Potential Desalination Plant in Santa Cruz, CA

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Abstract

Water is an essential part for human life; however, as water becomes scarcer, communities are coming up with new and innovative ways to retrieve water. Since the Earth consists of 30% land and 70% water, it only makes sense to utilize the 70%. Currently, there is a process called desalination where seawater, brackish groundwater, and or river water is being converted into a public potable water source. Desalination plants, usually found near coastal cities, are being utilized worldwide providing water for their own communities. With the current water shortage faced found in Santa Cruz, the city of Santa Cruz has proposed of building a desalination plant; however, as new modern technology often entails, the proposal was received with much skepticism. Questions about environmental impacts and research were sought after. In the past, there have been much political activities due to the plants, some even resulting in court. However, with the structure of a desalination plant in Santa Cruz, it will not only provide a rainfall-independent water resource for the immediate now, but also provide a water resource in times of extreme climate change that is to be expected. The motivation to have a readily available water resource will be measured to see if the environmental, financial, and political costs will outweigh the benefits.

Introduction

Currently, there is a water crisis in Santa Cruz that the city is fully aware of, and is now declared a Stage 1 Water Shortage Alert. Although, there are water conservation acts in place, extreme measures need to be taken; therefore, the city of Santa Cruz has drafted a proposal to build a desalination plant. The overall context of our project is to analyze the use of desalination plants in other parts of California and the world, and to see if implementing the desalination plants in Santa Cruz is a viable option.

Objective

The main objective is to access the viability of building a desalination plant in the Santa Cruz, using financial viability analysis and comparative studies to previous desalination plants. The challenge for this project is to investigate the ongoing water crisis in Santa Cruz, and to see the cost benefits of utilizing a desalination plant.

Hypothesis

Hypothesis: Is it politically, financially, and environmentally viable to build a desalination plant in Santa Cruz?

In order for desalination plant to be viable, it would have to be economically feasible, have enough support such as that from voters, and be environmentally neutral and or positive.

Data Sources

For the politics we used local papers, local community member groups and local officials to gauge the political climate. For financial analysis we analyzed data from water budgets, water plans, city budgets, water supply alternative reports and desalination financing reports. For the environmental analysis we looked at environmental impact reports, newspaper articles about equivalent desalination reports and various governmental reports on desalination plant environmental effects in Australia.

Methods and Assumption

Water Demand

Initially we looked at the demands of the Santa Cruz and Soquel Water District to assess the water needs and whether or not a desalination plant would be necessary. Currently the water supply for the Santa Cruz Water District includes three surface water sources and one groundwater well source. Together these sources produce a year-round average of 10 million gallons/day but this production often does not meet water demands (Erler &Kalinowski 2011). These sources are also limited because surface water sources are often important habitat for native and endangered species. Groundwater sources are also limited because removing too much water from aquifers lowers the water table below sea level and risks saltwater contamination. With this current water supply, and a lack of water storage capacity, the water demand is often not met and the Santa Cruz Water District is now in a water crisis. We used an estimate of the water demand by the city (Erler & Kalinowski 2011). For the supply estimate we looked at the production in Santa Cruz and did a regression on the data, the linear regression had the highest R^2 value so we used that formula to extrapolate the supply for the future. We placed the supply data on the demand graph to show the difference between supply and demand and the need for additional water sources in figure 3.

Environmental Impacts

Australia, known for being the driest inhabited continent, is much known for their use of desalination plants. One of the biggest desalination plant found in Australia is the Victorian Desalination Plant located in Bass Coast in southern Victoria, Australia. The project was completed in December 2012. The plant is capable of supplying up to 150 billion liters of water per year to Melbourne, Geelong, and other towns (State Government Victoria 2012). With a freshwater source becoming available, the environmental impacts of a desalination plant comes into questioning. Two of the main environmental issues faced with any desalination plants are the surrounding habitat of the plant and the energy used to facilitate the plant. In the case of the desalination plant found in Australia, the study report found that "…several protected species could be affected by the plant's construction and operation-including the orange-bellied parrot, the growling grass fog and the giant Gippsland earthworm- but none would be left "significantly" worse off." (State Government Victoria 2012). The marine habitat was a concern as well; however, monitoring and managing the discharge of saline concentration into the ocean is required. In addition, in order to avoid increasing local levels of ocean salinity regulating the dilution of the concentration is required. However, all these measures can be fully achieved without much difficulty. Moreover, the plant uses the most energy-efficient method of desalinating water, reverse osmosis, and include energy recovery devices to reduce power consumption. Its power supply is located underground with the pipeline (State Government Victoria 2013).

Another example of a successfully running desalination plant is in Sand City, California. Sand City Coastal Desalination Plant is the first full-scale seawater desalination facility in California. It is capable of producing about 98 million gallons of water and uses reverse osmosis process to desalinate brackish seawater. The plant became operational in April 2010. The plan for this project was to provide the community with a long-term water supply. Unlike the desalination plant found in Australia, the Sand City desalination plant chose not to run on renewable energy but rather to maximize energy efficiency, including energy recovery devices, and in result was able to decrease the energy use for a desalination plant by 60% (Water Technology 2010) One of the biggest environmental impact desalination plants has is of pulling water from the ocean as well as dumping back a diluted concentration of that water. In order to decrease the impact, Sand City utilizes brackish water. Less energy is used in purifying brackish water. In addition, the water released back into the ocean has the same salinity level as the water in Monterey and is released at the same depth as where the water was initially retrieved, making the impact on the ecology at effectively zero (Water Technology 2010).

Politics

Due to the amount of the controversy surrounding this project it is important to analyze the political history of the project as well as the public opinion about the project. The desalination project for Santa Cruz is a collaborative project lead by the City of Santa Cruz Water Department (SCWD) and the Soquel Creek Water District. The SCWD has specific needs for supplemental water supply which includes drought protection and protecting endangered species. The SCWD also has concerns about the current water supply, which they share with the Soquel Creek Water District. These concerns are overdrafting groundwater resources and that groundwater supply is at-risk for contamination by seawater intrusion. Rising out of these common needs and concerns in 2007 the City and the District joined together to share the costs corresponding to evaluating the proposed desalination project. Together the agencies created a joint goal that is to conserve, protect and create reliable water resources, which they believe can be met by the installation of the desalination facility. The timeline for the project, shown in the figure below, began in 2008 and is currently in its final stages of implementation. The Draft Environmental Impact Report was released on May 13, 2013 and included an extended 90-day comment period that closed on August 12, 2013. After this comment period a Draft EIR Public Review Summary Report was released which summarized public review process and provided an account of the public noticing and public hearings that were conducted, and the comments received on the Draft EIR. The next steps in the process of approval are to prepare a Final EIR and then put the project to vote by the city of Santa Cruz.

In the 90-day comment period more than 400 citizens, government agencies, organizations, and businesses mostly expressed concerns about the project. Many of the comments expressed concerns about the noise and visual impacts on the coast, as well as plans to offset high energy use by buying credits off-site. (Brown 2013) In addition several of the comments criticized the report for not including a complete and fully researched list of cheaper and more environmentally friendly alternatives to the proposed project. Another criticism of the project was that it did not include a water conservation alternative, which could significantly reduce water demand. These comments and the general public dissent led officials to conclude the project likely would fail if it were put to a vote in 2014. For this reason we have concluded that this project will most likely fail due to lack of political support.

Financial Analysis

A formal cost benefit analysis has not been conducted for the desalination plant since it has not finished the planning or environmental analysis stages of development. To get an estimate of the costs of this project we examined the associated costs of desalination, including the cost of development, reverse osmosis membranes and pumping costs. The city estimates the cost of the proposed desalination plant at $114 million dollars, but this only considers the capital cost to build the facility and purchase the land ($scwd^2$ 2013). Planning costs are also rising, including $12 million dollars that have already been spent on coordination and recent project proposals. To estimate the operational and maintenance costs for the desalination plant we compared the costs of similar reverse-osmosis plants and took an average based on the capacity and size of the plant.

We also looked at different alternatives that have been suggested as potential water supply sources in the Santa Cruz Water Plan (Erler &Kalinowski 2011). In addition to the desalination plant, the Santa Cruz Water District has also looked into reclamation of wastewater for use on agricultural fields instead of groundwater, drilling more wells to access groundwater, and implementing a water conservation plan. In order to estimate the costs of each of these alternatives we had to look at various information sources and water plans. Below is a table made explicitly listing our estimates and sources of data for the cost-benefit analysis.

Figure 2: Table of Data Sources and Estimates for Costs

	Capital Costs ($ millions)		**Operating & Maintenance Costs ($ millions)**	
	Estimate	Data Source	Estimate	Data Source

A Do Nothing	$8.8	Estimate from loss of revenue due to water shortage	--	No action therefore no O&M
B Drilling Wells	$2.35	Bid for well drilling issued by scwd	$1.11	Estimated from current well production
C Reclamation Site	$49.3	Report on Alternative water supplies	$0.4	Report on Alternative water supplies
D Desalination Plant	$114	Financial report on desalination plant	$3.5	Comparison to equivalent plants
E Conservation Plan	--	No actual facility, therefore no capital costs	$0.6	Estimated from yearly average in water budget

Bernal 2013, Black et al. 2013, Cooey & Ajami 2012, Fiske & Stout 2000, Goddard 2009, scwd[2] 2013

To estimate the benefits of each alternative we estimated the water production capacity through comparison to equivalent projects. From that we used the baseline water rate in Santa Cruz, which is 748 gallons for $1.57 and used unit analysis to get an estimate of total revenue for each alternative in 2013 monetary values. For the conservation plan alternative we used the historic water savings for the program, which has been operating since 2000, averaged the values and reached an estimate of 155 mgy (Fiske & Stout 2000). We used these estimates and data in an incremental cost-benefit analysis (figure 4) to compare the alternatives.

To estimate the costs we placed all capital costs in Annual value using this formula $A = P\left[\frac{i(1+i)^T}{(1+i)^T-1}\right]$. We used T = 50 years as an arbitrary value to pay off the capital cost of each alternative, with an arbitrary 5% interest rate. To determine the cost of the do nothing alternative we took the estimated water demand, subtracted the estimated water supply, which is shown in figure 3, and we got a percentage of water shortage. The Santa Cruz water district places 5 stages of water shortages, 5%, 15%, 25%, 35%, and 50% and estimated the total revenue loss of each scenario in 2007 (Goddard 2009). We estimated the difference in supply and demand up to 2030, established the percentage of shortage and used the revenue losses for each stage to determine the cost. We determined this was a capital cost because it would be a cost sustained in one year and paid off over multiple years so we used a 50 year timeframe to pay off debt caused by this cost.

Figure 3: Table Displaying Estimate of Revenue Loss for Do Nothing Alternative

Year	Average Demand (mgy)	Estimated Supply (mgy)	Deficit %	Revenue Loss ($ millions)	Current Capital Cost (2013 $ millions)
2010	3757.5	3725.54	1%	$ 0.58	$0.67
2015	3923	3644.81	7%	$1.65	$2.21
2020	4087	3564.08	13%	$1.65	$2.21
2025	4190	3483.35	17%	$1.65	$2.21
2030	4291.5	3402.62	21%	$1.65	$2.21

Black et al. 2013

Calculation/Results

Water Demand

Figure 4: Graph Displaying Estimated Water Demand and Supply

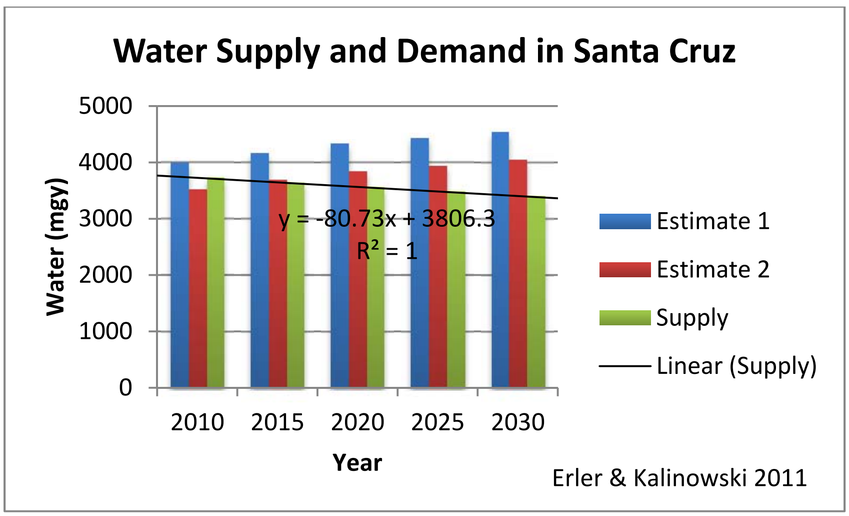

Figure 3 above The estimated water demand is increasing with the expanding population of Santa Cruz whereas the water supply has been steadily decreasing due to overexploitation of groundwater resources (Erler & Kalinowski 2011). This disparity between supply and demand has limited the development in UCSC, commercial buildings and private dwellings and increased water rates of residents. From these results we conclude that there is a need for additional water supply in Santa Cruz and desalination provides a feasible alternative.

Financial Analysis

Figure 4: Incremental Cost Benefit Analysis for Water Supply Alternatives in Santa Cruz

Compare	Project	B	C	Benefit/Cost (B/C)	ΔB	ΔC	ΔB/ΔC	Decision
	A Do Nothing	0	$0.52					
A - B					$0.86	$0.74	0.12	A > B
				0.07				
	B Drill Wells	$.086	$1.24					
A - C					$3.78	$3.1	1.22	C > A
	C Reclamation	$3.78	$3.1	1.22				
C - D					$-1.89	$8.29	-0.23	C > D
	D Desalination	$1.89	$11.4	0.17				
C - E					$-3.46	$-2.48	1.39	E > C
	E Conservation	$0.32	$0.62	0.52				

Black et al. 2013, Goddard 2009, scwd[2] 2013,

From the incremental cost-benefit analysis in Figure 4 the most cost effective alternative is the conservation plan. Unfortunately this analysis does not place a monetary value on the environmental benefits to an additional water supply that would give additional benefits to desalination and reclamation. It also fails to place environmental costs to additional groundwater pumping, in alternative B drilling additional wells, the water source is the same groundwater aquifer that is already being pumped from, which increases the danger for pumping below sea level and causing saltwater contamination to the groundwater. This analysis also assumes that each alternative fully meets water demand, which may not necessarily be true, especially in the case of the water conservation plan alternative.

Conclusions

Our initial hypothesis stated that constructing the desalination plant in Santa Cruz would only be a viable option only if it was environmentally, politically, and financially feasible; however, as research concluded that is not the case. Having a desalination plant would impact the environment; however, it was found that it would have a negative impact but not to a significant amount. Also, there are many different types of ways that a desalination plant can be utilized where the marine habitat can be left unaffected, such as that used in Sand City. In addition, the energy uses, such as the ones used in that of Victoria, Australia, can be energy friendly and efficient. Although, environmentally friendly, it was found that having a desalination plant comes with many political opposition. Such was found throughout the previous desalination plants. In the case of Santa Cruz, the proposal itself was met with much criticism. As mentioned previously, in the 90-day comment period, the community members, government agencies, and businesses expressed their concerns. Much of the comments were about not having enough research and information about the project's impact readily available. Due to much skepticism and opposition, the desalination plant in Santa Cruz does not have the political support it needs for it to be a viable option. In addition, financially the project is estimated at $114 million dollars, but this is only the capital cost of the land and the actual building of the plant. The costs of operation and maintenance can only be estimated at this point, and was explained previously. With the financial information provided, the cost seems to be higher than the water demand, currently being faced in Santa Cruz. With the costs outweighing the benefits for many community members, it seems that having a desalination plant in Santa Cruz fails to be financially viable. In conclusion, constructing a desalination plant in Santa Cruz may provide a rainfall-independent water source, it does not seem to outweigh the financial costs and provide any reassurance to the community members, thus lacking in political support.

Recommendation/Limitations

In order for the desalination plant in Santa Cruz to be a viable option, it needs to be environmentally, financially, and politically secure, and all three of these requirements can be fulfilled. Environmentally, there are many precautions and guidelines to take where having a desalination plant will not severely impact the environment, as some would presume, such as utilizing energy efficient tools. In addition, the water released back into the ocean can be tested in order for the concentration to have the same level of salinity as that of the ocean; therefore the impact the plant has on the ecology will be relatively low. Politically, the community needs to realize that Santa Cruz is already in a Stage 1 Water Alert, and that this condition will only worsen as time progresses. Constructing a rainfall-independent water resource may be the perfect solution for a coastal city, such as that of Santa Cruz. The community members need to be able to sacrifice some costs, environmentally and financially, for the benefits that will be provided through the desalination plants. Financially, the cost of water will continue to rise, and will heighten at some point, if action is not taken any sooner. Therefore, it may be wiser to invest in a project, such as that of a desalination plant, in order to have a more stable and secure water source, even in times of drought.

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