THESIS PROJECT PORTFOLIO

The Design of a Desalination Plant in the Bay of Bengal
(Technical Report)

An Analysis of Desalination in California in Response to the Drought
(STS Research Paper)

An Undergraduate Thesis

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Water scarcity is a growing problem in today's world with many countries experiencing some level of drought and water pollution due to climate change and inconsistent weather patterns. In order to address this water scarcity, many governments are turning to water desalination plants as a potential solution, especially if they have a coast line with unlimited access to the sea. In order to understand this technology, the technical portion of my capstone research was designing a desalination plant to produce 150 million liters of water per day (MLD) for the city of Chennai, India which has a water deficit of 300 MLD. Chennai relies heavily on the monsoon season to fill their four water reservoirs that are meant to provide water for the whole year, however, three out of the four reservoirs have consistently dried up. Desalination, in this case, could be a good solution for the water shortage in Chennai. To understand the social implications of desalination plants, my STS research looked into the rise of desalination in California, and the groups in favor of and in opposition to the technology and how they are shaping its development. These research topics address the larger issue of water scarcity and how different technologies are developed to be part of the solution.

The technical portion of my research involved designing a desalination plant for Chennai, India that included a pretreatment, reverse osmosis (RO), and post-treatment system. The Bay of Bengal was chosen as the water source for the plant and about 190 MLD of seawater would be taken from the bay. The first part of the plant is pretreatment where the water is prepared for RO by removing all of the suspended and dissolved solids from the water. The RO system is the main part of the desalination plant in which NaCl is separated from water by going through a series of membranes that keep the salt behind while the water passes through. Both the water and brine leaving RO go through post-treatment processes in which the water has the necessary chemicals added to comply with U.S. and Indian drinking water standards, and the salt is

crystallized into food-grade salt for sale. The overall capital cost of the project would be around $1 billion and the yearly revenue would be around $87MM using a best-case scenario where the major energy-consuming process in brine post-treatment is removed in favor of passive evaporation. Unfortunately, that still results in a negative profit of $72MM over the 20-year life of the plant. In order to produce a profitable plant, salt production would not be advised because there could then be reduced pumping power throughout the plant which would greatly reduce the utility costs.

For the STS portion, I researched the decision to use desalination as one of the main water purification methods in California in response to the drought. My research was conducted to better understand the controversy and different beliefs surrounding the production of water, in order to help lawmakers, become more aware of the impact different social, technical, and political groups have on a government effort. Many government agencies and state water boards have put funding towards building desalination plants and developing the technology. There are currently 12 plants throughout California and many more waiting to be approved. The main opposition to these projects come from environmentalist and conservationist organizations. These groups do not believe that enough water-saving and conservation measures have been taken to start implementing desalination. There are a number of harmful environmental effects associated with desalination plants including the brine waste and large in-take pipes, both of which are known for killing marine life, as well as the extremely high energy usage required to run the plants. These are all issues that environmentalists believe make desalination a poor choice in terms of drought mitigation. However, desalination is the only technology that would be reliable and consistent in producing water during a drought, so water boards are still pushing for their approval. I believe that desalination is a necessary part of California's drought

mitigation, especially with the ongoing research to improve the technology and reduce its negative environmental impacts. On the other hand, I also believe that more water-saving technologies and conservation measures should be implemented so that California is not solely reliant on desalination.

Through my studies on both the technical and social side of desalination technology, I gained valuable insights on how industrial desalination plants work and how they impact society. Designing a desalination plant gave me the technical understanding of how it operates and the intricate systems that comprise it. Researching California's implementation of desalination and how various groups responded to it, gave me insight into what the main issues are in terms of desalination technology and what kind of development it still requires. The sociotechnical research influenced the technical portion of my thesis by convincing my group that we should eliminate brine waste in order to solve one of the main environmental problems associated with desalination. Unfortunately, the amount of energy required to eliminate brine waste and produce salt made my team's design economically unfavorable, however, it leaves plenty of room for future engineering teams to explore how to design a desalination plant that reduces the negative environmental impacts and still makes a profit.