded to this question perceive economic growth, including jobs, as a principal benefit of hydraulic fracturing. Energy security and decreased energy prices received the second highest response rates from the academia and government group. Interestingly, no one from this stakeholder group selected the “do not perceive any benefits” options. Overall, the academia and government stakeholder group provided more varied responses to this survey question compared to the industry and environmental stakeholder groups.

The next survey question posed the statement asking, “In California, what do you perceive as the foremost *concerns* of oil and gas extraction using hydraulic fracturing?” Every participant responded to this survey question. Again, the participants were provided six different checkboxes in which he/she could check one or multiple answers of his/her choosing. The checkbox choices were; water quality, water quantity, air quality, and earthquakes. There was also a choice, “I do not perceive any concerns of oil/gas extraction using hydraulic fracturing.” The last checkbox provided for this question was an “other” option, in which participants were able to provide a variant answer or expand on a selected response. The collective percentage reflecting all participants for each answer of this survey question is provided in Figure 15, below.



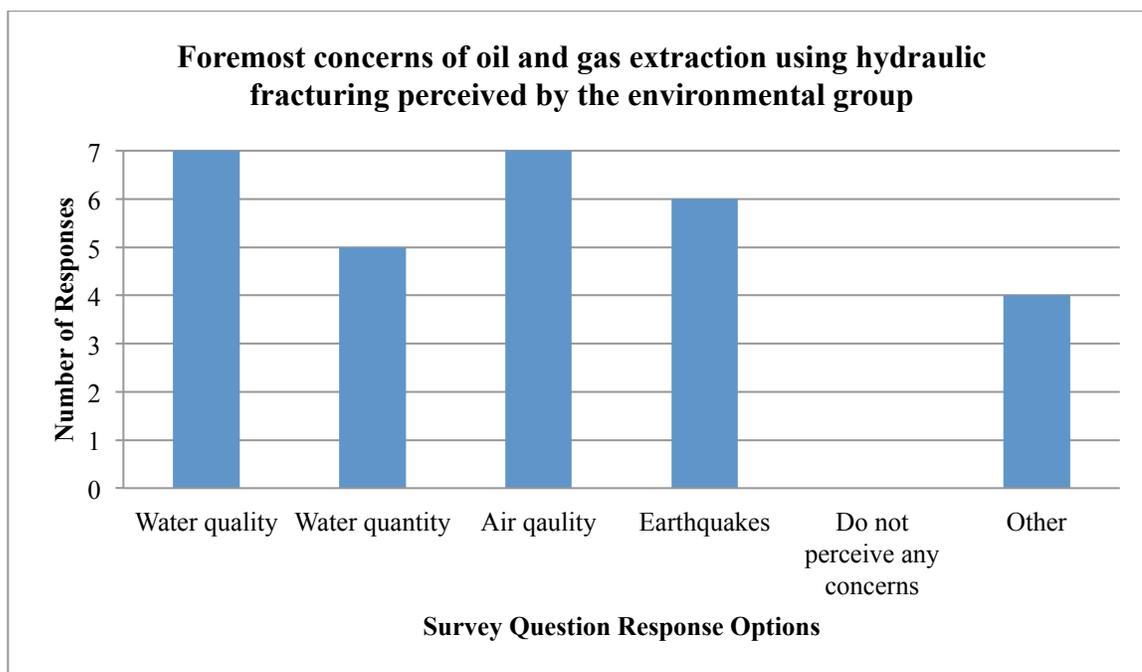
**Figure 15: Perceived foremost concerns of oil and gas extraction using hydraulic fracturing.** The figure above reflects the survey results for foremost concerns of oil and gas extraction using hydraulic fracturing in California as perceived by all the participating stakeholders in this study. The majority of responses indicate that water quality and air quality are upmost concerns of hydraulic fracturing.

As seen in Figure 15, the options that received the highest response rate were “water quality” and “air quality” for this survey question. Combined, these answers made up 46% of the total responses received for this survey question. The option with the lowest response was, “I do not perceive any concerns of oil/gas extraction using hydraulic fracturing,” with only a 4% response rate. Seven participants provided additional information under the “other” option, which is discussed in the results for specific stakeholder groups for this survey question. Results for this survey question are also categorized key stakeholder group responses. Figure 16 reflects the foremost concerns of hydraulic fracturing in California as perceived by the industry stakeholder group.



**Figure 16: Foremost concerns of oil and gas extraction using hydraulic fracturing as perceived by the industry stakeholder group. The results are divided equally and reflect that there are either no perceived concerns or that water quantity is a concern of hydraulic fracturing in California.**

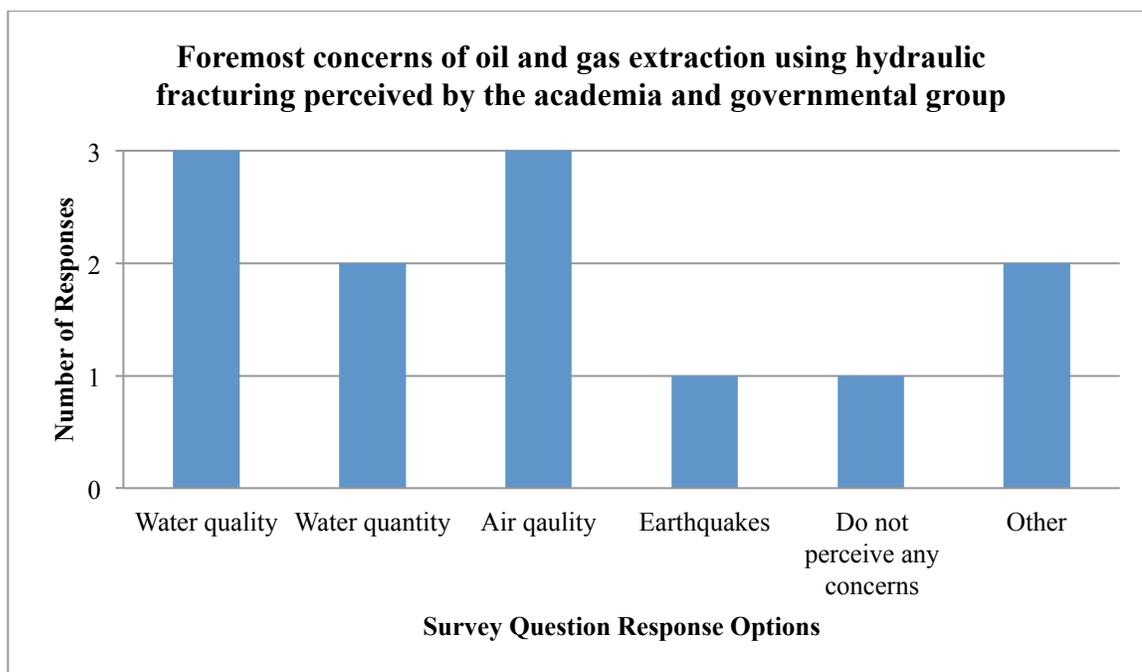
Figure 16 represents the results of the industry stakeholder group in response to the survey question indicating foremost concerns of hydraulic fracturing. The results are equally divided between the responses of “water quantity” and “do not perceive any concerns.” One industry stakeholder chose the “water quantity” option, while the second industry stakeholder selected the “do not perceive any concerns” option. No one from the industry stakeholder group selected any of the other response options and did not provide any further additional comments regarding this survey question. Figure 17 provides the results for the foremost concerns of hydraulic fracturing in California question as perceived by the environmental stakeholder group.



**Figure 17: Foremost concerns of oil and gas extraction using hydraulic fracturing as perceived by the environmental stakeholder group. The results indicate that environmental stakeholders perceive water quality and air quality as the foremost concerns of hydraulic fracturing in California.**

Figure 17 represents the results of the environmental stakeholder group in response to the survey question indicating foremost concerns of hydraulic fracturing. The results indicate that many environmental stakeholders perceive water quality and air quality to be foremost concerns of oil and gas extraction using hydraulic fracturing in California. Seven of the eight environmental stakeholders who responded to this survey question chose these two options. Earthquakes received the second highest response rate with six stakeholders selecting this option. Five environmental stakeholders indicated water quantity as a foremost concern of hydraulic fracturing in California. None of the participants from the environmental stakeholder group selected “do not perceive any concerns” for this survey question. A few environmental stakeholders selected the “other” option and provided additional feedback. For example, Tia Lebherz, Northern

California Organizer for Food and Water Watch, asserts that climate change and impact of food supply are additional concerns resultant of hydraulic fracturing in California. Leberz also selected water quality, water quantity, air quality, and earthquakes from the survey response options. Dr. Clyde Thomas Williams of the Sierra Club Water Committee adds that occupational and public health and safety are further concerns. Lastly, Shannon Biggs, Community Rights Program Director at the Global Exchange, notes concerns involving displacement of farms, climate change, and changes to the hydrologic cycle. Biggs further states that, “fracking is the worst idea for energy in California’s history [and] economically it is a disaster, other than making a handful of people wealthy at the expense of others.” Figure 18 provides the results of foremost concerns of hydraulic fracturing in California as perceived by the academia and government stakeholder group.



**Figure 18: Foremost concerns of oil and gas extraction using hydraulic fracturing as perceived by the academia and government stakeholder group. The results indicate that academia and government stakeholders perceive water quality and air quality as the foremost concerns of hydraulic fracturing in California.**

Figure 18 represents the results of the academia and government stakeholder group in response to the survey question indicating foremost concerns of hydraulic fracturing. The results indicate that academia and government stakeholders perceive water quality and air quality to be foremost concerns of oil and gas extraction using hydraulic fracturing in California. Three of the six academia and government stakeholders who responded to this survey question selected these two options. The option “do not perceive any concerns” and “earthquakes” received the lowest response rate. Two stakeholders from the academia and government group chose the “water quantity” option. A few academia and government stakeholders provided additional feedback to this survey question. For example, one stakeholder who requested to remain

anonymous indicated that a concern is the distraction from AB 32 and climate change goals. Another anonymous academia and government stakeholder added that there are “no significant concerns about hydraulic fracturing.” Although this stakeholder admits that, “water disposal in deep injection wells may be associated with minor earthquakes and ought to be studied more.” Responses from stakeholders from all groups are further discussed in the Discussion Chapter.

The third survey question addressed in this chapter states, “On a scale of 1 to 5, does SB 4 adequately address health and environmental dimensions, including water quality?” The participants are provided with a Likert scale to answer this question, in which option number 1 means, “SB 4 does *not at all* address health and environmental dimension,” and option number 5 means, “SB 4 *fully* addresses health and environmental dimensions.” Unlike the previous two questions, this survey question only allows the participant to select one answer. Nearly every participant answered this question. The results for this survey question are arranged according to affiliated stakeholder group. Table 3 reflects results from the industry stakeholder group regarding the ability of SB 4 to address health and environmental dimensions.

**Table 3: Industry stakeholder results to survey a question that asks, "On a scale of 1 to 5, does SB 4 adequately address health and environmental dimension?"**

1 SB 4 does NOT AT ALL address health & environmental dimensions.	2	3	4	5 SB 4 FULLY addresses health & environmental dimensions.
0%	0%	0%	0%	100%

Table 3 indicates that 100% of industry stakeholders perceive SB 4 to fully address health and environmental dimensions. The environmental stakeholder group reflects an opposing viewpoint compared to the industry stakeholder group regarding this survey question. Table 4 reflects results from the environmental stakeholder group regarding the ability of SB 4 to address health and environmental dimensions.

**Table 4: Environmental stakeholder results to survey a question that asks, "On a scale of 1 to 5, does SB 4 adequately address health and environmental dimension?"**

1 SB 4 does NOT AT ALL address health & environmental dimensions.	2	3	4	5 SB 4 FULLY addresses health & environmental dimensions.
56%	11%	11%	22%	0%

Table 4 demonstrates that many environmental stakeholders perceive that SB 4 does not at all address health and environmental dimensions. This option received a response rate of 56%. Interestingly, the second highest response is option number 4 with a response rate of approximately 22%. No one from the environmental group selected option number 5, which indicates that SB 4 fully addresses health and environmental dimensions. Table 5 reflects results from the academia and government stakeholder group regarding the ability of SB 4 to address health and environmental dimensions.

**Table 5: Academia and government stakeholder results to survey a question that asks, "On a scale of 1 to 5, does SB 4 adequately address health and environmental dimension?"**

1 SB 4 does NOT AT ALL address health & environmental dimensions.	2	3	4	5 SB 4 FULLY addresses health & environmental dimensions.
0%	0%	40%	20%	40%

Table 5 demonstrates that academia and government stakeholders favor the right side of the Likert scale for this survey question, indicating that SB 4 is more expected to address health and environmental dimensions. Option number 3 and option number 5 received the highest response rate with approximately 40% each. This feedback implies that these stakeholders consider SB 4 likely to partially or fully address health and environmental dimensions.

The following survey question is also a Likert scale question that states, “On a scale of 1 to 5, does SB 4 create a policy environment that enables investment in infrastructure and cost-effective recovery of oil and natural gas?” Option number 1 means “SB 4 does *not at all* enable investment in infrastructure and cost-effective recovery of oil/gas” and option number 5 means “SB 4 *fully* enables investment in infrastructure and cost-effective recovery of oil/gas.” Like the previous question, this survey question only allows the participant to select one answer. This particular question had a lower total response rate than the previous question. Approximately 24% of the total participants opted to skip this question. Table 6 reflects results from the industry stakeholder group regarding the ability of SB 4 to create a policy environment that enables investment in infrastructure and cost-effective recovery of oil and natural gas.

**Table 6: Industry stakeholder results to a survey questions that asks, "On a scale of 1 to 5, does SB 4 create a policy environment that enables investments in infrastructure and cost-effective recovery of oil and natural gas?"**

1				5
SB 4 does NOT AT ALL enable investment in infrastructure & cost-effective recovery of oil/gas	2	3	4	SB 4 FULLY enables investment in infrastructure & cost-effective recovery of oil/gas.
0%	0%	0%	0%	100%

Table 6 indicates that 100% of industry stakeholders perceive SB 4 to fully enable investment in infrastructure and cost-effective recovery of oil and natural gas. Table 7 reflects results from the environmental stakeholder group regarding the ability of SB 4 to enable investment in infrastructure and cost-effective recovery of oil and natural gas.

**Table 7: Environmental stakeholder results to a survey questions that asks, "On a scale of 1 to 5, does SB 4 create a policy environment that enables investments in infrastructure and cost-effective recovery of oil and natural gas?"**

1 SB 4 does NOT AT ALL enable investment in infrastructure & cost- effective recovery of oil/gas	2	3	4	5 SB 4 FULLY enables investment in infrastructure & cost- effective recovery of oil/gas.
17%	0%	33%	50%	0%

Table 7 indicates that environmental stakeholder opinions vary across the Likert scale in response to this survey question. Option number 4 receives the highest response rate of 50% and the second highest response rate is option number 3 with approximately 33%. Table 8 reflects results from the academia and government stakeholder group regarding the ability of SB 4 to enable investment in infrastructure and cost-effective recovery of oil and natural gas.

**Table 8: Academia and government stakeholder results to a survey questions that asks, "On a scale of 1 to 5, does SB 4 create a policy environment that enables investments in infrastructure and cost-effective recovery of oil and natural gas?"**

1 SB 4 does NOT AT ALL enable investment in infrastructure & cost- effective recovery of oil/gas	2	3	4	5 SB 4 FULLY enables investment in infrastructure & cost- effective recovery of oil/gas.
0%	20%	20%	60%	0%

Table 8 indicates that academia and government stakeholder opinions are primarily group in the middle of the Likert scale with a preferred right side. Option number 4 received the highest response rate among the academia and government stakeholders with approximately 60%. Option number 2 and option number 3 both received a response rate of 20%. Moreover, stakeholder responses from all three affiliated groups are collectively fairly evenly spread across the Likert scale with the majority of the responses falling in the middle with a preferred right side.

One of the final survey questions states, “If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?” Participants were only allowed to select one of these three provided options: deficient, appropriate, or excessive. To follow-up this question, the participants are asked to explain their rationale using specific examples where applicable. Table 9 reflects results from the industry stakeholder group regarding the goal of SB 4 to have effective regulation of oil and natural gas extraction using hydraulic fracturing in California.

**Table 9: Industry stakeholder results to a survey question that asks, "If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?"**

Deficient	Appropriate	Excessive
0%	100%	0%

Table 9 indicates that 100% of industry stakeholders perceive SB 4 to be appropriate if the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing. Table 10 reflects results from the environmental stakeholder group

in evaluating SB 4 as effective regulation of oil and natural gas extraction using hydraulic fracturing in California.

**Table 10: Environmental stakeholder results to a survey question that asks, "If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?"**

Deficient	Appropriate	Excessive
50%	50%	0%

Table 10 demonstrates that environmental stakeholders have split opinions regarding is SB 4 is deficient or appropriate. The option of “deficient” and the option of “appropriate” both receive a 50% response rate. Table 11 reflects results from the academia and government stakeholder group in evaluating SB 4 as effective regulation of oil and natural gas extraction using hydraulic fracturing in California.

**Table 11: Academia and government stakeholder results to a survey question that asks, "If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?"**

Deficient	Appropriate	Excessive
20%	80%	0%

Table 11 indicates that the majority of academia and government stakeholders perceive SB 4 as an appropriate policy measure if the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing. The option of “appropriate” received a response rate of 80%. The option of “deficient” received a lower response rate of 20%. Overall, the most commonly selected response among all of the stakeholders is the option of “appropriate.” Interestingly, despite the diverse group of stakeholders with varying positions on oil and gas exploration, not one participant perceived SB 4 to be an excessive piece of legislation in California. Nearly every stakeholder provided a follow-

up explanation to this survey question, which explained the rationale for the selected response. These rationales and further details regarding this survey questions are discussed further in the Discussion Chapter.

Lastly, the research survey asked each participant, “What policy measures or regulation would you recommend?” Every individual who participated in the survey filled out this open-ended question. Opinions varied among participants and many participants provided detailed responses. One participant suggested that an oil severance tax should be enacted in California. A few participants felt strongly that a complete ban on hydraulic fracturing and other well stimulation activities is necessary in California. Another participant suggested that major jurisdictional issues remain between DOGGR and the several other agencies that manage various aspects of oil and gas exploration and production. The recommendations are analyzed and described in more detail in the Discussion chapter.

## CHAPTER 6. DISCUSSION

The Discussion chapter critically examines the findings by drawing upon feedback and data collected through the stakeholder analysis and policy analysis. This chapter interprets what the findings may portend and offers additional analytical breakdown of the methods used for this research study. This chapter is organized in a sequence that corresponds with the Results Chapter in order to provide fluid correlations between the results and discussion. The products of the stakeholder analysis are presented first, and the results and discussion of the policy analysis are provided at the end of the Discussion Chapter.

The first stakeholder survey question asks, “In California, what do you perceive as the foremost *benefits* of oil and gas extraction using hydraulic fracturing?” As outlined in the Results Chapter, the industry stakeholders selected economic growth, energy independence, and energy security as the foremost benefits of oil and gas extraction using hydraulic fracturing in California. For example, the Western State Petroleum Association (WSPA) states that if hydraulic fracturing is used to “responsibly access the vast reserves of the Monterey Shale formation,” then there is potential for an estimated “200,000 new jobs in the Central Valley alone” (WSPA, 2013a). Suzanne Noble, Vice President of WSPA, remarks that, along with economic growth, energy security and energy independence are also beneficial outcomes from pursuing the Monterey Shale in California.

Conversely, the majority of environmental stakeholders do not perceive any benefits of oil and gas extraction using hydraulic fracturing. Similarly to the industry group, the majority of the academia and government stakeholders perceive economic growth (including jobs) as the foremost benefit of hydraulic fracturing in California. A research participant in the academia and government stakeholder group, Richard A. Muller, a professor of physics at UC Berkeley and co-author of the publication Why Every Serious Environmentalist Should Favor Fracking, argues that the development of shale gas using hydraulic fracturing can reduce greenhouse gas emissions and improve public health. Muller believes the use of hydraulic fracturing can improve air quality by reducing PM2.5, which is particulate matter 2.5 microns or smaller. PM2.5 is emitted from the burning of fuels. These emissions are highest when the fuel is a solid, such as coal. Particulate matter of this diminutive size can penetrate deep into the human lungs and can cause cardiorespiratory disease and ultimately death. Muller explains that “compared to coal, shale gas results in a 400-fold reduction of PM2.5, a 4,000-fold reduction in sulphur dioxide, a 70-fold reduction in nitrous oxides (NOx), and more than a 30-fold reduction in mercury” (Muller & Muller, 2013). Overall, the highest received response rate for this survey question across all stakeholder groups is “economic growth (including jobs).” Collectively, 32% of participants perceive economic growth to be the foremost benefit of oil and gas extraction using hydraulic fracturing in California.

The second stakeholder survey question asks, “In California, what do you perceive as the foremost *concerns* of oil and gas extraction using hydraulic fracturing?” Like the feedback received for the first survey questions regarding benefits, stakeholder

perceptions varied greatly. As outlined in the Results Chapter, industry stakeholder results are evenly split between perceiving no concerns of hydraulic fracturing and considering water quantity to be a significant concern of oil and gas extraction using hydraulic fracturing in California. Specifically, Noble does not observe any adverse impacts of hydraulic fracturing, and she emphasizes multiple benefits of oil and gas exploration and production. Dissimilarly, environmental stakeholders perceive water quality and air quality to be the foremost concerns of hydraulic fracturing in California. For example, Joni Clark Stellar, a concerned citizen activist, remarks that hydraulic fracturing is dangerous to the environment, and all incentives for oil and gas exploration and development should be redistributed for clean renewable investment and community-based energy development. Biggs also substantiates concerns by arguing that climate change is a relevant issue associated with diminished air quality as a result of hydraulic fracturing. Damon Nagami, Senior Attorney at the Natural Resources Defense Council, stated that drinking water contamination is a main concern. He also indicated that there are different pathways for groundwater contamination and conduits to reach drinking water supplies. Nagami explained that there is a “lack of information on where fracking is happening, what chemicals are being used, how much water is being used, and where the wastewater is going.” In a presentation to the California State Water Board, environmental justice groups expressed four primary causes of groundwater contamination due to well stimulation practices: (1) surface spills, leaks, and runoff, (2) well casing and cement failures, (3) fluids migration through fractures, and (4) improper disposal (Stano et al., 2014). The wastewater fluid can contain the original hydraulic

fracturing chemicals along with constituents that come in contact with the fluid deep underground. If stored or disposed of improperly, the wastewater can leak into the ground from surface waste pits or migrate from faulty disposal wells and come into contact with fresh groundwater. Methods in which faulty wells or fluid migration can contaminate fresh groundwater are described further in the Background Chapter. Academic and government stakeholders reflect similar environmental stakeholder concerns. The academia and government group also perceives water quality and air quality as the foremost concerns of hydraulic fracturing in California. Overall, stakeholders in this study perceived a range of existing concerns, with water quality and air quality being the most often cited concerns.

Another question that received significant stakeholder feedback asked, “If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?” To follow-up this question, participants are asked to explain their rationale using specific examples where applicable. As outlined in the Results Chapter, 100% of industry stakeholders consider SB 4 to be appropriate if the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California. Noble defends this stance by reasoning that, “SB 4 legislation language sets up the most stringent and protective regulatory structure for well stimulation operations in the nation.” Another industry stakeholder explains that SB 4 “provides direction on future production, water use reporting, community notifications, and state agency oversight,” and is, therefore, an appropriate policy measure administered in California. Interestingly, the industry stakeholders are comparatively supportive of SB

4 as both participants view SB 4 as an appropriate piece of legislation to regulate hydraulic fracturing activities. It may be reasonable to speculate that the support of the industry group stems from last minute amendments before Governor Brown signed the bill into law. These final amendments alter the way that SB 4 addresses and incorporates the California Environmental Quality Act (CEQA) into state regulations. CEQA requires developments in California to produce an environmental impact report (EIR) in order to address how the project potentially affects land, water, species, and other environmental elements. A final amendment to SB 4 includes the provision that DOGGR may approve permits before the scientific study is conducted and the findings are analyzed. As Governor Brown signed SB 4, he indicated that the bill needed some clarifying amendments, including advising the Department of Conservation to “develop an efficient permitting program for well stimulation activities that groups permits together based on factors such as known geologic conditions and environmental impacts” (Brown, 2013). As such, this notion would avoid conducting EIRs on an individual well basis. The provision groups wells in close proximity according to similar geologic and surface characteristics. Therefore, a single EIR will be administered according to the well group, instead of conducting an EIR on a specific well. It is alleged that oil lobbyists influenced these last minute amendments to SB 4, and, therefore, there has been a shift of the industry in support for SB 4 (Hein, 2013; Mulkern, 2013). Furthermore, the industry group may view SB 4 as being the conclusive and finalized regulations in place to address hydraulic fracturing and other well stimulation techniques in California into the future. For example, WSPA supports the defeat of SB 1132, which would have placed a

moratorium on statewide hydraulic fracturing, and states that the outcome of SB 1132 “clears a path for a concerted and collaborative effort to fully implement new statewide regulations embodied in Senate Bill 4” (WSPA, 2014).

On the other hand, environmental stakeholders are evenly divided between perceiving SB 4 as appropriate and as deficient. Stellar responded that SB 4 is a deficient piece of legislation. Stellar notes that the “challenge is not finding a balance between environmental protection and incentivizing growth. The challenge is transitioning away from fossil fueled growth economics and toward [a] sustainable economy based upon renewable energy resources.” Biggs also selected the option of “deficient” and substantiates her response by stating that, “fracking cannot be done safely, and cannot be regulated to stop harms from entering communities where fracking will be and is taking place.” Furthermore Leberherz who also selected “deficient,” states that, “anything short of a ban on fracking does not adequately protect California’s water, health, farmland, and climate.” Nagami perceives SB 4 to be inadequate and explains that, “interest groups are rarely completely happy with any environmental law...but SB 4 is a start and something to build on.” One environmental stakeholder who preferred to remain anonymous perceives SB 4 as appropriate because there was no regulation of fracking for 50 years, which has been ceased due to SB 4. Academia and government stakeholders view SB 4 as appropriate for the most part. For example, Muller deems SB 4 as appropriate but believes that the “dangers of fracking are misperceived by the public” and can be addressed through regulation. He further states that, “SB 4 provides the needed regulation, but does no needless overregulation.” Another academia and government

stakeholder, who abstained from using his/her name in this study, perceives SB 4 as appropriate but believes that “most or perhaps all of what SB 4 purports to do is unnecessary because there is no history of significant issues with hydraulic fracturing.” S/he further explains that good public policy for the oil and gas industry should provide assurance to the public that public health and safety are being safeguarded. This stakeholder views that parts of SB 4 do not have anything to do with hydraulic fracturing and are largely the product of efforts by opponents of all oil and gas extraction to increase costs and impose additional barriers on commercial oil and gas businesses. Unlike the industry group, many environmental stakeholders view SB 4 as an initial step to establish fundamental WTS regulations, and they are ambitious to inaugurate stronger provisions. For example, Nagami stated in an interview that, “SB 4 is a start and something to build on...it is important to get something that may not be perfect on the books that can be built on.” Collectively, stakeholders view SB 4 as an appropriate policy measure if the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing. Interestingly, none of the stakeholders from any of the three groups perceive SB 4 to be an excessive piece of legislation in California.

Lastly, the stakeholders were asked, “What policy measures or regulation would you recommend?” Nearly every stakeholder who participated in this study responded to this open-ended question. A comprehensive review of survey responses to this particular question is outlined in the Results Chapter. Opinions varied among participants, and many participants provided detailed responses. For example, Stellar, who is affiliated with the environmental stakeholder group, proposes California should remove all

incentives for oil and gas exploration and development, especially for export facilities. Stellar explains that further incentives need to be established for clean renewable investment for smart-grid technology, wind, solar, tidal, geothermal, and small hydropower plant development. One anonymous environmental stakeholder believes that additional measures to regulate methane emissions are a critical next step, and trade secret provisions need further transparency. In order to address the water quality concern, Muller suggests that if groundwater contamination is proven, then the perpetrator should be fined enough to make operations highly unprofitable (Muller & Muller, 2013). Muller indicates that stiff fines will “drive all operations to use industry best practices” and further water quality monitoring can be implemented through government and community inspections. The NRDC provides very specific recommendations to ensure well integrity and protect groundwater in a letter addressed to the California Conservation Director of the Department of Conservation titled, “Comments on the Proposed Draft Regulations for the Use of Well Stimulation in Oil and Gas Production in the State of California.” This letter recommends thorough monitoring and inspection for each producing well that has had a WST performed. Other specific recommendations are made regarding the layers of the well casing to ensure proper installation and maximum strength. For example, NRDC suggests that the operator must notify DOGGR immediately if well integrity fails and fluids have contaminated a source of protected water or any other unauthorized zone (NRDC, 2014). An anonymous academia and government stakeholder believes the jurisdictional organization and regulatory agencies need to improve the management of oil and gas developments in California. S/he

recommends that there should be statutory delineation of the jurisdictional issues between DOGGR, the Coastal Commission, and the BLM. Overall, stakeholders expressed divided attitudes towards SB 4 and hydraulic fracturing developments in California. Generally, there is internal agreement among the individuals of the stakeholder groups, although some specific questions partitioned comparable stakeholders.

As described in the Methods Chapter, this thesis uses a policy analysis to clarify a complex policy challenge, analyze relevant information and context, and outline implications for proposed actions. As such, the findings drawn from the policy analysis are described and interpreted further using a five-step process. The process used to facilitate the policy analysis include defining the problem, establishing evaluation criteria, identifying and assessing alternative policies, evaluating a selected policy, and proposing recommendations if applicable.

The initial phase in the policy analysis process is defining the problem with the objective to answer questions such as: What is the problem that SB 4 proposes to address? What was the event or series of events that was a catalyst for the creation of SB 4? As reviewed and outlined in the Review of Literature Chapter, there is an apparent lack of regulation and oversight regarding hydraulic fracturing and other WSTs in California. Oil and gas exploration and production companies are eager to further develop the Monterey Shale using WSTs. Therefore, with the prospect of increasing oil and gas operations using WSTs, the problem is defined as a lack of previous policy measures and regulations to properly assess and manage WSTs, including hydraulic fracturing, in California.

Next, evaluation criteria were established with the objective of answering key questions such as: How does SB 4 translate the problem into a specific set of goals? What government organizations were involved in the creation and administration of SB 4? As described in the Review of Literature Chapter, SB 4 represents California's first and only bill to provide a comprehensive statutory framework for hydraulic fracturing as part of a general well stimulation regulation in California. SB 4 was enacted in response to increased interest to pursue unconventional resources in the Monterey Shale Formation, perceived weak regulatory oversight, insufficient government and industry transparency, and an information gap between government agencies, the industry, and the public. DOGGR is appointed as the primary responsible government agency to undertake and enforce SB 4. Furthermore, DOGGR must collaborate and consult with multiple state government agencies to apportion responsibilities among each public entity.

Alternative policies were identified and assessed with the objective of fulfilling the following questions: What other alternative policy options were considered to address the original problem? What was the outcome of alternative policies? Several bills were proposed to address hydraulic fracturing and other WSTs in California. For example, SB 1132 (Mitchell/Leno), titled Well Stimulation Moratorium was proposed in 2014. This bill would impose a moratorium on hydraulic fracturing, acidizing, and other WSTs in California until the comprehensive scientific study on impacts of WSTs is complete. The bill also proposed to expand the study to impose the following requirements: identify all off-shore oil and gas exploration, evaluate potential impacts to ground and surface water, evaluate risks posed by flowback fluids and byproducts, and consider atmospheric

emissions such as greenhouse gases. SB 1132 failed on the Senate floor with a final vote of 16-16. On the other hand, SB 4 cleared the Assembly on a 47-17 vote and cleared the Senate by 28-8. SB 4 was signed on September 20, 2013 and went into effect January 1, 2014.

SB 4 was specifically selected for evaluation with the intention of answering the following questions: Did SB 4 solve the original problem? Did SB 4 achieve its goals and intended effects? As described in the Review of Literature Chapter, SB 4 imposes the following requirements: an independent scientific study, a new permitting system, chemical disclosure, and collaboration between DOGGR and various state agencies to develop further regulations and apportion responsibilities. The scientific study must be rigorous and peer reviewed. The study must include identification of existing and potential oil and gas reserves that are or may become drilling sites. As noted in the Review of Literature Chapter, State Oil and Gas Supervisor, Miller, revealed in 2011 that DOGGR is “unable to identify where and how often hydraulic fracturing occurs within the state” because there are no reporting requirements or regulatory parameters of when, how, and what needs to be reported when acquiring drilling permits (Miller, 2011). Therefore, the requirement of SB 4 to identify potential drilling sites is important because no reporting system was previously established. The new permitting systems is also advantageous because DOGGR’s present data are limited and unreliable as there are neither reporting requirements nor regulatory parameters of when, how, and what needs to be reported when applying for permits (Miller, 2011). The new permitting system requires disclosure of well identification number and location, expected time period for a

designated well stimulation treatment, a water management plan, and list of chemical constituents. The chemical disclosure requirement imposes the prerequisite for well operators to release chemical constituent details to DOGGR that previously were unmonitored. Overall, SB 4 can be regarded as an initial step in regulating WSTs in California, but stakeholder feedback collected in this study reflects recommendations for further needed regulation. Discussion of remaining gaps and proposed recommendations are recognized and discussed in the Conclusion Chapter. Due to the immaturity of the bill, it is difficult to determine if SB 4 fully achieves its goals at this point. Time will prove to be an indicator if SB 4 addresses its intended goals and effects.

Lastly, the policy process involves proposing recommendation with the intention to answer the following questions: Are there recommendations that can help SB 4 achieve its goals? What can be recommended to further address the original problem? Informed by stakeholder feedback presented in this chapter, there are possible further recommendations to enhance SB 4 and address the original problem. Such recommendations are outlined and reviewed in the Results Chapter. Specific proposed policy recommendations and best practices are described in the Conclusion Chapter.

## CHAPTER 7. CONCLUSION AND RECOMMENDATIONS

In this chapter, I propose recommendations informed by the stakeholder and policy analysis. The chapter ends with concluding key comments in regards to suggested improvements for comparable prospective studies. Recommendations are developed and presented in order to address foremost concerns of hydraulic fracturing in California according to stakeholder feedback and remaining perceived gaps in SB 4. Generalized, the proposed recommendations are related to water recycling, water and air quality sampling, testing, and monitoring, and completion of well-specific EIRs under CEQA.

Although many of the stakeholder participants identified the quantities of water required for hydraulic fracturing as a major concern, SB 4 does not incentivize the recycling or reuse of water. SB 4 does require disclosure of a well operator's use of water, but it does not implement any specific requirements in regards to the management of flowback fluid. A description of flowback fluid is provided in the Background Chapter. Promoting the recycling of water associated with hydraulic fracturing and other WST operations is particularly important because of the volume of water necessary for WSTs, the increasing number of oil and gas wells in California, and the decreasing volume of water availability in California. For example, Apache Corporation, an oil and gas exploration and production company with operations in Canada and Texas, is at the forefront of reducing fresh water use and successfully recycling WST fluids. California well operators should look at the Apache model for water reuse and recycling and apply

this model to California well exploration and production activities. Reuse and recycling of water fluids associated with WSTs not only decreases reliance on fresh water sources, but also reduces dependency on disposal wells. Reduced use of disposal wells can limit the risk of fluid migration into freshwater aquifers and the risk for induced seismicity. DOGGR and the State Water Resources Control Board should be required to collaboratively assess the probability of water recycling, including an analysis of associated costs and benefits.

SB 4 currently addresses water and air quality sampling, testing, and monitoring, but further provisions can strengthen this element of SB 4. Existing language in SB 4 allows property owners to request water and air testing through a third party with fees paid by the well operator. SB 4 currently states that landowners may request sampling and testing before operations begin and follow-up testing is performed “on the same schedule as the pressure testing of the well casing of the treated well” (Pavley, 2013). I recommend that follow-up testing and sampling take place after a WST, including hydraulic fracturing, but before the well is put into production. This change in follow-up air and water sampling and testing can help to better determine a cause and effect relationship between the specific WST step and potential adverse impacts on environmental elements. Included in this recommendation is that DOGGR establish requirements to test for specific chemical additives in the fracturing fluid that are known carcinogens. The potential for carcinogens to migrate into groundwater or to be emitted into the atmosphere may have adverse impacts on environmental and human health.

DOGGR should be required to post the baseline testing and follow-up testing results on their website for public access.

Finally, as discussed in the Discussion Chapter, EIRs are administered based on grouping oil and gas wells according to similar geological and surface issues. I recommend that EIRs be conducted on an individual well basis under CEQA in order to better assess each well for potential environmental impacts. There is no guarantee that an EIR conducted on a well “group” will adequately account for each well’s unique underground geology, well casing characteristics, and well-specific chemical constituents as part of the hydraulic fluid. Therefore, an EIR for each oil and gas well is more suitable in order to effectively determine the project’s effect on land, water, species, and other environmental elements.

The research and inferences in this study may yield insight into contextual factors that explain stakeholder perspectives regarding hydraulic fracturing in California. Accompanied by a policy analysis, the stakeholder analysis reveals projected benefits and concerns regarding emerging hydraulic fracturing developments at the state level. However, the study has some limitations. The surveys conducted for this thesis research only reflect a subset of the interested stakeholders that may not fully represent the perspectives of all stakeholders. A larger study, which would capture a greater number of stakeholder perspectives from diverse groups, could provide a more complete depiction of hydraulic fracturing benefits and concerns and more information about the likely efficacy of SB 4. The survey could have also been improved by specifying other well stimulation treatments, such as matrix acidizing and acid stimulation.

California can serve as a model for other states and the federal government in regard to implementing strategic projects and integrating regulations at the necessary level of operation. Therefore, California is currently at a critical point to address emerging oil and gas exploration and development that will seek to balance the interests of companies with the public interest and environmental considerations. California's legislation will likely produce a strong effect on the development of industry practices and regulations outside the state. The establishment of SB 4 represents a significant step toward increased rational government and industry transparency and accountability. It is hoped that the analysis and observations presented in this thesis will serve as a foundation of inquiry for future studies of hydraulic fracturing and other well stimulation treatments.

## REFERENCES

- Adugba, C. (2011). *Policy Analysis in Six Easy Steps*. Retrieved from Steps for a Successful Policy Analysis: <http://stepsforsuccessfulpolicyanalysis.blogspot.com>
- Aiello, D. (2013). CA Farmers Alarmed As Energy Companies Outbid Ag Water Districts For Resource. *Examiner*.
- Andrews, A., Folger, P., Humphries, M., Copeland, C., Tiemann, M., Meltz, R., et al. (2009). *Unconventional Gas Shales: Development, Technology, and Policy Issues*. Retrieved 2014, from CRS Report for Congress: <http://fas.org/sgp/crs/misc/R40894.pdf>
- API. (2010). *Water Management Associated with Hydraulic Fracturing*. American Petroleum Institute.
- Arthur, D., Langhus, B., & Alleman, D. (2008). *An Overview of Modern Shale Gas Development in the United States*. Retrieved 2014, from <http://www.all-llc.com/publicdownloads/ALLShaleOverviewFINAL.pdf>
- Arthur, D., & Cornue, D. (2010). *Technologies Reduce Pad Size, Waste*. Retrieved 2014, from The American Oil & Gas Reporter: <http://www.all-llc.com/publicdownloads/AOGR-0810ALLConsulting.pdf>
- Atkinson, N., & King, K. (2012). Flooding and fracking: a review of extreme weather impacts on drilling activities. *Natural Resources & Environment*, 27 (2), 28-36.
- Blevins, J. (2011). *A Unique Plug for a Restricted Wellbore*. Retrieved 2014, from Magnum Oil Tools: [http://www.magnumoiltools.com/assets/files/SPE%20146559%20-%20A%20Unique%20Plug%20for%20a%20Restricted%20Wellbore\[1\].pdf](http://www.magnumoiltools.com/assets/files/SPE%20146559%20-%20A%20Unique%20Plug%20for%20a%20Restricted%20Wellbore[1].pdf)
- BLM. (1983). *Title 43: Public Lands: Interior Part 3160—Onshore Oil and Gas Operations*. Retrieved 2014, from Bureau of Land Management: [http://www.blm.gov/pgdata/etc/medialib/blm/mt/blm\\_programs/energy/oil\\_and\\_gas/policy/cfr3160.Par.28656.File.dat/cfr3160.pdf](http://www.blm.gov/pgdata/etc/medialib/blm/mt/blm_programs/energy/oil_and_gas/policy/cfr3160.Par.28656.File.dat/cfr3160.pdf)

- Brady, W., & Crannell, J. (2012). Hydraulic Fracturing Regulation in the United States: The Laissez-Faire Approach of the Federal Government and Varying State Regulations. *Vermont Journal of Environmental Law*, 14, 39-70.
- Brown, E. (2013). *SB 4 Signing Letter*. Retrieved from [http://gov.ca.gov/docs/SB\\_4\\_Signing\\_Message.pdf](http://gov.ca.gov/docs/SB_4_Signing_Message.pdf)
- Burton, M. (2011). *Fracking Rules 2012*. Tennessee Environment and Conservation, Water Pollution Control. Department of State Division of Publications.
- Button, A. (2014). *Groundwater Monitoring Program for Oil and Gas Production Areas – SB 4*. Retrieved 2014, from State Water Resources Control Board: [http://www.waterboards.ca.gov/water\\_issues/programs/groundwater/sb4/index.shtml](http://www.waterboards.ca.gov/water_issues/programs/groundwater/sb4/index.shtml)
- CCST. (2014). *Advanced Well Stimulation Technologies in California*. Retrieved from California Council of Science and Technology: <http://ccst.us/publications/2014/2014wst.pdf>
- Chabot. (2013). *CabotOG*. Retrieved 2014, from Exploring the Hydraulic Fracturing Process: <http://www.cabotog.com/wp-content/uploads/2013/06/HydraulicFracturing-II.pdf>
- Chesapeake Energy. (2014). *Chesapeake Energy Corporation*. Retrieved from Hydraulic Fracturing Fluid: <http://www.chk.com/Operations/Process/Hydraulic-Fracturing/Pages/Hydraulic-Fracturing-Fluid.aspx>
- CIPA. (2014). *About CIPA*. Retrieved from California Independent Petroleum Association: <http://www.cipa.org/i4a/pages/index.cfm?pageid=91>
- Cleveland, C. (2010). *Deepwater Horizon Oil Spill*. Retrieved from The Encyclopedia of Earth: <http://www.eoearth.org/view/article/161185/>
- COGA. (2011). *Hydraulic Fracturing Whitepaper*. Colorado Oil and Gas Association, Denver.
- DEC. (2011). *Natural Gas Development Activities & High-Volume Hydraulic Fracturing*. New York State, Department of Environmental Conservation.
- Devold, H. (2013). *Oil and Gas Production Handbook: An Introduction to Oil and Gas Production, Transport, Refining and Petrochemical Industry*. Retrieved 2014, from ABB:

[http://www04.abb.com/global/seitp/seitp202.nsf/0/f8414ee6c6813f5548257c14001f11f2/\\$file/Oil+and+gas+production+handbook.pdf](http://www04.abb.com/global/seitp/seitp202.nsf/0/f8414ee6c6813f5548257c14001f11f2/$file/Oil+and+gas+production+handbook.pdf)

- Dobson, P. (2014). *Prospective Application of Well Stimulation Technologies in California*. Retrieved from California Council on Science and Technology:  
<http://www.ccst.us/publications/2014/2014wst4.pdf>
- DOC. (2013). *Oil and Gas Production: History in California*. Retrieved from California Department of Conservation:  
[ftp://ftp.consrv.ca.gov/pub/oil/history/History\\_of\\_Calif.pdf](ftp://ftp.consrv.ca.gov/pub/oil/history/History_of_Calif.pdf)
- DOG. (1988). *Memorandum of Agreement Between the State Water Resources Control Board and the Department of Conservation Division of Oil and Gas*. Retrieved 2014, from Division of Oil and Gas:  
[http://www.consrv.ca.gov/dog/for\\_operators/Documents/MOU-MOA/MOA\\_SWRCB\\_UIC\\_1988.pdf](http://www.consrv.ca.gov/dog/for_operators/Documents/MOU-MOA/MOA_SWRCB_UIC_1988.pdf)
- DOGGR. (2010). *2009 Annual Report of the State Oil & Gas Supervisor*. Retrieved from Division of Oil, Gas, & Geothermal Resources:  
[ftp://ftp.consrv.ca.gov/pub/oil/annual\\_reports/2009/PR06\\_Annual\\_2009.pdf](ftp://ftp.consrv.ca.gov/pub/oil/annual_reports/2009/PR06_Annual_2009.pdf)
- DOGGR. (2012a). *Pre-rulemaking Discussion Draft*. Retrieved 2014, from Division of Oil, Gas, and Geothermal Resources:  
[http://www.conservation.ca.gov/dog/general\\_information/Documents/121712DiscussionDraftofHFRegs.pdf](http://www.conservation.ca.gov/dog/general_information/Documents/121712DiscussionDraftofHFRegs.pdf)
- DOGGR. (2012b). *Well Counts and Production of Oil, Gas, and Water by County - 2012*. Retrieved from California Division of Oil, Gas, and Geothermal Resources:  
<http://www.conservation.ca.gov/dog/Documents/2012%20Oil%20and%20Gas%20Production%20by%20County.pdf>
- DOGGR. (2013b). *Oil, Gas & Geothermal- About Us*. Retrieved 2014, from The Division of Oil, Gas, and Geothermal Resources:  
<http://www.conservation.ca.gov/dog/Pages/aboutUs.aspx>
- DOGGR. (2014). *Hydraulic Fracturing in California*. Retrieved from Division of Oil, Gas and Geothermal Resources:  
[http://www.conservation.ca.gov/dog/general\\_information/Pages/HydraulicFracturing.aspx](http://www.conservation.ca.gov/dog/general_information/Pages/HydraulicFracturing.aspx)
- Economides, M., Hill, D., Ehlig-Economides, C., & Zhu, D. (2013). *Petroleum Production Systems* (Vol. 2). Upper Saddle River, NJ: Prentice Hall.

- EIA. (1993). *Drilling Sideways -- A Review of Horizontal Well Technology and Its Domestic Application*. Energy Information Administration, Oil and Gas, Washington.
- EIA. (2010). *The Geology of Natural Gas Resources*. Retrieved February 27, 2013, from U.S. Energy Information Administration:  
<http://www.eia.gov/todayinenergy/detail.cfm?id=110#>
- EIA. (2011). *Review of Emerging Resources: U.S. Shale Gas and Shale Oil Plays*. Retrieved from U.S. Energy Information Administration:  
<http://www.eia.gov/analysis/studies/usshalegas/pdf/usshaleplays.pdf>
- Encana. (2014). *Wellbore Construction*. Retrieved from Encana Corporation:  
<http://www.encana.com/sustainability/environment/water/protection/construction.html>
- EPA. (2002a). *40 CFR Part 350*. Retrieved 2014, from  
<http://www.gpo.gov/fdsys/pkg/CFR-2002-title40-vol24/pdf/CFR-2002-title40-vol24-part350.pdf>
- EPA. (2002b). *Exemption of Oil and Gas Exploration and Production Wastes from Federal Hazardous Waste Regulations*. Retrieved 2014, from U.S. Environmental Protection Agency:  
<http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/oil-gas.pdf>
- EPA. (2010a). *Chapter 116 - Emergency Planning and Community Right-to-Know*. (U.S. Environmental Protection Agency) Retrieved 2014, from U.S.C. Title 42 The Public Health and Welfare: <http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap116.htm>
- EPA. (2010b). *Hydraulic Fracturing Fact Sheet*. Retrieved March 24, 2014, from U.S. Environmental Protection Agency: <http://epa.gov/tp/pdf/hydraulic-fracturing-fact-sheet.pdf>
- EPA. (2011). *Draft Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*. U.S. Environmental Protection Agency, Research and Development.
- EPA. (2012a). *Hydraulic Fracturing Background Information*. Retrieved March 31, 2013, from United States Environmental Protection Agency:  
[http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells\\_hydrowhat.cfm](http://water.epa.gov/type/groundwater/uic/class2/hydraulicfracturing/wells_hydrowhat.cfm)

- EPA. (2012b). *Identification and Listing of Hazardous Waste*. Retrieved 2014, from U.S. Government Printing Office: <http://www.gpo.gov/fdsys/pkg/CFR-2012-title40-vol27/xml/CFR-2012-title40-vol27-part261.xml#seqnum261.4>
- EPA. (2012c). *UIC Program Primacy*. Retrieved 2014, from U.S. Environmental Protection Agency: <http://water.epa.gov/type/groundwater/uic/Primacy.cfm>
- EPA. (2012d). *Study of the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources*. U.S. Environmental Protection Agency, Office of Research and Development, Washington.
- EPA. (2013). *Summary of the Safe Drinking Water Act*. Retrieved April 21, 2013, from United States Environmental Protection Agency: <http://www.epa.gov/lawsregs/laws/sdwa.html>
- EPA. (2014a). *Crude Oil and Natural Gas Waste*. Retrieved 2014, from U.S. Environmental Protection Agency: <http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/index.htm>
- EPA. (2014b). *Emergency Planning and Community Right-to-Know Act (EPCRA)*. Retrieved 2014, from U.S. Environmental Protection Agency: <http://www2.epa.gov/epcra/what-epcra>
- EPA. (2014c). *Is My Facility's Six-Digit NAICS Code a TRI-Covered Industry?* Retrieved 2014, from U.S. Environmental Protection Agency: <http://www2.epa.gov/toxics-release-inventory-tri-program/my-facilitys-six-digit-naics-code-tri-covered-industry>
- EPA. (2014d). *Natural Gas Extraction - Hydraulic Fracturing*. Retrieved 2014, from U.S. Environmental Protection Agency: <http://www2.epa.gov/hydraulicfracturing>
- EPA. (2014e). *The Hydraulic Fracturing Water Cycle*. Retrieved February 27, 2014, from United State Environmental Protection Agency: <http://www2.epa.gov/hfstudy/hydraulic-fracturing-water-cycle>
- EPA. (2014f). *Wastes - Hazardous Waste*. Retrieved 2014, from U.S. Environmental Protection Agency: <http://www.epa.gov/wastes/hazard/index.htm>
- EPW. (2002). *Title XIV of the Public Health Service Act: Safety of Public Water Systems (Safe Drinking Water Act)*. U.S. Senate Committee on Environment & Public Works.

- Estrada, S. (2013). *Breaking the Fuel From the Rock*. Retrieved March 31, 2013, from National Geographic: <http://news.nationalgeographic.com/news/2010/10/101022-breaking-fuel-from-the-rock/>
- Fitch, H. (2011). *High volume hydraulic fracturing well completions*. Retrieved April 19, 2013, from State of Michigan: [http://www.michigan.gov/documents/deq/SI\\_1-2011\\_353936\\_7.pdf](http://www.michigan.gov/documents/deq/SI_1-2011_353936_7.pdf)
- FracTracker. (2014). *California Shale Viewer*. Retrieved from FracTracker Alliance: <http://maps.fractracker.org/latest/?appid=57ecf5feebea8428f80a749ec50921ad6>
- GWPC & ALL Consulting. (2009). *Modern Shale Gas Development in the United States: A Primer*. U.S. Department of Energy.
- GWPC & IOGCC. (2014). *About Us*. Retrieved 2014, from FracFocus Chemical Disclosure Registry: <http://fracfocus.org/welcome>
- Hanna, R. (2012). Horizontal Drilling and Hydraulic Fracturing – Is This the Cure to Our Energy Dependency? . (L. McGregor, Ed.) *Cambridge Trust Letter* , 21 (2), 1-3.
- Hansen, B. (2011). *Casing Perforating Overview*. Retrieved 2014, from EPA's Study of Hydraulic Fracturing and Its Potential Impact on Drinking Water Resources: <http://www2.epa.gov/hfstudy/casing-perforating-overview>
- Hein, J. F. (2013). *State Releases New Fracking Regulations Amid SB 4 Criticism, Controversy*. Retrieved from The Berkeley Blog: <http://blogs.berkeley.edu/2013/11/18/state-releases-new-fracking-regulations-amid-sb-4-criticism-controversy/>
- Howard, T. (2013). Letter to Fran Pavley.
- Hughes, D. (2013). *Drilling California: A Reality Check on the Monterey Shale*. Retrieved from Post Carbon Institute: [http://assets-production-webvanta-com.s3-us-west-2.amazonaws.com/000000/03/97/original/reports/Drilling-California\\_FINAL.pdf](http://assets-production-webvanta-com.s3-us-west-2.amazonaws.com/000000/03/97/original/reports/Drilling-California_FINAL.pdf)
- IPIECA & OGP. (2009). *Drilling Fluids and Health Risk Management*. International Petroleum Industry Environmental Conservation Association & International Association of Oil & Gas Producers.
- JPT. (2009). Continuous improvement led to the longest horizontal well. *Journal of Petroleum Technology* , 55-56.

- Kiparsky, M., & Hein, J. (2013). *Regulation of Hydraulic Fracturing in California: A Wastewater and Water Quality Perspective*. University of California Berkeley, Center for Law, Energy & the Environment, Berkeley.
- Klett, T., Schmoker, J., Charpentier, R., Ahlbrandt, T., & Ulmishek, G. (2005). *Petroleum Systems and Geologic Assessment of Oil and Gas in the Southwestern Wyoming Province, Wyoming, Colorado, and Utah*. Retrieved from U.S. Geological Survey: [http://pubs.usgs.gov/dds/dds-069/dds-069-d/REPORTS/69\\_D\\_CH\\_25.pdf](http://pubs.usgs.gov/dds/dds-069/dds-069-d/REPORTS/69_D_CH_25.pdf)
- Kramer, B. (2012). Federal Legislative and Administrative Regulation of Hydraulic Fracturing Operations. *Texas Tech Law Review*, 44 (837).
- Krishnamsetty, M. (2013). *Betting on the Monterey Shale*. Retrieved 2014, from <http://beta.fool.com/insidermonkey/2013/02/06/betting-monterey-shale/23711/>
- Kustic, T. (2012). *Voluntary Reporting of Hydraulic Fracture Stimulation Operations*. Retrieved 2014, from Department of Conservation: [http://www.consrv.ca.gov/dog/for\\_operators/Documents/NTO\\_3-2012\\_Fracking.pdf](http://www.consrv.ca.gov/dog/for_operators/Documents/NTO_3-2012_Fracking.pdf)
- MCOR. (2010). *Cross Section of Typical Horizontal Well*. (The Pennsylvania State University) Retrieved March 28, 2013, from Marcellus Center for Outreach & Research: <http://www.marcellus.psu.edu/resources/maps.php>
- Miller, E. (2011). *Response Letter to Senator Fran Pavley*. Retrieved from [http://www.consrv.ca.gov/dog/general\\_information/Documents/PavleyResponse%20Final.pdf](http://www.consrv.ca.gov/dog/general_information/Documents/PavleyResponse%20Final.pdf)
- Mulkern, A. (2013). *HYDRAULIC FRACTURING: Oil Lobbyists Seek CEQA Exemption Ahead of Calif. Frack Bill Vote*. Retrieved from Environment & Energy Publishing: <http://www.eenews.net/stories/1059986892/print>
- Muller, R., & Muller, E. (2013). *Why Every Serious Environmentalist Should Favour Fracking*. The Centre for Political Studies.
- Murza, M. (2014). *Senate Bill 4: A Past and Future Look at Regulating Hydraulic Fracturing in California*. UC Davis, California Environmental Law & Policy Center, Davis.
- NRDC. (2014). *Comments on the Proposed Draft Regulations for the Use of Well Stimulation in Oil and Gas Production in the State of California*. Natural Resources Defense Council.

- Ogbonna, J. (2013). *"Tapping the Untapped Wealth in our Backyard: Pathway to Local Content Development"*. University of Portharcourt, Department of Petroleum and Gas Engineering.
- Pavley, F. (2013). *Senate Bill No. 4*. Retrieved from California Legislative Information: [http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill\\_id=201320140SB4](http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB4)
- Powell, R., & Gomez, S. (2014). *Progress Report on the Senate Bill 4 Independent Scientific Study*. Retrieved 2014, from CA Frack Facts: <http://www.cafrackfacts.org/wp-content/uploads/2014/08/ISS-Progress-Report-August-2014.pdf>
- ProPublica. (2013). *What is Hydraulic Fracturing?* Retrieved February 27, 2013, from ProPublica: <http://www.propublica.org/special/hydraulic-fracturing-national>
- Ramudo, A., & Murphy, S. (2010). *Hydraulic Fracturing - Effects on Water Quality*. Retrieved 2014, from [http://www.cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/City%20and%20Regional%20Planning%20Student%20Papers/CRP5072\\_Water%20Quality%20Final%20Report.pdf](http://www.cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/City%20and%20Regional%20Planning%20Student%20Papers/CRP5072_Water%20Quality%20Final%20Report.pdf)
- Reheis-Boyd, C. (2014). *"Technically Recoverable" Oil in California's Monterey Shale Formation*. Retrieved from Western States Petroleum Association: <https://www.wspa.org/blog/post/“technically-recoverable”-oil-california’s-monterey-shale-formation>
- Reisner, M. (1986). *Cadillac Desert: The American West and Its Disappearing Water*. New York: Viking.
- Rintoul, W. (1990). *Drilling Through Time*. Sacramento: California Department of Conservation Division of Oil and Gas.
- Saint-Germain, M. (1998). *Six Step Policy Analysis*. Retrieved from PPA 670 Policy Analysis: <http://www.csulb.edu/~msaintg/ppa670/670steps.htm>
- Schenk, C. (1991). *Trends of Heavy Oil Production in California*. Retrieved from U.S. Geological Survey: <http://pubs.usgs.gov/of/1991/0339/report.pdf>
- Seale, R. (2007). *Open-hole Completion System Enables Multi-stage Fracturing and Stimulation Along Horizontal Wellbores*. Retrieved 2014, from [http://drillingcontractor.org/dcp/DC-julyaug07/DC\\_July07\\_PackersPlus.pdf](http://drillingcontractor.org/dcp/DC-julyaug07/DC_July07_PackersPlus.pdf)

- Stalder, W. (1941). *Contribution to California Oil and Gas History: California Oil World*. Los Angeles.
- Starrh and Starrh Cotton Growers v. Aera Energy LLC, Nos. F047540, F048555. (Court of Appeal of California, Fifth District July 20, 2007).
- SWRCB & Regional Boards. (2010). *Deconstructing Enforcement: A Primer on Water Quality Enforcement*. Retrieved 2014, from State Water Resources Control Board:  
[http://www.waterboards.ca.gov/water\\_issues/programs/enforcement/docs/deconstructing\\_enforce2010aug.pdf](http://www.waterboards.ca.gov/water_issues/programs/enforcement/docs/deconstructing_enforce2010aug.pdf)
- SWRCB. (2011). *Whom We Regulate*. Retrieved 2014, from State Water Resources Control Board:  
[http://www.swrcb.ca.gov/water\\_issues/programs/ciwqs/who\\_is\\_regulated.shtml](http://www.swrcb.ca.gov/water_issues/programs/ciwqs/who_is_regulated.shtml)
- SWRCB. (2014). *Statutory Water Rights Law*. Retrieved 2014, from State Water Resources Control Board:  
[http://www.swrcb.ca.gov/laws\\_regulations/docs/wrlaws.pdf](http://www.swrcb.ca.gov/laws_regulations/docs/wrlaws.pdf)
- Tiemann, M. (2014). *Safe Drinking Water Act (SDWA): A Summary of the Act and Its Major Requirements*. Retrieved 2014, from Federation of American Scientists:  
<http://fas.org/sgp/crs/misc/RL31243.pdf>
- U.S. G.P.O. (2005). *Energy Policy Act of 2005*. Washington D.C.
- Union of Concerned Scientists. (2013). *Decisions on Fracking*. Retrieved from Union of Concerned Scientists:  
[http://www.ucsusa.org/sites/default/files/legacy/assets/documents/center-for-science-and-democracy/Decisions\\_On\\_Fracking\\_Forum\\_Summary.pdf](http://www.ucsusa.org/sites/default/files/legacy/assets/documents/center-for-science-and-democracy/Decisions_On_Fracking_Forum_Summary.pdf)
- Walker, J. (2011). *California Class II Underground Injection Control Program Review*. Retrieved 2014, from Department of Oil, Gas, and Geothermal Resources:  
<http://www.conservation.ca.gov/dog/Documents/DOGGR%20USEPA%20consultant's%20report%20on%20CA%20underground%20injection%20program.pdf>
- Watson, T., & Bachu, S. (2009). *Evaluation of the Potential for Gas and CO2 Leakage Along Wellbores*. Society of Petroleum Engineers.
- Western Environmental Liner. (2009). *Primary Frac Pit Liners*. Retrieved 28 2013, April, from Western Environmental Liner: <http://www.westernliner.com/primary-frac-pit-liners.html>

- Williams, S. (2012). *Discovering Shale Gas: An Investor Guide to Hydraulic Fracturing*. Sustainable Investments Institute.
- WSPA. (2013a). *Climate Scientists Ignore California's Energy Realities*. Retrieved 2014, from Western States Petroleum Association:  
<https://www.wspa.org/blog/post/climate-scientists-ignore-california's-energy-realities>
- WSPA. (2013b). *What is WSPA?* Retrieved from Western States Petroleum Association:  
<https://www.wspa.org/what-is-wspa>
- WSPA. (2014). *With SB 1132 Behind Us, Let's Now Focus on SB 4 Implementation*. Retrieved from Western States Petroleum Association:  
<https://www.wspa.org/blog/post/sb-1132-behind-us-let's-now-focus-sb-4-implementation>

## Appendix A: Research Survey Full Text and Survey Questions

### Stakeholder & Policy Analysis of Hydraulic Fracturing in California

This survey should only take roughly 5 minutes.

California Senate Bill 4 (SB 4), Well Stimulation Treatment Regulations, provides an initial comprehensive statutory framework for hydraulic fracturing as part of a general well stimulation regulation in California.

Risks and benefits: I do not anticipate any risks to you participating in this survey. There are no direct benefits to you for your participation.

Compensation: You will receive no compensation for participating in this project.

Research records will be kept in a locked file cabinet or password protected server; only the researcher will have access to the records. Your name will not be associated with your answer unless you give explicit permission to do so.

Taking part in this survey is voluntary: You may skip any questions that you do not want to answer. If you decide to take part, you are free to withdraw at any time.

If you have questions, please contact: Graduate student researcher Karen Kniel at (925) 528-9550 or [kek364@humboldt.edu](mailto:kek364@humboldt.edu). Supervising professor Arne Jacobson at (707) 826-3184 or [aej1@humboldt.edu](mailto:aej1@humboldt.edu).

If you have any concerns regarding this project, or any dissatisfaction with any part of this study: you may contact the IRB Chair, Dr. Ethan Gahtan, at [eg51@humboldt.edu](mailto:eg51@humboldt.edu) or (707) 826-4545.

If you have questions regarding your rights as a participant: you may report them to the IRB Institutional Official at Humboldt State University, Dr. Rhea Williamson, at [Rhea.Williamson@humboldt.edu](mailto:Rhea.Williamson@humboldt.edu) or (707) 826-5169.

\* Required

**Statement of Consent \***

I understand that the researcher will answer any questions I may have concerning the project or the procedures at any time. I also understand that my participation in this study is entirely voluntary and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the researcher may terminate my participation in the study at any time. I understand that providing consent is inclusive of this research survey as well as any follow-up questions.

- Agree  
 Deny

**Please indicate your preferred level of participation. \***

- I give permission to be directly quoted with use of my name.  
 I give permission to be directly quoted without use of my name.  
 I do not give permission to be directly quoted.

**Name \***

First, Last

**Organization or Company****Position****How familiar are you with California Senate Bill 4 (SB 4)?**

1 2 3 4 5

Not at all familiar      Very familiar

**In California, what do you perceive as the foremost benefits of oil and gas extraction using hydraulic fracturing?**

(Please select all that apply)

- Energy security
- Energy independence
- Economic growth (including jobs)
- Decreased energy prices
- I do not perceive any benefits of oil/gas extraction using hydraulic fracturing.
- Other:

**In California, what do you perceive as the foremost concerns of oil and gas extraction using hydraulic fracturing?**

(Please select all that apply)

- Water quality
- Water quantity
- Air quality
- Earthquakes
- I do not perceive any concerns of oil/gas extraction using hydraulic fracturing.
- Other:

**On a scale of 1 to 5, does SB 4 adequately address health and environmental dimensions, including water quality?**

1 2 3 4 5

SB 4 does NOT AT ALL address health & environmental dimensions.      SB 4 FULLY addresses health & environmental dimensions.

**On a scale of 1 to 5, does SB 4 create a policy environment that enables investment in infrastructure and cost-effective recovery of oil and natural gas?**

1 2 3 4 5

SB 4 does NOT AT ALL enable investment in infrastructure & cost-effective recovery of oil/gas.

SB 4 FULLY enables investment in infrastructure & cost-effective recovery of oil/gas.

**How well does SB 4 strike the right balance between environmental protection and incentivizing economic growth?**

1 2 3 4 5

Very poor      Very well

**If the goal is to have effective regulation of oil and gas extraction using hydraulic fracturing in California, then is SB 4 deficient, appropriate, or excessive?**

- Deficient  
 Appropriate  
 Excessive

**Please explain your rationale for the previous question using specific examples where applicable.**

**What policy measures or regulations would you recommend?**

**May the researcher contact you with any follow-up questions? \***

Yes

No

## Appendix B: Senate Bill 4 Full Text

### Senate Bill No. 4

#### CHAPTER 313

An act to amend Sections 3213, 3215, 3236.5, and 3401 of, and to add Article 3 (commencing with Section 3150) to Chapter 1 of Division 3 of, the Public Resources Code, and to add Section 10783 to the Water Code, relating to oil and gas.

[Approved by Governor September 20, 2013. Filed with Secretary of State September 20, 2013.]

#### Legislative Counsel's Digest

SB 4, Pavley. Oil and gas: well stimulation.

(1) Under existing law, the Division of Oil, Gas, and Geothermal Resources in the Department of Conservation, or the division, regulates the drilling, operation, maintenance, and abandonment of oil and gas wells in the state. The State Oil and Gas Supervisor, or supervisor, supervises the drilling, operation, maintenance, and abandonment of wells and the operation, maintenance, and removal or abandonment of tanks and facilities related to oil and gas production within an oil and gas field regarding safety and environmental damage. Existing law requires an operator of a well, before commencing the work of drilling the well, to obtain approval from the supervisor or district deputy. Existing law requires the owner or operator of a well to keep, or cause to be kept, a careful and accurate log, core record, and history of the drilling of the well. Within 60 days after the date of cessation of drilling, rework, or abandonment operations, the owner or operator is required to file with the district deputy certain information, including the history of work performed. Under existing law, a person who violates any prohibition specific to the regulation of oil or gas operations is guilty of a misdemeanor.

This bill would define, among other things, the terms well stimulation treatment, hydraulic fracturing, and hydraulic fracturing fluid. The bill would require the Secretary of the Natural Resources Agency, on or before January 1, 2015, to cause to be conducted, and completed, an independent scientific study on well stimulation treatments, including acid well stimulation and hydraulic fracturing treatments. The bill would require an owner or operator of a well to record and include all data on acid treatments and well stimulation treatments, as specified. The bill would require the division, in consultation with the Department of Toxic Substances Control, the State Air Resources Board, the State Water Resources Control Board, the Department of Resources Recycling and Recovery, and any local air districts and regional water quality control boards in areas where well stimulation treatments may occur, on or before January 1, 2015, to adopt rules and regulations specific to well stimulation, including governing the construction

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of wells and well casings and full disclosure of the composition and disposition of well stimulation fluids, and would authorize the division to

allow well stimulation treatments if specific conditions are met. The bill would require an operator to apply for a permit, as specified, with the supervisor or district deputy, prior to performing a well stimulation treatment of a well and would prohibit the operator from either conducting a new well stimulation treatment or repeating a well stimulation treatment without a valid, approved permit. The bill would prohibit the approval of a permit application that is incomplete. The bill would require the division, within 5 business days of issuing a permit to commence a well stimulation treatment, to provide a copy to specific boards and entities and to post the permit on a publicly accessible portion of its Internet Web site. The bill would provide that the well stimulation treatment permit expires one year from the date that a permit is issued. The bill would require the division to perform random periodic spot check inspections during well stimulation treatments, as specified. The bill would require the Secretary of the Natural Resources Agency to notify various legislative committees on the progress of the independent scientific study on well stimulation and related activities, as specified, until the study is completed and peer reviewed by independent scientific experts. The bill would require the operator to provide a copy of the approved well stimulation treatment permit to specified tenants and property owners at least 30 days prior to commencing a well stimulation treatment. The bill would require the operator to provide notice to the division at least 72 hours prior to the actual start of a well stimulation treatment in order for the division to witness the treatment. The bill would require the supplier, as defined, of the well stimulation treatment to provide to the operator, within 30 days following the conclusion of the treatment, certain information regarding the well stimulation fluid. The bill would require the operator, within 60 days of the cessation of a well stimulation treatment, to post or cause to have posted on an Internet Web site accessible to the public specified information on the well stimulation fluid, as specified. The bill would require the division to commence a process to develop an Internet Web site for operators to report specific information related to well stimulation treatments and would require the Internet Web site to be operational no later than January 1, 2016. The bill would authorize the division to direct reporting to an alternative Internet Web site, as prescribed, and would require the division to obtain the data reported to the alternative Internet Web site and make it available to the public, as specified. The bill would provide that where the division shares jurisdiction over a well with a federal entity, the division's rules and regulations apply in addition to all applicable federal law and regulations. The bill would require a supplier claiming trade secret protection for the chemical composition of additives used in a well stimulation treatment to disclose the composition to the division, in conjunction with a well stimulation treatment permit application, as specified, but would, with certain exceptions, prohibit those with access to the trade secret from disclosing it. Because this bill would create a new crime, it would impose a state-mandated local program.

(2) Under existing law, a person who violates certain statutes or regulations relating to oil and gas well operations is subject to a civil penalty not to exceed \$25,000 for each violation.

This bill would make persons who violate specified provisions relating to well stimulation treatments subject to a civil penalty of not less than \$10,000 and not to exceed \$25,000 per day per violation.

(3) Existing law imposes an annual charge upon each person operating or owning an interest in an oil or gas well in respect to the production of the well which charge is payable to the Treasurer for deposit into the Oil, Gas, and Geothermal Administrative Fund. Existing law further requires that specific moneys from charges levied, assessed, and collected upon the

properties of every person operating or owning an interest in the production of a well to be used exclusively, upon appropriation, for the support and maintenance of the department charged with the supervision of oil and gas operations.

This bill would allow the moneys described above to be used for all costs associated with (A) well stimulation treatments, including scientific studies required to evaluate the treatment, inspections, and any air and water quality sampling, monitoring, and testing performed by public entities, and (B) the costs of the State Water Resources Control Board and the regional water quality control boards in carrying out specific responsibilities relating to well stimulation and groundwater monitoring, as specified.

This bill would require the supervisor, on or before January 1, 2016, and annually thereafter, to transmit to the Legislature and make available publicly a comprehensive report on well stimulation in the exploration and production of oil and gas resources in the state.

(4) Existing law, the Groundwater Quality Monitoring Act of 2001, requires the State Water Resources Control Board to integrate existing monitoring programs and design new program elements, as necessary, to establish a comprehensive monitoring program capable of assessing each groundwater basin in the state through direct and other statistically reliable sampling approaches.

This bill would require the state board, on or before July 1, 2015, to develop a groundwater monitoring model criteria, as specified, to be implemented either on a well-by-well basis or on a regional scale, on how to conduct appropriate monitoring on individual oil and gas wells subject to a well stimulation treatment in order to protect all waters designated for beneficial uses and prioritize the monitoring of groundwater that is or has the potential to be a source of drinking water.

(5) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would provide that no reimbursement is required by this act for a specified reason.

*The people of the State of California do enact as follows:*

SECTION 1. The Legislature finds and declares all of the following:

(a) The hydraulic fracturing of oil and gas wells in combination with technological advances in oil and gas well drilling are spurring oil and gas extraction and exploration in California. Other well stimulation treatments, in addition to hydraulic fracturing, are also critical to boosting oil and gas production.

(b) Insufficient information is available to fully assess the science of the practice of hydraulic fracturing and other well stimulation treatment technologies in California, including environmental, occupational, and public health hazards and risks.

(c) Providing transparency and accountability to the public regarding well stimulation treatments, including, but not limited to, hydraulic fracturing, associated emissions to the environment, and the handling, processing, and disposal of well stimulation and related wastes, including from hydraulic fracturing, is of paramount concern.

(d) The public disclosure of chemical information required by this act ensures that potential public exposure to, and dose received from, well stimulation treatment fluid chemicals can be reasonably discerned.

(e) The Legislature encourages the use or reuse of treated or untreated water and produced water for well stimulation treatments and well stimulation treatment-related activities.

SEC. 2. Article 3 (commencing with Section 3150) is added to Chapter

1 of Division 3 of the Public Resources Code, to read:

Article 3. Well Stimulation

3150. "Additive" means a substance or combination of substances added to a base fluid for purposes of preparing well stimulation treatment fluid which includes, but is not limited to, an acid stimulation treatment fluid or a hydraulic fracturing fluid. An additive may, but is not required to, serve additional purposes beyond the transmission of hydraulic pressure to the geologic formation. An additive may be of any phase and includes proppants.

3151. "Base fluid" means the continuous phase fluid used in the makeup of a well stimulation treatment fluid, including, but not limited to, an acid stimulation treatment fluid or a hydraulic fracturing fluid. The continuous phase fluid may include, but is not limited to, water, and may be a liquid or a hydrocarbon or nonhydrocarbon gas. A well stimulation treatment may use more than one base fluid.

3152. "Hydraulic fracturing" means a well stimulation treatment that, in whole or in part, includes the pressurized injection of hydraulic fracturing fluid or fluids into an underground geologic formation in order to fracture or with the intent to fracture the formation, thereby causing or enhancing, for the purposes of this division, the production of oil or gas from a well.

3153. "Well stimulation treatment fluid" means a base fluid mixed with physical and chemical additives, which may include acid, for the purpose of a well stimulation treatment. A well stimulation treatment may include more than one well stimulation treatment fluid. Well stimulation treatment fluids include, but are not limited to, hydraulic fracturing fluids and acid stimulation treatment fluids.

3154. "Proppants" means materials inserted or injected into the underground geologic formation that are intended to prevent fractures from closing.

3155. "Supplier" means an entity performing a well stimulation treatment or an entity supplying an additive or proppant directly to the operator for use in a well stimulation treatment.

3156. "Surface property owner" means the owner of real property as shown on the latest equalized assessment roll or, if more recent information than the information contained on the assessment roll is available, the owner of record according to the county assessor or tax collector.

3157. (a) For purposes of this article, "well stimulation treatment" means any treatment of a well designed to enhance oil and gas production or recovery by increasing the permeability of the formation. Well stimulation treatments include, but are not limited to, hydraulic fracturing treatments and acid well stimulation treatments.

(b) Well stimulation treatments do not include steam flooding, water flooding, or cyclic steaming and do not include routine well cleanout work, routine well maintenance, routine removal of formation damage due to drilling, bottom hole pressure surveys, or routine activities that do not affect the integrity of the well or the formation.

3158. "Acid well stimulation treatment" means a well stimulation treatment that uses, in whole or in part, the application of one or more acids to the well or underground geologic formation. The acid well stimulation treatment may be at any applied pressure and may be used in combination with hydraulic fracturing treatments or other well stimulation treatments. Acid well stimulation treatments include acid matrix stimulation treatments and acid fracturing treatments. Acid matrix stimulation treatments are acid treatments conducted at pressures lower than the applied pressure necessary to fracture the underground geologic formation.

3159. "Flowback fluid" means the fluid recovered from the treated well before the commencement of oil and gas production from that well following

a well stimulation treatment. The flowback fluid may include materials of any phase.

3160. (a) On or before January 1, 2015, the Secretary of the Natural Resources Agency shall cause to be conducted, and completed, an independent scientific study on well stimulation treatments, including, but not limited to, hydraulic fracturing and acid well stimulation treatments. The scientific study shall evaluate the hazards and risks and potential hazards and risks that well stimulation treatments pose to natural resources and public, occupational, and environmental health and safety. The scientific study shall do all of the following:

(1) Follow the well-established standard protocols of the scientific profession, including, but not limited to, the use of recognized experts, peer review, and publication.

(2) Identify areas with existing and potential conventional and unconventional oil and gas reserves where well stimulation treatments are likely to spur or enable oil and gas exploration and production.

(3) (A) Evaluate all aspects and effects of well stimulation treatments, including, but not limited to, the well stimulation treatment, additive and water transportation to and from the well site, mixing and handling of the well stimulation treatment fluids and additives onsite, the use and potential for use of nontoxic additives and the use or reuse of treated or produced water in well stimulation treatment fluids, flowback fluids and handling, treatment, and disposal of flowback fluids and other materials, if any, generated by the treatment. Specifically, the potential for the use of recycled water in well stimulation treatments, including appropriate water quality requirements and available treatment technologies, shall be evaluated. Well stimulation treatments include, but are not limited to, hydraulic fracturing and acid well stimulation treatments.

(B) Review and evaluate acid matrix stimulation treatments, including the range of acid volumes applied per treated foot and total acid volumes used in treatments, types of acids, acid concentration, and other chemicals used in the treatments.

(4) Consider, at a minimum, atmospheric emissions, including potential greenhouse gas emissions, the potential degradation of air quality, potential impacts on wildlife, native plants, and habitat, including habitat fragmentation, potential water and surface contamination, potential noise pollution, induced seismicity, and the ultimate disposition, transport, transformation, and toxicology of well stimulation treatments, including acid well stimulation fluids, hydraulic fracturing fluids, and waste hydraulic fracturing fluids and acid well stimulation in the environment.

(5) Identify and evaluate the geologic features present in the vicinity of a well, including the well bore, that should be taken into consideration in the design of a proposed well stimulation treatment.

(6) Include a hazard assessment and risk analysis addressing occupational and environmental exposures to well stimulation treatments, including hydraulic fracturing treatments, hydraulic fracturing treatment-related processes, acid well stimulation treatments, acid well stimulation treatment-related processes, and the corresponding impacts on public health and safety with the participation of the Office of Environmental Health Hazard Assessment.

(7) Clearly identify where additional information is necessary to inform and improve the analyses.

(b) (1) (A) On or before January 1, 2015, the division, in consultation with the Department of Toxic Substances Control, the State Air Resources Board, the State Water Resources Control Board, the Department of Resources Recycling and Recovery, and any local air districts and regional

water quality control boards in areas where well stimulation treatments, including acid well stimulation treatments and hydraulic fracturing treatments may occur, shall adopt rules and regulations specific to well stimulation treatments. The rules and regulations shall include, but are not limited to, revisions, as needed, to the rules and regulations governing construction of wells and well casings to ensure integrity of wells, well casings, and the geologic and hydrologic isolation of the oil and gas formation during and following well stimulation treatments, and full disclosure of the composition and disposition of well stimulation fluids, including, but not limited to, hydraulic fracturing fluids, acid well stimulation fluids, and flowback fluids.

(B) The rules and regulations shall additionally include provisions for an independent entity or person to perform the notification requirements pursuant to paragraph (6) of subdivision (d), for the operator to provide for baseline and followup water testing upon request as specified in paragraph (7) of subdivision (d).

(C) (i) In order to identify the acid matrix stimulation treatments that are subject to this section, the rules and regulations shall establish threshold values for acid volume applied per treated foot of any individual stage of the well or for total acid volume of the treatment, or both, based upon a quantitative assessment of the risks posed by acid matrix stimulation treatments that exceed the specified threshold value or values in order to prevent, as far as possible, damage to life, health, property, and natural resources pursuant to Section 3106.

(ii) On or before January 1, 2020, the division shall review and evaluate the threshold values for acid volume applied per treated foot and total acid volume of the treatment, based upon data collected in the state, for acid matrix stimulation treatments. The division shall revise the values through the regulatory process, if necessary, based upon the best available scientific information, including the results of the independent scientific study pursuant to subparagraph (B) of paragraph (3) of subdivision (a).

(2) Full disclosure of the composition and disposition of well stimulation fluids, including, but not limited to, hydraulic fracturing fluids and acid stimulation treatment fluids, shall, at a minimum, include:

(A) The date of the well stimulation treatment.

(B) A complete list of the names, Chemical Abstract Service (CAS) numbers, and maximum concentration, in percent by mass, of each and every chemical constituent of the well stimulation treatment fluids used. If a CAS number does not exist for a chemical constituent, the well owner or operator may provide another unique identifier, if available.

(C) The trade name, the supplier, concentration, and a brief description of the intended purpose of each additive contained in the well stimulation treatment fluid.

(D) The total volume of base fluid used during the well stimulation treatment, and the identification of whether the base fluid is water suitable for irrigation or domestic purposes, water not suitable for irrigation or domestic purposes, or a fluid other than water.

(E) The source, volume, and specific composition and disposition of all water, including, but not limited to, all water used as base fluid during the well stimulation treatment and recovered from the well following the well stimulation treatment that is not otherwise reported as produced water pursuant to Section 3227. Any repeated reuse of treated or untreated water for well stimulation treatments and well stimulation treatment-related activities shall be identified.

(F) The specific composition and disposition of all well stimulation treatment fluids, including waste fluids, other than water.

(G) Any radiological components or tracers injected into the well as part

of, or in order to evaluate, the well stimulation treatment, a description of the recovery method, if any, for those components or tracers, the recovery rate, and specific disposal information for recovered components or tracers.

(H) The radioactivity of the recovered well stimulation fluids.

(I) The location of the portion of the well subject to the well stimulation treatment and the extent of the fracturing or other modification, if any, surrounding the well induced by the treatment.

(c) (1) Through the consultation process described in paragraph (1) of subdivision (b), the division shall collaboratively identify and delineate the existing statutory authority and regulatory responsibility relating to well stimulation treatments and well stimulation treatment-related activities of the Department of Toxic Substances Control, the State Air Resources Board, any local air districts, the State Water Resources Control Board, the Department of Resources Recycling and Recovery, any regional water quality control board, and other public entities, as applicable. This shall specify how the respective authority, responsibility, and notification and reporting requirements associated with well stimulation treatments and well stimulation treatment-related activities are divided among each public entity.

(2) On or before January 1, 2015, the division shall enter into formal agreements with the Department of Toxic Substances Control, the State Air Resources Board, any local air districts where well stimulation treatments may occur, the State Water Resources Control Board, the Department of Resources Recycling and Recovery, and any regional water quality control board where well stimulation treatments may occur, clearly delineating respective authority, responsibility, and notification and reporting requirements associated with well stimulation treatments and well stimulation treatment-related activities, including air and water quality monitoring, in order to promote regulatory transparency and accountability.

(3) The agreements under paragraph (2) shall specify the appropriate public entity responsible for air and water quality monitoring and the safe and lawful disposal of materials in landfills, include trade secret handling protocols, if necessary, and provide for ready public access to information related to well stimulation treatments and related activities.

(4) Regulations, if necessary, shall be revised appropriately to incorporate the agreements under paragraph (2).

(d) (1) Notwithstanding any other law or regulation, prior to performing a well stimulation treatment on a well, the operator shall apply for a permit to perform a well stimulation treatment with the supervisor or district deputy. The well stimulation treatment permit application shall contain the pertinent data the supervisor requires on printed forms supplied by the division or on other forms acceptable to the supervisor. The information provided in the well stimulation treatment permit application shall include, but is not limited to, the following:

(A) The well identification number and location.

(B) The time period during which the well stimulation treatment is planned to occur.

(C) A water management plan that shall include all of the following:

(i) An estimate of the amount of water to be used in the treatment.

Estimates of water to be recycled following the well stimulation treatment may be included.

(ii) The anticipated source of the water to be used in the treatment.

(iii) The disposal method identified for the recovered water in the flowback fluid from the treatment that is not produced water included in the statement pursuant to Section 3227.

(D) A complete list of the names, Chemical Abstract Service (CAS) numbers, and estimated concentrations, in percent by mass, of each and

every chemical constituent of the well stimulation fluids anticipated to be used in the treatment. If a CAS number does not exist for a chemical constituent, the well owner or operator may provide another unique identifier, if available.

(E) The planned location of the well stimulation treatment on the well bore, the estimated length, height, and direction of the induced fractures or other planned modification, if any, and the location of existing wells, including plugged and abandoned wells, that may be impacted by these fractures and modifications.

(F) A groundwater monitoring plan. Required groundwater monitoring in the vicinity of the well subject to the well stimulation treatment shall be satisfied by one of the following:

(i) The well is located within the boundaries of an existing oil or gas field-specific or regional monitoring program developed pursuant to Section 10783 of the Water Code.

(ii) The well is located within the boundaries of an existing oil or gas field-specific or regional monitoring program developed and implemented by the well owner or operator meeting the model criteria established pursuant to Section 10783 of the Water Code.

(iii) Through a well-specific monitoring plan implemented by the owner or operator meeting the model criteria established pursuant to Section 10783 of the Water Code, and submitted to the appropriate regional water board for review.

(G) The estimated amount of treatment-generated waste materials that are not reported in subparagraph (C) and an identified disposal method for the waste materials.

(2) (A) At the supervisor's discretion, and if applied for concurrently, the well stimulation treatment permit described in this section may be combined with the well drilling and related operation notice of intent required pursuant to Section 3203 into a single combined authorization. The portion of the combined authorization applicable to well stimulation shall meet all of the requirements of a well stimulation treatment permit pursuant to this section.

(B) Where the supervisor determines that the activities proposed in the well stimulation treatment permit or the combined authorization have met all of the requirements of Division 13 (commencing with Section 21000), and have been fully described, analyzed, evaluated, and mitigated, no additional review or mitigation shall be required.

(C) The time period available for approval of the portion of the combined authorization applicable to well stimulation is subject to the terms of this section, and not Section 3203.

(3) (A) The supervisor or district deputy shall review the well stimulation treatment permit application and may approve the permit if the application is complete. An incomplete application shall not be approved.

(B) A well stimulation treatment or repeat well stimulation treatment shall not be performed on any well without a valid permit that the supervisor or district deputy has approved.

(C) In considering the permit application, the supervisor shall evaluate the quantifiable risk of the well stimulation treatment.

(4) The well stimulation treatment permit shall expire one year from the date that the permit is issued.

(5) Within five business days of issuing a permit to perform a well stimulation treatment, the division shall provide a copy of the permit to the appropriate regional water quality control board or boards and to the local planning entity where the well, including its subsurface portion, is located. The division shall also post the permit on the publicly accessible portion of

its Internet Web site within five business days of issuing a permit.

(6) (A) It is the policy of the state that a copy of the approved well stimulation treatment permit and information on the available water sampling and testing be provided to every tenant of the surface property and every surface property owner or authorized agent of that owner whose property line location is one of the following:

- (i) Within a 1,500 foot radius of the wellhead.
- (ii) Within 500 feet from the horizontal projection of all subsurface portions of the designated well to the surface.

(B) (i) The well owner or operator shall identify the area requiring notification and shall contract with an independent entity or person who is responsible for, and shall perform, the notification required pursuant to subparagraph (A).

(ii) The independent entity or person shall identify the individuals notified, the method of notification, the date of the notification, a list of those notified, and shall provide a list of this information to the division.

(iii) The performance of the independent entity or persons shall be subject to review and audit by the division.

(C) A well stimulation treatment shall not commence before 30 calendar days after the permit copies pursuant to subparagraph (A) are provided.

(7) (A) A property owner notified pursuant to paragraph (6) may request water quality sampling and testing from a designated qualified contractor on any water well suitable for drinking or irrigation purposes and on any surface water suitable for drinking or irrigation purposes as follows:

- (i) Baseline measurements prior to the commencement of the well stimulation treatment.
- (ii) Followup measurements after the well stimulation treatment on the same schedule as the pressure testing of the well casing of the treated well.

(B) The State Water Resources Control Board shall designate one or more qualified independent third-party contractor or contractors that adhere to board-specified standards and protocols to perform the water sampling and testing. The well owner or operator shall pay for the sampling and testing. The sampling and testing performed shall be subject to audit and review by the State Water Resources Control Board or applicable regional water quality control board, as appropriate.

(C) The results of the water testing shall be provided to the division, appropriate regional water board, and the property owner or authorized agent. A tenant notified pursuant to paragraph (6) shall receive information on the results of the water testing to the extent authorized by his or her lease and, where the tenant has lawful use of the ground or surface water identified in subparagraph (A), the tenant may independently contract for similar groundwater or surface water testing.

(8) The division shall retain a list of the entities and property owners notified pursuant to paragraphs (5) and (6).

(9) The operator shall provide notice to the division at least 72 hours prior to the actual start of the well stimulation treatment in order for the division to witness the treatment.

(e) The Secretary of the Natural Resources Agency shall notify the Joint Legislative Budget Committee and the chairs of the Assembly Natural Resources, Senate Environmental Quality, and Senate Natural Resources and Water Committees on the progress of the independent scientific study on well stimulation and related activities. The first progress report shall be provided to the Legislature on or before April 1, 2014, and progress reports shall continue every four months thereafter until the independent study is completed, including a peer review of the study by independent scientific experts.

(f) If a well stimulation treatment is performed on a well, a supplier that performs any part of the stimulation or provides additives directly to the operator for a well stimulation treatment shall furnish the operator with information suitable for public disclosure needed for the operator to comply with subdivision (g). This information shall be provided as soon as possible but no later than 30 days following the conclusion of the well stimulation treatment.

(g) (1) Within 60 days following cessation of a well stimulation treatment on a well, the operator shall post or cause to have posted to an Internet Web site designated or maintained by the division and accessible to the public, all of the well stimulation fluid composition and disposition information required to be collected pursuant to rules and regulations adopted under subdivision (b), including well identification number and location. This shall include the collected water quality data, which the operator shall report electronically to the State Water Resources Control Board.

(2) (A) The division shall commence the process to develop an Internet Web site for operators to report the information required under this section. The Internet Web site shall be capable of organizing the reported information in a format, such as a spreadsheet, that allows the public to easily search and aggregate, to the extent practicable, each type of information required to be collected pursuant to subdivision (b) using search functions on that Internet Web site. The Internet Web site shall be functional within two years of the Department of Technology's approval of a Feasibility Study Report or appropriation authority to fund the development of the Internet Web site, whichever occurs latest, but no later than January 1, 2016.

(B) The division may direct reporting to an alternative Internet Web site developed by the Ground Water Protection Council and the Interstate Oil and Gas Compact Commission in the interim until such time as approval or appropriation authority pursuant to subparagraph (A) occur. Prior to the implementation of the division's Internet Web site, the division shall obtain the data reported by operators to the alternative Internet Web site and make it available in an organized electronic format to the public no later than 15 days after it is reported to the alternative Web site.

(h) The operator is responsible for compliance with this section.

(i) (1) All geologic features within a distance reflecting an appropriate safety factor of the fracture zone for well stimulation treatments that fracture the formation and that have the potential to either limit or facilitate the migration of fluids outside of the fracture zone shall be identified and added to the well history. Geologic features include seismic faults identified by the California Geologic Survey.

(2) For the purposes of this section, the "fracture zone" is defined as the volume surrounding the well bore where fractures were created or enhanced by the well stimulation treatment. The safety factor shall be at least five and may vary depending upon geologic knowledge.

(3) The division shall review the geologic features important to assessing well stimulation treatments identified in the independent study pursuant to paragraph (5) of subdivision (a). Upon completion of the review, the division shall revise the regulations governing the reporting of geologic features pursuant to this subdivision accordingly.

(j) (1) Public disclosure of well stimulation treatment fluid information claimed to contain trade secrets is governed by Section 1060 of the Evidence Code, or the Uniform Trade Secrets Act (Title 5 (commencing with Section 3426) of Part 1 of Division 4 of the Civil Code), and the California Public Records Act (Chapter 3.5 (commencing with Section 6250) of Division 7 of Title 1 of the Government Code).

(2) Notwithstanding any other law or regulation, none of the following

information shall be protected as a trade secret:

(A) The identities of the chemical constituents of additives, including CAS identification numbers.

(B) The concentrations of the additives in the well stimulation treatment fluids.

(C) Any air or other pollution monitoring data.

(D) Health and safety data associated with well stimulation treatment fluids.

(E) The chemical composition of the flowback fluid.

(3) If a trade secret claim is invalid or invalidated, the division shall release the information to the public by revising the information released pursuant to subdivision (g). The supplier shall notify the division of any change in status within 30 days.

(4) (A) If a supplier believes that information regarding a chemical constituent of a well stimulation fluid is a trade secret, the supplier shall nevertheless disclose the information to the division in conjunction with a well stimulation treatment permit application, if not previously disclosed, within 30 days following cessation of well stimulation on a well, and shall notify the division in writing of that belief.

(B) A trade secret claim shall not be made after initial disclosure of the information to the division.

(C) To comply with the public disclosure requirements of this section, the supplier shall indicate where trade secret information has been withheld and provide substitute information for public disclosure. The substitute information shall be a list, in any order, of the chemical constituents of the additive, including CAS identification numbers. The division shall review and approve the supplied substitute information.

(D) This subdivision does not permit a supplier to refuse to disclose the information required pursuant to this section to the division.

(5) In order to substantiate the trade secret claim, the supplier shall provide information to the division that shows all of the following:

(A) The extent to which the trade secret information is known by the supplier's employees, others involved in the supplier's business and outside the supplier's business.

(B) The measures taken by the supplier to guard the secrecy of the trade secret information.

(C) The value of the trade secret information to the supplier and its competitors.

(D) The amount of effort or money the supplier expended developing the trade secret information and the ease or difficulty with which the trade secret information could be acquired or duplicated by others.

(6) If the division determines that the information provided in support of a request for trade secret protection pursuant to paragraph (5) is incomplete, the division shall notify the supplier and the supplier shall have 30 days to complete the submission. An incomplete submission does not meet the substantive criteria for trade secret designation.

(7) If the division determines that the information provided in support of a request for trade secret protection does not meet the substantive criteria for trade secret designation, the department shall notify the supplier by certified mail of its determination. The division shall release the information to the public, but not earlier than 60 days after the date of mailing the determination, unless, prior to the expiration of the 60-day period, the supplier obtains an action in an appropriate court for a declaratory judgment that the information is subject to protection or for a preliminary injunction prohibiting disclosure of the information to the public and provides notice to the division of the court order.

- (8) The supplier is not required to disclose trade secret information to the operator.
- (9) Upon receipt of a request for the release of trade secret information to the public, the following procedure applies:
- (A) The division shall notify the supplier of the request in writing by certified mail, return receipt requested.
- (B) The division shall release the information to the public, but not earlier than 60 days after the date of mailing the notice of the request for information, unless, prior to the expiration of the 60-day period, the supplier obtains an action in an appropriate court for a declaratory judgment that the information is subject to protection or for a preliminary injunction prohibiting disclosure of the information to the public and provides notice to the division of that action.
- (10) The division shall develop a timely procedure to provide trade secret information in the following circumstances:
- (A) To an officer or employee of the division, the state, local governments, including, but not limited to, local air districts, or the United States, in connection with the official duties of that officer or employee, to a health professional under any law for the protection of health, or to contractors with the division or other government entities and their employees if, in the opinion of the division, disclosure is necessary and required for the satisfactory performance of a contract, for performance of work, or to protect health and safety.
- (B) To a health professional in the event of an emergency or to diagnose or treat a patient.
- (C) In order to protect public health, to any health professional, toxicologist, or epidemiologist who is employed in the field of public health and who provides a written statement of need. The written statement of need shall include the public health purposes of the disclosure and shall explain the reason the disclosure of the specific chemical and its concentration is required.
- (D) A health professional may share trade secret information with other persons as may be professionally necessary, in order to diagnose or treat a patient, including, but not limited to, the patient and other health professionals, subject to state and federal laws restricting disclosure of medical records including, but not limited to, Chapter 2 (commencing with Section 56.10) of Part 2.6 of Division 1 of the Civil Code.
- (E) For purposes of this paragraph, "health professional" means any person licensed or certified pursuant to Division 2 (commencing with Section 500) of the Business and Professions Code, the Osteopathic Initiative Act, the Chiropractic Initiative Act, or the Emergency Medical Services System and the Prehospital Emergency Medical Care Personnel Act (Division 2.5 (commencing with Section 1797) of the Health and Safety Code).
- (F) A person in possession of, or access to, confidential trade secret information pursuant to the provisions of this subdivision may disclose this information to any person who is authorized to receive it. A written confidentiality agreement shall not be required.
- (k) A well granted confidential status pursuant to Section 3234 shall not be required to disclose well stimulation treatment fluid information pursuant to subdivision (g) until the confidential status of the well ceases. Notwithstanding the confidential status of a well, it is public information that a well will be or has been subject to a well stimulation treatment.
- (l) The division shall perform random periodic spot check inspections to ensure that the information provided on well stimulation treatments is accurately reported, including that the estimates provided prior to the commencement of the well stimulation treatment are reasonably consistent

with the well history.

(m) Where the division shares jurisdiction over a well or the well stimulation treatment on a well with a federal entity, the division's rules and regulations shall apply in addition to all applicable federal laws and regulations.

(n) This article does not relieve the division or any other agency from complying with any other provision of existing laws, regulations, and orders.

(o) Well stimulation treatments used for routine maintenance of wells associated with underground storage facilities where natural gas is injected into and withdrawn from depleted or partially depleted oil or gas reservoirs pursuant to subdivision (a) of Section 3403.5 are not subject to this section.

3161. (a) The division shall finalize and implement the regulations governing this article on or before January 1, 2015.

(b) The division shall allow, until regulations governing this article are finalized and implemented, and upon written notification by an operator, all of the activities defined in Section 3157, provided all of the following conditions are met:

(1) The owner or operator certifies compliance with subdivision (b) of, subparagraphs (A) to (F), inclusive, of paragraph (1) and paragraphs (6) and (7) of subdivision (d) of, and subdivision (g) of, Section 3160.

(2) The owner or operator provides a complete well history, incorporating the information required by Section 3160, to the division on or before March 1, 2015.

(3) The division conducts an environmental impact report (EIR) pursuant to the California Environmental Quality Act (Division 13 (commencing with Section 21000)), in order to provide the public with detailed information regarding any potential environmental impacts of well stimulation in the state.

(4) Any environmental review conducted by the division shall fully comply with all of the following requirements:

(A) The EIR shall be certified by the division as the lead agency, no later than July 1, 2015.

(B) The EIR shall address the issue of activities that may be conducted as defined in Section 3157 and that may occur at oil wells in the state existing prior to, and after, the effective date of this section.

(C) The EIR shall not conflict with an EIR conducted by a local lead agency that is certified on or before July 1, 2015. Nothing in this section prohibits a local lead agency from conducting its own EIR.

(5) The division ensures that all activities pursuant to this section fully conform with this article and other applicable provisions of law on or before December 31, 2015, through a permitting process.

(6) The division has the emergency regulatory authority to implement the purposes of this section.

SEC. 3. Section 3213 of the Public Resources Code is amended to read:

3213. The history shall show the location and amount of sidetracked casings, tools, or other material, the depth and quantity of cement in cement plugs, the shots of dynamite or other explosives, acid treatment data, and the results of production and other tests during drilling operations. All data on well stimulation treatments pursuant to Section 3160 shall be recorded in the history.

SEC. 4. Section 3215 of the Public Resources Code is amended to read:

3215. (a) Within 60 days after the date of cessation of drilling, rework, well stimulation treatment, or abandonment operations, or the date of suspension of operations, the operator shall file with the district deputy, in a form approved by the supervisor, true copies of the log, core record, and history of work performed, and, if made, true and reproducible copies of

all electrical, physical, or chemical logs, tests, or surveys. Upon a showing of hardship, the supervisor may extend the time within which to comply with this section for a period not to exceed 60 additional days.

(b) The supervisor shall include information or electronic links to information provided pursuant to subdivision (g) of Section 3160 on existing publicly accessible maps on the division's Internet Web site, and make the information available such that well stimulation treatment and related information are associated with each specific well. If data is reported on an Internet Web site not maintained by the division pursuant to paragraph (2) of subdivision (g) of Section 3160, the division shall provide electronic links to that Internet Web site. The public shall be able to search and sort the hydraulic well stimulation and related information by at least the following criteria:

- (1) Geographic area.
- (2) Additive.
- (3) Chemical constituent.
- (4) Chemical Abstract Service number.
- (5) Time period.
- (6) Operator.

(c) Notwithstanding Section 10231.5 of the Government Code, on or before January 1, 2016, and annually thereafter, the supervisor shall, in compliance with Section 9795 of the Government Code, prepare and transmit to the Legislature a comprehensive report on well stimulation treatments in the exploration and production of oil and gas resources in California. The report shall include aggregated data of all of the information required to be reported pursuant to Section 3160 reported by the district, county, and operator. The report also shall include relevant additional information, as necessary, including, but not limited to, all of the following:

- (1) Aggregated data detailing the disposition of any produced water from wells that have undergone well stimulation treatments.
  - (2) Aggregated data describing the formations where wells have received well stimulation treatments including the range of safety factors used and fracture zone lengths.
  - (3) The number of emergency responses to a spill or release associated with a well stimulation treatment.
  - (4) Aggregated data detailing the number of times trade secret information was not provided to the public, by county and by each company, in the preceding year.
  - (5) Data detailing the loss of well and well casing integrity in the preceding year for wells that have undergone well stimulation treatment. For comparative purposes, data detailing the loss of well and well casing integrity in the preceding year for all wells shall also be provided. The cause of each well and well casing failure, if known, shall also be provided.
  - (6) The number of spot check inspections conducted pursuant to subdivision (l) of Section 3160, including the number of inspections where the composition of well stimulation fluids were verified and the results of those inspections.
  - (7) The number of well stimulation treatments witnessed by the division.
  - (8) The number of enforcement actions associated with well stimulation treatments, including, but not limited to, notices of deficiency, notices of violation, civil or criminal enforcement actions, and any penalties assessed.
- (d) The report shall be made publicly available and an electronic version shall be available on the division's Internet Web site.

SEC. 5. Section 3236.5 of the Public Resources Code is amended to read:

3236.5. (a) A person who violates this chapter or a regulation

implementing this chapter is subject to a civil penalty not to exceed twenty-five thousand dollars (\$25,000) for each violation. A person who commits a violation of Article 3 (commencing with Section 3150) is subject to a civil penalty of not less than ten thousand dollars (\$10,000) and not to exceed twenty-five thousand dollars (\$25,000) per day per violation. An act of God and an act of vandalism beyond the reasonable control of the operator shall not be considered a violation. The civil penalty shall be imposed by an order of the supervisor pursuant to Section 3225 upon a determination that a violation has been committed by the person charged. The imposition of a civil penalty under this section shall be in addition to any other penalty provided by law for the violation. When establishing the amount of the civil penalty pursuant to this section, the supervisor shall consider, in addition to other relevant circumstances, all of the following:

- (1) The extent of harm caused by the violation.
  - (2) The persistence of the violation.
  - (3) The pervasiveness of the violation.
  - (4) The number of prior violations by the same violator.
- (b) An order of the supervisor imposing a civil penalty shall be reviewable pursuant to Article 6 (commencing with Section 3350). When the order of the supervisor has become final and the penalty has not been paid, the supervisor may apply to the appropriate superior court for an order directing payment of the civil penalty. The supervisor may also seek from the court an order directing that production from the well or use of the production facility that is the subject of the civil penalty order be discontinued until the violation has been remedied to the satisfaction of the supervisor and the civil penalty has been paid.
- (c) Any amount collected under this section shall be deposited in the Oil, Gas, and Geothermal Administrative Fund.

SEC. 6. Section 3401 of the Public Resources Code is amended to read:

3401. (a) The proceeds of charges levied, assessed, and collected pursuant to this article upon the properties of every person operating or owning an interest in the production of a well shall be used exclusively for the support and maintenance of the department charged with the supervision of oil and gas operations.

(b) Notwithstanding subdivision (a), the proceeds of charges levied, assessed, and collected pursuant to this article upon the properties of every person operating or owning an interest in the production of a well undergoing a well stimulation treatment, may be used by public entities, subject to appropriation by the Legislature, for all costs associated with both of the following:

- (1) Well stimulation treatments, including rulemaking and scientific studies required to evaluate the treatment, inspections, any air and water quality sampling, monitoring, and testing performed by public entities.
- (2) The costs of the State Water Resources Control Board and the regional water quality control boards in carrying out their responsibilities pursuant to Section 3160 and Section 10783 of the Water Code.

SEC. 7. Section 10783 is added to the Water Code, to read:

10783. (a) The Legislature finds and declares that protecting the state's groundwater for beneficial use, particularly sources and potential sources of drinking water, is of paramount concern.

(b) The Legislature further finds and declares that strategic, scientifically based groundwater monitoring of the state's oil and gas fields is critical to allaying the public's concerns regarding well stimulation treatments of oil and gas wells.

(c) On or before July 1, 2015, in order to assess the potential effects of well stimulation treatments, as defined in Article 3 (commencing with

Section 3150) of Chapter 1 of Division 3 of the Public Resources Code, on the state's groundwater resources in a systematic way, the state board shall develop model groundwater monitoring criteria to be implemented either on a well-by-well basis for a well subject to well stimulation treatment, or on a regional scale. The model criteria shall address a range of spatial sampling scales from methods for conducting appropriate monitoring on individual oil and gas wells subject to a well stimulation treatment, to methods for conducting a regional groundwater monitoring program. The state board shall take into consideration the recommendations received pursuant to subdivision (d) and shall include in the model criteria, at a minimum, the components identified in subdivision (f). The state board shall prioritize monitoring of groundwater that is or has the potential to be a source of drinking water, but shall protect all waters designated for any beneficial use.

(d) The state board, in consultation with the Department of Conservation, Division of Oil, Gas, and Geothermal Resources, shall seek the advice of experts on the design of the model groundwater monitoring criteria. The experts shall assess and make recommendations to the state board on the model criteria. These recommendations shall prioritize implementation of regional groundwater monitoring programs statewide, as warranted, based upon the prevalence of well stimulation treatments of oil and gas wells and groundwater suitable as a source of drinking water.

(e) The state board shall also seek the advice of stakeholders representing the diverse interests of the oil- and gas-producing areas of the state. The stakeholders shall include the oil and gas industry, agriculture, environmental justice, and local government, among others, with regional representation commensurate with the intensity of oil and gas development in that area. The stakeholders shall also make recommendations to the state board regarding the development and implementation of groundwater monitoring criteria, including priority locations for implementation.

(f) The scope and nature of the model groundwater monitoring criteria shall include the determination of all of the following:

- (1) An assessment of the areas to conduct groundwater quality monitoring and their appropriate boundaries.
  - (2) A list of the constituents to measure and assess water quality.
  - (3) The location, depth, and number of monitoring wells necessary to detect groundwater contamination at spatial scales ranging from an individual oil and gas well to a regional groundwater basin including one or more oil and gas fields.
  - (4) The frequency and duration of the monitoring.
  - (5) A threshold criteria indicating a transition from well-by-well monitoring to a regional monitoring program.
  - (6) Data collection and reporting protocols.
  - (7) Public access to the collected data under paragraph (6).
- (g) Factors to consider in addressing subdivision (f) shall include, but are not limited to, all of the following:
- (1) The existing quality and existing and potential use of the groundwater.
  - (2) Groundwater that is not a source of drinking water consistent with the United States Environmental Protection Agency's definition of an Underground Source of Drinking Water as containing less than 10,000 milligrams per liter total dissolved solids in groundwater (40 C.F.R. 144.3), including exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations.
  - (3) Proximity to human population, public water service wells, and private groundwater use, if known.
  - (4) The presence of existing oil and gas production fields, including the

distribution, physical attributes, and operational status of oil and gas wells therein.

(5) Events, including well stimulation treatments and oil and gas well failures, among others, that have the potential to contaminate groundwater, appropriate monitoring to evaluate whether groundwater contamination can be attributable to a particular event, and any monitoring changes necessary if groundwater contamination is observed.

(h) (1) On or before January 1, 2016, the state board or appropriate regional board shall begin implementation of the regional groundwater monitoring programs based upon the developed criteria under subdivision (c).

(2) In the absence of state implementation of a regional groundwater monitoring program, a well owner or operator may develop and implement an area-specific groundwater monitoring program based upon the developed criteria under subdivision (c), subject to approval by the state or regional board, if applicable, and that meets the requirements of this section.

(i) The model criteria for either a well-by-well basis for a well subject to well stimulation treatment, or for a regional groundwater monitoring program, shall be used to satisfy the permitting requirements for well stimulation treatments on oil and gas wells pursuant to Section 3160 of the Public Resources Code. The model criteria used on a well-by-well basis for a well subject to a well stimulation treatment shall be used where no regional groundwater monitoring plan approved by the state or regional board, if applicable, exists and has been implemented by either the state or regional board or the well owner or operator.

(j) The model criteria shall accommodate monitoring where surface access is limited. Monitoring is not required for oil and gas wells where the wells do not penetrate groundwater of beneficial use, as determined by a regional water quality control board, or do not penetrate exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations.

(k) (1) The model criteria and groundwater monitoring programs shall be reviewed and updated periodically, as needed.

(2) The use of the United States Environmental Protection Agency's definition of an Underground Source of Drinking Water as containing less than 10,000 milligrams per liter total dissolved solids in groundwater (40 C.F.R. 144.3) and whether exempt aquifers pursuant to Section 146.4 of Title 40 of the Code of Federal Regulations shall be subject to groundwater monitoring shall be reviewed by the state board through a public process on or before January 1, 2020.

(l) (1) All groundwater quality data collected pursuant to subparagraph (F) of paragraph (1) of subdivision (d) of Section 3160 of the Public Resources Code shall be submitted to the state board in an electronic format that is compatible with the state board's GeoTracker database, following the guidelines detailed in Chapter 30 (commencing with Section 3890) of Division 3 of Title 23 of the California Code of Regulations.

(2) A copy of the reported data under paragraph (1) shall be transferred by the state board to a public, nonprofit doctoral-degree-granting educational institution located in the San Joaquin Valley, administered pursuant to Section 9 of Article IX of the California Constitution, in order to form the basis of a comprehensive groundwater quality data repository to promote research, foster interinstitutional collaboration, and seek understanding of the numerous factors influencing the state's groundwater.

(m) The adoption of criteria required pursuant to this section is exempt from the rulemaking provisions of the Administrative Procedure Act (Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code). The adoption of criteria pursuant to this section

shall instead be accomplished by means of a public process reasonably calculated to give those persons interested in their adoption an opportunity to be heard.

SEC. 8. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because the only costs that may be incurred by a local agency or school district will be incurred because this act creates a new crime or infraction, eliminates a crime or infraction, or changes the penalty for a crime or infraction, within the meaning of Section 17556 of the Government Code, or changes the definition of a crime within the meaning of Section 6 of Article XIII B of the California Constitution