Lithium Extraction Policy in the Salton Sea and Thacker Pass:

A Critical Analysis of Emerging Regulatory and Multi-Sectoral Complexities

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Cover photo: Geothermal plant near the Salton Sea. *Emilie Chen / Flickr*

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To see The Nature Conservancy's research that overviews the environmental and economic impacts of lithium extraction, please see the report, Potential Lithium Extraction in the United States: Environmental, Economic, and Policy Implications.

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Executive Summary

Demand for lithium in electric vehicle batteries will exponentially increase in the next decade to supplant dependence on fossil fuels. Securing reliable sources of lithium in vast quantities is a focal point for automakers and nations across the globe. With new and expanded lithium extraction, questions arise on the impacts of extraction and whether current US federal and state policies are sufficient to protect the environment while also achieving economic development and other social and public health benefits. The purpose of this study is to gauge policy recommendations from stakeholders using the Salton Sea in California and Thacker Pass in Nevada as case studies.

In this process, I analyzed current lithium extraction technologies, extraction impacts, regulatory frameworks, and conducted 14 semi-structured interviews with stakeholders associated with the Salton Sea and Thacker Pass. However, these stakeholders do not represent the totality of interests for each location. Although the extraction and regulatory models deviate significantly between sites, they provide ample opportunity to compare locations and policy frameworks. There is no single solution for lithium extraction, but these case studies reveal highlighted concerns and potential future directions.

In the Salton Sea, direct lithium extraction (DLE) appears to offer the lowest impact of available extraction technologies, but the cumulative effects of extraction are unknown and need further investigation. Stakeholders believed California's review process is sufficient as long the state follows its own laws and regulations. Community engagement has been inclusive and representative of the area, though significant work is required to increase transparency and include community voices. The economic impacts of the lithium industry in Imperial County are potentially massive, but there is still about concern who will benefit from lithium production.

Extraction in Thacker Pass, however, was much more contentious due to the impacts of mining. Humboldt County and Lithium Nevada, the mining company operating the site, have worked to minimize the mine's environmental impact. Nonetheless, multiple environmental organizations strongly oppose the mining site because of the potential effect on air and water quality. These organizations are also concerned about the extensive disruptions of open-strip mining on the landscape and ecosystem. The County and Lithium Nevada dispute these claims and maintain that the mine's current plans sufficiently mitigate for associated negative impacts. The environmental review and community engagement processes are just as fraught between organizations with issues arising over the Bureau of Land Management's environmental impact report and the extent of community interaction. The economic impacts of Thacker Pass would also significantly expand Humboldt County's economic base.

For the Salton Sea and Thacker Pass, as well as all potential lithium extraction sites, local and regional environments will always be affected in some way, but there are varying levels of impact with each location and extraction technology. Ultimately, new state and federal policies are needed to generate sought-after outcomes, including the alteration of regulatory schemes, the expansion of government capacity, the fostering of widespread community engagement, and the delivery of equitable benefits for local communities. The below list of recommendations raises larger societal questions and creates urgency for the federal and state government to act. Recommendations include the following:

1. **Decrease the demand for raw materials:** demand for lithium and other critical minerals is growing. Aspirations for land preservation and other public goods are seemingly at odds with lithium production. To reduce the demand for lithium, long-term strategies need to assess why lithium is needed in the first place. American transportation systems

rely on personally owned vehicles (POV), and that is not likely to change soon. However, replacing electric vehicles one-to-one with internal combustion engine vehicles is untenable. The cumulative demand for lithium can be decreased by reforming how US transportation systems operate and adapting the urban form of cities over the span of decades to reduce the dependence on POVs.

2. **Increase urban mining (recycling) of lithium batteries and promote a circular economy:** In efforts to further reduce demand, the US needs to invest and plan for recycled lithium batteries in the next decade. The US should fund battery recycling operations and incentive the reuse of lithium batteries to make recycling a viable industry. This will help preserve land from raw material demands.
3. **Prioritize direct lithium extraction (DLE):** Of all lithium extraction technologies, DLE has the lowest environmental impact. Although the technology and commercialization of DLE are still coming on line, the US should prioritize DLE as the primary technology to extract lithium. Other extraction methods like evaporitic technology for brines or hardrock mining, even when following federal and state guidelines, will disrupt the surrounding environments and are associated with significant impacts.
4. **Reform through federal legislation and rulemaking:** Federal legislation regarding mineral extraction is antiquated with the General Mining Law of 1872 and the Mineral Leasing Act of 1920, which still dictate mining policy. As a result, mining is viewed as the best use of land, overriding all other land uses. Reform should look to weigh other beneficial land uses, provide stronger government objectivity and transparency, improve environmental review processes, and incorporate longer-term reclamation strategies

5. **Enhance federal and state agency capacity:** More funds are needed to expand federal and state agency capacity to deal with high-profile projects like the Salton Sea and Thacker Pass. There is tension in performing environmental reviews thoroughly and efficiently as well as including more robust community engagement. To accommodate these issues, more resources are needed for the local, state, and federal agencies that perform such reviews. Specifically for the Salton Sea and Thacker Pass, more capacity is needed for entities like the Lithium Valley Commission, the California Energy Commission, and the Bureau of Land Management.
6. **Inclusive community economic development and government support:** Communities should have a guiding voice in the development of industry that directly impacts their homes and livelihoods. Further, state and federal funding is needed to expand and improve infrastructure that minimizes environmental impacts and ensures current residents benefit from infrastructure upgrades. Additionally, government assistance is needed to bolster workforce development programs and ensure local residents have opportunities to access quality jobs with livable wages.

I. Introduction

Escalating carbon emissions characterized by anthropogenic activities pose an existential threat to the welfare of the planet and its inhabitants. Continued emissions will perpetuate and exacerbate worsening financial, social, and environmental upheaval. The transportation sector represents the largest emitter in the US, accounting for 29% of general greenhouse house emissions in 2019 with the overwhelming majority coming from carbon dioxide (US EPA, 2017). Finding solutions to transition the transportation sector are essential to a green energy shift to reduce emissions. Technological advances in battery technology in the last two decades have started to shift auto travel and show promise in alleviating transportation emissions. Within battery research and development and electric vehicle (EV) production, the lithium-ion battery is increasingly seen as the cornerstone of the transportation industry's transition. Production of lithium batteries rely on the extraction of a multitude of raw materials and downstream manufacturing, though the primary component is lithium.

Lithium is a lightweight alkaline metal often used in ceramics and glasses, lubricating greases, and air treatment among other uses. Since 2015, the largest use of lithium has resided in battery storage (Tabelin et al., 2021). The long-term projections of lithium demand have increased in the past decade. An estimated 65,000 tons of lithium was needed in 2020 to meet demand, though projected demand is set to reach 415,000 tons by 2050 (Tabelin et al., 2021). To meet global demand, the lithium industry requires an investment of $10 to $12 billion over the next decade (Kaunda, 2020). In spite of demand, there are serious doubts on whether supply can meet future demand for alternative vehicles (Martin et al., 2017; Tabelin et al., 2021; Vikström et al., 2013). Consequently, the expansion of existing extraction sites and the development of new sites are required to meet to meet future growth. The majority of the world's lithium production

comes from a handful over operations including five mineral operations in Australia, two brine operations in both Argentina and Chile, and two brine and one mineral operation in China (USGS, 2021).

Lithium and lithium battery production are seen as national priorities in order to create new quality jobs and to secure the lithium battery supply chain, which China now dominates (The White House, 2021). The US currently has one active mining operation in Clayton Valley, but multiple lithium deposits across the US offer an opportunity secure its supply chain. Two of the most prominent sites include the Salton Sea in California and Thacker Pass in Nevada. It is estimated that the Salton Sea could produce up to 40% of current global supply of lithium, an estimated $7.2 billion a year industry in the state (Chao, 2020). However, there are concerns over impact of lithium extraction on the environment and the economic and land use implications of extraction. This is especially concerning given the environmental disaster that has characterized the Salton Sea since the 1970s (Newburger, 2021). Likewise, there is concern over the environmental impact in Thacker Pass (Bosler, 2021). Further, the Nevada mining site is sacred to local Native American tribes as it was the site of a potential massacre of dozens of Native Americans by US forces in 1865, though this has also been the subject of dispute (Sonner, 2021).

The main objective of this study is to research and answer the following question: what state and federal policies could be enacted that would best promote lithium extraction in the Salton Sea and Thacker Pass that allow for environmental protection, while also supporting economic development and other social and public health benefits? To answer this question, I develop policy recommendations through semi-structured multi-stakeholder interviews.

In this paper, I first delineate the legacies and histories of the Salton Sea and Thacker Pass to provide context to both areas. Then I detail my methodology, which is comprised of

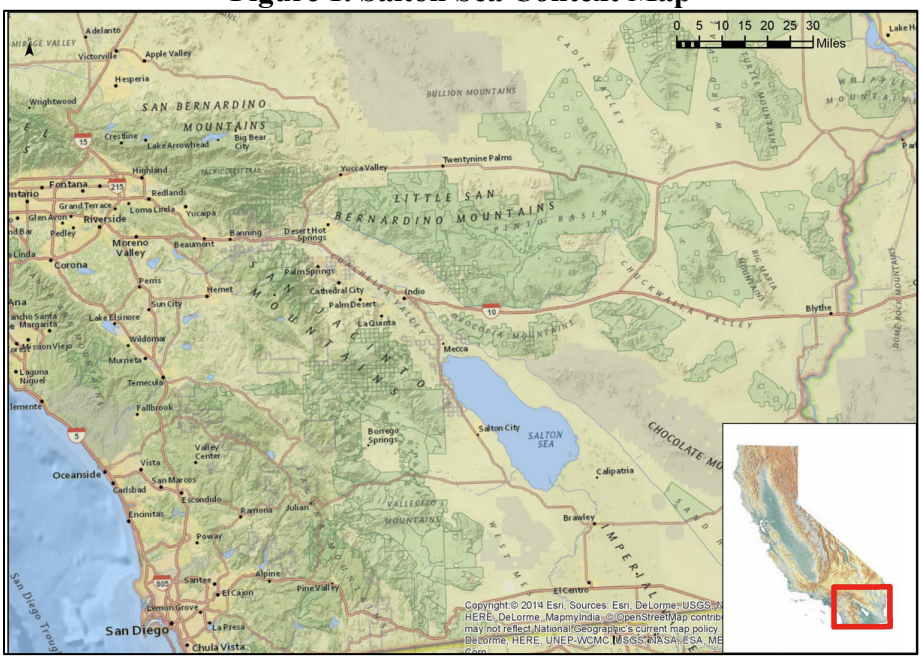
secondary research to outline different extraction methods and corresponding regulatory frameworks, as well as qualitative primary research to receive input from community, environmental, and industry stakeholders on policy recommendations. Next, I describe the known impacts of lithium extraction by examining water degradation, waste disposal, effects on flora and fauna, and effects on nearby human populations. Then I outline the regulatory frameworks and guiding policies of mineral extraction. I then detail those results by case study. Finally, I follow the results with the implications of diverging and converging interests in lithium development in the Salton Sea and Thacker Pass with a set of policy recommendations.

II. Salton Sea and Thacker Pass Context

A. The Salton Sea

The Salton Sea is landlocked lake with no current substantial inflow of water located in Imperial and Riverside Counties in southern California. The body of water has cyclically formed and dried over for over 1300 years, from natural flooding through the Colorado River. The current lake was formed in 1905 by accident when Colorado floodwater breached an irrigation canal under construction in the Imperial Valley (California Department of Fish and Wildlife [CDFW], 2022). For two years, the entire flow of the Colorado River filled the Salton Basin, resulting in a lake 45 miles in length, 7 miles wide, and 83 feet deep. It was recorded in 1891 as 30 miles long, 10 miles wide, and 6 feet deep (Delfino, 2006). Water levels were since maintained by irrigation runoff from the Imperial and Coachella Valleys and local rivers. Figure 1 below shows where the Salton Sea is situated in southern California.

Figure 1. Salton Sea Context Map



Source: California Natural Resources Agency, Salton Sea Management Program

However, agriculture runoff saw the sea experience rising levels of salinity and contamination in the 1970s. The shorelines of the lake have been receding and this accelerated after an agreement from the Imperial Irrigation District (IID) under the Quantification Settlement Agreement in 2006 that saw the IID transfer water to the San Diego County Water Authority and the Coachella Valley Water District. The agreement, however, saw, the state of California provide a pathway to restore the Salton Sea. Yet, this corner of the state has some of the worst air pollution in the country affecting local ecosystems and human populations, with a mix of dirt from farmland and windblown toxic dust from the Salton Sea's receding shores (James, 2017).

The Salton Sea is a critical resource for many species, though the fragile ecosystem puts many species at risk. Unfortunately, massive bird and fish die off are commonly observed (González et al., 1998; Jehl, 1996). For bird species this a growing concern due to the result of the significant loss of wetlands in California. The Salton Sea serves as a vital series of wetlands for birds in North America and supports high levels of avian biodiversity in the southwestern

United States (CDFW, 2022). Over 400 resident, migratory, and special status birds have been recorded in the lake and 270 of those species regularly use the area. Fish populations have crashed multiple times, first in the late 1980s and again in the early 2000s, which has in turn impacted bird species. It is speculated crashes are a result of salinity, cold winter temperatures, and high sulfide levels and anoxia associated with mixing events (Hurlbert et al., 2007).The deteriorating state of the Sea is anticipated to result in the further loss of fish species, increased exposures to soils from wind erosion, and bird declines due to food shortages (CDFW, 2022). The dire state affecting local ecosystems is also emblematic of the impacts on human health.

Residents of the Imperial Valley bear the steep consequences of the negative impacts of the Salton Sea. Just a handful of the notable statistics concerning air quality include peak daily concentrations of PM10 about 10 times the state and federal limits, one in five are diagnosed with asthma, and physician-diagnosed childhood asthma is about four times higher than those just across the border in Mexico (Johnston et al., 2019). It is even routine for some schools to fly brightly colored flags designating air quality for the day (James, 2017). The health consequences from the region's poor air quality can have debilitating effects for children, even impacting the financial stability of families (James, 2017).

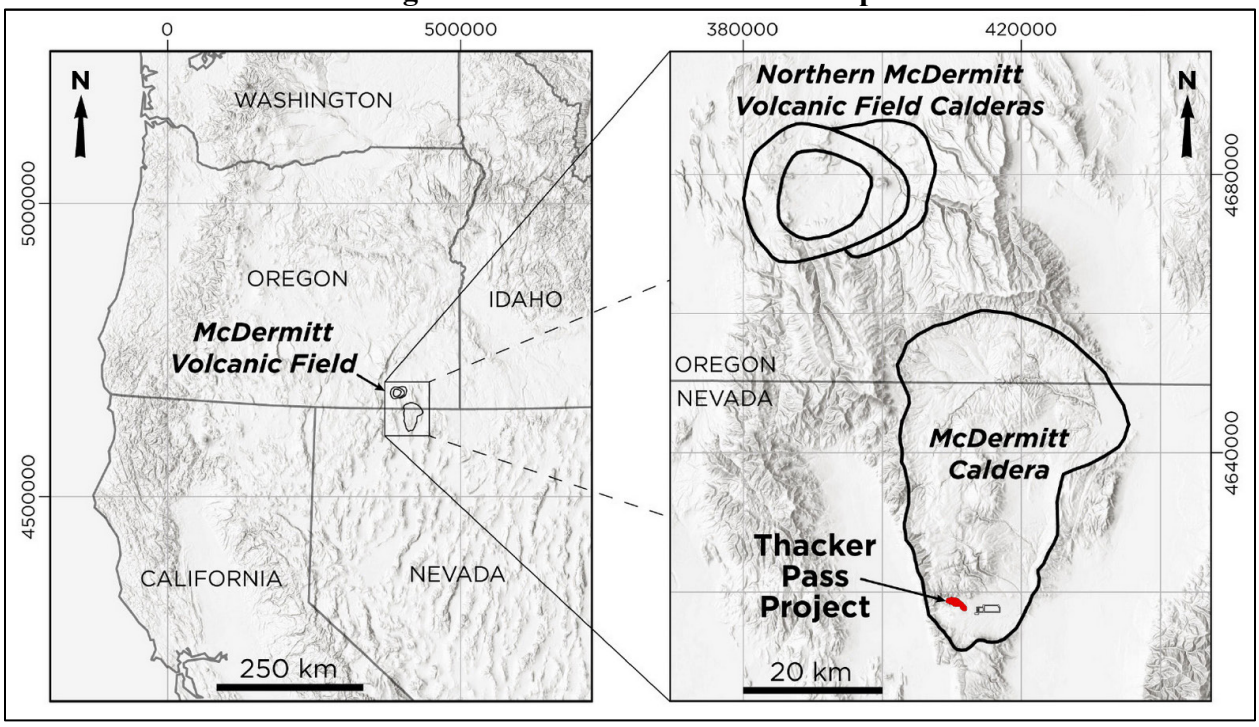
Imperial County is the least populous county in California with a 2020 population of 179, 702 (US Census Bureau, 2022b). As a whole, the region is known for is lackluster economic performance and high rates of poverty. The poverty rate for Imperial was 22% in 2019 compared to the state average of about 12% (US Census Bureau, 2022a). Imperial County's largest employers are government, agriculture, and retail trade, representing over 70% of employment. Further, the County is known as one of the nation's worst job markets (Zarroli, 2020). Before the COVID-19 pandemic, the unemployment rate in 2019 for the county stood at 21%, which is five

times the California unemployment rate of 4% (Bureau of Labor Statistics [BLS], 2022). The 2019 annual income for Imperial County was $41,655 compared to the state average of $71,351 (BLS, 2022a).

B. Thacker Pass

The Thacker Pass mine is located in Humboldt County, in the northwestern edge of Nevada. The mine site is also part of the McDermitt Caldera. The caldera is potentially one of the oldest of a sequence of calderas formed by the Yellowstone hotspot (Henry et al., 2017). It contains known deposits and concentrations of mercury, uranium, lithium, gallium, gold, and zirconium. Figure 2 below show the site of the Thacker Pass Project and the surround geography.

Figure 2. Thacker Pass Context Map



Source: Lithium Americas, Thacker Pass Project

Thacker Pass is also part of the much larger Basin and Range Province, a vast region in the western US and Mexico known for its impressive features and landscapes. The Northern Basin and Range, the northern portion of the larger province that resides in Oregon, Idaho and

Nevada, is known for its extensive sagebrush habitat, its dry climate, and its extreme range of seasonal temperatures. The region supports a diverse ecosystem with a range of endemic species. Protecting the sagebrush habitat has been crucial for protecting the greater-sage grouse, a bird species that has been in decline due to habitat loss (Oregon Conservation Society, 2006). The sage grouse has been a candidate for protection under the Endangered Species Act (ESA) but has faced opposition in Congress. Yet, current age-grouse advocates are optimistic about future protection under the ESA (McGlashen, 2021). Other species that rely on the habitat include the pygmy rabbit, the pronghorn, and the Lahontan cutthroat trout (Defenders of Wildlife, 2022)

Humboldt County itself is a large rural county with a recorded population of 17,285 in 2020 with the only major city of Winnemucca having a population of 8,436 (US Census Bureau, 2020). The economy of the county is divided between its main industries—mining, agriculture and agricultural services, and tourism and construction. The County is located in the gold mining center of the US and is the leading agricultural county in the state with over 100,000 acres under cultivation (Humboldt County, 2005). The 2019 unemployment rate in the county stood at 3% with the state averaging 4% (BLS, 2022). The average annual wage in 2019 for the County was $58,820 and $55,422 for the state (BLS, 2022b). Poverty in Humboldt County rested at 11% with the state average at about 13% (US Census Bureau, 2022a). As a whole, the County's employment and income numbers fair better than the state.

The area is home to multiple related indigenous tribes including the Shoshone-Paiute Tribes of the Duck Valley Reservation, the Fort McDermitt Paiute Shoshone Tribe, Lovelock Paiute Tribe, Fallon Paiute Shoshone Tribe, Pyramid Lake Paiute Tribe and the Reno-Sparks Indian Colony (Solis, 2021). The history of the area has had a few notable events. The first of which is a disputed massacre in 1865 of Paiute and Shoshone peoples by US cavalry forces.

Some members of tribes in the area claim the site of the massacre is within the proposed mine site, while the Bureau of Land Management maintains the referenced massacre in the area was more than 15 miles away (Malmgren, 2021). The area remains sacred to local tribes beyond the disputed site of the massacre, as it is the region where tribes harvest traditional foods, medicines, and supplies for sacred ceremonies (Flin, 2021).

III. Research Design

Semi-structured interviews with lithium extraction stakeholders were targeted in two geographic areas: the Salton Sea in California and Thacker Pass in Nevada. These locations were selected because of their large lithium deposits, the type of extraction technology used, and concerns surrounding environmental impacts. Commercial production of lithium in these areas is expected in the mid-2020s, making timely environmental analyses imperative to the creation of new policies to guide extraction. Even though the Salton Sea and Thacker Pass will use different extraction technologies and will follow different regulatory models, both areas highlight contrasting engagement strategies and offer insights on two emerging lithium production methods that may revolutionize the lithium industry.

The semi-structured approach allows for an in-depth exploration of the hazards and opportunities presented by lithium production in different physical and political environments. Ultimately, the purpose of the interviews is to answer the question: what state and federal policies could be enacted that would best promote lithium extraction in the Salton Sea and Thacker Pass that allow for environmental protection, while also supporting economic development and other social and public health benefits? However, before I developed an interview guide, I conducted secondary research on lithium extraction technologies and their

impacts, and then investigated the regulatory policies of the federal, California, and Nevada governments associated with lithium extraction.

To begin my secondary research on lithium technologies and their impacts, I reviewed peer-reviewed articles found through Google Scholar and journals such as the *Journal of Energy & Natural Resources Law, Sustainability*, *Science of The Total Environment*, and *Mineral Engineering*. I used a combination of key terms such as "lithium, mining, extraction, production, impacts, environment, hazards, and benefits" to search for articles. I scanned abstracts to identify if articles were associated with lithium technologies and their impacts. I read topic appropriate papers and then expanded my research into different lithium production methods of hardrock mining, direct lithium extraction, and evaporitic technology. Based on reported impacts of extraction, I then assessed the extraction regulatory policies of the federal government, California, and Nevada.

Since mineral extraction policy is an interconnected web of mining, energy, water, air, waste material, and environmental law, I used the General Mining Law of 1872 and mineral policies from the Environmental Protection Agency (EPA) and the Bureau of Land Management (BLM) as a foundation for the background of my regulatory research. The Mining Law of 1872, the EPA, and the BLM were selected because they are the cornerstone of mineral extraction policy in the US and the agencies that govern and dictate federal policy. This initial search then expanded into specific legislation governing the interconnection of mineral and energy policy with either water, air, waste removal, and environmental law. The whole process was then replicated on the state level for California and Nevada. Additionally, I scanned national and regional news publications to examine any new policies from the federal or state governments given the national spotlight on both the Salton Sea and Thacker Pass. Overall, this secondary

research of examining lithium technology and regulatory policy led to a more thorough understanding of mineral and lithium production and aided the formulation of specific research aims:

1. **Assess environmental impacts** on local and regional environments including but not limited to the impact on water quality and use, air quality, disposal of toxic substances, human population health, and the health of endangered flora and fauna.
2. **Evaluate current regulatory policies and identify new policies** on state and federal levels to safeguard against negative environmental impacts.
3. **Assess the relationships between stakeholders and policy decisions**, including the balance of economic development, community benefits, and sustainable production practices.

Seven questions were generated to represent these research aims, with dozens of prodding questions crafted to dig deeper into specific stakeholders' disciplines and areas of expertise (Appendix A). These questions were evaluated by The Nature Conservancy, UCLA faculty, and UCLA peers from the Master of Urban and Regional Planning Program before they were finalized.

Stakeholders for interviews were initially chosen through their connection to either lithium extraction, the surrounding communities of Thacker Pass or the Salton Sea, or their advocacy and expertise in issues that connect to lithium processing or its supply chain. Stakeholder groups consisted of the mining and energy industries, environmental and environmental justice organizations, community organizations, tribes, government officials, and academic researchers. Interviews were conducted over Zoom or on the phone and lasted anywhere from 30 to 60 minutes. Interviews began in January and ended in May. After

interviews commenced, a “snowball” method was employed to gain introductions to additional stakeholders. An effort was made to balance the variety of organizations and interests to include as many perspectives as possible. Out of 65 invited stakeholders representing 30 organizations, 14 stakeholders responded to interview requests. There were six stakeholders for the Salton Sea and eight for Thacker Pass. Stakeholders from the Salton Sea consisted of two community and environmental justice organizations, two environmental organizations, one industry consultant, and one academic researcher who also provides consultation to DLE industry research. Thacker Pass stakeholders consisted of four environmental organizations, one advocacy group, two government officials, and one industry consultant. After each interview, the conversation was transcribed and coded to highlight common themes surrounding the research question and aims. Regulatory frameworks for California, Nevada, and the federal government were used to ground observations. Each geographic area was analyzed on its own given the disparate nature of the two sites.

This methodology allowed for direct input from those most affected by state and federal government policies. The open nature of semi-structured interviews allowed participants to discuss freely, and in detail, what was most important to them. However, there are notable weaknesses of this design. First, the number of participants was limited given the time parameters of this study. The effort to balance perspectives meant more time attempting to contact unresponsive stakeholders, and this contributed to a lower participation rate. Further, the two case study areas differ significantly having their own niches, meaning more time was needed to understand the nuances of extraction technology, regulatory policy, ecosystems associated with each site, and the different community identifies and histories of the Salton Sea and Thacker

Pass. Further, extraction at each site is not in operation yet. This resulted in uncertainty about associated impacts, making the policy recommendations more speculative.

IV. Lithium Extraction Methods

The impacts of lithium mining are a function of intertwining mining methods and technology, government policy and regulations, the presence of human populations, and local and regional environments. However, research that details the impacts on areas surrounding lithium extraction is limited. The available research nonetheless offers a glimpse into effects of lithium production. It also integral to note that the publications from the dominant lithium-producing countries account for just 2% of the total publications on the subject. Much of the established literature focuses largely on impacts associated with battery technologies, not the impact of mining activities themselves. Studies on local communities and indigenous groups associated with lithium extraction are rarely studied (Agusdinata et al., 2018). Given the novelty of approaches of extraction methods in the Salton Sea and Thacker Pass, their respective impacts are somewhat speculative. The following sections provide a broader context to situate the mining projects in the Salton Sea and Thacker Pass by outlining total global lithium availability, extraction methods, associated impacts, and a summary.

A. Total Mineral Resources and Reserves

The amount of available lithium is divided into two categories: mineral resources and mineral reserves. Mineral resources are generally defined as the geologically assured quantity available for exploitation. This number is typically a more academic number with no relevance on real supply. Mineral reserves are the quantity of minerals that are currently exploitable due to technical and socioeconomic conditions, which is the more important figure for production (Vikström et al., 2013). In 2021, global Lithium resources totaled 89 million tons with 9.1

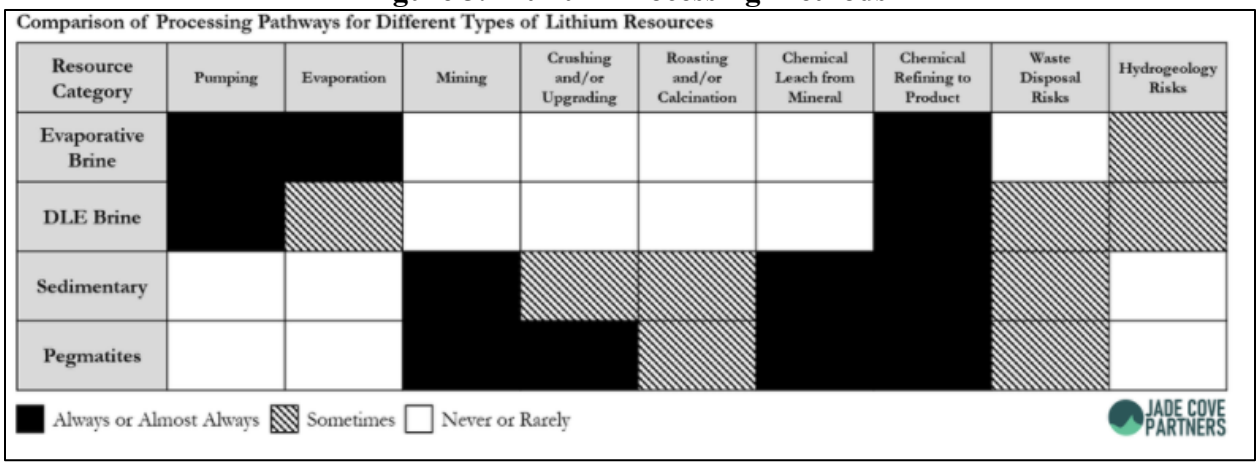
million tons in the US. Countries with large resources include Bolivia, 21 million tons; Argentina, 19 million tons; Chile, 9.8 million tons; Australia, 7.3 million tons; and China, 5.1 million tons. Lithium reserves worldwide total 22 million tons with the largest reserves in Chile, Australia, Argentina, and China (US Geological Survey, 2022). Estimated deposits in the Salton Sea could total 15 million tons that can produce 127,000 tons of lithium carbonate while Thacker Pass could total 13.7 million tons of lithium carbonate of lithium resources and produce 60,000 tons per year (Lithium Americas, 2022; Warren, 2021).

B. Extraction Processes

Extraction traditionally comes in two forms: through hard rock mineral excavation or evaporative brine. Alternatively, two other methods have gained notoriety that are the subject of this research. Three separate plants in the Salton Sea are using direct lithium extraction (DLE) from geothermal plants in brines while the ongoing mining project in Thacker Pass features lithium in composite clay. These sources offer the opportunity to significantly expand lithium reserves. Still, the vast majority of the current lithium production comes from either hard rock or brine sources that turn the extracted lithium into either lithium carbonate or lithium hydroxide. These compounds are then shipped to cathode producers before manufacturing into a lithium-ion battery (LIB) cell. However, downstream automakers prefer lithium hydroxide because lithium hydroxide cathodes can support a longer driving range without utilizing cobalt in the battery chemistry, which is both expensive and fraught with extraction issues. As its easier to process lithium into lithium hydroxide from mineral deposits, hard rock mined lithium is favored over brine (Graham et al., 2021). To understand the production process for each method, I provide brief descriptions of hard rock and clay excavation, evaporitic technology from brines, and DLE. Clay is combined with hard rock given their roughly similar methods and more detailed analysis

of lithium clay operations are almost non-existent. Figure 3 below provides a shortened review of different impacts associated with lithium extraction.

Figure 3. Lithium Processing Methods



Source: Jade Cove Partners, "The Sedimentary Lithium Opportunity"

1. Hard Rock and Clay Extraction

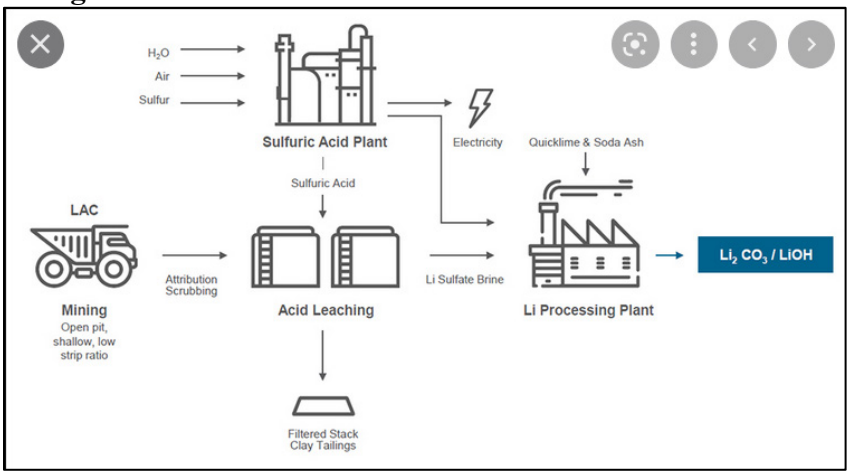
Hard rock mining is a more traditional form of mining compared to brine extraction. These mineral lithium deposits spread throughout the globe; however, the mining process is complex. The largest producers of pegmatite mining rests in Australia, Canada, China, Portugal, and Zimbabwe. Each mining site for lithium is unique and the actual mining must be designed to fit the physical site characteristics and chemical conditions of each mine (Kaunda, 2020). Hard rock extraction comes mainly from pegmatite formations such as spodumene, lepidolite, petalite, and zinnwaldite with spodumene being the most ubiquitous (Vikström et al., 2013). Processes for each pegmatite formation will differ slightly, so the focus of this section will rest on spodumene formations.

Typically, mine extraction is a seven step process including calcining, roasting, leaching, purification, precipitation, carbonation, and by-product production (Gu & Gao, 2021). Calcining is important to note as this steps requires heating over 1,000 C to convert the spodumene concentrate into a beta spodumene that is more amenable to extract the lithium (Karrech et al.,

2020; Tadesse et al., 2019). This is significant because this requires extensive use of natural gas or coal, meaning the carbon footprint is much higher than other lithium resources and much more capital intensive(Gu & Gao, 2021). There is also concern over the leaching process that requires the use of sulfuric acid. Pollutants in this process need to be properly recycled or discharged. Otherwise, toxic substances left in mining tailings risks polluting the mining site or the disposal site (García & Ballesta, 2017; Plumlee & Morman, 2011). After these seven steps, the existing concentrate is processed into either lithium carbonate or lithium hydroxide at another site (Sterba et al., 2019). Apart from this typical process, some innovative methods may have a less intense use of equipment, energy, chemicals, and smaller environmental footprint, but have yet to be applied at the industrial scale. These include fluorination, caustic pressure digestion, mechanochemical treatment, and bioleaching (Karrech et al., 2020).

Extraction from sedimentary clay deposits largely follow that of pegmatite mines. The methodology of extraction is dependent on the geological makeup of the site. Yet, a number of leading projects are proposing not using calcination. Rather, a chemical leach is used to extract the lithium from the sediment, after which the waste sediment can be stacked or back-filled into an open pit (Grant, 2019). Currently, there is a heavy concentration of potential deposit sites in both Nevada and California. Figure 4 provides a list of steps involved of hardrock lithium mining at Thacker Pass.

Figure 4. Hardrock Lithium Extraction at Thacker Pass



Source: Lithium Americas, Thacker Pass Project

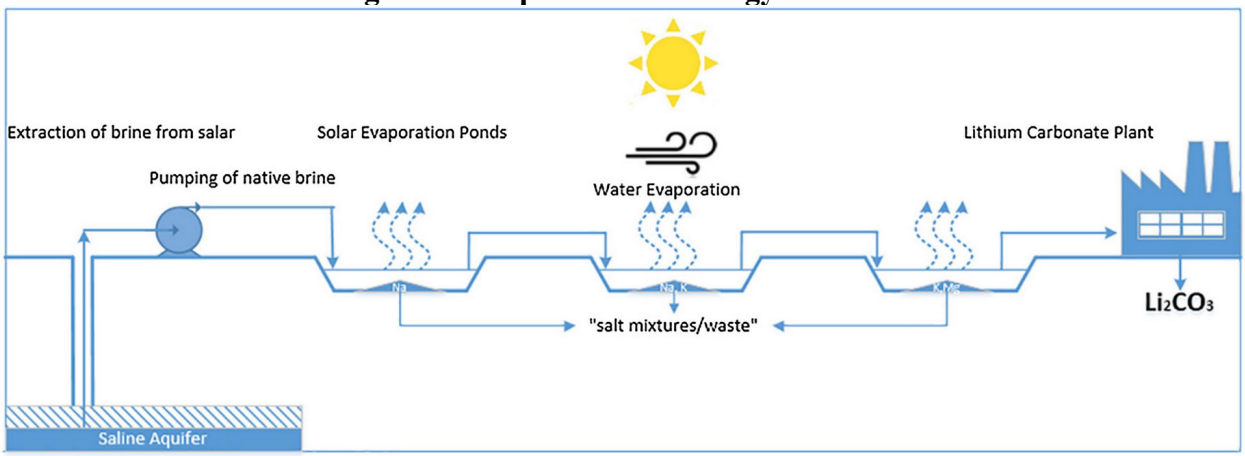
2. Brine: Evaporitic Technology

Brine operations are much less intensive than hard rock operations and remains the dominant source of lithium supply today. Most lithium from brine come from either Argentina, Bolivia, Chile, China, or the US (US Geological Survey, 2022). The "Lithium Triangle," which consists of Argentina, Chile, and Bolivia, account for over 50% of lithium reserves (Kaunda, 2020). Brine is pumped in this form from saline lakes (salars) into a series of open-air, evaporation ponds. The brine is either extracted directly from the surface of salars or deep under large saline expanses. The evaporation ponds increase the concentration of the brine though natural evaporation powered by the sun and wind until the concentration is approximately 6000ppm lithium in the form of lithium chloride. This evaporitic process is very cost effective as brines tend to occur at higher elevations. The lithium chloride is then pumped into a recovery or treatment plant where other chemicals are removed and then treated with sodium carbonate, precipitating lithium carbonate. This mixture is often redissolved and reprecipitated to reach the desired purity needed in the battery grade.

The process is however extremely time intensive and can take one to two years (Flexer et al., 2018; Kaunda, 2020). Much like hark rock mining for lithium, each brine is dramatically

different from the next. Salars will vary in their chemical compositions and each mining and processing design must be uniquely tailored to fit a specific salar. Piloting can take months if not years before large scale exploitation can start. Further, successful production from one salar does not guarantee the success of others based on the geological and chemical variability of each brine (Flexer et al., 2018; Kesler et al., 2012). There are concerns about this process, however. Brine evaporitic technology can consequently have negative impacts on water, flora and fauna, waste generation and disposal, and land subsidence (Kaunda, 2020). The lithium mixtures during the evaporitic process are a highly mobile element and there is a high chance that it will be released in the environment and potentially nearby communities (Agusdinata et al., 2018; Figueroa et al., 2013). In Figure 5 below, the image shows a conceptual overview of brine evaporitic process.

Figure 5. Evaporitic Technology in Brines



Source: Systematic review of lithium extraction from salt-lake brines via precipitation approaches (Zhang et al., 2019)

Brine: Direct Lithium Extraction

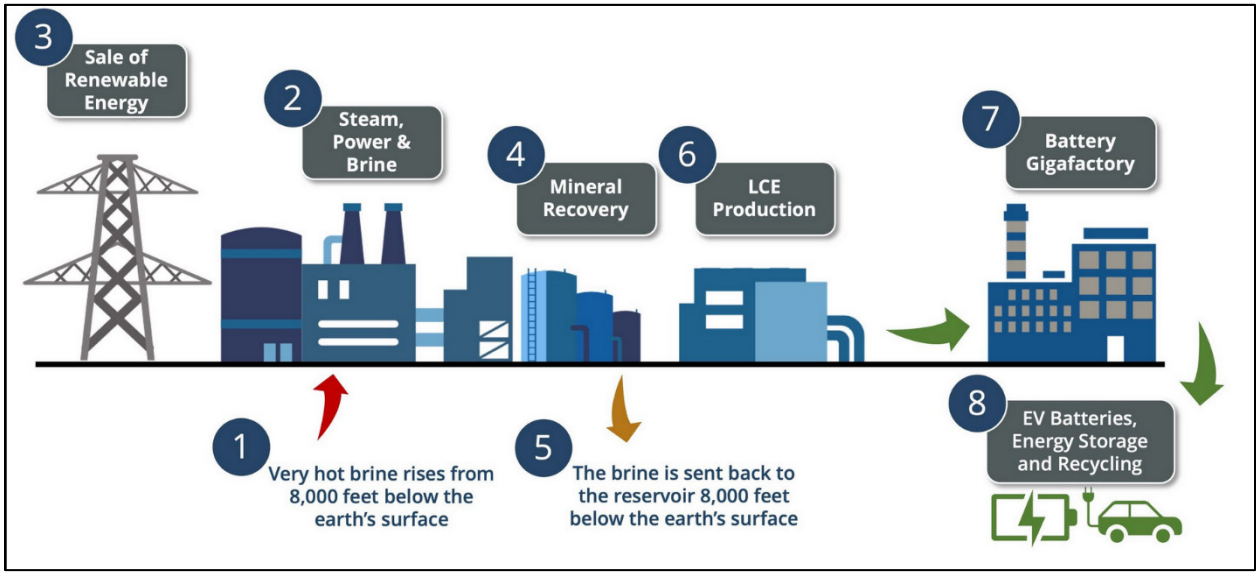
Direct lithium extraction (DLE) is the "newest" lithium technology, though no DLE commercial extraction currently exists. There are a limited number of commercial plants using DLE, but they also depend on evaporitic technology (Grant, 2020). Some of the technology in DLE has been around for the last 40 years, but there has been little incentive to invest in this extraction process given limited demand. There are current demonstrations of DLE across the

globe including in China (Qinghai Salt Lake, Qarhan Salt Lakes), France (Alsace), Germany (Upper Rhine Valley), Argentina, Arkansas (Smackover), Canada (Alberta), North Dakota, and in California's Salton Sea (Graham et al., 2021).

In practice, DLE is dependent on geothermal plants. DLE can either be added to existing plants of built into the plans of future plants. Traditionally, geothermal power plants will pump brine from revisors of water hot water miles beneath the Earth's surface. Heat from the brine is used to drive a turbine to produce electricity before the brine is reinjected into a large reservoir. DLE adds an extra few steps. Depending on location, the brine-water used for geothermal plants will have large traces of lithium. Thus, after brine-water is used to produce electricity in geothermal plants, the water goes through a filtration process where lithium is extracted. This process differs based on DLE technology, but can be categorized into three categories: absorption, ion exchange, and solvent extraction (Warren, 2021).

Initially, the high concentration of mineral in most geothermal brines has been considered a nuisance and created engineering challenges to deal with severe corrosion and scaling problems. However, DLE technology looks to overcome these issues. Even though commercial DLE projects do not exist, this technology has multiple advantages over other forms of extraction. It raises the lithium recovery rate to over 90% compared to a traditional brine which rests can range from 70% to lower than 50% (Flexer et al., 2018; Warren, 2021). It additionally reduces water consumption, reduces the amount of time to extract to mere hours or days, reduces the carbon intensity of development, and will eventually reduce the cost of mining (Graham et al., 2021). Below in Figure 6, the diagram provides a broad illustrative example of the DLE.

Figure 6. DLE Diagram from Controlled Thermos Resources



Source: Controlled Thermos Resources, Project

C. Extraction Impacts

1. Water Utilization and Degradation

One of the largest issues interrelated to almost every other concern is water degradation. Brine operations rely both on brine water and freshwater. Brine water is located within the limits of salars while freshwater is found on the borders of salar basins in free aquifers in alluvial fans and fluvial systems deposits (Kaunda, 2020). Yet, the amount of water requires an estimated 500,000 gallons of water per ton of lithium extracted (Fermin Koop, 2020). For example in Salar de Atacama, the amount of ground water pumped out the area from 2000 to 2015 increased by 21% resulting in groundwater levels in the region depleting as much as one meter in some places (Kaunda, 2020; Lombrana, 2019).

Even though such a massive amount of water is used, this water is not often suitable for human consumption and was unutilized before extraction began (Flexer et al., 2018). Total salt concentration is on average nine times higher in brine than sea water, making it unsuitable for both drinking water and irrigation. Still, the depletion of water may change the hydrodynamic

relation with surroundings and there are unresolved questions about the extent of this impact (Flexer et al., 2018; Marazuela et al., 2019). Liu et al. (2019) pointed out the water-intensive extraction has adverse cascading ramifications on aquifer depletion (Babidge & Bolados, 2018), hydric balance and ecosystems (Babidge & Bolados, 2018; Flexer et al., 2018), which has further raised concerns from local populations and environmentalists. Due to the evaporitic process for brines, trace amounts of lithium and other chemicals can be found in storage ponds, tailing piles, processed waters, evaporite basins, and transported products that might adversely impact human metabolism, neuronal communication, soil ecology, and aquatic life (Kaunda, 2020).

2. Waste Generation

One major shortcoming in the research on lithium extraction impacts is the lingering question of what to do with spent brine after lithium recovery. Few studies have researched this question and implications are therefore poorly understood. Of the 500,000 gallons of water used to extract one ton of lithium, 95% of the extracted brine water is not recycled. In regard to recycling water, there is also little research on its impact. The effects of water reinjection are completely unknown. Water reinjected may have other chemicals exogeneous to the native brine such as aluminum, titanium, manganese, iron derivatives, phosphates, silver, pyrrole, organic compounds, and ironic liquids among others which could seriously affect local ecosystems (Flexer et al., 2018).

3. Flora and Fauna

The effects on lithium mining on flora and fauna are not well known. Even in arid and high altitude locations that make up the Lithium Triangle, ecosystems are sensitive to change. The area is considered a biodiversity hotspot with unusual ecology and evolutionary rarities which are being put at risk (Izquierdo et al., 2015; Myers et al., 2000). As mentioned above, the impacts

of water usage could affect local flora and fauna in the region as water is the main limiting ecological factor in such a dry region. Water usage may even impact microbial activity in the vicinity and in salars themselves (Flexer et al., 2018).

One of the most distressing events center around lithium mining in the Tibet region that occurred over multiple years beginning in 2009. Villagers alleged that the mine spawned toxic chemical pollution resulting in the death of fish and yaks who drank from a nearby river. The mine denied any involvement related to the environmental damages and the government responded to protests with security crackdowns. The mine was shut down in 2014 to resolve land acquisition issues and local authorities pledged the mine would not restart until environmental issues were resolved. Still, villagers claimed the mine was in operation in 2014, resulting in further fish kills, though the company denied the mine had restarted. In 2019, the Youngy Company announced the mine would reopen with a new lithium ore processing plant, and also announced stronger environmental controls (Graham et al., 2021).

4. Human impact

The impact on local human communities range depending on the country where extraction is taking place. However, a common theme emerges where local populations are overlooked and receive little benefit from the mining operation itself. One major downside for local communities is that they face and experience the externalities of lithium on livelihood without experiencing much of the benefit (Graham et al., 2021). Communities in the vicinity of Salar de Atacama expressed concern over increased water shortages and the threatening of local ecosystems. On a broader scale, there are objections on regional and national levels over the misconduct of mining operations and foreign investments in lithium business (Liu & Agusdinata, 2020). The Lithium Triangle is seen only in the light of a raw material source, not in knowledge

development and in the other stages of LIB production downstream. It thereby loses out on notable economic activities that occur downstream. Still, Agusdinata et al. (2018) note that that the environmental and occupational health and safety risks stemming from brine extraction are comparatively higher than other sources with the health effects not clearly understood.

D. In Summary

Little is understood in the way of environmental impacts on lithium production beyond a handful of studies. What studies do exist focus extensively on brine technology and potential impacts in the Lithium Triangle. More research is needed on each extraction method, though generalizations will be difficult given the variability among extraction sites, even when comparing the same extraction method. Also, given the propriety nature of lithium technology, readily available data will be difficult to obtain.

V. Regulatory Frameworks and Policy Pertinent to Lithium Extraction

The defining regulations and laws that govern mineral extraction and thus mineral policy span several areas. Mineral extraction in its various forms are multifaceted operations that effect the land, water, air, wildlife, and the surrounding human populations. As such, regulations that govern extraction operate on multiple levels using different sets of rules. These rules are important for policy because they dictate the interactions and livelihoods of industries, communities, and ecosystems. The primary governing authority in the US comes from the federal government. Regulations are governed by broad-based environmental laws, a patchwork of mining, endangered species, water, waste, and air laws, which is in turned affected by acting White House administration policy. States can then impose further requirements, which is further again affected by executive policy from the state. With California's long environmental history and Nevada's mining history, lithium extraction operates through multiple systems of laws. The

below sections are divided into federal, California, and Nevada regulatory frameworks in order to give a brief overview of the rules and policies currently dictating lithium extraction.

A. Federal Framework

The federal framework for extraction relies on a multitude of laws that can be broken into the following subsystems: mining law, environmental protection, endangered species, clean water, clean air, and waste disposal. Given Thacker Pass resides on federal land, these rules will affect operations more for the Thacker Pass project than Salton Sea which is not on federal land. Still, both states are influenced by national frameworks, even though both sites are proposing different methods of extract lithium.

1. Mining Law

Mining in the US finds its regulatory and policy roots in the Mining Act of 1872. The primary objective of the mining law was to enable the free and open exploration and purchase of mining resources. The law was passed to encourage economic growth during the pick-and-shovel era of mining. Consequently, the law is set up in to protect claims and titles on the land for mineral exploration and lacks the nuances of the highly modernized and mechanical era of mining today (Woody et al., 2010). However, the rules regarding mining have changed little since and the initial framework is considered obsolete to deal with the multidimensional problems of mining, specifically environmental conservation. The political environment surrounding mining law makes making changes challenging if not impossible. In the past 15 years, legislation has been introduced to amend and update the law, but all efforts have failed. There have been notable mineral and mining policy developments since the passage of the 1872 law. Perhaps most importantly was the Mineral Leasing Act of 1920 that authorized the federal government to issue permits for mineral exploration on public lands and lease the rights to those

materials. Each law and amendment have served a vital role in the updating of mining and mineral policy. The breath of each is not described in detail here, though the below list is laid below in Table 1.

Table 1: Chronology of Federal Mining Law

Law	Objective
Mining Law of 1872	Serves as the governing legislation for mineral all mining policy. Declared all valuable mineral deposits in the US to be free and open to exploration and purchase
Mineral Leasing Act of 1920	Provides the leasing of minerals from public lands and requires a royalty to be paid by the amounts mined and sold
Materials Act of 1947	Provides the disposal of mining materials on public lands, both saleable and leasable
Mining and Mineral Policy of 1970	States that the continued federal policy is to foster and encourage private enterprise in the development of domestic mineral resources. This includes all minerals including geothermal.
Hard Rock Mining of Minerals (40 CFR Part 440), Created in 1975, amended in 1978, 1979, 1982, and 1988	The regulation covers wastewater discharges from ore mines and processing operations. Incorporated into the National Pollutant Discharge Elimination System (NPDES) permits.
Federal Land Policy & Management Act of 1976 (FLPMA)	Concerns the recording and maintenance of mining claims. Those with existing claims were required to record their claims with the Bureau of Land Management (BLM) and all new claims were required to be recorded with the BLM
Mineral Mining and Processing Effluent Guidelines (40 CFR Part 436), Created in 1975 and amended in 1976, 1977, 1978, and 1979	This covers mine drainage, mineral processing operations, and stormwater runoff. It was incorporated into the National Pollutant Discharge Elimination System (NPDES) permits
The Federal Mine Safety and Health Act of 1977 (30 USC § 801-966)	Regulations detail safety and health standards for preventing hazardous and unhealthy conditions, including measures addressing fire prevention, air quality, explosives, aerial tramways, electricity use, personal protection

Sources: United States Code, Bureau of Land Management—About Mining and Minerals, EPA—Ore Mining and Dressing Effluent Guidelines, EPA—Mineral Mining and Processing Effluent Guidelines, Mining in the United States: overview—Kevin Shaw and Daniel Whitmore

2. NEPA

The National Environmental Protection Act (NEPA), signed into law in 1970 requires federal agencies to assess the environmental effects of any major federal action that significantly affects the environment. The law serves as the broadest federal protector of the environment. There are three different levels of analysis from the NEPA: categorical exclusion determination, environmental assessment finding of no significant impact, and the environmental impact statement (EIS). The EIS is a more detailed and rigorous review used when proposed federal action will significantly affect the quality of the human environment on federal land or entails a federal agency. An EIS is likely used in any case of any mining operation when a federal trigger is initiated. The EIS will assess proposed federal action, a range of alternatives of action that can accomplish the proposed action, describe how the environment will be affected by each alternative, detail environmental consequences and their significance *(Environmental Impact Statement, 2022*). The process ends with an issuance of the record of decision (ROD) that explains the agency's ultimate decision. For mineral oversight, the BLM serves as the key agency. An EIS has taken anywhere from 51 days to 18 years to produce, with an average taking 3.4 years (deWitt & deWitt, 2008).

2. Plant and Wildlife Projection: Endangered Species Act

The Endangered Species Act (ESA) signed into law in 1973, is designed to protect imperiled plants and animals from extinction as a "consequence of economic growth and development untampered by adequate concern and conservation." This act of legislation is important to consider because it reverts the priority of land uses as designated by mineral and mining law. The ESA effectively supersedes mining claims and acts as an effective barrier against proposed or continued development (*Karuk Tribe of Cal. v. U.S. Forest Serv.*, 2012).

This is of critical importance to conservation efforts and can act to stymie development, remaining one of if not the most effective tools to protect imperiled species, their habitat, and potentially discarding mining claims. One of the drawbacks to the ESA is the timeline required to effectively protect and conserve ecosystems for animal and plant species. Protection under the ESA is supposed to takes two years, but it on average takes 12 years (Puckett et al., 2016). Additionally, the Migratory Bird Treaty Act (1918) is an important tool that protects nearly all bird species and makes is unlawful without a waiver to pursue, hunt, take, capture, kill, or sell listed protected birds. It also grants full protection for any bird parts including feathers, eggs, and nests. However, its powers of protections do not extend to the same extent as the ESA.

3. Water Laws

Water law and lithium extraction are guided by a multitude of federal acts. Federal legislation in terms of water and toxic water are not always interdependent but share the same principle of protecting drinking and ground water from contamination. Not all of the mentioned statues and rules may directly apply to the lithium extraction in the Salton Sea and Thacker Pass. Yet, they still represent the larger regulatory framework that seeks to create and preserve clean drinking water and protect water sources from toxins and other hazards as a result from industry activity. Their model helps shape federal policy which in turn influences local policy. Important among federal legislation includes the Clean Water Act (CWA) passed in 1972, the Safe Drinking Water Act in 1974, the Surface Water Treatment Rule in 1989, and the Ground Water rule in 2006. The CWA is most important among these in terms of mining. Additional crossing cutting toxic waste and accountability legislation is listed later in this section, but include multiple federal acts aimed at preventing contaminants from leaching into groundwater.

4. Air Quality: The Clean Air Act

Air quality is mostly dictated by the Clean Air Act (CAA) passed in 1970. The CAA regulates air emissions from stationary and mobile sources and authorizes the EPA to establish the National Ambient Quality Standards to protect the health and the welfare of the public (US EPA, 2016). Stationary sources include factories and chemical plants, which are obligated to install pollution control equipment and meet specific emission limits under the CAA. The act has been amended several times, in 1977 and 1990. Under the CAA, states are required to submit a State Implementation Plan (SIP) that describe: "how air basins designated as nonattainment areas will be brought into compliance with federal and state ambient air quality standards. compliance with federal and state ambient air quality standards" (Formation Environmental, LLC et al., 2016). This is especially important for the Salton Sea which has experienced poor air quality. Two different air boards in the Salton Sea develop and implement their SIPs: the Imperial County Air Pollution Control District and South Coast Air Quality Management District.

5. Toxic Material and Accountability

Toxic materials and accountability legislation provide an essential framework and needed resources for hazardous disposal and cleanup. As toxic waste pertains to extraction there are three main pieces of legislation, the Resource and Conservation and Recovery Act (RCRA), the Toxic Substance Control Act (TSCA), and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The RCRA focuses on preventing the release of hazardous waste materials into the environment. Most mining materials that are high-volume, low-hazard: are exempt from regulation under the RCRA, though such wastes are now the primary responsibility of individual states (US EPA, 2015b). The TSCA focuses on controlling the development and application of new and existing chemical substances (US EPA, 2015a).

Lastly, CERCLA enables the federal government to clean up any site where there is an unremedied release of a hazardous substance (US EPA, 2015c). This is particularly important because if frees money for the areas and also gives communities access to digestible technical knowledge through a series of different programs (Zaragoza, 2019).

6. Executive Policy

The implementation of regulatory frameworks is contingent on US executive policy. The Trump-Pence Administration dismantled major climate policies and rolled back rules governing clean water, air, wildlife, and toxic chemicals, a total of 122 rollbacks (Popovich et al., 2020). The administration in this process loosened mining regulations and gave the green light on new mineral projects including the protect at Thacker Pass (Scheyder, 2021). Then in 2020, President Trump signed an executive order to protect and build the US rare earths industry and their associated supply chains, which includes lithium (Rapoza, 2020). However, action on a whole for lithium supply chains appears limited.

The Biden-Harris Administration on the other hand has gone through major efforts to prioritize US mining for strategic materials like lithium (Department of Energy [DOE], 2021; DOE, 2022). President Biden also recently authorized the use of the Defense Production Action that will provide federal money to help jump start new mines and expand existing ones (Holzman, 2022). This comes with some opposition from some community and tribal groups, including the People of Red Mountain, a tribal group that opposes the Thacker Pass project (Daly, 2022). In terms of regulatory review processes, the administration appears to have finalized the first of two phases of how federal agencies comply with environmental law (Clark & Niina, 2022). This includes NEPA and phase two of this plan appears that it will likely impact NEPA as well.

B. California-Specific Framework

California's environmental protections mirror those of the federal guidelines with a couple exceptions in terms of lithium extraction. This includes the California Environmental Quality Act, geothermal energy, and the swelling of organizations and policy support surrounding lithium extraction in the Salton Sea and Salton Sea restoration efforts. As a whole, regulations and policies supporting the nexus between lithium extraction, environmental protection, and human health are intricate and complex. Much of the purview rests with the California Energy Commission and the California Environmental Quality Act. Still, direct lithium extraction (DLE) on a commercial scale is an untested method in California and elsewhere in the world. The definitive impacts of DLE are thus unknown and new rules may need to be added once DLE's impacts are wholly known. Still, California statues and regulations make a sprawling network of rules that aims to protect Californians and states resources.

1. California Environmental Quality Act

Like NEPA, the California Environmental Quality Act (CEQA) is the state's broadest environmental law that determines whether an activity is subject to an environmental review, the steps involved in an environmental review, and the required content of environmental documents. Also, like NEPA, there are levels of review. The most common types of CEQA review documents include a negative declaration (ND), mitigated negative declaration (MND), and an environmental impact report (EIR). An EIR is used when there is a significant effect on the environment. Environmental categories withing CEQA are exhaustive. The current draft EIR for geothermal-lithium project from the Energy Source Mineral Atlis Project covers 12 topics, though over 20 are in consideration shown below in Table 2 (Chambers Group Inc., 2021).

However, only one of the three projects require an EIR as the two other projects are preexisting geothermal plants that are currently in operation.

Table 2. CEQA Topics Under Consideration for Lithium Extraction in the Salton Sea

CEQA Topics	
• Aesthetics • Biological Resources • Geology/Soils • Hydrology/Water Quality • Noise • Recreation • Utilities/Service Systems • Agriculture and Forestry Resources • Cultural Resources • Greenhouse Gas Emissions	• Population/Housing • Transportation/Traffic • Wildfire • Air Quality • Energy • Hazards & Hazardous Materials • Mineral Resources • Public Services • Mandatory Findings of Significance • Tribal Cultural Resources

Source: Lithium Valley Commission December Convening 2021

2. Geothermal Energy and the Warren-Alquist Act

The technology to extract lithium, DLE, requires the use of geothermal energy production. The statues and regulations that define geothermal energy production are recorded in the California Code of Regulations (14 CCR 2, Ch. 2-4). These are managed within the California's Department of Conservation, specifically within the Geologic Energy Management Division (CalGEM). CalGEM supports the development of energy production including renewable energy from wind to solar PV. The most consequential law affecting lithium production within geothermal is the Warren-Alquist Act in 1974 with the most recent addition passed in 2020. The act established the California Energy Commission, the governing body that now oversees development of lithium extraction in the Salton Sea (California Energy Commission, 2022). The Energy Commission has exclusive jurisdiction over the permitting of thermal power plants over 50 megawatts (MW) or larger. This entitles the Energy Commission to act as a one-stop shop in issuing permits. Powerplants 49.9 MW go through the county rather than the California Energy Commission to receive their permit. As such, firms like Controlled

Resource Thermos are ensuring their powerplant is under the designated 50MW to avoid triggering review by the Warren-Alquist Act (Controlled Thermos Resources, 2022; Neupane et al., 2022).

3. California Endangered Species Act

California has a long history of creating regulatory schemes for protecting endangered wildlife. Again, like the ESA, the California Endangered Species Act (CESA) is the state's most effective tool to safeguard plant and wildlife species. The CESA was passed in 1970 and predates the federal ESA. The California Department of Fish and Wildlife (CDFW) oversees the CESA with about 250 species currently listed under the CESA (CDFW, 2022c). The CDFW will at times play a role in the CEQA process as when issues arrive with the CESA (CDFW, 2022). In in the Salton Sea, there are about 20 sensitive bird species that regularly use the lake (CDFW, 2022b). Although as stated previously, declining quality of the sea has led to a dwindling or bird populations and will likely continue to negatively affect bird species in the area.

4. Clean Water, the Imperial Irrigation District, and Water Rights

Water statue and rules and their governing bodies are a distinct element in California and also within the Imperial and Eastern Coachella valleys. The California State Water Resources Control Board (CSWRCB), a part of the California Environmental Protection Agency, is responsible for the laws and regulations protecting California's waterways. The Porter-Cologne Water Quality Control Act, passed in 1969, expanded the enforcement power of the CSWRCB and the subsequent nine regional water quality control boards. Other important legislation and projects includes the Sustainable Groundwater Management Act passed in 2014, the Recycled Water Policy amended in 2018, and California's State Water Project. These broader regulations and projects provide a broad set of regulations for enabling the continued use of clean water.

The Imperial Irrigation (IID) remains paramount in water policy for the Salton Sea. The IID supplies water to roughly 500,00 acers of Imperial Valley farmland. Around 90% of IID water is supplied for agricultural purposes, with just about 2% dedicated to geothermal energy production (McKibben & Dobson, 2022). The IID receives its water exclusively from the Colorado River. The most notable action from the IID in the past two decades comes from the Quantification Settlement Agreement of 2003, an agreement from the IID, the San Diego Water Authority, and multiple other federal, state, and local water agencies. The IID agreed to transfer large quantities of water to the San Diego Water Authority, and provided a pathway for the California to restore the Salton Sea (Formation Environmental, LLC et al., 2016). Water usage and its associated policy are vital for geothermal energy and lithium extraction given the need to secure water despite citations from the lithium industry indicating water usage will be minimal.

5. Clean Air

Air pollution laws known as the California Air Pollution Control Laws or the 'bluebook" provides all the air-pollution related statues from other California codebooks. The primary governing board for the state is the California Air Resources Board (CARB). Important functions include protecting the public from harmful effects of air pollution and developing programs and action to combat climate change (CARB, 2022a). The Salton Sea Air Quality Monitoring Network, maintained by the IID with the collaboration with CARB and the EPA, monitors and characterizes windblown dust in the Imperial Valley (IID, 2022). As such, there are direct ties to water transfer agreement in 2003. As mentioned in the federal air policy section, Imperial County Air Pollution Control District and the South Coast Air Quality Management District monitors, maintains, and enforces National Aire Quality Standards for the Salton Sea through a State Implementation Plan under the Clean Air Act.

Other notable actors and programs within air quality that might influence lithium extraction policy in the Salton Sea include the Community Outreach and Enforcement team that works to implement and promote CARB's Environmental Justice and Supplemental Environmental Project programs. Additionally, the Community Air Protection Program, created in 2017 aims to reduce exposure in communities most impacted by air pollution (CARB, 2022b). This has led to the approval of two Community Emissions Reduction Programs in the Salton Sea region.

6. Waste and Toxic Materials

Waste and toxic hazards is governed by the California Integrated Waste Management Act which establishes standards for solid waste and disposal to protect air, water, and land from pollution. The Hazardous Waste Control Act of 1972 created the legal standards for hazardous waste in the state. Hazardous waste laws and regulations are subject to the Department of Toxic Substance Control (DTSC). The DTSC administers the state hazardous waste programs including CEQA as well as federal programs mentioned in the federal toxic materials section.

7. California Policy

California is pushing for the development for geothermal and lithium production. Governor Gavin Newsome outlined his vison for the lithium at the Salton Sea in the California Blueprint. It proposes to provide incentives to advance the clean energy market in California, provide residents in the Imperial Valley a share of the benefit from these projects, include labor standards that deliver community benefits, and ensure lithium production is done in a clean and sustainable way (Office of the Govenor, 2022). Much of the policy steering comes from the Blue-Ribbon Commission on Lithium Extraction in California (LVC). It was initiated by Assembly Bill 1657 that authorized the California Energy Commission to convene the Lithium Valley Commission. The LVC is charged with reviewing and analyzing issues and incentives

regarding lithium extraction use, which also collaborates with the US EPA and the US Department of Energy. The LVC is made of a 14 member group that represents industry, government and community representatives. The work of the LVC will culminate in report to the legislature by October 1 of 2022 (Commission, 2002).

C. Nevada-Specific Framework

Nevada like the federal and California governments have similar protections and follows US federal guidelines where appropriate. As Thacker Pass represents a hard rock mining method, there exists a series of specific Nevada mining laws that will apply to Thacker Pass. Mining has specific regulations represented in the different permits required for project operation. Additionally, there are waste laws and general policies from the Nevada that will guide lithium mining. Although Governor Steve Sisolak have shown support for the mine, Nevada has not shown the same level of attention as California to the Salton Sea. This may be a function of the existing Nevada regulatory framework that administers new mining projects. Further, the support and opposition to Thacker Pass is itself playing out on multiple levels from local environmental and indigenous groups to larger national conversations concerning federal mining law.

1. Federal Role

The federal government owns and manages about 85% of Nevada's land and thus plays a large role in mining regulations. Consequently, most mine operations must obtain a state permit and permission from the BLM. The BLM in Nevada has more than 180,000 active mining claims, about 49% of BLM total claims. There are currently 198 authorized mining plans of operation and 282 active exploration notices (BLM, 2022.). The BLM administrators more than $2 billion in surface management reclamation bonds. In practice, federal frameworks like NEPA play a crucial role in mining for the state of Nevada. Although there are multiple government

bodies and regulations involved on different levels, mining is fairly straightforward in Nevada's regulatory framework. Even though Thacker Pass is the state's first hardrock lithium mine, it falls neatly in into the regulations provided by the state.

2. Mining Regulations

Nevada's mining laws and policies are divided into the two phases, mining before 1989 and mining after 1989. From the 1860s to 1989, few regulations existed to protect communities and ecosystems from the impacts of mine pollution (NDCNR, 2022). Tailings, leftover mine waste that can contain containments, were dumped into surface water drainages, affecting downstream waterways, hazardous to ecosystems and human health populations. Mining reform in 1989 brought three important developments. One, independent oversight thought the creation of the Bureau of Mining Regulation and Reclamation (BMRR), which is now responsible for administering Nevada's mining laws and regulations. Second, it brought protections for water in a zero-discharge framework that prohibits mines from releasing any process fluids. Lastly, it brought containment to monitor and ensure the use of hazardous chemicals are contained.

Currently the BMRR operates through three prongs—the Regulation, Closure, and Reclamation Branches. Regulation conducts inspections of mining facilities to confirm operations are compliant with permit regulations. Closure ensures that mining sites are stabilized with final closure and will not present a future threat to the environment. Closure plans must be submitted two years before the closure date. Regulation and Closure are governed by the same set of Nevada Revised Statues (NRS) (445A.300 - 445A.730) and Nevada Administrative Code (NAC) (445A.350 - 445A.447). Reclamation regulates mining and mineral exploration through the reclamation permit program that rehabilitates land after mining and acts to prevent potential environmental threats. It is also governed by NRS (519A.010 - 519A.280) and the NAC

(519A.010 - 519A.415). As part of the permitting process, mines must obtain water and air permits.

2. Water Rules

The basic statutory principles of Nevada water law are covered in Chapters 533 and 534 of the NRS with the Nevada Division of Water Resources acting the responsible agency to conserve, protect, manage, and enhance the State's water resources. In terms of mining however, the BMRR is responsible for water resources at mine sites and issuing the Water Pollution Control Permit (WPCM). The WPCM is needed prior to the construction of any mining, milling, or other beneficiation process activity. Permits are valid for a duration of five years though permit renewals are available for mining operations beyond five years. Still, the WPCP must remain in effect throughout the life of the mine. The WPCM application requires documents detailing the design, construction, operation, and closure of operations (NDEP, 2022c). Additionally, if mining operations discharge pollutants to surface waters, the mine operators must obtain a National Pollutant Discharge Elimination System (NPDES) permit, which is issued through the Nevada Bureau of Water Pollution Control. The NPDES permit program originates from the federal Clean Water Act and authorizes states to perform the permitting, administrative, and enforcement aspects of the program (EPA, 2014).

3. Air Quality Permitting

The Bureau of Air Pollution Control and Air Quality Planning monitors and tackles challenges maintaining air quality throughout the state. Any process or activity that is an emissions source requires an air quality permit. Unlike the WPCM, the BMRR does not issue the air quality permit, but rather the Bureau of Aur Pollution Control (NDEP, 2022d). There are four

general air quality permits that are divided by the tons of pollutants emitted, which comes with associated fees: Class I, Class II, Surface Area Disturbance, and a General/COLA permit.

4. Reclamation Permit and Mine Closure

The Reclamation Branch of the BMRR is responsible for the issuing Reclamation Permits. Reclamation permits encompass actions during or after mining exploration or operation in order to return the land to safe and stable condition that ensures the public safety and minimizes adverse visual effects (NDEP, 2022b). These permits are issued prior to any construction of any exploration, mining, milling, or other beneficiation process activity that proposes to create disturbances over five acres (NAC 519A.010-519A.415).

Further, a Final Plan for Permanent Closure must be submitted to the BMRR two years prior to the anticipated closure of a mine site (NDEP, 2022a). The Final Plan will provide closure goals and a detailed methodology of activities necessary to achieve chemical stabilization of all known and potential contaminants as the site and must include a post-closure monitoring proposal for a period of 5-30 years to provide additional data that stabilization has been achieved. The request for Final Closure is made following the completion of the post-contaminant period.

VI. Results and Analysis

This section provides detailed stakeholder responses by site. Although the questions posed to stakeholders were almost identical, thematic responses varied greatly between the two sites. This again is a function of different extraction technologies, governing regulatory frameworks, ecosystems associated with each site, and the different community identities and histories. Insights from stakeholders in the Salton Sea center on the community impacts of energy and industrial expansion. The project at Thacker Pass represented a more contentious

environmental battle according to stakeholders, with ongoing litigation to stop lithium mining by environmental organizations and three tribes. To address these differences, each case study is presented separately below, allowing for a closer look at associated environmental impacts, regulatory insights, community engagements, economic impacts, and broader societal implications. An abbreviated version of results is shown below in Table 3. Policy dimensions are represented throughout each subsection.

Table 3. Highlighted Results of Stakeholder Interviews

	Salton Sea	Thacker Pass
Site Context	▪ Known for environmental hazards as the result of agricultural policy and receding water lines. ▪ Three different projects piloting extraction using novel DLE techniques. ▪ Companies include Controlled Thermal Resources, EnergySource Minerals, and Berkshire Hathaway Energy.	▪ Located in the northwestern edge of Nevada in the McDermitt Caldera. ▪ Extraction would use traditional hardrock mining methods in clay. ▪ Lithium Nevada, a subsidiary of the Canadian owned Lithium Americas, is the sole operator of the Thacker Pass project.
Environmental Impact	▪ DLE impacts local environments to a lesser extent than other extraction methods. ▪ Will grow geothermal energy production ▪ Concerns over extensive water, air quality, and toxic waste disposal. ▪ Air quality needs to be addressed before other industries move to the region ▪ Cumulative impacts unknown.	▪ Concern for multiple plant and wildlife species that are fragile to environmental change ▪ Danger from groundwater pollution that may span over 300 years. ▪ Efforts to reduce carbon footprint and impacts as well as water use by industry.
Environmental Review Processes	▪ Frustration over lack of capacity of federal and state agencies. ▪ Permitting processes can put unnecessary tensions between the industry and community. ▪ Trust in CEQA and California regulations ▪ Concern over CEQA exemptions ▪ Desire for more community consultation in review processes.	▪ Industry anchors and begins projects using their own resources without extensive oversight, which may incentivize firms to mine regardless of impacts. ▪ Lack of capacity and technical expertise from government agencies. ▪ Questions of regulatory capture of state and federal agencies. ▪ Mining laws in Nevada have gradually evolved to increase environmental protections, though some stakeholders say this is insufficient. ▪ Misaligned General Mining Law of 1872.
Community Engagement	▪ More inclusive and representative community involvement. ▪ Concerted efforts to engage communities but can be inaccessible given format for engagement. ▪ Desire more transparency from both government and industry entities. ▪ Strong need for more community education on impacts and extraction processes.	▪ Inconsistent community engagement during the COVID-19 pandemic. ▪ Yet, there is ongoing engagement between industry, government officials, and communities. ▪ Interactions with the plurality of tribes in the area was minimal by the BLM. ▪ Communities lack the technical expertise and support needed to fully understand project dynamics.

Economic Impacts	▪ May offer tangible benefits to communities that feature higher unemployment and health burdens. ▪ Battery industries may co-locate in the region. ▪ Concern over who will actually have employment opportunities ▪ Projects may rebrand the region and help mitigate environmental hazards from the Salton Sea. ▪ Infrastructure needs could be addressed.	▪ Mine creates economic opportunities that will amplify throughout the region. ▪ Increases US energy and security independence in the face of a global supply deficit of lithium ▪ Reduces global supply chain emissions by producing processing lithium on-site.
Other Voiced Concerns	▪ Global Context: Seen as a crucial piece to alleviate impacts of climate change. ▪ Development Model: Opportunity to include communities in a meaningful way and develop a more equitable model.	▪ Sacrifice: stakeholders raised questions on who is bearing the price of sacrifice and at what cost for new lithium demand. Much of larger society does not have to shift its habits or culture. Instead, the burden of transition is placed on frontline communities.

A. Salton Sea

The commercial viability of DLE in the Salton Sea remains unsettled, though academic researchers providing consultation to the lithium the industry believe use of DLE is inevitable based on current progress. However, the environmental history of the Salton Sea in conjunction with neglected and underrepresented communities in the region present a tense dynamic with industry forces. The success or failure of lithium production will likely be judged by the demonstration of commercial extraction, community benefits, and Salton Sea restoration. In the six interviews conducted multiple themes emerged, including issues on environmental impacts, environmental review processes, community engagement, economic impacts, and questions on whether lithium extraction would follow typical resource extractive models. Although there are three major projects, in addition to government grants funding extraction research, much of the perceived impact is speculative and will remain so until larger scale pilots are successful. Policy recommendations were largely focused on the impact of industry expanding in the area, which will come with its own housing, infrastructure, and environmental concerns.

1. Environmental Impacts

Interviewed stakeholders expressed a mixture of enthusiasm and hesitancy about environmental impacts from geothermal expansion and lithium production. It was important for stakeholders to discuss lithium in context to other areas, potential negative externalities, and Salton Sea restoration and public health. Most stakeholders thought impacts would be relatively small. However, several community and environmental organizations still had reservations about the unknown cumulative impacts of expanded industry on the region.

1.1. Lithium Extraction in Context

For stakeholders aware of the potential for DLE at the Salton Sea, it was important to contextualize three points—the potential smaller footprints of DLE in comparison to other extraction methods, the total lithium reserves available at the Salton Sea, and using the area to expand renewable energy sources. One researcher noted, “the traditional ways of mining lithium are really thrashing the environments in other countries. In contrast, the footprint of geothermal lithium extraction is very small, it's 100 times smaller than a solar deposit in Chile and it's at least 10 times smaller than a typical open pit mine in Australia.” Although DLE holds promise in reducing cumulative emissions and could serve as a vital source of lithium in the SSGF, multiple stakeholders remained cautious of large-scale commercial impacts in the Salton Sea, citing the unknown cumulative impact on the region.

1.2. Environmental Concerns

The existing state of the Salton Sea was described as “dire” by one environmental stakeholder, commenting the water levels had declined significantly over the past decade. Concerning the potential impact of industry moving into the Salton Sea, they went on to say, “geothermal and lithium are moving into an area that isn’t exactly pristine, but they are moving

into an area that is fraught with a history and decades of environmental damage and degradation, and a population that is the most severely impacted in the state." Still, explicit environmental concerns for those interviewed included impacts on water usage, air quality, waste disposal, and emissions from the associated transportation of lithium products.

Community organizations raised concerns about water usage, a divisive topic in the arid Salton Sea region. A community group stated that DLE could use about 2,400 acre-feet of water per year. But when speaking to both lithium researchers and environmental stakeholders on the overall water impact of DLE on the Salton Sea, they viewed water usage as trivial. An environmental stakeholder indicated that if as much as 150,000 acre feet a year are consumed by geothermal and lithium production, that amount is insignificant compared to the water already used in the region. According to the Imperial Irrigation District (IID), 2.5 million acre feet were used in 2020 (IID 2022). One researcher stated that 90% of current IID water goes directly to the agriculture industry, with only 2% going to geothermal. They suggested water conservation efforts should be aimed at the agriculture industry to increase efficiency and reduce waste. Comments from the Imperial Irrigation District indicated that it remains optimistic about balancing the future water needs of lithium extraction with those of agriculture.

Air quality is a serious concern, as geothermal plants produce steam. An environmental stakeholder commented that if steam is 99% water vapor, the other 1% is potentially significant in terms of total pollutant loading from the estimated large quantities of geothermal and lithium production. They noted, "whatever is downwind will be affected. If it blows over a habitat, it's going to affect species." Transportation emissions are an additional concern. Imperial county already has some of the worst air quality in the state (Singh 2021). Adding diesel emissions could further exacerbate air quality. There was also concern on the waste products generated

from DLE, if waste is toxic, and how it would be disposed of. Questions about air quality and waste disposal remain unanswered to many community and environmental groups. The totality of impacts may not be known yet, with one environmental stakeholder indicating, “we don't know what the actual environmental impacts could be or how much. There are a lot of questions that have not been answered and won't be answered until they actually get these demonstration projects up and running.” Another stakeholder also mentioned that since DLE technologies are not being disclosed, how could they analyze environmental impacts associated with extraction technologies?

In sum, the majority of those interviewed saw the overall impacts of lithium extraction in the Salton Sea region as potentially small. Environmental stakeholders did not believe extraction was entirely benign, but still believed any issues could be properly mitigated. Not knowing the overall impacts associated with extraction, they were curious as to what those impacts were going to be and how the state and industry would mitigate them. As one environmental consultant concluded, “these associated industries can be developed in a way where they mitigate their impacts but we need to figure how to contain it, how to reduce the risks associated for communities, and be honest about it.”

1.3. Salton Sea Restoration and Human Health

The lingering consequences of the Salton Sea’s receding shoreline, combined with mismanaged agricultural policy, are detrimental to both human health and economic livelihoods in the region. According to some stakeholders, lithium extraction could play an active role in the rehabilitation of the Salton Sea. As a whole, geothermal and DLE seemed compatible with habitat restoration according to those interviewed. Several stakeholders were even optimistic there might be an opportunity to link restoration, industry, and the state into a broader deal that

would improve conditions in the region. However, the environmental stakeholders cautioned that geothermal and lithium producing entities were not responsible for the negative impacts of the Salton Sea that preexist. They noted, “the burden for solving that health issue shouldn't be placed solely on the backs of the geothermal or lithium industries, because they're not responsible. We need to look at the agricultural industry.”

Even though environmental restoration was seen as important for stakeholders, it was seen as a lower priority than human health and economic development. However, restoration could become a priority if lithium extraction gains a strong foothold as the battery manufacturing industry may seek to co-locate in the Imperial or Coachella Valleys. As one stakeholder noted, “you can’t have the industry in the area if you don’t fix the health situation, we can’t bring thousands of people here and give them all asthma.” The majority of stakeholders, including all community and environmental stakeholders, indicated it should be the state’s responsibility and wanted the state to take a more active role in habitat restoration.

1.4. Review Processes

Stakeholders expressed a variety of opinions on the current regulatory framework and review process, expressing trust in the system while maintaining that the state needs more capacity and needs to follow its own rules. The review process itself is unfolding now, so ideas and policies about the process are still in formation. There is a strong level of trust in the California Environmental Quality Act (CEQA) and National Environmental Protection Act (NEPA) processes. One community advocate commented, “one of the best protections will have been, among others, CEQA and NEPA. It gives the community the power to file suits if we find that there are failures in the decisions of the permitting process. The communities need to

maintain that power." Another researcher stated, "we don't need more laws, we just need to enforce the laws we have."

Still, stakeholders indicated the process could be improved. One environmental stakeholder commented that the permitting process creates tension between industry and the community, stating, "it seems as though CEQA and NEPA are inefficient, but the inefficiency is government who doesn't put in the sufficient manpower to get these processes done quickly." Commenting on potential industry resistance, one environmental stakeholder noted it should not be a larger issue and said that if an industry rises or falls on a CEQA analysis, that industry has much bigger problems. In terms of community engagement, which is covered in greater depth below, most stakeholders believed CEQA could be done in a way to instill greater community confidence and support.

With specific regard to permitting for the Salton Sea, one environmental stakeholder thought a programmatic environmental impact report (EIR) would make more sense as it would analyze the cumulative effects of extraction more holistically rather than producing an EIR for each project. They further explained there could be a "menu of mitigation measures" for industry to choose from. In such a scenario, other EIRs would likely not be needed; a negative declaration or an environmental assessment would suffice. Overall, it would result in much more work on the front end but could allow for a more efficient process and save time in the future.

Multiple interviewees expressed concern about special exemptions from CEQA that allow the industry to circumvent regulatory codes. One environmental organization indicated that Imperial County is asking for multiple environmental waivers and said they would likely oppose them all. Given the large economic impact of lithium extraction and the potential of the lithium-ion battery industry coming to Imperial County, there is concern that California government will

focus less on potential threats and their adverse impacts. The same environmental group that said it would likely oppose any exemptions also said that now was the time to ensure the government was doing their due diligence. They stated, “now really is the time to start raising these questions and getting requirements in place because we don't know if [DLE] is actually going to work. If it does work and the government says it’s all systems go, we will have missed our opportunity.”

Beyond potential exemptions and the CEQA process, there is concern about a report from the Lithium Valley Commission coming out in October 2022 to the California Legislature addressing extraction impacts. Some thought this report was going to come out too late, as the state budget may have already been finalized. As a result, any impacts that need to be mitigated might be missed. One last concern expressed by an environmental stakeholder included a transparent data collection process for air monitoring. Currently, geothermal companies self-collect and self-report their data. The stakeholder suggested that there needs to be sufficient funding for objective state staff to do the monitoring, and then create genuine sanctions when regulations are violated. Overall, there appears to be trust in the processes of the state, with the caveat that the state follows its own rules. However, the inability to prioritize permitting processes and the lack of government capacity to handle environmental protection remain lingering concerns.

2. Community Engagement

The bulk of concern from interviewees representing organizations focused on community engagement and how the community would be impacted by lithium extraction. This section is further divided into community interactions and needed technical expertise. As a whole, stakeholders expressed that there was a lot of caution on the behalf of community about ongoing

geothermal and lithium projects. They also commented community perceptions were never static, but always evolving.

2.1. Community Interactions

As lithium extraction activities ramp up in the Salton Sea region, interactions between community members, government, and industry could represent a new chapter of more inclusive engagement, but issues still plague the process. As an environmental justice advocate emphasized, “one of the largest barriers that exist within government is the fact that government is not very good at engaging communities. They lack policies, they lack expertise, they lack capacity building. This is now starting to change, but we're not there yet.”

A more inclusive process was initiated with the creation of the Lithium Valley Commission (LVC) that includes members from Alianza Coachella Valley, Comite Civico del Valle, Audubon California’s Salton Sea Program, the Torres Martinez Desert Cahuilla Indians, and the Quechan Indian Tribe. Their inclusion has enabled a variety of groups to participate in decision-making. However, questions arise from stakeholders as to the quality of engagement, and whether this representation is sufficient. Multiple issues were raised by community and environmental stakeholders. Although there is representation of the community, one person interviewed thought it was more “grass tops versus grass roots,” suggesting a disconnection between representatives and the community. This may be an indication of a lack of capacity within the LVC as well as some underlying tension between Riverside and Imperial Counties. The network of environmental and community organizations surrounding the Salton Sea is small. The groups involved with the LVC are also partners with other organizations attending meetings questioning lithium extraction’s impact. Another stakeholder commented that the LVC is verging

into the territory of not effectively engaging communities. Part of their concern resides in the lack of sufficient transparency in the decision-making process.

According to multiple community stakeholders, communities in the region believe that industry and government are not often going to have communities' best interests in mind. Even in the context of more representation on the LVC, there is a level of uneasy trust. The relationships between community, industry, and the government are seemingly improving, though building relationships take time, and any existing barriers and concerns are not removed overnight. One environmental justice advocate remained resolute that the government and industry needed to address community concerns. They stated, "is extraction really that safe? OK, show us. Is there economic opportunity here? OK, well let's see it. I would even go so far as asking is this something that's favorable to our community, to help alleviate the harm that's been done to our community." They went on to say, "the legacy of harm that some communities are living with and will continue to live with needs to be considered." Although community opinion is not static, community advocates emphasized they want to be part of the discussion and understand the implications of a new industry in the region and how it's going to affect them.

LVC meetings have also been a point of dispute. The LVC meets publicly once a month and provides additional context to the project and addresses issues brought up. In an early 2022 LVC meeting, community organizations noted that LVC staff brought in food, coffee, Spanish translation, and made efforts to engage community members. However, some community advocates were less than enthusiastic about the overall quality of these meetings, indicating that translation services were inadequate and suggesting the format was inaccessible. They went on to say, "the community needs a space to really react and share their thoughts and questions. The

monthly five -hour meetings are not appropriate for that." Stakeholders suggested additional meetings to give the community the proper space in addition to the current monthly meetings.

As a whole, community interaction with the LVC appears mixed, with a more inclusive approach representing a milestone in itself. This is a stark comparison to previous community engagement and represents a completely different methodology in comparison to Thacker Pass. Still, greater levels of transparency about ongoing projects remain a notable frustration.

2.2. Technical Expertise

One of the largest barriers according to both lithium extraction researchers and community organizations is the technical nature of DLE and enabling community members and environmental groups to understand DLE processes and impacts. One researcher suggested, "a big failing of that whole process with the CEQA and NEPA sequence is laying things out in a way that's digestible by the general public, and not leaving them frustrated and feeling like they don't have a voice in the whole thing." Consequently, stakeholders said community members feel discouraged in commenting on reports and listening in on LVC meetings. For example, the draft EIR produced by EnergySource is over one thousand pages long. The EIR speaks to some issues like waste disposal and water use that are concerns for community members, but its format remains inaccessible.

One stakeholder who has been meeting with other environmental organizations and explaining the impacts laid out by the EnergySource EIR, said it's almost impossible for the lay person to read such documents and gather information. Nonetheless, only one of three companies piloting DLE need to produce an EIR. Multiple stakeholders suggested it should be the job of companies to explain the technical details in a simple language that is non-scientific. According to community organizations interviewed, some of the best information about geothermal and

lithium production has come directly from the industry. Communities say this is not enough. This also raises questions about the impartiality of geothermal and lithium firms if they are explaining their own impacts. Objectivity from an independent source would allow communities an impartial perspective. Yet, given the nascent and proprietary connections to DLE research along with limited government capacity to produce objective opinions, there are no other sources besides environmental nonprofits to assist with such efforts. The community organizations interviewed suggest the inability to understand DLE details hampers their ability to advocate for policies on the behalf of community members.

3. Strategic and Economic Benefits and Concerns

Lithium extraction offers opportunities at multiple scales. The economic benefits of a nascent and burgeoning lithium-ion battery industry have regional implications. Despite the possibility of new industries and a new labor market, there are strong skeptics about how and if lithium production can bring about environmentally safe and equitable outcomes for the region.

3.1. Expanding Economy: Lithium Valley Agglomeration

There were mixed reactions from stakeholders to the expansion of geothermal energy and lithium production in the Lithium Valley, characterized by a combination of optimism and caution. As a county with one of the highest levels of poverty in the state (Public Policy Institute of California 2021), stakeholders explicitly said Imperial County needs more employment opportunities, particularly for youth, in industries other than agriculture or the prison system. One stakeholder commented, “[lithium extraction] represents something the US is in desperate need of. And that's an environmentally friendly reliable supply chain of lithium that will employ our own citizens.” A mineral and extraction researcher working on multiple DLE projects noted, “we could produce thousands of pretty high paying jobs down there which would benefit those

communities tremendously." Going further they said, "the tax revenues, both at the local, county, state, federal levels, could be funneled back into those communities to help them with their underlying issues including infrastructure needs." These jobs would be in geothermal and lithium production, but more importantly in battery manufacturing, which will provide more jobs. One European battery manufacturer has already signed an agreement that they will build and locate a $4 billion 54-gigawatt-hours battery factory in the Imperial Valley (Shultz 2022).

Multiple stakeholders suggested extraction and battery manufacturing were just the beginning of the lithium industry in the region. Such jobs would be contingent on workforce development programs to train new workers, and to retrain older residents to transition from existing occupations. Stakeholders familiar with the Imperial Valley Economic Opportunity Investment Plan, which outlines potential industry growth in the future, suggest key policies from the government should focus on workforce development programs and the return of revenue flow to the communities. Across all stakeholders interviewed, all believed there is a real benefit to the community but cautioned that those benefits stem from how the federal, state, and local governments administer their plans.

3.2. Infrastructure and Economic Distribution Concerns

The geothermal and lithium extraction industries will increase the industry footprint in the region, though a much larger impact will exist if the lithium-ion battery industry emerges in the area. Imperial County and the surrounding region have preexisting infrastructure concerns, an issue noted by almost every stakeholder interviewed. These include housing and basic welfare needs. The Imperial Valley Economic Opportunity Investment Plan has asked for funds from the federal and state government to support transportation improvements in roadways and railways, power grid line improvements, and associated impacts that come with the anticipated growth in

jobs from geothermal, lithium, and battery production. Several stakeholders indicated financial support from multiple layers of government will be necessary to accommodate for anticipated growth.

Although there is promise of economic opportunity and growth, community and environmental organizations expressed concern and caution about who will benefit from the creation of employment opportunities. One environmental advocate noted that there were a host of social justice concerns, including job availability for local residents and the quality of those jobs. Another community advocate said the promise of new jobs is almost disrespectful. They stated, “it's not really clear to us what new employment opportunities really means, if it will be accessible to us; we’re not just a labor force.” Community organizations and the LVC are discussing what jobs and how many jobs will be available. However, much of this still remains unknown and is thus speculative. Neither the LVC nor the industry have provided specific job numbers, which is a function of the uncertainty surrounding commercial lithium production and to what degree lithium-ion battery industries will co-locate in the area. Nonetheless, workforce development programs and infrastructure enhancements will also take time to implement and build, adding to the complexity and tension of the situation.

The actual impacts of industries on communities are also of concern. The relationships between communities in the Inland Empire bring up a mydaid of issues. One stakeholder said, “we already have this fear of the logistics industry moving closer to our communities. And we were told by the Energy Commission they are looking at the Eastern Coachella Valley as part of their plan, but what does that mean to our community? What is it going to become?” There is also skepticism about the implementation of economic development plans, as community members have experienced broken promises previously. An environmental justice advocate

warned, “I worry that it's going to just be another industry where there are some jobs, but the high stuff will be developed in other communities.” Further, with the expansion of the battery industry and potential infrastructure development, there are additional questions and concerns on the environmental impacts of such growth. Even though it was not discussed extensively by the stakeholders, the associated development could have a significant impact on the area’s resources.

4. Global Comparisons and New Development Models

Most stakeholders connected extraction to global conversations about lithium production and climate change. Stakeholders expressed the necessity of reducing global emissions to fight against climate change and saw the Salton Sea as part of the solution. Additionally, there was recognition of the social and political ramifications of placing industries in the US rather than relying on other nations who do no not have the same set of environmental protections. Several people interviewed stated that the impacts in the US would be much less severe than in South America, Australia, or China, and noted the importance of a consolidated supply chain. Reflecting on US consumption of resources, one interviewee stated, “the US has a very high standard of living, and we consume a lot of resources, and in doing that, we thrash the environment of other countries.” Although several stakeholders commented on how a domestic lithium supply would be better for the environment over using lithium from other countries, stakeholders still had reservations and questions about how the US would proceed with extraction, especially in the Salton Sea. One commented, “we are at an inflection point here, the choices we make will have real repercussions for the Salton Sea, the communities, and how the industry is perceived.” They went on to say, “we need to do it right, in a green way which still has its own issues, but we can do it better and part of that hinges on how the community is involved.”

B. Thacker Pass

As with the Salton Sea, lithium extraction in Thacker Pass is complex and multi-dimensional. In the eight interviews conducted with stakeholders, multiple themes emerged. The challenges posed by the Thacker Pass project are all interconnected and cross-cutting. The largest issue confronting the mine site is whether the project should continue or not, with some environmental organizations vehemently opposed to lithium mining. Stakeholders spoke to environmental impacts, environmental review processes, community engagement, economic impacts, and raised questions concerning domestic and global lithium demand.

1. Environmental Impacts

Stakeholders from environmental organizations raised issues about the potential impacts to the ecosystem of the McDermitt Caldera. Stakeholders from the County government and the industry conversely felt environmental impacts are properly mitigated. The dynamic between the two groups plays throughout this this section. The main concerns are manifested in land use, plants and wildlife, and specific water concerns that are intertwined with the first two.

1.1. Land Use Degradation

One of the first issues the majority of environmental stakeholders discussed was the overall land disturbance that would result from a lithium mine at Thacker Pass. According to environmental groups, the environmental consequences of the mine would last generations, affecting everything in the region including water, soil, the organisms and bacteria deep within the earth, and the plants and wildlife that populate the area. The Reclamation Permit given to Lithium Americas from the Department of Conservation and Natural Resources indicated the total land disturbance is registered at just below 5,600 acres (2020). However, the acreage is

likely an underestimate. The acreage pertains to just the project site, with stakeholders indicating that damages encircle a much wider geography.

As such, several organizations asserted the land impact from a mine would categorially alter the ecosystem. One stakeholder questioned the ability for land to return to its natural state after mining: “I don't know that mining here is commensurate with healthy landscapes on a site-specific level. And I don't know that once you tear it all apart, that you can actually put it back together again; we're not that smart.” Nonetheless, Humboldt County officials pushed back on this narrative, claiming the impacts were an exaggeration: “resistance to the mine makes it seem like going back to what we used to see in the 1930s and 40s and we're going to be washing away the mountainside and we're going to be polluting streams and groundwater. Nothing could be farther from the truth.” County officials maintained the integrity of Nevada’s mining laws and were to some degree perplexed by the focus on the Thacker Pass lithium mine given other mines developed in Humboldt County, Nevada.

1.2. Plants and Wildlife Protection

According to environmental organizations representing litigation to stop Thacker Pass mining operations, the mine presents a fairly extensive danger to plants and wildlife. Again, while the current project site is listed at 5,600 acres, the impacts of the mine operations could extend beyond the parameters of the mine site, affecting a wider area and a larger number of species. Several environmental organizations commented that the McDermitt Caldera is characteristic of Nevada’s landscapes and is a region full of endemic plants and wildlife.

Noted wildlife deemed at-risk include the Kings River pyrg (an endemic freshwater snail), pygmy rabbit, greater sage-grouse, and golden eagle. Losing any of these species would have downstream repercussions, according to one environmental representative. A mine would

potentially negate the work done by conservationists to protect species, preventing them from needing to be listed under the Endangered Species Act (ESA). For example, the Kings River pyrg has been listed twice (in 2005 and 2012) in the Nevada Wildlife Action Plan as a "Species of Conservation Priority" (Great Basin and Resource Watch 2019; Nature Reserve 2022). Additionally, the greater-sage grouse has been the subject to one of the largest conservation efforts in US history to prevent listing on the ESA (Kershaw 2015). The golden eagle also requires protection and is typically shielded by the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act. Further, the golden eagle is a sacred animal to surrounding tribes. Concerns about plants and wildlife extend beyond the noted few here but serve to represent larger thematic issues at Thacker Pass.

According to one environmental stakeholder, the larger problem is that despite being imperiled, many species do not have regulatory protection and should be listed under the ESA. They noted that protecting species under the ESA is difficult and can take more than a decade (Puckett et al. 2016). Stakeholders warned there was a strong chance of mining wiping out a number of species before any federal protection can be provided. Due to the General Mining Law of 1872, the ESA is one of the few laws that can assist in conserving wildlife when a mine is proposed. The mining law serves as the foundation for current US mining practices and essentially allows a mine claim to supersede other uses of the land, circumventing some regulations.

Other stakeholders held a different view of the proposed impact of mining. One of the stakeholders interviewed, a wildlife biologist, noted the area was the "Holy Land" for species like the greater-sage grouse, meaning the region has some of the best-known habitat for the sage grouse. They acknowledged the mine would impact the habitat for most wildlife, but they stated

the County had been in discussions with Lithium Nevada to ensure there was a minimal impact on flora and fauna. County officials also claimed they felt confident and comfortable with the plan moving forward as the mining operation had considered and planned around their impact on wildlife, specifically in regard to greater sage-grouse habitat.

1.3. Water and Air Concerns

Directly associated with land disturbance and longevity of species in the region are environmental concerns around water quality and usage. To have sufficient water, the project will use high volumes of water from the Quinn River Valley aquifer. Lithium Nevada is also buying water rights in the surrounding area to accommodate the needs of the project (Lithium Americas 2021a). One environmental stakeholder warned that this would impact the water table, potentially limiting the water availability to local farmers and ranchers. The degree of water use is predicated on technical modeling processes. Lithium Nevada reported the mine will use 2,600 acre-feet of water/year for the first four years and 5,200 acre-feet of water/year after four years. The amount equates to 9% of the perennial supply for the Quinn River Valley. For context, irrigation consumes just under 83,000 acre-feet/year in the Quinn River Valley (Lithium Americas 2021b). Lithium Nevada has also stated that their project is designed with significant water recycling technologies to minimize water consumption by using the same water over and over again. Still, some stakeholders have disputed the figures produced by Lithium Nevada.

There are also serious concerns related to backfilling the mine with tailings after mining has occurred. Tailings are a by-product of mining, consisting of mineral particles and water. Dry stacking of tailings is used to process and store tailings to reduce impacts on the environment. Two stakeholders expressed concern about the storage plan of dry tailings in Lithium Nevada's operational plans. Without proper storage of these by-products, the tailings could seep into

groundwater resources, posing a risk of arsenic and antimony contamination. Further, the stakeholder noted there was no analysis on the neutralization of the tailings. Without effective treatment, the tailings will still have acid in them and could impact water quality. This is a point of contention where environmental groups have singled out the lack of detailed plans to assess whether or how ground water quality downgradient would be effectively mitigated (Western Watersheds Project v. US Department of the Interior 2021). The EIR indicated groundwater quality could exceed the standards for antimony, arsenic, sulfate, and TDS (BLM 2020; Penn et al. 2021). Thus, there is concern on the effectiveness of the current mitigation plan and a lack of transparency about the details of the plan itself.

Additionally, tailings noted above will be treated with sulfuric acid. Due to the scale of the mining operation at Thacker Pass, plans include the building of an on-site sulfuric acid plant. Some stakeholders believed this was a minor issue because the Lithium Nevada would be mitigating their impact with new technology, emitting less than 40 tons of SO2 per year, which amounts to 2% of current SO2 emissions from the nearby North Valmy power planted located in Valmy, Nevada (Lithium Americas 2021). Still, because of the extensive amount of sulfuric acid used on site, there are concerns from multiple environmental groups about air and water quality. Regardless of Lithium Nevada's technology, several stakeholders maintained the constant air pollution would have cumulative effects and the air quality in the area would decrease significantly.

2. Environmental Review Processes

The quality and extent of environmental analyses are major point of friction between stakeholders at Thacker Pass. The largest issues center on the normative standards of review, the environmental impact statement (EIS) produced for Thacker Pass, and reclamation policy.

2.1. Issues with Normative Standards

Several stakeholders thought current regulations and policies at the state and federal level lacked impartiality and the necessary rigor to perform an effective environmental review. The process of developing a mine starts with industry investigating the availability of mineral resources and committing its own financial resources to a proposed project. According to one environmental advocate, industry involvement at the beginning of the process is the first flaw. As a consequence, the same stakeholder noted, "the more money that's invested, the more likely a company will be unwilling to walk away from a project, even if it has fatal flaws. Instead, these companies double down." To fix this process, a stakeholder recommended that environmental reviews occur much earlier in the process, which would better inform decision making on whether or not a firm should pursue mining. Currently, industry is the often the first party to provide information to communities about a project. Another stakeholder stated, "the [company looking to mine] essentially come in with a sales pitch to the community. It can be ultimately and genuinely helpful, but really seems like an effort to assuage opposition. There is no sense of independent assessment."

When it comes to the EIS, there are significant concerns according to the majority of environmental stakeholders. One stakeholder commented that the EIS review process lacks the rigor it deserves: "it's an opportunity for developers and for the BLM [Bureau of Land Management] to check a box and say they did it." The stakeholder further commented this may also represent a lack of capacity and technical expertise by the government to perform these tasks. The issue of government capacity was brought up by each environmental organization that participated in this study. According to one stakeholder, agencies do have expertise on some, but not all, aspects of a project. Consequently, there are gaps. Another concern is regulatory capture

from federal agencies. Two stakeholders stated the BLM was too lenient with industry and the priorities of mining companies, neglecting their duty to administer public lands. This raises the questions of government agencies' objectivity and ability to provide an independent assessment.

Other stakeholders pushed back on the negative assessment of the environmental review processes by the state and federal government. County officials stated that the system as a whole is currently designed to meet the demands of all parties and believed the EIS and the Nevada mining permitting process is administered fairly. Another stakeholder maintained the integrity of the environmental review process, and also explained regulations are constantly morphing to meet current demands. They cited the Clean Air Act, the Clean Water Act, and National Environmental Protection Act (NEPA) as pieces of legislation that evolve and work to protect the environment. Despite the poor record of mining contamination in Nevada noted by every stakeholder, several stakeholders state that Nevada now has some of the most protective rules in the US and the most responsible reclamation policy on the planet. However, there are still shortfalls in regulatory policy according to those interviewed. Some cited the lack of consistency within government agencies such as the BLM. They said the same set of rules, regardless of a project, should be applied and that the process should be transparent. Another stakeholder commented that there can and always will need to be improvements, noting recent work on a bad actor mining bill that would disqualify any actor with a blemish on their record from violating environmental laws.

2.2. Thacker Pass Processes

While environmental stakeholders are concerned about the overall process of environmental approvals related to mining, there are specific concerns related to Thacker Pass. All environmental organizations expressed concern about the pace of the permitting by the BLM

through the EIS. The Trump Administration expediated the permitting process to six months, with final approval given approval in January of 2021, just before the Biden Administration took office. The process typically takes on average 3.4 years (deWitt and deWitt 2008). Now there is concern from all environmental stakeholders interviewed that Thacker Pass will be used as a standard for future mining projects, with a stakeholder commenting, "the way this was permitted and rolled-out sets an enormously bad example." County officials refute the idea that the EIS was fast-tracked, citing that Lithium Nevada had been reporting their findings to the BLM for the past seven years. To the County, the permitting process was not the six months of action from the EIS, but the years of preparation and mitigation planning. However, no environmental organization interviewed accepted this rationale and commented the EIS was of poor quality. All stakeholders noted that consistency between administrations representing opposing political parties is an underlying point of contention within government agencies.

Further, there is concern that given the urgency of climate change combined with the current federal administration's efforts to reduce emissions, the state and federal agencies will not hold Lithium Nevada as accountable for environmental compliance as they should. One environmental stakeholder believed more weight needs to be put on holistic approaches and long-term impacts, putting an emphasis on performing environmental reviews correctly so that ecosystems and people are not harmed as we attempt to address climate change.

2.3. Reclamation Strategies

Stakeholders agree that as an open pit mine, the Thacker Pass project will disturb the land and landscape. Still, the consequences of long-term impacts are disputed and raise questions about what the reclamation process will look like and how long will parties be responsible for the land itself. Two stakeholders explicitly mentioned that the mitigation plans for mine reclamation

and closure appear to be a box-checking exercise for the BLM and industry. They noted that a new framework is needed so that, “perpetual treatment would extend liability for decades to centuries, not just years. Previous efforts to return land back to its previous state have been terrible.” Another stakeholder mentioned the legacy of mining in the Intermountain West: “you can’t go fishing in some streams and rivers because of the mercury. This is the legacy of mining in the 1800s.” The stakeholder went on to ask, “Was this mining really worth all those metals? To be pulled out back then? Where we are now is no different”. Again, County officials referred to Nevada’s new mining policies, pointing to the work of the Reclamation Branch of Nevada’s Nevada Department of Environmental Protection (NDEP). As to not perturb the landscape drastically and leave an open scar in the land, Lithium Nevada plans to fill in the mine as they work for the next 41 years.

2.4. The Larger Issue: Federal Legislation

At odds with current conservation efforts at Thacker Pass is the larger framework that supports mining in the US, whose foundations rest on the General Mining Law of 1872 and the Mineral Leasing Act of 1920. Multiple stakeholders referenced the 1872 Mining Law as the cornerstone of how industry and society has approached mining for 150 years. According to these stakeholders, the law allows industry to follow a different set of rules that prioritizes “mining claims” over other land uses and environmental consequences. One stakeholder noted that the law was written in a different time and reflects different values, and that the US sees mining and conservation differently today: “the real issue is on the concentration of resources, but ‘resources’ is never interpreted as environmental resources, but solely as mineral resources. We need to broaden the scope of interpreting that law”. This relates to the Mineral Leasing Act of 1920 that prioritizes mining as the highest and best use for public land. In following these

precedents, a stakeholder commented, “nothing else matters.” Still, other federal and state legislation is used to guide permitting processes and protect water, air, and the surrounding environment. In sum, without changing federal legislation, environmental stakeholders believe the US will be caught in a cycle where mining outweighs all other potential land uses and allows industry to evade stronger regulations.

3. Community Engagement

The community engagement efforts of Lithium Nevada, Humboldt County, and BLM are described as insufficient by multiple stakeholders. While community engagement related to lithium extraction was raised as a stakeholder concern within the Salton Sea region, the level of outreach and inclusion noted at the Salton Sea stands in stark contrast to perceptions about the processes surrounding the Thacker Pass project. Common themes expressed by environmental stakeholders include limited interactions, objections to the degradation of cultural sites, and the inability of industry and government to convey the technical aspects and impacts of mining.

3.1. Community Interactions

The style and depth of interactions varied widely between Lithium Nevada, BLM, and the NDEP with community groups and tribes. The most significant concern for engagement was during the preparation of the EIS, which occurred during the global COVID-19 pandemic. Environmental groups described the interactions as minimal and strongly feel that a pause was necessary given the ongoing public health crisis. According to multiple stakeholders, many community members and tribes have a limited capacity to participate in public forums, and the added challenge of a global pandemic almost nullified the prospect of meaningful engagement.

Interactions with local and regional tribes appear to be especially problematic according to some interviews. Stakeholders noted that the engagement with local and regional tribes was

more limited than would be effective, noting three letters submitted to tribes as the scope of engagement witnessed (Aadland 2022). Most environmental stakeholders interviewed believed that tribes were not properly consulted: “if they [BLM] want to do this right, they need in-person engagement over a longer-period.” Engagement with tribes from a variety of stakeholders indicated there is not a uniform position by some tribal nations. One environmental stakeholder stated, “do we talk to the 30 or 40 people who are resisting this project, or do we talk to the 60 or more people who have submitted job applications for the mine. There’s no clear answer here.”

Several stakeholders noted the comment period was fairly limited at 30 days. One interviewee commented, “it was just ridiculous, having such a short time to review all those documents and then comment on them.” Nevertheless, there is dispute within the community about what should be done and who should be approached to address these issues. Outside the EIS, there were also various levels of community engagement and support based on geography. Some stakeholders noted that Lithium Nevada currently holds regular meetings with the Fort McDermitt Paiute and Shoshone Tribe and the City of Orovada that have changed as community concerns evolved. Larger questions about city infrastructure arose; some communities wanted to minimize industry impact while others sought to benefit from a larger presence of industry. In short, community interest is not monolithic, and outreach appears uneven. Nonetheless, one environmental stakeholder thought it was likely that most of the community would support the mine. The stakeholder also discussed the dynamic of community interests versus the priority of preserving land and wildlife and argued that preserving the land itself is more important than community interests.

3.2. Cultural Objections

There are objections over the use of the project site because of the cultural and historical significance of the area. One such issue revolves around reports of a Native American massacre having occurred at the project site, which is contested (Flin, 2021). The presence of the mine site has been contentious among and within tribes, with varying levels of support or disapproval (Bosler, 2021; Penn et al., 2021). Several stakeholders expressed concern about the massacre site, in addition to the cultural significance of the area for local tribes. Ultimately, they believed Thacker Pass should be off limits, noting that, "with cultural sites there's really no kind of mitigation. You can't move what's sacred."

Several tribes are engaged in the process of talking with Lithium Nevada, and others are engaged in a lawsuit over the project. The Reno-Sparks Indian Colony, the Northern Paiute group Atsa Koodakuh wyh Nuwu (the People of Red Mountain), and Winnemucca Colony filed a complaint against the BLM, alleging that the agency violated federal laws when issuing permits to Lithium Nevada. Among the complaints, the tribes allege that the BLM failed to identify historic properties on the Thacker Pass site (Rothberg, 2022; Scheyder, 2021; Turner, 2021). Although tribal considerations are important aspect of the Thacker Pass project, it must be noted that no tribal stakeholders were interviewed as part of this study, despite efforts to set up interviews. Thus, the multitude of voices from different tribes about this historical site and the prospect of mining are not represented here.

Additionally, there is another potential cultural site with artifacts from pioneers from the 19th century. An industry stakeholder commented that there was a team conducting a study of the area related to cultural sites, and would follow the required protocols, especially if human remains were found that could include potential remains from the aforementioned massacre.

3.3. Technical Expertise

Another component of community engagement is centered on communities' lack of technical expertise to understand project details. Every stakeholder, from environmental groups to industry members, commented on this issue. The responsibility of informing the public about the technical aspects of the project and its impacts most often falls to the industry itself. As mentioned previously, a problematic dynamic may exist if the companies presenting the information are also the ones benefiting from the mining operation.

Stakeholders shared several ideas in changing this dynamic and providing more education to community members. Multiple stakeholders used superfund sites as an example for how to move forward. Through the Comprehensive Environmental Response, Compensation, and Liability Act, communities can apply for technical support to get an analysis on some aspect of a site. A similar model could be adopted at Thacker Pass, as one stakeholder said, "what this really comes down to is the community needs to get good information." The challenge of this process relates to the initial exploration, assessment, and presentation of initial information by the mining company. Two different stakeholders called for an independent assessor to present the technical aspects, as they felt the industry and BLM were incapable of providing objective insights. Payment for this independent assessment would either come from the mining company or from a general royalty fund provided by the federal government through previous mineral extraction funds. Alternatively, the potential to use a nonprofit organization as an independent source of information was discussed. As a consequence of the current system, community members do not understand the details of mining processes and cannot advocate for themselves.

Those familiar with Lithium Nevada's operation and engagement commented that Lithium Nevada is attempting to be forthright and educate the community, with efforts still

ongoing. They also commented that there is a general shortage of experts from a workforce perspective in these kinds of operations as lithium exploration booms across the state and globe. Even though Lithium Nevada has been working on the conceptual idea of Thacker Pass lithium mining for several years, the implementation and production of the technical aspects of the project have occurred more recently.

4. Economic Impacts

County, industry, and a multiple environmental stakeholders noted that there are significant opportunities tied to lithium extraction at Thacker Pass. The two biggest benefits center on the large amounts of lithium production in the face of climate change, and the economic opportunities production would bring to the entire region. As one environmental stakeholder commented, "lithium is the most essential single ingredient for a rapid transition away from fossil fuels." They admitted the impact of mining would completely alter the area, and they also acknowledged that lithium from Thacker Pass would help the US shift away from importing lithium and batteries from countries that have less stringent environmental laws. Another stakeholder said projects like Thacker Pass are essential for the US to have energy independence and security, cautioning that the US relies too much on other sources for lithium.

The economic benefits of Thacker Pass could provide opportunities for the whole region according to county officials. Humboldt County currently has proposed two major operations that will help grow the local economy—the Thacker Pass project and a salmon farm. Both would result in around 300 jobs according to the County. County stakeholders expressed optimism about the benefits this would create for the region, meaning there would be additional ancillary businesses and general services that would grow from Thacker Pass and the salmon farm. Humboldt County officials said the projects presented an opportunity to build better

infrastructure, grow new business, and stabilize the County's economy. Additionally, they said it would allow the economy to diversify to let residents work in new fields and help retain families and college graduates from the area. An industry stakeholder posited that the jobs at Thacker Pass were not typical mining jobs, but technical positions with salaries that would start at $60,000 and average $100,000 per year. For context, the median salary for Humboldt County in 2019 f was $58,820 (U.S. Bureau of Labor Statistics 2022). However, stakeholders noted that government support is needed to help economic expansion—both in infrastructure and workforce development.

5. Bigger Questions

A larger theme emerged from conversations with stakeholders that largely focused on which communities were "being sacrificed" to meet domestic and global lithium demand, and the necessity to reduce demand for lithium and other raw materials. These concerns relate to larger socio-ecological considerations.

5.1. Sacrifice

In discussions with stakeholders about lithium mining, a common theme of sacrifice emerged—sacrifice of land, ecology, and people, some willingly and others not. As one stakeholder commented, "we're trying to decide how to design this economy of the future, it seems like we're going to use the same corporate extractive colonial models that we've built in the past and that's not going to solve our problems right now." Another commented, "what we're doing with the energy transition and the so-called critical minerals is that we're putting the burden of the transition upon the hand of communities." Some stakeholders insinuated rural communities were a sacrificial lamb to feed the ongoing needs of lithium demand. There is tension in this idea with disagreement on how much extraction is tolerable moving forward. One

environmentalist warned “we have to accept some collateral damage as we transition because right now the entire planet is suffering.” An industry stakeholder also said the US is entering a phase where people want minerals like lithium, but society does not want the impacts of those materials. They expounded further that if the US wants to take meaningful action to go electric or reduce their emissions as soon as possible, the materials for that infrastructure will bring some negative environmental impacts and potentially take a decade or more to build.

This brings out the dichotomy of needing to extract lithium to combat climate change versus protecting the environment at the cost of supplying a viable alternative to fossil fuels. However, multiple stakeholders rejected this idea, calling it a false choice. Rather, they said lithium extraction should be done elsewhere, just not at Thacker Pass. Yet, there was disagreement on this with some supporting direct lithium extraction (DLE), some just opposing Thacker Pass, and yet others calling for minimal or no extraction whatsoever. Still, one environmentalist commented, “we accept the ravages of mining because we feel that we need to have our devices and our cars.” They went on to say that without an internal reflection from society, communities and ecosystems will keep hurting.

5.2. Reduced Demand

Demand for lithium comes from societal and individual needs, including transportation, energy storage, and small technological devices like cell phones and laptops. At Thacker Pass, stakeholders made repeated calls for finding ways to reduce the societal demand for raw materials by changing energy habits and the design of cities, and by recycling lithium-ion batteries. One stakeholder thought attention should shift from lithium extraction to society itself. Rather than embracing mining, they commented, the US should be adopting stronger conservation codes. One stakeholder commented on inverting the sacrifice required by

communities: “we're all responsible for what's happening with changing climate, and we all need to take a hit in some way. I think we all need to say there's got to be some kind of shared sacrifice here.” Some supporters of the mine commented on the importance of embracing these policies, but also acknowledged that there is a significant time gap in having more transit-oriented cities, retrofitting buildings, and the emergence of a circular economy. The idea of changing consumptive habits in a privileged society like the US is almost intractable. Those opposed to mining at Thacker Pass counter that drastic change is unlikely if something is not done immediately to embrace the gravity of the moment.

VII. Concluding Policy Recommendations

The aim of this study was to answer the question: what state and federal policies could be enacted that would best promote lithium extraction in the Salton Sea and Thacker Pass that allow for environmental protection, while also supporting economic development and other social and public health benefits? It is a question that asks whether extraction can be done differently, whether policies can simultaneously facilitate low to no environmental impact, alleviate greenhouse gas emissions, achieve equitable economic outcomes, and ensure tangible community benefits. Can lithium extraction have it all? Given the divergent perspectives of stakeholders and complexity of issues raised during the stakeholder interview process, arriving at a simple answer to this question would be an oversimplification and still remains speculative.

The policies and frameworks that govern and guide lithium extraction at the Salton Sea and Thacker Pass, as well as the rest of the US, involve multiple spheres. Each extraction technology and extraction location have different needs. It seems multi-benefit lithium extraction is possible on different scales but is contingent on the action and implementation of federal, state, and local policies. This is further predicated on more abstract questions on what levels of

environmental impacts are acceptable, and who and how much should different communities, industries, and other entities benefit? Nonetheless, stakeholders identified several areas where improvements could generate sought-after outcomes. Specific recommendations include the following:

1. Decrease the demand for raw materials: As noted by all environmental stakeholders, the challenge is not to find new ways to responsibly consume more, but instead to consume less. The preservation of lands and waters will always be at odds with industry as long as there are competing interests that can commodify public goods. Reducing demand for lithium requires us to ask: why do we need it in the first place? The rapidly rising demand for lithium comes from multiple sectors, but the transportation sector is the main source. Reducing lithium demand means reducing transportation demand, which inevitably leads to how transportation infrastructure is developed in the first place.

One set of solutions looks to the relationship between urban areas and the urban form. Many cities, especially American cities, are designed on autocentric needs. Yet, changing the form of urban areas takes decades (Manville, 2017). Further, cars are for the most part needed to participate in American society (King et al., 2019). Based on decentralized employment concentrations, low-wage workers often have no other option than using a personally owned vehicle (Glaeser & Kahn, 2001; Pendall et al., 2016). US cities in the long-term need to prioritize transit solutions, first and last mile connections, neighborhood walkability, and consider zoning changes to modify the separation of housing from amenities. This is not the only answer to decrease lithium demand and does not directly address decentralized employment concentrations. Still, these set of solutions are part of a much broader topic and deserve their own respective attention. A deep body of literature already exists exploring these topics in-depth.

2. Incentivize urban mining and push a circular economy: One of the most pressing issues confronting lithium extraction and the energy transition is the exponentially growing demand of lithium and other critical mineral resources. Urban mining, otherwise known as recycling, needs to become a priority in order to reduce demand. In the next 10 years, the US will face its first surge of used lithium-ion batteries from electric vehicles that could be repurposed for either grid storage or used again for automotive transportation. Federal policy should require two actions: funding for urban mining technology and economic incentives for battery reuse.

Additional grant funding is necessary to support nascent industries and extend current research. Without federal intervention, there is no incentive for battery manufactures and automakers to recycle materials. As cobalt prices rise due to lack of supply, the economic incentive for recycling becomes stronger, but vehicle manufacturers are reducing the amount of cobalt in batteries because of cobalt shortages and child labor concerns. Potential actions to address this issue could either penalize firms for not recycling their lithium-ion batteries or pay firms to recycle them. In doing so, the US could commit to a circular economy, preserving land and alleviating tension on raw material demands.

3. Prioritize direct lithium extraction (DLE): Assuming that impacts associated with DLE in the Salton Sea would remain minimal as this technology type scales up, DLE appears to offer the lowest impacts of available extraction technologies. The use of geothermal energy offers additional benefits in the production of a consistent source of renewable energy. Locations like the Salton Sea Geothermal Field offers vast quantities of lithium that would help address US and perhaps global demand for lithium production. Other areas, such as Nevada and Arkansas, should be looked at for potential sites for DLE. Focusing on DLE could help assuage demand for

lithium in other areas that are more resource intensive and have stronger environmental impacts like evaporation technology or hardrock mining.

4. Reform extraction regulations through federal legislation: Extraction laws, particularly mining law, do not incorporate the societal values and concerns of our time. This brings up issues over competing land use interests, government objectivity and improved review processes, and long-term reclamation strategies. A combination of solutions to these problems would help shift US perspectives on sustainable resource extraction.

Foremost among mining law, federal legislation regarding mineral extraction is antiquated, as the General Mining Law of 1872 and the Mineral Leasing Act of 1920 continue to dictate mining policy. Conservation efforts are disregarded in the face of mining claims, with few exceptions such as protections from the ESA. Nonetheless, policy should require less than a species to be in peril to prevent environmental harm, as public lands and waters are held in the public trust. The state and federal governments have a duty to steward these lands and waters well for future generations, not just for short-term profits.

Further, broader and deeper efforts are required to independently analyze mineral extraction sites before, during, and after mining projects. Currently, industry performs initial surveys and explores the possibility of extraction using their own funding. As a result, companies have a strong economic incentive to follow through on a project if its profitable, regardless of severe environmental impacts. To address this issue, an independent organization with public trust or a government agency could instead perform initial site investigations. However, given the technical and propriety nature of extraction technologies and the multiple skillsets required to scope mining claims., this approach would be difficult to implement. BLM or other government

agencies would be overburdened by the task of scoping mining sites, especially considering there are over 11,000 lithium brine claims in Nevada alone.

As an alternative, two specific actions could be undertaken to address the issue of industry involvement and lack of transparency in the environmental review process. However, these solutions are not comprehensive and other actions are still required. First, an EIS could be required earlier in the review process. Second, a federal mineral royalty tax could be established for multiple purposes, including recuperating lost capital expenditure costs for firms or providing additional resources to allow more efficient environmental reviews. As part of these changes, standardized and formalized participant and community engagement needs to accompany the EIS process. While this engagement is currently required, the Thacker Pass project demonstrates that it can be limited and narrow. With added capacity, BLM could provide a more in-depth process to let communities voice questions and challenges.

Lastly, reclamation accountability needs to endure for the length of time that impacts are felt from mining activities. Nevada is one of few states to have an updated reclamation law that was passed in 1989. The law provides cradle-to-grave oversight of all exploration and metal mining projects in the state. This should be required at the federal level. Additionally, the Nevada law should require reclamation over a longer time span. The impacts of mining do not cease in the years after mining has stopped but can continue for generations. Perpetual reclamation efforts could be funded by the above noted federal mineral royalty.

5. Enhance federal and state environmental agency capacity: Associated with the previous point, every stakeholder commented on the time-consuming approvals process and the lack of capacity of both federal and state agencies. Regulations are helpful in ensuring projects safeguard against adverse impacts. However, with limited capacity and technical expertise, the

process is back-logged and uneven across projects. Government agencies need more capacity to perform a more robust environmental analysis and engage communities in a more widespread fashion. Agency budgets are dictated by the current federal administration. Therefore, to ensure consistency over time, some mechanism is required to shield agency budgets from the pivot swings of federal elections. Without proper funding, a land management agency such as the BLM that lacks capacity will inevitably underperform and instill a lack of confidence in the public. What this mechanism could be remains unknown and needs further research.

Overall, this strategy could touch upon all environmental agencies, but in terms of lithium extraction, this has application to specific governmental bodies. For the Salton Sea and California, on a local level, this includes local air monitoring districts, water districts, and the governments of Imperial and Riverside Counties. Just as important, the capacity of the Lithium Valley Commission and the larger California Energy Commission need further support and expansion. In Nevada, agency support is needed on several levels including the Bureau of Mining Regulation and Reclamation, the Nevada Department of Wildlife, and funding to help enhance tribal agency capacity. On the federal level, this entails the US Department of Energy and the BLM.

6. Inclusive community economic development and government support:

Communities should have a guiding voice in the development of industry that directly impacts their homes and livelihoods. All aspects of the community should be represented and included as part of the decision-making process. This is taking place in some form in the Salton Sea, though it should be repeated elsewhere and expanded on given noted shortcomings on transparency and engagement strategies. If lithium-ion battery related industries locate in areas like the Salton Sea, federal government assistance is needed on multiple fronts. First, financial support is needed to

help expand and improve infrastructure that minimizes environmental impacts and ensures current residents benefit from infrastructure upgrades. Secondly, government assistance is needed to bolster workforce development programs and ensure local residents have opportunities to access quality jobs with livable wages.

VIII. Future Directions

The recommendations above serve as potential solutions, as recommended by stakeholders, to the challenges associated with lithium extraction. Additional stakeholders from the Salton Sea and Thacker Pass should be interviewed, particularly those representing government agencies, industry, and tribes. Further, stakeholders working within geographies with other prominent lithium deposits should also be interviewed. While Nevada and California will drive government and industry standards related to lithium extraction, other states with less regulatory oversight require attention as well. Each sub-topic discussed including environmental impacts, environmental review processes, community engagement, and economic impacts deserve their own attention to explore policy recommendations in-depth. Stakeholder interviews could focus on policy and regulatory processes to build a more robust analysis of competing and complementary demands. One point of focus could be to elicit feedback on how to address gaps in either the CEQA or NEPA permitting processes. Other topics need their own attention as well, including the developing field of lithium-battery recycling. All policy recommendations should be assessed on their own to enlighten their effectiveness, constraints, and viability.

Appendices

Appendix A

Interview Protocol

Research Question: *What state and federal policies could be enacted that would best promote lithium extraction in the Salton Sea and Thacker Pass that allow for environmental protection, while also supporting economic development and other social and public health benefits?*

Framing (3 min)
I want to thank you for taking time out of your schedule for this interview. 30 minutes is short, so I'm going to go ahead and get started.

My plan is to briefly go over the purpose of what and why I'm interviewing you, privacy concerns, and ask a few questions with additional prodding questions in a loose format. Does that sound alright to you?

About Me:
I'm a Master of Urban and Regional Planning student at UCLA focusing on economic development and environmental policy. I'm working with The Nature Conservancy (TNC) to identify how and if lithium production can be done in a way that protects the environment, while also gauging if policy can support economic development, and other social and public health benefits. To do this, I am interviewing stakeholders and experts about lithium production and potential opportunities and hazards. I am here to speak your expertise/role in **[specific discipline or organization-geothermal energy, species protection, etc.]** in **[the Salton Sea/Thacker Pass**]. This information will be synthesized by myself and potentially used by TNC to see what action, if any, is needed to advocate for policies in **[the Salton Sea/Thacker Pass]**. My hope is for this interview to be a loosely structured conversation where you can speak to what you think is most important.

I take privacy seriously. I sent you a form detailing this study last week. Do you have any questions? Are you still willing to participate?

Before we start, may I record this interview? The recording is strictly for my own use so I can transcribe our conversation. It will not be shown to anyone else.

Questions (25 min)
Note: *Questions are divided into the following sections: Opening, Regulatory Processes, Benefits, Challenges, and Recommendations. Prodding questions beneath numbered questions will be used to dig further into subject content and the interviewee's expertise. Not all questions will be appropriate for each stakeholder. Bolded sections in brackets will change according to the interviewee. Based on interviewee responses, questions may not be asked in chronological order as numbered below. The structure is intended to allow for the interviewee to speak to what's most important to them.*

Main Questions

1) Why does lithium extraction in [**Thacker Pass/the Salton Sea]** represent to you? Why is it important?

2) What are the most significant challenges, if any, facing lithium extraction in **[Thacker Pass/the Salton Sea]?**

3) Are there environmental impacts you are concerned about?

4) With current federal and state regulatory laws, do you believe lithium extraction can be done in a way that protects the environment?

5) How would you improve regulatory processes?

6) What are the greatest benefits, if any, to extraction in **[Thacker Pass/the Salton Sea]**?

7) How has engagement with your organization **[organization or invested interest]** looked like in the run-up to lithium production; (*alternative question if stakeholder is driving lithium production engagement)* How has your **[organization]** engaged with other organizations in the run-up to lithium production?

8) Do you have any policy recommendations, regulatory or otherwise, regarding lithium extraction?

Prodding Questions for Each Main Question

Opening (3 min)

1) Why does lithium extraction in [**Thacker Pass/the Salton Sea]** represent to you? Why is it important?
   a) What is your vision of this region 10 and 50 years from now?

Challenges (8 min)

2) What are the most significant challenges, if any, facing lithium extraction in **[Thacker Pass/the Salton Sea]?**

General

a) Why should this be a larger concern?
b) Are there policies in place to help this prevent/overcome this challenge?
c) Do you see a way forward to resolve any disputes?

Industry and Jobs

a) What processes within the actual production can be done to make the industry more sustainable?

Health and Environmental Justice

a) Do you have concerns that this will negatively affect the health of local communities?
b) Have government or industry officials done anything to mitigate concerns? Is more work needed?

3) Are there environmental impacts you are concerned about?
    i) Do you have specific concerns around water and water usage, land use, air, or impacts on animal and plant life?
    ii) *Transition response to regulatory protections*

Regulatory Processes (5 min)

4) With current federal and state regulatory laws, do you believe lithium extraction can be done in a way that protects the environment?
    a) Are the any shortcomings in current regulatory frameworks?
    b) Are any rules or regulations not being applied?
    c) Are environmental protections too prohibitive or not go far enough?

5) How would you improve regulatory processes?
    a) What kind of oversight, if any, is needed?
    b) Are there alternative models you would like to see applied?
    c) Do you believe reported data required by state and federal regulations is sufficient?
    d) Is there other data or information that would be helpful to have from proposed lithium sites?

Benefits (3 min)

6) What are the greatest benefits, if any, to extraction in **[Thacker Pass/the Salton Sea]**?
    a) How will these benefits distribute on national, regional, and local levels?
    b) Are there any other associated benefits from extraction local communities will experience?

Community and Stakeholder Engagement (4 min)

7) How has engagement with your organization **[organization or invested interest]** looked like in the run-up to lithium production; *alternatively,* How has your **[organization]** engaged with other organizations in the run-up to lithium production, for example local community based groups, government agencies, or environmental groups?
    a) Who are the most important stakeholders in lithium production?
    b) Are there groups that should be consulted that have not been included?
    c) How do you envision engagement occurring in the future?
    d) Knowing what you know now, would you do anything differently?
    e) There is some opposition to extraction with___, do you see any way to resolve this conflict?

Recommendations (5 min)

8) Do you have any policy recommendations, regulatory or otherwise, regarding lithium extraction?

a) How can the **[Nevada/California**] and federal government better support your vision of **[Thacker Pass/the Salton Sea]**?

Bonus

a) Are policies beyond the extraction segment of the supply chain needed to ensure environmental protection? (Cell components and electronics manufacturing location, recycling, societal behavioral changes)
b) Around $7 billion was set aside from the recent Infrastructure Investment and Jobs Act for the lithium battery supply chain. How you think some of this money should be spent in **[Thacker Pass/ the Salton Sea]**?

Closing (2 min)

That wraps up my line of questioning. I want to thank you again for your time. I appreciated the opportunity to speak and listen to you. I think your insights, perspective, and expertise are important to understanding lithium production and its real world implications. If I do have any follow-up questions to clarify any statements, do you mind if I reach out to you via email?

[I believe I have everything I need, especially since I have this recording.] Do you have any last questions for me?

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