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Sensor Acquisition for Water Utilities: Addendum

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1 Introduction

The Department of Homeland Security (DHS) has tasked a multi-laboratory team to evaluate current and future needs to protect the nation's water distribution infrastructure by supporting an objective evaluation of current and new technologies. This effort has

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been funded as part of an Operational Technology Demonstration (OTD). Lawrence Livermore National Laboratory and Sandia National Laboratories were tasked with the development of a technology acquisition process, referred to as the Task 2 effort. Lawrence Livermore National Laboratory and Sandia National Laboratories have met the requirements of this task with the following two deliverables: (1) *Sensor Acquisition for Water Utilities: A Survey and Technology List*, UCRL-TR-210488/SAND2005-2671P and (2) *Compiled Database of Water Sensors*, UCRL-MI-211877 submitted April 29, 2005 and May 2, 2005 respectively. This addendum serves to identify potential areas for follow on effort and funding that are a natural progression of the Task 2 work.

2 Discussion

In Task 2's review and compilation of the current state of water sensor technology and consultation with various members of the OTD Task 1 Advisory Board, we have identified two key areas that would benefit from additional funding and effort: (1) the development of a more detailed methodology for selecting sensors for various specific applications, and (2) the expansion of the Task 2 sensor database into an advanced database.

2.1 Toward a More Detailed Sensor Down Selection Criteria

The Task 2 report, *Sensor Acquisition for Water Utilities: A Survey and Technology List*, UCRL-TR-210488/SAND2005-2671P, identifies sensor acquisition parameters in Table 3 and in Section 4.2. Review of previous studies of Early Warning Systems (EWS), sensor technology, and discussions with water utilities demonstrate that no single sensor can meet all of the various water distribution systems' needs (ASCE, 2004; AWWA, 2005). While it would be convenient to apply a one-size-fits-all down selection process for all utilities, it would be inappropriate, as the selection of contaminant sensors is a complex problem that requires extensive and detailed analysis (AWWA, 2005; Kiwa, 2004).

It is desirable to have a down selection methodology that would be useful for specific classes of water distributions systems. Categorizing water utilities into classes by, for example, the age or the size of the water distribution system, or by the financial resources available to the utility, could assist in focusing the generalized sensor down selection process for specific utilities. Such a refined down selection capability could involve a thorough system analysis including, but not limited to, water distribution system studies such as the TEVA effort to reduce parameteric uncertainty in complex water distribution systems. This tool may include multiattribute utility theory to evaluate alternatives for complicated problems with multiple objectives (e.g., Dyer et al., 1998), or might involve a stochastic approach to guide optimal sensor placement within distribution systems (e.g., Murray, 2004; Johannesson et al., 2004). Such methodologies have been successfully applied to problems including the disposition of surplus weapons grade plutonium, the siting of an electricity generation facility (Dyer et al., 1998), improved predictions of contaminant transport through geologic material (Aines et al., 2002), and improved sensor and source analysis for atmospheric dispersion problems (Johannesson et al, 2004). Additional fidelity could include the economic considerations for both (1)

employing current technologies in an EWS role for water distribution systems and (2) developing emerging sensor technologies specifically for water distribution system use.

While the authors refer to sensor-placement issues, alert management, and emergency response, a few more references and discussion points may be relevant here. Some of the emergency response capabilities that the Department of Homeland Security is investing in should be considered -- for instance the recent TOPOFF3[3] interagency exercise for emergency response to atmospheric release may be relevant to water distribution EWS emergency response issues.

2.2 Toward an Expanded Sensor Database

The sensor database, *Compiled Database of Water Sensors*, UCRL-MI-211877, was necessarily submitted as a Microsoft Excel spreadsheet[4] given the time and budget constraints. While the database is comprehensive in both number of sensors represented with relevant attributes for selection criteria and is searchable on several different levels using the sensor parameters, this tool could be more powerful by incorporating the list into an advanced and dynamic database. To maintain its usefulness, the database would need to be a "living" document with a point of contact to add new sensor information as it became available. Additionally, a communication path, such as an internal web site, should be established that would facilitate sensor information going back and forth between water utilities, vendors, test programs, and the database point of contact.

An alternative to developing a more advanced database is to incorporate the sensor database information into EPA's more comprehensive water sensor database currently being developed. This would allow the DHS effort to add benefit to an existing program. The upcoming EPA database is likely to be the central source of sensor data and will be a resource to continue the dataflow with water utilities, vendors, and test programs.

An inherent weakness on part of the sensor database is the dependency on information from private vendors. The gathering of current, relevant, and objective information is a difficult task. To address this problem, comprehensive involuntary testing programs of sensors such as the EPA's Technology Testing and Evaluation Program (TTEP)[5] can provide reliable performance information from an objective source.

3 Conclusion

The Task 2 component of the DHS Water OTD has successfully completed the requirements to provide a sensor acquisition strategy and technology list through the timely submittal of the previously identified documents. The Task 2 work has contributed to the larger water community's efforts to define and understand Early Warning Systems for water distribution systems by synthesizing previous efforts by other agencies and developing a list of sensor technology.

[3] http://www.ojp.usdoj.gov/odp/exercises.htm#topoff3
[4] Note there is companion text in the document, *Compiled Database of Water Sensors: Instrument Descriptions*, UCRL-MI-211877, providing a summary of each of the sensors in the database.
[5] http://www.epa.gov/ordnhsrc/tte.htm

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