especially migratory birds, suffer from high heat produced by reflections and from disorientation caused by the lake-like appearance of the farms from the air.[13] The beautiful and exotic nature of the desert has been traded for the benefits, environmental and economic, of green technology and city expansion. Lancaster, though, has mounted investigations and created laws that have led to wildlife preserves and limits on where development can occur.[14] As the city has moved forward with green technology projects, it has been recognized by the State of California as an exemplary "green" city, a model for future developments in sustainable cityscaping. Air pollution has been dramatically reduced, much of the city's electricity needs are cleanly met, and jobs have been created, all benefiting Lancaster tremendously. I only wonder if in our vision for the future, we have lost sight of the place we call home.

13 "Solar Farms Threaten Birds," Scientific American Global RSS, http://www.scientificamerican.com/article/solar-farms-threaten-birds/.

14 "Supervisors Knock down Antelope Valley Wind Turbine Study," http://latimesblogs.latimes.com/lanow/2012/01/antelope-valley-wind-turbine-plan.html

Bunker Hill Mining and Metallurgical Superfund Site

Candice Peters

Writers' Comment: I wrote "Bunker Hill Mining and Metallurgical Superfund Site" in my senior year at UC Davis, for Dr. Robert Rice's "Toxic Tragedies" class. Majoring in Environmental Toxicology, my background at that point was primarily in the science behind environmental contamination. Writing this paper allowed me to explore the impact industrialization and pollution can have on specific communities. I am grateful to have had the opportunity to investigate the human and political aspects of environmental toxicology.

Instructors' Comment: Our society is faced with recurring toxic tragedies in the workplace, in consumer products and in the environment. Often society responds slowly, where resolution may require a century of struggle. A legacy is a notable distrust that citizens feel toward social institutions (industry, government) reflected today in bitterly partisan opinions on topics such as mining activity (including fracking), global climate change and food safety (including genetically modified organisms). We see a continuing tension between safety and productivity, between regulation and personal liberty. The tragedy of lead includes its use in indoor paint and as a gasoline additive as well as the refining process, of which this paper describes an egregious example. We must hope that examining these failures of the market system will help us understand how to improve toxic regulation and to reduce the impact of future tragedies.

– Robert Rice, Department of Environmental Toxicology

The Bunker Hill Mining site is the most egregious example of heavy metal pollution to have occurred in the United States. Established in 1885, the Bunker Hill Mining Company shaped both the economic development and the environmental destruction of northern Idaho. Extraction and purification of heavy metal ore produces contaminant-laden air emissions along with wastewater tailings. The local community noticed the deleterious effects of the company's pollution as early as 1899. Farmers with land downstream from the operation complained of run off damaging their property and injuring their livestock. The farmers filed an injunction with the courts to stop operations, which the company fought tooth and nail. In 1910, the US District Court awarded one dollar in reparations to sixty landowners (Aiken, 1994). This confrontation between the farmers and the company would set the stage for decades of legal battle. In 1983, the US Environmental Protection Agency (EPA) declared Bunker Hill a superfund site after over a century of mining activity. The site encompasses 21 square miles in the Silver Valley of the South Fork of the Coeur d'Alene River. This area is currently home to more than 7,000 people in five residential areas, many of whom still deal with the toxic legacy left by the Bunker Hill mining company (Sheldrake & Stifelman, 2003).

The company's construction of a lead smelter in 1917 cemented Coeur d'Alene as a mecca of silver and lead production. Upon completion, the smelter was the largest of its kind in the world. Bunker Hill officials hoped to eliminate their dependence on the Guggenheim-controlled Smelter Trust, as well as cut down on freight and production costs. The officials were also aware of the accompanying unhealthy lead emissions, as multiple studies on the subject had already been conducted in Europe (National Academies, 2005). The town of Kellogg was selected as the site of the smelter over other options such as Portland, OR because officials determined that fewer people would be affected by the emissions in Kellogg. The company preemptively received assurance from the US government that it would not be sued for environmental damage resulting from the smelter. In return, Bunker Hill promised to pay for any resulting damage. Furthermore, the officials knew of the dangers posed to metal workers. Dr. Royd Sayers, a medical professional working for the Bureau of Mines, wrote to Bunker Hill manager Stanly Easton with suggestions to protect worker health. He emphasized the importance of controlling fumes, but the company chose instead to focus on employee

hygiene as the primary means of reducing lead exposure. Men afflicted with lead poisoning were transferred away from the smelter, and the company blamed the poisoning on workers' inability to adhere to protocol (Aiken, 1994).

By the 1920s, community members were becoming increasingly aware of the noxious smoke. Resident Matt Kaiser had been complaining since the introduction of the smelter, and in 1925 he threatened to take Bunker Hill Mining Company to court. The Bunker Hill Company was equally successful in defending against this legal attack as before against the farmers. Stanly Easton and the company did try to remedy the situation with the installation of a baghouse, a building fitted with large cloth bags to contain emissions. The baghouse was only moderately effective at capturing the potential airborne pollutants, and it did nothing to curb the amount of mining tailings being released into the nearby waterways. During the early 1930s, a Coeur d'Alene Press editor, John Know Coe, was able to draw greater community attention to the gross pollution of Lake Coeur d'Alene. He published a series of articles lobbying state and local government to act. Coe pointed to Canadian mines, which achieved similar production rates with significantly lower environmental impact. In rebuttal, the company produced extremely biased studies from the US Bureau of Mines demonstrating little to no impact (National Academies, 2005). This resulted in other local newspapers attacking the Coeur d'Alene Press for threatening the mining industry and therefore the economy of the area. The Idaho State Legislature nevertheless responded to Coe's accusations by creating the Coeur d'Alene River and Lake Commission. Experiments by Dr. M.M. Ellis of the US Bureau of Fisheries concluded, "There is but one solution for this pollution problem as far as fisheries are concerned, namely the exclusion of all mine wastes from the Coeur d'Alene River" (National Academies, 2005). Unfortunately, environmental efforts lost momentum during the Great Depression and World War II.

After the war ended, concerns about public health began to reemerge. The passage of the Water Pollution Control Act and the Mining Waste Pollution Control Act by Congress in 1948 placed renewed pressure on the Bunker Hill Mining Company. The company added a new acid plant to collect sulfur dioxide emissions and improved smoke stacks on the smelter (National Academies, 2005). Though these small steps did help diminish environmental impact, workers at the plant continued to be

exposed to dangerously high levels of heavy metals. In 1961, an anonymous group of workers under the name of the Committee for United Trade Union Activity acted upon the renewed environmental interest to shed light on the Bunker Hill lead problem. The Committee wrote a public letter to the Governor of Idaho, Robert Smylie, pleading for an investigation into the health effects of lead on the workers and residents of Kellogg. The letter received a great deal of attention from the press, prompting the Bunker Hill Mining Company to maintain a facade of environmental consciousness. By the mid 1960s, Bunker Hill's expenditures on pollution control exceeded $8,000,000 (Aiken, 1994). The mill tailings were diverted into settling ponds instead of being dumped directly to the river. A wastewater treatment plant was installed. While these measures dramatically increased water quality, the citizens of the Coeur d'Alene Valley still considered environmental pollution their most important quality-of-life issue (National Academies, 2005).

With the passage of the Clean Air Act and the Federal Water Pollution Control Act of 1970 and 1972, respectively, ever increasing pressure was placed on the company to improve conditions. The downfall of the Bunker Hill mining company began shortly thereafter, on September 3, 1973. The primary air pollution control device, the baghouse, caught fire. Two sections of the bag itself and the roof were destroyed. State health officials investigated the site of the fire, and determined that the damage was great enough to substantially increase emissions if production continued. Nonetheless, the two sections were not replaced until November of 1973 and March of 1974. While the smelter was without a fully functional baghouse, the price of lead was skyrocketing, so smelter production increased. The average lead emissions increased from 11.7 tons per month to 35.3 tons per month after the fire (Aiken, 1994). Problems for the Bunker Hill Company continued through 1974. In April, two children in Kellogg were hospitalized with symptoms of lead poisoning. The same month, numerous horses in the area died, and the company paid reparations for nine of the animals. Bunker Hill sent out warnings to all landowners informing them of the accumulation of lead in the area, admitting a possible contamination problem and advising against allowing livestock to graze on the land (Aiken, 1994).

The increased ambient lead levels following the fire attracted the attention of the EPA and the community. By 1977, nine more families had brought suits against the Bunker Hill Company, demanding com-

pensation for health problems in their children. On September 28, 1978 the EPA established an ambient air lead level standard of 1.5 micrograms per cubic meter. The Bunker Hill Mining Company, along with other smelters, believed this restriction was economically and technically infeasible. Bunker Hill spent over $20 million to increase pollution control, but nevertheless received non-attainment status (National Academies, 2005). The company responded by ending their cooperation with the government and sealing their records. The State of Idaho, the EPA and the Occupational Safety and Health Administration (OSHA) placed ever increasing regulatory pressure on Bunker Hill. The expenditures to keep up with the new regulations, coupled with competition from new smelters forced Bunker Hill to close down operations in the fall of 1981. Over two thousand workers lost their livelihoods. Superfund legislation was passed in 1980, and by 1983 the Bunker Hill Mining and Metallurgical complex was placed on the National Priorities List for cleanup (Aiken, 1994).

Two major human health studies were conducted during the course of Bunker Hill mining operations. The first came in 1974. Within one mile of the smelter, the ambient air lead levels exceeded 20 μg/m3. House dust was 1.2% lead by weight on average. Blood lead levels in school children in the closest town to the smelter, Smelterville, averaged around 70 μg/dL. The second study came in 1983 when the area was decreed a superfund site. Blood lead levels in preschoolers averaged 21 μg/dL. The primary route of exposure was determined to be ingestion of contaminated soil and dust from normal play and hand to mouth contact. The EPA set a goal in 1991 to lower children's blood lead levels to less than 10 μg/dL, and by 2001 only 3% of children exceeded this level (Sheldrake & Stifelman, 2003).

The high blood lead levels found in the Bunker Hill community are particularly concerning when the many detrimental health effects of lead are considered. Chronic toxicity usually occurs when blood lead levels reach 40 μg/dL. The nervous system is the primary target of lead toxicity, with both the central and peripheral systems affected. Lead exposure can lead to encephalopathy, with symptoms including poor attention span, memory loss, hallucinations, muscle tremors and headache. Higher exposures can lead to paralysis, coma and ataxia. Young children and fetuses are most susceptible to nervous system disorders because proportionally more lead is circulated into the brain during development. At

low levels, lead exposure can lower children's IQs, alter behavior patterns and decrease ability to concentrate. Lead damages the peripheral nervous system by breaking down the myelin sheath. This impairs the nerve's ability to transduce impulses, leading to extreme muscle weakness and lack of coordination (Flora et al., 2012).

The primary mechanism of lead toxicity in humans is induction of oxidative stress. Oxidative stress occurs when free radicals are produced too quickly, and antioxidants present in the body cannot detoxify them quickly enough. Lead reacts with substances present in the body to form reactive oxygen species, including superoxide, singlet oxygen and hydrogen peroxide. Reactive oxygen can cause DNA damage and protein oxidation. In addition to producing free radicals, lead can also bind to and deactivate glutathione, the primary antioxidant available to reduce reactive oxygen species. This reduces the body's ability to deactivate the reactive oxygen species (Flora et al., 2012).

Since the declaration of a Superfund site, huge strides have been taken to reduce blood lead levels through clean up of the century's worth of contamination in the Coeur d'Alene Valley. In 1985, the Lead Health Intervention Program was created in an effort to quickly lower blood lead levels in children. The program focused on education of the public and on parental counseling, in conjunction with biological monitoring (Sheldrake and Stifelman, 2003). This allowed the community to take steps toward healthier blood lead levels while the large-scale cleanup began. Cleaning the soil was identified as the best way to lower lead concentration in air, water and dust, subsequently lowering blood lead levels. Environmental objectives were set for clean up of all yards and commercial properties with lead concentrations above 1000 mg/kg and to achieve interior dust lead levels of under 500 mg/kg in community homes. Removal of just the top 30 cm of contaminated soil and installation of a clean soil barrier can lead to a blood lead level decrease of 1.7 ug/dL in an average two year-old. A further reduction of 5.6 ug/dL can occur upon cleanup of the greater community (Sheldrake and Stifelman, 2003). To date, two million cubic yards of contaminated soil have been removed, 400 acres of safe habitat for waterfowl have been created, and 1,000 acres of hillside have been revegetated.

The EPA is continuing to implement this clean up project. Soil and blood lead levels are still being monitored. The contiguous yard clean up and soil removal continues, with an emphasis being placed on high-risk

homes, such as those with small children or pregnant women. Within the next ten years, the EPA also hopes to address the problem of road damage from the clean up effort (EPA, 2013). The restoration continues 130 years after mining operations began, a haunting testament to the long-lasting impact of human expansion.

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