University of California
Agriculture and Natural Resources | California Institute for Water Resources

Regulating the Social and Environmental Costs of Hydraulic Fracturing in California

Principal Investigators:

Brent M Haddad (Principal Investigator)
Environmental Studies Department, UC Santa Cruz

Technical Completion Report for project: NIWR2014CA323B
Project period: March 1, 2014 – February 28, 2015

Project Summary

Introduction:
California's Monterey and Santos shale, two underground formations located in the San Joaquin and Los Angeles basins, respectively, collectively cover 1,752 square miles and contain approximately 13.7 billion barrels of oil, more than 50% of the nation's total estimated recoverable resources (U.S. Energy Information Administration, 2013). While this extensive resource has the potential to provide substantial benefits, expanded development of unconventional oil and gas production (i.e., hydraulic fracturing) could require dramatic changes in the quantity and quality of water available for other uses, posing significant environmental and socioeconomic risks in California (Bryner, 2003; Carter, 2010; Schindler & Donahue, 2006).

In this paper, we propose a review and synthesis of existing literature to assess: 1) the possible impacts of expanded use of hydraulic fracturing in California on the state's water resource users, 2) the legal and institutional mechanisms that currently exist to identify, regulate, and mitigate those impacts and 3) possible future government and community action to balance the needs of the environment, existing water users, and the newly expanded energy development sector.

We also propose a series of structured interviews that specifically address: 1) which government agencies and stakeholders will be engaged in the development of regulatory policies for hydraulic fracturing in the state, 2) how these institutions may be used to manage hydraulic fracturing activities to prevent significant impacts to protected salmonid species, critical habitat, and agricultural users, and 3) areas in which institutional capacity may be inadequate to address hydraulic fracturing impacts to water resources.

There is a small, but growing, literature on the impacts of unconventional oil and gas development and possible regulatory approaches. However, much of this effort is focused on relatively water-rich areas, such as the eastern United States, and therefore does not address some critically important features of water use that are present in California (Kuwayama, Olmstead and Krupnick, 2013). Our proposed review would highlight four related aspects of water use that are unique to California and would be significantly affected by expanded use of hydraulic fracturing in the state. First, shale formations that hold the most promise for energy development are located in areas with protected fish species.

The quantity and quality of instream flow in these areas is a factor that currently limits the ability of threatened and endangered fish species to recover. Second, with few exceptions, water in California is fully appropriated by existing users. Unconventional oil and gas technology requires large amounts of water and would therefore require re-allocation of existing water rights. This re-allocation will likely affect agricultural users and rural communities. Irrigators in the state are currently constrained not only by water availability in a semi-arid climate, but also by the need for water in meeting environmental goals. Third, because of the unique water delivery system in California, localized water use in the southern San Joaquin Valley has the potential to affect patterns of water use and environmental outcomes in other parts of the state, such as the Sacramento-San Joaquin Delta (Delta). Fourth, there is evidence that hydraulic fracturing may

degrade the quality of groundwater and surface water. Therefore, even if issues surrounding allocation of water are resolved, possible water quality impacts could mean that less water is functionally available for environmental protection and irrigation.

Hydraulic Fracturing in Areas with Protected Fish Species

Expanded use of hydraulic fracturing has the potential to affect critical habitat for fish protected under state and federal Endangered Species Acts (ESA). A number of Evolutionary Significant salmonid populations are located in watersheds that are likely to be impacted by hydraulic fracturing in the Lower Monterey and Santos shale. Other protected species such as the Delta smelt, with critical habitat in the Delta, may potentially be affected by alterations to the spatial distribution of water demands. Salmonid habitat along California's Central Coast, in the San Joaquin Valley and the Delta may be impacted by hydraulic fracturing activity in the Lower Monterey and Santos shale plays. (See Appendix A).

The South-Central California Steelhead population is listed as 'endangered' under the ESA. Reduced instream flow and modifications to natural flow regimes as a result of water diversions and modification of natural flow regimes are the primary threats to population viability for these fish (National Oceanic and Atmospheric Association Fisheries, 2012). Development of oil and gas resources through hydraulic fracturing in California's South-Central Coast has the potential to exacerbate the threats to protected salmonids through additional water diversions from local streams or mining of groundwater sources.

Although the Lower Monterey Shale formation does not lie under currently protected salmonid species habitat, hydraulic fracturing has the potential to affect patterns of water use and fish habitat in the Delta. Irrigators in the southern San Joaquin Valley largely rely on water exported from the Delta, and these water diversions can degrade the structure and function of freshwater ecosystems that provide critical habitat for Central Valley Salmon and Steelhead, which are listed as 'threatened' under the ESA (Moyle, Katz & Quiñones, 2010; Beccante, 2012). Hydraulic fracturing in the Lower Monterey Shale may affect the availability of groundwater for irrigation in the southern San Joaquin Valley and thus make agriculture in the region more dependent on Delta exports.

Impacts of Hydraulic Fracturing on Agricultural Users and Rural Communities

The potential for large scale hydraulic fracturing pose important questions regarding water management and the potential impacts to the state's agricultural economy. California agriculture uses approximately 80 percent of the state's developed water supply to produce more than 400 commodities, and in 2011, the industry generated $43.5 billion in revenue, 11 percent of the U.S. total (Begley et al., 2006; California Department of Food and Agriculture 2012). Some of the most productive irrigated farmland in the world lies above the Lower Monterey Shale (See Appendix B). A key issue for water quantity with respect to agriculture in the Central Valley is whether the total amount of water consumed for the development of shale oil and gas will result in a significant long-term loss of water resources within the region.

Market transactions such as temporary water leases or permanent land purchases are a possible source of water for hydraulic fracturing operations. The agricultural sector is a likely candidate to supply this water (Brewer et al., 2008; Western Governors' Association, 2012). Our paper will explore potential impacts of hydraulic fracturing on agricultural water supply and address institutional question such as: Will agriculture-to-energy water transfers be allowed? If so, under what conditions? What will the economic and community impact of these transfers be, and where will they be felt? How will existing institutions address the impacts of reallocation on other water users as well as local rural economies?

Effects of Hydraulic Fracturing on the Spatial Distribution of Water Use

The spatial scale that is used to calculate overall net water use can make a large difference in defining the scarcity of water with regard to hydraulic fracturing in the Central Valley. In California, where water users can be separated from water sources by hundreds of miles, it is not only the magnitude, but also the location of use that matters (Galbraith, 2012; Ground Water Protection Council and ALL Consulting, 2009; Nicot & Scanlon, 2012; Veil & Puder, 2006). Hydraulic fracturing in the Lower Monterey Shale has the potential to alter the spatial distribution of water use in California. An extensive water conveyance system transfers water from the northern region of the state to the southern portion, via the Delta, and has played a seminal role in the development of California's economy.

The inter-connected nature of water supply in disparate regions in the state makes it important to consider not only the localized effects of hydraulic fracturing, but also the wider, inter-regional effects of reallocating water within regions. If, for example, North-of-Delta water users become suppliers of water to South-of-Delta hydraulic fracturing operations, political pressure to increase Delta water exports intensify. A spatial shift in water use would distribute impacts non-uniformly throughout the agricultural economies of the Sacramento and San Joaquin Valleys, and affect salmonid species, which depend on freshwater inflows to the Delta.

Water Quality Impacts

In addition to its potential impacts on the quantity and distribution of water use, hydraulic fracturing has been shown to have adverse impacts on water quality. The water quality impacts from shale oil and gas development include: contamination of surface water and groundwater as a result of erosion during construction and maintenance of infrastructure; spills and releases of chemicals and fluids; underground migration of gases and chemicals; and injection of fluids underground (Kuwayama, Olmstead, & Krupnick 2013; Olmstead et al. 2013; Vidic et al. 2013).

Contaminated water has potentially significant implications for drinking water supplies, agricultural production, and fish species (Cutler & Miller 2005; Pennsylvania State University, 2010). Once freshwater is delivered to a well site for use in hydraulic fracturing, the acquired water is combined with chemical additives and, in some cases, more than 90 percent of the water used does not return to the hydrologic cycle, due to post-development treatment methods. Water quality degradation from hydraulic fracturing poses a significant risk to land resources, wildlife habitat and public health (Beccante, 2012; Hansen, Mulvaney and Betcher, 2013; Jackson et al., 2013; Kibble et al., 2013; Kim, 2013; Osborn et al. 2001; Warner et al., 2013).

The long-term effects of oil and gas contamination on aquatic life are difficult to determine, however recent studies suggest that effects of exposure to water used in the hydraulic fracturing process include: reduced fertility, kidney and liver damage, immune suppression, and cancer (Holowenko, MacKinnon & Fedorak, 2002; MacKinnon & Boerger, 1986; Papoulias & Velasco, 2013; Weltman-Fahs & Taylor, 2013). This is potentially a serious concern in areas such as California's Central Coast, where agricultural water users rely heavily on groundwater supplies, and freshwater is co-managed to recharge aquifers and provide adequate habitat for endangered South Coast Steelhead populations.

Information Transfer/Outreach Program

Methods:

Our proposed work will proceed in two phases. First, we will we will analyze existing literature from the physical, biological and social sciences to assess the possible impacts of expanded use of hydraulic fracturing in California on the state's water resource users. Second, we will conduct a series of structured interviews with stakeholders likely to be affected by an expansion in hydraulic fracturing in California.

To review how various scientific communities are studying the impacts of hydraulic fracturing to water resources management and protected species, we will review and conduct a content analysis of relevant scientific articles. An interdisciplinary review of the literature will reveal the primary mechanisms by which the stakeholders in California are likely to be impacted by hydraulic fracturing, and will clarify the specific links between hydraulic fracturing and potential impacts to protected fish species, water use in the agricultural sector, the spatial distribution of water use, and water quality in the state.

We will then carry out archival and secondary research as well as structured interviews with scientists and policymakers in state and federal institutions that are likely to be engaged in scientific and public policy discussions regarding hydraulic fracturing in California. We will focus on regional and state institutions from the administrative and regulatory community, such as the State Water Resources Control Board and the California Department of Fish and Wildlife, as well as water management institutions, such as the Department of Water Resources. We will also investigate national policymaking bodies, such as the Bureau of Reclamation and U.S. Fish and Wildlife Service to evaluate their structures and procedures regarding water quality, water supply management and the protection of threatened and endangered species in the context of hydraulic fracturing in California.

We will conduct structured interviews with individuals within the administrative and regulatory agencies, as well as key water management stakeholders in the Central Valley. The interviews will be designed to identify the government agencies and stakeholders that are likely to be engaged in the development of policies for regulating hydraulic fracturing, and the obstacles and institutional barriers that these actors are likely to encounter when attempting to fit their environmental, economic and political agendas into the development of policies designed to regulate hydraulic fracturing in California, and assess the extent to which existing policies and

regulation within their respective agency can be applied to water management issues related to hydraulic fracturing. Our budget calls for three interview trips to the Monterey and Santos Shale Region, as well as Sacramento, and registration costs for one conference, since research on fracking is expanding rapidly and we would like to be familiar with its cutting edge.

Notable Achievements

Our research will lead to a better understanding of the potential impacts that shale oil and gas development will have on California water users and the environment. Our research will provide a detailed assessment of the legal and institutional framework by which hydraulic fracturing is likely to be regulated in the state. This project will benefit policymakers as well as environmental and economic stakeholders, by establishing clear linkages between hydraulic fracturing and impacts to water resources in California, providing critical information for decision-making and policy development.

Our synthesis of the potential impacts of hydraulic fracturing to California's water resources will be presented in the California Institute for Water Resources' report series, as well as academic conferences, and the findings of the study will be submitted to relevant peer review journals for publication. Additionally, the findings of potential impacts to environmental and agricultural water users in California will be summarized into policy briefs, which will be distributed to appropriate entities and made available to interested stakeholders upon request.