WATER SYSTEM CONSOLIDATION FOR WESTINGHOUSE SAVANNAH RIVER COMPANY

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Abstract. As part of a water distribution study for Westinghouse Savannah River Company (WSRC), Metcalf & Eddy, Inc. (M&E) evaluated the potential for total or partial consolidation of the site's water supply systems. Under current operation, the site meets water demand through 28 systems serving populations from 1000 to 6000 consumers. With an overall 24-hour average water demand of 1080 gallons per minute (gpm) and peak water demands varying in each system from 10 to 750 gpm, the site area for consolidation covers approximately 300 square miles. Multiple consolidation alternatives were evaluated for consolidation of the drinking water supply. Potential shifts in population centers and area demands was an important element considered in the study.

The evaluation of the alternatives considered available groundwater and surface water quality and quantity to meet the projected demand while considering capital costs, operational reliability and flexibility, and low life-cycle cost. Hydraulic analysis of the water distribution transmission lines for each alternative were modelled using an M&E digital computer modeling program. Ranking and weighting of both economic and non-economic factors allowed for a recommendation of a final alternative for consolidation. It was shown that in many cases, non-economic factors could be as important, if not more important, than economic factors.

INTRODUCTION

Many smaller municipalities consider consolidation of multiple small well water or surface water systems to be a prohibitively expensive alternative to upgrade their system's reliability and flexibility. However, this study reveals that capital costs should not be the only factor determining the selection of an upgrade alternative. Life-cycle costs and non-economic factors are sometimes more important in the selection than capital costs.

This study provided an independent study and evaluation of alternatives for the consolidation of domestic water systems and well water systems at the Savannah River Site (SRS) of WSRC. The need for this study was documented by both WSRC and the Department of Energy (DOE) in two previous studies. The common conclusion of these studies was that an independent "engineering study be conducted" (DOE and NUS, 1992) to determine the most technically solid and economically attractive alternatives to improve the SRS water system (WSRC, 1992). Both studies considered consolidation alternatives and recognized the need for further study.

The SRS site, Figure 1, located on the Savannah River near Jackson, South Carolina, is a DOE facility serving in the nuclear industry. SRS has 28 domestic water systems, each containing production, treatment, supply and storage capabilities. The systems are remotely located from each other. The systems are divided into 14 large systems servicing major production areas of the site and 14 small systems serving minor support facilities including site entrance barricades. Thirteen of the large systems treat and distribute groundwater; one of the large systems, which treats Savannah River water, is currently being changed to a groundwater supply. All of the 14 small systems treat groundwater. The large systems either include or will include treatment systems to meet secondary maximum contaminant limits (MCLs) as determined by the South Carolina Department of Health and Environmental Control (SCDHEC). The smaller systems are not required to meet the secondary MCLs.

Figure 1. Location of SRS site.

A unique circumstance that had to be considered was the potential for shifts in population centers and area demands. Each area of SRS serves a specific function. If that area is no longer required for site operation, the area could be shut down and the working population transferred to another area on site. This presents a unique challenge to meet the demands of the shifting population.

Most of the systems were designed and developed in the 1950s prior to the promulgation of State or Federal drinking water regulations. As a result of recent SCDHEC system audits, DOE submitted a draft plan to SCDHEC describing planned system modifications to address State regulations and audit findings. The plan was adopted and identified as the "current upgrade" plan. This plan included 19 separate enhancement projects with completion dates ranging from 1992 to 1997. However, the upgrade maintained the integrity of the 28 individual area systems with the exception of two, which were planned to be consolidated.

In the process of reviewing this upgrade plan, SCDHEC indicated willingness to accept consolidated systems if it is proven to be more favorable than the current upgrade program. SRS committed to SCDHEC to have an independent engineering consulting firm evaluate the feasibility of consolidation alternatives.

Purpose

The purpose of the study was twofold. M&E was to develop preliminary consolidation alternatives and, based on capital costs, life-cycle costs, and non-economic impacts, rank each in order of recommendation. Secondly, the recommended alternatives were to be compared with the current upgrade plan. An independent recommendation, made from these comparisons using the economic and non-economic comparisons between the recommended consolidation alternatives and the current upgrade, was to be made to WSRC for use in determining the future course of the SRS upgrade.

ALTERNATIVES DEVELOPMENT

Key to the development of the alternatives was the knowledge of separate area function, description, topography, and demand flow including the combined use of some wells for domestic, fire, process, and service purposes in some areas. Using both field observations and existing reports and operating documents, M&E was able to obtain insight into SRS costs, equipment and system configuration.

Of the 28 systems, it was determined that the 14 smaller system demands would not be considered in the consolidation study since they have low 24-hour demands, are typically remote from the large areas, and have existing well systems which will not require additional treatment for secondary MCLs.

For the development of the preliminary alternatives, domestic water demands were used. Other factors considered in the alternatives development were the costs associated with the use of existing equipment, the variation of SRS topography and its affect on hydraulic system requirements, and availability of water sources. Scattered throughout SRS are elevated storage tanks, water treatment facilities, and water wells. The use of these existing facilities in the consolidated alternatives would help to reduce the overall costs of consolidation.

Site topography was considered because of the elevation differentials from area to area. In a consolidated system, variations in ground and tank overflow elevations could have potentially caused excessive pressures in the water transmission pipes. System pressure would be influential in the sizing and configuration of any alternative piping systems.

Alternatives development and recommendation was based on a three step process: (1) Hydraulic modelling to develop system configurations, with recommendation of final alternatives based on capital costs of each configuration, (2) Life-cycle cost development of the final alternatives, and (3) Ranking and recommendation of the alternative of choice using economic and non-economic bases.

Capital Cost Development

Once the preliminary alternatives were conceptually designed using the hydraulic modelling and other tools, unit prices for the concepts were obtained from vendor quotes (used for major equipment), recent bids at WSRC (used for construction costs) and other cost estimating sources. The unit prices and construction quantities were used to compute total capital costs for each preliminary alternative.

A contingency was added to the capital costs to allow a fair comparison with the current upgrade program which has this contingency included. Other costs added into the capital costs included both costs associated with upgrades to each areas water system and costs associated with cancellation of some upgrade activities already underway in several areas. It was noted that the higher capital cost alternatives tended to be the alternatives with the most consolidated systems. This was expected since consolidation is a construction intensive effort where maintaining the separate systems requires minimal construction effort.

Three preliminary alternatives were selected to be used as the basis for the more extensive life-cycle cost analysis. These final alternatives were selected due to their relatively low capital costs and use of more consolidated systems. Other alternatives contained more consolidated systems or were lower in capital costs. However, the selected final alternatives allowed M&E to base its final analysis on alternatives containing relatively low capital costs and consolidated systems. Compared to the current upgrade, two of the three alternatives had lower capital costs.

Life-Cycle Cost Development

The three domestic alternatives, three well water alternatives and the corresponding current upgrade, were subjected to a 30-year present worth life-cycle cost analysis.

Operation and maintenance life cycle costs included annual maintenance, equipment replacement cost, and compliance testing. These costs were calculated to a present worth value for 1996 as is the case of the current upgrade costs. The inflated annual costs are discounted to a present worth value for 1996. Adding all capital costs and operation and maintenance costs, inflated and discounted, yielded a total cost that was used for comparison purposes.

Economic and Non-Economic Ranking of Final Alternatives

Economic Ranking. Economic factors are important to the development of final alternative recommendations. While capital costs are important for site budget considerations, water utilities are typically evaluated based on life-cycle costs. In the evaluation, capital and operation and maintenance costs were each given equal weights and ranked from lowest cost (top rank) to highest.

Non-Economic Ranking. While economics are important in the selection of a water system, non-economic factors are also important. It was important that the final alternatives be economically attractive while providing a high degree of flexibility. System reliability also was identified as having a high priority to SRS and SCDHEC since several incidents involving unplanned depressurization of area distribution piping systems had occurred. System operability was also a high priority. Alternatives with more consolidation provided fewer numbers of water treatment plants and equipment to run, allowed more consistent operation, and required less manpower. Flexibility was determined by the following factors:

- hydraulic sensitivity to shifting are demands, population changes, and simultaneous peak demands
- treatment and storage capacity
- system line break sensitivity

System reliability was determined by the following factors:

- duplicate source and backup treatment
- sharing of source, treatment, and storage facilities between consolidated systems
- isolation of areas due to system line breaks

The operability aspect was determined by the following factors:

- manpower and upkeep requirements due to multiple facilities
- levels of remoteness of multiple systems

After ranking the final alternatives non-economically, it was determined that the current upgrade planned at SRS was the lowest ranked alternative. The final alternative containing the fully looped distribution system combining multiple remote areas was the highest ranked alternative non-economically.

FINAL RANKING AND CONCLUSIONS

Each final alternative and the current upgrade alternative were ranked to make a final recommendation. Equal weight was given to all ranking criteria since treatability, operability, and reliability were so important to SCDHEC.

The top ranked alternative was the completely looped system. This was true for both the domestic and well water alternatives compared. The completely looped system had the highest ranking in non-economic criteria and had lower life-cycle cost when compared to the current upgrade alternative. In fact the current upgrade, keeping all the 14 large systems independent, had the lowest ranking of all alternatives considered. It was concluded from the study that the current upgrade plan was neither the most economically nor non-economically attractive alternative for development of a water system for the SRS site to meet the current SCDHEC drinking water requirements.

The fully looped distribution system contained inherent advantages such as:

- flexibility in responding to shifting demands, populations, and facility missions
- increased treatment and storage capacity
- increased backup in case of line breaks
- duplicate source and backup treatment by connecting remote areas
- fewer new source, treatment, and storage facilities were required due to the shared capacities
- lower upkeep and manpower requirements due to the reduced number of new facilities required
- lower life cycle costs due to the reduced operation and maintenance costs

Capital costs should not be the only determining factor in the selection of any type of water supply system. As shown, the recommended alternative for development at SRS was actually a high capital cost alternative. However, due to its superior ranking in low operation and maintenance costs and system flexibility and reliability, it handily beat the other alternatives in overall ranking. Non-economic factors greatly influenced the selection process.

FUTURE CONSIDERATIONS

After finalizing the results of the study, DOE requested that M&E develop additional variations to the final alternatives above to more fully consider potential site mission changes or population shifts. An additional 19 alternatives were developed for consideration and comparison against the current upgrade.

Basing this evaluation on the same criteria described above, a ranking system was developed for all the new alternatives. After considerable evaluation, it was determined that minor variations of the previously recommended large, looped alternative were the most highly ranked alternatives, both economically and non-economically. The results of this second phase of the study enhanced the results of the original study: a large, looped system is the best alternative for development of a consolidated water supply system at SRS.

A looped system should always be considered for any water supply system design. It will likely be the alternative with the highest rankings in a study that requires a high level of non-economic factors.

LITERATURE CITED

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