

**MAKING WATER PURE: A HISTORY OF WATER SOFTENING
FROM POTASH TO TIDE**

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ABSTRACT

Making Water Pure: A History of Water Softening from Potash to Tide, is a history of water softening in the United States from 1860 through 1970. Water's materiality, specifically its tendency to dissolve geological features, consistently interfered with labor processes, especially those that relied on the use of soap or steam. For this reason, the management and control over the quality of water in both domestic and industrial spaces was regular and in many cases economically imperative. Nineteenth-century laborers dealt with hard water on the individual level. They experimented with a variety of different chemicals and methods, including the addition of lye, coffee, blood meal, and wool fiber to water. Throughout the twentieth century, the requirements of industrial efficiency as well as new consumer technologies demanded fast, easy, and standard ways to soften water. This motivated manufactures to produce mechanical water softening systems and synthetic chemicals. This dissertation traces this change and asserts that the history of getting water soft is a history of environmental control and management. Water softening is a lens through which to explore often overlooked actors in the history of managing nonhuman nature such as women, domestic workers, laborers, home economists, advertisers, and commercial chemists. Hard water is a thread that connects usually separate categories such as the home and the factory, industrial chemicals and household cleaners. The control over water was uneven and incomplete and allows for the exploration of the tensions intrinsic in the attempted mastery over nature. The regularity of making soft water reveals not only society's relationship with water, but the social nature of water itself. Water is a product of ecological, social, and technological discourses and practices-- a hybrid of both environment and culture. To soften water was

to make nature fit; it was an effort to standardize nonhuman nature so that it would cooperate with certain technologies, processes, and cultural assumptions.

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CHAPTER 1 MAKING PURE WATER: AN INTRODUCTION

In the late 1960s, American newspapers reported that waste water polluted with laundry detergent was killing lakes.¹ To be more exact, complex synthetic phosphates in detergents caused massive algae blooms or eutrophication. Mats of green smelly algae covered the surfaces of lakes across the United States. As algae multiplied, they gobbled up oxygen and caused fish and other aquatic life to die. In response to pollution, grass roots organizers, state and local governing bodies, and the federal government all contemplated how to control the situation. People involved, as well as historians who later studied these incidents, seemed to miss the irony of eutrophication in lakes.² Ecological chaos in lake water was the result of a product intended to control water in the home. In the 1940s, detergent chemists had added phosphates to laundry detergents to subdue the salts present in hard water, common throughout the United States. These salts reacted with other material in detergent and disrupted the cleaning process. The eutrophication controversy was about water pollution, but it was also about water control. The story of control over hardness in water, or water softening, began long before the

¹ See for example, Sherwood Davidson Kohn, "Warning: The Green Slime is Here," *New York Times* March 22, 1970, page 232; "The Eutrophication Menace," *New York Times* Dec 16, 1969, page 46.

² Although historians have produced excellent works having to do with eutrophication, none discuss phosphates as a water softener. On cultural eutrophication see, William McGucken, *Lake Erie Rehabilitated: Controlling Cultural Eutrophication, 1960s-1990s* (Akron, Ohio: University of Akron Press, 2000); Terence Kehoe, *Cleaning Up the Great Lakes- From Cooperation to Confrontation* (DeKalb: Northern Illinois University Press, 1997). For an account written by a limnologist see also W.T. Edmondson, *The Uses of Ecology: Lake Washington and Beyond* (Seattle: University of Washington Press, 1991) see especially chapter 3, "The Detergent Problem," 89-138.

1960s. Phosphates are one example of many products and processes people created to control the minute ions of water. Since at least the early nineteenth century, people have endeavored to make water that is better suited to their needs. To soften water was to make nature fit.³

Making Water Pure is a history of people's relationship with hard water through the lens of labor, as well as the chemicals and technologies they produced to soften hard water, between the 1860s and the 1970s. Water is an extremely important substance for domestic and industrial labor. Yet water, and more specifically its penchant to dissolve minerals, proved quite antagonistic particularly when used with soap or in the steam boiler. The natural minerals in hard water interfered with the proper function of both technologies. For this reason, people defined hard water as bad and in turn attempted to change the materiality of water. To remove minerals, or to make water soft, was a process by which people acted upon nonhuman nature to regulate its chemical variability in an attempt to make it conform to their needs. Doing this was easier said than done. Water is a fickle compound, and its unruliness often tempered people's efforts at control. Various water softening processes discussed in this dissertation greatly improved water quality and therefore the function of some tools used for labor. Others, however, introduced environmentally disastrous chemicals into waterways. As people made water better in one place, they could also make it worse in another.

³ Douglas C. Sackman, "Putting Gender on the Table: Food and the Family Life of Nature," in Virginia J. Scharff ed. *Seeing Nature Through Gender*, (Lawrence: University Press of Kansas, 2003) 173. When he says people are making nature "fit" Sackman is referring to anthropologist Claude Levi-Strauss's argument that humans use fire to turn food from raw to cooked, thus making it nature fit for human use.

Water is a hybrid material, a product of both nature and culture. People not only changed the chemical makeup of water, but they also projected onto it various cultural beliefs about race, gender, and class. At any time, water could be hard or soft, bad or good, evil or not, high- or low-class even Christian or un-Christian. The materiality of water, its chemical and ecological characteristics, played a role in shaping human perceptions and responses to water and indeed, their fellow humans. Ultimately, a history of water softening reveals not only the history of a society's relationship with water, but the social nature of water itself. Water is a product of social, economic, and technological discourse and processes. This is exemplified most clearly in the fact that hard water is actually the norm, or the most "natural," water in the United States. Yet people's propensity to see it as something unnatural, underscored by the reference to softening water as "fixing" or "normalizing" it, provides a clear indication of the social nature of water.

In the nineteenth century, water users dealt with the problem of hard water on an individual level. Launderers used cisterns to catch rain water, generally considered free of minerals. They also added homemade caustic soda or lye to their wash tubs depending on how hard their water felt. Industrial workers too approached hard water as individuals, experimenting with different compounds and methods they heard rumors or gossip about. People understood the nuances of water they used through the productive work that they did both within and outside of the home. They defined water that left unsightly soap scum on clothes or scale in a boiler as bad and hard and soft water as clean, good, and pure.

Throughout the twentieth century, a barrage of water softening products enabled people to soften water more efficiently, but also distanced them from the act of changing

water. In the 1880s, a new industry dedicated to softening water began to make some chemists and entrepreneurs a lot of money, a response to the growing demand for soft water in the industrial sector. By the early 1930s, they also saw the opportunity for profit not just in industrial spaces but in domestic spaces as well. Labor in the home, especially new consumer technologies such as washing machines, which became popular after World War II, demanded water with low hardness. The requirements of both industrial and domestic technologies spurred innovations in commercial water softening products. Just as dams fed the needs of industrialization and consumption with larger quantities of water in the early twentieth century, chemists, scientists, engineers, home economists, and advertisers ensured the proper *quality* of water for these processes. After World War II, chemists increasingly built water softeners into products intended for other uses with water for example laundry soap. In doing so they introduced products that removed users from the water softening process. Users knew little about the ways in which the chemicals they used acted upon nonhuman nature.

The amount of time and effort people spent combating hard water in the United States is not surprising. After all, some amount of hardness is present in water in nearly every state in the country. Hardness is measured by the amount of dissolved minerals present in water, most often calcium and magnesium ions. Sulfates, chlorides, and bicarbonates,

also occur naturally in hard water, owing to water's role as a universal solvent.⁴ These ions enter water through the leaching of rocks, minerals, and soils in bodies of water and underground aquifers. In a 1923 survey of municipal water supplies across the country, the United States Geological Survey (USGS) found that municipal water plants in thirty states contained hard water.⁵ The survey did not consider users of well water, which tend to have a higher hardness and would probably have increased the number. It can be reasonably assumed that all well water users would have at least moderate hardness. A later report published in 1962 found that in a survey of the one hundred largest cities in the United States, only twenty-nine cities reported soft water.⁶ Municipal softening is the exception and not the rule in the United States. Engineers decided in the early twentieth century that the softening process was not worth the cost. In fact, some locations add

⁴ Water's role as a solvent is the property that underlies historians' exploration of water pollution. Joel Tarr, *The Search for the Ultimate Sink: Urban Pollution in historical perspective*, (Akron, OH: University of Akron Press, 1996); Martin Melosi, *Precious commodity : providing water for America's cities* (Pittsburgh, PA: the University of Pittsburgh Press, 2011); Martin Melosi, *The sanitary city: environmental services in urban America from colonial times to the present* (Pittsburgh, PA: the University of Pittsburgh Press, 2008); on the chemistry of waters see, Samuel Faust, *Chemistry of Natural Waters* (Ann Arbor, Mich.: Ann Arbor Science, 1981).

⁵ W.D. Collins, *The Industrial Utility of Public Water Supplies in the United States*, United States Geological Survey, Department of the Interior, (Washington: Government Printing Office, 1923).

⁶ Charles N. Dunfor and Edith Becker, *Public Water Supplies of the 100 Largest Cities in the United States, 1962*, Geological Survey-Supply Paper 1812 (Washington DC: Government Printing Office, 1962), 27.

hardness minerals to water because soft water can erode pipes.⁷ The map below, Figure 1, created by the USGS with data collected in 1975, shows the regularity of hard water in the United States.⁸ While locations along the eastern seaboard and northwest have relatively soft water, the rest of the country has moderately or harder water. Having low hardness, however, does not necessarily mean minerals do not influence labor. Even a low amount of hardness, for example thirty milligrams per liter, can produce problems for both workers and machines. The map should not indicate that water hardness is static. Heavy rain, flooding, and draught can influence the movement of water and therefore hardness. Yet at the same time, since geological features remain static, ground waters would have had similar hardness for long periods of time.

⁷ Dunfor and Becker, *Public Water Supplies of the 100 Largest Cities in the United States*, 27. On municipal softening see, C. Hershel Koyl, "Practical Water softening for Municipalities," *Municipal Journal and Engineer*, vols. 20 & 21 1906: 309-11, 9-12; Julian Griggs "Report of Committee on Water Works and Water Supply," *Municipal Engineering* vol. 31, 1906: 344-46. Despite the feasibility and popularity of water softening, the application of these techniques remained sparse among municipal water works systems. One reason for this was economic, but another hinged on competing definitions of pure water. Sanitary engineers and public health officials, the people who made decisions about municipal water works, did not consider hard water impure the way that actors involved in industry did. The need for the removal of germs as well as to make water physically agreeable for customers is discussed prominently in works of sanitary engineers at the turn of and first decades of the twentieth century. See M.N. Baker, *Portable water and methods of detecting impurities* (New York: D. Van Nostrand company, 1899); George Whipple, *The Value of Pure Water* (New York: Wiley, 1907).

⁸ John C. Briggs and John F. Ficke, *Quality of Rivers of the United States, 1975 water year; based on the National Stream Quality Accounting Network (NASQAN)* (Reston, VA: U.S. Geological Survey, 1977).

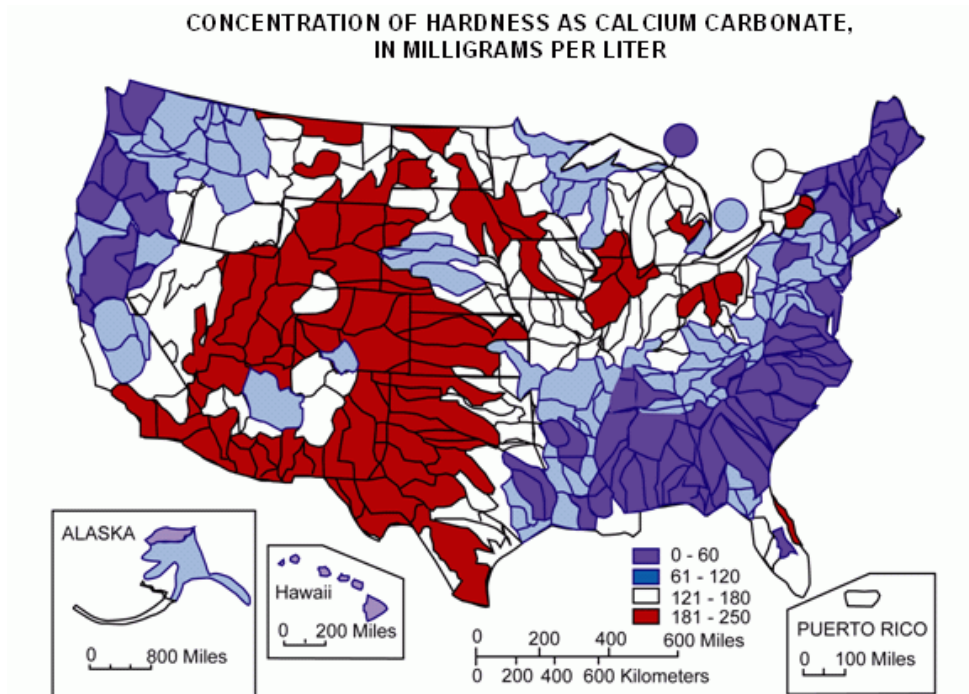


Figure 1. Hardness Map of the United States. United States Geological Survey, 1975.

A Brief History of Hard Water

This story begins in the immediate post-bellum United States, a period which saw great change in water softening techniques and the availability of those techniques. While people managed the hardness of water prior to 1860, several changes during the late nineteenth century brought water softening into the forefront of people's lives in new ways. However, the timing of this story should not give the impression that people did not consider hard water before this period.

Hard water aggravated perhaps the most well-known ancient hydraulic systems, the Roman aqueducts. In a technical survey of the Roman aqueducts, the classics scholar Rabun Taylor noted that maintenance workers needed to reach nearly every part of the system because of "...the swift and inexorable accumulation of calcium carbonate, or

lime.”⁹ This maintenance was required because water used in these systems was extremely hard. The volume of water also caused the quick accumulation of mineral deposits. Roman labor needed to regularly remove deposits so they did not block aqueduct channels.

In the seventeenth century, alchemists and chefs differentiated between using hard and soft water. Early modern alchemists in the European context relied on both hard and soft water and the ability to know the difference for their work. In one entry of John French’s 1667 edition of *Art of Distillation*, a recipe called for the use of soft water. French recommended that for the calcination of crystal, which referred to the calcination of lime, one should add the crystal to a fire, grind it into a fine powder, wait eighteen hours and then put it into rain water or “May dew.”¹⁰ In another recipe, French instructed readers to use common water. French most likely meant hard water when he referred to common water. The first known entry for soft water in the Oxford English Dictionary was also in the seventeenth century. Thomas Tyron’s 1691 book of cookery called *Wisdom’s Dictates* called for the use of good soft water in boiling peas.¹¹ These examples

⁹ Rabun Taylor, *Public Needs and Private Pleasures: Waster Distribution the Tiber River and the Urban Development of Ancient Rome* (Roma: L'erma di Bretschneider, 2000) 30.

¹⁰ John French, *The Art of Distillation: or a Treatise of the Choicest Spagyricall Preparations, Experiments, and Curiosities, Performed by way of Distillation* (London: Printed by E. Cotes for T. Williams at the Bible in Little-Britain, 1667) *Othmer Library of Chemical History Rare Books Collection*, Science History Institute, Philadelphia, PA.

¹¹ Thomas Tryon, *Wisdom’s Dictates, or, Aphorisms & Rules, Physical, Moral, and Divine, for Preserving the Health of the Body, and the Peace of Mind...to Which is Added a Bill of Fare of Seventy Five Noble Dishes of Excellent Food, for Exceeding those Made of Fish or Flesh*, (London: Printed for Tho. Salisbury, 1691) 164.

make clear the importance of understanding the variation in water for early modern alchemy and cookery, yet they offer little in evidence that these practitioners made any effort to soften hard water. More than likely, they relied on a cistern to catch rain water, considered soft water. Launderers throughout this period probably also preferred soft to hard water and relied on rain catchment devices. Unfortunately, these sources are more difficult to capture as seventeenth century laundresses were less likely than alchemists to record their work.

Hard water is not always bad, and it had value for different purposes. For example, brewers preferred to use hard water. In an article about water used for brewing in 1879, the author wrote, "...it necessary follows that hard water which contains those salts is not nearly so extractive as soft; we can, therefore, retain by using it, more saccharine matter in our beer, and thus, to a great extent, diminish the risk of its becoming acid."¹² Salts in hard water helped ensure the proper pH balance in beer. Within the brewing community, people agreed that hardness salts in water improved taste and preservation of finished beer. People also valued hard water for its restorative properties, specifically in mineral springs.¹³ Throughout the eighteenth century in Europe, doctors, landowners, and boosters touted local mineral springs for their

¹² Harry Yerburgh, "Water for Brewing," in Joseph Holmes, ed., *A Series of Prize Essays on Practical Brewing* (Leeds: Joseph Holmes, 1879) 72. See also Alexander Morrice, *A Treatise on Brewing* (London: Knight and Compton, 1802) 83.

¹³ Although people thought mineral waters had restorative properties, many people also believed hard water should not be drank.

medicinal purposes.¹⁴ They promoted the power of high concentrations of minerals in springs and streams including those containing hardness minerals such as magnesium sulphates, commonly called Epsom salts, and other minerals such as Sulphur. Although the actual medical properties of these springs remains questionable, they attracted visitors with a resort like atmosphere. The historian of science, Christopher Hamlin, emphasized the importance of analyzing waters with high mineral content in the history of water analysis. In fact, in the early nineteenth century the first water analysis came from business interests connected to mineral springs of spa towns in Europe. Hamlin noted that these analyses were a stepping-stone to more scientific analysis of the late nineteenth century.¹⁵ Both brewing and mineral springs proved people accepted and valued hard water depending on the context.

In many contexts, people thought that hard water was bad. For this reason, chemists experimented with water softening in the eighteenth century. In the 1730s, a London chemist, Peter Shaw, discovered that alkaline salts, such as the sodium carbonate common in soap making, reduced water hardness.¹⁶ In Edinburgh in 1756 a Dr. Francis Home conducted forty-five experiments to soften water. He used alkaline salts, such as soda ash, potash, or lye, with hard water in order to precipitate the hardness minerals. Dr.

¹⁴ Christopher Hamlin, *A Science of Impurity: Water Analysis in Nineteenth Century Britain* (Bristol, UK, and Berkeley, CA: Adam Higler and University of California Press, 1990) see especially chapter one “The Most Difficult Operation in Chemistry: The Analysis of Mineral Waters” 16-47.

¹⁵ Hamlin, *A Science of Impurity*, see especially chapter two, “Water Analysis and the Hegemony of Chemistry, 1800-40” 47-73.

¹⁶ Moses Baker, *The quest for pure water; the history of water purification from the earliest records to the twentieth century* (New York: American Water Works Association, 1949) 415-439.

Home purported this simple discovery would make the hardest of water fit for all use. Two years later a Dr. John Ruttly, another chemist, examined thirty-eight springs of water in Dublin. He believed knowing water's hardness was invaluable information, writing that without properly understanding water's variety, "we could not but at random be supplied with gruel, puddings and even a smooth mixture or milk and water."¹⁷ In the European context, the interest in the chemistry of hard and soft water did translate into some large-scale effort to soften water in the early nineteenth century, although these softening plants serves as an exception and not a rule.¹⁸

This dissertation is about changing hard water into soft water. It was only in the beginning of the eighteenth century that chemists began to experiment with changing the chemical makeup of water to make it soft. This dissertation is situated within the acceleration of that change, roughly the end of the nineteenth century when a broad group of people attempted to make hard water soft. During this change, new technologies related to industrialization made soft water a necessity. Chemists and commercial entrepreneurs offered something novel, products that could erase the problems of specific places, removing water from its geological context. Instead of removing minerals from an aqueduct or simply relying on rainwater, the people in the period of this study began to consider ways to change the mineral make up of water, instead of merely dealing with its consequences. The trend of changing water continued into the twentieth century as people made their own soft water.

¹⁷ Quote from John Ruttly, *A Mythological Synopsis of Water* in Baker, *The quest for pure water*, 418.

¹⁸ Baker, *The quest for pure water* 420- 425.

Historians, History, and Water

What do scholars talk about when they talk about water? The body of scholarship that deals with water is vast, ranging from histories of flooding to the ways humans have tried to control rivers.¹⁹ Historians have framed entire schools of thought around bodies of water, notably Atlantic History, treating oceans and seas as places of exchange, conflict, and interaction.²⁰ This dissertation stands alone as a scholarly pursuit into the history of water softening.²¹ Studying hard water requires a different approach to the history of water, one that favors a water molecule over an entire river or ocean, emphasizing water's ecological materiality. Its focus is not on a history of hard water, rather hard water in history. Using an interdisciplinary approach from environmental history, science, technology, and society studies, and geography, it argues for in interactive relationships between culture and water to accomplish three tasks: define water as a social entity, explore its role in envirotechnical systems, and finally underscore the

¹⁹ For two general historiographical journal articles that deal with the breadth of histories dealing with water see Sebastian R. Prange, "Scholars and the Sea: A Historiography of the Indian Ocean," *History Compass* 6, (September 2008): 1382-1393; see also, Matthew Evenden, "Beyond the Organic Machine? New Approaches in River Historiography," *Environmental History* 23 (2018):698-720.

²⁰ For just two examples for Atlantic history see, Bernard Bailyn *Atlantic History: Concept and Contours* (Cambridge, MA: Harvard University Press, 2005); Jack Greene and Philip Morgan, eds., *Atlantic History: A Critical Appraisal* (Oxford: Oxford University Press, 2009).

²¹ Published histories that do fall under the subject of hard or soft water fall into two categories: corporate histories and technical manuals. On corporate histories see, Nalco Chemical Company, *Finding the Customer Need and Filling it: A History of the Nalco Chemical Company* (Naperville: Nalco, 1989); On the history of the alkali industry used in water softening see, Dow Chemical Company, *Dow Soda Ash*, (Midland, Michigan: Dow Chemical Company, 1957); on softening in technical manuals see, Charles P. Hoover, *Water Supply and Treatment* (Washington, DC: National Lime Association, 1951), 76- 111; Betz Laboratories, *Betz Handbook of Industrial Water Conditioning* (Trevose, PA: Betz Laboratories, 1991).

importance of water quality for industrialization in the late nineteenth century and consumption in the early twentieth. The tools of industrial and consumer capitalism demanded soft water. Therefore, people defined and changed the water they used.

Hard water is a social as much as an environmental substance. Environmental historians have done much work in defining water as not merely an artifact of nature but also culture characterizing nonhuman nature as something hybrid. Geographers and anthropologists ascribe to a similar theory preferring to explore what they call the social nature of water.²² Both disciplines agree, in the words of Richard White, that nonhuman nature is “at once a cultural construct and a set of actual things outside of us and not fully contained by our constructions...”²³ To say that water is a cultural construct is clear from its multiple meanings; water is a singular object with multiple ontological forms. People understand water as tool, a border, an annoyance, a resource, a medium of social

²² For the hybrid turn in environmental history see, Richard White, “From Wilderness to Hybrid Landscapes: The Cultural Turn in Environmental History,” *Historian*, 66 (Fall 2004), 557–64; Richard White, *The Organic Machine: the Remaking of the Columbia River* (New York: Hill and Wang, 1996); William Cronon, “The Trouble with Wilderness; or, Getting Back to the Wrong Nature,” in William Cronon, ed., *Uncommon Ground: Rethinking the Human Place in Nature*, New York: W.W. Norton & Co., 1995, 69-90; Christopher C. Sellers, *Crabgrass Crucible: Suburban Nature and the Rise of Environmentalism in Twentieth-Century America* (Chapel Hill: The University of North Carolina Press, 2012); Kendra Smith-Howard, *Pure and Modern Milk: an Environmental History Since 1900* (Oxford: Oxford University Press, 2013). Anthropologists have used the different meanings of water across cultures and societies to point to the social nature of water. On this see, Clifford Geertz, “The Wet and the Dry: Traditional Irrigation in Bali and Morocco,” *Human Ecology*, Vol. 1, No. 1, (March 1972): 23-39. On the dialectical approach to water and society see, Jamie Linton, *What is Water? The History of Modern Abstraction* (Vancouver: University of British Columbia Press, 2010), 24-46.

²³ White, *The Organic Machine*, x.

relations, and a corporeal necessity.²⁴ Water also has inherently ecological characteristics. Its materiality, specifically its propensity to dissolve other substances, makes it an extremely diverse and complex substance. It is within this tension, between society's intended role for water and its ecological materiality, that people impart definitions onto water. Hard water is an example of the social constitution of different waters. Water is not a thing, rather a process that is constantly changing in both ecological materiality and cultural understanding. The tension reveals a dialectical or reciprocal relationship between water and people.²⁵ People and water continuously make and remake one another.

This dissertation emphasizes the relationship between water and diverse groups including women, laborers, commercial chemists, home economists, and advertisers. Historians that write about the social nature of water too often focus on the role of engineers, policy makers, public health officials, and scientists, all important actors in the

²⁴ For works that deal with the multiple ontologies of water see, Julian Yates, Leila M. Harris, Nicole J. Wilson, "Multiple Ontologies of Water: Politics, Conflict, and Implications for Governance," *Environment and Planning D: Society and Space*, 2017, Vol. 35(5) 797-815; Patrick Carroll "Water and Technoscientific State Formation in California," *Social Studies of Science*, Vol. 42, No. 4, Water Worlds (August 2012), 489-516; Stefania Barca, *Enclosing Water: Nature and Political Economy in a Mediterranean Valley, 1796- 1916* (Cambridge: The White Horse Press, 2010). Emma Norman, *Governing Transboundary Waters: Canada, the United States, and Indigenous Communities* (New York: Routledge, 2014).

²⁵ On the dialectical approach to water and society see, Jamie Linton, *What is Water? The History of Modern Abstraction* (Vancouver: University of British Columbia Press, 2010), 24-46. See also Karl Wittfogel, *Oriental Despotism: A Comparative Study* (New Haven: Yale University Press, 1957); Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West*. (New York; Oxford: Oxford University Press, 1992).

processes of defining water, however not the only ones.²⁶ This dissertation introduces new characters who also used, defined, and engaged in relationships with water.

Throughout history, these people knew nature most intimately through the work that they did. By focusing on water used for labor, this dissertation recovers the history of people's everyday interactions with water. Home launderers consistently defined the water they used and in turn it influenced their household hydraulic systems. Railroad mechanics too demarcated water. Both did so in a more immediate and less scientific manner than historians tend to give their focus. Situating hard water alongside human history is important because it extends the analysis of hybrid or social nature of water beyond the laboratory or the engineering library into the homes of nineteenth century women and along water stations throughout the country.

Hard water consistently interfered with labor related technologies, thus it lends itself to an envirotechnical approach. An envirotechnical approach emphasizes seeing the

²⁶ See for example Chang, *Is Water H2O? Evidence, Realism and Pluralism* (Boston Studies in the Philosophy of Science, 2012); Joel Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspectives* (Akron, OH: The University of Akron Press, 1996); Paul Charles Milazzo, *Unlikely Environmentalists: Congress and Clean Water, 1945-1972*, (Lawrence, Kan.: University of Press Kansas, 2006); Martin Melosi, *The Sanitary City: Environmental Services in Urban America from Colonial Times to the Present*, (Pittsburgh, Pa.: the University of Pittsburgh Press, 2008); On water law see, see Donald Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902* (Albuquerque: University of New Mexico Press, 1992), Pisani, *From Family Farm to Agribusiness: The Irrigation Crusade in California, 1850-1931* (Berkeley, CA: University of California Press, 1984), Norris Hundley, *The Great Thirst: Californians and History* (Berkeley, CA: University of California Press, 1992. On irrigation and other large-scale projects see, Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1986); Carol Sheff, *The Artificial River: The Erie Canal and the Paradox of Progress, 1817-1862* (New York: Hill and Wang, 1996) A departure from this is Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and their Land* (New York: Basic Books, 2012).

environment as a part of technological systems, interrogating the boundary between nature and technology.²⁷ In the case of locomotives and doing the wash, tools for labor and water were both interdependent and interactive.²⁸ Exploring these relationships using hard water uncovers often overlooked envirotechnical systems. While historians such as Mark Feig and Jeremy Vetter have used an envirotechnical perspective for the formation of railroads, neither extends their analysis into the maintenance and management of railroads.²⁹ Railroads relied on vast quantities of good quality water. The proper function of rail roads was as much a mechanical as environmental endeavor.

²⁷ On envirotechnical systems see, Smith-Howard, *Pure and Modern Milk*; Sara Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhone*, (Cambridge, MA: Harvard University Press, 2011); Jeremy Vetter, *Field Life: Science in the American West During the Railroad Era*, (Pittsburgh, PA: University of Pittsburgh Press, 2016); Thomas Hughes, *Human-Built World: How to Think about Technology and Culture* (University of Chicago Press, 2004); Camille Lyans Cole, "Precarious Empires: A Social and Environmental History of Steam Navigation on the Tigris," *Journal of Social History*, Volume 50, Issue 1, 1 September 2016, Pages 74–101; On envirotechnical disasters see, Lisa Ruth Rand, "Falling Cosmos: Nuclear Reentry and the Environmental History of Earth Orbit," *Environmental History* 24, (January 2019): 78-103; Sara Prichard, "An Envirotechnical Disaster: Nature, Technology, and Politics at Fukushima," *Environmental History* 17, (April 2012): 219-243.

²⁸ On the interdependent and interactive nature of technologies see, Hugh S. Gorman and Betsy Mendelsohn, "Where does nature end and culture begin? converging themes in the history of technology and environmental history," in Martin Reuss and Stephen H. Cutcliffe (eds.), *The Illusory Boundary: Environment and Technology in History* (Charlottesville and London: University of Virginia Press, 2010): 265-291.

²⁹ Jeremy Vetter, *Field Life: Science in the American West during the Railroad Era* (Pittsburgh, Pennsylvania: University of Pittsburgh Press, 2016); Mark Feig, *The Republic of Nature: an Environmental History of the United States* (Seattle: University of Washington Press, 2012).

Similarly, historians have not yet extended the envirotechnical approach into the home.³⁰ Cisterns, washboards, washing machines, and water all made up parts of the home washing system, an amalgam of technology and non-human nature. Too often historians fail to see nonhuman nature within the walls of the home. In other words, sometimes the hybrid nature of water can go too far in one direction as people define water in some places as solely a cultural artifact. The tendency to see water indoors as a product of culture, manipulated by humans in such a way as to render it unrecognizable from its natural state, has effectively erased the natural variation of water in the home. An envirotechnical approach reasserts the presence of nature in the home.³¹ Even as water became increasingly wrapped up in the realm of culture at the end of the nineteenth century, specifically treated and connected to pipes, it still contained within it ecological variation, most obviously hardness minerals. Therefore, to focus on laundry work as an envirotechnical system reveals the constant battle between launderers and nonhuman nature.

³⁰ Historians have done much to extend a technological history of the home, however few deal with these technologies as envirotechnical. See Ruth Schwartz Cowan, *More work for Mother: the ironies of household technology from the open hearth to the microwave* (New York: Basic Books, 1983). Cowan explores technological systems that are outside of the home, but stops short of an envirotechnical approach.

³¹ For examples of histories that emphasize the environment indoors see, Douglas Sackman, "Putting Gender on the Table: Food and the Family Life of Nature," in Virginia Schaff, ed., *Seeing Nature through Gender* (Lawrence: University Press of Kansas, 2003): 169-194; Michelle Murphy, *Sick Building Syndrome and the Problem of Uncertainty: Environmental Politics, Technoscience, and Women Workers* (Durham: Duke University Press, 2006).

An envirotechnical approach revealed the stakes of using the wrong kind of water in labor practices and therefore the impulse to soften water. During the nineteenth century hard water interfered with the efficient function of locomotives and washboards and soap. At the turn of the twentieth century, hard water continued to cause problems in the industrial sectors as high-pressure boilers made older softening techniques obsolete. Hard water also affected technologies for the home including such as the automatic washing machine and the automatic dishwasher making clothes and dishes appear dirty and dingy. The proper function of the tools and machines of industrialization and mass consumption demanded a certain quality of water. The effect of hard water on the tools of labor changed the relationship between people and water. They defined hard water as bad and in turn this reinforced the act to changing water through softening.

The requirements of envirotechnical systems that relied on soap and steam galvanized the commercial production of water softening techniques that attempted to standardize water throughout the twentieth century. In turn, soft water lubricated the needs of an expanding industrial and consumer society. I situate this argument within recent scholarship on modern water. Geographers most frequently employ the term modern water which has roots in environmental history, specifically the work of Donald Worster. Describing the American West, Worster wrote that it is a culture and society that is “built on, absolutely dependent on, a sharply alienating, intensely managerial relationship with nature.”³² Speaking specifically about water, he argued that this managerial relationship alienated water from its wider environmental and cultural contexts. In Worster’s account, hydraulic engineers used science as well as the power of

³² Worster, *Rivers of Empire*, 5.

the state to bring increasingly larger quantities of water to people, turning nature into a natural resource. In turn, this water fueled economic modernization. Industrialization, urbanization, and agricultural modernization required increasingly higher quantities of water at the end of the nineteenth century.³³ Modern water is this highly abstracted water, removed from its cultural or environmental contexts employed to fuel economic modernization. In short, modern water helped build the modern world but did so by separating it from people and place. Water softening is a part of modern water. While an industrialized economy increasingly needed larger quantities of water, it also demanded high quality water. Water softening and the close attention to water quality in industry and the home provide an example of the frequent manipulation of water to turn it into a usable and therefore valuable resource through standardization and management.

There are consequences to modern water illuminated by water softening. The geographer Jamie Linton wrote that “Modern water rests on the presupposition that water and society are fundamentally distinct, which allows us to imagine that we can manipulate water without profound social consequences.”³⁴ Synthetic laundry detergents

³³ For the most comprehensive work on modern water see, Linton, *What is Water?* See also, On the transition from an empirical view of water to a scientific view see, Christopher Hamlin, “‘Waters’ or ‘Water’? –Master Narratives in Water History and their Implications for Contemporary Water Policy,” *Water Policy*, Vol. 2, Issue 4-5, (2000): 313-325.

³⁴ Jamie Linton, “Modern Water and its Discontents: a history of hydrosocial renewal,” *WIRES Water* 2014, 1: 110-120. The idea of modern water closely aligns with argument made by Carolyn Merchant that during the Scientific Revolution people increasingly came to understand nature as something separate from people that required domination, see Carolyn Merchant, *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper & Row, 1980); see also Carolyn Merchant, *Ecological Revolutions: Nature, Gender, and Science in New England* (Chapel Hill: University of North Carolina Press, 2010).

with built in water softeners, and the pollution they caused, epitomize an example of the environmental consequence of modern water. These chemicals changed the makeup of water, abstracting people from the natural ecological variation of water as well as what they put into their water more generally. An analysis of how synthetic chemicals changed water reveals a domestic counterpart to the modernization of water.³⁵ If steam engines and industrial plants required soft water so too did the bathtub, automatic washing machine, and automatic dishwasher. Manufacturers needed to acquaint the public not only with these new technologies, but also the correct type of water they required.

By unraveling the social nature of water and its role in certain envirotechnical systems, this dissertation attempts to reacquaint water within its historical, social, and environmental context.³⁶ In this way, it offers a critique of modern water. To standardize water quality, in effect removing it from its social or environmental context, was contingent on decisions made by commercial chemists, laborers, advertisers, and consumers throughout the late nineteenth and early twentieth centuries. At the same time,

³⁵ Karen Bakker, “Water: Political, biopolitical, material” *Social Studies of Science*, Vol. 42, No. 4, Water Worlds (August 2012), 616-623. On the rise of water use in the home see, Joel Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, Ohio: University of Akron Press, 1996) especially chapter seven, “Water and Wastes, a Retrospective Assessment of Wastewater Technology in the United States, 1800-1932” 179-217.

³⁶ For other works that do this see, Jessica Teisch, *Engineering Nature: Water, Development, and the Global Spread of American Environmental Expertise* (Chapel Hill: University of North Carolina Press, 2011); Sara Prichard, “From hydroimperialism to hydrocapitalism: ‘French’ hydraulics in France, North African, and beyond” *Social Studies of Science*, Vol. 42, No. 4, Water Worlds (August 2012), 591-615; Konstantinos Chatzis and Gabriel Dupuy, “How to dispense with empiricism: the ‘Caquot formula’ and post-war drainage policy in France,” *Water Policy*, Vol. 2 Issue 4-5, 2000, pages 267-281.

the need for soft water underscores the importance of quality water in twentieth century modernization. If industrial modernization relied on modern water, then so too did mass consumption in the postwar period.

Overview of the Dissertation

The history of water softening is fruitful, interdisciplinary, and sometimes even a little weird. For these reasons, this dissertation examines the history of water softening not from one narrow perspective, for example the history of water softening as a business, rather it casts a wide net, focusing on stories and events that underscore the broad history of water softening in relation to labor. Laundry work plays a large role in the story. This is because laundry work, more so than other labor in the home, required soft water.

Demands for soft water was the loudest in places like domestic manuals in the nineteenth century and consumer research reports in the 1940s. Chapter one and chapter four deal directly with products and processes for getting clothes clean throughout the second half of the nineteenth century and the post war period respectively. Chapter two introduces the need for soft water in the industrial sector from roughly 1870 through 1910 by examining softening along rail lines. Rail roads are not just a case study for industrial softening, but exemplify the growing demand for more efficient softening techniques in the era of steam. Chapter three, set between 1924 and 1940, melds the history of industrial and domestic softening together using the Hagan Engineering Company as its subject. The company synthesized an efficient water softening chemical for use in industrial work, an amalgam of complex phosphates. The company also introduced this chemical into American homes as a product that could make soft rain water. This chapter is set in both

the laboratory and the home. By the 1950s, complex phosphates could be found in nearly every American home. The organization of this study is chronological, although the epilogue suspends chronology to suggest some broad currents and thoughts about water during the American Environmental movement. To explore these facets of the history of hard water, I utilize diverse archival sources including domestic manuals, corporate records, and scientific journals. The mix of business, consumer, and scientific sources suggest the wide cast of people who engaged hard water throughout American history.

Chapter one examines hard water in the laundry from the end of the Civil War through the first decades of the twentieth century. The sheer amount of water used in getting clothes clean warrants an examination of people and nonhuman nature when doing the wash. Nearly all launderers agreed that soft water should be used in the laundry. The difficulty of washday meant that the use of soft water took on an amplified importance. The diverse group of people engaged in laundry work, including free black women, native and immigrant white women, Chinese men, and white men, yields a fruitful examination of people's relationship to hard water. These diverse experiences illuminate the ways that gender, class, and race shaped how people used, defined, and changed the quality of their water. This chapter serves to not only explore the methods in which people softened water but also how cultural factors defined these interactions.

Like soap, locomotives also demanded soft water to avoid boiler scale and to function efficiently, the subject of chapter two. Unfortunately, this was something railroad workers understood only after railroad hydraulic systems were firmly in place. New technology, such as the multitube steam boiler, exacerbated the situation and made traditional techniques for dealing with hard water obsolete. This chapter traces a shift

from experimental softening methods employed by individuals through the growth of commercial companies and laboratories that enabled railroad workers to outsource questions about water to chemists. By the early twentieth century, railway workers could send a sample of water along a rail line to Chicago or Philadelphia to have it analyzed in a lab. In turn, these companies returned a nicely packaged compound that would change the nature of water along a rail line. In doing so, commercial companies took the responsibility for both knowing and changing water away from individuals. They employed science to correct water. In both chapters one and chapter two, people defined good or pure water in relationship to the outcome of technologies such as soap or the steam boiler.

Chapter three continues to see people's commitment to making good water in the industrial sector while expanding into domestic spaces. The first part of the chapter recounts a partnership made in the early 1920s between the United States Bureau of Mines and the Hagan Corporation of Pittsburgh, Pennsylvania. The partnership employed chemists to explore more efficient ways to soften water for boilers. The partnership represented a modern social and scientific research project. The result was the application of a complex phosphate compound, sodium metaphosphate, for use in industrial boilers. The company celebrated their technological triumph, invoking the discourse of power over nature and male technological triumph. In 1927 the company began marketing sodium metaphosphate for use as a home water softening chemical called Calgon. The company marketed their product as something that could make water natural and normal, ironically defining water full of laboratory made chemicals as natural. Many homemakers adopted Calgon as it suited the needs of new technologies such as the automatic washing

machines and dishwashers. An examination of both sodium metaphosphate and Calgon revealed the similarities between industrial and household softening methods.

Recounted in chapter four, by 1950 soap manufacturers used complex phosphates to create synthetic laundry detergents with built in water softening abilities. This marks a change from previous water softening techniques. Synthetic detergents represented a transfer of softening water directly into a product not meant specifically for that purpose. Their adoption by women in the home was based on their performance in automatic washing machines and their ability to work in both hard and soft water. It is in this chapter that the environmental consequences of water softening come to light. Phosphates, carried into waste water, caused widespread pollution. This chapter explores the pollution conflict considering how gendered prescriptions tied to synthetics shaped the conflict. This chapter shows the environmental consequences of attempting to control and standardize water throughout American households. It was within the context of changing ideas about the environment and water that American women confronted the pollution problem. Commentators beckoned women to choose between clean clothes and a clean environment. Their actions in the market proved they wanted both.

The epilogue pulls back from the specific problem of eutrophication in water to focus on pollution control more broadly. As the federal government allocated money into the field of pollution control beginning in the 1950s, companies involved in water softening pivoted to pollution control. The epilogue uses the Calgon Corporation to suggest the period between the 1950s and 1970s offered unique financial opportunities to interests involved in water quality. Leaders at Calgon embraced pollution control, using their experience with water softening to jockey for government contracts related to waste

water treatment. Marketing executives at Calgon relied on an intimate relationship with water in order solve the country's most pressing environmental problem.

Hard water matters because people interacted with it daily. In the nineteenth century people organized their homes around hard water. Railroad mechanics scraped its residue from the machines in their charge. Chemists diligently worked to make a cleaning product immune to hard water. Water softening reflected a century long process of attempting to make water fit for labor. Measuring the success and failures of this attempted standardization fill the pages of this dissertation. The regularity of attempted control over the chemical variation of nonhuman nature reveals the interconnected relationship between ecology, technology, and people throughout history.

CHAPTER 2
DOMESTICATING WATER: CULTURE, ENVIRONMENT,
AND LAUNDRY 1840-1919

Laundry work is a lens through which historians can make sense of the dialectic relationship between humans and nature, as well as the hybrid, or social, nature of water. When doing the wash, water is critical. In a nineteenth-century household, one wash and rinse of the family laundry required approximately fifty gallons, or about four hundred pounds of water. Generally, launderers washed once per week, using 2,600 gallons of water per year.¹ Washerwomen or laundresses, women who took in the washing of other people's families, used even more water, sometimes washing as much as seven days a week. Using that much water meant there was a connection between both humans and nature. It is the burden of this chapter to explore those relationships.

The relationship between people and water was contingent on the local chemical and ecological makeup of water itself. When women noticed that water caused wasted soap and a grey color in clothes, they deemed that water hard water. They concluded it was unacceptable in the wash; soft water was the panacea for all water ills. Hard water was an annoyance that filled the pages of women's advice columns and domestic manuals. Fanny Field, writing in the Housekeeper section of the *Ohio Farmer* in 1880 claimed, "...hard or broke water isn't fit for a Christian woman to wash with any way..." Likewise, a contributor to the magazine wrote in 1903 that, "Hard water is an

¹ Susan Strasser, *Never Done: A History of American Housework*, (New York: Pantheon Books, 1982) 105.

abomination in kitchen, laundry, or bath.”² Fortunately, launderers knew how to both acquire and soften water. Launderers’ knowledge of the nuances of water reveal a distinct environmental knowledge, the ability to identify hard water and subsequently manipulate its minute ions to soften it.

Cultural factors including gender, class, and race influenced how and to what degree launderers used water in the wash. There were a variety of historical actors engaged in laundry work throughout the nineteenth century. Rural, middle class, and working-class women, interacted with the water for the wash differently. In rural American homes, gendered work customs dictated how men and women used with water. As men managed water outside of the home, women remained the experts and managers of water within the home, especially as it related to domestic labor. Since laundry work necessitated soft water, rural Americans associated soft water with women.

Beginning in the 1830s, domestic advice literature encouraged middle class women, who employed domestic workers, to understand housework for instructional purposes. They pushed the labor, and with it the risks, of the laundry onto the bodies of working class laundresses, both white and black. Of course, what is considered domestic work existed outside of the home at the turn of the century, therefore, this chapter also examines laundry work in commercial laundries and as a subject in university settings. By the end of the nineteenth century, both Chinese and white men did laundry work, in

² Fanny Field, “The Housekeeper, Home Papers. – No. 3.” *Ohio Farmer*, April 3, 1880, 222; “The Farm Water Supply,” *Ohio Farmer*, December 5, 1903, 24.

the case of the latter, staffed by women.³ White laundry owners emphasized their access to clean and soft water through technological means to thwart their competition, Chinese laundry owners and washerwomen. Around the same time, domestic scientists, tasked with creating informed consumers within the context of a burgeoning consumer culture, increasingly talked about water for the wash as a scientific tool, reinforcing a new ontology of water. Broadly then, this chapter highlights moments from roughly the 1840s to the 1910 in which people thought about and interacted with hard and soft water in diverse ways related to getting clothes clean.

Gender and Water in the Rural Household

Rose Granger, a character in a parable published in an 1884 edition of the *Michigan Farmer*, loved her husband, St John., but she noticed his lack of vigor when it came to household responsibilities. On one summer day in their new home, Rose readied for washing by organizing the copper kettle to boil water, two tubs for soaking and rinsing, soap, and the washboard. When Rose went to gather the water, she saw that their cistern was empty.⁴ A leak had rendered the rain catchment device useless. St. John saw no

³ Historians have explored laundry work done by each other these individual groups, yet rarely pay attention to the role that water played in the work. See, Tera Hunter, *To 'Joy My Freedom: Southern Black Women's Lives and Labor After the Civil War*, (Cambridge, MA: Harvard University Press, 1997); Arwen Mohun, *Steam Laundries: Gender Technology, and Work in the United States and Great Britain, 1880-1940* (Baltimore, MD: The Johns Hopkins University Press, 1999); Joan Wang, "Gender, Race, and Civilization: The Competition between America Power Laundries and Chinese Steam Laundries, 1870s-1920s" *American Studies International* 40, (Feb., 2002):52-73; David Katzman, *Seven Days a Week: Women and Domestic Service in Industrializing America*, (New York: Oxford University Press, 1978).

⁴ "Miscellaneous. ST. JOHN'S WIFE," *Michigan Farmer*, April 22, 1884, 6

problem with their lack of rainwater. He suggested his wife use well water as he promised to get the cistern fixed. His wife said she would wait for the rain. A few days later, with the cistern still unfixed, St. John demanded to know where his clean shirts were. He had a meeting in town and was fastidiously neat in his personal appearance. Rose replied, "You'll find them all in the clothes-basket, I guess, waiting for rain." St. John asked her to soften the well water. "I never did such a thing in my life," Rose said, "the lye makes one's hands so sore. Besides, it hurts the clothes." Referring to the well water she exclaimed, "It's such hard work to wash in it; I don't believe I am strong enough to do it." And she returned to her book. St. John had to go to his meeting in a dirty shirt, and he promptly fixed the cistern the next day so that Rose could do her work with soft water. In the end, the story served as a tale of St. John's foible; his wife could not be expected to work in a home that he allowed to fall into disrepair. His apathy meant no clean linen. The story of St. John also illuminated the gendered work customary in nineteenth-century American homes. In their home, like in most American households, doing the wash was a feminized task. For this task, Rose relied on a specific type of water. Well water, full of leached lime and calcium from soil and rock, simply would not do for the task of washing, a fact that St. John overlooked when he told his wife to use well water. His ignorance suggested the gendered nature of knowledge necessary for the production of clean clothes, specifically as it related to the non-human environment. To do the laundry, women needed soft water.

Traditionally, the task of producing clean clothes belonged to women, although men engaged in the task, notably male Chinese immigrants in the 19th century American

West.⁵ Instead of pointing to a more egalitarian understanding of laundry work, the regularly of Chinese men's laundry work served to reinforce laundry as a feminine task. Nineteenth-century commentators combined xenophobia, racism, and gendered discourse in descriptions of Chinese laundrymen. If white men did the laundry, they risked engaging in a feminine task. White men endeavored to unsex Chinese launder owners. This prompted scholar Joan Wang to write that "Laundry work has thus traditionally been one of the most powerfully gendered of all domestic tasks."⁶

The pages of the diary of Martha Ballard described the work of doing the washing herself or with the help of a girl.⁷ Fifty years later and west of Martha Ballard's Maine homestead, Rachel Haskell did the family washing for her children and husband in Aurora, Nevada. Haskell noted that even though the wash made her back ache, she would rather do it herself than send it to town. Many women, however, relied on the help of others. Writing from California in 1854 Abby Mansur described a woman who lived near her and took in the washing for a reasonable price. Mansur noted the woman made a decent wage to support herself.⁸ Popular magazines and housekeeping manuals in the nineteenth century both reflected and prescribed women's task of washing clothes.

⁵ Wang, "Gender, Race, and Civilization"; Rose Hum Lee, *The Growth and Decline of Chinese Communities in the Rocky Mountain Region* (New York: Arno Press, 1978).

⁶ Wang, "Gender, Race, and Civilization," 52.

⁷ Martha Moore Ballard, *The Diary of Martha Ballard, 1785-1812*, (Camden, Me: Picton Press, 1992) March 5, 1787.

⁸ Abby Mansur, MS Letter Written to Her Sister, March 6, 1854; Rachel Haskell, "A Literate Woman in the Mines: the Diary of Rachel Haskell, 1867, in *Let them Speak for Themselves, Women in the American West, 1849-1900*, ed. Christiane Fischer (Hamden, CT: Archon Books, 1977): 56, 65.

Publications aimed at female readers frequently ran stories related to the household with information on laundry work. Women wrote these articles securing their status as experts.⁹

Women in the nineteenth century knew how to not only identify hard and soft water, but also when to use each kind when related to their domestic labor. Part of managing water was knowing when to use different kinds. Many recipes published in the nineteenth century assumed that women knew not only how to identify hard and soft water, but also when to use each, indicating a widespread knowledge about the nuances of nonhuman nature. Published recipes in rural magazines, most often submitted by readers, frequently specified between hard and soft water. In the recipe section of a 1848 edition of the *Southern Cultivator*, the author noted of cabbage and other greens, “In order to appear green at table, they must be boiled in hard water.”¹⁰ The trend of differentiating hard and soft water in recipes continued throughout the nineteenth century. In 1875 a contributor to the *Ohio Farmer* noted a recipe for artificial honey required soft water, “Mix 8 pounds refined sugar and ½ oz alum in one pint of clear soft water.”¹¹ Another recipe for whiskey pickles called for five or six gallons of soft water mixed with

⁹ For just a few examples see: “Laundry Work,” *Southern Cultivator*, July 1896, 360; Mrs. JWM, “Washing Clothes,” *Southern Cultivator*, March 1870, 89; “Washing. How to Lighten its Labors,” *Southern Cultivator*, October 1878, 407.

¹⁰ “Domestic Economy, Recipes, &c.” *Southern Cultivator*, June 1848, 6, page 93.

¹¹ “Domestic Department, Household Hints and Recipes,” *Ohio Farmer*, December 11, 1875, page 375.

the alcohol to pickle a batch of cucumbers.¹² While these recipes fail to mention why hard or soft water may be more useful in each case, they do indicate both the importance of and regularity that women engaged with different types of water.

In rural homes, men had their own tasks in which knowledge about water mattered. Editors of agricultural periodicals frequently made the delineation between hard and soft water in articles produced for men. This is most apparent in relation to the care of animals. For example, in the *Michigan Farmer's* column, "Veterinary Department," a veterinary surgeon recommended for a mare with fistulas of the neck applying a mixture of "sulphate of zinc pulv, one drachm, glyerine two ounces, soft water half pint, mix altogether and apply with a syringe twice a day."¹³ The column frequently differentiated between the use of hard and soft water in making medical mixtures for animals. An article about killing cattle ticks with kerosene published by the *Southern Cultivator*, noted the success of the mixture was dependent on the type of water used, "Rain or soft water is better than hard water or that containing lime."¹⁴ These examples show that hard and soft water was pivotal to proper animal care, a kind of knowledge created by and distributed to men. As Rose Granger proved, however, gendered lines divided the application of hard and soft water and when it came to domestic tasks,

¹² "To Make Whiskey Pickles," *Ohio Farmer*, August 31, 1872 page 554. For more examples of recipes that distinguish between hard and soft water see, "Vinegar from Maple Sap," *Ohio Farmer*, Mar 13, 1869, page 171; "Dyspepsia Bread," *Ohio Farmer*, February 17, 1877, page 110; "Canning Green Corn and Beans," *Ohio Farmer*, July 13, 1899, page 31.

¹³ "Veterinary Department: Probably Fistula of the Neck," *Michigan Farmer*, October 16, 1883, 8.

¹⁴ Howard Evakts Weed, "Remedy for Cattle Ticks," *Southern Cultivator*, March 1893, 151.

women were responsible for the management of water. In the realm of domestic tasks, rural magazines placed the responsibility of water management squarely on the shoulders of women. The *Michigan Farmer* printed, “No one but a woman and a housekeeper knows how important a factor water becomes in domestic economy, nor how large a supply is needed for every day’s consumption.”¹⁵

Throughout the nineteenth century doing the wash would have looked similar across the country, a multistep process that involved various tools.¹⁶ The difficulty of washday meant that the use of soft water took on an amplified importance. The night before washing day launderers sorted and soaked clothing in water. The next day, they woke early in order to finish the process with plenty of daylight for drying clothes outside. A large kettle was necessary to boil water on either a stove or fireplace. If there was a lot of washing, launderers utilized two kettles. They employed at least two laundry tubs each with boiled water diluted with cold water as to not burn the hands. The launderer placed the first article of clothing in the first tub, scrubbed it with soap, and then used a wash board to remove dirt and oil. The use of the washboard necessitated some elbow grease to dislodge dirt and oil from fabric. Launderers found washboards indispensable labor saving technology and used wooden boards or bats throughout the eighteenth century. During the 1830s, inventors began to patent improved washboards including the metal fluted washboard. After soaping and scrubbing against the

¹⁵ “The Value of Water,” *Michigan Farmer*, January 16, 1883, 7.

¹⁶ On washing as a multi-step process see, Mohun, *Steam Laundries*, 19-21. This description of doing the wash has been taken primarily from two sources: Leslie, *The House book*, 9-22; Catherine Beecher, *A treatise on domestic economy For the Use of Young Ladies at Home and at School* (New York: Harper & brothers, 1845) 285-302.

washboard, launderers then wrung the article of clothing before placing it into the next tub to rinse. Once rinsed, the launderer again wrung the article and placed it along a close line to dry. Launderers repeated these steps for each piece of clothing; soaping, scrubbing, wringing, rinsing, and wringing again every piece of dirty clothing in the household. Large items such as bed linens, table linen, and towels could be washed in the kettle, using a wash stick or wooden fork, then rinsed in cold water. Additional buckets for starch as well as bluing were also necessary in some cases. Hand cranked mechanical washing machines had become available in the mid nineteenth century, but these were expensive and not widely adopted by launderers.¹⁷ After the launderer completed the wash, she then had to clean the tubs, buckets, and other utensils. The description above gives only the most basic directions of doing the wash in the nineteenth century. Additionally, launderers made soap, rendered lye, removed stains, whitened clothes, and finally ironed and folded clothes. In short, the labor of laundry was extremely hard and time-consuming work to be done once every week.

Due to its difficulty, laundry was an almost universally hated task. In 1867 Rachel Haskell wrote in her diary, “Swept and dusted house prior to beginning the great domestic dread of the household; washing.”¹⁸ Hard water made this already arduous and time-consuming task more difficult because it wasted soap, causing an insoluble precipitate that then required more scrubbing to remove from clothing. “The labor of

¹⁷ Faye E. Dudden, *Serving Women, Household Service in Nineteenth Century America*, (Middletown, CT : Wesleyan University Press, 1983), 142. On the history of hand cranked washing machines see, Sigfried Giedion, *Mechanization Takes Command, a Contribution to Anonymous History* (New York: Oxford University Press, 1948) 551-552.

¹⁸ Rachel Haskell, in *Let Them Speak for Themselves*, 56, 65.

washing is very augmented by having to use hard water,” wrote a contributor to the *Southern Cultivator* in 1878.¹⁹ The fatty acids in soap, used to attract grease and oil, instead prefer to react with the calcium and magnesium ions in hard water. Together they form an insoluble precipitate of lime soap, or soap scum, turning water a cloudy grey color. The reaction left behind unaesthetic matter on clothes that required more scrubbing to remove. It also wastes soap, which cannot do its job until it reactions with all the free ions of hard water. In other words, it caused the decomposition of soap.²⁰ Hardness minerals provide an example of the materiality of water interfering with the tools used for the washing process, pivotal to the reproduction of the home. This disruption gave rise to the emphasis on using soft water in the wash, which in turn would affect the materiality of water.

Since washday was so arduous and labor intensive, writers encouraged women to adopt the best methods. Soft water was an important part of good washing technique. In 1870, a “Mrs. JWM” claimed in the *Southern Cultivator*, “The first point in washing is to secure plenty of clear soft water, and good soap.” “In the first place,” the *Michigan Farmer* advised in 1854, “in order to do a washing well and easily, it is necessary that every housekeeper should be provided with a plentiful supply of soft water..”²¹ Through

¹⁹ “Washing, How to Lighten its Labors,” *Southern Cultivator*, October 1878, 10.

²⁰ Edward Livingston Youmans, *The Hand-Book of Household Science: a Popular Account of Heat, Light, Air, Aliment, and Cleansing, in Their Scientific Principles and Domestic Applications: Adapted for Academies, Seminaries and Schools* (New York: D. Appleton, 1859).

²¹ Mrs. JWM, “Washing Clothes,” *Southern Cultivator*, March 1870, 89; “Washing Again,” *Michigan Farmer*, December 1, 1854, 372; “Laundry Work,” *Southern Cultivator*, July 1896, 360.

their domestic work, women gained experiential knowledge about how different types of water reacted with other household tools, such as soap. Environmental knowledge proved indispensable for this task of washing precisely because washing was so difficult.

Access to both hard and soft water was crucial to the function of nineteenth-century American households. People ensured this access in two ways: cisterns or chemical softening. Cisterns provided homes with soft rainwater and played a pivotal role in household water systems. Households constructed various types of cisterns from elaborate structures to simple barrels placed level with the kitchen window.²² While periodicals and domestic manuals assumed women to be responsible for the use of domestic water, it was a man's responsibility to construct the devices to provide a home with this water. "The man who arranges for a constant supply of water, both soft and 'hard' and makes proper arrangements for the disposal of the waste," wrote one author, "has banished the terrors of 'wash day' and greatly lightened the work in the kitchen." Another claimed that, "men should be ashamed of themselves, who have not sufficient forethought and industry to construct cisterns."²³ These periodicals suggest that men needed to be responsible for the conditions and contexts in which women did their work, but do not suggest that they understood exactly why or when women used soft water. Gendered labor customs in nineteenth century America divided men and women, but these customs did not exist in isolation. The need for soft water not only influenced the

²² Henry T Williams and "Daisy Eyebright," *Household Hints and Recipes*, (Boston: Peoples Publishing Company, 1884) 55-56.

²³ "The Value of Water," *Michigan Farmer*, January 16, 1883, 7; "Washing, How to Lighten its Labors," *Southern Cultivator*, October 1878, 10.

household hydraulic system, but also dictated social customs as to who was responsible for their management and upkeep.

What of places that received little rain water? Softening with chemicals was always an option, but there was also another form of getting soft water to those places. Newspaper records from the arid regions of the Western United States suggest it was not uncommon for people with the entrepreneurial spirit to offer the delivery service of soft water directly to customers. In 1871, a man named Frank Merrill promised the delivery of soft water to anyone in the town of Santa Cruz, California. Similarly, in 1875 in the arid Pioche, Nevada, the Crystal Springs Water Company delivered water in large of small quantities to townspeople.²⁴ The advertisement promised pure and soft water. While it is unclear where exactly these companies acquired soft water, they do offer another means for acquiring soft water so important for domestic tasks.

Some launderers softened hard water using chemical methods, with homemade or store-bought caustics. The best way to eliminate hard water was to add an alkali metal to it such as lye, soda ash, or potash. It should be noted here that prior to the mid-nineteenth century, in general, people used the term lye to refer to either sodium carbonate or potassium carbonate. After this time, a shift occurred in which people called sodium carbonate soda ash or washing soda, while lye referred to caustic soda or sodium hydroxide.²⁵ In the early nineteenth century, many women made their own water softening chemicals. To render lye from wood ashes, a contemporary writer, Juliet

²⁴ “Business Cards,” *Santa Cruz Weekly Sentinel*, July 22, 1871; *The Pioche Record (Pioche, Nevada)*, November 6, 1875.

²⁵ On the difference between washing soda and lye see Rose Flora, *The Laundry* (Ithaca, NY: NY state college of agriculture, Cornell University, 1909), p. 47.

Corson, recommended slowly collecting ashes from the family's fireplace and letting them accumulate in a barrel with a perforated bottom. Under the tub lay another tub. When the first tub was full of ashes, she instructed a family member to pour buckets of warm water over it. The ashes undergo lixiviation, a separation of the soluble from the insoluble. Whatever drained through the bottom into the other tub was then boiled and the remaining salts were called lye.²⁶ Writing about her life in Illinois in 1826, Christiana Holmes Tilson complained that making lye took nearly half of the washday. She described the process as "...the labor of brining from raw materials anything at all presentable for family use..."²⁷ When soft water was not available from a cistern or other type of catchment, women used homemade potash or soda ash to soften water. They rendered lye either from wood ashes to make potassium carbonate or from seaweed and kelp to make sodium carbonate.²⁸ Both the formation and use of lye prove women's work in and on nature. The application of lye to water proved their ability to manipulate non-human nature.

Some women were ambivalent about the use of water softening chemicals in the laundry. St. John's wife pointed out the harmful effects caustic chemicals could have on one's body. She proclaimed that, "The lye makes one's hands so sore." Many people used caustics sparingly because of the belief that they caused injury to clothes. An article

²⁶ Juliet Corson, *Family living on \$500 a year: a daily reference-book for young and inexperienced housewives* (New York: Harpers & Brothers, 1888) 98-101.

²⁷ Christiana Holmes Tilson, *A Woman's Story of Pioneer Illinois*, Milo Milton Quaife, ed. (Chicago, R.R. Donnelley & Sons Company, 1919) 146.

²⁸ On the difference between washing soda and lye see Rose Flora, *The Laundry* (Ithaca, NY: NY state college of agriculture, Cornell University, 1909):47. Corson, *Family living on \$500 a year*, 98.

in the *Southern Cultivator* wrote, “Now, although we admit great utility, we particularly caution all parties not to use too much of these powerful alkalies (sic), because cotton fabrics are partially dissolved by a strong, hot soda, potash, or lime lye.”²⁹ Despite the potential hazards of using caustics such as potash and lye, many people used it because soft water was so important to the laundering process.

By the middle of the nineteenth century, the growth of the alkali industry in America and Britain made chemicals used in the family wash more widely available for purchase. In doing so, industrialization removed one form of work, rendering lye, from the home. Innovations in the commercial production of alkaline metals occurred during the industrial revolution in Europe. In 1775, the French Academy of Sciences spurred innovation by offering a prize to anyone who could find a more efficient way to manufacture soda ash which had been bound by access to glasswort plants. Most soda ash in eighteenth-century Europe was imported from Spain and the Canary Islands. By the end of the decade French chemist Nicolas Leblanc had answered the call, perfecting a process that relied on sodium chloride, or common salt, to make sodium carbonate.³⁰ This process allowed soda ash to be manufactured on a large scale in any region. The soda industry

²⁹ “The Chemistry in the Laundry,” *Southern Cultivator*, Atlanta, Vol. 25. (May 1867): 158.

³⁰ Dow Chemical Company, *Dow Soda Ash*, (Midland, Michigan: Dow Chemical Company, 1957). On the history of the alkali industry see, Leebert Lloyd Lamborn, *Modern soaps, candles and glycerin: a practical manual of modern methods of utilization of fats and oils in the manufacture of soap and candles, and of the recovery of glycerin* (New York: D Van Nostrand, 1906) 85-97; Frank Hall Thorp, *Outlines of industrial chemistry; a text-book for students* (New York: Macmillan Co, 1898) 73-80. For figures on soda ash imports see Dennis S. Kostick, “The Origin of the U.S. Natural and Synthetic Soda Ash Industries,” Wyoming State Geological Survey Public Information Circular 39, 1998, 11-30 and Day, W.E. , 1888, Sodium salts, in “Mineral resources of the United States- Calendar Year 1887” (U.S. Geological Survey): 651-658.

slowly grew in Europe, and by the 1850s European soda ash was widely available in the United States. In 1869 the United States imported 59,578 tons of soda ash from England and 118,357 tons in 1885.³¹ By the end of the nineteenth century synthetic soda ash produced in New York, Michigan, and Louisiana as well as natural mines in the western United States greatly reduced imports from England. Soda ash was an important material in the glassmaking industry and the manufacture of paper. It also became an important labor saving chemical in the household. The accessibility of lye meant that women no longer needed to manufacture it to make soap and soften water. Many women would have preferred to purchase lye from the grocer or druggist instead of making their own.³² The addition of water softening chemicals shows most clearly women's work on nature. Launderers needed to manipulate the water they used in order to do their work. The use of sodium carbonate too shows the connection between the home and the industrializing country. Although primarily produced for industrial tasks, manufacturers sold soda ash to druggists and grocers for household use. Women's household labor stood on the periphery of an industrializing economy, but it intersected with new industrial products and processes. Water softening with commercial soda ash connects domestic work with nature to a larger economic context and system.

There was a heavy environmental cost to the large-scale production of soda ash. The LeBlanc process allowed manufacturers to make sodium carbonate without

³¹ Kostick, "The Origin of the U.S. National and Synthetic Soda Ash Industries," 26.

³² For an example of this see, Letter from Mary Jones to Charles Colcock Jones, 4 September 1862, in *The Children of Pride: A True Story of Georgia and the Civil War*. Robert Myers, ed. (New Haven, CT: Yale University Press, 1972):1845; "Home-Made Soap," *Freeman*, Indianapolis, IN, September 7, 1889.

geographic boundaries, but it also yielded high amounts of hydrochloric acid as a byproduct. In 1838 air pollution from hydrochloric acid gas encouraged citizens to take legal action against the alkali industry in Liverpool, England. Not only air pollution, the production of soda ash also produced insoluble sulfur waste products, known in England as galligu. In general, alkali manufacturers would merely dump this waste into the surrounding environment. Galligu polluted streams and when left to waste could catch fire.³³ In the United States, the Solvay Process company, the largest manufacturer of soda ash at the end of the nineteenth century, caused heavy pollution in the surrounding ecological area of their Syracuse, New York plant. They deposited byproduct, from their ammonia-soda process, into surrounding waste beds that leached into the ground water and polluted nearby Onondaga Lake.³⁴

Consumers of soda ash believed a small amount of the substance could be useful when introduced into the surrounding environment. Many rural farmers felt that wash wastewater could be useful. “The bitter of the alkaline principle, and the clogging effect of the greasy matter on the movements of minute insects, if not fatal is certainly offensive to all kinds inhabiting walls or trees,” a commentator in the *Workingman’s Advocate* said

³³ William McGucken, *Biodegradable: Detergents and the Environment*, (College Station: Texas A&M University Press, 1991) 117. For the environmental legacy of Galligu see, Peter Reed, “Galligu: An Environmental Legacy of the Leblanc Alkali Industry, 1814-1920, Royal Society of Chemistry Environmental Chemistry Group, www.envchemgroup.com/galligu-an-environmental-legacy-of-the-leblanc-alkali-industry-1814-1920.html

³⁴ Tom Perrault, Sarah Wraight, Meredith Perreault, “Environmental Injustice in the Onondaga Lake Waterscape, New York, USA,” *Water Alternatives* 5(2): 485-506.

in 1835.³⁵ The commentator assumed that putting water with alkali onto a wall or tree might keep out unwelcomed insects due to the offensive nature of the material. Other rural magazines claimed that alkaline water strengthened and nourished trees and plants. Too much alkaline, however, could be bad. In 1853, a contributor to the *Southern Cultivator* claimed that water with potash killed an entire orchard of apple trees. The contributor noted that in moderation, the alkalis in wash water can be successfully applied to the soil of fruit trees.³⁶ The use of domestic wastewater in the surrounding home environment shows the hydrosocial process of wash water. Water flowed towards the productive work of women in the home. Once there, launderers assessed that water as to whether it was hard or soft, making the appropriate changes to fit it to their needs with chemicals. Water then served as a tool in the production of clean clothes, and finally returned to the surrounding environment to serve a new task. The pollution caused by the soda industry as well as the usefulness of small amounts of soda ash in the natural environment acknowledge the contradictory aspects of the environmental history of water softening when viewed from both the production and consumption sides.

Adjusting the hardness or softness of water to suit different household needs was crucial environmental knowledge to the functioning of mid-nineteenth century American households for the work of both men and women. Since this environmental knowledge

³⁵ “On Preventing the attacks of insects,” *Workingman’s Advocate*, August 29, 1835. See also, “Notes by S.W.” *The Genesee Farmer*, December 1864, 371; “Liquid Manure,” *Maine Farmer*, June 5, 1869, 1; “Protection of Cabbage against Worms,” *Southern Cultivator*, September 1871, 351.

³⁶ “Apple Trees Killed by Potash,” *Southern Cultivator*, July 1853, 217.

related to work, it maintained a gendered component due to the gendered nature of work in the nineteenth century American home. This section has focused on water in the middle western states notably places such as Ohio and Michigan that generally have a moderate amount of hardness as well as incorporating sources from the western and southern United States. There was a wide variety of chemical variation in the water used across these spaces, yet launderers described hardness not in scientific terms, rather in the way that it related to their work processes. This points to an empiricist view of water over an essentialist or scientific view. For this reason, the cultural understanding definition of hardness as something that interferes with laundering, tied these divergent locations together. While the natural geological formations that caused minerals to deposit into waters of Georgia or Nevada might have been scientifically very different, their effects on clothes were surprisingly consistent. For this reason, the examples of hardness in these locations can be appreciated for their cultural similarities rather than their scientific differences.

Class and Caustics

While many people chose to do their own laundry, others preferred to hire someone else to do the work, suggesting a class dimension to the labor of laundry. The historian Susan Strasser wrote, "...it appears that women jettisoned laundry, their most hated task,

whenever they had any discretionary money at all.”³⁷ Throughout the nineteenth century, some domestic workers who lived in the homes of their mistress, where between one and two servants would have been common, did the washing along with other household work. Regularly, however, domestic workers refused to do the laundry making contracted washerwomen or laundresses common. These workers engaged in day work, coming to a home just once per week for the day.³⁸ Affluent people did not simply push the labor of laundry work onto the working poor, divorcing themselves from the task. Instead, from the 1820s through the end of the decade, domestic literature advised middle-class women to instruct and supervise paid domestic workers including contracted washerwomen. To instruct domestics, they had to know themselves how to properly launder clothes. Therefore, middle-class women read about the laundry and hard water for cultural reasons, rather than to do the wash themselves. At the same time, they pushed the risks of laundry work onto the bodies of other women. Doing the wash involved using boiling hot water and heavy tools. The exposure to caustic softening chemicals made the process even more dangerous. Washerwomen and laundresses frequently used caustic materials such as soda ash and lye which had a detrimental effect on their hands and skin. Affluent and middle-class families, however, were not the only people who employed laundresses. Many of the laboring poor in urban areas relied on a hired laundress because acquiring

³⁷ Strasser, *Never Done*, 105; Similarly, Tera Hunter wrote, “Laundry work was the single most onerous chore in the life of a nineteenth-century woman and the first chore she would hire someone else to perform whenever the slightest bit of discretionary income was available.” Tera Hunter, *To ‘Joy My Freedom: Southern Black Women’s Lives and Labor After the Civil War*, (Cambridge, MA: Harvard University Press, 1997) 56.

³⁸ On hired domestics and the laundry see, Katzman, *Seven Days a Week*, 117.

the tools for the wash cost too much money.³⁹ Therefore, although class differentiated how and to what extent women engaged with the water for the wash, the reality defied a straightforward class characterization. Since most nineteenth-century American woman detested laundry work, many, regardless of social class, contracted out the labor of washing and with it, the risks, pushing the effects of caustic chemicals onto the bodies of washerwomen and laundresses.

Between 1790 and 1830, industrialization and the growth of a national market altered class relationships in the United States. Men increasingly found work in urban areas as factory managers, retailers, businessmen, and clerks and brought their families into a burgeoning middle class. An emblem of this new social class was the ability to hire domestic servants.⁴⁰ By pushing the labor of the household onto servants, in conjunction with the increased availability of consumer goods, middle class women explored activities beyond housework including education, social activities, and leisure. In response to the changing role of women both within and outside of the home, a cohort of writers, including Catherine Beecher, worried about what she referred to as the “decay of the female constitution,” a result of wealthy, especially young women, neglecting their

³⁹ On the urban poor and laundry see Strasser, *Never Done*, 113.

⁴⁰ Dudden, *Serving Women*, 112; See also, Christine Stansell, *City of Women: Sex and Class in New York, 1789-1860* (New York: Knopf: Distributed by Random House, 1986); Jeanne Boydston, *Home and Work: Housework, Wages, and the Ideology of Labor in the Early Republic* (New York: Oxford University Press, 1990); Thomas Dublin, *Transforming Women's Work: New England Lives in the Industrial Revolution* (Ithaca: Cornell University Press, 1994); Paul E. Johnson, *A Shopkeeper's Millennium: Society and Revivals in Rochester, New York, 1815-1837* (New York: Hill and Wang, 1978).

roles in the home.⁴¹ By neglecting these skills, wealthy women lost essential tenets of their womanhood. Beecher and others wanted to raise housework into a proper profession through education and training. Throughout their works, they emphasized the appropriate role of women as educators and mothers. Writing in what the historian Nancy Cott called the “canon of domesticity,” Beecher and others including Sara Josepha Hale, Eliza Farrar and Catherine Marie Sedgwick, situated middle-class women’s power inside of the home and specifically in the knowledge of how to run a well-ordered household.⁴² The presumed audience of these writers would have been middle-class women who increasingly had money as well as time to spend on literature.⁴³

These authors advised women to embrace the role of the manager in the home, including teaching and supervising domestic servants. This allowed middle-class women to enjoy new opportunities for leisure and work in the public sphere while simultaneously retaining traits associated with femininity including education and a connection to the

⁴¹ For Beecher see, *A Treatise on Domestic Economy For the Use of Young Ladies at Home and at School* (New York: Harper & brothers, 1841); Catherine Beecher and Harriet Beecher Stowe, *The American Woman's Home: or, Principles of Domestic Science; Being a Guide to the Formation and Maintenance of Economical, Healthful, Beautiful, and Christian Homes* (New York: J.B. Ford and company, 1869); “How to Redeem Women’s Profession from Dishonor,” *Harper’s New Monthly Magazine* 31 (November 1865): 710.

⁴² Cott, *The Bonds of Womanhood*, 64; Dudden, *Serving Women*, 164; See also Annette Kolodny. *The Land Before Her: Fantasy and Experience of the American Frontiers, 1630-1860* (Chapel Hill: University of North Carolina Press), 161-167;

⁴³ Mary Ryan, *The Empire of Mother- American Writing about Domesticity, 1830 to 1860* (New York: Institute for Research in History and the Haworth Press, 1982); on the readership of Eliza Leslie’s books see, Anne-Marie Rachman, “Bibliographical Essay of Eliza Leslie,” *Michigan State University Digital Repository*, accessed February 12, 2020, https://d.lib.msu.edu/content/biographies?author_name=Leslie%2C+Eliza%2C+1787-1858.

home.⁴⁴ In the preface to one domestic manual written by Eliza Leslie in 1841, she stated why women should read her domestic manual, “The design of the following work is to impart to novices in house-keeping some information on a subject so that they may be enabled to instruct unpractised (sic) domestics, or, in case of emergency, to assist personally in forwarding the indispensable work in the family.”⁴⁵ Born in 1787, Leslie was a popular American author of cookbooks and other works related to etiquette and household management. One of her works, *Directions for Cookery*, was the most popular cookbook of the nineteenth century.⁴⁶ In her words, her assumed reader, middle class women, only needed to know how to do tasks in the home to educate servants, or in the case of an emergency only, do the task themselves. Catherine Beecher echoed this sentiment. In 1841 she wrote about servants, “Most persons, of this class, depend, for their knowledge in domestic affairs, not on their parents, who are usually unqualified to instruct them, but on their employers.” She continued that, “When a lady finds that she must employ a domestic,” she must fix their ignorance and carelessness with, “kind and patient teaching.”⁴⁷ Both authors felt that readers needed knowledge about the housework to act as teachers, rather than do to the work themselves.

⁴⁴ Dudden, *Serving Women*, 156.

⁴⁵ Leslie, *The House Book*, 3 ,

⁴⁶ On Leslie see, “Leslie, Eliza (1787-1858).” in *Encyclopedia of American Food and Drink*, by John F. Mariani. 2nd ed. Bloomsbury, 2014.

⁴⁷ Catherine Beecher, *A Treatise on Domestic Economy*, 211. Beecher maintained a similar sentiment in, Beecher, *Miss Beecher’s The Housekeeper and Healthkeeper* (Bedford, MA: Applewood Books, 1873) 428-429. Although Beecher and others writing in this period wanted to emphasize proper gender roles over class or religious differences, in reality only middle class and affluent women would have read advice literature.

In many instances between the 1840s and 1880s, published works that dealt with the management of the household instructed the manager of the home to closely supervise how servants did the laundry, including their use of hard and soft water. For example, Leslie wrote in 1841 that women must closely supervise servant's use of water softening chemicals such as lye or soda ash. "Some washerwomen and servants are in the habit of putting in more than the allotted quantity of soda," wrote Leslie. This practice caused clothes, "...very soon to slit and drop into pieces." She continued that it was difficult to supervise the laundress, "when the washing is not done under your own immediate inspection."⁴⁸ Some forty years later in 1885, a contributor writing in the newly founded *Good Housekeeping* magazine claimed the supervision of servants in the laundry was imperative. The article stated, "Every young housekeeper should understand that, without her own careful supervision, few ordinary servants will take the trouble to wash properly, and, in order to oversee the work, it is necessary to know how it should be done..."⁴⁹ The author continued that the housekeeper should know soft water is preferable to hard. The knowledge related to water helped middle class women adhere to proper prescriptions of womanhood, reflecting a kind of cultural knowledge about laundry work and soft water. It is important to note that although middle class women

⁴⁸ Leslie, *The House Book*, 24. On supervising domestics see, Faye E. Dudden, *Serving Women, Household Service in Nineteenth Century America*, (Middletown: Wesleyan University Press, 1983), 156-192. On the importance of supervising servants see, Sarah Lloyd, *The Useful and the Beautiful or, Domestic and Moral Duties Necessary to Social Happiness* (Philadelphia: Lippincott, Grambo & Co., 1854). This sentiment towards servants and chemicals can also be found in Ellen Richards, *The Chemistry of Cooking and Cleaning; a Manual for Housekeepers* (Boston: Estes & Lauriat, 1882), 79-80; George Peltz, *The Housewife's Library* (Philadelphia; Hubbard, 1883) 327, 359-360.

⁴⁹ Mrs. Eliza R. Parker, "In the Laundry How to Wash and Iron," *Good Housekeeping*, August 8, 1885, 11-12.

endeavored to educate domestic servants, it is likely they learned the most about housework in ways difficult to document especially through experience and teaching from other women in their lives such as neighbors, sisters, or mothers.

As middle-class women increasingly placed a higher standard on supervising the laundry, laboring women would have done it directly, more intimately facing the risks and danger associated with laundry work. After the 1870s, newspapers and medical journals began to report on these dangers. Although people employed laundresses throughout the nineteenth century, the growth of the profession in the 1880s made the risks more visible. According to statistics compiled from census data, in 1870 there were 58,102 laundresses working the United States. In twenty years that number grew to 216,631 and again grew to 335,282 by 1910.⁵⁰ The growth was due to a spike in urbanization and immigration during that time. More married than unmarried women worked as laundresses and many transitioned from live-in domestic servants to day work finding laundry work more flexible. After the Civil War, the South witnessed a dramatic rise in black washerwomen who took in the clothing of others instead of living in the homes of their employers. The relative economic and social freedom domestic laundry work engendered drew many black women to this position in the post war era.⁵¹

Laundresses either came to a family's home, or took in the laundry of others in their home. Instead of doing the wash once per week, laundresses often did the washing of five

⁵⁰ Katzman, *Seven Days a Week*, 45.

⁵¹ Hunter, To 'Joy My Freedom, 55-59. On freedom laundry work could allow see, S.E. Boggs, "Wash-Ladies, an Emergency and what came of it," *Good Housekeeping*, October 26, 1889, 297-298. On this trope see also, "A Washerwoman," *The Independent*, November 10, 1904, 1073-1076. On laundresses more generally see Katzman, *Seven Days a Week*, 85; Strasser, *Never Done*, 113.

or six families per week. As such, they faced a higher exposure to the problems related to hard water.

Hard water created a heavy financial and corporeal tax on laundresses. In hard water areas, laundresses needed to use more soap, which cut into their profits since many supplied their own washing materials. Hard water necessitated the purchase of softening chemicals, especially in urban areas where space restraints made cisterns impractical.⁵² Handling lye and other water softeners proved a dangerous tax on women's bodies. In 1882, when interviewing a woman about a burn sustained while doing the wash, a lecturer at Rush Medical College noted, "Our questions elicit the fact that she has been using a strong solution of washing soda in her laundry tub, in order to save some labor of scrubbing her clothes with her hands."⁵³ Some families had pushed the risks and costs of water softening onto the bodies of other women.⁵⁴

The risks and costs of water softening are most clear in medical journals that discuss the effects the use of chemicals in the wash could have on women's hands,

⁵² On this burden see, Walter George Atkins, *The Modern System of Water Purification*, (London: E. & F.N Spon, 1894), 23-35; "Washing, How to Lighten its Labors," *Southern Cultivator*, October 1878, 10.

⁵³ James Nevins Hyde, "Original Lectures: on Certain Cutaneous Affections of the Hands, a Clinical Lecture Delivered at the Rush Medical College," *Medical News*, December 9, 1882, 645. See also, Arthur Van Harlingen, "Clinical Lecture: On the Treatment of Eczema of the Hands," *Philadelphia Medical Times*, June 14, 1883.

⁵⁴ Newspapers at the end of the nineteenth century reported on burns washerwomen faced from doing the laundry, exemplifying another risk associated with doing the wash. For an example of a woman scalded in the face with wash water see, "Peculiar Accident to a Laundress," *New York Times*, Jan 22, 1896. On the case of a laundress who lost part of her ear from a scalding incident see, F.P. Hoover, "Report of Seven Cases of Malformations of Ear, Accompanied by Complete Closure of the External Canal," *Medical Herald* 15, September 1896, 419-420.

labelled by doctors as washerwoman's itch. Washerwoman's itch was an occupational hazard caused by contact with the alkaline salts used in the washing process. Frequent use of caustic chemicals can be extremely damaging to the skin. The testimony of a woman who worked in a soap factory provided an extreme explanation of the effect, "The caustic soda in it first turned their nails orange-color and then it ate off their finger tips til they bled."⁵⁵ Washerwoman's itch was less severe, but frequently mentioned in medical publications. J.R. Kippax, M.D. described washerwoman's itch as a simple inflammation of the skin, "... characterized by an erythematous, papular, vesicular or pustular eruption with burning and itching." Erasmus Wilson, a doctor credited with helping found the specialty of dermatology, noted the pain washerwoman's itch caused. "The itching and smarting are sometimes intolerable," he wrote in an 1852 treatise. "Occasionally the papulae are intermingled with small vesicles or pustules, which speedily burst, and terminate by desquamation."⁵⁶ The makers of Cuticura Soap, who sold a soap that claimed to cure skin diseases, marketed their product specifically to washerwomen in a series of advertisements in the *New York Times* in the 1880s. The advertisement described the affliction as "...itching, scaly, and pimply humors of the

⁵⁵ Helen Campbell, *Prisoners of poverty: Women wage-workers, their trades and their lives*, (Boston: Little Brown & co., 1887): 192.

⁵⁶ John R. Kippax, *A hand-book of diseases of the skin, and their homoeopathic treatment* (Chicago: Gross & Delbridge, 1890): 237-248. Erasmus Wilson, *On diseases of the skin*, (Philadelphia: Lea and Blanchard, 1852):267-68. On the contributions of Wilson see, Mark Allen Everett, "Erasmus Wilson and the Birth of the Specialty of Dermatology," *International Journal of Dermatology*, May 1978, 345-352.

scalp and skin...”⁵⁷ Washerwoman’s itch was an unpleasant diagnosis for anyone who faced it.

Washerwoman’s itch illuminated the relationship between class distinction and water softening. As the name suggested, the medical condition affected working-class women. Adding caustics to the water remade its chemical variation into something more efficient and cost effective. To save money and time, washerwomen employed these chemicals. Yet doing so increased the danger of the water and produced a physical malady on the skin of some women. Medical doctors defined the condition linking it to gender and class through its name, washerwoman’s itch. In doing so, they associated hard water with women and labor. Hard water not only shaped women’s bodies, but their bodies shaped the definition and discourse about water. In the case of washerwoman itch, both technology, for example caustic chemicals, and society, in the form of discourses about class and work, mediated the dialectic relationships between these workers and water.

That so many women regularly handled dangerous chemicals contradicted the nineteenth and early twentieth-century notion that women were frail creatures. Popular publications obliquely addressed this contradiction by trivializing it, calling attention to instances, some clearly apocryphal, of irrational women misusing lye in fits of rage. Newspapers frequently reported on people who had been poisoned or blinded by these chemicals using language that emphasized the gendered nature of laundry work.⁵⁸ Most

⁵⁷ “Itchyosis,” *New York Times*, May 9, 1885, 2.

⁵⁸ “Burned by Concentrated Lye,” *Boston Daily Globe*, March 4, 1892; “She Threw Lye,” *Los Angeles Times*, December 18, 1896; “Husband Too Attractive,” *The Washington Post*, June 29, 1916, 6.

instances involved women poisoning other women in fits of jealousy or rage. Women even used caustic alkalis to teach a cheating husband a lesson. In 1892, the *Boston Daily Globe* reported a woman threw lye on her husband in a fit of jealousy after discovering he had been unfaithful. In 1896, the *Los Angeles Times* ran an article about two women who quarreled over a “trivial matter,” or so editorialized the probably-male reporter. The quarrel resulted in one woman throwing lye into the face of the other. The headline from a story 1916 printed by *The Washington Post* says enough, “Husband too attractive: to avert dangers, wife mutilates him with concentrated lye.” Whether apocryphal or not, these instances illuminate the way these products contained gendered persecutions. These stories relied on the assumption that women could easily access these caustic chemicals, usually under their sinks. These sensational stories rarely involved laundresses; however, they demonstrate the gendered nature of such products and of laundry labor in general.

In total, the number of washerwomen declined in the second decade of the twentieth century. However, the number of black washwomen increased. Both class and race distinctions defined who used harmful water softening chemicals. At the beginning of the twentieth century, the number of immigrants working as domestic servants fell reducing the number of white domestic workers overall.⁵⁹ Black women increasingly migrated north and filled these positions. In 1889 Isabel Eaton recorded the large number of black women who took in laundry in the city of Philadelphia. Noting a preference for contract work, she reported, “The degree which laundry work, for example, has been removed from the household may be seen by the fact that there are but thirty-one private laundresses in the ward, while 1097 colored women in the ward support their families by

⁵⁹ Katzman, *Seven Days a Week*, 44-94.

taking in washing or doing ‘day’s work,’ as they call washing by the day at the employer’s house.”⁶⁰ By private laundresses, Eaton referred to those women who would have worked as a regular domestic in the home doing the laundry and most likely other household tasks. The 1097 other women enjoyed the freedom of working at home, being able to take care of young children in the family and incurring only small expense of coal and washing supplies. Although it allowed for more freedom, the constant washing exposed black women to the harms of laundering, and specifically the use of caustic water softening chemicals, at a much higher rate. According to David Katzman, by 1920 seventy three percent of all laundresses in the United States were black.⁶¹ While water softening divided people by gender lines, this is insufficient to describe the totality of women’s experiences with hard water. An examination of the process of softening water must also consider the ways in which class and race distinctions influenced people’s interactions with water.

Race, Class, and Commercial Laundries

At the turn of the twentieth century, the proliferation of commercial power laundries changed both working-class and middle-class women’s relationship to the water they used in a rapidly urbanizing country. In the South and in rural areas, women continued to employ washerwomen to do their laundry. In urban areas, commercial power laundries became increasingly common. In commercial laundries, men and machines took over

⁶⁰ Isabel Eaton, “Special Report on Negro Domestic Service in the Seventh Ward, Philadelphia,” in W.E.B. DuBois, *The Philadelphia Negro: A Social Study* (1889): 504.

⁶¹ Katzman, *Seven Days a Week*, 72.

washing and water softening. As men wrestled the practical application and knowledge about laundry away from women, a growing education movement ensured that at least some, specifically white middle class women, maintained their familiarity with this household skill. Laundry work became an important tenant of domestic science and later home economics. Instructors in the movement increasingly brought science into the study of the home, emphasizing the chemistry of common household tasks. As some women interrogated the science behind laundry, they ensured the reproduction of knowledge about water softening and water chemistry.⁶² Ultimately, men and mechanization distanced working-class women engaged in washing clothes from the water they used. At the same time, education brought the science of laundry work and water softening into the homes of women who paid to put their laundry out.

In the early nineteenth century, commercial laundries flourished in urban areas due to technological, demographic, and cultural changes allowing laundry owners to turn a household skill into a mechanized service.⁶³ Laundry owners designed their services like a factory in which workers did individualized tasks aided by modern machinery. An increasing emphasis on sanitary reform, which began after the Civil War, made these institutions culturally legitimate.⁶⁴ Increasing urbanization at the end of the twentieth century also made power laundries more feasible for some people. Women found it difficult if not impossible to do the task of washing in small tenements. Water, too played

⁶² Merchant, *Ecological Revolutions*, 251-260.

⁶³ Mohun, *Steam Laundries*, 1-11.

⁶⁴ Suellen M. Hoy, *Chasing Dirt the American pursuit of cleanliness* (New York: Oxford University Press, 1995).

an important role in the growth of steam laundries. The historian Arwen Mohun wrote, “The key to both sanitary reform and the growth of laundries in an urban context was steady, reliable, clean supply of water.”⁶⁵ Municipal water systems allowed commercial laundry owners, who had large amounts of capital, to obtain large quantities of water. The convergence of these factors made commercial laundries popular and ultimately led to a decline in the number of washerwomen in all urban areas in the United States except the South.⁶⁶

White commercial laundry owners used gendered and racial rhetoric connected to ideas about machines and technology to negotiate their own identities as well as challenge their competition, Chinese laundries and washerwomen. Male Chinese immigrants had done laundry work since the middle of the nineteenth century in the American West due in large part to the uneven sex ration in the region. By the final two decades of the century, many Chinese men moved eastward and opened commercial laundries in eastern cities.⁶⁷ In a 1903 interview with the Chinese businessman Lee Chew, he said that, “The reason why so many Chinese go into the laundry business in this country is because it requires little capital and is one of the few opportunities that are open.”⁶⁸ With little capital, Chinese laundries generally used non mechanical techniques,

⁶⁵ Mohun, *Steam Laundries*, 30.

⁶⁶ Katzman, *Seven Days a Week*, 61-62.

⁶⁷ Wang, “Gender, Race, and Civilization,” 58.

⁶⁸ “The Life Story of a Chinaman,” in Werner Sollors and Hamilton Hold (eds.) *The Life Stories of Undistinguished Americans as Told by Themselves: Expanded Edition*, (New York: Routledge, 1999) 180.

including traditional washtubs, washboards, and other hand powered machines.⁶⁹ White commercial laundry men used gender and racialize rhetoric to attack Chinese laundries. Since laundry work had traditionally been a feminized task, commercial laundry men embarked on a process of what the historian Joan Wang called “gender clarification.”⁷⁰ She argued that white commercial laundry owners used existing cultural rhetoric and idioms that linked masculinity and machinery to both feminize and delegitimize Chinese laundry owners, their main competitors. White laundry owners depicted Chinese laundries as non-technological using racialized discourses of civilization.

Commercial laundrymen also used these tactics to challenge washerwomen. In the case of washerwomen, they also employed nonhuman nature in their claim to authority on cultural grounds. In one advertisement from 1918 featured in *The American Outlook*, a periodical dedicated to the interests of laundry owners and dry cleaners published by the Laundry Machinery Company in Chicago, commercial laundry owners advertised their access to clean water at the expense of washerwomen. The full-page ads asked in large black letters, “How Many Times Does She Change the Water?”⁷¹ The advertisement suggested that washerwomen failed to change the water they used between soaping and rinsing. The creator intended to question the credibility of washerwomen by interrogating the water they used. The advertisement claimed modern commercial laundries had equipment far superior to “the washerwoman’s five

⁶⁹ Wang, “Gender, Race, and Civilization,” 59.

⁷⁰ Wang, “Gender, Race, and Civilization,” 54.

⁷¹ “The Right Kind of Advertising and Why,” *The American Outlook*, August 1918, pages 2-4.

minutes desperate rubbing on the washboard.” Another advertisement in the periodical portrayed washerwomen as unsanitary, alluding to their low social class. “Washerwomen—with their improvised equipment consisting of pots, boilers and tubs waste thousands of gallons of water every week...In addition to this enormous waste of water, your clothes are ‘washed’ in alleys and in huts that are far from sanitary and where thousands of disease germs may breed.”⁷² In their desire to convert women to power laundries, commercial laundry owners relied on class rhetoric to delegitimize washerwomen. This class rhetoric assumed that washerwomen could not provide their customers with clean, suitable water for washing. Commercial laundry owners also intended to balance their claim to technological authority without undermining middle class women’s domestic role. About this, Mohun wrote, “Acknowledging middle-class consumer’s expertise but not that of working-class laundresses (who surely knew more about how to get clothes clean than their middle-class sisters) allowed laundrymen to split women along class lines.”⁷³

Commercial laundry owners prioritized the use of soft water and publicized this to gain customers. An advertisement in *The American Outlook* announced that modern facilities used modern water softening techniques. It said, “In modern laundries as many as 600 gallons of this velvety water pour over your clothes during every washing.”⁷⁴ The

⁷² Advertisement, *The American Outlook*, October 1921, page 17.

⁷³ Arwen Mohun, “Industrial Genders,” in Nina E. Lerman, Ruth Oldenziel, Arwen Mohun (eds.) *Gender & Technology: a Reader*, (Baltimore: Johns Hopkins University Press, 2003) 164.

⁷⁴ “Soft Water and Your Bill for Wearing Apparel,” *The American Outlook*, December 1919, 2-3.

importance of soft water for industrial use galvanized new water softening methods, both chemical and mechanical, at the turn of the twentieth century.⁷⁵ Managers took over the responsibility of water softening in commercial laundries. Due to the nature of the work, specifically task oriented and mechanization, women had much less contact with water in general. In a typical power laundry, most women, the majority of workers were women, worked as sorters, markers, ironers, and folders. Men operated the washing machines. A commercial laundry would have only employed a small handful of women to hand wash delicate clothing, but generally no more than two or three women per laundry.⁷⁶

In removing women from contact with water, commercial laundry owners reduced the risk that caustic chemicals such as lye and washing soda could have on women's bodies. Power laundry work, however, exposed workers to other problems. According to a report by the U.S. Senate made in 1911, the most frequent health effects women mentioned were complaints about leg, back, and arm pain. While the study found no complains about caustic alkies, there were comments about the use of bleach.⁷⁷ Bleach could be quite harmful in the commercial laundry. In 1929, an article in the *Philadelphia Tribune* noted that one hundred black laundry workers, most of whom were women, were exposed to chlorine gas when the safety valve of a bleaching machine malfunctioned.

⁷⁵ For some examples of commercial laundry softening systems see, "Laundering in the Panhandle," *The American Outlook*, March 1920, page 6; "Making a Dream Come True," *The American Outlook*, June 1922, page 4.

⁷⁶ U.S. Senate, 61st Congress, 2nd Session, Document No. 645, *Report on Conditions of Woman and Child Wage-Earners in the United States*, vol. 12, Employment of Women in Laundries, (Washington, DC. 1911) 18-25.

⁷⁷ U.S. Senate, Report on Conditions of Woman and Child Wage-Earners in the United States, page 30-33.

Due to inhalation of the toxic fumes, many went to the hospital.⁷⁸ That year, the *Philadelphia Tribune* also noted the poor working conditions black women suffered in laundries.⁷⁹ Citing a survey conducted in sixteen states by the Women's Bureau of the Department of Labor, the article noted that black women worked the longest hours and are paid just over half of what their white counterparts were paid. Poor working conditions of laundry workers, especially black workers, would continue throughout the twentieth century. Although water softening technologies removed the risks of using some caustic chemicals, they were still dangerous and uncomfortable work spaces.

When they industrialized a home industry, commercial laundrymen took skills away from women and endeavored to take jobs away from washerwomen. Their success took feminized household skills and mechanized them. When it came to water softening, however, their application of industrial techniques did prevent the common and painful skin conditions many women faced. During the same period, some middle class white women found themselves more informed than ever about the specific skills of laundry work.

Modern Water and Domestic Science

Changes at the end of the nineteenth century altered how some middle-class women thought about water softening, beyond the use of commercial laundries. By the last two decades of the century, domestic writers began to focus on the role of education in the home, not to instruct servants, but rather so that women could make sense of new

⁷⁸ "100 Overcome by Escaping Gas Fumes," *Philadelphia Tribune*, January 17, 1929.

⁷⁹ "Our Women are Overworked and Underpaid in Laundries," *Philadelphia Tribune*, December 26, 1929.

household technologies. A new generation of writers integrated science into the work of the home with the stated goal of creating informed consumers. Like commercial laundries, the proliferation of domestic science owed much to the sanitary movement and industrial and consumer culture. Historians have explored the growth of home economics, a compromised name that included domestic science, manual arts, home ecology, and argued that it created new avenues for women to pursue professional careers in both academic and social reform.⁸⁰ Home economics also presented a generation of middle class women with a new way of knowing nature through scientific means. In this context, domestic scientists began to talk about water not through empirical ways, but rather an essentialist view incorporating chemical and scientific factors of water. Water softening played a key role in this representation of a new ontology of water, one that linked water to science so far as it related to the household. Thus, in this context, water became a contact point between science and consumption. This was a key component of the modernization of water in the domestic sphere, in which science served to promote economic modernization through domestic consumption. While the goal of domestic scientists was to influence others to make good purchasing decisions using science, they also reinforced the validity of new consumer products.

In the 1880s, both changes in the production of goods, and the mass advertising and availability of mail order catalogues facilitated a shift in the way women did work in the home. Soap, packaged meat, canned goods, and bread could be easily purchased, especially in urban settings. Rural women had access to goods through mail order

⁸⁰ On the name of the movement see, Sarah Stage, “Introduction Home Economics: What’s in a Name?” in Stage and Vincenti (eds.), *Rethinking Home Economics*, 1-13.

catalogues and traveling salesmen. Some people felt that the explosion of new products necessitated a new approach to using and understanding them. Motivated by anxieties about burgeoning consumer culture, domestic scientists and later home economists wanted to train women to be able to understand these new consumers' goods to make informed purchases. They wanted women to understand the "economy" of things, that is to say the economic, social and industrial connections between the goods they purchased. The question then became how to prepare the American homemaker for her new responsibility as a consumer.⁸¹

For domestic scientists, the way to answer this question was to use science to create informed consumers. Thus, they began a process of bringing scientific knowledge into household processes. Prior to the end of the nineteenth century, some female authors had already begun integrating science into their works. As early as 1837, one author made the case for chemistry, "You will perceive, from the examples now given, that chemistry is a science which is intimately connected with the peculiar business of women."⁸² Their goal was to use science to elevate housework and in many cases focused on the science of food and cookery. The historian Caroline Lieffers has examined the process by which cookbooks brought scientific knowledge into the homes of English

⁸¹ Carolyn Goldstein, *Creating Consumers: Home Economists in Twentieth Century America* (Chapel Hill: University of North Carolina Press, 2012); on the growth of consumer culture see, Alan Trachtenberg, *The Incorporation of America: Culture and Society in the Gilded Age* (New York: Hill and Wang, 1982); William Leach, *Land of Desire: Merchants, Power, and the Rise of a New American Culture* (New York: Pantheon Books, 1993).

⁸² Mrs. Phelps, *The Female Student; or, Lectures to Young Ladies on Female Education*, (New York: Leavitt, Lord, & Co., 1836) 223.

women throughout the nineteenth century.⁸³ If cookbooks expanded women's knowledge related to the chemical and physical properties of cooking as well as the science of nutrition and digestion, then discussions about chemicals in the family wash brought water chemistry into the home. The addition of this subject to domestic advice literature was in response to the growth of products connected to the alkaline industry: soap and water softeners. It spurred new conversations about the use of these materials and ultimately added a dimension to the question of how and why women began to emphasize the biophysical materiality of water.

Ellen Swallow Richards's *The Chemistry of Cooking and Cleaning: A Manual for Housekeepers*, published in 1882, represented changes in thinking about household tasks such as laundry. Her work ushered in a new era of domestic science firmly grounded in both the hard sciences and growing American consumer society. Any discussion of either domestic science or home economics is not complete without Richards. Carolyn Merchant credited Richards with playing an integral part in introducing Americans to ideas about the connection between the home and the environment. Richards learned about the environment roaming her father's farm in Massachusetts in the mid nineteenth century, not far from the White Mountains of New Hampshire. Throughout her early years, Richards excelled at intellectual pursuits as well as more practical matters like helping her father when he opened a general store. At age twenty six she attended Vassar College and studied with the astronomer Maria Mitchell. There Richards found a passion for chemistry. She was particularly keen on the study of water chemistry, "She entered

⁸³ Caroline Lieffers, "'The Present Time is Eminently Scientific': The Science of Cookery in Nineteenth Century Britain," *Journal of Social History*, Vol. 45, No. 4 (Summer 2012): 936-959.

into a new world that would become her domain-- the analysis of water and its contents invisible to the naked eye."⁸⁴ It is not surprising then that Richards became an important figure in the emerging discipline of sanitary chemistry and engineering working with notable American chemist in the field William Ripley Nichols. As a woman working in a field almost exclusively dominated by men, Richards faced much adversity. She was forced into gender segregated work upon arrival at the Massachusetts Institute of Technology and was repeatedly denied entrance into the doctoral program there.

Richards championed for women's education especially in the sciences. She was a member of the Women's Education Association and through this organization instructed women in the science of chemistry. In 1875 Richards raised funds to set up a woman's laboratory at MIT. Richards was also very interested in the connection between science and the home. She played a role in connecting these ideas integrating environmental science and chemistry issues into concerns about the safety and rationality of the home.

⁸⁴ Robert K. Musil, *Rachel Carson and Her Sisters: Extraordinary Women Who Have Shaped America's Environment*, (New Brunswick: Rutgers University Press, 2014) see especially chapter 2, "Don't Harm the People: Ellen Swallow Richards, Dr. Alice Hamilton, and their heirs take on polluting industries," 53-88. Quote from page 58. Carolyn Merchant, *Earthcare: Women and the Environment* (New York: Routledge 1996) 140-143.

The Chemistry of Cooking and Cleaning exemplified this.⁸⁵ Inspired by James F. Johnston's *The Chemistry of Common Life*, Richards aimed to present the science behind every day domestic tasks, instructing women in applied science. Unlike the domestic manuals produced in the mid nineteenth century, Richards's work spent equal time and energy on domestic work and the science behind it.

Richards reasoned early in her book that it was imperative for women to understand the science of cooking and cleaning to make informed decisions about new products. In her preface, Richards stated her primary concern, "The number of patent compounds thrown upon the market under fanciful and taking names is a witness to the apathy of housekeepers. It is time that they should bestir themselves for their own protection. A little knowledge of the right kind cannot hurt them, and it will surely bring a large return in comfort and economy."⁸⁶ To avoid the dangers of the new labor saving chemicals and compounds, women needed to understand the science behind them. What followed was a manual dedicated to teaching nonscientific readers the practical side of chemistry. That is to say, Richards used concepts and practices women were already familiar with in the home through their work and applied scientific information to the

⁸⁵ Ellen Swallow Richards, *The Chemistry of Common Life; a Manual for Housekeepers* (Boston: Estes & Lauriat, 1882). James F. Johnston, *The Chemistry of Common Life* (New York: D. Appleton, 1855). Overlap of science and domestic work can be seen in other publications by Richards including, *Food Materials and their Adulterations* (Boston: Estes and Lauriat, 1886); Ellen Richards and Alpheus Woodman, *Air, Water, and Food from a Sanitary Standpoint* (Countway Medicine John Wiley & Sons Chapman & Hall 1909); Ellen Richards, *The Cost of Food; a Study in Dietaries* (New York: J. Wiley & sons, 1901). Richards also published a large number of works not related to domestic science for example, Richards, *Conservation by Sanitation; Air and Water Supply; Disposal of Waste (Including a Laboratory Guide for Sanitary Engineers)*, (New York: Wiley, 1911).

⁸⁶ Richards, *Chemistry of Cooking and Cleaning*, viii-ix.

knowledge. “All the substances about which we know anything are composed of a few elementary bodies,” wrote Richards, “The grain of wheat, the flesh of animals, the dangerous poison, all are capable of being separated into the simple substances of which they are composed.”⁸⁷ Richards then built off this simple concept to explain that all things are made up of seventy elementary substances that react with one another. She continued, “It is important for everyone to remember that laws govern all chemical changes; for one is often asked to believe that some chemical sleight of hand can make one pound of washing-soda worth as much as two...” In a rather simple and brief way, Richards has explained the fundamental principles of chemistry: the world is made up of elements and those elements interact with one another in a prescribed way.

In a chapter titled, “The Chemistry of Cleaning,” Richards explained the importance of chemical substances that aid in the washing process. The chapter began with a discussion of oil and grease. Not readily soluble in water, women must rely on alkaline metals mixed with fat in order to aid the washing process. Richards goes on to explain the chemical reaction that renders soap and how soap is able to remove oil and grease. Richard’s chapter included a lengthy discussion of alkali metals and noted the availability of such products. To soften water Richards recommended using soda ash, but she warned, “Soda ash is now the cheapest form of alkali, and housekeepers will do well to remember this fact when they are tempted to buy some new ‘--ine,’ or ‘crystal.’”⁸⁸ While Richards blended scientific knowledge with the need to mediate consumerism, she also asserted that readers must have a grasp of science in order to manage her servants,

⁸⁷ Richards, *Chemistry of Cooking and Cleaning*, 3.

⁸⁸ Richards, *Chemistry of Cooking and Cleaning*, 66.

echoing Beecher and Leslie. She warned of a young housewife tempted to solve all of her problems with new modern technologies, “She thinks that if her servants are provided with all modern appliances for doing work quickly and well, it is their fault if they do not accomplish it.” Yet, according to Richards, it would be her own fault for not properly educating herself.⁸⁹

The historian Nina Collins wrote that two philosophies existed about domestic education at the end of the nineteenth century. Some practitioners, like Richards, emphasized knowing the why of household work over the how. In other words, skill development was second to the acquisition of knowledge. On the other hand, others underscored technical skill development as well as the science behind household work. Collins showed that these two schools grew out of geographic necessity.⁹⁰ Women in the west did their housework without domestic help so needed both technical and scientific education. This difference was highlighted by manuals and publications created by domestic science programs in state agricultural colleges.

In 1909 the New York State College of Agriculture at Cornell published a twenty-eight bulletin series intended to bring information about domestic science to farmer’s wives. One titled *The Laundry*, was meant for rural women to learn helpful ways to do the laundry on their own without any paid help. Written by Rose Flora, who would be influential in the creation of the Home Economics Department at Cornell, it combined information about the practical aspects of doing laundry as well as the science behind it.

⁸⁹ Richards, *Chemistry of Cooking and Cleaning*, 79.

⁹⁰ Nina Collins, “Domestic Sciences at Bradley Polytechnic Institute and the University of Chicago,” *Journal of the Illinois State Historical Society*, Vol. 95, No. 3 (Autumn, 2002), pp. 275-299.

The forty-page bulletin carefully explained the chemistry behind the home laundry examining some of the most popularly used chemicals in the laundry process.⁹¹ It included a lengthy discussion of the effects of acids and bases on clothing as well as descriptions of common chemicals used in laundering: sodium carbonate, sodium hydroxid, sodium baborate, and ammonium hydroxid. Flora deftly explained the properties of hard and soft water concluding that, “The very characteristic which renders water so valuable as a detergent (a cleansing agent) -- its solvent power--- is the cause of its greatest shortcomings, for on its way to us water may pass over or through soils which contain soluble substances of an undesirable nature.” The most undesirable of all was lime salts that cause hard water. Written when the Home Economics movement had fully embraced questions of consumption, Flora also explained the many water softening agents on the market.⁹² The bulletin also detailed some of the more practical sides of doing the laundry including information on when, how, and where to do the family wash.

Drexel Institute in Philadelphia, Pennsylvania, offered a two-year course in domestic science. The comprehensive training course was designed for women who

⁹¹ Rose Flora, *The Laundry* (Ithaca, NY: NY state college of agriculture, Cornell University, 1909). For more on Flora’s role within the larger home economics movement see, Megan Elias, “‘Model Mamas’: The Domestic Partnership of Home Economics Pioneers Flora Rose and Martha Van Rensselaer,” *Journal of the History of Sexuality*, Vol.15, No. 1 (Jan, 2006), pp 65-88. On other bulletins produced by Universities as well as state extension departments intended for the use of farm women see Carrie Alberta Lyford, “Bibliography of Home Economics,” *Department of the Interior Bulletin*, 1919, No. 46. Pp. 10-17.

⁹² Juniata L. Shepperd, *Laundry Work, for Use in Homes and Schools* (St Paul, MN: Webb publishing co, 1902) explained that in general washing compounds available on the market were generally just sal soda, so a smart housewife would just purchase sodium carbonate directly. She also found borax to be an expensive alternative to sal soda.

wanted to pursue work teaching domestic science in either public or private schools and combined the how and why of understanding the science of laundry work. The course relied on both lecture and demonstration, soliciting the use of the school's innovative laboratories and practice kitchens. Students took classes in general chemistry, physics, and biology, as well as more directed courses such as chemistry of foods and biology of hygiene and sanitation. The course also included a class called laundry work described as, "The exposition of the scientific principles involved in the various processes is followed by actual practice in the laundry."⁹³ Laundry courses taught at colleges and universities were a practical way to teach scientific principles as well as technical demonstrations.

One domestic science manual written in 1914 incorporated changes in the way women acquired water into questions about the laundry. E.L. Marsh wrote in *Laundry Work in Theory and Practice* that for most women, water simply came out of the tap and it was impossible to know where the water had originated and what types of matter had dissolved with in it.⁹⁴ In order to gauge one's own water supply, Marsh recommend women do the following at home: fill two test tubes one with rain water and one with tap water. Slowly add drops of dissolved soap. Note how much soap it took to form the

⁹³ "At Drexel Institute: A Two Years' Course in Domestic Science," *The American Kitchen Magazine*, vol. 4, no. 1 Oct 1895, p 39- 41.

⁹⁴ E.L. Marsh, *Laundry Work in Theory and Practice*, (London: Longmans, Green & co., 1914). For its use in American courses see Department of the Interior, "Monthly Records of Current Educational Publications," *Bulletin*, 1919, No. 42. Pp. 92. Another example of an European manual used in the United States to teach laundry courses is Florence Jack, *The Art of Laundry Work: Practically Demonstrated for Use in Homes and Schools* (Edinburgh: T.C. & E.C.. Jack, 1896)

lather.⁹⁵ Using rainwater would serve as a control sample to gauge how hard or soft one's tap water was. Marsh's manual is filled with experiments related to water chemistry and exemplified the use of the scientific method to teach domestic science.

Marsh, a staff teacher at the national training school of cookery in London, included lessons to be given to a class of children on laundry. Although published in England, Marsh's work was frequently used in American courses on domestic science. The first lesson focused on water as Marsh claimed, "Water is the most important material in the laundry work, therefore it is being dealt with before the others - soap, soda, etc...."⁹⁶ What followed was more reminiscent of a lesson in physical science than housework. Marsh explained the physical states of water, natural sources of the substance, and a discussion about what rain is. She continued to explain water's role as a solvent, recommending the use of glasses containing salt and water and sand and water to demonstrate this principle. Building off of this notion, Marsh then explained what made water hard connecting this lesson on the physical environment to laundry work, "Explain that hard water curdles soap, and wastes it. Let two girls wash their hands, one in cold hard water, and the other in cold boiled water. Notice the extra amount of time and soap used in getting a lather in the water not boiled."⁹⁷ From there Marsh explained other materials used in laundry work, soap, alkalies, starch and other chemicals and how they react with water. The chapters that followed explain and demonstrated the removal of stains and the proper technique for washing different fabrics and materials. The first

⁹⁵ Marsh, *Laundry Work in Theory and Practice*, 7.

⁹⁶ Marsh, *Laundry Work in Theory and Practice*, 5.

⁹⁷ Marsh, *Laundry Work in theory and practice*, 8.

chapter of the guide incorporated much more of the why of washing than the how that proceeds it. When reading Marsh's words, the reason seems clear. Since most issues, techniques, and strategies for doing the wash had to do with how materials interact with different types of water, the foundation of a course on laundry must begin with foundational information about water. Thus, according to Marsh and other instructors, understanding the principles behind how water, a tool used in housework, acted was imperative in the work process of laundry. Laundry work, in Marsh's explanation, was fundamentally work with nonhuman nature.

Marsh, Richards, and courses taught at colleges made clear the availability of this information through courses and institutions. Extension work also indicated this information was being disseminated to women beyond the classroom. At the end of the nineteenth century, information related to the how and why of laundry work was also becoming more widely available in other ways. Prominent domestic scientists like Ellen Richards and Isabel Bevier were frequent contributors to *The American Kitchen Magazine*. This and other magazines dedicated to women's work disseminated information to a broad group of women. Promoters of the new opportunities available to women in domestic science boasted that this information was now available for ladies, house servants, shop girls, new immigrants, and even children. Domestic science was also taught in settlement houses, part of Progressive efforts to help the urban poor. Teaching the poor about proper and rational domestic science, boosters claimed, would enable them to lift themselves out of poverty and dependence. Finally, some women saw the movement as an opportunity for them to assert their own professional independence. Caroline Reed Wadhams, who studied at the teacher college of Columbia University,

taught classes about domestic work at hotels and recreation centers for a nominal fee. Wadhams also published works declaring that domestic science was no longer only for women in higher institutions. She said, "...the most important facts of household arts have been carried to hundreds of thousands of homes by printed matter such as books and magazines. It is obvious that instructions by print rather than by teachers offers the only practical method of quickly spreading the science and arts of the household to all homes."⁹⁸ Part of this dissemination of knowledge was Wadhams's own series of books: *Simple Directions for the Cook*, *Simple Directions for the Chambermaid*, *Simple Directions for the Waitress or Parlor Maid*.⁹⁹ The guide contained instructions for the laundress, without the detailed science behind laundry work. The directions also warned laundresses about the dangers of chemicals used in laundering and indicated that these chemicals would most likely be under lock and key in the household.

Ironically, as middle-class women learned about the complexity of chemical interactions between water, acids, fats, and alkalis, most of them sent their laundry to either a washerwoman or commercial laundry. Water softening, then, was a means through which to learn water chemistry; it was a way to educate women in non-traditional subjects in a safely traditional manner. It was also a way to reinforce the validity of new consumer culture. Some of these kinds of courses and materials would have been available to working-class women, but would have focused on the practical side of

⁹⁸ Caroline Reed Wadhams, *Simple Directions for the Laundress*, (New York: Longmans, Green and Co., 1917) introduction.

⁹⁹ Wadhams, *Simple Directions for the Cook* (New York: Longmans, Green and Co., 1917); *Simple Directions for the Chambermaid* (New York: Longmans, Green and Co., 1917); *Simple Directions for the Waitress or Parlor Maid* (New York: Longmans, Green and co., 1917).

laundry work rather than the scientific and chemical components. How some women thought about and actually softened water would continue to be based on such cultural factors throughout the first decades of the twentieth century.

Conclusion

In the domestic social arrangements of nineteenth-century America, people relied on water for their work. Yet as this chapter has proven, they relied on soft water. Launderers needed water that lacked natural hardness minerals since they interfered with the process of doing the wash, specifically the use of one specific technology, soap. Work customs dictated that whoever was responsible for the washing acquire soft water. In the rural household, this influenced the physical water system of the home and reinforced the definition of rain water as good water. The need for soft water also encouraged the manipulation of the biophysical nature of water, first with homemade chemicals and eventually store-bought powders. Softening water could even physically remake the skin of someone's hands revealing that productive domestic tasks were in fact bodily and labor intensive. Both class and race demarcated to what extent some people interacted with water. These examples suggest the dialectic relationship between people and nature, remaking not only aspects of water, but also labor.

Commercial launderers most clearly displayed the social nature of water. In employing the discourse of pure, soft water, they juxtaposed it with the water lower-class washerwomen used, which they implied was hard and impure. They also defined soft water as part of the masculine and technological triumph of the commercial laundry owner over household drudgery. As laundry men wrestled control of the laundry from

some women, others used water in the classroom. Domestic scientists continued to understand water as a tool to be used in the home, but also understood it as an object through which to connect science and consumption. If economic modernization relied on consumption in the home, water served to lubricate the mission.

In the broad history of water softening, the examination of laundry work revealed the various options people employed to soften water. By the end of the nineteenth century, cisterns, homemade softening chemicals, and store-bought caustics. Hardness minerals in water made a considerable impact upon launderers and resulted in these techniques. These processes had the power to reshape household water systems, the skin of a washerwoman's hand, and reinforce consumer culture. As society continued to gender the laundry, despite commercial laundrymen's attempts to undo this social definition, water softening too became a feminized task.

CHAPTER 3
HAMMERS, CHISELS, AND HEMLOCK: SCIENTIFIC WATER
CORRECTION ON AMERICAN RAIL LINES, 1860-1910

In 1874, the committee on locomotive boilers of the American Railway Master Mechanics' Association declared boiler scale, minerals clung to the walls of a boiler, a great evil. "To obviate these evils," the committee wrote, "namely: danger from explosion, expense of repairs, loss of time, and waste of fuel—very many methods have been devised having in view the prevention and removal of scale."¹ Boiler scale, or boiler incrustation, was a troublesome side effect of hard water. As water evaporated within the walls of a steam boiler, hard water left behind minerals that could strongly adhere to the side of the machine. People working intimately with locomotive boilers thought scale an evil for two reasons. First, as the committee mentioned, scale obstructed the mechanical function of a boiler and could cause it to explode. Boiler explosions were extremely common throughout the nineteenth century. Industrial workers feared loss of property as

¹ "Report of the Committee on the Operation and Management of Locomotive Boilers, Including the Purification of Water," *Seventh Annual Report of the Proceedings of the Annual Convention of the American Railway Master Mechanics' Association* (Cincinnati: Wilstach, Baldwin & Co.) The committee consisted of men from across the country including a representative from the Northern Pacific, International-Great Northern Railroad which operated in Texas, the Ohio & Mississippi, Philadelphia and Columbia Railroad, and Central of New York. Their diverse geographic makeup suggests a widespread concern about scale. Industrial workers frequently used the term evil in relation to boiler scale. See also, *Fifth Annual Report of the American Railway Master Mechanics' Association*, (Cincinnati: Wilstach, Baldwin & Co., 1872) 138.

well as loss of limb and life because of these explosions.² Secondly, scale severely impeded the efficiency of a boiler. As scale accumulated, it adhered to the sides and tubes of the boiler, and reduced the heat transfer from metal to water. Therefore, a boiler caked in scale required more fuel to run efficiently. The removal of scale was difficult, especially because of the unique design of locomotive boilers. A boiler might be out of commission for an entire day for scale to be removed. Although a boiler was dependent on water, the latter's materiality interacted with heat and pressure within the machine to leave behind unwanted minerals.³ In the case of a steam boiler, nonhuman nature and technology were interdependent, but water's materiality also caused tension especially when it risked explosion and inefficiency. It is within this tension that industrial laborers sought to define and change the chemistry of water within the boiler.

Steam technology enabled industrialization in the United States. By the first decades of the nineteenth century, steam technology powered mills and water pumps replacing water power and allowing for industrial productivity in locations far from rivers

² Contemporary newspapers covered boiler explosions with much interest throughout the nineteenth century. The magazine *The Locomotive* was practically dedicated to dissecting boiler explosions. In 1866 financiers opened the Hartford Steam Boiler Inspection and Insurance Company which specialized in loss or damage resulting in steam boiler explosions. On the company see, Ad for Hartford Steam Boiler Inspection and Insurance, *The Locomotive*, volume 1, October, 1866, page 172.

³ The boiler was an envirotechnical system. For a history on the term envirotechnical see, Sara Pritchard, "An Envirotechnical Disaster: Nature, Technology, and Politics at Fukushima," *Environmental History*, Vol. 17 (April, 2012): 219-245. For just two examples of histories that employ this see, Sara Pritchard, *Confluence: The Nature of Technology and the Remaking of the Rhone*, (Cambridge, MA: Harvard University Press, 2011); Jeremy Vetter, *Field Life: Science in the American West During the Railroad Era*, (Pittsburgh, PA: University of Pittsburgh Press, 2016). On the relationship between nature and the construction of the railroads see, Mark Fiege, *The Republic of Nature, an Environmental History of the United States* (Seattle: University of Washington Press, 2012) see especially chapter six "Iron Horses," 228- 264.

and streams.⁴ Steam power enabled an increase in agricultural output, goods that in the 1830s and 1840s steam powered boats transported to growing urban areas. In the 1840s and 1850s, steam powered locomotives promised the fast and efficient travel of goods and people. Between 1840 and 1865 track mileage expanded from 3,000 to 31,000 miles aided by human, animal, and mechanical labor like the steam shovel.⁵ While boiler scale affected many industrial operations that used steam technology, nowhere was it a more pressing problem than along railroad lines. Steam boilers fueled massive growth and expansion in the United States. Water both powered and threatened the prime mover of this development, the steam boiler.

Railroad mechanics, more than any other group, were left to deal with the negative effects of boiler scale. They spent little time contemplating the complicated relationship between their machines and nature. Instead, they translated the natural ecological variation of water into an economic problem, weighed in wasted fuel, time, and profits, in the processes defining hard water as bad. Historians have pointed out the impulse during the railroad era to reimagine time and space in relationship to cost.

⁴ Ruth Schwartz Cowan, *A Social History of American Technology* (New York: Oxford University Press, 1997) 73-75; On the domination of the steam engine in the history of the industrial revolution see William Rosen, William Rosen, *The Most Powerful Idea in the World: a Story of Steam, Industry, and Invention* (New York: Random House, 2010) preface. On the history of steam technology see, Richard Hills, *Power from Steam: a History of the Stationary Steam Engine* (Cambridge: Cambridge University Press, 1989) p 1; Hunter Louis, *A History of Industrial Power in the United States*, (Charlottesville: University of Virginia Press, 1979). See also Richard Wilkinson, "The English Industrial Revolution," 80-100, in Donald Worster, ed., *The Ends of the Earth: Perspectives on Modern Environmental History* (Cambridge; New York: Cambridge University Press, 1988).

⁵ James Oakes, Michael McGerr, Jan Ellen Lewis, Nick Cullather, Jeanne Boydson, Mark Summers, Camilla Townsend, Karen Dunak, *Of the People: A History of the United States Volume 1, to 1877*, (Oxford University Press) 385.

Railroad planners and boosters wanted to, in the words of the historian Richard White, “...lay out the physical infrastructure of railroad—its tracks, bridges, tunnels, stations—so that movement yielded the highest possible revenues.”⁶ White and others, including Barbara Young Welke, have critiqued this ethos namely its effects on the environment and personal safety. For railroad mechanics, the mantra of efficiency energized their attempts to fix boiler scale beginning in the 1860s, although often with little knowledge of the complicated chemical problem. Station workers, trained in the mechanical rather than chemical arts, removed incrustation with hammers, chisels, potatoes, and tree bark, observing if the latter two materials turned hard scale into a soft sludge they could easily remove. Their experimentation sometimes led to even more serious problems in their machines such as metal corrosion. The failure of station mechanics coupled with the strong cultural compulsion not to waste fuel and fear of boiler explosions promoted innovation in water softening techniques and technologies for both rail stations and beyond. The difficulty of using existing methods along rail lines, specifically the addition of caustic materials, left space for commercial water softening to become a recognized field in the industrial sector.

By the end of the twentieth century water softening became a large-scale commercial industry with manufacturers producing both chemicals and machinery to combat the effect of hard water specifically in the industrial arena. Manufactures

⁶ Richard White, *Railroaded: the Transcontinentals and the Making of Modern America* (New York: W.W. Norton & Co., 2012), 144; Barbara Young Welke, *Recasting American Liberty: Gender, Race, Law, and the Railroad Revolution, 1865-1920* (New York: Cambridge University Press, 2001). See also Wolfgang Schivelbusch, *The Railway Journey: the Industrialization of Time and Space in the Nineteenth Century* (Oakland: University of California Press, 2014).

produced techniques specifically for railroads, but soon offered technologies for other industries. Chemists, as well as the occasional pharmacist, touted their product's ability to "correct" water, employing the rhetoric of science and analysis. Railroad workers sought the most efficient solution to the problem of hard water and as a result the production of quality water became a source of entrepreneurial and commercial gain.

This chapter explores the growth of commercial techniques to deal with hard water in industrial spaces. It occupies an important period in the history of water softening, one that follows the transition from experiential methods through to the proliferation of water analysis as a mean of correcting water problems. The period marked a shift in the ways industrial workers thought about water. The adage of whatever wet was good was, in fact, not good enough. Mechanics placed quality of water on equal standing as quantity of water. Water along rail lines would set up an important precedent that continued into the twentieth century of defining water quality not only for domestic consumption, but also for industrial work.⁷ The demands of machines that relied on water reoriented thinking about good-quality water. For mechanics pure water meant soft water.

⁷ On the history of water quality for domestic consumptions see, Joel Tarr, *The Search for the Ultimate Sink: Urban Pollution in Historical Perspectives* (Akron, OH: The University of Akron Press, 1996) especially chapter six, "Disputes Over Water-Quality Policy, Professional Cultures in Conflict," 159- 178; Martin Melosi, *Precious Commodity: Providing Water for America's Cities* (Pittsburgh, Pennsylvania: University of Pittsburgh Press, 2011); Martin Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore: Johns Hopkins University Press, 200). On water quality in age of miasmas see, Conevery Bolton Valencius, *The Health of the Country: How American Settlers Understood Themselves and Their Land* (New York: Basic Books, 2002) see especially chapter five, "Waters," 133-159.

In the Belly of the Steam Engine

Writing in the mid eighteenth century, the French mechanical engineer Bernard Forest de Belidor described the triumph of the steam boiler, “It must be acknowledged that this is the most wonderful of all machines.”⁸ He compared the steam boiler to an animal, “nothing of the world of man approaches so near to animal life. Heat is the principle of its movements there is in its tubes circulation like that of the blood and veins of animals, having valves which open and shut in proper periods.” Belidor exhibited a popular sentiment during the period about human mastery over nature. It was so complete that humans could create animals made specifically for their work.⁹ For the engineer Robert Armstrong, the steam engine, or more specifically the steam boiler, was more like an animal than Belidor realized. Writing in 1838 in response to Belidor’s comments, he said that the boiler also performed some things, “that have a closer resemblance to those in the animal economy, denominated involuntary...the separation of excrementitious matters, and which in physiology is considered to be a peculiar vital function.”¹⁰ In other words, a

⁸ Belidor is quoted in Robert Stuart, *A Descriptive History of the Steam Engine*, (London: Knight and Lacey, 1824): 1. His writing fits in with popular Cartesian notions of the time about animals and machines. On cultural thinking of animals as living machines see Clay McShane and Joel Tarr, *The Horse in the City: Living Machines in the Nineteenth Century* (Baltimore: The Johns Hopkins University Press, 2007): 2-9.

⁹ For contemporary examples of this rhetoric see, James R. Leib, *Lecture on the Nature and Objects of the Modern Philosophy*,” (Philadelphia: Clark & Raser, Printers, 1830): 14; Michael Reynolds, *Stationary engine driving. A practical manual for engineers in charge of stationary engines* (London: C. Lockwood and co., 1881) p 18. Stephen P. Rice found this rhetoric pervasive in their study of textual reference to machines in Antebellum America, Stephen P. Rice, *Mining the machine: languages of class in early industrial America* (Berkeley: University of California Press, 2004): 19-22.

¹⁰ Robert Armstrong, *A practical essay on steam engine boilers, as now used in the manufacturing district around Manchester* (Manchester: J & J Thomson, 1838) 75-76.

boiler, like an animal, produced excrement. Armstrong, tongue and cheek aside, described the tendency of water used in a steam boiler to leave material behind after evaporating. Steam engines had been producing excrement long before they were employed along railroads lines. Understanding the problem of hard water scale on locomotive boilers requires a brief history of these machines. Evolving boiler technology, motivated by the desire to heat water more efficiently, ultimately led to the evolution of a machine that was very incompatible with hard water.¹¹

In the early eighteenth century, Thomas Newcomen developed the first commercially successful steam engine in England. A steam engine starts with a boiler, a metal sphere heated entirely from the outside.¹² Newcomen's boiler was called a shell boiler because it contained a copper shell over water. An external heat source heated the water, generally in a fire beneath the boiler. Once the water boiled, steam traveled through a long tube or pipe at the top of the boiler forcing a piston upwards and a connected pipe downwards. His steam engine worked like a seesaw. Using another pump, more water then caused the steam to rapidly condense, converting it back to water and creating a powerful vacuum. The vacuum pulled the piston back downward bringing up whatever was being pumped on the other side. The cold water drained and the cycle

¹¹ On the history of steam technology see, Richard Hills, *Power from Steam: a history of the stationary steam engine* (Cambridge: Cambridge University Press, 1989) p 1; Rosen, *The Most Powerful Idea in the World*; Hunter Louis, *A History of Industrial Power in the United States*, (Charlottesville: University of Virginia Press, 1979). See also Richard Wilkinson, "The English Industrial Revolution," 80-100, in Donald Worster, ed., *The Ends of the Earth: Perspectives on Modern Environmental History* (Cambridge; New York: Cambridge University Press, 1988).

¹² For a technological history of steam boilers specifically see, Sebastian Teir, *The History of Steam Generation*, (Helsinki University of Technology Department of Mechanical Engineering, Steam Boiler Technology eBook, Espoo, 2002).

repeated again.¹³ Newcomen's engine enabled water to be pumped out of mines without the use of a water wheel and effectively lowered the cost of removing water from deep coal mines. His engine, however, relied on the burning of so much coal that the machine was only cost effective in a coal mine, literally on top of a fuel source.

James Watt would be remembered most notably in history for his steam engine, which improved on Newcomen's design in what journalist William Rosen's popular account of steam technology referred to as an "innovation in efficiency." On the subject Rosen wrote, "From the beginning, Watt recognized the problem in terms of wasted fuel, which meant wasted money, and therefore an opportunity."¹⁴ Watt improved the design by separating certain parts the heated and cooled the steam. In doing so, the mechanical function required less heat and therefore less water. Watt also improved upon Newcomen's boiler designing a horizontal or wagon boiler. Since the water rested horizontally over an external fire, it provided a larger heating surface.

In the early years of the nineteenth century, an American, Oliver Evans, and a British inventor, Richard Trevithick, independently worked on a new type of boiler, with the goal to improve fuel economy.¹⁵ They both constructed what would come to be called a flued or Cornish boiler. These types of boilers had two cylinder shells, one inside of the other, and rested horizontally with water in the space between the cylinders. The inner

¹³ On Newcomen's engine see Rosen, chapter two "A Great Company of Men," 18-42.

¹⁴ Rosen, *The Most Powerful Idea in the World*, 103.

¹⁵ Cowan, *A Social History of American Technology*, 72.

cylinder acted as a flue, containing a furnace or fire grate. When the inner cylinder was heated, it heated the surrounding water.

This type of design created a much larger heating surface than earlier shell or wagon boilers, thus increasing steam pressure and temperature. In doing so, the flued boilers greatly increased the fuel economy of a boiler. By the first decade of the nineteenth century, Evans had constructed devices for the first two manufacturing plants in the United States powered by steam, a flour mill in Pittsburgh and a gristmill in Lexington. His flued boiler was mostly used in steam plants and in some early locomotives and ships.¹⁶ In the history of the stationary steam engine written by Richard Hills, he noted the advantages of this new type of boiler: they withstood higher pressures and the position of the fire greatly increased fuel efficiency because it connected directly with water.¹⁷

The next innovation in boiler technology built off the flued boiler to add more flues or tubes. The fire tube boiler relied on multiple tubes within a single cylinder. The Lancashire boiler is an example of a fire tube boiler, containing two fire tubes. Throughout the early nineteenth century, innovators continued to add small tubes running through the cylinder increasing the heating surface area within the boiler. Perhaps one of the most famous early locomotives, Robert Stephenson's *Rocket*, designed in 1829, employed a multi-tubed boiler system with twenty-five copper fire-tubes running through a cylinder. John Steven's experimental locomotive boiler, constructed in the United

¹⁶ Cowan, *A Social History of American Technology*, 73-76. For more on relationship between steam and society see, Carroll Pursell, *The Machine in America: A Social History of Technology* (Baltimore: The Johns Hopkins University Press, 1995).

¹⁷ Hills, *Power from Steam*, 2.

States in 1825, contained twenty wrought iron tubes.¹⁸ Multi-tube boilers provided the answer to a problem engineers faced, how to extract the most heat from water. According to J.B. Snell, the author and former managing director for the Romney Hythe & Dymchurch Railway, "...this could only be done by increasing the amount of heating surface, where heat could be transferred to the water in the boiler. The length of the boiler could not be much increased; therefore the amount of heating surface in the boiler's cross-section had to rise."¹⁹

Multiple small tubes provided a larger heating surface than one large tube. Steam locomotives almost exclusively contained multi-tubed boilers which allowed them to efficiently extract heat. The multi-tubed boiler, however, had one major disadvantage, especially for railroad mechanics. According to Hills, "In Cornish boilers, the sediment fell to and remains at the bottom from where it could be easily washed out through the draining-down pipe."²⁰ In most cases mechanics either simply washed away sediment or scraped away hardened scale from the bottom or sides of a boiler. Multi-tube boilers aggravated the issue of boiler scale and incrustation. The existence of large amounts of tubes within the boiler meant scale could cling and harden to more, often harder to reach, surfaces.

The multi-tubed boiler proved a boon for the locomotive industry. It enabled locomotives to operate at higher temperatures and pressure. Yet the specific type of boiler

¹⁸ Smith Hempstone Oliver, *The First Quarter Century of Steam Locomotives in North America*, (Washington, DC: Smithsonian Institute, 1956) 10.

¹⁹ J.B. Snell, *Mechanical Engineering: Railways*, (London: Longman, 1971) 61.

²⁰ Hills, *Power from Steam*, 129.

used also ran into new problems. As the railroad age raged on, discussions about water and scale increased with railroad mechanics responsible for fixing related problems. New technology of the railway age, specifically the multi-tube boiler, changed how people charged with the maintenance of those technologies thought about and interacted with water. Mechanics could no longer efficiently remove scale using older traditional methods. The multi-tube boiler, and what railway workers expected of them in terms of function, galvanized the need for soft water along rail lines, or at least an efficient way to handle unruly hard water.

Railroad Mechanics' Bad Water

Railroads have a unique hydraulic system in which water flowed in the direction of capital, or the movement of freight and people.²¹ Locating engineers used technical expertise to construct infrastructures that brought water towards railroad tracks. Station men ensured water filled locomotive boilers, so that it could move trains towards destinations and more capital. As water evaporated throughout this process, it left some hardness ions clung steadfast to the forest of tubes inside of a boiler. As mechanics noticed millimeters of scale impeded the function of boiler and risked explosions, they translated an environmental phenomenon into an economic problem. New technologies such as the multi-tubed boiler meditated the relationship between mechanics and water. The function of an envirotechnical system, such as a boiler, also forced mechanics to

²¹ On the unique problems related to water and railroads in the arid west see, Richard J. Orsi, "Railroads and Water in the Arid Far West: The Southern Pacific Company as a Pioneer Water Developer," *California History*, Vol. 70, No. 1 (Spring 1991): 46-61.

define water, illuminating the social process of water quality. Since the hydraulic system of a railroad flowed towards capital, it necessitated some people be responsible for making it flow there in the most efficient manner possible.

Steam locomotives use a tremendous amount of water with a constant demand for water along locomotive runs, see Figure 2. C.R. Knowles the superintendent of water service for the Illinois Central Railroad offered the following approximations. In 1916 he estimated the annual consumption of water by locomotives, note the figure is for locomotive supply only, was 450 billion gallons.²² That equates to nearly 3.7 trillions pounds of water, 681,374 olympic-size swimming pools, or 1.3 million forty-gallon bathtubs.²³ Knowles alluded to a great increase in the use of water at the beginning of the twentieth century using specific figures from the Illinois Central: 72 million gallons used in 1895, 141 million gallons in 1905, and finally 238 million gallons in 1915. Knowles claimed, “Assuming the water stations to be spaced an average distance of 20 miles apart, it is necessary to maintain nearly 13,000 water stations to supply the water required by more than 60,000 locomotives hauling 1,000,000,000 passengers and 2,000,000,000 tons of freight annually.”²⁴ The amount of water used relied on localized factors including power

²² C.R. Knowles, “Railway Water Supply,” April 20, 1917, *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1917) 4873-4893.

²³ Calculated by the author. It is difficult to find water use data to compare this figure to for this time. For instance, a survey of annual reports published by the United States Geological Survey from 1906 to 1916 provide no cumulative for water used in the United States for either domestic or industrial uses. Some historic reports of municipal water work contain information but do not delineate national water usage.

²⁴ Knowles, “Railway Water Supply,” 4873-4874.



Figure 2. A Station Worker in Fairmont, West Virginia, January 1928. Source: University of Pittsburgh Digital Collections, Monongahela Railway Company Photographs.

and speed of the locomotive, conditions of cars, and geographic factors such as curvatures and gradients of tracks.

The need for large quantities of water meant that rail road engineers, responsible for water supply lines, often transformed the local landscape for their water needs.²⁵ In the proceedings of the New York Railroad Club in 1900, W.L. Derr of the Erie Railroad noted engineers obtained water supplies from practically any conceivable source including cities and villages, wells, and streams. All three sources required the laying of grids of interconnected pipes, usually leading to a water tower near the tracks. A common practice was to dam streams to create reservoirs specifically for the use along lines which transformed landscapes most notably.²⁶ Derr included good practice for reservoir sites for irrigation articulated by the United States Geological Survey: choosing the best location for a dam depending on availability of materials and a sufficient spillway as well as a geographic analysis taking declivity of slope, geography of proposed reservoir site and gauge of how fast the water would reach the reservoir. Best practice, however, was not always available for railroad dams. “As railway water works are generally confined to

²⁵ On environmental impact of the railroads see, White, *Railroaded*, especially Chapter 11 “Creative Destruction”, 455-498; Fiege, *The Republic of Nature*, especially “Six Iron Horses Nature and the Building of the First U.S. Transcontinental Railroad,” 228-264; Andrew Isenberg, *The Destruction of the Bison: An Environmental History, 1750-1920* (Cambridge, England; New York, New York: Cambridge University Press, 2000) especially chapter 5, “The Wild and the Tame,” 123- 163.

²⁶ W.L. Derr, “Notes on Railway Water Supply,” March 15, 1900, *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1917) Volume 10, pages 3- 40. On dam construction from engineering standpoint see, J.B. Johnson, “The Location and Construction of Dams,” *Engineering Magazine*, vol. 10, January 1896, 654-670.

much narrower limits than irrigation work, it may not always be possible to choose a site embodying all or even a greater number of these conditions,” Derr wrote.²⁷ For this reason, railroad dams were often constructed hastily and without proper attention to the local environmental conditions.

If the quantities of water needed for rail lines reshaped local landscapes, the quality of water used had the power to reshape the inside of mechanical parts of locomotives. Water for railroad use was heavily dependent on both local cultural and ecological conditions. The Baltimore & Ohio Railroad faced a specific problem in their water stops in the area near Pittsburgh due to environmental factors caused by human activity. Runoff from nearby coal mines had transformed much of the water in the area highly acidic. Acidic water caused the corrosion of metal in locomotive boilers. Similarly, high alkalinity in water in the Western United States also interfered with the functionality of locomotives. Sulfates, highly concentrated in alkaline waters in some western states particularly Nebraska and Wyoming, caused problems in boilers.²⁸ The most persistent problem for railroad mechanics was hardness in water. Railroad workers, specifically mechanics, classified types of water by its effect on the function of machines. Mechanics called hard water bad water.

²⁷ Derr, “Notes on Railway Water Supply,” 4.

²⁸ Testimony of Mr. H.B Hodges, March 15, 1900, *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1900) Volume 10, pages 28-29. On acid water in Pittsburgh see, “Pure Water for Engines.; Baltimore and Ohio Railroad Locomotives Damaged by Impurities,” *The New York Times* September 7, 1902. There was much debate about the actual influence of the use of alkali waters, see Testimony of Professor C. Kershel Koyl, *Official Proceedings of the New York Railroad Club, 1905*, 224-225.

Unlike a dam for irrigation or even a water supply for manufacturing purposes, engineers were often restricted to proximity to tracks for where they could source their water resulting in a lack of attention to water quality especially in between the 1850s and 1880s, the early decades of rail travel. Looking back to that time, in 1905 a commentator in the proceeding of the New York Railroad Club noted “There was a time in the West when railroad men considered anything that was wet was water and they used it because they were obliged to—to get over the road.”²⁹ In 1900, another said of engineers, “Their only idea was to get water that could be had easily; anything wet was good enough.”³⁰ Scaling from hard water proved that anything that was wet, was indeed not good enough. The preoccupation with getting locomotives “over the road,” meant engineers failed to consider the quality of the water they sourced. Engineers, when choosing a water source, knew little about the chemical medley present in most waters. If they did acknowledge the existence of large amounts of calcium or magnesium ions, they did not take its possible influence on boilers into account. It was only after mechanics saw the effect of water on the multi-tube boiler beginning in the 1860s that they realized and made distinctions between bad and good water instilling social definitions on nonhuman nature. Mechanics frequently derided engineers for their preoccupation with quantity over quality.³¹ Railroad mechanics’ ire towards engineers about water quality revealed the

²⁹ *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1905) Vol. 15, 1904-1905, 227. Testimony of Mr. Kennicott.

³⁰ Testimony of Angus Sinclair, March 15, 1900, *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1900), 34-36.

³¹ Testimony of Angus Sinclair, March 15, 1900, *Official Proceedings of the New York Railroad Club* (New York, NY: New York Railway Club, 1900), 34-36.

different interaction between those who worked to procure water and those who dealt with the machines that relied on water.³² For locating engineers, any water was good enough so long as it could be used to get trains across track. Mechanics, however, experienced water differently. When a mechanic demanded pure water, they needed something that worked in their machines properly. Both natural and anthropogenic forces, such as the decision of an engineer, caused problems for boilers.

In the case of nineteenth-century railroads, cultural factors influenced who worked in machine shops and therefore who dealt with the effects of hard water. Gender shaped the outcome of men and women's interactions with hard water as it related to the steam boiler. Railroads rarely employed women in the nineteenth century. The first influx of women employed by railroads came during World War I. A summary of women in railroad work published in 1917 by the New York Railroad Club noted that women should be employed in "railroad housekeeping," jobs such as cleaning cars, selling tickets, dispensing information, and performing clerical duties. The article wrote that women should not be employed in mechanical shops because, "a woman's mind does not grasp the mechanics of machinery easily."³³ Therefore, it would have been unlikely for women to work directly with steam technology affected by hard water. Railroad work was also segmented along racial and ethnic lines. This is especially true for the

³² This sentiment can also be found in the textile industry, see J.F. Tonn, "Some Practical Factors in the Selection and Use of Detergents," *American Dyestuff Reporter*, New York, October 22, 1923, Vol. 12, 762-764.

³³ Stuart Bready, "Women in Railroad Work," *Official Proceedings of the New York Railroad Club*, Vol. 28, December 1917, 5012-5027, quoted from page 5016. On the few instances of women employed for railroads in the nineteenth century see Walter Licht, *Working for the Railroad: The Organization of Work in the Nineteenth Century* (Princeton, New Jersey: Princeton University Press, 1983), 215.

construction of track, which relied heavily on black laborers as well as immigrant labor from Mexico, Europe and Asia.³⁴ Southern railroads in the antebellum era used the labor of enslaved people for the construction of railroads, as well as for the maintenance and function of these lines. Enslaved men worked as track repairmen, station helpers, brakemen, firemen, enginemen and as skilled laborers in machine shops.³⁵ After the close of the Civil War, they continued to be an essential labor force in the South, in many instances a convict or penal workforce perpetuating the practice of forced labor.³⁶ In the antebellum United States, increasingly in both the north and south native-born whites relegated black workers to service positions. Expectations of racial divisions of labor would have kept free black workers out of machine shops or work with steam boilers.

Hard water was common throughout a vast majority of rail lines across the United States making the problem geographically widespread. Meetings of the Western Railway Club, the New York Railroad Club, the Pacific Coast Railway Club, and the Southern and Southwestern Railway Club all held discussions or presentations about how to

³⁴ Eric Arnesen, *Brotherhoods of Color: Black Railroad Workers and the Struggle for Equality* (Cambridge: Harvard University Press, 2001) 5-14.

³⁵ Licht, *Working for the Railroad*, 67-69. On the use of hired enslaved people on the Atlantic Coast Line Railroad see, Howard Douglas Dozier, *The Atlantic Coast Line Railroad* (Houghton Mifflin Company, 1920) 90. For the overlooked but significant history of black railroad workers see, Eric Arnesen, *Brotherhoods of Color: Black Railroad Workers and the Struggle for Equality* (Cambridge: Harvard University Press, 2001).

³⁶ Scott Nelson, *Steel Drivin' Man: John Henry and the Untold Story of an American Legend* (New York: Oxford University Press, 2006); Karin Shapiro, *A New South Rebellion: The Battle Against Convict Labor in the Tennessee Coalfields, 1871-1896* (University of North Carolina Press, 1998).

combat hard water indicating the widespread nature of the problem.³⁷ Even in a soft water area, it was more than likely that a line would encounter some hard water. Making the problem even more frustrating was the natural variation of water even along the same line. Take for example water analysis a chemist compiled for the Pennsylvania Rail Road in October of 1927.³⁸ Water for the Fort Wayne station used 35,000 gallons daily from a local city supply. On the day of analysis, the water contained 13.71 grains per gallon of calcium carbonate, a relatively high number. Monroeville, a station only 20.6 miles away, obtained water from Flat Rock Creek which contained 5.25 grains per gallon of calcium carbonate. Compare this to the next station, Middlepoint which got its water from a deep well. It had the highest concentration of calcium carbonate with 26.51 grains per gallon. Middlepoint was only 19 miles away from the previous station. Water in one area could be perfectly soft, while water twenty miles away could cause serious problems for mechanics and station men alike.

Mechanics and station men worried about hard water and scale for two reasons, the possibility that it could cause explosions and the hindrance of the efficient function of the boiler. During the nineteenth and into the twentieth century, boiler explosions

³⁷ “Water Used in Boilers,” *Official Proceedings of the Western Railway Club* 15, January 20, 1903, (Chicago: Illinois) 241- 268; Testimony of H.B. Hodges, *Official Proceedings of the New York Railroad Club* 10, March 15, 1900 (New York, NY: New York Railway Club, 1917): 28-31; Mr. H. Stillman, “The Treatment of Water for Boilers,” *Official Proceedings of the Pacific Coast Railway Club* 2, September 15, 1900 (San Francisco) pages 118 -124; Address by W.A. Converse, “Boiler feed waters; what they contained, and why they cause trouble,” *Proceedings of the Southern and Southwestern Railway Club*, May 16, 1911 (Atlanta: Georgia) 7-27.

³⁸ “Western Region Fort Wayne Division – Water Supplies October 1927,” Pennsylvania Railroad Company. Test Department. Box 667, Folder 353.41 “Boiler Water Softeners 1905-1927,” Hagley Library, Wilmington, DE.

occurred frequently in the United States. Throughout the decade there were several high-profile steam ship boiler explosions that resulted in high casualties including the Aetna in 1824, the Pennsylvania in 1858, and the Sultana in 1865.³⁹ Of the explosion on the Aetna, the Maryland Gazette wrote, “The explosion was so violent that almost everything in the cabins was demolished, the desk torn to pieces, and the vessel rendered a complete wreck.”⁴⁰ Locomotive boiler explosions were also common. The magazine, *The Locomotive*, dedicated most of its pages to reporting on boiler explosions. In November of 1879 a passenger locomotive boiler exploded and killed the engineer and fireman; another locomotive explosion in Portland, Oregon killed the engineer in 1874 but spared the fireman.⁴¹ In addition to scale, boiler explosions happened for a variety of different reasons, including the deterioration or mishandling of the boiler, the malfunction of a safety valve, or an uncontrolled fire in the heating apparatus that then caused the boiler to explode.⁴²

³⁹ On the Pennsylvania see, “Cause of the Explosions of the Pennsylvania,” *New York Observer and Chronicle*, Vol. 36, Issue 26, July 1, 1858 page 206; “The Explosions of the Pennsylvania,” *New York Times*, June 16, 1958, page 5. On the Sultana see, Gene Eric Salecker, *Disaster on the Mississippi: The Sultana Exploration, April 27, 1865* (Annapolis: Naval Institute Press, 2015).

⁴⁰ On the Aetna see, “Most Distressing Disaster,” *The Maryland Gazette* (Annapolis, Maryland) May 20, 1824.

⁴¹ “Explosion of the ‘Lehigh.’” *The Locomotive*, January 1880, page 1.

⁴² “Boiler Explosions,” *Proceedings of the Meeting of Organization and Minutes of First Regular Meeting of the Railway Master Mechanics*, Cincinnati, OH: Wilstach, Baldwin & Co., 1868) 55-60; “Report of Committee on Operation and Management of Locomotive Boilers, Including Purification of Water,” *The Sixth Annual Report of the American Railway Master Mechanics' association* (Cincinnati: Wilstach, Baldwin & Co., 1873) 11-12.

Most of *The Locomotive* was dedicated to discussing boiler explosions and theories as to why they exploded. Articles also mentioned who, if anyone was killed. Each issue included a list of boiler explosions for the year with accidents by month and the numbers of persons killed or injured. In 1911, every month counted over 29 explosions with the highest at 76. The published lists of boiler explosions illuminated the ubiquity of reliance on steam power. Public schools, commercial buildings, industrial plants, locomotives, and marine transportation vessels all relied on boiler either for heating or power.⁴³ Railroad laborers had a genuine fear of boiler explosions, especially those engineers and firemen who worked closely with them. For this reason, railroad workers, discussed and experimented with the best ways to prevent and remove scale.

Beside the fear of explosions, hard water presented an issue for mechanics because it interfered with the efficiency of a boiler. Seen in this way, mechanics translated an ecological phenomenon into an economic problem. The Railway Master Mechanics Association was the primary authority on boiler problems in the second half of the nineteenth century. The group spent a great deal of time and energy discussing the question of bad water. The association, founded in 1868, was made up of master mechanics from different railroad companies with the purpose of creating a place to exchange information related to their business.⁴⁴ The timing of the creation of the group reflected the increasing move towards systematic organization in railroad work as rail lines came to expand in track number as well as complexity of operation. In most

⁴³ See for example, "Boiler explosions in 1911" *the Locomotive*, April 1912, 53.

⁴⁴ *Constitution and by-laws of the American Railway Master Mechanics' Association*, (Cincinnati, OH: Wilstach, Baldwin & Co., 1868).

railroads the master mechanic would have overseen all mechanical shop work. Master mechanics gained their authority from direct handling and work with machines.⁴⁵

The mantra of efficiency permeated the writings of master mechanics. In the proceedings of the first meeting, the noted purpose of the organization was to make comprehensive knowledge of the mechanical arts available so that “motive power departments will be managed with increased efficiency and economy; railway corporations will be directly benefited, and great advantage will accrue to the traveling public.”⁴⁶ The proclamation continued that nearly half the operating costs in railways came from mechanical departments. The aim of the organization was to “materially lessen operative expenses.” As water moved along rail lines, mechanics needed to ensure it flowed in the most efficient way possible. Hard water interfered with the efficient flow of water, thus the efficient flow of capital.

Mechanics monetized hard water. In 1871 during a discussion about hard water, a Mr. Hamm of the New York Central Rail Road noted it cost two cents per mile more on divisions that had hard water than those that did not. Another commenter said that hard water caused nearly seventy percent of boiler repairs in machine shops leading to higher maintenance costs.⁴⁷ It was not uncommon during the final decades of the twentieth century for railway workers to obsess over efficiency. The efficient movement of railroads relied on order and control of space as well as the efficient function of

⁴⁵ Licht, *Working for the Railroad*, 12-18.

⁴⁶ *The First Annual Report of the American Railway Master Mechanics' Association*, (Cincinnati: Wiltach, Baldwin & Co., 1868) 37-38.

⁴⁷ *The Fourth Annual Report of the American Railway Master Mechanics' Association*, (Cincinnati: Wiltach, Baldwin & Co., 1871) 26, 20.

machines. In 1887, the engineer Arthur Wellington published *The Economic Theory of the Location of Railways* in 1887 as a testament to this ethos.⁴⁸ The subtitle makes his purpose clear: “an analysis of the conditions controlling the laying out of railways to effect the most judicious expenditure of capital.” Wellington attempted to translate local features into elevation, grades, and curves, systematically dominating nature in the name of capital.⁴⁹ For master mechanics, quality of water played an important role in the most judicious expenditure of capital.

Master mechanics shared this ethos, but also witnessed the incomplete dominance over nature as the water they used caused chaos in their machines. The incomplete dominance over nature, which hampered the ethos of efficiency, encouraged mechanics to experiment with the removal of scale and the purification of water.

From Oil Cakes to Scientific Correction: Experimenting with Hard Water

Railroad mechanics sought solutions to the problem of hard water, concerned with the efficiency of locomotive boilers. Efficiency thus drove the process, however, the complexity of the problem and a lack of scientific expertise along lines hampered mechanics’ ability to prevent boiler scale. Known remedies for dealing with hard water such as boiling feed water or the use of alkali metals proved impractical to implement on a large scale. With little other choice, mechanics experimented with whatever they could, often with little success. The need for efficient descaling and failure on the part of

⁴⁸ Arthur Mellen Wellington, *The Economic Theory of the Location of Railways* (New York: John Wiley & Sons, 1887).

⁴⁹ White, *Railroaded*, 143.

mechanics to fix the problem created a space for the first commercially available compounds to deal with the problem of hard water in industry, boiler compounds. Boiler compounds, usually compounds created by chemists and amateur chemists alike, combined vegetable matter with chemicals such as soda ash or potash. While some compound makers had a reputation as forgeries, many did indeed ameliorate problems inside of boilers. Towards the end of the nineteenth century, many commercial boiler compound manufacturers began to rely on scientific water analysis, done for specific locations along rail lines. These manufacturers translated the local geographic history of water into chemical compounds. Once seen in this way, they were able to engineer compounds to change the chemical makeup of water to reduce scaling. Boiler compounds represented the commercialization of water softening techniques and technology. These techniques cemented the necessity of water analysis in industrial work.

The implementation of the multi-tube boiler in locomotives caused mechanics to abandon older methods of scale removal and experiment with new substances. The standard way to ameliorate scale caused by hard water was to use a hammer and chisel to physically remove the offending material. This method worked well with the use of early shell boilers. An article in the engineering periodical *Safety Valve* from 1896 claimed, “Many engineers resort to the plan of removing boiler scale by the use of the pick, hammer and chisel, but this is only temporary relief, and besides does much to weaken the iron and cause the very worst form of corrosion.”⁵⁰ The multi-tubed boiler required a new method for the removal or prevention of scale since it was too difficult to manually remove scale. Mechanical removal also wasted time. In the proceedings of the master

⁵⁰ *The Safety Valve*, Vol. 10 No. 12 December 1896 page 648

mechanics association from 1874, one mechanic noted that the work to empty a boiler and allow it to get cool to remove scale often wasted an entire working day.⁵¹ The traditional hammer and pick was not a practice of efficient railroading.

The Master Mechanics Association dedicated a significant amount of discussion to the problem of hard water, but found that existing methods to remove hardness from water often proved impractical to be implemented along rail lines. In 1872 the Association created a committee on purifying water for boilers. The committee was tasked with collecting information and disseminating recommendations of how to purify water. This first report enthusiastically endorsed boiling water before feeding it into the locomotive boiler in order to remove offending minerals. Mechanics, however, immediately pushed back against this declaration. Although seemingly simple, boiling huge amounts of water used in steam locomotives was neither practical nor economic for most mechanics at a station. Boiling feed water required the erection of extra tanks and a heating apparatus to warm the tanks to be located at stations. The master mechanic of the Atlantic and Great Western Railroad balked at the idea of heating the 26,000 gallons of water he used in a day. Boiling feed water also greatly increased fuel costs since extra coal would be required to boil water.⁵² This solution was impractical. In 1873, after considerable push back from mechanics, the committee changed its endorsement to recommend using only rain or surface water.⁵³ While seemingly more practical than

⁵¹ *The Fifth Annual Report of the American Railway Master Mechanics' Association*, (Cincinnati: Wiltach, Baldwin & Co., 1872) 25.

⁵² *Ibid*, 90

⁵³ *The Sixth Annual Report of the American Railway Master Mechanics' Association*, (Cincinnati: Wiltach, Baldwin & Co., 1873), 20.

boiling, this recommendation too had its drawbacks. Engineers placed water tanks in a way that they became part of an interrelated hydraulic system. Finding a new water source would require labor, capital, and the power to distribute such things. Finding a new source of water would have been difficult.

Railroad hydraulic systems prevented the easy addition of chemicals used in domestic water softening such as potash and soda ash.⁵⁴ The process of adding chemicals to feed water required purifying water before it went into the boiler. The problem with this method was that it required the careful attention of an attendant responsible to weigh out the correct amount of chemical in the correct proportion to water and then continuously stir the reagent. A paper published in the proceedings of the master mechanics explained the process: An attendant first weighed out the amount of lime and put it into a vat covered with water. After an hour and a half, the attendant should add more water to the vat and stir thoroughly with the end of a shovel or hoe.⁵⁵ The *Street Railway Journal* succinctly summarized the problem: “It is not desirable to have an expert chemist in charge of every steam plant to supervise the water purification. It is, on the other hand, desirable to have a water purification apparatus so simple that it will require practically no knowledge of chemistry for its operation. In fact, that it should be

⁵⁴ On these methods see, Moses Baker, *The quest for pure water; the history of water purification from the earliest records to the twentieth century* (New York: American Water Works Association, 1949) 415-439.

⁵⁵ H.E. Smith, “Notes on the Chemical Features of Water Purification,” *Report of the Proceedings of the Thirty-Second Annual Convention of the American Railway Mastery Mechanics Association* (Chicago: The Henry O. Shepard Company, 1899), 108.

as nearly automatic as possible."⁵⁶ Before the turn of the twentieth century, no such system was available for practical use along rail lines.

With limited options, mechanics experimented with their own remedies acting as amateur chemists. In 1874, the Committee on Water Purification published their findings on how mechanics dealt with boiler scale. The Committee noted that station men added things such as fruits, molasses, slop, vinegar, cane-juice and vegetables to boilers. Some found starchy substances such as potatoes, corn, and oil-cake worked well while others swore by the scale prevention powers of tannic-acid-bearing barks such as oak and hemlock.⁵⁷ A supposed industry lore helps to understand the experiential nature of adding such compounds to boilers. The old adage went that a Scottish miner once cooked his potatoes for lunch in a boiler. He forgot about his lunch and left the potatoes cooking all day. When he returned and opened the lid of the boiler, he found it completely clean and lacking of any hard scale.⁵⁸ An article written in 1901 in *The Engineer*, noted these remedies had shallow scientific bases: "Almost everything has, at one time or another, been put into a boiler to keep the scale soft, such as oak bark and shavings, because of the tannic acid they contain; distillery slops, on account of their acetic acid; potatoes, corn, etc., for their starch; leather, slippery elm and manure, for their gelatinous matter; molasses and sugar, because of the saccarates of lime formed. Innumerable other

⁵⁶ "Automatic Apparatus for Feed-Water Softening," *The Street Railway Journal*, Volume 20, October 4, 1902. 589-88.

⁵⁷ *The Seventh Annual Report of the American Railway Master Mechanics Association* (Cincinnati: Wilstach, Baldwin & Co., 1874) 26-27.

⁵⁸ John Ross, *Dearborn a Century of Excellence*, 1987, Box 3, Folder 64, BetzDearborn, Incorporated Records, 1892-1997, Science History Institute Archives, Philadelphia, Pennsylvania, from here on cites as BetzDearborn, Incorporated Records.

substances have been used without judgment or reason.”⁵⁹ Despite the declaration that these substances did not work, station workers would have found at least some success. The acetic acid in fruits would have mildly reduced carbonates present in hardness while starchy materials would have made precipitates more gelatinous, thus preventing their accumulation into a solid scale forming mass. Although their methods were not perfect, these accounts proved mechanics and station men would have employed empirical methods for dealing with hard water. Experimentation with water alludes to its social and material character as well as the continuous interaction between station men and water. Few if any would have had any chemical background. Thus, their work on incrustation relied on experimental and empirical data they collected themselves.

As mechanics attempted to alleviate problems of boiler scale, commercial entrepreneurs and amateur chemists sensed their struggle, as well as a potential market for water treatment for industrial purposes. Beginning in the 1870s, they sold the first type of commercial remedy for hard water along rail lines, known as boiler compounds. These compounds, amalgamations of known water softening chemicals such as soda ash and caustic soda with other materials, flourished in the final decades of the nineteenth century. Mechanics and station men frequently employed the use of boiler compounds, but not without hesitation. They learned that some boiler compound sellers peddled products with little actual power to prevent boiler scale. In 1874 a Mr. Jackman of the Chicago, Alton & St. Louis Railroad admitted to experimenting with twenty different boiler compounds. While some did not work at all, Jackman noticed that those that did

⁵⁹ “The Softening of Feed Waters for Boilers,” *The Engineer*, September 1, 1901, 333-334.

tended to work on only one section of a line. They did not necessarily produce any harm, but the compounds he experimented with also did not get rid of or prevent boiler scale. Furthermore, paying for the compounds themselves often cost more than cleaning the boiler. Mr. Jackman compared one man who sold him a boiler compounds to a physician he once knew. During a cholera outbreak in 1854, one of Mr. Jackman's employees fell ill. A physician administered a special compound he claimed would cure cholera. The man died the next day. The physician told Mr. Jackman he thought he had prepared a medicine to knock out cholera but maybe instead it might cure a mild case of diarrhea. Mr. Jackman concluded his story, "It is a great deal so with these boiler compounds." While some boiler compounds contained soda ash, which would reduce the hardness in some types of water, others seemed like an amalgamation of whatever the salesperson had in his kitchen cabinet. An article published by *The Chemical Engineer* found one purported compound to be a mixture of coffee, blood meal and salt while another was simply wool fiber.⁶⁰

The failure of boiler compounds on some sections and not others encouraged a sharper attention to the analysis of water. The proliferation of boiler compounds, as well as mechanic's distrust of them, made busy work for railroad chemists, new additions to departments of test in the last quarter of the nineteenth century. While railroad chemists did not experiment with water softening techniques themselves, they did offer an

⁶⁰ William M Booth, "Boiler Waters and their treatment," *the Chemical Engineer* vol 1 no 6, April 1905, 362

important service along rail lines: water analysis.⁶¹ Water analysis became a significant part of the hydraulic system in industrial spaces. Trained chemists could offer something that mechanics could not, an accurate characterization of the water being used to power locomotives. Analysis along railroad lines offered a scientific reading of the nuances of water and suggested that through this knowledge it could be more easily controlled.

In an effort to distance themselves from fake compounds makers, some boiler compounds makers began to offer their own water analysis. The Dearborn Drug and Chemical Works of Chicago, Illinois set itself apart from other boiler compound sellers by offering water analysis. Dearborn presented an example of an organized boiler compound manufacturing service beyond individual sellers and chemists. In 1887, William H. Edgar, a Chicago pharmacist, and Frank E. Mariner, a chemist, founded Dearborn Drug and Chemical Works. According to a history of the company, Edgar and Mariner felt as though Chicago, as a hub of westward expansion for railroads, occupied an advantageous location to set up a serious boiler compound operation.⁶² From the onset, Dearborn publicized water analysis as a way to differentiate the company from other boiler compound sellers. The guiding philosophy of Edgar was that there was not a cure all for boiler treatment. Instead, properly maintaining the healthy fuel economy of a boiler relied on the careful testing of the water that went into the machine. An

⁶¹ On Chemists along rail lines see, C.B. Dudley and F.N. Pease, "Chemistry applied to railroads," *The Railroad and Engineering Journal*, Vol. LXII, No. 12, December 1889, 554-557; Charles Dudley, *Annual Report of the P.R.R Laboratory for 1891*, March 8, 1892, Pennsylvania Railroad Company. Test Department. Box 458, Folder "Motive Power Department annual report papers 1892," Hagley Library, Wilmington, DE. This box contains reports written by Dudley from 1886-1902.

⁶² John Ross, *Dearborn a Century of Excellence*, 7, BetzDearborn, Incorporated Records.

advertisement for Dearborn from 1898 claimed, “We have no proprietary article ‘in stock.’ We learn what you need by an analysis of your feed water. We prescribe a remedy to get your particular case exactly. This prescription is filled and recorded, to be refilled when wanted.”⁶³ The company encouraged boiler users to send a gallon of water to their laboratory for analysis. In turn, chemists at the company could properly create a compound specifically for that particular water source. Mechanics then added the compound directly into a boiler.

The Dearborn Company referred to their work as scientific water correction, a term that alluded to how modern industries should handle water. They specialized in correcting the conditions resulting in the imperfect water supplied to boilers, both stationary and locomotive.⁶⁴ Scientific correction relied on water analysis in order to translate geography into chemistry. Each gallon of water sent to the Dearborn Company contained within it features of the surrounding geography whether it be dolomite, limestone, or quartz. Water analysis involved the separation of those materials from water and their translation into chemical elements.⁶⁵ Devonian Limestone districts became medium carbonate waters; ones a mechanic could correct with Formula “A” from an expansive book of treatments. Water near gypsum deposits turned into medium heavy

⁶³ Advertisement in *The National Engineer*, October 1898, Box 5, Folder 28, BetzDearborn, Incorporated Records.

⁶⁴ Pamphlet, “Laboratory Analysis and Control,” undated, Box 5, Folder 39, BetzDearborn, Incorporated Records.

⁶⁵ On the specific techniques to analyze the hardness of water see, “Report of Committee on Standard Methods of Water Analysis to the Laboratory Section of the American Public Health Association,” *The Journal of Infectious Diseases*, Supplement No. 1 (May, 1905), 55- 64.

carbonate, corrected with a compound of acetic acid, elm, sulfate of soda, and corn meal.⁶⁶

More than geography, the Dearborn Company boasted the ability to correct the natural cycles of water that may interfere with the proper function of a boiler with analysis. Chemists at Dearborn would not only check the condition of water once, but also maintained a continuous relationship with customers and their water. A pamphlet produced by the company wrote,

Of equal importance, is the checking of conditions to keep the treatment adjusted to any changes that may occur in the character of water, and thereby hold the advantage gained. This is the function of laboratory control. Heavy rainfall, long drouth, changing seasons, and other causes may contribute to changes in the character of the water supply. Additional samples are obtained from time to time and the treatment varied as such changes occur so that its high efficiency is always maintained.⁶⁷

The effort made by chemists at Dearborn to correct the variation of water was in line with the desire to make railroads and other industrial processes run more efficiently.

Some railroad workers continued to be suspicious of boiler compounds and other chemicals aimed at scientific correction. The chemical engineer William Booth condemned most ingredients that went into boiler compounds claiming excess soda ash and caustic soda led to other problems while compounds made of vegetable origins were downright dangerous. Of water samples, Booth claimed, "The less scientific members of the boiler compound guild carefully consign each sample of water to the sewer and send the regular goods. Others have a stock analysis which is sent to customers of a given

⁶⁶ See Dearborn formulas books in Box 4, Folders 21 and 24, BetzDearborn, Incorporated Records.

⁶⁷ Pamphlet, "Laboratory Analysis and Control," undated, Box 5, Folder 39, BetzDearborn, Incorporated Records.

locality whether it contains iron, lime, or magnesium sulphates or carbonates.”⁶⁸ Despite this, companies that specialized in water analysis and correction flourished at the turn of the twentieth century, see Figure 3. The Dearborn Company continued to grow while others such as the George W. Lord Company of Philadelphia and the Betz Company in Boston analyzed water and sold compounds in the early twentieth century.⁶⁹ The success of these operations demonstrated the market for scientific water analysis and correction in the industrial sector.

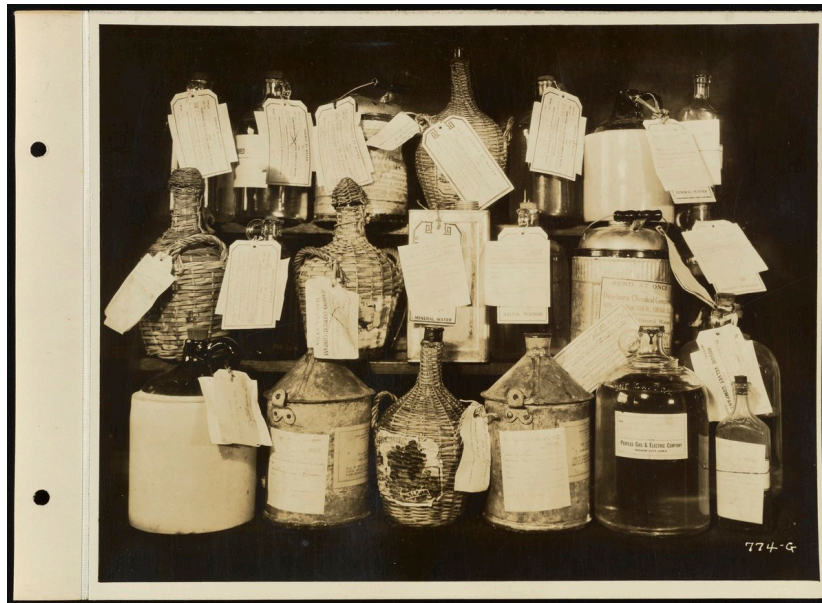


Figure 3. Assorted Water Samples sent to Dearborn Chemical Company, 1934.

Science History Institute. Philadelphia.

⁶⁸ William M Booth, “Boiler Waters and their treatment,” *the Chemical Engineer* vol 1 no 6, April 1905, 362

⁶⁹ On the Betz Company see, John Drew Betz, *Betz History*, Box 1, Folder 1, BetzDearborn, Incorporated Records. On the Geo. W. Lord. Company see, George W. Lord, *Boiler Troubles and their treatment*, (Philadelphia: Harris and Partridge, 1910) 68. See also “Lord’s Boiler Compounds,” *The Safety Valve*, v. 10 p. 682.

The success and proliferation of water analysis and specialty made boiler compounds illuminated the importance of water quality for the demands of industrialization. A locomotive is an envirotechnical system. It not only required industrialized mechanical parts, but water that was compatible within these mechanical parts. Manufacturers like the Dearborn Company employed science to manage the chemistry of water inside of a boiler. As such, these commercial enterprises absorbed the responsibility of analyzing and manipulating water away from laborers moving it into the laboratory space.

Intermittent Softening Systems Fail the Efficiency Test

By the end of the twentieth century boiler compounds proliferated throughout railroads. Yet by this time, they were not the only method to softening water in the industrial sector. By the last decade of the nineteenth century, numerous commercial firms offered large scale water softening mechanisms. These machines relied on older softening techniques such as the addition of soda to water, but fitted them specifically for large scale use, attaching mechanical stirrers and filters so that a human did not have to continuously manage the system.

A Chicago based chemist, Cass Kennicott, created an early example of this type of softener. Kennicott worked as a chemist in the packinghouse of Nelson Morris and Company and the Consumers Ice Company in Chicago. Working with industries in the Midwest, he had a sense of the problems that hard water caused. In 1899 he applied for a patent for an “apparatus for purifying water.” Kennicott’s invention relied on the method of adding lime or soda to water to form a precipitate, but with a few important

mechanical innovations.⁷⁰ His invention was essentially a precipitating tank and a water purifying apparatus. A downward flaring conduit in the tank received water to be purified from an inlet at the top. The flowing water powered a small motor adjacent to the tank which regulated the amount of chemical precipitant entering the tank. A mechanical stirrer then mixed the water with the chemical reagents. The purified water flowed out of the bottom of the tank. Since impure water flowed into the top of the tank as pure water flowed out, Kennicott called his invention the continuous process of water softening. The apparatus only required one precipitating tank, instead of the cumbersome two that had previously been implemented to soften water. The mechanical stirrer relieved a laborer of the duty of stirring the mixture. The mechanism that automatically added chemicals to the mixture also replaced the hands on chemist many mechanics felt they needed to soften feed water. Kennicott's system solved most issues that made mechanics weary of chemical softening. His apparatus showed great innovation in the mechanical aspects of water softening, making a chemical process practical for industrial purposes.

A few Chicago industries purchased Kennicott's machine called "the Kennicott Water-Softener," but the apparatus remained little known until Kennicott presented it to the President of the Union Pacific Railroad. The President was so impressed with Kennicott's water-softener that he ordered twenty-five across the Midwest, where carbonates formed particularly hard scale. Kennicott's company continued to grow and

⁷⁰ Cass Kennicott, "Apparatus for purifying water." U.S. Patent 646108A filed June 5, 1899 and issued March 27, 1900.

by 1916 the Union Pacific had thirty seven Kennicott Plants.⁷¹ Plants speckled the United States with Kennicott softening plants operating along the lines of the Wabash Railroad; Chicago, Burlington & Quincy Railway; Pittsburgh & Lake Erie Railroad; and the National Railroad of Mexico. The company also boasted sixteen varieties of water softeners with capacities between 4,000 to 20,000 gallons per hour. In order to appeal to industries' hesitation with chemical knowledge, the company offered free water testing. A brochure promised a free analysis of water as long as a sample was provided.⁷² Kennicott's continuous softening apparatus and the chemical analysis his company assuaged the doubts mechanics and station men held about water softening.

Yet by the second decade of the twentieth century, many railroad superintendents abandoned large softening systems. An article published in the *Railway Maintenance Engineer* in 1916 claimed these kinds of water softening systems were too difficult to maintain.⁷³ The article noted that in some cases a lack of clear organization of who was in charge of the softening plants often left them unattended. Supervisors entrusted the plants to the bridge and building forces of the railroad. Therefore, mechanics, those who felt the effects of bad water the most, had no control over the plants. To this end the article noted, "The operation of the plants was not, as in some cases, intrusted (sic) to the tender

⁷¹ Letter from the Permutit Company to E.M. Waring, PA RR, April 11, 1916. Pennsylvania Railroad Company. Test Department. Box 667, Folder 353.41 "Boiler Water Softeners 1905-1927," Hagley Library, Wilmington, DE.

⁷² Undated Brochure from the Kennicott Water Softener Company, *Soft Water: How to Obtain it for Railroads and Industrial Purposes*. Analysis of water samples can also be found in advertisements for the company, *Ice and Refrigeration*, vol 20, June 1901, page 26.

⁷³ "Progress in Water Softening," *Railway Maintenance Engineer*, Vol. 12, No. 7, July 1916, 194-195.

mercies of some other officer, who might or might not be in sympathy with water treatment.” In other words, mechanics did not control softening plants. Those who did had little direct relationship with the ill effects of hard water. That is not to say that other industries did not employ softening systems. The Pittsburgh Filter Manufacturing company in Pennsylvania, the Wefugo Company of Cincinnati, Ohio, and the New York Continental Jewell Filtration Company all constructed water softening plants for railroads, street railway companies, as well as other manufacturing interests like steel factories, ice plants, malt houses, and textile works. Hotels, office buildings, and other commercial establishments saw the value of soft water and installed softening plants as well.⁷⁴ While many industries relied on new mechanical softening systems, for railroads chemicals that could be used directly in boiler was the most efficient and economical fix. For this reason, boiler compounds and scientific boiler control proliferated during the early twentieth century.

⁷⁴ “Some Recent ‘Continental Jewell’ Filtration and Water Softening Plants,” *Municipal Engineering* vol 23.1902: 410.

CHAPTER 4
BOILERS, BABIES, AND THE DOMESTICATION
OF SODIUM METAPHOSPHATE, 1925-1942

In 1933 the Hagan Corporation of Pittsburgh published a promotional booklet called “A Clean Boiler Story.”¹ The booklet was a marketing tool for the sale of one of their products, Hagan Phosphate, a chemical that prevented boiler scale by sequestering calcium and magnesium ions in water, a new synthetic chemical quite different and chemically more complex than the vegetable and alkaline based boiler compounds sold by The Chemical Dearborn Company. The booklet told the story of James Hopwood and his journey from a boiler operator to an inventor of a new chemical system to combat problems that arose from boilers and water. Small images of a cartoon Hopwood and unnamed boiler plant manager punctuated the pages showing both men in an office, inspecting a boiler plant and drum full of boiler compounds, and finally in the laboratory where chemists working for Hagan discovered the chemical. The final image shows the plant operator sitting with his wife and children in his home. His wife looks at him, adorningly, as if to say you did well, choosing Hagan Phosphate. The tone of the booklet is admiring, a story of male technological triumph.²

¹“A Clean Boiler Story,” 1933, Box 5, Folder “Hagan Superseded Bulletins,” Calgon Corporation Records, 1919-1997, MSS 0693, Thomas and Katherine Detre Library and Archives, Senator John Heinz History Center, from here on cited as Calgon Corporate Records.

² On the narrative of male technological triumph see, Ruth Oldenziel, *Making Technology Masculine: Men, Women and Modern Machines in America, 1870-1945* (Amsterdam: Amsterdam University Press, 1999); Nina Lerman, Ruth Oldenziel and Arwen Mohun (eds.) *Gender and Technology: a Reader* (Baltimore: The Johns Hopkins University Press, 2003) especially Ruth Oldenziel “Why Masculine Technologies Matter,” in 37-72; Roger Horowitz (ed.) *Boys and Their Toys: Masculinity, Technology, and Class in America* (New York: Routledge, 2001).

The promotional material for Hagan Phosphate looked quite different from another product sold by the Hagan Corporation, Calgon. Take for example one booklet from 1946 entitled, “Calgon for Home Made Rain,” written by Marjorie Gilbert.³ Calgon, explained Gilbert, was a specialty designed household chemical that would make water as soft as rain. The chemical could “normalize” water, making it fit for domestic tasks such as laundering clothes and cleaning dishes. The company assumed that women, more specifically the female household manager, would purchase their product. The design of the booklet reflected this assumption, containing multiple visuals of women engaging in household tasks such as doing the laundry, the dishes, and washing a baby. While there are similarities between “A Clean Boiler Story” and “Homemade Rain” such as an appeal to managers, the gendered differences are stark. From the imagery to the purported uses of each product, the materials obscure the fact that Hagan Phosphate and Calgon serve the same purpose, to soften water. What may seem even more opaque is that Hagan Phosphate and Calgon are the same chemical in the same form, molecularly dehydrated water-soluble sodium metaphosphate, or sodium metaphosphate for short.

This chapter recounts the process in which an engineering company refashioned an industrial water softening chemical, initially intended for use in industrial boilers, for use in the kitchen, laundry, and bath. The commercial application of sodium metaphosphate, or Hagan Phosphate, or Calgon, marked a point in the history of water softening when industrial and household softening converged. The thread that connected the home and the boiler plant was hard water and the need to correct water in both

³ Marjorie Gilbert, “Homemade Rain,” Box 5, Folder “Calgon Laundry Bulletins and Leaflets,” Calgon Corporate Records.

places.⁴ It also signaled a new era of water softening in which laboratory made synthetic chemicals proliferated. The discovery of phosphate for softening would not have been possible without innovations in industrial chemistry or the cooperation between private corporations and the government.

The Hagan Corporation, a small engineering firm based in Pittsburgh, Pennsylvania, in cooperation with the United States Bureau of Mines (USBM), first discovered the sequestering ability of complex phosphates in the field of water softening in the late 1920s. The scientists involved, notably the leader of the study Dr. Ralph Hall, were the first researchers to explore the merits of complex phosphates in water treatment. Their work represented modern industrial research that relied on a partnership among scientists, private enterprise, and the government. The USBM and the Hagan Corporation jointly funded the project motivated by the desire to create more efficient industrial systems. Hall's work represented a truly modern social and scientific research project in which individuals, government, and business were willing to profit. The application of complex phosphates to water softening would boom in the 1940s when soap companies added these chemicals to new synthetic laundry detergents, discussed more in the next chapter.

⁴ On history of the relationship between home and industry see, Arwen Mohun, "Industrial Genders: Home/Factory," *Gender and Technology*, 153-177; Cowan, *More Work for Mother*, 3-15; Goldstein, *Creating Consumers*, see esp chapter 5 "Product Testing, Development, and Promotion: Corporation Investment in Home Economics, 1920-1940," 174-207.

After the discovery, the Hagan Corporation embarked on a process of domesticating sodium metaphosphate.⁵ That is to say the company made it desirable and acceptable for use in the home. In that process, which relied on a description of the product as natural and feminine, the company abstracted the chemical from its industrial origins. It erased the fact that industrial users also relied on sodium metaphosphate and reinforced the trope of male creator and female consumer.⁶ Hagan also engaged in some rhetorical abstraction. The company manufactured and sold a chemical that served to correct-- or to use their rhetoric, *normalize* water-- effectively distancing water from its natural ecological condition while simultaneously defining it as something natural. In a rhetorical slight or hand, or more accurately a social construction of water, the company defined normal water as a substance that contained there chemical, complex synthetic materials. Managing unruly water was important for the use of boilers as well as new consumer technologies, for example the automatic dishwasher and washing machine. Modern industrial capitalism and consumerism required quality water for use in new

⁵ On domesticating a product originally intended to industrial use see, Michelle Mart, *Pesticides, a Love Story* (Lawrenceville: University of Kansas Press, 2015) and Edmund Russel, *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring* (Cambridge: Cambridge University Press, 2001).

⁶ On gender and consumption see, Roger Horowitz and Arwen Mohun, *His and Hers: Gender, Consumption, and Technology* (Charlottesville: University Press of Virginia, 1998), see especially, Steve Lubar, "Men/Women/Production/Consumption," 7-38 and Joy Parr, "Shopping for a Good Stove: A Parable about Gender, Design, and the Market," 165-188; For consumption and gender outside of the United States see, Joy Parr and Gunilla Ekberg, "Mrs Consumer and Mr Keynes in Post War Canada and Sweden," *Gender & History*, Vol. 8 No. 2 August 1996, 212-230.

technologies. Yet since consumers had corrected or normalized water, rhetoric that suggested the water imparted with chemicals was somehow natural, neither manufacturers nor consumers thought much about what happened to that water as it became waste. People may have been done with water, but its materiality promised that it would end up somewhere else. And surely it did, still saturated with phosphates used to soften water. As the next chapter will show, the consequences of correcting water came to light as phosphates, which would later be added to synthetic laundry detergent and used in mass in the 1950s, increasingly caused pollution in lakes around the country. Synthetic chemicals, produced in laboratories backed by industry and the government, would come to represent a new era in water softening. One in which the dual goals of efficiency and profit through consumption made good quality water imperative in both the industrial and domestic spheres.

Ralph Hall and Sodium Metaphosphate

In 1922 the Hagan Corporation, an engineering firm in Pittsburgh, Pennsylvania, in cooperation with the United States Bureau of Mines, embarked upon the largest and most comprehensive study of the problem of hard water in industrial boilers ever undertaken. The result was the discovery of orthophosphates, a new group of chemicals to soften water. Writing after the study, the corporation claimed, “All previously conceived theories of how scale forms in a steam boiler have been relegated to the scrap heap, and a new irrefutable chapter in boiler chemistry has been written.” Of the treatise on boiler economy published by the head of the study, Dr. Ralph Hall, one corporate bulletin claimed, “What Adam Smith’s classic ‘The Wealth of Nations’ is to economics, Dr.

Hall's classic 'Boiler-Water Conditioning' is to treatment of boiler water."⁷ To say the company was pleased with the results would be an understatement. Despite the triumphant rhetoric the company boasted, the application of phosphates in the field of water softening was not without its setbacks. In fact, the discovery in the field of industrial chemistry was the product of a failure in mechanical technology. The application of phosphates was contingent on this failure, as well as on changes in the field of chemistry and the structures available for industrial research.

The Hagan Corporation was in the business of control. The first patent filed by the small Pittsburgh company in 1917 was an automatic method for controlling the fuel feed into a furnace. The problem, as described in the patent, was that variations in the conditions within a furnace, such as the pressure, could cause the stoker to malfunction. This method and apparatus would automatically regulate the pressure working with any type of stoker, or fuel feeding mechanism.⁸ By 1922, Hagan boasted an entire system of combustion controls including regulating equipment to control stokers, fan speeds, and pressure as well as a consulting department that specialized in control apparatuses related to blast furnaces, stoves, coke ovens, and metallurgical furnaces.⁹ Hagan's products attempted to control the "erratic conditions of boiler operation," and remake "the entire

⁷ William W. Hopwood and G.A. Binkly, draft of history of Hagan Corporation, 1949, Box 1, Folder "J.M. Hopwood Life Story," Calgon Corporation Records. See also "Water for Steam Generation," 1926, and "A Clean Boiler Story," 1933, Box 5, Folder "Hagan Superseded Bulletins," Calgon Corporation Records.

⁸ Brown, Francis. Method of controlling combustion. U.S. Patent 1463141A filed March 28, 1917.

⁹ *Sweet's Engineering Catalogue, 8th Annual Edition* (New York: Sweets Catalogue Service, Inc., 1922) 874.

boiler plant into one smoothly operating unit responding to steam demand.”¹⁰ The company marketed their product to industrial users of both stationary and locomotive boilers.

With a focus on the function of the entire boiler plant system, in 1920 the Hagan Corporation introduced an apparatus to control the conditions of water inside of a boiler, the Hagan Deconcentrator. Hagan marketed their device as a special pump and sand filter that removed water from a boiler, filtered it, and returned it, “deconcentrated.” The Deconcentrator worked with a water softening system. First, either an automatic feeder or boiler technician added soda ash or another boiler compound to hard water. Instead of precipitating into hard scale once the water turned to steam, the calcium and magnesium salts reacted with the soda ash to form a soft sludge. Sludge, unlike scale, could then be easily removed by a technician once it settled on the bottom of a boiler, through the blow down process. The Deconcentrator promised to remove the labor of the technician by filtering out the sludge. The device relied on traditional water softening techniques like those employed on railroads, but promised a modern method to remove the pesky byproducts of chemical softening. The Hagan Corporation marketed the machine to small boiler operations that were unable to house or afford large chemical settling tanks. Thanks to the apparatus, the offending materials “are washed to the sewer instead of

¹⁰ Hagan Bulletin No. 104, *Compensated Draft, the Hagan system of Automatic Control* (Hagan Corporation, 1928) 1.

being allowed to insulate the heat absorbing surfaces.”¹¹ The Deconcentrator promised more efficient heat absorption by the boiler, thus more efficient combustion in the industrial sector. It is worth noting that neither boiler operators nor makers of softening chemicals thought much about where the byproduct sludge went after being washed into the sewer. Generally, this soft sludge would have dispersed easily in water due to its simple chemical nature. It is unclear whether people involved in industrial boiler control would have known this fact, but quotes like those from the company indicate they did not spend much time contemplating the issue.

An article published by the *Journal of the American Water Works Association* in 1923 found merit in the Deconcentrator, especially for smaller operations that did not have the capital for large scale water-softening endeavors, however, it was not perfect. The Deconcentrator rounded out a list of systems and machines used to purify water for boiler use including filters, the lime and soda process, and zeolite softeners. Although the author praised the Hagan corporation’s product, he concluded that, “Like many others that have been used, the system is not a ‘cure-all,’ but has a peculiar usefulness in limiting scale formation, where a more elaborate system could not be installed with economy.”¹² Despite the adequate review, consumers soon began returning the devices,

¹¹ *Sweet’s Engineering Catalogue*, 874; see also “Trade News,” *Power Plant Engineering*, Vol. 25 July 21, 1921, 692; and Sheppard T. Powell, “Purification of Water for industrial Use,” *Journal of the American Water Works Association*, Vol. 10 No. 1, January 1923, 12-16. For more on Hagan’s role in combustion control see, K.R. Warrington and Francis Sill, “Combustion Control Co-ordinates New Power Plant,” *Combustion*, December 1931; Raymond F. Forbes, “Combustion Control Increases Boiler-Plant Efficiency,” *Power*, July 31, 1928; T.A. Peebles, “Steam Pressure Reduction with Control of Superheat,” in Folder, “Trade catalogs, 1931,” Hagley Library, Wilmington, DE.

¹² Powell, “Purification of Water for industrial use,” 15.

claiming they did not work properly and hard scale continued to form in their boilers. A history about the Hagan Corporation published in *Chemical & Engineering News* in 1949 wrote that “deconcentrators began to come in through the backdoor of the plant as rapidly as newly-ordered ones went out the front.”¹³ The Hagan Corporation had a problem.

J.M. Hopwood, the President of the company, was perplexed as to why, despite removing the minerals that caused scale, boilers with “deconcentrated” water continued to form hard insoluble crud along the walls of boilers. Having faith in the mechanical soundness of his product, Hopwood hired a chemist, Henry Jackson, to explore the problem. After months of examining faulty deconcentrators, Jackson echoed Hopwood’s suspicions. “This is not a mechanical problem,” he declared, “it is a chemical one.”¹⁴ According to Jackson, something caused the sand in the filter to dissolve, thus rendering the Deconcentrator ineffectual.

Lacking any infrastructure to explore the problem of scale formation in a scientific manner, Hopwood reached out to the Pittsburgh Station of the United States Bureau of Mines (USBM). Using a contact that a Hagan employee had from serving in the army during World War I, Hopwood secured a cooperative agreement with the Bureau of Mines. In January of 1922, the Hagan Corporation and the USBM entered into an agreement to participate in a study with the goal of obtaining information about the

¹³ Everett P. Partridge, “Calgon-- A Chemical Development from a Nonchemical Background,” *Chemical & Engineering News*, 1949, 27(12) 840-843.

¹⁴ William W. Hopwood and G.A. Binkly, draft of history of Hagan Corporation, 1949, Box 1, Folder “Hagan History,” Calgon Corporation Records. See also Partridge, 1949, 840.

mechanisms of boiler water scale.¹⁵ This became the first scientifically-based research into scale formation; it was the first-time experts examined problems related to hard water in an institutional setting using modern scientific techniques. The goal of each party was clear. The study employed the use of a Hagan Deconcentrator as the primary device through which to examine scale. The Hagan Corporation hoped to find out why their devices were not working. The USBM saw research into boiler scale as part of a broader interest in the conservation and efficiency of fuel. During the 1920s, the Pittsburgh Experiment Station had a robust research agenda, balancing issues related to safety and efficiency in the mining industry. In 1925, A.C. Fieldner, the supervising chemist at the station noted that within the industry, “research on more economical utilization and the prevention of waste should be encouraged by every possible private and public means.”¹⁶ The Hagan Corporation offered the USBM such a private partnership, providing funds and materials in exchange for laboratory facilities. Hall, a physical chemist employed by the USBM, would lead the research.

The cooperation between the USBM and the Hagan Corporation represented modern industrial research that relied on a partnership among scientists, private

¹⁵ “Mechanisms of Boiler Scale Formation,” 1922, Box 19, Folder 340:F5, Records of the U.S. Bureau of Mines, Record Group 70: National Archives at Philadelphia.

¹⁶ A.C. Fieldner, “Significant Progress in Research on Fuels,” *The Annals of the American Academy of Political and Social Science*, Vol.119, Science in modern industry (May, 1925) 14. For a brief agency history on the Pittsburgh Experiment Station see, Robert J Tuchman and Ruth F. Brinkley, *A History of the Bureau of Mines Pittsburgh Research Center*, United States Department of the Interior. The Pittsburgh Experiment Station also frequently cooperated with local Pittsburgh Institutions. For its cooperation with the Carnegie Institute of Technology see, “The New Metallurgical Laboratories at the Pittsburgh Experiment Station,” *Science*, Vol. 63, No. 1626 (Feb 26, 1926) 223-224.

enterprise, and the government. Beginning in the twentieth century, corporations employed the use of science to improve upon existing technologies. Companies such as General Electric, DuPont, and AT & T created large laboratories in order to test their technological investments and improve upon existing technology.¹⁷ Historian of technology John Kenly Smith noted “Industrial research evolved from attempts to improve existing technologies by pursuing a more fundamental understanding of underlying phenomena.”¹⁸ World War I created an imperative for the United States government to become involved with some sectors of industrial research, notably synthetic organic chemicals like those used in dyes and pharmaceuticals.¹⁹ The desire to manufacture explosives and war gases encouraged the federal government to embark on large research studies. Agencies such as the Bureau of Mines and the Chemical Warfare Service relied on industrial scientists and chemists as well as raw materials from private corporations. In turn, the government also helped private companies by disseminating industrial expertise and investing large amounts of capital in their companies. After the war, a new generation of chemists and private enterprise had benefitted from a

¹⁷ On relationship between research and American industrial firms see, Thomas C. Lassman, “Industrial research transformed: Edward Condon at the Westinghouse Electric and Manufacturing Company 1935-1942” *Technology and Culture*, Vol. 44, No. 2 (April 2003): 309-339; John Kenly Smith, “The Scientific Tradition in American Industrial Research,” *Technology and Culture* 31, No. 1 (Jan 1990): 121-131.

¹⁸ Kenly Smith, “The Scientific Tradition in American Industrial Research,” 123.

¹⁹ Kathryn Steen, *The American Synthetic Organic Chemicals Industry: War and Politics, 1910-1930* (Chapel Hill, NC: University of North Carolina Press, 2014) see especially chapter three, “Mobilization: Synthetic Organic Chemicals in War, 1914-1918,” 78-112; see also Anthony S Travis, *Synthetic Nitrogen Industry in World War I: Its Emergence and Expansion* (Cham: Springer, 2015).

partnership with government entities. Private enterprise was willing to profit from the experience and capital gained during the war.

The role of the Bureau of Mines in the Hall study also suggested the participation of the federal government in creating modern water. Historians have explored this connection, notably in the Western United States. Donald Worster described the importance of engineers and scientists working through the Bureau of Reclamation in bringing proper order to water in the west. Jamie Linton summarized that modern water relied on the state-hydraulic paradigm.²⁰ The participation of the USBM in this project offered another way in which the state ventured into the process of making modern water. Within the context of the Pittsburgh Experiment Station, the supervising chemist, A.C. Fieldner, felt it was favorable to direct money towards addressing the problem of water quality with the intended goal to make water more efficient through scientific

²⁰ Worster, *Rivers of Empire*, 257-308; Linton, *What is Water?*, 113; Most discussion of controlling water come from the historiography related to the western United States, see also Carroll, “Water and Technoscientific State Formation in California,” ; Mark Reisner, *Cadillac Desert: The American West and its Disappearing Water* (New York: Viking, 1986); Norris Hundley, *The Great Thirst: Californians and Water, 1770s-1990s* (Berkeley: University of California Press, 1992); Donald J. Pisani, *To Reclaim a Divided West: Water, Law, and Public Policy, 1848–1902* (Albuquerque: University of New Mexico Press, 1992); Donald J. Pisani, *Water and the American Government: the Reclamation Bureau, National Water Policy, and the West, 1902-1935* (Berkeley: University of California Press, 2002). For other works that deal with the environmental-management state see, Marsha L. Weisiger, *Dreaming of Sheep in Navajo Country* (Seattle: University of Washington Press, 2009); Louis S. Warren, *The Hunter's Game: Poachers and Conservationists in Twentieth-Century America* (New Haven: Yale University Press, 1997); Mark David Spence, *Dispossessing the Wilderness: Indian Removal and the Making of the National Parks* (New York: Oxford University Press, 1999); Arthur F. McEvoy, *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850–1980* (New York: Cambridge University Press, 1986); Andrew C. Isenberg, *The Destruction of the Bison: An Environmental History, 1750–1920* (New York: Cambridge University Press, 2000).

research.²¹ In doing so, the agency proved the backing of the federal government in a process aimed to standardize and control water.

While the Bureau of Mines provided the team of chemists to investigate the hard water problem, the advancements made by Hall in the history of boiler scale control were contingent in many ways on his benefactor, the Hagan Corporation. Hopwood gave him a clear mandate: assess the function of the Deconcentrator.²² Although it seemed like a mechanical issue, Hall concluded that the filter could not function properly because of some chemical issue. Theoretically the Deconcentrator should have worked with a water softening system so that calcium and magnesium ions precipitated as soft sludge which the Deconcentrator could easily remove. If hard scale was forming, then the Deconcentrator never had a chance, since it can only remove soft matter. This influenced Hall's approach as he increasingly understood the problem was not mechanical, rather it lay at the intersection of a complex envirotechnical system. His work did not focus on the chemical act of softening water, rather he explored what conditions in the boiler made the water softening chemicals unable to do their job. Hall deemed this new approach, boiler water conditioning. In 1927 he remarked that "The softening of water and boiler-water

²¹ *Mechanism of Boiler Scale Formation 1922*, page 2. Box 19 Folder "340:F5" Records of the U.S. Bureau of Mines, Record Group 70: National Archives at Philadelphia.

²² "Mechanisms of Boiler Scale Formation," 1922, page 19. See also R.E. Hall, C.E. Coleman, Grant Fitch, *The Chemical Treatment of Boiler Feed Water*, (Pittsburgh Experiment Station), 1922, page 11-13 . Box 19, Folder "Chemical Treatment of boiler feed water," Records of the U.S. Bureau of Mines, Record Group 70: National Archives at Philadelphia.

conditioning are radically different.”²³ Boiler water conditioning treated scale as a process in which water softening was only one component. In an effort to soften water, a mechanic might ask how much of a chemical can remove hardness and subsequently administer that amount, purifying feed water. From the perspective of water conditioning, a chemist would take this question one step further: how does the softened water continue to act throughout the rest of the boiler’s process from moving through feed tubes to evaporation and the end product, steam.

While the Hagan Corporation’s directives effected Hall’s study of scale, he was also influenced by the historical context in which he was working, specifically changes in scientific investigation. The Hagan endeavor was an example of what the scholar of technology Leo Marx called an amalgamation of science and industry which steadily increased at the end of the nineteenth century.²⁴ More so, however, Hall’s approach to the problem of boiler scale was influenced by the growth of a new chemical discipline, physical chemistry. Advances in the discipline of physical chemistry made Hall’s discovery possible.

In the late nineteenth century, physical chemistry took root in Europe and practitioners brought their new methodological approach to the United States shortly thereafter through University and industrial channels. Physical chemistry combined

²³ R.E. Hall, G.W. Smith, H.A. Jackson, J.A. Robb, H.S. Karch, E.A. Hertzell, *A Physico-Chemical Study of Scale Formation and Boiler Water Conditioning*, (Pittsburg, PA: Carnegie Institute of Technology, 1927) 1-2. Box 4, Calgon Corporate Records.

²⁴ Leo Marx, "Technology": The Emergence of a Hazardous Concept, *Social Research*. Vol. 64, No. 3, Technology and the rest of culture (FALL 1997), pp. 965-988.

aspects from chemistry, physics, and mathematics.²⁵ Prior to the 1880s, European chemists held steadfast to the belief that their primary task was to synthesize and characterize new material. The historian John Servos described a small group of outsiders living in Germany who believed chemists spent too much time and energy focusing on the structure and properties of chemicals involved in chemical reactions. According to Servos, the group “sought to redirect chemists’ attention from the substances participating in chemical reactions to the reactions themselves.”²⁶ To paraphrase Servos, practitioners of physical chemistry shifted attention from what to how and why. Borrowing from physics, physical chemistry aimed to explore how natural forces, such as pressure and temperature, governed chemical reactions.

Physical chemists focused on reactions related to chemical equilibrium. Chemical equilibrium happens when the reactants forming products are balanced with those same products changing back into reactants. Take for example the chemical reaction of nitrogen and hydrogen. When mixed together one nitrogen atom bonds with three hydrogen atoms to create ammonia. Throughout the nineteenth century, European chemists forced this reaction, as ammonia was a pivotal material for the production of gunpowder and fertilizer. The problem with the process of mixing the two compounds, however, was that it produced very small amounts of ammonia. This was because as the hydrogen and nitrogen (reactants) produced ammonia (product) the ammonia changed

²⁵ A few comprehensive examples on the history of physical chemistry are: John Servos, *Physical Chemistry from Ostwald to Pauling* (Princeton, NJ: Princeton University Press, 1990) 4-13; see also Cathy Cobb, *Magick, Mayhem, and Mavericks: the Spirited History of Physical Chemistry*, (Amherst, NY: Prometheus Books, 2002); Keith Laidler, *The World of Physical Chemistry*, (New York: Oxford University Press, 1995).

²⁶ Servos, *Physical Chemistry*, 4-13.

back into hydrogen and nitrogen moving towards a natural balance rather than the chemists' wishes. The French chemist, Henry Louis Le Châtelier, posited correctly that stresses such as temperature and pressure placed on a chemical reaction could change the equilibrium. Using a thermodynamic equation created by another physical chemist, Willard Gibbs, which calculated how temperature and pressure affect equilibrium, the German chemist Fritz Haber discovered a more efficient way to produce ammonia. The Haber process, sometimes called the Haber - Bosch process, used a high-pressure device in which to house the chemical reactions. The device forced equilibrium to favor the production of ammonia.²⁷

If traditional chemistry meant organizing matter, then physical chemistry should be associated with efficiency. "Physical chemistry, its proponents claimed, might not generate comparable products, but it could lead to new, and more efficient, and more profitable processes," wrote Servos.²⁸ The Haber process is an excellent example of the application of physical chemistry to aid in industrial efficiency. Before the advent of the high-pressure ammonia process, the compound could not be produced on an industrial scale. Physical chemists working in the United States eagerly applied physical chemistry techniques to industrial processes. Hall was among this crop of chemists using physical chemistry to fix an industrial problem, boiler scale.

Like Haber, Hall approached boiler scale as a problem of chemical equilibrium. He believed that if hypothetically the correct amount of soda ash was added to hard

²⁷ Cobb, *Magick, Mayhem, and Mavericks*, see esp chapter 15 "Thermochemistry: Willard Gibbs and the Quiet Insurrection," 177- 185. On Le Châtelier's principle see also Servos, *Physical Chemistry*, 169-170.

²⁸ Servos, *Physical Chemistry*, 68.

water, then there should not be any scale. Furthermore, the soda ash should not interfere with the sand filter of the Hagan Deconcentrator. In December of 1923, he noted recent books written about boiler scale neglected the concept of chemical equilibrium in boiler water. Hall began with a set of theoretical questions suggesting that perhaps the problem of scale related to a problem with equilibrium caused by temperature and pressure of boilers and then tested his theoretical data.²⁹ His findings fit squarely within the new discipline of physical chemistry. He concluded that no treatment for boiler water took into account operating pressure or temperature. He called his work boiler conditioning taking into account these physical forces. The success of boiler conditioning was ranked by the steam produced, unlike softening which measure its success based on the makeup of feed water. "When this viewpoint is accepted," wrote Hall, "a discussion of water conditioning becomes a broad proposition in which the different types of softening systems today, such as lime, soda ash hot or cold, base exchange processes, concentrators, and what not assume proportions of more necessary parts in a larger whole."³⁰ That larger whole took into account not only hardness, but also operating temperatures and pressures of a boiler.

²⁹ R.E. Hall, G.W. Smith, and H.A. Jackson, "Boiler water treatment from the standpoint of chemical equilibrium," December 12, 1923 (Department of the Interior, Bureau of Mines Pittsburgh Experiment Station), Box 18, Folder "Mechanism of scale formation (2)," Records of the U.S. Bureau of Mines, Record Group 70: National Archives at Philadelphia.

³⁰ Letter from R.E. Hall to A.C. Fieldner, December 18, 1925. Box 18, Folder "Boiler water conditioning with special reference to high operating pressure and corrosion." Records of the U.S. Bureau of Mines, Record Group 70: National Archives at Philadelphia.

After theoretical examination, Hall and his team turned to a series of experiments to analyze feed water, boiler water, scale and sludge and the final product, steam. Hall's research revealed that sodium carbonate or soda ash, used to adjust the conditions of water in a boiler was not suitable for use in boilers with a pressure above 200 pounds per square inch. At this pressure, the solubility of the product increased rapidly, which meant more and more soda ash needed to be added to the boiler if it was to continue working to precipitate calcium and magnesium ions. Second, high pressures caused soda ash to decompose into caustic soda and carbon dioxide. An increase in these two substances greatly increased the alkalinity of boiler water which caused a host of other problems including embrittlement and corrosion.³¹ The goals of the Hagan Corporation, and more specifically Hopwood, would be challenged when Hall determined the Deconcentrator would not work under these conditions and could do nothing to change them. Hall found that the Deconcentrator was just not a useful device in the prevention of scale. According to a corporate history written by G.A Binkly and William Hopwood, J.M's grandson, this finding was difficult for Hopwood to accept. He wanted the Deconcentrator to work, after having invested sizable money in researching problems related to it. Yet Hagan's emphasis on fuel efficiency and fuel economy would help Hopwood forget the Deconcentrator. Binkly and Hopwood wrote, "J.M. Hopwood was not content with just a new theory on an old problem. He wanted to know how this new thinking could be applied to licking the problem."³² Hall then began his search for a chemical that would

³¹ Kieth Piercy, "Feed Water Conditioning and Modern Developments," *High Spots*, October 1934, 2-5, Box 2, Folder "High Spots," Calgon Corporate Records.

³² William W. Hopwood and G.A. Binkly, draft of history of Hagan Corporation, 1949, Box 1, Folder "Hagan History," Calgon Corporation Records.

allow for better equilibrium in a boiler. Upending nearly forty years of boiler practice, Hall searched for a chemical to replace soda ash in industrial water softening.

Hall turned his attention to finding a new chemical that could handle the minerals present in hard water that was more stable at high pressures and temperatures. He first tested trisodium phosphate which had been used sporadically as a water softener throughout the nineteenth century. He found some success, but ultimately rejected the compound because it caused the formation of deposits on feedlines and other regulators in a boiler operation. Testing trisodium phosphate, however, brought him to the conclusion that phosphates maintained relatively stable forms at high pressures. After much trial and error, Hall established the value of a long forgotten chemical curiosity, sodium metaphosphate. First synthesized in the eighteenth century, chemists found little practical application for sodium metaphosphate. Hall discovered that the use of this chemical was unique because it did not precipitate calcium and magnesium like other softeners. In fact, when used these minerals seemed to just disappear. Sodium metaphosphate's usefulness was in its ability to sequester calcium and magnesium ions, effectively "tying up" the ions so they could not precipitate onto boiler surfaces.³³

³³ R.E. Hall, "Boiler Water Conditioning," *The Michigan Technic*, March 1926, 12-15. R.E. Hall, "A System of Boiler Water Treatment Based on Chemical Equilibrium," *Ind. Eng. Chem.*, 1925, 17(30), 283-290; R.E. Hall, "Water treatment for continuous steam production," *Mechanical engineering: the journal of the American Society of Mechanical Engineers*, 1924, 46, 810-817; R.E. Hall, "Investigation of boiler-water treatment," *Power Plant Engineering*, 1924, 28, 843-845; R.E. Hall, "Boiler-water conditioning with special reference to high operating pressure and corrosion," *Mechanical engineering*, 1926, 317-325; R.E. Hall, "Fundamentals in the conditioning of boiler water," *Proceedings of the Engineers Society of Western Pennsylvania*, 1925, 41(9) 347-377; R.E. Hall, "Some suggestions regarding harmonious relationship between boiler water and metal," *Combustion*, 1931, 40-45.

After the successful application of sodium metaphosphate to sequestering calcium and magnesium in water, the Hagan Corporation quickly set up the infrastructure to sell and market its new chemical. Hopwood offered Hall a position running the industrial research side of his corporation, Hall Laboratories, Inc. Hall accepted the position, leaving the USBM in order to profit from his discovery. Hall's relocation was reminiscent of the flood of government chemists back to the industrial sector after World War I. Gaining knowledge and expertise funded by the government, chemists could join private industries in order to profit from their new knowledge.

In effect, the federal government underwrote many aspects of modern industrial capitalism. Actions of scientists, government, and private enterprise was more than just cooperation. It was also coordinated role of uplifting industrial capitalism.

The Hagan Corporation and Hall Laboratories were a match made in industrial efficiency heaven. The company claimed, "Hagan Corporation is recognized as the pioneer in the automatic combustion control field, and the scientific soundness of Hall Laboratories' work in the field of boiler water conditioning has commanded world acclaim."³⁴ Together, Hagan and Hall marketed dual service for both the heat generating and the steam generating parts of any boiler operation, promising high efficiency with low maintenance costs. Efficient boiler operation relied on the application of sodium metaphosphate. Beginning in 1933, the Hagan Corporation marketed the product as Hagan Phosphate and Buromin, an ode to the role of the Bureau of Mines in its discovery. Chemically the same, Buromin included a consulting service in the price of

³⁴ *Dual Service News*, June 1936, Box 2, Folder "Dual Service" Calgon Corporate Records.

purchase, to ensure the water in a boiler plant was operating correctly.³⁵ The company emphasized the simplicity of applying Hagan Phosphate to water. A plant operator placed the powdered chemical in an apparatus made from iron wire with a mesh screen that measured about one cubic foot.³⁶ The apparatus had hooks so it would be suspended in a boiler water feed tank just below water level. Water should be heated to between ninety to one hundred and ten degrees Fahrenheit.

The operator left the chemical until it had completely dissolved in about thirty minutes and then stirred the tank thoroughly. Once dissolved, the water could then be fed directly into the boiler. Industrial users could purchase Hagan Phosphate in a one pound paper bag or a one hundred pound drum.³⁷

Promotional materials created by the Hagan Corporation hailed the progress made by the men involved, linking masculinity and technology through science. This is most apparent in the company magazine, *High Spots*, a monthly publication for Hagan Corporation employees. One article from 1936 claimed that Hall's research enabled industries to grow to their full potential. The article said, "The greater temperatures and ratings of today's immense boilers could not have been attained if the knowledge of water which Hall obtained through his long years of research were still bottled up in the

³⁵ *Dual Service News*, October 1936, Box 2, Folder "Dual Service" Calgon Corporate Records; "Let's Get Acquainted!" *The Calgonizer*, August, 1934, Box 2, Folder "The Calgonizer," Calgon Corporate Records.

³⁶ Hagan Phosphate pamphlet, undated, Box 5, Folder "Calgon Laundry Leaflets and Bulletins, Calgon Corporate Records.

³⁷ *Hagan Phosphates for Boiler Water Conditioning*, promotional pamphlet 1958, Box 5, Folder "Hagan Bulletins E-H, Calgon Corporate Records.

mystery of chemistry.”³⁸ In another article in *High Spots*, an author wrote that as modern manufacturing evolved so too did engineers at Hagan, helping countless companies modernize with high and efficient combustion through their state of the art techniques and technologies.³⁹ Leaders of the Hagan Corporation wrote, edited, and published *High Spots*, frequently James Hopwood himself contributed, with an agenda to lift company morale. Despite this, publications such as *High Spots* helped to create the link between men and technology with a process the historian Ruth Oldenziel argued was in progress during the 1930s.⁴⁰ Engineers laid claim to the role of producers of industrial water softening chemicals and technologies. However, in 1933, the Hagan Corporation began marketing sodium metaphosphate to women for use in the home. Their marketing materials continued to connect masculinity and technology, even as they invited women to use this technology.

Domesticating Sodium Metaphosphate

On December 10, 1933, the *Los Angeles Times* included a small blurb about sodium metaphosphate in its “What’s New in Science” column. It claimed that the chemical “softens hard water, dissolves lime soaps in the washer, does no harm to silk, wool,

³⁸ Harry Stanley, “Again and Again -- A New Standard!” *High Spots*, vol. 3 no. 11, November 30, 1936, 8. Box 2, Folder “High Spots,” Calgon Corporate Records.

³⁹ “Chevrolet Modernizes with Hagan Combustion,” *High Spots*, vol 3, no. 8, August 28, 1936, page 12. Box 2, Folder “High Spots,” Calgon Corporate Records.

⁴⁰ Oldenziel, *Making Technology Masculine*, see especially chapter two, “From Elite Profession to Mass Occupation,” 51-90.

rayon, or cotton nor affects colors, yet emulsifies grease and makes washing easy.”⁴¹

Another newspaper article from *The Times* in Munster, Indiana from 1936 asserted that sodium metaphosphate meant cleaner white clothes and could produce mechanically and bacterially clean dishes in the dishwasher. How and why did sodium metaphosphate make the transition from preventing scale in industrial boilers to assisting in cleaning tasks such as laundering and dishwashing? The Hagan Corporation did not merely repackage sodium metaphosphate; the company domesticated the chemical.⁴² To domesticate sodium metaphosphate, advertisers at the new Calgon subsidiary relied on gendered and environmental rhetoric, selling directly to consumers who they defined as the modern woman, while simultaneously defining their product as something natural. Calgon, they claimed, could produce natural or normal water. Advertisements from the company reflected what male advertising executives thought about women. Nonetheless, Calgon found success in the home precisely because it catered to modern water problems as well as modern water uses such as in increased use in personal hygiene. Calgon was the answer to problems modern technologies and practices presented.

According to the Hagan Corporation, the decision to apply sodium metaphosphate to cleaning processes grew out of a glut of supply of the chemical. An article from *Chemical & Engineering News* said that once Hall and Hopwood decided to market

⁴¹ “Calgon for Laundering,” *The Los Angeles Times Sunday Magazine*, December 10, 1933, page 19.

⁴² The historian Michelle Mart most clearly defined domesticating a product in relation to pesticides in the home. According to Mart, the military first used synthetic pesticides during World War II. After the end of hostilities, manufacturers needed to show people that their products were safe and ready for home mainly through advertisements. Michelle Mart, *Pesticides, a love story*, 21-27.

sodium metaphosphate commercially, they struggled to find a supplier to produce it on a large scale. One manufacturer agreed to only source sodium metaphosphate if the Hagan Corporation purchased one million pounds in the first year of operation. Hopwood agreed and subsequently encouraged his chemists to find new uses for their product. According to the article, “Throughout that year and the succeeding ones, Mr. Hopwood customarily saluted each individual in the organization each day with the query, ‘Haven’t you got a new use for this phosphate yet?’”⁴³ With this mantra in mind, the Hall Laboratories soon began experimenting with other applications of sodium metaphosphate. Understanding Hagan Phosphate’s ability to combat the effects of hard water, chemists at Hall Laboratories began plans to fit their star chemical for the use in both industrial and domestic cleaning operations. Their efforts resulted in a new company charged with selling sodium metaphosphate specifically for cleaning applications, Calgon, Inc, a portmanteau of calcium gone. The company marketed and sold Calgon, a commercial name for sodium metaphosphate.

One of the major tasks of introducing Calgon into the home was defining what it was and what it did. Marketing materials relied on an environmental discourse to do this, more specifically the depiction of Calgon as something that was normal and natural. Sometimes this environmental rhetoric was explicit. For example, in 1934 the company claimed that its product was useful because it had obtained “mastery of calcium and magnesium in water.”⁴⁴ Calgon’s most important message, however, was less explicit and

⁴³ Everett P. Partridge, “Calgon-- A Chemical Development from a Nonchemical Background,” *Chemical & Engineering News*, 1949, 27(12) 840-843.

⁴⁴ “Calgon: The remarkable story of an even more remarkable product,” 1934, Box 5, Folder “Calgon Laundry Bulletins and Leaflets” Calgon Corporate Records.

relied on a distinctly feminized relationship to water. The company defined Calgon, rarely using the term sodium metaphosphate, not as a water softener, but rather as *the* “water normalizer.” The company defined normal water in this way, “Rain that has not struck the ground is ‘normal’ water. It is free of the minerals that are picked up after it strikes the earth and flows through soil and over rocks...Since Calgon prevents them with reacting with soap, Calgonized water is really ‘normalized water, similar to rain.’”⁴⁵

Advertisements frequently connected Calgon and some kind of natural nature. One newspaper advertisement from 1935 claimed that Calgon created “Normalized water as pure as the purest rain water.”⁴⁶ Advertisements assumed human control over water through chemical means, while simultaneously defining this water as natural. To say Calgon made rain water, advertisers relied on an environmental discourse to sell a consumer product. Knowledge of the specific historical context in which women relied on rainwater for use in the household reveals the gendered dimension to Calgon’s claims.

Calgon frequently reminded readers about the historic relationship between women and rain water. An advertisement for Calgon featured in the *St-Louis Post-Dispatch* in 1938 featured a graphic of a small rain cloud next to the words “Grandma Treasured Her Rain Barrel.”⁴⁷

⁴⁵ “Calgon,” Box 5, Folder “Calgon Laundry Bulletins and Leaflets” Calgon Corporate Records. Numerous bulletins from this folder discuss Calgon as a water normalizer. See also bulletins from Box 5, Folder “Calgon Laundry.”

⁴⁶ Advertisement, “Pittsburghers Perfect New Product to Normalize Water,” *The Pittsburgh Press*, January 21, 1935, page 25.

⁴⁷ Advertisement, *St Louis Post-Dispatch*, October 4, 1938, Page 14

A bulletin produced by Calgon wrote, “Grandmother had a better chance of reaching a fine old age with smooth, young skin than we in this generation,” one bulletin wrote, “Her clothes, curtains, etc. were brighter too, because she used rain water from the cistern, or the barrel by the porch.”⁴⁸ These advertisements asserted that it was women who were responsible for collecting normal rain water to use in efficient household tasks. Modern plumbing, Calgon claimed, changed how women produced soft water. That same Calgon bulletin said, “By a simple twist we turn on our faucet for water, but it isn’t the same as the water Grandmother used.” Faucet water, bringing water from wells, lakes, and rivers directly to American’s taps passed over rock and soil collecting harmful material along the way. Women needed to improve that water in order for it to be efficient for use in the family wash. According to Calgon, that water needed to be normalized; it needed to be standardized to remove harmful minerals with Calgon. Only normal water could make the household washing efficient and economical. Calgon was the water normalizer and women needed to have normal water to do work in the home. The company claimed modern conveniences such as plumbing changed how people got soft water, but never refuted it was a woman’s responsibility to maintain a constant source of such water.

These gendered and environmental notions influenced the design of the package to reflect its naturalness. Grocery and homewares stores sold Calgon in two sized boxes for domestic use, 19oz and 2.75 lbs. The boxes were rectangular with Calgon written across the center in lowercase type. Each box displayed multiple raindrops, cascading

⁴⁸ “Calgon,” Box 5, Folder “Calgon Laundry Bulletins and Leaflets” Calgon Corporate Records.

diagonally across the box. The raindrops served to remind women of the water their grandmother's use: pure, soft rain water. The type of water that cleaned effectively and efficiently and was so hard to acquire in the face of modern plumbing systems. The design of the box simultaneously reminded women what the contents of the package did. The product took that bad water from their faucet and made it normal, mastering its pitfalls, and controlled it. Feminine environment control had been commercialized.

As representatives at Calgon established what its product was, they further domesticated it by making it readily available for home managers through samples with instructions on how it should be used. In the 1930s, advertisers at Calgon created what they called the "Prove it Yourself" campaign. This campaign offered free samples of Calgon, and encouraged women to try Calgon for themselves. These samples and other materials produced by the company provided detailed descriptions of how to use Calgon. One bulletin titled *Calgonized Water*, gave detailed descriptions on how to use Calgon for washing silk and rayon; cotton, wool, and linen; and for using with shampoo.⁴⁹ The company hoped detailed instructions would ensure that women used their product in the most efficient manner and thus would be more satisfied with it.

Throughout the 1930s, home managers could gain information about Calgon from demonstrations in home goods stores and from reading columns in newspapers that regularly wrote about topics related to the home. It was not uncommon in the 1930s for department, grocery, and homeware stores to offer demonstrations of new products. In 1938 a store in Dayton, Ohio advertised a Calgon demonstration between a showing of a

⁴⁹ "Calgonized Water," Box 5, Folder, "Calgon Laundry Bulletins and Leaflets, Calgon Corporate Records.

ketchup dispenser and something called an Ade-O-Matic Surface Oven.⁵⁰ On September 16, 1937, the Pittsburgh based department store, Kaufmanns, offered a Calgon demonstration at 10:30 am, 2:00 pm, and again at 4:00 pm.⁵¹ A column devoted to domestic concerns published by the Pittsburgh Post-Gazette called “Shopping with Polly,” promised that what Grandma got with a rain barrel, modern women can have with a chemical process.⁵² The placement of Calgon in spaces that were familiar to homemakers aided in the domestication of sodium metaphosphate.

Decision makers at Calgon hoped women might become familiar with Calgon if commercial launderers used the product. Promotional material from the 1930s suggested that commercial laundry owners could gain more customers if they used Calgonized water. In turn, more women would be familiar with the product and likely to buy it for the home. People at Calgon encouraged laundry owners to offer demonstrations with Calgon in their laundries. In addition to demonstrating the power of Calgon in hard water, one brochure wrote, “By putting a teaspoon of Calgon in a glass of water and gargling with it, the salesman can convince her of its harmlessness.”⁵³ By using Calgon, a laundry owner could “...create an entirely new impression of modern laundering.” A brochure also promised, “This new product promises to provide the most important sales argument

⁵⁰ “Semi-Annual Housewares Fair,” *Dayton Daily News*, October 4, 1938, page 5.

⁵¹ Kaufmanns advertisement, *Pittsburgh Sun-Telegraph*, September 15, 1937, page 22.

⁵² “Shopping with Polly,” *Pittsburgh Post-Gazette*, November 9, 1937, page 11.

⁵³ “Calgon: The remarkable story of an even more remarkable product,” 1934, Box 5, Folder “Calgon Laundry Bulletins and Leaflets” Calgon Corporate Records. This folder also contains numerous ads aimed at the use of Calgon in commercial laundries which reference the “Prove it Yourself” campaign.

ever presented to you for taking the laundry out of milady's basement and placing it in your washroom."⁵⁴ According to the logic of advertisers at Calgon, laundry owners could gain customer confidence by using Calgon, but first needed to acquaint women with the product. It is unclear if commercial laundry owners held demonstrations with Calgon, or if women demanded Calgonized water. Throughout the 1930s, the salesman at the company continued to sell to commercial laundries offering fifty-pound cartons.⁵⁵

During the 1940s and 1950s, Marjorie Gilbert, the company's home economics advisor, played a large role in disseminating information about the product.⁵⁶

Advertisements in newspapers and women's magazine's such as *Good Housekeeping*, offered women the opportunity to request a sample of Calgon directly from the company. Many of these advertisements noted that requests could go directly to Marjorie Gilbert, of the Calgon Homemakers Service.⁵⁷ Gilbert, like other home economists during this period, served as a medium through which information about Calgon was disseminated. Gilbert also penned various bulletins published by the company including a bulletin titled *Calgon Queries* and one titled *Calgon for Home Made Rain*.⁵⁸ In both bulletin's Gilbert's

⁵⁴ Ibid.

⁵⁵ On this see, Promotional pamphlet, 1940, "Now! Wet-Cleaning..." Box 5, Folder "Calgon Laundry Bulletins and Leaflets."

⁵⁶ Although the Calgon Corporate records contain material written by Gilbert, they contain very little information about her daily activity at the company or her life. In 1954 a newspaper article from the Pittsburgh Press described her as the "economics director" for Calgon. "Around the Town," *The Pittsburgh Press*, May 1, 1954, page 4.

⁵⁷ Advertisement, *Good Housekeeping*, September 1941. Vol. 113, No. 3, page 184; Advertisement, *Good Housekeeping*, April 1941 Vol. 112, No. 4, page 192.

⁵⁸ Box 5, Folder, "Calgon Laundry Bulletins and Leaflets, Calgon Corporate Records.

tone is friendly and modern. Each bulletin uses the familiar trope of Grandma's rain barrel, with Gilbert playfully asking "Who wants a rain barrel?" According to an article in the *Philadelphia Inquirer* entitled "Visitor Likes Phila. Water," Gilbert visited the city in 1950 and tested the hardness water supplies.⁵⁹ She reported low hardness in homes east of Broad Street and moderate hardness in the water west of Broad Street thanks to water supplied from the Schuylkill River. During her trip, Gilbert gave a demonstration at the Benjamin Franklin Hotel to show how Calgon could improve water used in the home laundry. Through both her writings and demonstrations, Gilbert served to reinforce the gendered ideology embedded in new consumer products, as well as serve as a guide for the new technologies available in the home.

As modern household technologies such as the automatic washing and dish washer became more popular, the mastery of water become not just a way to save time and money but a necessity for their proper function. Calgon had always been marketed as an adjunct to soap, but as automatic washing machines became ubiquitous, Calgon took on a new task, keeping the automatic labor saving technologies clean and working efficiently. It was in the early 1940s that automatic washing machines began appearing in American homes in large numbers. By 1941, 52 percent of such households had a power washing machine.⁶⁰ Manufacturers first marketed electric washing machines in the years between 1910 and 1920, while automatic machines, which automatically spun clothes between cycles, appeared by the end of the 1930s. Arwen Mohun and Ruth Schwartz Cowan attributed the widespread acceptance of the automatic washing machine to a

⁵⁹ "Visitor Likes Phila. Water," *The Philadelphia Inquirer*, March 1, 1950.

⁶⁰ Schwartz Cowan, *More Work for Mother*, 107.

combination of technological, economic, and cultural factors, including the widespread availability of both municipal water and electricity, the expansion of consumer credit and post war prosperity, and the continued emphasis on cleanliness and personal hygiene.⁶¹

By the 1920s, many manufacturers offered soap in the form of laundry chips, granules, flakes or powders. Soap powders such as Rinso, manufactured by Unilever, combined crushed soap with caustic materials such as soda ash.⁶² Manufacturers promised less work in the laundry as launderers could add powders directly to wash water, instead of rubbing clothes against soap bars. Soap powders worked effectively in traditional wash tubs as well as electric washing machines that did not spin clothes dry automatically and mostly replaced bar soap by the 1930s.⁶³ Soap powders, however, caused problems in automatic washing machines. In a by now familiar chemical reaction, soap and soda ash reacted with hard water ions to form an insoluble curd within the walls of the machine. As the automatic washing machine spun clothes between cycles, it forced the curd to deeply penetrate fabrics, making it extremely difficult to remove.⁶⁴ The force

⁶¹ Schwartz Cowan, *More Work for Mother*, 93- 94, 173; Mohun, *Steam Laundries*, 247-270.

⁶² On soap powders see, Vincent Vinikas, *Soft Soap, Hard Sell: American Hygiene in the Age of Advertisement*, (Ames: Iowa State University Press, 1992) 93; On soap powders and the history of Unilever see, Charles Wilson, *The History of Unilever: A Student in Economic Growth and Social Change* (New York: Praeger, 1954-1968) 121, 188.

⁶³ John W. McCutcheon, "Synthetic Detergents and Emulsifiers – Up to Date," *Soap and Chemical Specialties*, July 1955, Vol. XXXL, No. 7. Pages 50-61.

⁶⁴ Cooperative Extension Service, Michigan State University, "The Detergent Puzzle," Extension Bulletin E-726, November, 1971, pg. 2.; Allen L. Hammond, "Phosphate Replacements: Problems with the Washday Miracle," *Science*, Vol. 172, No. 3981 (Apr. 23, 1971), pp. 362-363.

of the cycle also caused soap curd to get stuck on the walls of the washing machine causing build up in machines. This presented a problem even in soft water regions as an average load of wash contained enough hardness ions to produce soap curd.⁶⁵ Automatic washing machine manufacturers had been concerned with problems related to hard water since at least the 1920s. The American Washing Machine Manufacturers Association, an industry group, cooperated with both home economics departments at universities and soap manufacturers to determine the best soap to use in their machines under certain washing conditions. The association requested these groups assist in finding out information about the effects of hard water on machines.⁶⁶

As more Americans purchased automatic washing machines, the problem took on a new immediacy. A 1949 Calgon bulletin claimed that the company had been in cooperation with various automatic machine companies to determine a new and improved way to do the wash that combatted hard water problems. It said that, “Manufacturers of automatic machines recommend Calgon for use in their machines, since it offers the best means of controlling water hardness. Such control is especially important in the automatic machine since there is the danger of soap film adhering to both clothing and the machine itself. Tests have proved that ordinary methods of water softening will not work in the automatic machines.”⁶⁷ In a bulletin entitled, *Happy to Wash with You*, the

⁶⁵ Robert E. Gosselin, “The Detergent Controversy,” in Roger P. Smith (ed.), *A Primer of Environmental Toxicology*, (Philadelphia, PA: Lea & Febiger, 1992) 193.

⁶⁶ *Annual report of the American Washing Machine Manufacturers Association*, 1920, (Chicago: publisher not available) page 4.

⁶⁷ “The New Way to Machine-Wash your Clothes,” 1949, Calgon Corporate Records, Box 5, Folder “Calgon Laundry Bulletin and Leaflets.”

company claimed Calgon improved the efficiency of any washing machine. Advertising executives emphasized the claim that a modern automatic washing machine could only work as efficiently as water permits. Water with dissolved minerals would hurt the efficiency of the machine.⁶⁸ By tailoring sodium metaphosphate's use to new trends in laundering, Calgon was able to stay relevant in the home-washing field especially as synthetic detergents slowly gained steam in the 1940s and laundry soap remained the most popular option.

New technologies redefined how launderers used Calgon. Early directions for using Calgon in the laundry were simple: add a half a cup of Calgon plus half the usual amount of your favorite soap and add hot water to your wash tub. Three inches of suds indicated the water was ready for the clothes.⁶⁹ Direction changed with the automatic washing machine and required a bit more precision in relation to water hardness. In 1948, directions for using Calgon in an automatic washing machines were as follows, add soap plus Calgon to the soap dispenser based on the hardness chart.⁷⁰ The hardness chart provided a scale from one grain per gallon through twenty five in increments of five. Each number corresponded to the number of heaping tablespoons the launderer needed to use. For example, one grain of hardness required one teaspoon while twenty grains required eight. In hard water areas, the launderer should only use between one half to

⁶⁸ See "Happy to Wash with you," Calgon Corporate Records, Box 5, Folder "Calgon Laundry Bulletin and Leaflets" and "Calgon in your Hotpoint," Box 5, Folder "Calgon Laundry."

⁶⁹ Pamphlet 1941, "Easy Chair Day in the Laundry," Box 5, Folder Calgon Laundry Bulletins and Leaflets," Calgon Corporate Records.

⁷⁰ Promotional material 1948, "Calgon for the Frigidaire Automatic Washer," Box 5, Folder "Calgon Laundry Bulletins and Leaflets." Calgon Corporate Records.

three fourths the amount of soap usually necessary. Depending on hardness, even less soap could be used. If hardness is not known, users could do a simple test. Take a gallon of water and dissolve enough Calgon to make the water feel slippery. Once the amount is determined, use ten times the amount in the washing machine. The directions also noted that water hardness varied from season to season and should be adjusted accordingly. Despite the use of an automatic machine, these directions still require participation from the user. Launderers not only needed to know the hardness, but make decisions about how much soap and chemicals to put into the machine. This could be even more subjective depending on different seasons. Although Calgon abstracted water from its natural state, it still required home launderers to assess and manipulate their water based on those assessments. Modern household technologies such as the automatic washing machine required more attention to hardness.

The automatic dish washer relied heavily on treated water opening another market for Calgon.⁷¹ In an article in *Soap and Chemical Specialties* published in 1955, Calgon chemist Kurt Albrecht said that before 1934 the mechanical dishwasher did not exist (despite being on the market since the 1920s).⁷² He wrote that the use of a mechanical dishwasher would be better classified as a mechanical dish soiler. Machines removed food but left thin film on dishes, precipitated hardness ions. Users of mechanical dishwashers would then have to physically remove the film by scouring or soaking. The

⁷¹ It is difficult to find the exact number of dishwashers bought in the United States in the post war period. In general, large appliances such as dishwashers, washing machines, ovens, and refrigerators grew after World War II.

⁷² Kurt Albrecht, Calgon, "Dishwashing Machine Detergents," *Soap and Chemical Specialties*, January 1955, Vol. XXXL No. I: page 33.

manual and the mechanical action made the dishwasher an unacceptable household device. According to the Hagan Corporation, automatic dishwasher manufacturers came to the company and asked it to develop a water softener to be used in the dishwasher.⁷³ The result was Calgonite, a blend of the water softening power of Calgon with soaps developed specifically for dishwashers. Users of mechanical dishwashers could automatically add Calgonite into their wash thanks to a dispenser developed by the company.⁷⁴ The Hagan Corporation boasted that it saved the mechanical dishwashing industry. Whether this is entirely true, the proliferation and need of Calgonite pointed to the ways in which new household technologies demanded a specific water quality.

In both the cases of dishwashers and washing machines, advertisers at the Calgon Corporation took advantage of increased awareness of cleanliness and sanitation in the household. Suellen Hoy, in her monograph about cleanliness in America, noted a steady rise in cultural attitudes concerning cleanliness and sanitation beginning at the end of the nineteenth century. Increasing weight placed upon cleanliness fueled the sales of personal and home cleaning products in the 1920s and 1930s.⁷⁵ Calgon capitalized on this cultural moment in order to situate itself as a necessary product in securing clean and germ free

⁷³ The Hagan Corporation claimed it saved the mechanical dishwashing industry in this advertisement, "Developed in Pittsburgh Pennsylvania and it saved an industry," *Pittsburgh Post-Gazette*, January 3, 1951, 33.

⁷⁴ Pamphlet undated, "Directions for using Calgonite in Mechanical Dishwashers," Box 5, Folder "Calgon Laundry," Calgon Corporate Records. On Calgonite see also, "The Story of Calgonite Brought Up-to Date," Box 5, "Calgon Dishwashing," Calgon Corporate Records.

⁷⁵ Suellen M. Hoy, *Chasing Dirt the American pursuit of cleanliness* (New York: Oxford University Press, 1995). On consumer products and hygiene see, Vincent Vinikas, *Soft Soap, Hard Sell: American Hygiene in the Age of Advertisement*, (Ames: Iowa State University Press, 1992)

laundry. Marketing material about Calgonite claimed the product could remove bacteria from tableware, eliminating such sanitary issues as trench mouth, a disease attributed to dirty glassware in bars.⁷⁶

Advertisers at Calgon marketed their product not just for productive work, but also for bodily use, emphasizing changing uses of water in the home. By the 1920s, indoor plumbing became more standard in the United States. Most middle class Americans would have had access to cold and hot water as well as a flush toilet and bathtub that drained. This was not the same for rural or lower class people, but even the urban poor would have had running water by the end of the nineteenth century.⁷⁷ Indoor plumbing created the means to improve on personal and family health and hygiene. The geographer Karen Bakker advanced that the toilet and tub became “symbolic of the sensual and aesthetic roles played by water in urbanization and cultural modernization.”⁷⁸ Calgon capitalized on the cultural role of water in the bath, which was indicative of cleanliness and modern convenience. There was nothing better than taking a bath in Calgonized water, the company claimed. A pamphlet from 1941 wrote, “Nothing is more refreshing than a bath in Calgonized water. It feels so silky and leaves the skin clean and smooth.”⁷⁹ The pamphlet emphasized how Calgon could create water that felt better than

⁷⁶ “The Story of Calgonite Brought Up-to-Date,” 1937, Box 5, Folder “Calgon Dishwashing,” Calgon Corporate Records.

⁷⁷ Cowan, *More Work for Mother*, 86-90.

⁷⁸ Bakker, “Water: Political, Biopolitical, Material,” 618.

⁷⁹ Pamphlet, 1941, “A Beauty Bath for Fine Fabrics and Soft Hands,” Box 5, Folder “Calgon Laundry Bulletins and Leaflets,” Calgon Corporate Records. In one newspaper advertisement, Calgon claimed to have a beauty research department, Advertisement, Calgon, *Pittsburgh Post-Gazette*, March 11, 1938, page 4.

the water that came out of the faucet. It alluded to the importance of water and its tactile sensation. By the 1950s, Calgon encouraged women to buy three boxes, one for the laundry, kitchen, and bath.⁸⁰ Seen together, Calgon for sensual purposes as well as for use with new household technologies emphasize the importance of water quality in modern water. People relied not just on increasingly larger quantities but also quality.

The image that Calgon advertisers developed was that of a white middle class woman who used modern technologies and conveniences in her household. In the company's depiction, advertisers assigned the responsibility for cleanliness to women.⁸¹ More than just women, the company also contributed to what historian Carl Zimring has described as the confluence of whiteness and cleanliness.⁸² By depicting only white women in their advertising and marketing materials, executives at the company connected white skin to pure and natural water. Therefore, soft water, and its use by white women, in many ways represented a social order in which white people maintained cultural authority through things such as hygiene and cleanliness. The company cast a wide net in terms of potential customers by situating their product as useful in the kitchen, laundry, and bath. Upper, middle, and lower class women could all find uses for

⁸⁰ Advertisement, Calgon, *Pittsburgh Post-Gazette*, November 10, 1958, page 14.

⁸¹ Hoy, *Chasing Dirt*, 171-174.

⁸² Carl Zimring, *Clean and White: A history of environmental racism in the United States*, (New York: New York University Press, 2015). On cleanliness, race, and civilization see, Timothy Burke, *Lifebuoy men, lux women: commodification, consumption, and cleanliness in modern Zimbabwe* (Durham, N.C.: Duke University Press 1996).

Calgon from a luxurious bath to domestic economy. Despite the blurred class lines, advertisements by Calgon demonstrated a racial, as well as gendered, gatekeeping. Water softening was a necessity and luxury for white women as managers of cleanliness in the home.

In the process of domesticating sodium metaphosphate, the Hagan Corporation, turned Calgon and Hagan Phosphate into two different things. The company was able to do so by defining Calgon as something natural and feminine, while simultaneously conflating whiteness with modernity and cleanliness. Advertisements for Hagan Phosphate never assumed that boiler plants would need rain water or normal water, instead Hagan advertised efficient water through male technological and scientific expertise.

An examination of Calgon proved the total abstraction of water from its social and ecological relationships was not quite complete. For example, as directions for automatic washing machines showed, launderers still needed to know the hardness of their water in order to properly use Calgon. This suggested that water, even though it had come from pipes, had not been entirely removed from its natural ecological state. Yet, the incessant use of the terms normal and pure, as well as the reminder of rain water, continued to define water for Calgon consumers. In defining water as normal, advertisers, as well as the chemists such as Hall, removed it from its social nature, that is the fact that “pure” water actually contained in it chemicals. This signaled from the company that the waste water filled with sodium metaphosphate was safe and for their purposes it was. Sodium metaphosphate was gentle on skin, hands, clothes and even babies. Therefore, no one thought much about what happened to the phosphates in waste water.

Conclusion

Private industry, the federal government, industrial chemistry and capitalism, babies' diapers, and women's washing machines are all wrapped up in the same story about water. Situating hard water and water softening as a historical process makes clear the connection between these usually different categories. More than just hard water, what also holds these threads together is the importance of water quality in modern work. Just as sodium metaphosphate allowed industrial boilers to operate at higher temperatures, it also enabled the proliferation of automatic washing machines in American households. Increasingly, envirotechnical systems came to dominate both industries and the home, making water quality an equally important concern as mechanical function.

As water became suited for modernity, there seemed to be an ambivalence about what that meant for water. Users of Calgon thought about water quality quite regularly. Yet they rarely thought about what happened when that water drained out of bathtubs and washing machines. Perhaps this would not have mattered if certain historical contingencies did not lead to the explosion of complex phosphates in other materials, jettisoning them into nearly every home by the mid-1950s. Yet these chemicals did find themselves in American homes because of a confluence of ecological, economic, and social reasons that all stemmed back to the need for soft water in industry and in the home. The outcome of this, put into place by the discovery of Ralph Hall, would show the ecological consequences of human's mastery over the minute ions of water.

CHAPTER 5
A CHOICE BETWEEN CLEAN WATER AND CLEAN
LAUNDRY: THE ENVIRONMENTAL COST
OF WATER SOFTENING

In the late 1960s, all around the nation a green, smelly slime slowly crept into America's lakes. In Seneca Lake, south of Lake Ontario in upstate New York, a local fisherman, Fred Mohan, brought up his lure after trolling down below only to find it absent of fish and choked by green slime. It was ruining his hobby. Writing in the local newspaper he pondered, "Whether a fish will strike a lure with hooks covered in slimy stuff, I'm not sure..." Four hundred miles to the southwest gelatin-like slime lapped the shores of Kelley's Island, a Lake Erie swimming and fishing resort. The island's three hundred residents looked on in concern and disgust as their once clear blue water turned a pea-soup green. The slime forced local health officials to restrict water consumption for the community as it crept into water supplies. The green intruder was not only unaesthetic but downright dangerous for local ecologies. A Michigan newspaper blamed it for a string of dead carp found belly up in the Grand River.¹ These lakes were undergoing what limnologists call eutrophication, a natural aging process characterized by an abundance of plant growth, specifically algae. The process in these cases, however, was anything but natural. Nitrogen and phosphate in waste water caused this natural process to "run amok," in the words of Arthur Hasler, director of the Laboratory of Limnology at the

¹ Fred Mohn, "The Fish Hook," *The Ithaca Journal* (Ithaca, New York) Jul. 5, 1968; "Slime affects water on isle in Lake Erie," *The Journal Times* (Racine, Wisconsin) Sept 10, 1969; "Kelleys Island Experience Lesson for the Rest of the Nation," *The Jackson Sun* (Jackson, Tennessee) Oct. 27, 1969. Norris McDowell, "City Ready to Undertake Treatment of Phosphates," *Lansing State Journal* (Lansing, Michigan) July 19, 1970.

University of Wisconsin.² More specifically, complex phosphates like those in Calgon and synthetic laundry detergents, seemed to be doing the most damage, acting as a fertilizer and fueling algae blooms.

By the time eutrophication became a household name, synthetic detergents, synthetic cleaning agents made from petroleum, had largely replaced other laundry soap in American households. In the late 1920s, German and American chemists introduced the first cleaning agents made of synthetic materials. They were widely accepted in the textile industry, but still had the same downfalls as soap in hard water. Detergent chemists experimented with adding substance to these new synthetics to assist in hard water. The solution they found was to “build up” these materials with complex phosphates which had experienced a resurgence since Ralph Hall discovered their softening powers. Synthetic built laundry detergents represented a new era in the history of water softening, one in which cleaning products contained within them materials that could change the chemistry of water. After World War II, soap manufacturers had made detergents widely available. Home launderers adopted these products because they made the difficult task of washing easier and more streamlined, worked well in automatic washing machines, and finally worked in either hard or soft water.

Synthetic detergents enjoyed twenty years of growth and acceptance until they began polluting lakes. The historians William McGucken and Terence Kehoe have published comprehensive historical accounts of the eutrophication controversy, yet they

² Arthur D. Hasler and Bruce Ingersoll, “Dwindling Lakes,” *Natural History Magazine*, 77(9): 8-19, November 1968.

fail to incorporate the gendered dimensions so central in the conflict.³ An examination of the conflict using a gendered analysis revealed the ways in which people constructed narratives about the environmental crisis based on the gendered nature of certain products. Since their inception in the 1940s, advertisers equated laundry detergent with women's work in the home while also depicting the use of these products as indicative of a good wife and mother. So, while detergents are part of a larger trend during the environmental movement in which people questioned the price of postwar products and technologies, they cannot be unanchored from these existing discourses or associations. Specifically, the eutrophication controversy was shaped and shaped by social forces such as gender performance and prescriptions. Both the public and the detergent industry blamed women for the problem. Women had long been responsible for the care of the earth, and new environmental currents in the 1960s reasserted this notion.⁴ Tension arose when that care of the earth clashed with productive work in the home. Many women approached this tension in the marketplace using their power as consumers to make decisions about the environment by purchasing new no phosphate detergents. Ultimately, these decisions shaped the detergent controversy most strongly when they forced the

³ William McGucken, *Lake Erie Rehabilitated: Controlling Cultural Eutrophication, 1960s-1990s* (Akron, Ohio: University of Akron Press, 2000) while McGucken does outline the response of some women who organized against eutrophication, he does not offer an analysis of the gendered dynamics of the whole conflict. Terence Kehoe, *Cleaning Up the Great Lakes- From Cooperation to Confrontation* (DeKalb: Northern Illinois University Press, 1997). For an account written by a limnologist see also W.T. Edmondson, *The Uses of Ecology: Lake Washington and Beyond* (Seattle: University of Washington Press, 1991) see especially chapter 3, "The Detergent Problem," 89-138.

⁴ Carolyn Merchant, *Earthcare: Women and the Environment* (New York: Routledge, 1995).

largest detergent manufacturers to substantially lower the phosphate count of their products.

Historians also failed to acknowledge that water softening chemicals caused the problem of eutrophication. Detergent manufacturers added these chemicals specifically to cleansing agents so that they could make water conditions appropriate for washing machines, as well as sell one formula in both hard and soft water areas. Overlooking this fact obscures the importance that society placed on securing a specific water quality in modern water. Not acknowledging the centrality of soft water in the eutrophication controversy is also indicative of the successful abstraction of water. Detergent chemists created a product that did not require users to consider the ecological variation of water. Instead, they celebrated a complete washing product that could be used anywhere, regardless of water quality, without having to add a softener. With synthetic cleaners built with complex phosphates, detergent chemists standardized the water for the home wash across the United States. Yet, as the eutrophication of lakes showed, standardizing water in one place resulted in created ecological chaos in another. The eutrophication controversy represented the culmination of a hundred years of attempting to made soft water in the household wash.

From Turkey Red Oil to Tide: A History of Surface Active Agents

A discussion of synthetic detergents requires a brief history of surface active agents, or surfactants. Soap's ability to clean stems from its role as a surfactant, a substance that can increase the solubility of an otherwise insoluble substance. In the case of a soap molecule, its water loving head and water fearing tail means that it can position itself between water and other substances such as oil. Soap effectively lowers the surface

tension of water, allowing substances to become wet and then to be removed in water.⁵ In addition to use for cleaning, the textile industry widely used surface active agents to aid in the dyeing process. Textile workers applied surfactants to aid in the wetting of fabric, or make the material more penetrative for dyes. Throughout the nineteenth century, some chemists related to the textile industry conducted experiments on surface active agents besides soap. One result was the discovery of sulfonated fatty oils in 1834, or animal and vegetable fats treated with sulfuric acid and caustic soda. The soluble oils obtained have better wetting properties than soap and were used in the textile industry not to clean, but rather as wetting and penetrating agents. Sulfonated fatty oils, like soap, did not work well in hard water, thus were not applied to cleaning processes. Perhaps the most well-known of this class of chemicals was sulfonated castor oil, or Turkey-red oil called for its ability to thoroughly wet fabrics to be dyed the color Turkey-red. These chemicals served to evenly distribute dye on fabric but had limited detergency, or cleaning, power.⁶

In the 1920s, German chemists produced new wetting agents by treating fatty alcohols, obtained by the hydrogenation of fatty acids, with sulfuric acid. Known as alkyl sulfates, these surface active agents contain a hydrophilic and hydrophobic end like soap making them both excellent wetting agents that also had cleaning power. Unlike sulfonated fatty oils, they also proved to work well in hard water. These compounds, however, only worked well if their hydrophobic, or alkyl chains were relatively short.

⁵ Donald Price, "New Developments in Surfactants," *Soap and Chemical Specialties*, July, 1960, vol. XXXIV. 47- 50, 105-107.

⁶ McGucken, *Biodegradable*, 13-14; On sulfonated oil in textile processing see Donald Price, *Detergents: What They Are and What They Do* (New York: Chemical Publishing Co., 1952) 102.

Coconut oil produced the ideal product while mixed animal fats containing tallow tended to produce unstable compounds. The German firm H.T. Bohme produced the first commercial synthetic detergent product called the Avirol series in 1926. Two years later they introduced Gardinol, another series of fatty alcohol sulfate detergents. By 1930s, German companies introduced synthetics such as Gardinol and the Igepon series manufactured by I.G. Farben into the United States through sponsorship by American chemical companies.⁷

During the 1930s, there was a sharp rise in the availability of synthetic surface active agents with the textile industry as the largest consumer. In a 1932 article of the *American Dyestuff Reporter*, a trade magazine for the textile industry, a commenter noted that there were so many synthetic sulphonated oils available there needed to be better practices of standardization for the product. The author recommended a sulphonated oil association.⁸ Promotional material for Gardinol, for which Procter & Gamble, National Aniline & Chemical Company, and E.I. Du Pont de Nemours & Co., Inc had become selling agents, made clear the product's greatest appeal, its ability to perform more efficiently than soap specifically in hard water. The pamphlet boasted, "The Gardinol products give no marked precipitation or scum of sticky insoluble matter which results when soap is used in hard water. Furthermore, the degree of water hardness in no way

⁷ Robert E. Gosselin, "The Detergent Controversy," in Roger P Smith ed., *A Primer of Environmental Toxicology* (Philadelphia, PA: Lea & Febiger, 1992) 188-193; McGucken, *Biodegradable*, 14-15. For I.G. Farben, see Peter Hayes, *Industry and Ideology: IG Farben in the Nazi Era* (Cambridge: Cambridge University Press, 1987).

⁸ American Dyestuff Reporter, January 4, 1932, Vol. 21, 1-2, 27.

affects the efficiency of Gardinol.”⁹ Gone were the days of insoluble soap curd interfering with the production of quality textile merchandise. The use of sulphonated oils use was widely adopted in textile processing plants.

In 1933 Proctor and Gamble introduced Drift, soon after renamed Dreft, for home use as the first synthetic all-purpose cleaner intended for use in the laundry. The formula for Dreft originally used sulfated fatty alcohol made from coconut oil. During the 1930s researchers in both Germany and the United States explored the possibility of creating a surfactant from something besides fatty raw material. The historian William McGucken wrote, “By the late 1930s, immediately preceding WWII, synthetic detergents based on nonfatty raw materials were just beginning to appear in small quantities. The changeover from fatty to non-fatty raw materials was greatly accelerated through the adoption of techniques developed during the war.”¹⁰ Those techniques had to do with petroleum chemicals. Since the first decade of the twentieth century the petroleum industry had been experimenting with more efficient ways to refine their product into the more useful gasoline. The result was high octane fuel oils and a litany of easily manipulated hydrocarbon byproducts. Chemists utilized these byproducts to make a variety of products during and immediately after World War II including synthetic rubber,

⁹ Gardinol Corporation, *Gardinol for Cotton and Linen* (Wilmington, DE: The Gardinol Corporation, 1937) 16,17. See also, Gardinol Corporation, *Gardinol, a Review of the Uses of Alcohol Sulfates in the Textile Industry* (Wilmington, DE: The Gardinol Corporation, 1934).

¹⁰ McGucken, *Biodegradable*, 17.

insecticides, weed killers, soil fumigants, and surface-active agents.¹¹ Scientists called those substances used as surface active agents secondary alkyl sulfates. They made up the largest class of new surface active agents. The most widely used surfactant of this kind was alkyl benzene sulfonate (ABS).

Soap and detergent manufacturers turned to ABS over alkyl sulfates, used in Gardinol, for two reasons. First, alkyl sulfates broke down at high temperatures, thus were not effective in the high heat required for proper laundering. ABS could not be used for what people in the soap industry classified as “heavy duty detergents” which meant the family wash.¹² Synthetics such as ABS were also immune to price fluctuations common in the market of fatty raw materials. Beginning in the early twentieth century, demand for oils and fats in both the cosmetic and food industries outstripped world supply. Supplies were especially scarce during World War II.¹³ ABS represented an alternative to the use of fatty raw material. Despite its merit, ABS also had two serious shortcomings. It was nearly four to five times the cost of soap. Unfortunately, ABS also shared with soap the undesirable property of reacting with the salts of hard water. In other words, the nearly thirty-year endeavor to make something that worked better in hard

¹¹ G. Egloff and M.L. Alexander, “Petroleum Chemistry,” *Industrial and Engineering Chemistry*, Vol. 43, No. 4, August 1951, 809-819; W.K. Griesinger and J.A. Nevison, “Synthetic Detergents from Petroleum,” *Progress in Petroleum Technology*, (American Chemical Society: Washington, DC, 1951) 324-333.

¹² Gosselin, “The Detergent Controversy,” 191.

¹³ On the soap industry and difficulties with finding a reliable source of fatty raw material see, Charles Henry Wilson, *The History of Unilever: A Study in Economic Growth and Social Change* (New York: Praeger, 1954) 52, 72.

water arrived in much the same place it started, at least in the field of laundry detergent.¹⁴ New petroleum based detergents were little better than soap at all in terms of cleaning ability especially in hard water areas. Moreover, they also cost more money making them even less attractive than soap. These two facts run against the grain of what is considered a triumphant narrative of the rise of postwar synthetic materials. While detergent manufacturers considered new synthetics to be modern, that did not necessarily indicate they were better than older methods of cleaning.

The detergent industry would not be deterred adding to their formulas complex phosphate compounds; the very compounds made popular for water softening by Ralph Hall and Calgon. Manufacturers such as Proctor and Gamble and eventually Lever Brothers and Colgate Palmolive “built” their detergent formulas adding phosphates that served to solve both their economic and environmental problems. Writing in the *Journal of the American Oil Chemists’ Society*, a chemist from the Wyandotte Chemicals Corporation described a builder as something that, “...may be generally defined as a material which, when added to a synthetic detergent or soap, will improve its performance. It is not a diluent but contributed to the overall effectiveness of the cleaning operation.”¹⁵ Phosphates substantially lowered the cost of household detergent and sequestered calcium and magnesium ions. They enabled ABS to work in hard water.

¹⁴ P.T. Vitale, J. Ross, and A.M. Schwartz, “Carbon Soil Removal in the Presence of Polyphosphates in Hard Water,” *Soap and Chemical Specialties*, June 1956; Gosselin, “The Detergent Controversy,” 191-192.

¹⁵ M.G. Kramer, “Builders for Detergents,” *The Journal of the American Oil Chemists’ Society*, November 1952, Vol. 29 529-534.

In the years since Hall used complex phosphates to sequester calcium and magnesium ions out of water for boiler use, other chemists and manufacturers experimented with this class of chemicals for similar purposes. In 1942 Charles Schwartz and C.J. Munter from Hall Laboratories, Inc published a review of phosphates in water conditioning in *Industrial and Engineering Chemistry*. They credited Hall with galvanizing an increase in research in the use of phosphate writing, “The result has been the chemical counterpart of a gold rush, as attested by the number of patents issued in which these materials are mentioned.”¹⁶ Among the new patents had to do with the investigation of polyphosphates. Polyphosphates were chemically similar to metaphosphate, the main component in Calgon. Production wise, chemists rendered polyphosphates by dehydrating certain phosphoric salts. Metaphosphate, on the other hand, was the result of heating those same salts.¹⁷ Compounds such as sodium tripolyphosphate, sodium tetrphosphate, and tetra sodium pyrophosphate were examples of this class of chemical that stood out for their commercial applications. In the 1930s

¹⁶ Charles Schwartz and C.J. Munter, “Phosphates in Water Conditioning,” *Ind. Eng. Chem*, 1942, 34(1), 32-40; the importance of Hall’s contribution to the study of phosphate compounds is echoed in Henry W. Easterwood, “Recent Developments in the Phosphate Field,” *Ind. Eng. Chem.*, 1942, 34(1) 13-19.

¹⁷ On this see Everett P. Partridge, Victor Hicks, and G.W. Smith, “A Thermal, Microscopic and X-Ray Study of the System $\text{NaPO}_3 - \text{Na}_4\text{P}_2\text{O}_7$,” *J. Am. Chem. Soc.* Vol. 63. 1941, 454-65; S.J. Ashcroft, E. Keen and C.T. Mortimer, “Thermochemistry of Formation of Sodium Polyphosphates from Sodium Orthophosphates,” *Trans. Faraday Soc.*, 1969, 65, 2851-2855. For broad history of the preparation of phosphate see, Joseph William Mellor, *A Comprehensive Treatise on Inorganic and Theoretical Chemistry Volume II*, (London, New York: Longmans Green) 847-871 Mellor shows how various chemists including Thomas Graham and T. Fleitmann worked with different types of metaphosphates in the nineteenth century, however, they found no commercial or practical application for their uses.

numerous soap manufacturers applied for patents related to the use of polyphosphates as soap builders.¹⁸ According to one patent filed by Proctor and Gamble, the use of sodium tetraphosphate added to soap reduced the hardness of water without raising the alkalinity of it like other builders such as soda ash.¹⁹ An article in *Soap and Chemical Specialties* noted, “The inclusion of polyphosphates in detergents pioneered by Hall was a weapon that the detergent technologist could use to control calcium and other deposits.”²⁰

By the 1940s the most widely used builder was sodium tripolyphosphate (STP). In 1968 C.Y. Chen who worked in research and development for the Monsanto Company called STP the “work-horse” of the detergent phosphates.²¹ Adding STP to detergent formulas, he claimed, not only lowered the cost of detergent formulas, but also improved performance by sequestering water hardness and improving handling properties. In 1950, the detergent industry was ruled by three manufacturers: Proctor and Gamble, Colgate Palmolive, and Lever Brothers. Each offered a heavy duty detergent, Tide, Fab, and Surf respectively. While Tide and Surf contained large amounts of STP, Fab contained a high level of orthophosphate. These phosphates made each product affordable as well as

¹⁸ For a list of patents related to polyphosphates and metaphosphate see Easterwood, 1942, 18-19.

¹⁹ Walter C. Preston, 1937, “Soap Builder of Reduced Alkalinity,” United States Patent. No. 2,093,927. Filed May 8, 1935. Issues September 21, 1937.

²⁰ Kurt Albrecht, Calgon, “Dishwasher Machine Detergents,” *Soap and Chemical Specialties*, January 1955. Vol. XXXL No. I. Page 33.

²¹ C.Y. Shen, “Properties of Detergent Phosphates and Their Effects on Detergent Processing,” *The Journal of the American Oil Chemists’ Society*, Vol. 45, July 1968, 510-516.

functional in hard and soft water.²² Monsanto's detergent, All, was also enjoying some share of the market. All contained in its formula pyrophosphate. Workhorse in hand, detergent manufacturers marketed their products at cheap costs unbounded by the natural water conditions across the United States. These complex phosphates descended from Ralph Hall.

A detergent that could be used anywhere was advantageous to detergent manufacturers looking to sell one formula on a national level. Manufacturers of Dreft originally tested the product in hard water areas only, specifically the towns of Troy and Oxford, Ohio and Crawfordville, Indiana.²³ After these initial tests, they advertised the product nationally in both hard and soft water areas. In early advertisements for Dreft, Procter and Gamble emphasized its product's function in hard water. An advertisement from 1936 claimed that Dreft, "Completely banishes dingy, soapy, hard water scum—prevents premature dulling and graying of colors in dainty, expensive things." The company also emphasized that the product was not a water softener claiming it, "Makes 5 times greater suds than any soap in the HARDEST WATER. Not a water softener – a

²² On the big three see, Martin Stevens, "Detergent Problems: Growing Pains Cause Trouble but the Advance Goes On," *Barron's National Business and Financial Weekly*, October 1950, page 11.; On their chemical formulas see, Chester A Snell Consulting Chemist. Chemical analysis of *All*, July 26, 1950 Box 767 Folder 21; Chemical analysis of *Fab*, July 26, 1950 Box 767 Folder 21; Chemical analysis of *Surf*, July 26, 1950 Box 767 Folder 21; Chemical analysis of *Surf*, July 26, 1950, Box 767 Folder 21, Consumers' Research, Inc. Records. MC 3. Special Collections and University Archives, Rutgers University Libraries from here on cited as Consumers' Research, Inc, Rutgers University.

²³ "Dreft led the way," *Soap and Chemical Specialties*, Sept 1958. Vol. XXXIV No. 9. Page 47- 50, 121.

complete washing agent.”²⁴ Some advertisements for Tide included mention of hard water. One advertisement from 1949 claimed, “Tide Works Extra Miracles in Hard Water.” Yet most tended to leave out mention of hard water instead making broad claims about working better than soap.²⁵ An advertisement from 1950 claimed, “Tide does a better washing job than any soap on earth.” This decision was most likely strategic so as not to alienate potential customers in soft water districts and suggest the national usability of Tide. Large detergent manufacturers such as Procter and Gamble would have advertised nationally, rather than regionally. Advertisements reflected the desire not to be branded as a product for only use in hard water.

Detergent manufacturers praised their new products, touting that they had brought modernity into the American home. The fact that by 1953 synthetic sales eclipsed soap sales supported their claims.²⁶ Yet, as the next section will show, the shift from soaps to synthetics was bumpy and incomplete. Donald Price, an industry chemist writing about detergents in 1952, claimed “When the synthetics were applied in consumer products, they became a commercial success overnight.” He continued, “Also, since the synthetic detergents became a commercial success without our having to know too much about

²⁴ Advertisement, *The Bismarck Tribune* (Bismarck, North Dakota) August 28, 1936, page 6.

²⁵ Tide in hard water see, Advertisement: TIDE Ladies' Home Journal; Apr 1949; 66, 4; Women's Magazine Archive pg. 84; As working better than soap, Advertisement: TIDE! Ladies' Home Journal; Sep 1950; 67, 9; Women's Magazine Archive pg. 32

²⁶ J. Ralph Macon, Atlantic Refining Co., “Detergent Market Trends,” *Soap and Chemical Specialties*, March 1955. Vol. XXXL No. 3. Page 41- 44. For other statistics on synthetic sales see, Arthur C. Nielsen, Jr, A.C. Nielsen Co. “Household Detergent Sales,” *Soap and Chemical Specialties*, March 1958, Vol. XXXIV, 54-58, 223; “Soap and Syndet Sales Reach Record High,” *Soap and Chemical Specialties*, January 1958, Vol. XXXIV, 163.

them, the need for fundamental research did not seem urgent.”²⁷ A lack of fundamental research included overlooking the possible environmental impact of synthetic detergents and where they went after they swirled down the drainpipes of the American homes.

The Shaky Rise of Synthetics

A 1951 motivation research study about Trend detergent conducted by Ernest Dichter’s Institute for Motivational Research, Inc wrote this about women’s acceptance of synthetic detergents, “And, although she doesn’t know why the modern detergents are more effective than her old friend soap...she has come to accept the magic and unexplained quality of detergents which have made the impossible of yesterday possible today.”²⁸ The word magic and unexplained conjured up the idea that consumers blindly accepted new and modern products in the post war era. Writing about the invention of synthetics, the FMC Corporation who manufactured complex phosphates wrote, “When phosphate detergents were formulated and introduced to the American homemaker, their success was instantaneous and the emancipation of American women from the drudgery of

²⁷ Price, *Detergents*, 137, 140.

²⁸ *A Psychological Research Study of the Sales and Advertising Problems of Trend Detergent, 1956*, pg. 11. Box 19 folder 515C, Ernest Dichter Papers, Series I. Research Proposals and Reports (Accession 2407A), Hagley Museum and Library, Wilmington, DE 19807, from here on cited as Ernest Dichter Papers, Series I. On the work of Dichter see, Stefan Schwarzkopf and Rainer Gries, eds. *Ernest Dichter and Motivation Research: New Perspectives on the Making of Post-War Consumer Culture*, (New York: Palgrave Macmillan, 2010).

laundry tubs and wringer washers was underway.”²⁹ The words of both male psychologists involved in motivational research and detergent manufacturing interests portrayed the male technological triumph in the service of women. This narrative also assumed that the acceptance of new synthetics by consumers, more specifically female consumers, was somehow natural and foreordained. The truth was less straightforward. Why did consumers switch from not just soap to synthetics, but from soap plus softeners to synthetics? While the addition of softening to the discussion seems small, this emphasizes the role of hard water in decisions about what to use in the family washing machine. Ultimately consumer’s adoption of synthetics was slow and incomplete. Consumers switched to synthetic detergents because they made the difficult task of washday easier, worked better in automatic washing machines, and performed better in hard water areas. Launderer’s decisions to switch were not foreordained, nor rooted in the belief in a magic product. Instead the threshold of performance for synthetics really was higher and launderers took notice, after some hesitation.

When detergents first became widely available and reasonably priced, many consumers had reservations, specifically about using chemicals in the wash. Another study conducted in 1951 by the Institute for Motivational Research for Fab detergent found that fifty percent of all respondents thought synthetics were dangerous to use because they were harmful to fabrics. One respondent noted, “. . .one of them detergents.

²⁹ FMC Corporation, Pamphlet, “Phosphates The Environment and You,” Carton 2, Folder “Detergents,” Records of the National Industrial Pollution Control Council, Record group 40.7.7 National Archives, College Park, Maryland, from here on cited as NIPCC records.

They just got holes all over the shirts when she used it. They have some strong chemicals in them. And when these chemicals get into water, I think they might turn into some acid or something. It has an ‘eating’ effect.” Taking about Tide and Fab, another respondent said, “But I think they have a harsh ingredient. I think there is too much—a certain chemical they use for cleaning.”³⁰ Advertisers used that information to market Fab as something safe for both clothes and users.³¹ Many detergents ads from the late 1940s and early 1950s emphasized the gentle nature of their product on both hands and clothing. Women’s reaction to chemicals is related to historic anxiety linked to caustic chemicals in the wash, but was also representative of concern about new chemical products. Chemicals in the household were, of course, not new. Yet the post war period was a period of increased availability of new synthetic products such as herbicides, new food additives, and synthetic cleaning products.³² It is worth noting that consumers expressed little concern about what new synthetic detergents did to waste water. Instead, their primary focus remained on how these synthetics would react with the washing process.

Despite reservations about chemicals, consumers switched to synthetics for a combination of reasons. First, cultural attitudes held by women towards laundry, mainly

³⁰ *A Psychological Research Study on the Sales and Advertising Problems of Fab*, November, 1951, pg 24. Box 6, Folder 101.C, Ernest Dichter Papers, Series I.

³¹ On this see, Felso advertisement, *Ladies Home Journal*, February 1953, page 125; Proctor and Gamble marketed Tide as “tough on dirt—but easy on your hands,” see Tide ad, *Ladies Home Journal*, Oct 1951, Vol. 68, 10, pg. 5.

³² On chemicals used in the home in the early twentieth century see, Margaret Doff, *Chemistry of the Household* (Chicago: American School of Home Economics, 1907) 115-118. On new products in the post war era see, Ruth M. Leverton, “Nutritional Trends and the Consumer’s Food,” *Journal of Home Economics*, Vol. 56, No. 5, May 1964, 317- 320; Clara Leopold, “Products Designed for Modern Cleaning,” Extension Service, University of Nebraska College of Agriculture and Home Economics, 1965.

that it was still an unpleasant and arduous task, influenced the adoption of synthetics, yet some male commentators and advertisements portrayed the laundry as just the opposite. An examination of this fact revealed the incongruencies of prescribed norms and women's actual feelings towards the wash.³³ Male psychologist writing about female consumer's attitudes towards detergent in the 1950s concluded that they had a deep emotional attachment to the laundry. The executive summary of the Fab detergent study wrote: "To women, washing is more than just a chore or getting clothes clean. She feels intense emotional involvement. Her wash dramatizes her role as the guardian of her family's cleanliness."³⁴ Therefore, it concluded, women would choose the detergent that would reinforce this role. As a result, advertisements for synthetics contained bright colors and smiling women, no mentioned of the drudgery of wash day. A 1958 ad for Tide featured a woman in an empty bucolic field save for a line of clean white linen. She stares into a white shirt smiling blissfully.³⁵ Many advertisements emphasized children, linking the use of detergent to the home and family. One advertisement for Tide from 1957 featured a woman tousling a young girl's hair while another young girl looks on adoringly. The advertisement says, "Next to us... Mommy likes Tide-clean clothes."³⁶

³³ On the diversity of women's post war experiences beyond traditional roles see, Joanne Meyerowitz (ed.), *Not June Cleaver: Women and Gender in Postwar America, 1945-1960* (Philadelphia: Temple University Press, 1994); Susan M. Hartmann, *The Home Front and Beyond: American Women in the 1940s* (Boston: Twayne Publishers, 1982).

³⁴ *Executive Summary – Our Major Findings and Their Practical Implications for FAB*, 1959, pg. 9, Box 6 Folder 101B, Ernest Dichter Papers, Series I.

³⁵ Advertisement: New Tide clean! *Ladies Home Journal*; February 1958: 75, 2: Women's Magazine Archive, page 125.

³⁶ Advertisement: Tide-Clean, *Ladies' Home Journal*: April 1957, 74, 4: Women's Magazine Archive, page 185.

Both male psychologists and male advertising executives, celebrated women's traditional role in the home while assuming and reinforcing their place there through consumption.³⁷ This was prolific in the post war era and described by the historian Lizabeth Cohen as women's "dependency and retreat from the public sphere."³⁸ Television reflected this dominant construction of womanhood with figures such as June Cleaver and Harriet Nelson who exemplified the idealized post war mother and wife. Advertisers at Tide capitalized on this to sell their product. A 1956 advertisement for Tide detergent featuring Harriet Nelson, a paradigmatic post war mother and wife on the popular radio turned television program *Ozzie and Harriet*. In the advertisement, Harriet excitedly tells Ozzie about the Tide included in their automatic washing machine. She proclaims the detergent is just perfect for it, presumably not because it does not precipitate the ions of hard water, but because it keeps Ozzie's clothes looking clean.³⁹

Despite the purported emotional connection to the laundry, as well as images of women in ecstasy as they did the wash, women's magazines tended to portray laundry as it had been historically, an arduous and unpleasant task. They explained it as an obligation. Writing in *Good Housekeeping* in 1948, Ruth Bien of the Good Housekeeping Bureau noted, "Call it by whatever fancy name you like, getting rid of dirt is a chore—a

³⁷ On post war connection between consumption and the family see, Elaine Tyler May, *Homeward Bound: American Families in the Cold War Era* (New York: Basic Books, 1988); Lizabeth Cohen, *A Consumer's Republic: The Politics of Mass Consumption in Postwar America* (New York: Knopf, 2003);

³⁸ Cohen, *A Consumer's Republic*, 150.

³⁹ Advertisement: Tide-Clean, *Ladies' Home Journal*: April 1956; 73, 4: Women's Magazine Archive, page 108.

day-in and day-out chore, too.”⁴⁰ Talking about general cleaning in the home, including laundry, dishes, walls, and woodwork, Bien alluded to a common sentiment among women, cleaning was not an emotional undertaking, rather an obligation. In the same issue, writing specifically about laundry soaps, Helen Kendall said that not only was laundry common, but also complex. It required knowledge related to fabrics, soils and water, things that needed consideration even in the era of washing machines.⁴¹ Thus despite the conclusions of male psychological researchers, the consensus about laundry work was that it was unpleasant yet simultaneously complex. These two factors encouraged women to look to products that would make the wash more efficient and easier. Synthetics fit the bill.

The use of synthetics made the wash easier and more efficient especially combined with an automatic washing machine. As the previous chapter mentioned, new automatic washing machines performed poorly with traditional soap.⁴² The addition of a softeners such as Calgon fixed the problem for some, however, by the 1950s, this method was falling out of favor with launderers who preferred synthetics that had built in softeners. This is demonstrated by a letter sent to *Consumers' Research Bulletin*. In 1957, a Mrs. Bill Quinn sent the consumer group a letter in which she claimed to have made a

⁴⁰ Ruth Bien and Helen Kendall, “Soaps,” *Good Housekeeping*, November 1948, 146-147.

⁴¹ “Automatic Wash Needs Skill, Too,” *New York Times*, February 24, 1949; this sentiment is also clear in Clara Leopold, *Soaps and Other Detergents*, Extension Service, University of Nebraska College of Agriculture and Home Economics, 1955.

⁴² This was confirmed by a study conducted by the US Department of Commerce, Bureau of Domestic Commerce, “Economic Effects of Large Scale National Use of Alkaline Detergents,” July 15, 1971, Carton 6, Folder “FTC Hearings,” NIPCC records.

discovery so important that the American housewife needed to know.⁴³ She said she had been “cautioned by many” never to use soap in her new automatic machine. Hesitant to give up her regular laundry soap, Fels Naptha, Quinn experimented with Calgon. She wrote, “After much trial and error experimentation, I finally came up with a mixture that solved all my washing problems.” That mix included regular laundry soap, ammonia, and about three fourths cups of Calgon. This recipe resulted in “sweet smelling, beautifully washed clothes from the machine.” A month later a representative of the publication responded to Mrs. Quinn thanking her for her letter, but noting that in recent years women have not shown interest in making their own laundry soap mixtures at home. The author wrote, “It seems that every one (sic) is so busy that consumers as a whole are willing to settle for using commercial products as they come, to avoid little extra time or trouble.” The exchange revealed the connection between the detrimental use of traditional soap in the machine and the proliferation of new synthetics. Since soap was ill advised in the machine, many women switched to synthetics finding them easier and less time consuming. Synthetics skipped the step of adding additional chemicals such as Calgon since they had built in water softeners. Underlying the exchange was a growing reluctance to use traditional soap in automatic machines.

Manufacturers frequently reminded potential consumers of this fact. A 1951 edition of *Consumers' Research Bulletin* noted in their annual write-up of household appliances that, automatic washing machine manufacturers recommended synthetics to

⁴³ Letter from Mrs. Bill Quinn to the editors of *Consumers' Research Bulletin* January 26, 1957, Box 767, Folder 7, Consumers' Research, Inc, Rutgers University. Letter from Frank Hinek to Mrs. Quinn, February 8, 1957, Box 767, Folder 7, Consumers' Research, Inc, Rutgers University.

avoid an insoluble curd on clothes.⁴⁴ It should be noted, however, that hard water was not a save all for washing machines. The bulletin also mentioned that soft water could cause corrosion and damage to some of the metal surfaces of the washing machine. Despite this reality, representatives of automatic washing machines clung steadfast to using synthetic in machines. Like Calgon, many washing machine manufactures cooperated with synthetic detergent makers. Throughout the 1950s, a box of Tide came in Maytag and RCA automatic washing machines. Proctor and Gamble boasted twenty-five other automatic washer manufactures recommended Tide too.⁴⁵ Apex, Bendix, Frigidaire, General Electric, Hotpoint, Norge Westinghouse, Whirlpool and even Maytag recommended the use of All detergent their automatic machines according to an All advertisement from 1953.⁴⁶ These partnerships provided a way for the public to become familiar with new synthetics. Yet these strategies also had to do with acquainting the public with the proper product to standardize the water quality used in machines. Detergent manufactures controlled the variation of water used in American washing machines. Their product, specifically with its built-in softener, abstracted water from its

⁴⁴ “Consumer’s Research Annual Cumulative Bulletin,” Household Appliances, September 1951, *Consumers’ Research Bulletin*, pg 40, Box 767, Folder 7, Consumer’s Research Archive, Rutgers University.

⁴⁵ For Maytag see, Advertisement: TIDE Ladies' Home Journal; Jul 1955; 72, 7; pg. 29; Advertisement: TIDE Ladies' Home Journal; Jun 1954; 71, 6; pg. 5; Advertisement: TIDE-CLEAN Ladies' Home Journal; Jan 1956; 73, 1; pg. 5; Advertisement: TIDE-CLEAN Ladies' Home Journal; Mar 1956; 73, 3; pg. 34 Advertisement: Tide! Ladies' Home Journal; Aug 1956; 73, 8; pg. 122; For RCA see, Advertisement: TIDE-CLEAN Ladies' Home Journal; May 1956; 73, 5; pg. 176; Advertisement: TIDE-CLEAN Ladies' Home Journal; Nov 1956; 73, 11; pg. 5. All advertisements retrieved from the Women's Magazine Archive.

⁴⁶ Advertisement: all Better Homes and Gardens; Mar 1953; 31, 3; Women's Magazine Archive pg. 16.

geological variation, while simultaneously abstracting users from the actual process of water softening. Companies transferred the addition of water softening chemicals, necessary for the wash, into their complex and built products. New labor saving technologies required not only modern cleaning products, but also modern water.

Due to their built nature, synthetics worked well in both hard and soft water without requiring the extra step of adding a softener. This reason made them more appealing and swayed consumers towards synthetics. Respondent in the FAB study confirmed this claim, “It works well in hard water.” When asked if she had to use hard water, the respondent replied, “No. I used FAB in Ohio which has very hard water, and here, too. It dissolves real fast, and there is no residue...and there’s nothing left on the side of the machine.”⁴⁷ Without outright recommending soap over a synthetic, an extension bulletin written by Clara Leopold in 1955 noted the shortcomings of soap. Leopold noted that soaps require soft or softened water, cause film or scum in hard water, are hard to rinse with hard water, and can be used only after the users softens both wash and rinse water.⁴⁸ Synthetic detergents on the other hand, could be used in hard or soft water, created no hard water scum, did not need to be used with a water softener, and hard water required less synthetic detergent than soap. The adoption of synthetics over soap worked without having to take the extra steps to softening hard water. Another extension bulletin wrote, “The phosphate built compounds are just as effective as soap in

⁴⁷ *A Motivational Research Study on New Opportunities for New FAB in the Detergent Market*, July 1959, page 144, Box 6, Folder 101.1C, Ernest Dichter Papers, Series I.,

⁴⁸ Clara Leopold, “EC55-1109 Soaps and Other Detergents” (1955) *Historical Materials from University of Nebraska-Lincoln Extension*. 3265, pg. 4.

soft or softened water and are twice as effective as soap in hard water.”⁴⁹ The regularly with which content created for consumers discussed how well synthetics worked with different types of water revealed the centrality of water, and more specifically its natural ecological variation, was to decisions about which products to use.

The Environmental Cost of Water Softening

The addition of water softening chemicals, specifically pyrophosphates, to synthetic laundry detergent had an unintended environmental consequence. A failure to account for what happened to water containing high levels of these chemicals in waste water meant municipal sewers flushed millions of pounds of phosphates into natural water courses. A study conducted in 1972 found that in 1940, on average, raw effluent contained three milligrams per liter of phosphorus. By 1970s, that number increased to eleven milligrams per liter.⁵⁰ Once in water, phosphate, a natural nutrient, caused an excess of growth of phytoplankton and algae. The excess in plant life heavily disrupted the normal ecosystem of a water course and causes unaesthetic qualities. An examination of this conflict using a gendered analysis revealed the ways in which men and women constructed narratives about environmentalism. The public and detergent manufacturers tended to both implicitly and explicitly blame women for the problem, even though agricultural and industrial run off contributed to the eutrophication problem as well. Women used their

⁴⁹ Miller, Mary May, "EC261 Soap and other Detergents" (1950). *Historical Materials from University of Nebraska-Lincoln Extension*. 2165, pg. 4.

⁵⁰ Litke, "Review of Phosphorus Control Measures in the United States," 8. For the study referenced see, L.J. Hetling and I.G. Carcich, Phosphorus in Waste-Water: Environmental Quality Research and Development Unit, New York State Department of Environmental Conservation Technical Paper 22.

status as consumers to shape the detergent industry. They showed their disapproval for polluting detergents by turning to ecology and smaller brand detergents.⁵¹ In the controversy, consumers were forced to reckon with the reality that their decisions affected far away ecologies. Ultimately, the phosphate controversy beckoned a new element of the hydrosocial cycle. One in which consumers connected the relationship between the water they used in a washing machine and the far away environments.

This was not the first-time synthetic laundry detergents had been involved in an environmental scandal. Beginning as early as the 1950s, many professionals in the sewage disposal field noted an excess of foam in treatment plants. In 1953, the American Water Works Association formed a task group to explore the effects synthetic detergents had on water supplies and water treatment plants. The task force found, “The syndet effect most often has been excessive frothing on aeration tanks.”⁵² The task force noted frothing had become a problem since the proliferation of household synthetic detergents, although it claimed the connection between the two was tenuous. The connecting between frothing in sewage treatment and synthetic became clear when in the early 1960s research project carried out at MIT, Berkeley and the University of Wisconsin all claimed

⁵¹ On the relationship between environmentalism and consumption see, Thomas Jandt, *Greening the Red, White and Blue: The Bomb, Big Business, and Consumer Resistance in Postwar America* (New York: Oxford University Press, 2014).

⁵² Task Group Report, “Characteristics and Effects of Synthetic Detergents,” *Journal (American Water Works Association)*, Vol. 46, No. 8 (August 1954), pp. 770. See also, Clair Sawyer, “Sewage Works, Effects of Synthetic Detergents on Sewage Treatment Processes,” *Sewage and Industrial Wastes*, Vol. 30, No. 6 (Jun., 1958), pp 747-775; Jesse M. Cohen, “Syndets in Water Supplies,” *Soap and Chemical Specialties*, September 1959, Vol. XXXV, 53-56, 119.

conclusively that synthetics, specifically ABS, caused problems in sewage treatment.⁵³ These studies also found that around 40% of ABS entered into water untreated causing foaming of surface waters. Synthetic surfactants such as ABS could also find their way into groundwater and became a large problem on the shallow ground waters specifically on Long Island. The incident largely remained out of the public eye because it mostly affected sewage treatment plants. Pressured by Congress, the detergent industry eventually replaced ABS with another surfactant, linear alkyl sulfonate, a biodegradable surfactant.

For the most part, detergent manufacturers contained the ABS controversy to within the sewage treatment plant. The pollution caused by pyrophosphates, on the other hand, entered into the public consciousness because of its effects on well-known places such as Lake Erie. In 1965 the Canadian magazine *Maclean's* published an article with the title "Death of a Great Lake" about eutrophication in Lake Erie. In the same year, *Newsweek* declared the Great Lakes the dead sea. The *New York Times* also publicized the issue, running stories with the titles "The Eutrophication Menace," and "Warning the Green Slime is Here" in 1969 and 1970.⁵⁴ Writing about detergents in *Science*, Philip Abelson noted "In a few months the mass media have succeeded in transforming the image of these products from essential cleaning materials into prime agents in the

⁵³ McGucken, *Biodegradable*, 42.

⁵⁴ Alan Edmonds, "Death of a Great Lake," *MacClean's*, November 1, 1965; Sherwood Davidson Kohn, "Warning: The Green Slime is Here," *New York Times* March 22, 1970, page 232; "The Eutrophication Menace," *New York Times* Dec 16, 1969, page 46.

pollution of natural waters.”⁵⁵ By the late 1960s, the media thrust eutrophication into the national lexicon.

The controversy came to light in a time of changing environmental consciousness in American society. Post war prosperity and the population boom had the dual effect of creating a higher standard of living, in which people demanded environmental amenities such as access to clean air and clean water, while also reducing open spaces and creating products and technologies that threatened these amenities.⁵⁶ Part of the new environmental ethos was also a more fluid and interconnected relationship between humans and the environment, thanks in part to the proliferation of the science of ecology

⁵⁵ Philip Abelson, “Excessive Emotion about Detergents,” *Science*, September 11, 1970, Vol. 169, No. 3950,

⁵⁶ On the environment as an amenity see, Samuel Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985* (New York, NY: Cambridge University Press, 1987); Andrew Hurley, *Environmental Inequalities: Class, Race, and Industrial Pollution in Gary, Indiana* (Chapel Hill, NC: The University of North Carolina Press, 1995), see especially chapter three, “Opposition to Blind Progress: Middle-Class Environmentalism, 46- 76. On anxiety about new postwar products and technologies see, Thomas Dunlap, *DDT: Scientists, Citizens, and Public Policy* (Princeton, NJ: Princeton University Press, 1980); Thomas Robertson, *The Malthusian Moment: Global Population Growth and the Birth of American Environmentalism* (New Brunswick, NJ: Rutgers University Press, 2012); Adam Rome, *Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism* (Cambridge: Cambridge University Press, 2001); Mart, *Pesticides A Love Story*; On disappearing open space see, James Morton Turner, *The Promise of Wilderness: American Environmental Politics since 1964* (Seattle: University of Washington Press, 2012).

in the 1950s.⁵⁷ The detergent controversy exemplified a consumer product that interfered with access to clean water.

Historians agree on the general outline of the eutrophication controversy. By 1965 there had been various state, federal, and international studies that concluded cultural eutrophication was the result of excess nutrients entering into lakes from municipal sewage effluent, particularly phosphorus from synthetic laundry detergents, connecting human action to environment degradation.⁵⁸ In 1970, one study conducted by an the American and Canadian International Joint Commission (IJC) noted that of 35.7 million pounds of phosphorus that entered into Lake Erie in 1967, 25 million pounds originated in detergents. The report found that industrial sources and land drainage, specifically phosphates in fertilizer and manure, also accounted for the number of phosphorus in the

⁵⁷ On the interconnected relationship between humans and the environment see, See Nancy Langston, “Gender Transformed: Endocrine Disruptors in the Environment,” in Virginia Scharff, ed., *Seeing Nature through Gender*, 129-166; Rachel Carson, *Silent Spring* (Cambridge, MA: Houghton Mifflin Company, Riverside Press, 1962); Linda Nash, *Inescapable Ecologies: A History of Environment, Disease, and Knowledge* (Berkeley: University of California Press, 2006) see especially chapter four “Modern Landscapes and Ecological Bodies” and chapter five “Contesting the Space of Disease; Christopher Sellers, *Crabgrass Crucible: Suburban Nature and the Rise of Environmentalism* (Chapel Hill: University of North Carolina Press, 2012); on ecology and environmentalism see, Donald Worster, “The Ecology of Order and Chaos,” in *The Wealth of Nature: Environmental History and the Ecological Imagination* (New York: Oxford University Press, 1993) 156-170; Thomas Dunlap, *Saving America’s Wildlife: How Science Changed Our Minds* (Princeton, NJ: Princeton University Press, 1988); Matt Cartmill, “The Bambi Syndrome,” in Cartmill ed., *A View of Death in the Morning: Hunting and Nature through History* (Cambridge, MA: Harvard University Press, 1993).

⁵⁸ Edmondson, *The Uses of Ecology*, 91.

lake, but at a much lower rate, 1.8 percent and 9.6 percent respectively.⁵⁹ Since these sources were relatively small compared to detergents, as well as difficult to regulate especially agricultural runoff, people focused on laundry detergents.

Throughout the next ten years, grassroots activists, the detergent industry, both the United States and Canadian federal governments, and the scientific community fought over what to do about the problem. Some groups favored the removal of phosphates from consumer products, while others, including the detergent industry, championed enhanced sewage treatment methods.⁶⁰ Discussions about the role of phosphates in lake pollution preoccupied these parties for the next decade. In 1969 and again in 1970 members of the House of Representatives introduced amendments to the Federal Water Pollution Control Act that would ban the use of phosphates in detergent. These failed to make it out of committee and ultimately the detergent industry blocked any mention of phosphate detergent in the 1972 Clean Water Act. Despite these setbacks, a number of municipalities and states enacted legislation banning phosphates.⁶¹ It worth noting local

⁵⁹ McGucken, *Lake Erie Rehabilitated*, 99. A study conducted by the United States Public Health Service also indicated detergents as the major cause of phosphates in Lake Erie. See, Beatrice Hort Holmes, *History of Federal water resources programs and policies, 1961-1970* (Washington, DC: United States. Dept. of Agriculture. Economics, Statistics, and Cooperatives Service) 70.

⁶⁰ McGucken, *Lake Erie Rehabilitated*, 21; Edmondson, *The Uses of Ecology*, 91.

⁶¹ McGucken, *Lake Erie Rehabilitated*, 141. On state and local bans see, Alex Cohen and David Keiser, "The Effectiveness of Incomplete and Overlapping Pollution Regulation: Evidence from Bans on Phosphate in Automatic Dishwasher Detergent," *Journal of Public Economics*, Vol. 150, June 2017, 53-74. See also, David Litke, "Review of Phosphorus Control Measures in the United States and Their Effects on Water Quality," United States Geological Survey Water-Resources Investigations Report 99-4007. For a table with state bans see page 6.

and state governments that banned or set standards for phosphates in detergents did not do so for dishwashing detergent nor softeners such as Calgon.

While industry and government battled a ban on phosphates, popular responses framed the problem as a choice between clean clothes or a clean environment, providing an ultimatum between the environment or a central tenant of work in the home. Caroline Merchant argued that throughout history women had been making the care of the earth their priority.⁶² Rachel Carson embodied this ethic that grew and spilled out into the public arena during the environmental movement. Yet observers of the detergent controversy also blamed women for the pollution their synthetic laundry detergents produced. In 1971 American satirist Art Buchwald wrote about the controversy in an article that appeared in newspapers across the country. He quipped that, “The housewife has to make a choice between clothes that are whiter than white or water that is cleaner than clean.”⁶³ In another article ran with the headline “White Shirt Ordeal Spawned Pollution,” Buchwald claimed water pollution began in 1931 when two women competed to get their husbands’ shirts cleaner. They use the newest products, Dynamite and Zap in place of traditional soap. Dynamite and Zap accompanies the waste water into the nearby river, first killing fish and eventually causing the river to become a health hazard. One day, one of the women’s husbands, Mr. Holbrook, fell into the polluted river. He swallowed one gulp of water and died immediately. At the funeral the minister said,

⁶² Carolyn Merchant, *Earthcare: Women and the Environment* (New York: Routledge, 1995).

⁶³ The story was originally published by the LA Times. For just a few other publications see, Art Buchwald, “What’s Laundry Soap? Phosphate Dilemma Solved,” *The Decatur Herald* (Decatur, Illinois) November 18, 1971 page 6; “Anybody Remember Laundry Soap,” *The Sheboygan Press* (Sheboygan, WI) November 18, 1971, page 37.

“You can say anything you want about Holbrook, but no one can deny he had the cleanest shirts in town.”⁶⁴ In another article from 1972, the author Robert Rodale joked there was another option other than destroying the environment and not having clean clothes: soap and water. “Your parents used it,” the author said, “and somehow they all managed to find it adequate for cleaning clothes.”⁶⁵

The articles purposefully take a sarcastic tone; however, they reveal underlying assumptions about the nature of the controversy. Framing the problem in this manner placed the blame directly on the shoulders of women. Seen in this way, the rhetoric denigrates the work that women do in the home. The sarcastic tone of both pieces assumes the ridiculousness of the whole controversy. Of course, women should choose another option besides destroying the environment. Yet this is indicative of larger currents in American language and rhetoric that tended to place women’s work in the home below that of market or men’s work. The author who casually suggested women go back to soap and water is clearly ignorant of the complex switch from synthetic laundry detergents. And the fact that he makes no mention of returning to soap *plus* a softener, suggests he lacked the knowledge of how to properly launder clothing in the first place.

The rhetoric surrounding the detergent controversy displayed a feminized version of a discourse in the environmental movement described by Richard White in his article,

⁶⁴ Art Buchwald, “White Shirt Ordeal Spawned Pollution” *The Montana Standard* (Butte, Montana) March 1, 1970;

⁶⁵ Robert Rodale, “Soap Can Help Clean Up Pollution,” *Tampa Bay Times* (St. Petersburg, Florida) January 9, 1972, page 85.

“Are you an environmentalist, or do you work for a living?”⁶⁶ White contemplated why environmentalism seemed opposed to productive work. He argued that environmentalists equated work with the destruction of nature, focusing on logging, mining, and farming. What White failed to see was that, in the case of detergent, people have also been willing to equate productive work in the home with the destruction of nature. They seemed to ask, are you an environmentalist, or do you have a clean house? Doing so assigned blame not just to loggers or miners for environmental degradation, but to female launderers as well.

The detergent industry and allied industries opposed a ban of phosphate based on how female consumers would react. A 1971 report published by the National Industrial Pollution Control Council (NIPCC), a representative for industries in environmental matters, revealed underlying assumptions about the female detergent user.⁶⁷ The detergent sub-committee organized important representatives of the industry -- the chairman was Howard J. Morgens, then President of Procter & Gamble while the vice chairman was Milton Mumford, the chairman of Lever Brothers.⁶⁸ The report noted that the industry could not remove phosphates without a proper substitute because it would

⁶⁶ Richard White, "Are You an Environmentalist or Do You Work for a Living: Work and Nature," in *Uncommon Ground: Rethinking the Human Place in Nature*, ed. William Cronon (New York: W. W. Norton, 1995), 171–185.

⁶⁷ On the NIPCC and the coal industry see, Richard Vietor, *Environmental Politics and the Coal Coalition* (College Station: Texas A & M University Press, 1980) 35- 48; for a critical examination of the NIPCC see, William H. Rodgers, Jr, “The National Industrial Pollution Control Council: Advise or Collude?” 13 *B.C. Indus. & Com. L. Rev.* 719 (1972).

⁶⁸ Letter, William J Clark to Maurice Stans, June 9, 1971, Carton 1, Folder “Detergents,” NIPCC records.

“seriously degrade the performance which housewives have come to expect from such products.”⁶⁹ Perhaps most important of these expectations was the understanding that detergents would work well in hard or soft water. The report also noted that women did the laundry under a variety of conditions depending on differences in water hardness, degree and type of soil on clothing, and differences in equipment. These factors forced women to use detergents based on their own standards, rather than exact direction on the box. Thus, if the phosphate contents were to be reduced, the sub-committee concluded that, “most women would simply increase the amount of detergent they use; the result would be approximately the same amount of phosphate into sewage, but at a higher cost to housewives.”⁷⁰ Like other male commentators, the detergent industry defined detergent users as female, prescribing women’s role in the home within the context of an ecological debate. The industry made underlying assumptions about whose fault eutrophication was while simultaneously assigning blame for future pollution even if the detergent formula were to be changed.

While the detergent industry used gendered rhetoric, in conjunction with a weaponization of science and government task forces, to evade a ban on phosphates, female consumers showed a widespread interest in how their laundry detergent affected the natural world. *Good Housekeeping* ran a report after having received a flood of

⁶⁹ National Industrial Pollution Control Council Detergent Sub-Committee, *Detergents a Status Report*, March 1971 (U.S. Government Printing Office, Washington, D.C.)

⁷⁰ This sentiment appears in a pamphlet created by Lever Brothers Company entitled “Detergents and the Environment,” 1970. Carton two, Folder “Detergents,” NIPCC Records.

inquiries from concerned consumers asking *What are the facts? How serious is the problem? What can be done?*⁷¹ Extension service bulletins also dealt with the issue. Most of these publications outlined the positive and negative facts about phosphates. The Michigan Extension Service offered a grim outlook about substituting synthetics for soap.⁷² The bulletin wrote that soap should only be used in soft water and unfortunately water softeners such as Calgon should not be used because of their phosphate count. Older softening techniques such as washing soda should also be avoided because automatic washers spun precipitated curd deep into fabrics. The bulletin concluded with recommendations. First, consumers should support more complete sewage treatment, although it was unclear exactly how, while simultaneously reducing the amount of phosphate detergent used in the home. Achieving the use of less phosphate would require some individual changes in the home. The bulletin wrote, “Relax standards a bit. Must (author emphasis) clothes be “whiter than white?”” The bulletin ended on an individualized note, “Recognize the fact that people pollute and that people must do something about it.”

Many publications that discussed the phosphate controversy stressed individual consumer action. The responsibility of individuals was a dominant discourse during the environmental movement. For instance, anti-litter campaigns such as ‘Keep America Beautiful’ criticized individual litterbugs for excess trash in public spaces. It placed the

⁷¹ “The Institute Report on the Detergent Dilemma,” *Good Housekeeping*, January 1971, pages 74-75.

⁷² Cooperative Extension Service, Michigan State University, “The Detergent Puzzle,” Extension Bulletin E-726, November, 1971.

onus of responsibility on individuals to keep the world clean, in this case at the behest of can and bottle producers.⁷³ Writing in the *Home Economics Magazine* in 1970, Patty Chapin warned against blaming external forces for the environmental crisis. She wrote, “The prevalent policy of blaming political scapegoats like phosphate detergents or utility companies for the environmental mess rarely yields constructive change. In fact, it is precisely this narrow focus that got us into the environmental dilemma in the first place.”⁷⁴ In the same magazine, Henriette Flack also put the individual in environmental solutions, “Every person is involved in environmental decision making.”⁷⁵ It is probable that many authors for the magazine worked or had worked closely with industries as home economists.⁷⁶ Individual solutions to the problem took pressure off industries, but also encouraged people to tackle the problem themselves. Many launderers did so using their power as consumers.

Sensing the growing anti-phosphate sentiment, small manufacturers began to produce no phosphate detergents. By the fall of 1970, the department store Sears offered a no phosphate detergent. Around the same period, the North American Chemical

⁷³ Robert Friedel, “American Bottles: The Road to no Return,” *Environmental History* 19 (July 2014): 505-527.

⁷⁴ Patty Chapin, “Where do we go from here,” *Home Economics Magazine*, November 1970, F-29 & F44.

⁷⁵ Henrietta Fleck, “Facing the Environmental Crisis,” *Home Economics Magazine*, December 1970, page F9 & F28

⁷⁶ See for example Mary E. Purchase, an Associate Professor at the New York State College of Human Ecology who defended the detergent industry in a pamphlet, “Water Pollution – Detergents and Domestic Wastes,” Carton 2, Folder “Detergents,” NIPCC Records.

Corporation introduced a new no phosphate detergent it cleverly called Ecolo-G.⁷⁷ Ecology detergents, as the media dubbed them, promised that consumer could have both clean clothes and clean water. A newspaper ad for Ecolo-G from 1970 claimed, “Tomorrow you can wash your clothes without polluting a river.”⁷⁸ Another Ecolo-G ad featured the Kienast family, who briefly gained fame for having the first surviving quintuplets using fertility drugs (Figure 4.). In the ad the matriarch, Peggy Jo, smiles at her children and husband with the quote, “I care about my family’s world and I care about my family’s wash.” The Ecolo-G ads aimed to reconcile productive work in the home and the environment by offering an alternative to phosphate detergent.

A study commissioned by Proctor and Gamble from 1971 illuminated the ambivalent feeling some female consumers had about phosphate and ecology detergent.⁷⁹ The study, conducted by Ernest Dichter’s Institute interviewed sixty-nine women, all of whom described their occupation as housewife, about their feelings on laundry detergent. It should be noted that the research study does not identify where the respondents lived.⁸⁰ The study focused on how these women responded to pollution caused by synthetic detergents. The report found that changes in the 1960s including the consumer movement and environmental movement had created a new kind of consumer. The report wrote,

⁷⁷ McGucken, *Lake Erie Rehabilitated*, 138.

⁷⁸ Display ad 138, *The Washington Post, Times Herald*, October 8, 1970, pg C 18.

⁷⁹ *What Information do Consumers Want about the Cleaning Products They Buy?* Box 107, folder 2466C, Ernest Dichter Papers, Series I.

⁸⁰ *Ibid*, 3. In the description of the method, the report noted consumers were interviewed in Croton-on-Hudson, New York; Chicago, Illinois; and Dallas, Texas, but gives no indication as to whether they lived in those three locations or not.

“Not only does today’s modern consumer expect the detergent manufacturer to produce a good efficient product which will satisfy her laundry performance needs but also her needs as a responsible individual and concerned citizen.”⁸¹ Many interviewees cited Lake Erie as the catalyst for thinking about the detergent they used as well as noting the desire to “do something” about the pollution problem like try an ecology detergent. Yet, when asked to assign a personality to a hypothetical woman who purchased ecology detergent, respondents answered she is “...perceived as a knowledgeable consumer, one who is aware of the facts and exhibits concerns about her family’s welfare. To achieve this however, she must sacrifice her desire for convenience and personal satisfaction which she is not really willing to do.”⁸² On the other hand, a woman who chooses phosphate detergent, “...is viewed as a modern independent housewife who is interested in convenience, cost, and personal satisfaction but who is doubtful that she is doing the right thing.” The research study went a step further and asked the respondents to identify themselves with either the regular or ecological detergent. Twenty identified with the ecological brand while twenty-seven identified with the regular brand. Ten said they did not know, while two chose soap flakes.⁸³ Although a small sample, this can be read as an indication of trends or patterns in detergent as pollution became an issue. The movement of many respondents towards the ecology detergent showed in practice how some people responded to the growing environmental sentiment of the time period albeit feeling as though they gave something up. At the same time, those who were willing to continue to

⁸¹ Ibid, 10.

⁸² Ibid, 27.

⁸³ Ibid, 19.

use phosphate detergent admitted to feeling as though she was making the wrong decision to maintain a high standard in domestic work. The report indicated that most respondents wanted something that could continue to efficiently do productive work in the home, but that was also safe for the environment. The study made clear that soap was not the answer.

Trends in the detergent market indicated that ecology detergent was beginning to find favor, see Figure 4. However, they suffered a setback in 1971. The essential problem of the phosphate controversy was how to find a suitable substitute to act as a water softener in laundry detergent. The problems with ecology detergents as well as the substitute championed by the big three, nitrilotriacetic acid (NTA), prove it was not an easy fix. Ecology detergent producers substituted phosphates for precipitating materials such as carbonates and silicates. Like softeners of old, these chemicals reacted with the calcium and magnesium ions of hard water forming an insoluble precipitate. Like lye or soda ash, these chemicals were also highly alkaline and caustic.⁸⁴ In March of 1971, the Food and Drug Administration tested Ecolog-G and another nonphosphate detergent, Bohack's Nophosphates, for toxicity. It found the detergents to be, "toxic, corrosive to intact skins and produce, on contact, a severe eye irritation...They create an actual burn"⁸⁵ Under the Federal Hazardous Substances Act, the FDA required these and other nonphosphate detergents that used precipitates to include hazardous warning labels.

⁸⁴ Allen L. Hammond, "Phosphate Replacements: Problems with the Washday Miracle," *Science*, Vol. 172, No. 3981 (Apr. 23, 1971), pp. 361-363

⁸⁵ Jonathan Fuerbringer, "Pollution-free doesn't always mean safe," *Boston Globe*, March 23, 1971, pg. 17.



Figure 4. The Detergent Dilemma, November 17, 1971. Source: Temple University Libraries, Special Collections Research Center.

Ecology detergents faced even more bad press when in August of 1971 a fifteen-month-old child died from ingesting nonphosphate detergent. The caustic material entered her windpipe, burning it and causing suffocation after six days.⁸⁶ By 1972, the Federal Trade Commission forced Ecolo-G to remove the claim that its product “stop pollution,” since no government agency had verified this claim.⁸⁷

The big three detergent manufactures did not employ precipitating softeners because they worried about safety as well as performance. Instead, the industry began investing in the production of NTA, another substance that would sequester the hardness in water much like phosphates called a chelating agent. The industry had experimented with chelating agents, but the success of complex phosphates retarded their implementation in detergent formulas.⁸⁸ In replacing phosphates with NTA, the industry was optimistic they could eventually fully remove phosphates. Yet government agencies such as the Federal Water Pollution Control Administration expressed concerns about the effect of dumping billions of pounds of NTA into wastewater would have on the environment. In the spring of 1970, the National Institute of Environmental Health Sciences suspected NTA of causing birth defects and possibly cancer.⁸⁹ In December of

⁸⁶ McGucken, *Lake Erie Rehabilitated*, 162.

⁸⁷ “Ecolo-G Detergent Firm Agrees to PTC Banning Misleading Advertising,” *Wall Street Journal*, February 24, 1972, pg. 36.

⁸⁸ A.K. Prince and W.R. Merriman, Technical Service and Development Dow Chemical Company, “Is soap outdated?” *Soap and Chemical Specialties*, July 1958, Vol. XXXIV, 39-42, 87.

⁸⁹ Edmondson, *The Uses of Ecology*, 93- 94; see also, Neil Chernoff, *Material and Fetal Effects of NTA, NTA and Cadmium, NTA and Mercury, NTA and Nutritional Imbalance in Mine and Rats*, December 1, 1970. National Institute of Environmental Health Sciences Research Triangle Park, North Carolina. Not for publication. Carton 1, Folder “Detergents,” NIPCC Records.

1970, the detergent industry agreed to remove NTA from any formulas until further data on NTA could be compiled. A representative of Proctor and Gambled noted the company lost over seven million dollars in binding contracts to produce NTA.⁹⁰ The potential danger of NTA left larger detergent manufacturers without a suitable substitute for phosphates.

In the United States, the biggest change in the detergent market came not from obligation to the government, but rather from the market. Large detergent manufacturers faced growing competition from ecology brand detergents, despite their shortcomings. No phosphate detergents captured about ten percent of the detergent market forcing the large brands to reassess their strategies.⁹¹ Between 1971 and 1972, Lever Brothers, Colgate-Palmolive, and Tide voluntarily reduced the phosphate count in their detergents significantly.⁹² Previously formulas had contained as much as 30 to 35 percent phosphate. New low phosphate formulas contained as little as 8 percent. Without a sufficient substitute, the perceived cleanliness of clothes suffered. The reduction of phosphates in detergents helped some lakes, but cultural eutrophication continued to be a problem throughout the next fifty years. The reduction of phosphate was not a cure all. They were, however, an easy target in a sector of labor most Americans could sacrifice performance and simplicity, the home.

⁹⁰ McGucken, *Lake Erie Rehabilitated*, 172.

⁹¹ Gosselin, "The Detergent Controversy," 201.

⁹² "Industry's Voluntary Actions to Reduce the Use of Phosphates in Detergents," *NIPCC Interim Report on Pollution*, 1971, Carton 1, Folder "Detergents," NIPCC records.

Conclusion

In the story of eutrophication, with its varying interest groups and complicated link to federal and state environmental policy, it is easy to forget that the fundamental problem lay in the ability to soften water. What happens when the long history of water softening is told in connection with the eutrophication controversy? What happens when we see the long history of water softening in the eutrophication controversy? First it makes clear the time, capital, effort, and energy that has gone into tempering unruly water throughout history. It helps us see that polyphosphates are a point on a continuum in which people have been controlling and manipulating water in the home throughout history. Second, the separation of the eutrophication controversy and the history of water softening is indicative of historian's tendency to ignore the nature that is within the walls of the home. In seeing the eutrophication controversy as part of the story of water softening, it is clear that one of the major events of the American environmental movement was not only about protecting water in one place, but also about standardizing it in another, in the home. More than irony, the failure to see this standardization of nature in one place is an indication of a society that is far removed from the function of the products they use, and from the ways in which they manipulate and control non-human nature every day. The history of water softening is a reminder that nature should be seen within the four walls of the home and as such any change to its intricate ecological interconnections should be thoughtfully and fully considered.

EPILOGUE

WATER CONTROL AS A PATH TO PROFIT

Ironically, as phosphates began to pollute lakes, representatives at Calgon Inc., purveyor of complex phosphates, were well into a process of rebranding the company as an expert in pollution control. Other companies who marketed chemicals and technologies to abate hard water such as the Dearborn Chemical Company and Betz Laboratories also expanded into the pollution control field. Congress made federal funds available for waste water treatment in the 1956 Federal Water Pollution Control Act, the 1966 Clean Water Restoration Act, and again in 1972 with the passage of the Clean Water Act. These acts, as well as the 1965 Water Quality Act, also set waste water standards for industries.¹ Encouraged by increasing federal funds, throughout the late 1950s and 1960s, companies historically involved in water softening leveraged their experience with water control to jockey for a piece of federal largess. Specifically, they offered chemicals and technologies that removed pollutants from water in waste water treatment settings. People involved in these companies saw water quality as they always had, a path to profit. As society and the federal government increasingly placed value on clean water, whether for aesthetic or developmental purposes, private companies engendered to take advantage of that, just as they had taken advantage of the value of soft water.

One of the largest forays into pollution control came from a company directly involved in polluting, especially eutrophication, Calgon. Since Hall Laboratories began

¹ For a history of the passage of these federal acts see, Paul Milazzo, *Unlikely Environmentalists: Congress and Clean Water, 1945-1972* (Lawrence: University of Kansas, 2006).

the commercial production of sodium metaphosphate in the 1930s, the company expanded their repertoire to offer a variety of water treatment chemicals for industries, as well as more household products.² Having an in-house laboratory, Hall Laboratories, allowed for the expansion of products. For example, beginning in the late 1940s, the company marketed Micromet, an amalgamation of different phosphates, to treat corrosion in commercial water systems.³ Movement into other areas of water treatment beyond softening was a trend for many companies beginning in the 1920s. For example, Betz Laboratories and Dearborn Chemical Works, notable pioneers in scientific water correction for boilers, expanded both their services and products. Betz continued to market products for the control of scale, and offered chemicals for the control of corrosion in industrial equipment from steam pipes to air conditioning equipment.⁴ The Dearborn Chemical Company became a leader in the prevention of rust. Like Calgon, these companies built off their experience with water treatment to offer more services. Product diversification was especially important as locomotives switched from steam to diesel in the 1940s. National Aluminate Corporation (NALCO), which became popular in the industrial sector selling sodium aluminate for the prevention of scale, needed to

² For product expansion see Hagan Corporation and Calgon Corporations Annuals Reports, Box 3, Calgon Corporate Records.

³ On Micromet see, Box 4, Folder “Domestic and Small Water Systems – Micromet Space Ads,” Calgon Corporate Records.

⁴ Barbara Shalita Samuelson, “Pollution Problems Being Solved by Betz Laboratories,” *Investment Dealers’ Digest*, November 7, 1966, in Box 3, Folder 43, BetzDearborn, Incorporated Records. On Dearborn and rust control see, Box 4, Folder 30 “NO-OX-ID AND NO-OX-Idized Wrappers; Underground Protection, Engineering Data, 1946-1950” and Box 5 Folder 36 “Booklets – “No-OX-IED, circa 1933-1951” BetzDearborn, Incorporated Records.

diversity in the 1940s. A corporate history noted, “The replacement of steam locomotives by diesel units eliminated virtually half of Nalco’s business over a period of a few years.”⁵ To combat this loss, the company developed new products for cooling systems and combustion boating the treatment of both water and fire in industrial plants.

In the late 1940s, the Hagan Corporation created a waste water management and engineering department within Hall Laboratories and used the department as a springboard for pollution control in the 1960s. Growth in that department was at first marginal.⁶ In the mid-1960s, W.W. Hopwood, then president of the company, claimed new pollution control measures made the waste water management department more relevant than ever. Calgon, Hopwood claimed, discovered water before it was popular, a nod to recent government regulation.⁷ He also connected his company’s experience with water in order to situate it as a leader of water treatment and therefore pollution control. During a speech to some financial analysts in 1966 he said the expansion of activities “...stems from our storehouse of basic technical knowledge and practical experience in the behavior of water.”⁸ He continued that the current clamor for pollution control meant that their mission to control waste water would be invigorated. In the company’s annual

⁵ Bulletin, Nalco Chemical Company, *Finding the Consumer Need and Filling It: A History of the Nalco Chemical Company* (Napperville, IL: Nalco, 1989).

⁶ W.W. Hopwood, Presentation before the Los Angeles Society of Financial Analysts, April 28, 1966, Box 9 Folder 2, Calgon Corporate Records.

⁷ Jack Markowitz, “Calgon, Dravo, Chester Work Waters,” *Pittsburgh Post-Gazette*, June 17, 1969.

⁸ W.W. Hopwood, Presentation before the Los Angeles Society of Financial Analysts, April 28, 1966, Box 9 Folder 2, Calgon Corporate Records.

report from 1964, Hopwood directly connected water softening to water pollution.⁹ He claimed that hardness in water was the first major pollutant in American waterways. The second major pollutant, he said, was sewage from cities. A history removing the first major pollutant, that of nature's contamination, made the company prepared to tackle the second major pollutant. By connecting hard water to other pollutants, Hopwood made a case for the expertise of his company.

In 1965, the company put a plan into place to try to get new business in the field of waste water control and management. In February of that year, top advertising and marketing executives at Calgon met to plan a program to capitalize on federal initiatives to prevent water pollution. The team agreed the program should highlight Calgon's history with water treatment, available chemicals and mechanical products, as well as neutrality in the political fight over pollution control.¹⁰ The team wanted to reach groups including the federal water pollution control administration, public authorities, local and state governments, as well as civic and conservation groups. Their goal was to receive government contracts for money allocated to municipal sewage treatment as well as grab the attention of industries who would soon face waste water effluent standards. One member noted, "We're after the upper level decision makers. We need to reach the guys at the top." The company also aggressively advertised their program to industrial companies that used a lot of water.¹¹

⁹ *1964 Annual Report, Calgon Corporation*. Box 9, Folder "The Challenging Problems of Water, Advertising Campaign" Calgon Corporate Records.

¹⁰ Minutes for February 20, 1965 meeting at Calgon Center, Box 9, Folder 2, Calgon Corporate Records.

¹¹ Interoffice Correspondence, Calgon Corporation, August 20, 1965, Box 9, Folder 3, Calgon Corporate Records.

The program discussed in February of 1965 became a presentation entitled “The Challenging Problem of Water” created by Calgon advertising manager Robert Newcomer. Newcomer joined the company in 1951 and was named advertising manager in 1957. During that time, he led the effort in marketing industrial products before being promoted to director of marketing for the consumer products division in 1967.¹² “The Challenging Problems of Water” outlined the many problems related to water notably the increased use in nearly all water sectors in the 1960s and as well as pollution. Pollution, Newcomer claimed, meant that there would not be enough water for domestic, industrial, and irrigation purposes. This created the challenging problems of water, or how to ensure water in sufficient quantity and quality to satisfy daily needs.¹³ Other interested groups have suggested solutions the Calgon Corporation found fanciful including desalting, cloud seeding, weather control, and the cross-country transfer of water. The answer instead, was much simpler according to the company. The problem of water required sound water management. “As water management specialists,” the presentation claimed, “we believe each plant should: be responsible for its own water, use it in the most economical way, pay its rightful share to maintain quality.”¹⁴ With the correct management tools, Calgon believed it could maintain an everlasting supply of usable water.

¹² On Newcomer see, “Men and Business,” *Pittsburgh Post-Gazette*, March 29, 1967, page 27.

¹³ “The Challenging Problem of Water,” Box 9, Folder 3, Calgon Corporate Records.

¹⁴ “The Challenging Problem of Water,” Box 9, Folder 3, Calgon Corporate Records.

In the presentation, executives at Calgon committed to a technical solution to water problems. They had, as they had historically, put their faith in science and engineering as the solution to water problems. Edgar Paulson, the manager of waste water engineering at Hall Laboratories, echoed this sentiment at a presentation given before the International Water Quality Symposium in 1965. The symposium was a gathering of people involved in water treatment sponsored by dealers and manufacturers of water conditioning equipment. The symposium addressed concerns about water including pollution and a possible water shortage. Panels included titles such as “What is the Water Quality Situation?”, “Are we Running Out of Water?”, and “Getting and Managing Water for Industry.” In his speech, Paulson put the problem of pollution in very pragmatic terms asking, “How much money do all of us, as consumers and taxpayers, want to spend to keep our rivers clean?” Despite economic considerations Paulson noted “There is no pollution problem that cannot be technically solved.”¹⁵ Technology is where Calgon and other water softening companies had put their faith since the age of scientific water correction.

Executives involved in the “Challenging Problems of Water” campaign created a series of advertisements meant to familiarize potential customers with Calgon’s waste water treatment capacities. The advertisements highlighted secondhand water, or water that had been treated in treatment plants and then reused. The four ads featured someone washing lettuce in a colander, a coffee maker, a baby in the bathtub, and a surgeon

¹⁵ “Trends – Planned or Perchance,” an address by Edgar Paulson manager, process and waste water engineering Hall Labs, before the International Water Quality Symposium, August 26, 1965, Box 9 Folder 2.

washing his hands respectively. Each advertisement asked the reader would you do that in secondhand water? Below the question, it claimed that “you would” and “you do.” Each ad highlighted where water had been before. For example, the ad for washing a baby said, “The clean water that bathes a baby today could have cooled a motor, quenched a fire, watered a rose garden, washes dishes, made paper, tempered steel, iced a drink, or even bathes another baby only a day or two ago. More and more water is used water.”¹⁶ The same format was used for the ads containing the other images. The ads highlight the social nature of water. They envision a more complex hydrologic cycle in which water flows towards some use, is used, and then is treated to be used again. While government officials, private companies, and scientists talked endlessly about secondary and tertiary waste water treatment during the 1960s, these advertisements provide the clearest example of how pollution control worked. And how it might be a sustainable answer to the water problems in the 1960s. Through these advertisements and their water pollution campaign more broadly, executives at Calgon attempted to situate the company as intimately aware of the environmental problems faced in the 1960s. It is difficult to know, however, if the role of complex phosphates in pollution contributed to their thinking.

The foray of polluters into pollution control was a theme throughout the 1960s and 1970s. Other industrial polluters such as Dow Chemical Company, E.I. du Pont de Nemours & Co., Inc, and Monsanto Chemical offered pollution control systems either

¹⁶ Advertisements, Box 9 Folder “The Challenging Problems of Water 2” Calgon Corporate Archives.

through their companies or purchased subsidiaries.¹⁷ Manufacturing behemoths such as Alcoa and the Coca-Cola company purchased subsidiaries to serve as environmental divisions. As society placed faith in engineering and science to fix the problems of pollution, it is not surprising that engineering firms and chemical companies offered to ameliorate the problems of pollution while also expanding their monetary and growth possibilities. Companies continued to invest in pollution control technologies and services. In 1982, *Chemical Engineering News* claimed chemical companies outstripped other sectors in pollution control spending nearly 880 million dollars on water and air pollution control.¹⁸ By the 1970s, polluters and pollution controllers had undergone a swift corporate integration. On this subject, in 1970 a commentator writing for a Berkeley, California based magazine noted, “To the military industrial complex, we can now add an eco-pollution-industrial complex, with a vested interest in continuing economic growth and environmental malaise.”¹⁹

In many ways, water softening and water pollution control represent similar handling of water problems. At the turn of the twentieth century, society placed a higher standard on soft water for industrial and domestic purposes. Science and engineering firms fixed the problem without fully questioning other alternatives. By defining the water they used as bad, impure and therefore not valuable, instead of the machines or

¹⁷ For more information on what these and other companies offered in pollution control management see, “1968-1969 Pollution Control Directory” *Environ. Sci. Technol.* 1968, 2, 10, 799-986.

¹⁸ “Chemical firms increase pollution-control funds” *Chem. Eng. News* 1982, 60, 21, 7.

¹⁹ Martin Gellen, “The Making of a Pollution-Industrial Complex,” *Ramparts* 8, no. 11, May 1970 (Berkeley, CA: Ramparts Magazine, 1970).

other labor processes, people concluded that resources and effort should go into changing the molecules of water. Similarly, faced with the problem of pollution, as Hopwood pointed out a problem related to water's propensity to dissolve things both natural and manmade, corporations rallied to defined not the junk that polluted water as bad, rather defined the water itself as bad. This in turn solidified the need to change the water, rather than habits that led to pollution. The need for a certain quality of water, to ensure post war development, motivated industries to eagerly hop on the pollution control bandwagon. This logic was underpinned by the federal government who in 1956, 1965, 1966 and again in 1972 institutionalized the value of a certain quality of water. Although pollution and hard water presented different problems, in many ways a focus on pollution control and abatement and water softening is closely related. For industrial companies both within and outside of the water treatment area, the control of water represented a path to profit.

Postscript

When working on this project, I was surprised by how many people revealed to me their personal relationships with hard water. I had one friend tell me that she hated the way Philadelphia's water made her hair feel. Even the low level of hardness made her hair rough and tangled. My aunt and uncle constantly worried about how the hard water from their well affected the pipes in their old home. A fellow scholar noted that their partner hated the water in their hometown in Florida. Unaccustomed to the hardness, they thought there was something very wrong with the water. I even once heard a coworker, in a fit of frustration, yell into the ether "Calgon take me away." The outburst was a

reference to the company's advertising campaign in the 1960s in which a busy mother magically escaped into a bathtub of Calgonized water. My mother had her own relationship with and memories of the struggle to subdue hard water. Living in Long Island as a young woman, she remembers the phosphate ban in detergents in the early 1970s in Suffolk County. She recalled driving with her mother into neighboring Nassau County to, in the words of my grandmother, "get the good stuff."

One story that stands out is a discussion I had with the curator of rare books at the Science History Institute, Jim Voelkel, about his experience with hard water. In 2010 Jim remembered being at an event at the Institute in which a chemist offered him an apocalyptic warning. A full ban on phosphates was coming and his dishes, the chemist proclaimed, would never be the same. Indeed, a change in automatic dishwashing detergent was coming. While by 1980, most synthetic laundry detergents contained little to no phosphates, dishwashing compounds continued to use complex phosphates as water softeners into the twenty first century. Dishwashing manufacturers avoided a phosphate ban due to lower levels of the chemical in their products throughout the 1980s and 1990s. Yet, eventually the tides turned on dishwashing detergents. In 2010, thanks to a string of new instances of eutrophication, seventeen states banned phosphates in automatic dishwashing detergents.²⁰ Shortly thereafter, automatic dishwasher detergent manufacturers voluntarily removed phosphates from their products. Jim soon learned that the pessimistic old chemist was right. He noticed that his dishes were much less clean, and in his words, his dishwasher basically stopped working. In response, Jim turned to

²⁰ Alex Cohen and David Keiser, "The Effectiveness of Incomplete and Overlapping Pollution Regulation: Evidence from Bans on Phosphate in Automatic Dishwasher Detergent," *Journal of Public Economics*, Volume 150, June 2017, 53-74.

rinse aids such as Jet Dry, something he'd never used before. Jet Dry and other rinse aids contain chelating agents, those substances that work to sequester calcium and magnesium ions. While Jet Dry also boasts bacteria killing materials as well as surface active agents, their main appeal is as a water softener.

In 2019 Jim purchased a new automatic dishwasher. It contained similar features of dishwashers he'd had before including a space for both detergent and a rinse aid. He was surprised, however, to find that the manufacturers had installed a featured in which a light came on to alert the user if there was no rinse aid in the intended space. This new light, along with a free package of the rinse aid Jet Dry, served to emphasize the necessity of using a water softener in the dish washing process. In the case of Jim's washing machine, hard water had influenced his buying practices and even the design of his washing machine. Jim also joked that although the rinse aid is helpful, his dishes just aren't as clean as they used to be.

The story of my colleague as well as other personal experiences with hard water illuminate people's interaction and interdependence with water. While Henry Cavendish and other chemists might argue tooth and nail that water is two hydrogen atoms and one oxygen atom, most people know better. To borrow a phrase from Jamie Linton, "Water is what we make of it" and throughout the late nineteenth and twentieth centuries, people have made a lot of soft water.²¹

²¹ Linton, *What is Water?* 3.

BIBLIOGRAPHY

Primary Source Manuscripts

Detre Library & Archives, Heinz History Center, Pittsburgh, Pennsylvania
Calgon Corporate Archives
Hopwood Family Collection

Carnegie Mellon University Libraries, Pittsburgh, Pennsylvania
Mellon Institute of Industrial Research Records

Hagley Museum and Library, Wilmington, Delaware
Carol Litchfield collection on the history of salt
Ernest Dichter Papers
Ernest Dichter Papers, research proposals and reports
Lake Mohonk Mountain House data file
Philadelphia Quartz (PQ) Company records
Pennsylvania Railroad Company records
Trade Catalogues and Pamphlets

National Archives and Records Administration at College Park, College Park, Maryland
Records of the National Industrial Pollution Control Council, Record Group
40.7.7
Records of the Extension Service, Record Group 33.

National Archives and Records Administration at Philadelphia, Philadelphia,
Pennsylvania
Records of the U.S. Bureau of Mines, Record Group 70

The Science History Institute, Philadelphia, Pennsylvania
BetzDearborn, Incorporated Records
The Dow Chemical Historical Collection

Special Collections and University Archives, Rutgers University Libraries, New
Brunswick
Records of Consumers' Research, Inc.

Copley Library Special Collections, University of San Diego, San Diego, California
Emmett J. Culligan Papers

Newspapers, Periodicals and Journals

American Dyestuff Reporter, Secaucus, New Jersey
The American Kitchen Magazine, Boston, Massachusetts
The American Outlook, Chicago, Illinois

Bulletin of the American Home Economics Association, Washington, DC
Chemical & Engineering News, Easton, Pennsylvania
Chicago Daily Tribune, Chicago, Illinois
Consumer Bulletin Annual, Washington, New Jersey (Consumers' Research Inc.)
Cornell Bulletin for Homemakers, Ithaca, New York
Engineering New Record, New York
Forecast for Home Economics, Dayton, Ohio
Good Housekeeping, New York
Harper's Bazaar, New York
Harper's Magazine, New York
Journal of the American Water Works Association, Baltimore, Maryland
Journal of Home Economics, Washington, DC
Ladies Home Journal, Des Moines, Iowa
The Los Angeles Times, Los Angeles, California
Maine Farmer, Augusta, Maine
Michigan Farmer, Middleburgh Heights, Ohio
The Municipal Journal and Public Works Engineer, London, England
The New York Times, New York
The Ohio Farmer, Columbus, Ohio
Pittsburgh Post-Gazette, Pittsburgh, Pennsylvania
Philadelphia Tribune, Philadelphia, Pennsylvania
Power Plant Engineering, Chicago, Illinois
Redbook, New York
Soap, New York
Soap and Chemical Specialties, New York
Soap Gazette and Perfumer, New York
Soap and Sanitary Chemicals, New York
Southern Cultivator, Augusta, Georgia
The Washington Post, Washington, DC

Published Proceedings

Annual Report of the American Railway Master Mechanics Association, Cincinnati, Ohio,
 Southern and Southwestern Railway Club, Atlanta, Georgia
 Official Proceedings of the Western Railway Club, Chicago, Illinois
 Official Proceedings of the New York Railroad Club, Chicago, Illinois
 Proceedings of the New England Railroad Club, Boston Massachusetts
 Report on Conditions of Woman and Child Wage-Earners in the United States, U.S. Senate, 61st Congress, 2nd Session, Document No. 645

Printed Primary Sources

Abell, L.G. *The Skillful Housewife's Book, or complete guide to domestic cookery, taste, comfort, and economy*. New York: D. Newell, 1846.

- Atkins, Walter George. *The Modern System of Water Purification*. London: E & F.N Spon, 1894.
- Ballard, Martha Moore. *The Diary of Martha Ballard, 1785-1812*. Camden, ME: Picton Press, 1992.
- Beecher, Catherine. *A Treatise on Domestic Economy For the Use of Young Ladies at Home and at School*. New York: Harper & Brothers, 1845.
- Beecher, Catherine and Harriet Beecher Stowe. *The American woman's home: or, Principles of domestic science; being a guide to the formation and maintenance of economical, healthful, beautiful, and Christian homes* New York: J. B. Ford, 1869.
- Campbell, Helen. *Prisoners of poverty: Women wage-workers, their trades and their lives*. Boston: Little Brown & co., 1887.
- Corson, Juliet. *Family living on \$500 a year: a daily reference-book for young and inexperienced housewives*. New York: Harpers & Brothers, 1888.
- Du Bois, W.E.B and Isabel Eaton. *The Philadelphia Negro: A Social Study, together with a special report on domestic service by Isabel Eaton*. (Philadelphia, 1899).
- Flora, Rosa. *The Laundry*. Ithaca, NY: NY State College of Agriculture, Cornell University, 1909.
- Hooker, Mary. *The Young Housekeeper's Friend: or, a guide to domestic economy and comfort*. Boston: Tappan and Whittemore, 1845.
- Jack, Florence. *The art of laundry work: practically demonstrated for use in homes and schools*. Edinburgh: T.C. & E.C.. Jack, 1896.
- Johnston, James. *The Chemistry of Common life*. New York: D. Appleton, 1855.
- Leslie, Eliza. *Directions for Cookery, in its Various Branches*. Philadelphia: Carey & Hart, 1840.
- *The House book, or, a manual of domestic economy: for town and country*. Philadelphia: Carey & Hart, 1840.
- Marsh, E.L. *Laundry work in theory and practice*. London: Longmans, Green & co., 1914.
- Phelps, Lincoln, Mrs. *The Female Student; or, Lectures to Young Ladies on Female Education*. New York: Leavitt, Lord, & Co., 1836.
- Reed Wadhams, Caroline. *Simple directions for the chambermaid*. New York:

- Longmans, Green and Co., 1917.
- *Simple Directions for the Laundress*. New York: Longmans, Green and Co., 1917.
- *Simple directions for the waitress or parlor maid*. New York, Longmans, Green and co., 1917.
- Richards, Ellen Swallow. *The Chemistry of Common life; a manual for housekeepers*. Boston, Estes & Lauriat, 1882.
- *Conservation by sanitation; air and water supply; disposal of waste (including a laboratory guide for sanitary engineers)*. New York: Wiley, 1911.
- *The cost of food; a study in dietaries*. New York: J. Wiley & sons, 1901.
- *Food materials and their adulterations*. Boston: Estes and Lauriat, 1886.
- *Laboratory notes on industrial water analysis; a survey course for engineers*. New York: J. Wiley & Sons, 1910.
- Thorp, Frank Hall. *Outlines of industrial chemistry; a text-book for students*. New York: Macmillan Co, 1898.
- Shepperd, Juniata L. *Laundry Work, for use in homes and schools*. St Paul, MN: Webb publishing co, 1902.
- Williams, Henry T and Daisy Eyebright. *Household Hints and Recipes*. Boston: Peoples Publishing Company, 1884.
- Wilson, Erasmus. *On diseases of the skin*. Philadelphia: Lea and Blanchard, 1852.
- Youmans, Edward Livingston. *The hand-book of household science: a popular account of heat, light, air, aliment, and cleansing, in their scientific principles and domestic applications: adapted for academies, seminaries and schools*. New York: D. Appleton, 1859.

Secondary Sources

- Adas, Michael. *Dominance by Design: Technological Imperatives and America's Civilizing Mission*. Cambridge, Mass: Belknap Press of Harvard University Press, 2006.
- Arnesen, Eric. *Brotherhoods of Color: Black Railroad Workers and the Struggle for Equality*. Cambridge: Harvard University Press, 2001.

- Baker, Moses. *The quest for pure water; the history of water purification from the earliest records to the twentieth century*. New York: American Water Works Association, 1949.
- Bakker, Karen. "Water: Political, biopolitical, material" *Social Studies of Science* 42, no. 4, (August 2012): 616-623.
- Barca, Stefania. *Enclosing Water: Nature and Political Economy in a Mediterranean Valley, 1796- 1916*. Cambridge: The White Horse Press, 2010.
- Bederman, Gail. *Manliness & Civilization: A Cultural History of Gender and Race in the United States, 1880-1917*. Chicago: University of Chicago Press, 1995.
- Blanc, Paul David. *Fake Silk: The Lethal History of Viscose Rayon*. New Haven: Yale University Press, 2016.
- Bolton Valencius. Conevery. *The Health of the Country: How American Settlers Understood Themselves and Their Land*. New York: Basic Books, 2002.
- Bowler, Thomas. *Making Modern Science - A Historical Survey*. Chicago: University of Chicago Press, 2005.
- Boydston, Jeanne. *Home and Work: Housework, wages, and the Ideology of Labor in the Early Republic*. New York: Oxford University Press, 1990.
- Burke, Timothy. *Lifebuoy Men, Lux Women: Commodification, Consumption, and Cleanliness in Modern Zimbabwe*. Durham, N.C.: Duke University Press 1996.
- Carroll, Patrick. "Water and Technoscientific State Formation in California," *Social Studies of Science* 42, no. 4 (August 2012): 489-516.
- Carson, Rachel. *Silent Spring*. Cambridge: Cambridge University Press, 1962.
- Cartmill, Matt. "The Bambi Syndrome." In *A View of Death in the Morning: Hunting and Nature through History*, edited by Matt Cartmill, 161-189. Cambridge, MA: Harvard University Press, 1993.
- Chang, Hasock. *Is Water H₂O?: Evidence, Realism and Pluralism*. Dordrecht: Springer, 2014.
- Chatzis, Konstantinos and Dupuy, Gabriel. "How to dispense with empiricism: the 'Caquot formula' and post-war drainage policy in France." *Water Policy* 2, no. 4-5 (2000): 267-281.

- Clake, Allison. *Tupperware: The Promise of Plastic in 1950s America*. Washington, DC: Smithsonian Institution Press, 1999.
- Cobb, Cathy. *Magick, Mayhem, and Mavericks: The Spirited History of Physical Chemistry*. Amherst, NY: Prometheus Books, 2002.
- Cohen, Alex and Keiser, David. "The Effectiveness of Incomplete and Overlapping Pollution Regulation: Evidence from Bans on Phosphate in Automatic Dishwasher Detergent," *Journal of Public Economics* 150 (2017: 53-74.
- Cohen, Lizabeth. *A Consumer's Republic: The Politics of Mass Consumption in Postwar America*. New York: Knopf, 2003.
- Cole, Camilla Lyans. "Precarious Empires: A Social and Environmental History of Steam Navigation on the Tigris," *Journal of Social History* 50 (September 2016):74–101.
- Collins, Nina. "Domestic Sciences at Bradley Polytechnic Institute and the University of Chicago." *Journal of the Illinois State Historical Society* 95, no. 3 (Autumn, 2002); 275-299.
- Cott, Nancy, *The Bonds of Womanhood: "Woman's Sphere" in New England, 1780-1835*. New Haven: Yale University Press, 1997.
- Cronon. William, editor. *Uncommon Ground: Rethinking the Human Place in Nature*. New York: W.W. Norton & Co., 1995.
- Dublin, Thomas. *Transforming Women's Work: New England Lives in the Industrial Revolution*. Ithaca, NY: Cornell University Press, 1994.
- Dudden, Faye. *Serving Women, Household Service in Nineteenth Century America*. Middletown, Conn.: Wesleyan University Press, 1983.
- Dunlap, Thomas. *DDT: Scientists, Citizens, and Public Policy*. Princeton, NJ: Princeton University Press, 1980.
- *Saving America's Wildlife: How Science Changed Our Minds*. Princeton, NJ: Princeton University Press, 1988.
- Edmondson, W.T. *The Uses of Ecology: Lake Washington and Beyond*. Seattle: University of Washington Press, 1991.
- Elias, Megan. "'Model Mamas': The Domestic Partnership of Home Economics Pioneers Flora Rose and Martha Van Rensselaer." *Journal of the History of Sexuality* 15, no. 1 (Jan, 2006): 65- 88.

- Faust, Samuel. *Chemistry of Natural Waters*. Ann Arbor, Mich.: Ann Arbor Science, 1981.
- Fiege, Mark. *Irrigated Eden: The Making of an Agricultural Landscape in the American West*. Seattle: University of Washington Press, 1999.
- Fiege, Mark. *The Republic of Nature, an Environmental History of the United States*. Seattle: University of Washington Press, 2012.
- Fischer, Christiane ed. *Let Them Speak for Themselves: Women in the American West, 1849-1900*. Hamden, CT: The Shoe String Press Inc., 1977.
- Geetz, Clifford. "The Wet and the Dry: Traditional Irrigation in Bali and Morocco." *Human Ecology* 1, no.1 (March, 1972): 23-39.
- Goldstein, Carolyn. *Creating Consumers: Home Economists in Twentieth Century America* Chapel Hill: University of North Carolina Press, 2012.
- Gosselin, Robert. "The Detergent Controversy." In *A Primer of Environmental Toxicology*, edited by Roger P. Smith, 188-193. Philadelphia, PA: Lea & Febiger, 1992.
- Harper, Kristen. *Make it Rain: State Control of the Atmosphere in Twentieth-Century America*. Chicago: the University of Chicago Press, 2017.
- Hartmann, Susan. *The Home Front and Beyond: American Women in the 1940s*. Boston: Twayne Publishers, 1982.
- Hamlin, Christopher. *A Science of Impurity: Water Analysis in Nineteenth Century Britain*. Bristol, UK, and Berkeley, CA: Adam Higler and University of California Press, 1990.
- "‘Waters’ or ‘Water’? –Master Narratives in Water History and their Implications for Contemporary Water Policy." *Water Policy* 2, no. 4-5 (2000): 313-325.
- Hays, Samuel. *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955-1985*. New York, NY: Cambridge University Press, 1987
- Hills, Richard. *Power from Steam: A History of the Stationary Steam Engine*. Cambridge: Cambridge University Press, 1989.
- Horowitz, Roger, ed. *Boys and Their Toys: Masculinity, Technology, and Class in America*. New York: Routledge, 2001.

- Horowitz, Roger and Mohun, Arwen editors. *His and Hers: Gender, Consumption, and Technology*. Charlottesville: University Press of Virginia, 1998.
- Hoy, Suellen. *Chasing Dirt the American pursuit of cleanliness*. New York: Oxford University Press, 1995.
- Hughes, Thomas. *Human-Built World: How to Think about Technology and Culture*. University of Chicago Press, 2004.
- Hum Lee, Rose. *The Growth and Decline of Chinese Communities in the Rocky Mountain Region*. New York: Arno Press, 1978.
- Hundley, Norris. *The Great Thirst: Californians and Water, 1770s-1990s*. Berkeley: University of California Press, 1992.
- Hunter, Tera. *To 'Joy My Freedom: Southern Black Women's Lives and Labor After the Civil War*. Cambridge, MA: Harvard University Press, 1997.
- Hurley, Andrew. *Environmental Inequalities: Class, Race, and Industrial Pollution in Gary, Indiana*. Chapel Hill, NC: The University of North Carolina Press, 1995.
- Isenberg, Andrew C. *The Destruction of the Bison: An Environmental History, 1750–1920*. New York: Cambridge University Press, 2000.
- Mining California: An Ecological History* (New York: Hill and Wang, 2005).
- Katzman, David. *Seven Days a Week: Women and Domestic Service in Industrializing America*. New York: Oxford University Press, 1978.
- Kehoe, Terence. *Cleaning Up the Great Lakes- From Cooperation to Confrontation*. DeKalb: Northern Illinois University Press, 1997.
- “Merchants of Pollution?: The Soap and Detergent Industry and the Fight to Restore Great Lakes Water Quality, 1965-1972.” *Environmental History Review* 16, (1992): 21-46.
- Kenly Smith, John. “The Scientific Tradition in American Industrial Research,” *Technology and Culture* 31, no. 1 (Jan 1990): 121-131.
- Kerber, Linda. “Separate Spheres, Female Worlds, Woman's Place: The Rhetoric of Women's History.” *Journal of American History* 75 (Jun. 1988): 9-39.
- Kline, Ronald. *Consumers in the Country - Technology and Social Change in Rural America*. Baltimore, MD: Johns Hopkins University Press, 2000.

- Laidler, Keith. *The World of Physical Chemistry*. New York: Oxford University Press, 1995.
- Lamborn, Leebert Lloyd. *Modern soaps, candles and glycerin: a practical manual of modern methods of utilization of fats and oils in the manufacture of soap and candles, and of the recovery of glycerin*. New York: D Van Nostrand, 1906.
- Langston, Nancy. "Gender Transformed: Endocrine Disruptors in the Environment." In *Seeing Nature through Gender*, edited by Virginia Scharff, 129-166. Lawrence: University of Kansas Press.
- Lassman, Thomas. "Industrial research transformed: Edward Condon at the Westinghouse Electric and Manufacturing Company, 1935-1942." *Technology and Culture* 44, (Apr., 2003): 306-339.
- Leach, William. *Land of Desire: Merchants, Power, and the Rise of a New American Culture*. New York: Pantheon Books, 1993.
- Lerman, Nina, Oldenziel, Ruth and Mohun, Arwen, editors. *Gender and Technology: a Reader*. Baltimore: The Johns Hopkins University Press, 2003.
- Licht, Walter. *Working for the Railroad: The Organization of Work in the Nineteenth Century*. Princeton, New Jersey: Princeton University Press, 1983.
- Lieffers, Caroline. "'The Present Time is Eminently Scientific': The Science of Cookery in Nineteenth Century Britain." *Journal of Social History* 45, no. 4 (Summer 2012): 936-959.
- Linton, Jamie. *What is Water? The History of Modern Abstraction*. Vancouver: University of British Columbia Press, 2010.
- Louis, Hunter. *A History of Industrial Power in the United States*. Charlottesville: University of Virginia Press, 1979.
- Mart, Michelle. *Pesticides, a Love Story*. Lawrenceville: University of Kansas Press, 2015.
- Marx, Leo. "'Technology': The Emergence of a Hazardous Concept," *Social Research* 64, (Fall 1997): 965-988.
- McEvoy, Arthur F. *The Fisherman's Problem: Ecology and Law in the California Fisheries, 1850-1980*. New York: Cambridge University Press, 1986.
- McGaw, Judith. "Introduction: The Experience of Early American Technology." In *Early American Technology: Making and Doing Things from the Colonial Era to*

- 1850, edited by Judith McGaw, Chapel Hill, 1994.
- “Why Feminine Technologies Matter.” *Gender and Technology: a Reader*. Edited by Lerman, N, Oldenzien, R, Mohun, A,
- McGovern, Charles. *Sold American: Consumption and Citizenship, 1890-1945*. Chapel Hill: University of North Carolina Press, 2006.
- McGucken, William. *Biodegradable: Detergents and the Environment*. College Station: Texas A&M University Press, 1991.
- *Lake Erie Rehabilitated: Controlling Cultural Eutrophication, 1960s-1990s*. Akron, Ohio: University of Akron Press, 2000.
- McShane, Clay and Joel Tarr. *The Horse in the City: Living Machines in the Nineteenth Century*. Baltimore: The Johns Hopkins University Press, 2007.
- Meikle, Jeffrey. *American Plastic: A Cultural History*. New Brunswick: Rutgers University Press, 1995.
- Melosi, Martin. *The sanitary city: environmental services in urban America from colonial times to the present*. Pittsburgh, PA: the University of Pittsburgh Press, 2008.
- Merchant, Carolyn. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper & Row, 1980.
- *Ecological Revolutions: Nature, Gender, and Science in New England*. Chapel Hill: University of North Carolina Press, 2010.
- *Earthcare: Women and the Environment*. New York: Routledge 1996.
- “Gender and Environmental History,” *Journal of American History* 76 (March 1990): 1117-1121.
- Meyerowitz, Joanne, ed. *Not June Cleaver: Women and Gender in Postwar America, 1945-1960* Philadelphia: Temple University Press, 1994.
- Mohun, Arwen. *Steam Laundries: Gender Technology, and Work in the United States and Great Britain, 1880-1940*. Baltimore, MD: The Johns Hopkins University Press, 1999.
- Musil, Robert K. *Rachel Carson and Her Sisters: Extraordinary Women Who Have Shaped America’s Environment*. New Brunswick: Rutgers University Press, 2014.
- Nash, Linda. *Inescapable Ecologies: A History of Environment, Disease, and Knowledge*

- Berkeley: University of California Press, 2006.
- Nash, Roderick. *Wilderness and the American Mind*. London: Yale University Press, 1967.
- Norman, Emma. *Governing Transboundary Waters: Canada, the United States, and Indigenous Communities*. New York: Routledge, 2014.
- Norton, Mary Beth. *Separated by their Sex: Women in Public and Private in the Colonial Atlantic World*. Ithaca: Cornell University Press, 2011.
- Norwood, Vera. *Made from This Earth: American Women and Nature*. Chapel Hill; London: The University of North Carolina Press, 1993.
- Oldenziel, Ruth. *Making Technology Masculine: Men, Women and Modern Machines in America, 1870-1945*. Amsterdam: Amsterdam University Press, 1999.
- Oliver, Smith Hempstone. *The First Quarter Century of Steam Locomotives in North America*. Washington, DC: Smithsonian Institute, 1956.
- Parr, Joy. *Domestic Goods: The Material, the Moral and the Economic in the Postwar Years*. Toronto; Buffalo: University of Toronto Press, 1999.
- Parr, Joy. "What Makes Washdays less Blue? Gender, Nation, and Technology in Postwar Canada." *Technology and Culture* 38 (January 1997): 153-186.
- Parr, Joy and Eckberg, Gunilla. , "Mrs Consumer and Mr Keynes in Post War Canada and Sweden," *Gender & History* 8 (August 1996): 212-230.
- Prendergast, Neil. "Raising the Thanksgiving Turket: Agroecology, Gender, and the Knowledge of Nature," *Environmental History* 16 (October 2011): 651-677.
- Perrault, Tom, Wright, Sarah, and Perrault, Meredith. "Environmental Injustice in the Onondaga Lake Waterscape, New York, USA." *Water Alternatives* 5, no. 2 (2012): 485-506.
- Pisani, Donald J. *To Reclaim a Divided West: Water, Law, and Public Policy, 1848-1902*. Albuquerque: University of New Mexico Press, 1992.
- . *Water and the American Government: the Reclamation Bureau, National Water Policy, and the West, 1902-1935*. Berkeley: University of California Press, 2002.
- Potter Hoover, Charles. *Water Supply and Treatment*. Washington, DC: The National Lime Association, 1936.
- Price, Donald. *Detergents: What They Are and What They Do*. New York: Chemical Publishing Co., 1952.

- Prichard, Sara. "An Envirotechnical Disaster: Nature, Technology, and Politics at Fukushima," *Environmental History* 17, (April 2012): 219-243.
- Prichard, Sarah. *Confluence: The Nature of Technology and the Remaking of the Rhone*. Cambridge, MA: Harvard University Press, 2011.
- Prichard, Sarah. "From hydroimperialism to hydrocapitalism: 'French' hydraulics in France, North African, and beyond." *Social Studies of Science* 42, no. 4, (August 2012): 591-615.
- Pursell, Carroll. *The Machine in America: A Social History of Technology*. Baltimore: The Johns Hopkins University Press, 1995.
- Rand, Lisa Ruth. "Falling Cosmos: Nuclear Reentry and the Environmental History of Earth Orbit," *Environmental History* 24, (January 2019): 78-103.
- Reisner, Mark. *Cadillac Desert: The American West and its Disappearing Water*. New York: Viking, 1986.
- Reuss, Martin and Cutcliffe, Stephen editors. *The Illusory Boundary: Environment and Technology in History*. Charlottesville: University of Virginia Press, 2010.
- Rice, Stephen P. *Mining the machine: languages of class in early industrial America*. Berkeley: University of California Press, 2004.
- Robertson, Thomas. *The Malthusian Moment: Global Population Growth and the Birth of American Environmentalism*. New Brunswick, NJ: Rutgers University Press, 2012.
- Rome, Adam. *Bulldozer in the Countryside: Suburban Sprawl and the Rise of American Environmentalism*. Cambridge: Cambridge University Press, 2001.
- "Give Earth a Chance': The Environmental Movement in the Sixties." *Journal of American History* 90 (September 2003): 525-554.
- Rosen, William. *The Most Powerful Idea in the World: a story of steam, industry, and invention*. New York: Random House, 2010.
- Russel, Edmund. *War and Nature: Fighting Humans and Insects with Chemicals from World War I to Silent Spring*. Cambridge: Cambridge University Press, 2001.
- Sackman, Douglas C. "Putting Gender on the Table: Food and the Family Life of Nature." In *Seeing Nature Through Gender*, edited by Virginia J. Scharff. Lawrence: University Press of Kansas, 2003.

- Schivelbusch, Wolfgang. *The Railway Journey: The Industrialization of Time and Space in the Nineteenth Century*. Oakland: University of California Press, 2014.
- Schwartz Cowan, Ruth. "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology." In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, edited by Trevor Pinch, Thomas Parke Hughes and Wiebe Bijker, 253 -272. Cambridge, MIT Press, 2012.
- *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave*. New York: Basic Books, 1983.
- *A Social History of American Technology*. New York: Oxford University Press, 1997.
- Servos, John. *Physical Chemistry from Ostwald to Pauling*. Princeton, NJ: Princeton University Press, 1990.
- Sheff, Carol. *The Artificial River: The Erie Canal and the Paradox of Progress, 1817-1862*. New York: Hill and Wang, 1996.
- Smith-Howard, Kendra. *Pure and Modern Milk: An Environmental History since 1900*. Oxford: Oxford University Press, 2013.
- Snell, J.B. *Mechanical Engineering: Railways*. London: Longman, 1971.
- Spence, Mark David. *Dispossessing the Wilderness: Indian Removal and the Making of the National Parks*. New York: Oxford University Press, 1999.
- Stage, Sarah. "Introduction Home Economics: What's in a Name?" In *Rethinking Home Economics: Women and the History of a Profession* edited by Sarah Stage, 1-13. Ithaca: Cornell University Press, 1997.
- Stage, Sarah and Virginia B Vincenti, editors. *Rethinking Home Economic: Women and the History of a Profession*. Ithaca: Cornell University Press, 1997.
- Steen, Kathryn. *The American Synthetic Organic Chemicals Industry: War and Politics, 1910-1930*. Chapel Hill, NC: University of North Carolina Press, 2014.
- Stine, Jeffery and Joel Tarr. "At the Intersection of Histories: Technology and the Environment," *Technology and Culture* 39 (October 1998): 601-640.
- Strasser, Susan. *Never Done: A History of American Housework*. New York: Pantheon Books, 1982.
- Straub, Alexandra. "Development and Environment: Industrial Action in the Anthracite

- Region of Pennsylvania, 1947-1968," *Pennsylvania History* 86 (April 2019):195-221.
- Sutherland, Daniel. *Americans and their servants: Domestic Service in the United States from 1800-1920*. Baton Rouge and London: Louisiana State University Press, 1981.
- Taylor, Rabun. *Public Needs and Private Pleasures: Waster Distribution the Tiber River and the Urban Development of Ancient Rome*. Roma: L'erma di Bretschneider, 2000.
- Tarr, Joel. *The Search for the Ultimate Sink: Urban Pollution in historical perspective*. Akron, OH: University of Akron Press, 1996.
- Teisch, Jessica. *Engineering Nature: Water, Development , and the Global Spread of American Environmental Expertise*. Chapel Hill: University of North Carolina Press, 2011.
- Tier, Sebastian. *The History of Steam Generation*. Helsinki University of Technology Department of Mechanical Engineering, 2002.
- Trachtenberg, Alan. *The Incorporation of America: Culture and Society in the Gilded Age*. New York: Hill and Wang, 1982.
- Travis, Anthony S. *The Rainbow Makers: The Origins of the Synthetic Dyestuffs Industry in Western Europe*. Bethlehem: Lehigh University Press, 1993.
- Travis, Anthony S. *Synthetic Nitrogen Industry in World War I: Its Emergence and Expansion*. Cham: Springer, 2015.
- Turner, James Morton. *The Promise of Wilderness: American Environmental Politics since 1964*. Seattle: University of Washington Press, 2012.
- Tyler May, Elaine. *Homeward Bound: American Families in the Cold War Era*. New York: Basic Books, 1988.
- Vetter, Jeremy. *Field Life: Science in the American West During the Railroad Era*. Pittsburgh, PA: University of Pittsburgh Press, 2016.
- Vietor, Richard. *Environmental Politics and the Coal Coalition*. College Station: Texas A & M University Press, 1980.
- Vinikas, Vincent. *Soft Soap, Hard Sell: American Hygiene in the Age of Advertisement*. Ames: Iowa State University Press, 1992.

- Wang, Joan. "Gender, Race, and Civilization: The Competition between America Power Laundries and Chinese Steam Laundries, 1870s-1920s." *American Studies International* 40, (Feb., 2002): 52-73.
- Warren, Louis, S. *The Hunter's Game: Poachers and Conservationists in Twentieth-Century America*. New Haven: Yale University Press, 1997.
- Weisiger, Marsha L. *Dreaming of Sheep in Navajo Country*. Seattle: University of Washington Press, 2009.
- White, Richard. "Are You an Environmentalist or Do You Work for a Living: Work and Nature." In *Uncommon Ground: Rethinking the Human Place in Nature*, edited by William Cronon, 171-185. New York: W. W. Norton, 1995.
- "From Wilderness to Hybrid Landscapes: The Cultural Turn in Environmental History," *Historian* 66 (Fall 2004): 557-64.
- *The Organic Machine: the Remaking of the Columbia River*. New York: Hill and Wang, 1996.
- *Railroaded: the Transcontinentals and the Making of Modern America*. New York: W.W. Norton & Co., 2012.
- Wilkinson, Richard. "The English Industrial Revolution." In *The Ends of the Earth: Perspectives on Modern Environmental History*, edited by Donald Worster, 80-100. Cambridge; New York: Cambridge University Press, 1988.
- Wilson, Charles Henry. *The History of Unilever: A Study in Economic Growth and Social Change*. New York: Praeger, 1954.
- Wittfogel, Karl. *Oriental Despotism: A Comparative Study*. New Haven: Yale University Press, 1957.
- Worster, Donald. "The Ecology of Order and Chaos." *Environmental History Review* 14, (Spring-Summer, 1990):1-18.
- Worster, Donald. *Rivers of Empire: Water, Aridity, and the Growth of the American West*. New York; Oxford: Oxford University Press, 1992.
- Yates, Julian, Harria, Leila, and Wilson, Nicole. "Multiple Ontologies of Water: Politics, Conflict, and Implications for Governance," *Environment and Planning D: Society and Space* 35, no. 5 (2017): 797-815.
- Young Welke, Barbara. *Recasting American Liberty: Gender, Race, Law, and the Railroad Revolution, 1865-1920*. New York: Cambridge University Press, 2001.

Zimring, Carl. *Clean and White: A history of environmental racism in the United States*.
New York: New York University Press, 2015.