Mobile Water Treatment Facility Evaluation and Design

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Abstract:

The revised intent of this project is to define a prototype portable water treatment unit that is both cost effective and can meet current state and federal requirements for safe drinking water. The ability to meet such standards is critically important, given the fact that those consuming the water assume it is safe. During a disaster those impacted may be desperate for water leaving little or no time for proper testing. To the uninformed all mobile water sanitation units are impressive, yet the intended use, performance and knowledge of the designers vary widely.

I faced a variety of leadership opportunities in developing this project, most of which were initially unforeseen. In the execution of this project I became a mediator between a state agency and outside vendors. Personal gain motivated some, while others felt the project would only lead to additional regulations, red tape and work. The SEPHLI experience was a great help in allowing me to recognize my own decision and problem solving style, while working with others with completely different traits. The time limits established for this leadership project pushed me to complete as much as I did. Although I feel strongly that the certification of these water treatment units is important, I likely would not have continued with my investigation after the initial shortcomings. However, the requirement and desire to complete the SEPHLI leadership project motivated me to continue. While a great deal of work is still outstanding to fulfill my initial project statement, I feel it is a worthwhile endeavor and will continue working toward that effort.

Introduction / Background:

A continuous supply of clean safe drinking water is essential for human health. During periods of natural disaster the water supply of many communities may be compromised, contaminated or lost all together. In West Virginia, flooding is the most common form of disaster. The treatment facilities needed to produce clean potable water are often damaged by these same flooding events. The lack of clean safe water poses a health threat due to the complications of dehydration including cerebral edema, seizures, kidney failure or death. If the disaster event occurs during periods of hot weather, the situation worsens.

The floods of 2001 and 2002 inundated the towns of Welch and Mullens, as well as several smaller communities. The estimated cost due to loss of property, lost productivity and cleanup is 64 million dollars. During the rescue and response phase of this event, a handful of portable water treatment units mobilized to the area in an attempt to provide clean water. Upon arrival, they were confronted by state health officials who attempted to verify the quality of the finished water product. Some of the technologies and techniques used to purify the water were not familiar, therefore the

public health representatives attempted to apply guidelines for stationary municipal treatment plants. None of the portable units could meet these standards, therefore the water produced had to be boiled and cooled prior to consumptions or for use in cooking or washing utensils.

The need to restore large scale municipal water treatment service cannot be overstated. Even if the municipal water produced does not meet drinking water standards, it is likely suitable for cleanup purposes. Additionally, bottled water produced offsite in a factory setting, away from the disaster, is preferable to that produced by mobile treatment facilities. However, supplying the quantity of bottled water needed has proven difficult in emergency situations. Damaged roads and bridges often limit the weight, width or height of the vehicles that can pass. The distribution of bottled water is also hindered by the inherent inefficiencies of trucking water over the road. It is often impossible to get the quantity needed in an acceptable time frame. The quantity of potable water needed is often underestimated. In order to avoid the spread of disease, potable water is needed for hand washing, cooking, utensil washing as well as drinking. Therefore, during an emergency situation involving water distribution, the permanent municipal source should be restored as quickly as possible, as much accessible bottled water should be procured and mobile water sanitation units should be operated to supplement the supply as needed.

The initial goal of this project was to produce a document, or the beginnings of a document, that can be presented for consideration as a part of the State Code of West Virginia. The document would detail the physical requirements of mobile water treatment units for acceptability in providing potable water. This is still a long-term goal and I hope to have a hand in developing this in the future. The goal and intent of this project has since changed into producing a design of a prototype unit that may meet these future guidelines.

Project Description, Objectives and Methodology:

As stated above the initial intent of the project was to develop a document that would describe the proper design and operation of mobile water treatment plants. The hope was that this document would eventually become part of state code. When I approached staff members within our central office and informed them of my intentions, none were excited about the idea. The most often heard comment was that it was none of our business. If a water system does not operate sixty days a year and serve at least twenty-five individuals, it is not defined as a public water system and therefore not under state control. None of the emergencies to date in West Virginia resulted in water outages lasting sixty days or more. Therefore, most of the upper management in our office are comfortable in the stance that this is not their problem. When I asked who or what agency is responsible for these units, I was told that would lie with the Sanitarian on site at the time of the emergency. From my personal experience, I know that the local county sanitarians are not equipped to make these determinations. I base this on the fact that the sanitarians call our office for guidance when these units show up at

emergency sites. As the current situation stands mobile water treatment systems in West Virginia are untested and unregulated.

At this point, I decided to begin field testing of the available units. The rational for this was that with performance data in hand, I could better make the argument for the effectiveness of the units. This is where I encountered the second setback in the process. Neither of the two units I had access to could produce water meeting current state guidelines for turbidity as depicted in Appendix A. Turbidity is a unit of measure related to the particulate matter remaining in treated water. The measure of turbidity speaks of the overall effectiveness of the treatment process. The 1996 Safe Drinking Water Act requires a turbidity of 0.3 nephrolytic turbidity units (NTU) or less ninety-five percent of the time the filter is in operation. Higher readings indicate more particulate matter in the finished water. This matter could be bacteria, other microorganisms, viruses or more benign inert material. On one occasion, the testing took place on site in parallel with a municipal water treatment plant using the same raw water. I arranged for this so I could compare the results of the mobile unit with the in place municipal treatment plant. The municipal plant had no difficulty with producing water near 0.1 NTU. This result was verified with multiple meters and test equipment. Both of the mobile units tested were using some variety of string would or pleated cartridge filtration with no presedimentation. The raw water in both cases was not overly cloudy or otherwise difficult to treat. A disturbing factor related to this exercise is that an exact copy of at least one of these units has been sold to a local utility. I am certain that it is not the only portable unit ever sold, and each of these customers assumes the units produce safe water. This situation did present me with an unforeseen leadership opportunity, as it permitted me to explain the consequences of providing tainted drinking water to the general public.

I did not know exactly how to proceed at this point and upon the recommendation of SEPHLI staff I contacted Dr. Jamie Bartram, Ph.D., a professor of Environmental Engineering at the Gillings School of Global Public Health. Dr. Bartram has extensive international experience with water treatment through his service with the World Health Organization. Contacting Dr. Bartram was by far the most productive action taken in the development of this project. His suggestions included looking at international suppliers of mobile water treatment units, rapid deployment and retrieval of the units, and the possibility of incorporating these units into the permanent “ordinary” infrastructure. These suggestions and others really helped me to redevelop my project. The idea of redeployment and repurposing made me begin to consider the costs of these units. Ideally the units should have a low initial construction cost given that the possibility of loss or damage is high in a disaster zone. I surmised that a “throw away” unit may be best as each component could likely be repurposed or recycled locally within the impacted community. This idea is not original as after the 2001 flood a mobile municipal plant belonging the West Virginia rural water association became part of a damaged municipal plant. This mobile unit was neither cheap nor easily deployable, but rather a large sand filter mounted on a tractor trailer. This filter served the community of Mullens for many years after, until a new plant was constructed in 2006. I also got the feeling that Dr. Bartram was not a big fan of these mobile water treatment units, however his

email was positive and offered many good suggestions. Momentarily, I considered abandoning everything and trying to come up with easier, less menacing project that might fulfill the SEPHLI requirements. This was a short lived thought as I feel strongly that these units can be successful and fill an important need. I decided a refined design was needed.

I then began my research on some of the international units as suggest by Dr. Bartram. Many portable units are available and I have included examples of a few in Appendix B. Unfortunately, most of these units rely on some advanced form of treatment such as microfiltration or reverse osmosis. The question then becomes not if the unit will work, but rather who will operate it. Very few water plant operators in West Virginia have experience with these advanced forms of filtration and treatment. Learning to operate such a system requires time and training, neither of which is available in an emergency. In addition, these units are quite expensive. Most are built for water polishing, not emergency use. A typical use may involve removing a specific contaminant from an already treated water or providing ultrapure water for a specific use, such as a laboratory or hospital. None that I found are specifically designed for emergency potable water applications. This is likely due to the low return on investment given the sporadic need and usage. This again reinforces my concept of a cheap, recyclable system. The available raw water quality is also questionable for the commercial units. As previously noted, the commercial treatment plants are for making good water better, not for making bad water good enough. During flood event, there seems to be nothing but bad water, rendering the commercial units I found as useless.

Prior to beginning my career in public health I worked for an engineering consulting firm in the private sector. As a designer, I had the opportunity to design a few municipal water treatment plants, one of which could produce in excess of four million gallons of potable water per day. With this knowledge and the pilot test data I gathered for the two mobile units, I was convinced that the observed performance problems stem from the lack of sedimentation and depth filtration. I then surmised that perhaps it would be better to minimize existing, proven technology rather than trying to reinvent the wheel. I started by looking at locally available trailers, pumps, containment vessels, generators and chemical feeders. Most of the items proposed are available from building and hardware stores. In the case of the small pool used for the presedimentation basin, I found that item at Wal-Mart. The filtration units are pool filters with a combined area of 9.82 $ft.^2$. The units are plumbed in series to mimic the mixed media filter in an ordinary plant, so only half this area counts toward water filtration. The resulting production rate would be approximately14,000 gallons of potable water per day produced in two, eight-hour shifts. The volume is based on the assumption that half of the water produced would be used for back washing. Federal Emergency Management Agency (FEMA) guidelines suggest providing one gallon of water per day per person in an emergency situation. This is in contrast to the 60 gallons per day used to size ordinary municipal water treatment plants. Therefore at one sixtieth the size of a conventional plant a miniaturized portable unit should be sufficient to sustain a community in times of disaster. Given the fact that many of the proposed items are procured from building supply stores, replacement parts should be obtainable in a reasonable time frame. This

concept also lends itself to the repurposing of the component parts upon reestablishing the normal water supply. The generator, lights, pumps and even the trailer itself could be useful in a disaster zone. If not the unit could be retrieved or redeployed in other impacted areas.

Results:

The schematics and some of the relevant design calculations are included in Appendix C of this report. I plan to have more detailed drawings and design data for my presentation at the December SEPHLI retreat. So the conclusion of the project is a concept of a device that may work. I am not satisfied with this and will endeavor to develop a prototype unit for testing and refinement. This presents the problem of funding and liability. I am at this point willing to donate my concept and provide guidance to someone willing to build the unit. However, I cannot place my professional licensure and my family's well being in jeopardy in order to complete my goal. As a professional engineer in the state of West Virginia I am personally liable for every design I produce. This is regardless of whether or not I receive any compensation for the work. This project represents a device that could make people sick if constructed or operated incorrectly. I certainly would be included in any pending litigation if this occurred. In addition, few of the items needed to construct the proposed mobile water treatment plant have received NSF61 certification. NSF International is a not-for-profit, non-governmental organization that provides testing and certification of items that come in contact with drinking water, as well as other functions. The manufacturers of swimming pool filters and the proposed polyethylene barrels likely do not have intentions of securing NSF61 certification for their items, as they were never intended for contact with public drinking water. This produced yet another facet of the liability issue, although I believe most of these issues could be resolved with some effort. It may appear that I am quite cavalier with the suggestion that human beings be provided with drinking water, during emergency periods, from equipment that is not certified. The fact is, the health risk presented by the lack of water far exceed that of ingesting some infinitesimal amount of a regulated water contaminant. Most of the regulated contaminants and all of the contaminants that may leach from a pool filter only produce adverse affects through long term chronic exposure. In an emergency water of good clarity (less than 0.3 NTU) properly disinfected will suffice for short term use.

My initial goal and project intent of producing a Code of State Rule for Mobile Water Treatment Units now seems fanciful and far off. Actually developing a prototype that can produce such water seems more attainable. The eventual rule is however still a long term goal, that if completed, may serve as a model for other states. As for now the status of the new rule remains, long term.

Conclusion:

Proposing anything new through state and federal government is difficult. In our region of the country the difficulty is even greater, due to the fierce independence of those we serve. Throughout the development of this project I found myself in communication with

either those who did not want to regulate a single additional item or those who do not wish to be regulated. However, both groups sporadically contact me for my assistance and advice. This project has more than anything been an exercise in flexibility, reevaluation and compromise. Rather than being discouraging, the exercise has given me clarity and a renewed desire to complete my initial goals. Throughout it all, I have not questioned the value and ultimate good of producing safe water, on site, during emergency situations. Every piece of information or knowledge obtained through this process has helped me to restate the initial thesis and refine the project goals while still staying true to the initial project concept.

Leadership Development:

The SEPHLI leadership project was eye opening to me in that it forced me to reflect on the results that occurred due to the actions I initiated. I do not think that I would have ever noticed this in my day to day leadership activities. The SEPHLI tools enable me to evaluate my performance and react to others knowing that I come to the table with certain predetermined traits and tendencies. I do not suggest that this means I will be unyielding or try to manipulate the situation to fit my styles, only that I will recognize that I may be coming from a predetermined viewpoint that needs modification.

My learning project, as stated above, is an ongoing exercise and will bear fruit in due time. The greatest learning opportunities, however, did not come through the successes but the setbacks. The most telling test result I received from any of the SEPHLI scoring was the Myer-Briggs Intuition score of a perfect 30. This seems in contrast with my pragmatist change style indicator score of 6 yet in reality it is not. I tend to be willing to moderate and listen to others yet always feel that my initial assumptions are correct. I think that I have always suspected this, yet never acknowledged it. The leadership project demonstrated this perfectly when the initial field testing resulted in failure. How could this be, I already predetermined that the units would succeed and lead to next step in my project. Rather than accept the setback and evaluate the failure within the framework of the project, I attacked the manufactures of the units. This in itself was not a bad thing, as I firmly believe each of these units is a threat to public health, however most of my outrage was due to my initial lapse in judgment and my intuition letting me down. Although I will always rely heavily on my intuition, I am trying to be more honestly open-minded rather than the condescending pragmatist I have been in the past.

My initial stumbling with the mentoring process ultimately resulted in the greatest benefit I received from this program. Although our communications were brief, it was an exercise in me letting go and asking someone else for help. I hope that this is a lesson I do not soon forget. The greatest lesson I learned was how to properly evaluate and select a mentor. A true mentor is one who can provide insight and knowledge based on their past practices and expertise. Although there is value in the experience of problem solving with a peer group, the sage advice and guidance of someone who has already been down that road in invaluable. This was not only the most valuable part of the SEPHLI experience for me, it was the hardest. Again, I strongly rely on my intuition.

The individual development plan also proved to be beneficial to me throughout the year. I managed to fully implement two of my three items. The last item, which involved cutting edge water treatment technologies, was to go hand in hand with my leadership project. However, upon reevaluating my project I went with the low tech approach for reasons explained earlier in this report. I did manage to begin regular, scheduled monthly meetings with my staff. This has not been without its own thorns, yet we are now all committed to the process and it is proceeding as planned. As stated earlier, pragmatism and mediation is not a problem for me. What is a problem is when consensus is the agreed upon approach and the outcome does not please me. I am working on this and the staff meetings have been a great arena for practice.

The SEPHLI program has been a great experience for me. Seeing all of the pieces come together and the interrelation of the readings, exercises and projects has been very rewarding. I hope to take what I have learned and implement it within my life, as well as my leadership career. I give sincere thanks to the SEPHLI staff and contributors for producing such an excellent program.