Arsenic Removal from OU Water

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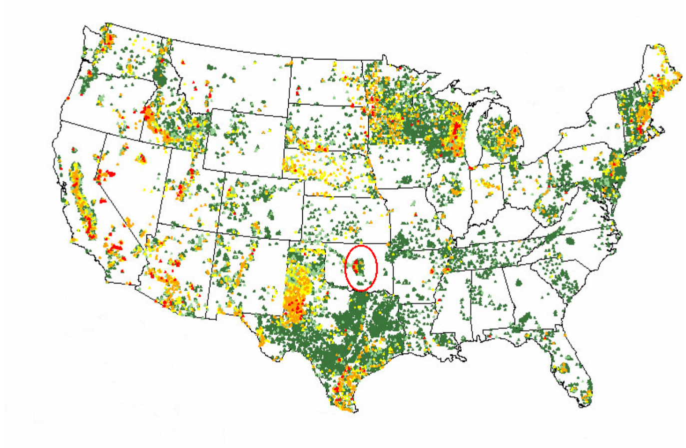


Arsenic Law

Under the 1996 amendments to the Safe Drinking Water Act, the EPA has decided to review the old acceptable arsenic levels in drinking water; and as the previous levels of 50 ppb will be replaced by a 0 ppb non-enforceable and 10 ppb enforceable levels of arsenic in all public drinking water systems effective as of January 23, 2006. The reason for this recent change from the old 50 ppb rule that was established in 1975 is that a March 1999 report by the National Academy of Sciences concluded that the current standard does not achieve EPA's goal of protecting public health and should be lowered as soon as possible.

Recent studies have linked long-term exposure to arsenic in drinking water to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. Non-cancer effects of ingesting arsenic include cardiovascular, pulmonary, immunological, neurological, and endocrine (e.g., diabetes) effects. Short-term exposure to high doses of arsenic can cause other adverse health effects that are irreversible in some cases.

OU Arsenic Situation

Well Data

With the new arsenic rule, the campus of the University of Oklahoma (OU) is now faced with the ultimatum to find a solution for its problem. Most of the problem wells in the Norman area are located on campus property, and are used to supply on-campus buildings with potable water. OU's maximum water consumption peaks toward the spring semester when residence halls and overall demand increases due to the heat. Currently, peak consumption reaches 1.5 million gallons per day. The maximum capacity of the water grid is around 2.0 million gallons per day, due to water towers limitations. The average arsenic content for all wells being presently used is 35 ppb. This automatically makes the whole system non-compliant with the 2006 deadline.

Well Constraints

OU's constraint is the geographical limitations presented by the campus boundaries. Any wells drilled outside campus property belong to the City of Norman. All the operational wells are situated in the Westheimer Airpark North of Robinson Street along HWY 77. A piping network connects them all to one main pipeline going down Berry Street towards the main campus. OU's restrictions are extremely limiting because of the small area allocated to drilling wells.

Water Purchase Option

The current plant implemented by the University of Oklahoma, at this point, is purchasing water from the City of Norman. Buying water from Norman may not be the least expensive option available to OU, because the price that will be set by the City of Norman for water purchase is unclear as of now. To date the University of Oklahoma has not made a decision on a solution to the lowering of arsenic level limits in 2006. Several alternatives to the water purchase option were proposed by various studies.

CH2M Hill Report

In 2002, the City of Norman and the University of Oklahoma hired CH2M Hill to do an analysis of the water supply in the Norman area and find the best way to become compliant with the 2006 MCL of 10 ppb. The report treated the well field of Norman and OU as one entity, and the solution given was the best for the community as a whole. The report is public domain, and available upon request from the Norman Public Library. The report analyzed all of the above treatments and looked at water purchase from Oklahoma City, blending the water, and drilling new wells. This report assumed the OU's water was incorporated into Norman's water, so the report is a rigorous examination of Norman's water problem and not OU's.

CE 5244 Arsenic Report Findings

An Arsenic study was submitted by a group of graduate civil engineering students at the University of Oklahoma College of Civil Engineering and Environmental Science, CE 5244 Water and Wastewater Treatment Course. The Civil Engineering report was submitted on April 22, 2001 to the City of Norman under the title of "Arsenic Removal in Groundwater". The Civil Engineers recommended the university use the process coagulation/filtration, and for Norman to drill wells to solve their arsenic problem.

Alternative Water Treatment Options Examined In This Study

There are many ways of treating arsenic in water. Here are some methods that were examined in this study:

Ion Exchange

Water is run through a bed of resin. The arsenic adsorbs to the resin. The resin is regenerated every few hours by running sulfuric acid through the bed.

Coagulation/Filtration

A liquid is added to the water causing a solid to precipitate out of the water. The arsenic adsorbs to the solid, and the solid is filtered out.

Nanofiltration

Water is pushed through a membrane. The water is filtered into two streams. One with a high concentration of arsenic, and the other has a low concentration of arsenic. The stream with the high concentration must be discarded in some way.

Ion Exchange Details

The design for an ion exchange facility is broken up into many parts. The facility will be housed in a building just north of Robinson Street, between Flood and Berry, on OU's airport campus. All designs will be based on the CH2M Hill design capacity of 2.08 million gallons per day. This value is approximately 30% higher than the maximum OU demand, but with OU growing in population and water demand annually, using this value near to the maximum flow of OU's well system is prudent.

Ion Exchange Facilities

Two important practical matters should be discussed. First, there is no reason that this process should not be readily expandable. Placing valves and connections in such a way that another column could be added if demand exceeds the process capacity is prudent, even though it is unlikely that the well field could support more than 2 million gallons per day. Second, with these columns in parallel, the capability exists to exchange the resin and regenerate the columns individually. Thus, the water supply to OU will not be cut off the several times a day that regeneration is required.

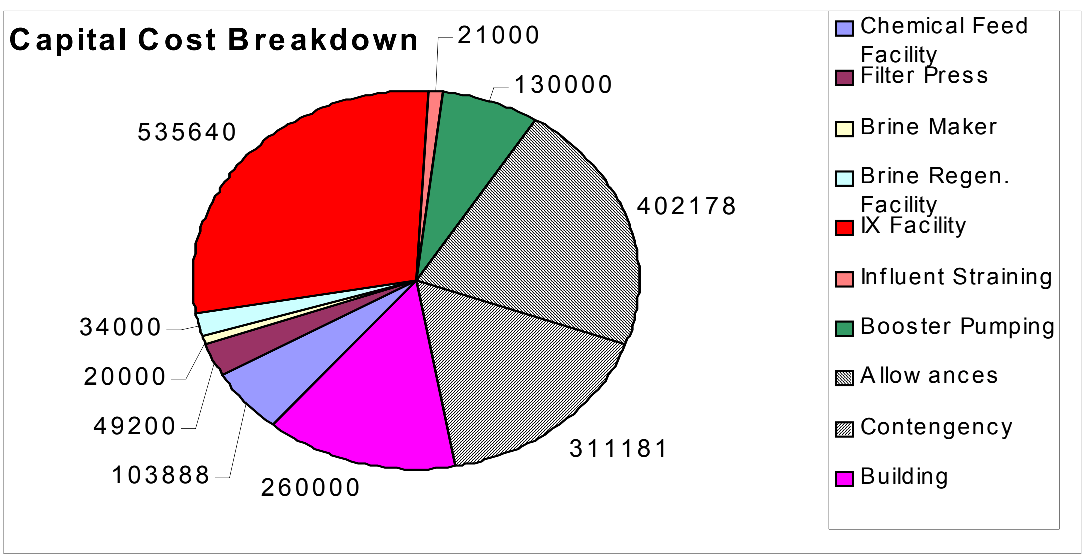


Figure #1: *Breakdown of Capital Costs*

Economic Evaluation

The economic attractiveness of all three water treatment options and the water purchase option were compared on equal grounds, for a project life time of 20 years. Figure 2 is a summary of the results obtained for the present cost of all four options.

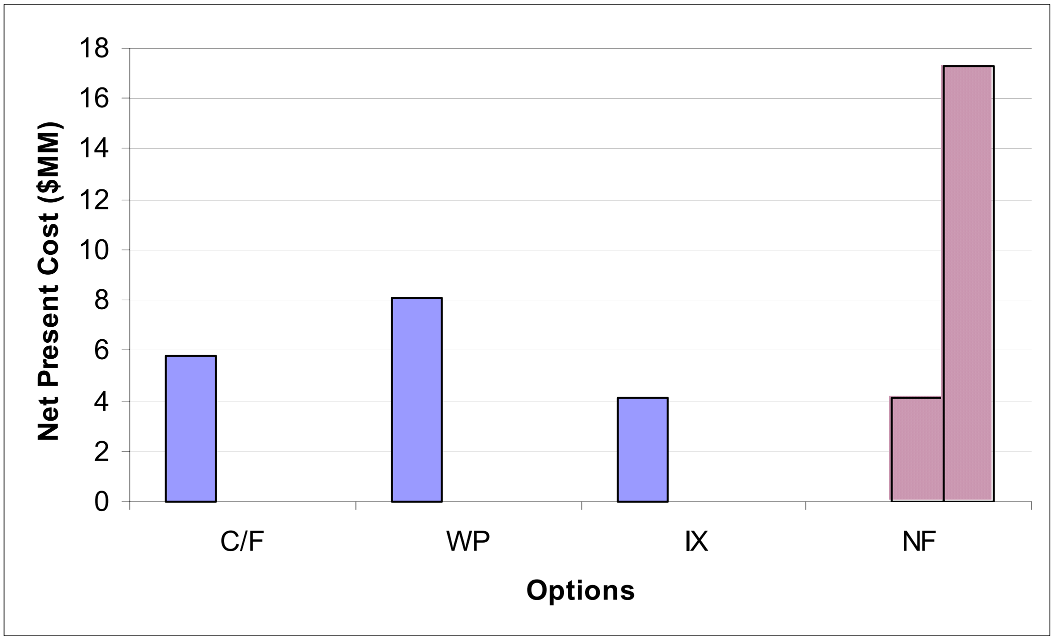


Figure 2: Net Present Cost for four potential Arsenic problem solutions for OU.

As a result of the economic feasibility comparison, an Ion Exchange facility turned out to be the clear winner among the treatment options, with a net present cost of approximately $4,000,000. Moreover, the IX treatment facility has a net present cost approximately half that of the water purchase option. In fact the water purchase option, evaluated at the current water price of $1.14/1000 gal, turned out to be the most expensive with a net present cost of $8,000,000. Nanofiltration was not considered as a realistic option due to tremendous uncertainty in the cost.

Ion Exchange vs. Water Purchase

A mathematical model was developed in order to compare the net present cost of building an Ion Exchange facility to the purchase of water from the City of Norman option. The main objective of the mathematical model was to simulate the Arsenic situation at the University of Oklahoma and find the most economically attractive solution by minimizing the net present cost, for a project life time of 20 years. The model was given the opportunity to choose between building a treatment facility or purchasing water from the City of Norman, in year of the project life time. Moreover, if the model made a decision to build a treatment facility, it was also given the ability to upgrade the existing facility in order to increase the water production capacity. The mathematical model was also provided with the finance equations necessary for it to be able to consider borrowing money from a bank and to figure out the optimum way to pay off the loan within the project lifetime. Time value of money as well as water price inflation were taken into account by the model.

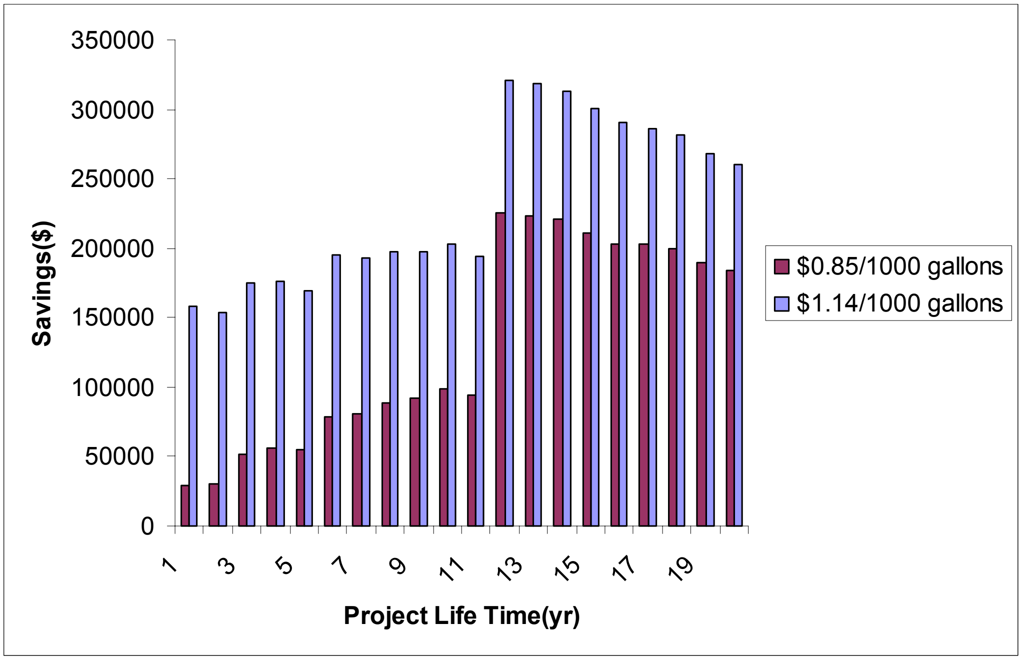


Figure 3: Savings made IX facility and Water Purchase as a function of time and water price graph.

As can be seen from Figure 3, the IX option results in significant savings, for every year of the project lifetime, when compared to the Water Purchase option. For approximately the first half of the project lifetime the savings start out low, $50,000 for the $0.85 price and $150,000 for the $1.14 price, and increase steadily until the money borrowed for the capital investment is paid off. This occurs approximately midway through the project lifetime, at which point the savings roughly double and stay constant until the last year.

Figure 4 is a summary of the net present cost results obtained from the mathematical model for the IX facility versus Water Purchase options comparison.

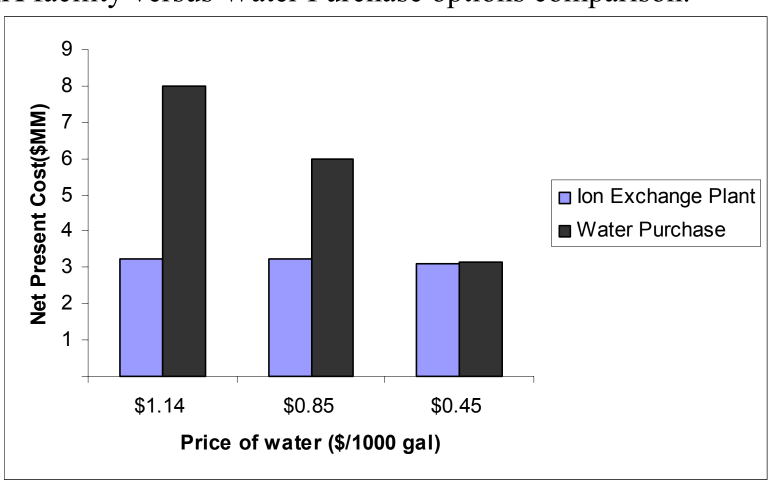


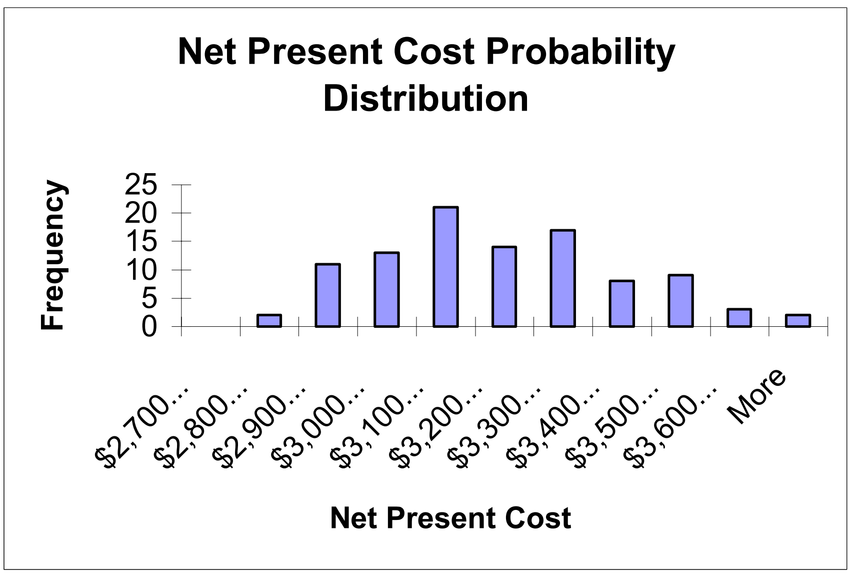
Figure 4: Net Present Cost for IX facility and Water Purchase as a function of water price graph.

Assuming that the price of water charged by the City of Norman remains constant at the current value of $1.14/1000 gal, for the next 20 years, the Ion Exchange facility option will result in approximately $5,000,000 of net present cost savings. It is also apparent from Figure 5 that the maximum allowable price of water for the WP option to match the economic attractiveness of the IX option is an unrealistic price of $0.45/1000 gals. Any price charged by the city of Norman that is above this number, results in loss of money if the WP option is chosen. It should also be taken into consideration that the price of water is not expected to stay constant or drop. Conversely, it is expected to increase, because of Norman's overwhelming growth that is projected to result in water shortage by year 2010.

Risk Assessment

The risk associated with building an IX treatment facility was evaluated by running a Monte Carlo simulation with 100 scenarios, with approximately 50% uncertainty into the operating cost and the water demand. The results are shown in figure 5.

***Figure 5:** Stochastic results of model*



Conclusion

In conclusion, ion exchange is the preferred solution to the OU Arsenic problem according to the findings of this report. The present cost over 20 years for Ion Exchange is about $4 million while the cost of purchasing water from Norman at the current price is $8 million.

Other treatment options were also investigated and eliminated due to high risk and/or present cost. Coagulation/Filtration was found to have a present cost of $6 million, and Nanofiltration has a large amount of uncertainty associated with the capital costs, with estimates ranging from $5 million to $17 million.