EXECUTIVE SUMMARY

OBJECTIVES.

The objectives of this project were to: **1.)** Host an expert workshop to identify research needs for opportunistic premise (i.e., building) plumbing pathogens (OPPPs); **2.)** With the assistance of the workshop participants, prepare this research report that critically reviews the state of the knowledge of OPPPs and identifies key research gaps; and **3.)** Develop and rank a list of requests for proposals (RFPs) that address these key research gaps.

BACKGROUND.

The successful mitigation of microbiological hazards in drinking water represents one of the 10 greatest engineering achievements of the 20th century. Widespread implementation of water treatment and disinfection have virtually eliminated incidence of diseases such as typhoid in the United States. In 2008, however, the U.S. Centers for Disease Control and Prevention acknowledged that a greater incidence of waterborne disease outbreaks are attributable to microbes that persist and grow in premise plumbing (especially *Legionella pneumophila*) versus traditional fecal-borne pathogens leaving the treatment plant. "Premise plumbing" refers to the portion of potable water distribution systems beyond the property line and in buildings (e.g., businesses, schools, private homes, apartments). Addressing these OPPPs poses a logistical challenge because water systems are designed and regulated to control pathogens leaving the water treatment facility, whereas OPPPs reside and multiply in building water systems. The five model OPPPs that were the focus of this study were: *Legionella pneumophila*, *Mycobacterium avium* Complex (MAC), *Pseudomonas aeruginosa*, *Acanthamoeba* spp., and *Naegleria fowleri*. In particular, addressing these OPPPs is challenged by research gaps in four key areas: **1.) Epidemiology**. Increasing incidence of infection and outbreak and broad, non-traditional susceptibility groups suggest that OPPPs are more than "opportunistic" in that a significant and increasing portion of the population is at risk. However, because *L. pneumophila* is the only reportable OPPP, and only on a voluntary basis, there is very little information on the actual incidence of diseases caused by OPPPs. Further, while several studies have demonstrated premise plumbing to be a source of opportunistic pathogen infection, very little is known about dose-response and to what extent potable water contributes to disease relative to other sources. **2.) Methodology**. There are no detailed accepted standardized methodologies or protocols for detecting and quantifying viable and infectious OPPPs in potable water, especially when the objective requires simultaneous monitoring of multiple pathogens. Specifically, knowledge gaps exist with respect to optimal selection of monitoring points, sampling methods, and sample processing. Further, culture-based methods can be influenced by reduced recovery of viable cells, can provide poor quantitation, are time-consuming, and are subject to contamination. While molecular-based methods are gaining ground, improvements are still generally needed in terms of their target specificity and detection limits for live and infectious pathogens. **3.) Microbial Ecology**. Premise plumbing is a unique ecological niche and home to a robust microbial ecology of which OPPPs are integral members. In particular, the bacterial OPPPs have a tendency to infect and grow in pathogenic and non-pathogenic amoeba, a process that not only enhances bacterial OPPP reproduction, but can also increase their virulence. Many OPPPs are also relatively resistant to disinfectants (especially *M. avium* Complex) and thrive under the

extreme oligotrophic condition of drinking water. Understanding the range of environmental conditions and key interactions with other microbes is critical to development of strategies to limit OPPP proliferation in building plumbing. **4.) Engineering Controls.** There are currently no known engineering controls that reliably limit proliferation of all OPPPs under all circumstances. Further, some approaches may reduce numbers of one pathogen, but may stimulate another, or have unintended consequences on the integrity of the plumbing system as a whole. In spite of the complexity of the situation and depending on the circumstances, it appears that combined efforts of various stakeholders, ranging from water utilities to building proprietors, may be effective in reducing risks to consumers.

APPROACH.

The workshop participants gathered and consulted to guide the development of this critical review document. Expertise included representatives from academia, utilities, government agencies, and industry. For the preparation of this document the participants were assigned to teams and challenged to summarize the state of the knowledge and identify knowledge gaps in the four key areas of Epidemiology, Methodology, Microbial Ecology, and Engineering Controls. Nine conference calls were conducted from September to December, 2011, for discussion and development of this literature review. Contributing authors developed written text, which were integrated into this final document and further reviewed by the workshop participants and the PAC. On March 25 and 26, 2012, an expert workshop was conducted in Falls Church, Virginia, where key outcomes of the review, critical knowledge gaps, and emergent research needs were presented and discussed in great depth. The purpose was to recommend a path forward to generate the fundamental and practical knowledge necessary to addressing the importing public health challenge that OPPPs pose. A total of 20 RFPs were developed and ranked by the workshop participants. These RFPs may be considered by research sponsors that share in their understanding of the importance of OPPPs.

RESULTS/CONCLUSIONS.

The ultimate products of this report are the 20 ranked RFPs, described in the final chapter. These summarize and highlight the most pressing research needs for addressing OPPPs. Two of the top three RFPs dealt with Epidemiology research needs. Specifically, determining the prevalence, incidence and trends of OPPP disease was identified as the top research need. Expanding this to identify sources and weights of various sources of OPPP disease ranked third. The second highest ranked RFP highlighted the need for improved Methodology in terms of appropriate sampling and monitoring strategies that provide meaningful data for determining risk of OPPP infection or outbreaks. The fourth highest ranked RFP called for a molecular-based spatial and temporal survey of OPPPs in premise plumbing systems. The fifth highest ranked RFP called for a study to determine the level of control that water treatment plants and the distribution system microbiome have on premise plumbing Microbial Ecology. The top ranked RFP with respect to Engineering Controls is research calling for identification of the fundamental factors/mechanisms that control detachment and release of OPPPs from biofilms in premise plumbing, which ranked 6th overall. Specifically, the 20 RFP titles, in ranked order, were:

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FOREWORD

The Water Research Foundation (Foundation) is a nonprofit corporation dedicated to the development and implementation of scientifically sound research designed to help drinking water utilities respond to regulatory requirements and address high-priority concerns. The Foundation's research agenda is developed through a process of consultation with Foundation subscribers and other drinking water professionals. The Foundation's Board of Trustees and other professional volunteers help prioritize and select research projects for funding based upon current and future industry needs, applicability, and past work. The Foundation sponsors research projects through the Focus Area, Emerging Opportunities, and Tailored Collaboration programs, as well as various joint research efforts with organizations such as the U.S. Environmental Protection Agency and the U.S. Bureau of Reclamation.

This publication is a result of a research project fully funded or funded in part by Foundation subscribers. The Foundation's subscription program provides a cost-effective and collaborative method for funding research in the public interest. The research investment that underpins this report will intrinsically increase in value as the findings are applied in communities throughout the world. Foundation research projects are managed closely from their inception to the final report by the staff and a large cadre of volunteers who willingly contribute their time and expertise. The Foundation provides planning, management, and technical oversight and awards contracts to other institutions such as water utilities, universities, and engineering firms to conduct the research.

A broad spectrum of water supply issues is addressed by the Foundation's research agenda, including resources, treatment and operations, distribution and storage, water quality and analysis, toxicology, economics, and management. The ultimate purpose of the coordinated effort is to assist water suppliers to provide a reliable supply of safe and affordable drinking water to consumers. The true benefits of the Foundation's research are realized when the results are implemented at the utility level. The Foundation's staff and Board of Trustees are pleased to offer this publication as a contribution toward that end.

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RESEARCH NEEDS FOR OPPORTUNISTIC PATHOGENS IN PREMISE PLUMBING

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