

A Methodology Towards Estimating Backflow Contamination Risks

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Purpose

- Describe Methodology Under Consideration for Estimating the Potential Public Health Risks from Cross-Connections and Backflow
- Describe the Use of Available Data in the Methodology
- Determine Additional Areas for Consideration as Part of the Risk Assessment Methodology
- Determine the Potential Usefulness of the Methodology in Estimating Potential Public Health Risks
- Consider the Methodology for Use in Estimating the Risks from Other Pathways as they are Discussed During the Workshop

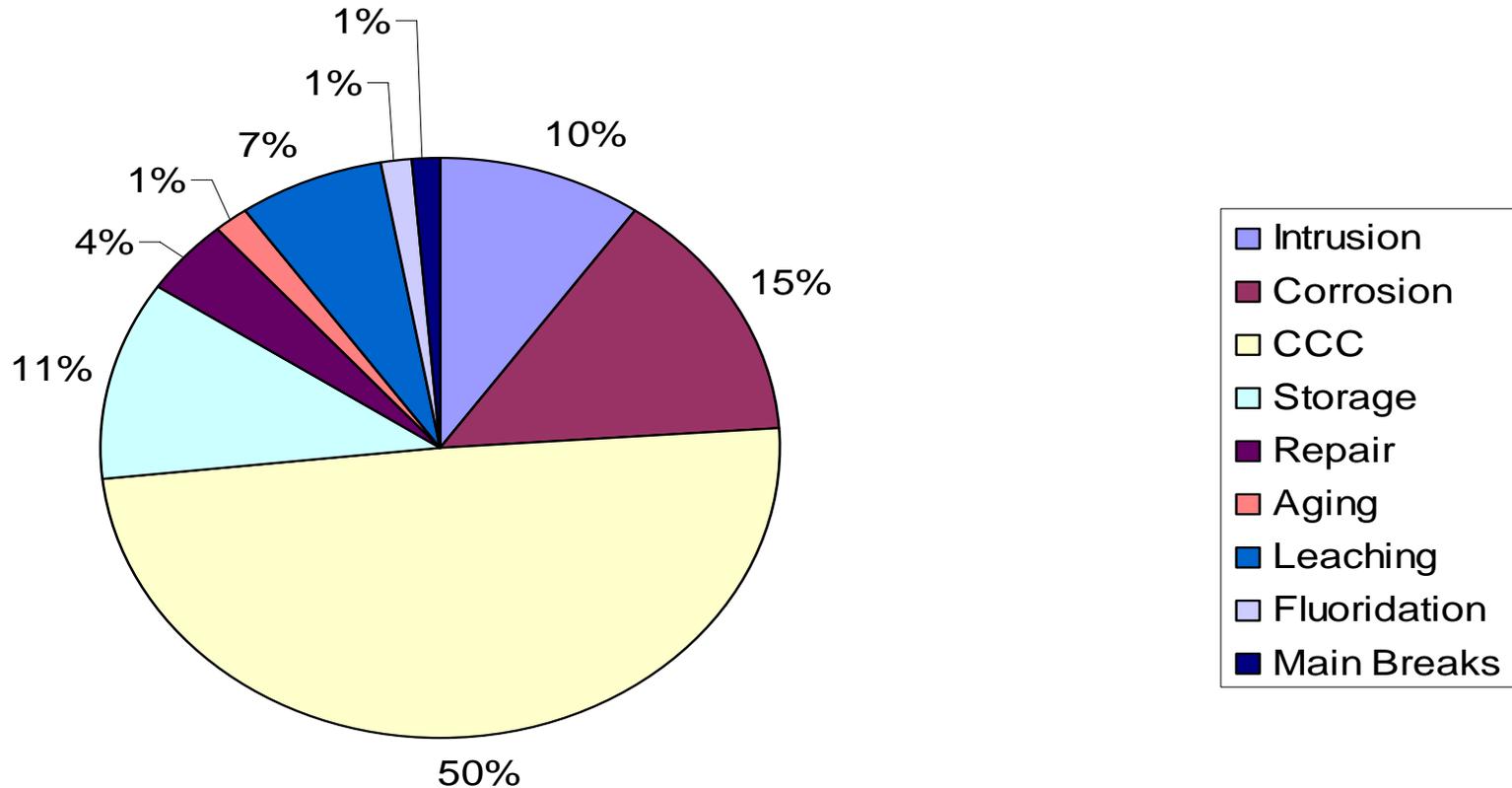
Overview

- Risk Assessment Challenges
- Methodology Components
- Available Data
- Elaboration on Status of Individual Components
 - Example of application of exposure assessment methodology using model
- Anticipated Next Steps for Baseline Risk Estimation
- Anticipated Next Steps for Estimating Risk Reduction Opportunities
- Model Development for Other Pathways



Why Focus on Cross Connections in Initial Model?

Causes of Distribution System Outbreaks, 1981-2002



Risk Assessment Challenges

Risk Assessment Challenges

- Limited Data on Occurrence and Concentrations
 - Range of potential contaminants
 - Many backflow contaminants typically not considered distribution system contaminants
 - Most contaminants not monitored for in distribution systems
 - Contaminants of most concern vary by system in some cases
 - Monitoring frequencies
 - Many backflow contamination events are intermittent or short in duration
 - Distribution system monitoring may miss many of these events due to frequencies of monitoring typically conducted
 - Contaminant plumes traveling through system
 - Monitoring would have to be conducted shortly after the event to detect it
 - Monitoring locations
 - Many backflow contamination events affect only a portion of the distribution system
 - Distribution system monitoring conducted at discrete locations and may not capture some event

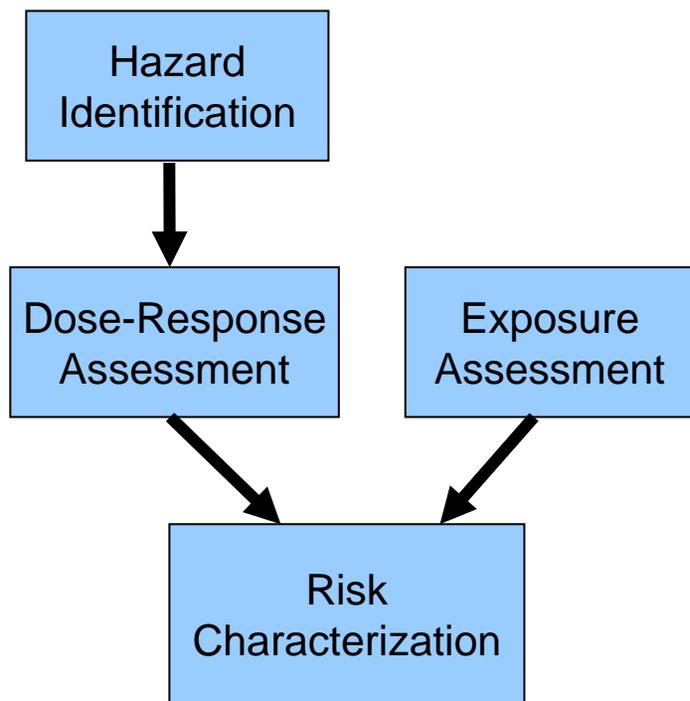
Risk Assessment Challenges

- Not Feasible to Base Risk Assessment Strictly on Measured Contaminant Concentrations in Consumed Water
- Limited in Ability to Collect Meaningful Data in a Study
 - To determine contaminant occurrence and concentrations systems would have to monitor continuously for all contaminants at all locations
- Duration and Spatial Variation of Contamination Must be Considered
- How to Address Contaminant Mixtures in Assessment

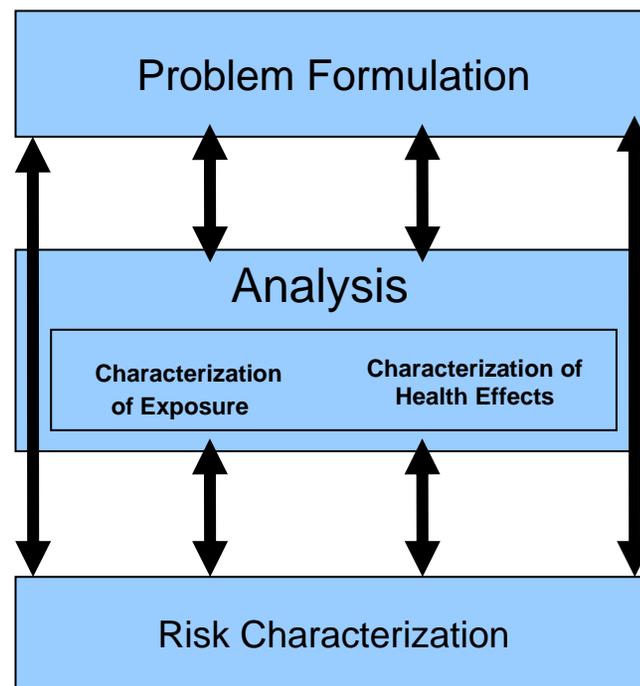
Estimating Baseline Risks from Cross-Connections and Backflow

Methodology Development

- Methodology Summary
 - EPA developing a methodology based on existing frameworks for both chemical and microbial risk assessments



Chemicals



Microbes

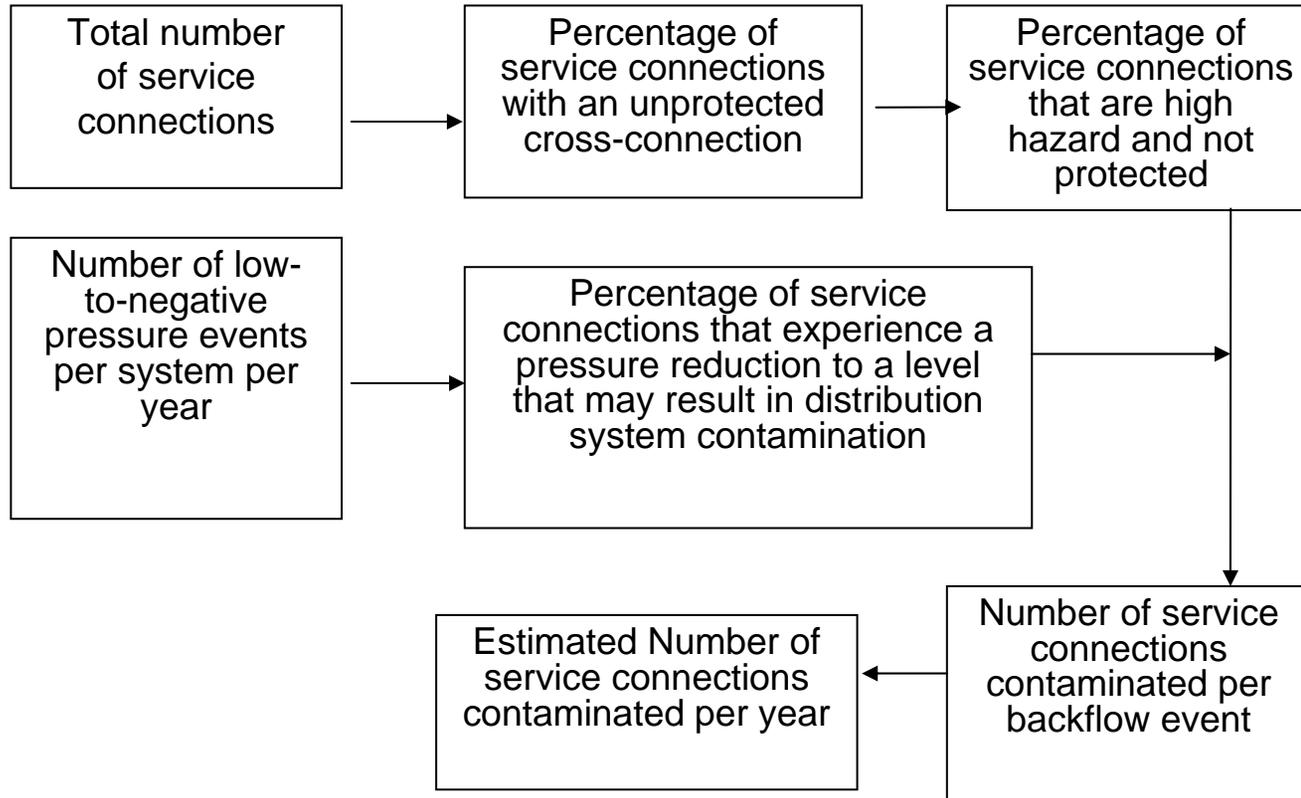
Methodology Development

- Identifying Data for Each Component of the Risk Assessment Methodology Under Development
 - Hazard Identification
 - **Exposure Assessment**
 - **EPA has built a model for potentially estimating the public health risks from cross-connections and backflow in Community Water Systems**
 - Examines a portion of the exposure assessment component
 - Based on the occurrence of events that allow for contamination of the distribution system
 - Discussion of the model is the primary focus of this presentation
 - Dose-Response Assessment
 - Risk Characterization

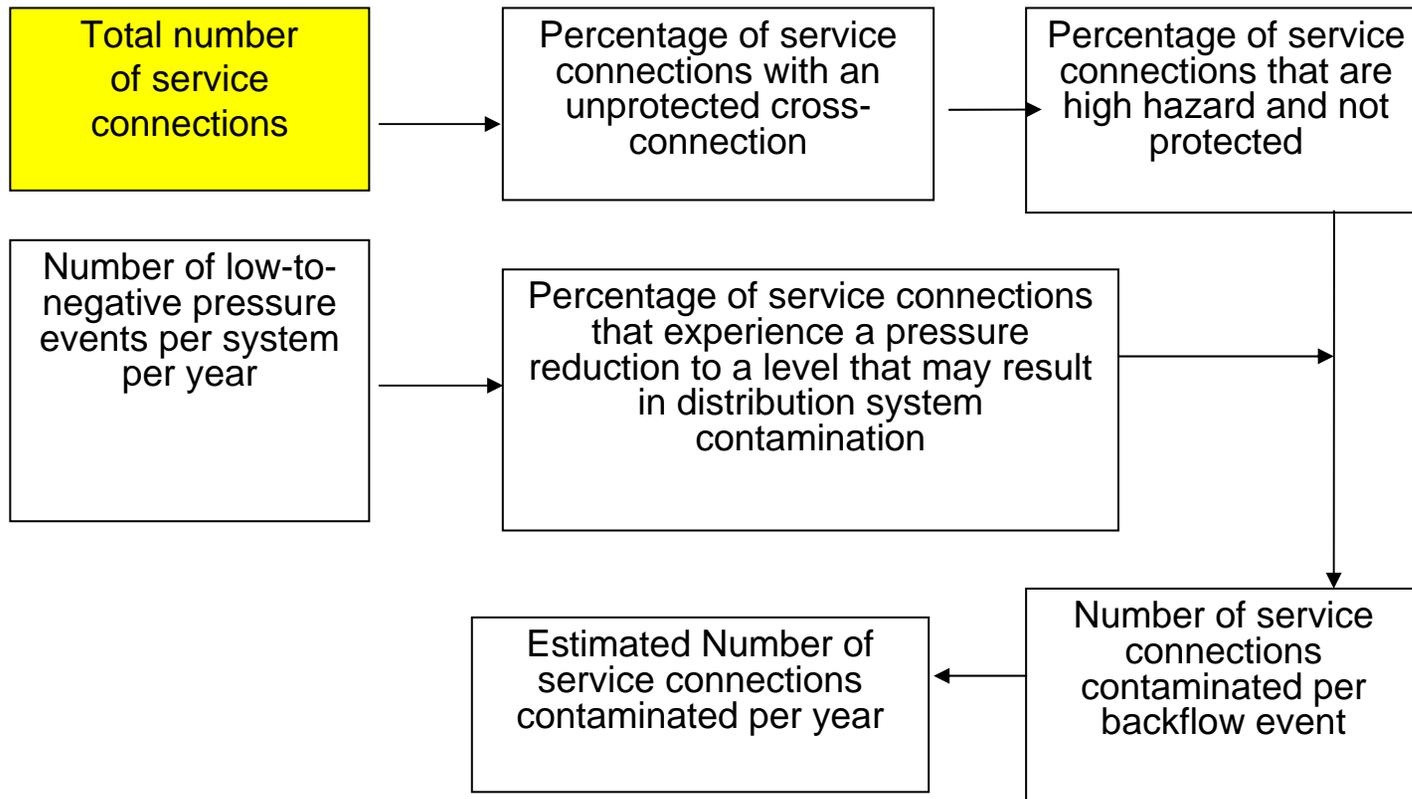
Hazard Identification

- Methodology Components
 - Contaminants entering the distribution system from cross-connections and backflow that pose a public health risk
- Available Data
 - Range of contaminants
 - Metals, radionuclides, viruses, protozoa, bacteria (including indicators), hydrocarbons, and household and industrial chemicals
 - Most common contaminants based on documented presence
 - Microbial – norovirus, *Giardia*, *Shigella*, pathogenic *E. coli*, *Cryptosporidium*, echovirus, and other sewage organisms
 - Chemical –pesticides (e.g., termiticides), herbicides, detergents
 - Studies underway on real-time online monitoring
- Next Steps
 - Identify representative contaminants based on how often they occur, the level of concern and availability of dose-response information

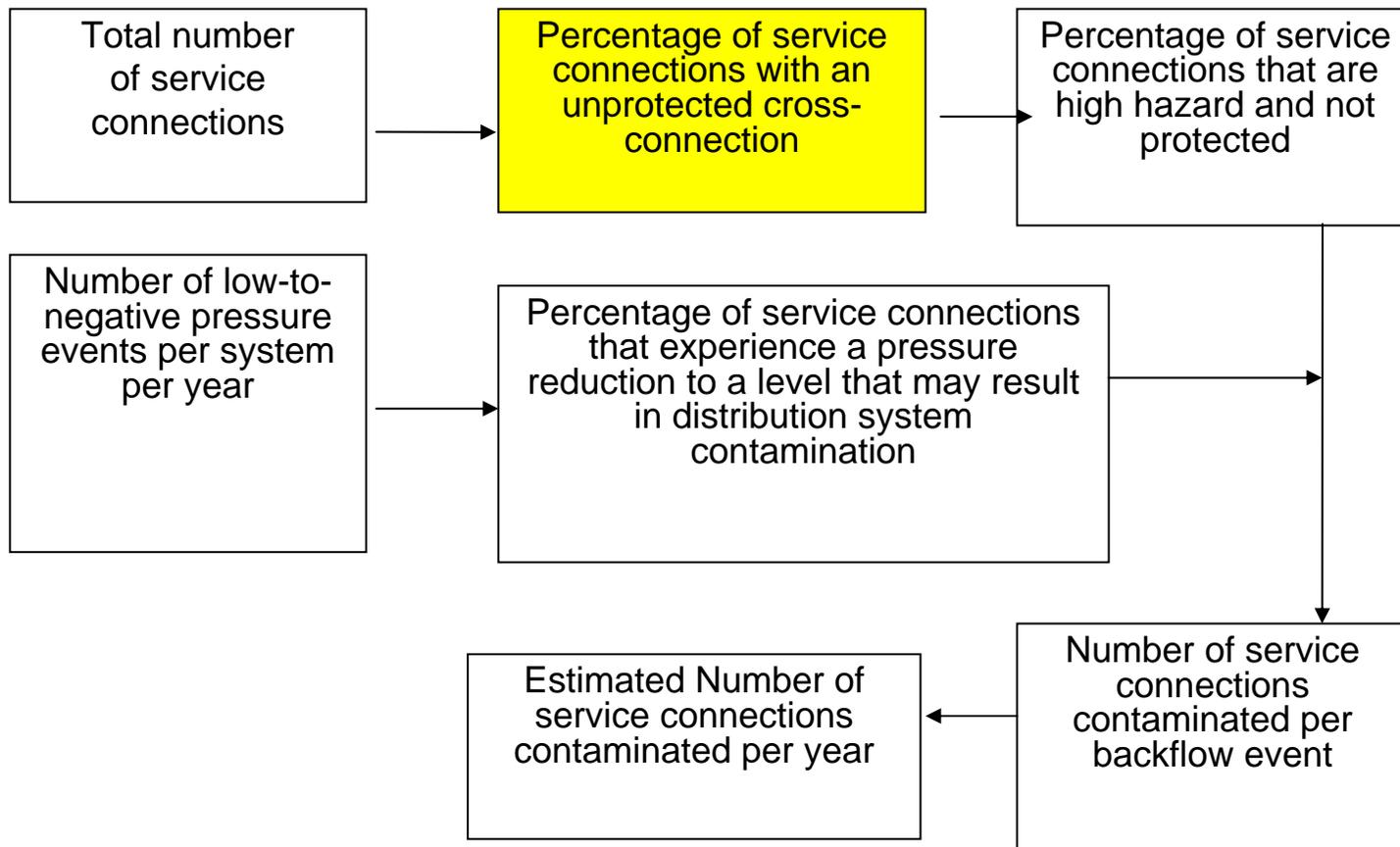
Model for Determining Exposure



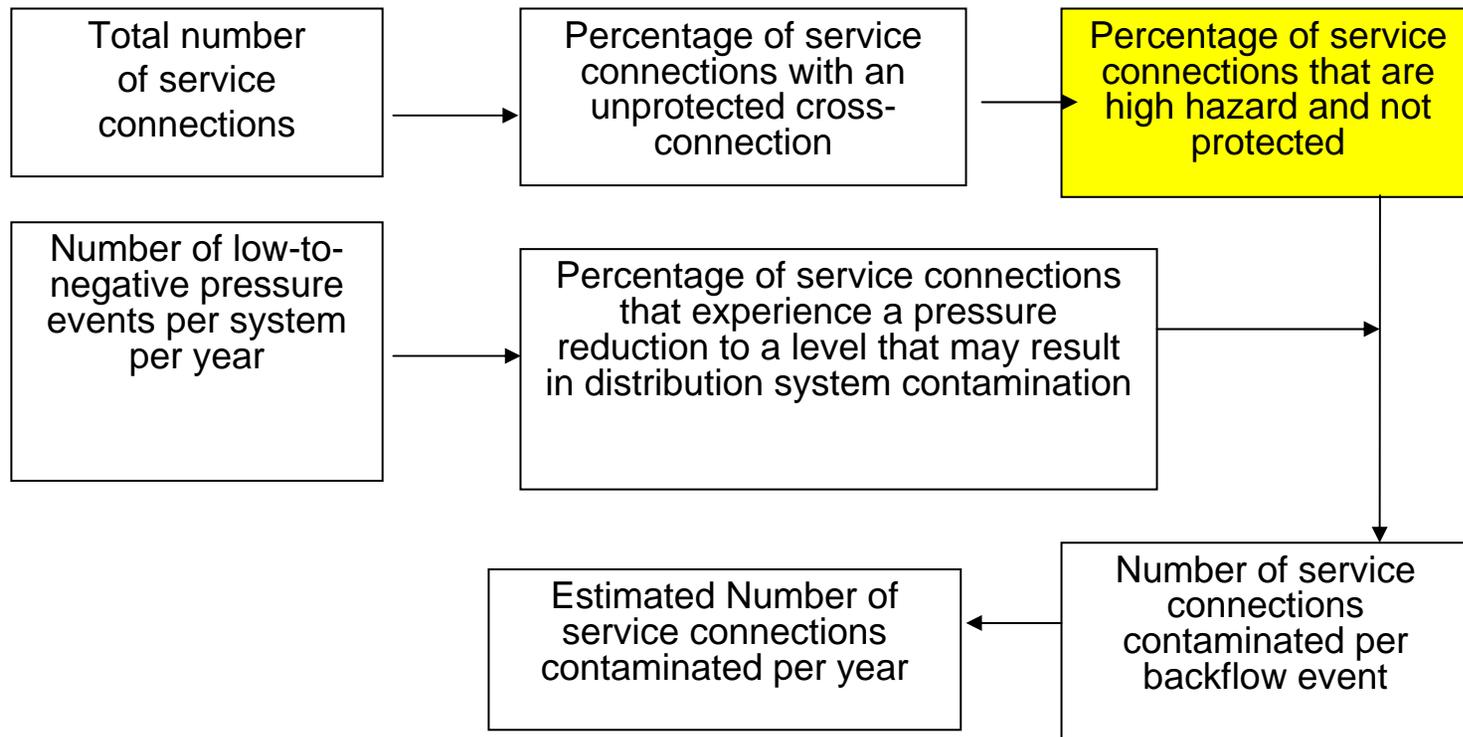
- Estimated Number of Service Connections in the United States (total and by size category)
 - EPA’s Safe Drinking Water Information System for number of systems
 - EPA’s Community Water System Survey (2000) for number of service connections per system



- Occurrence of Service Connections with Unprotected Cross-Connections
 - Percentage of service connections with a cross-connection from ABPA 1999 survey for commercial settings and of 188 households in Davenport, Iowa study for residential settings

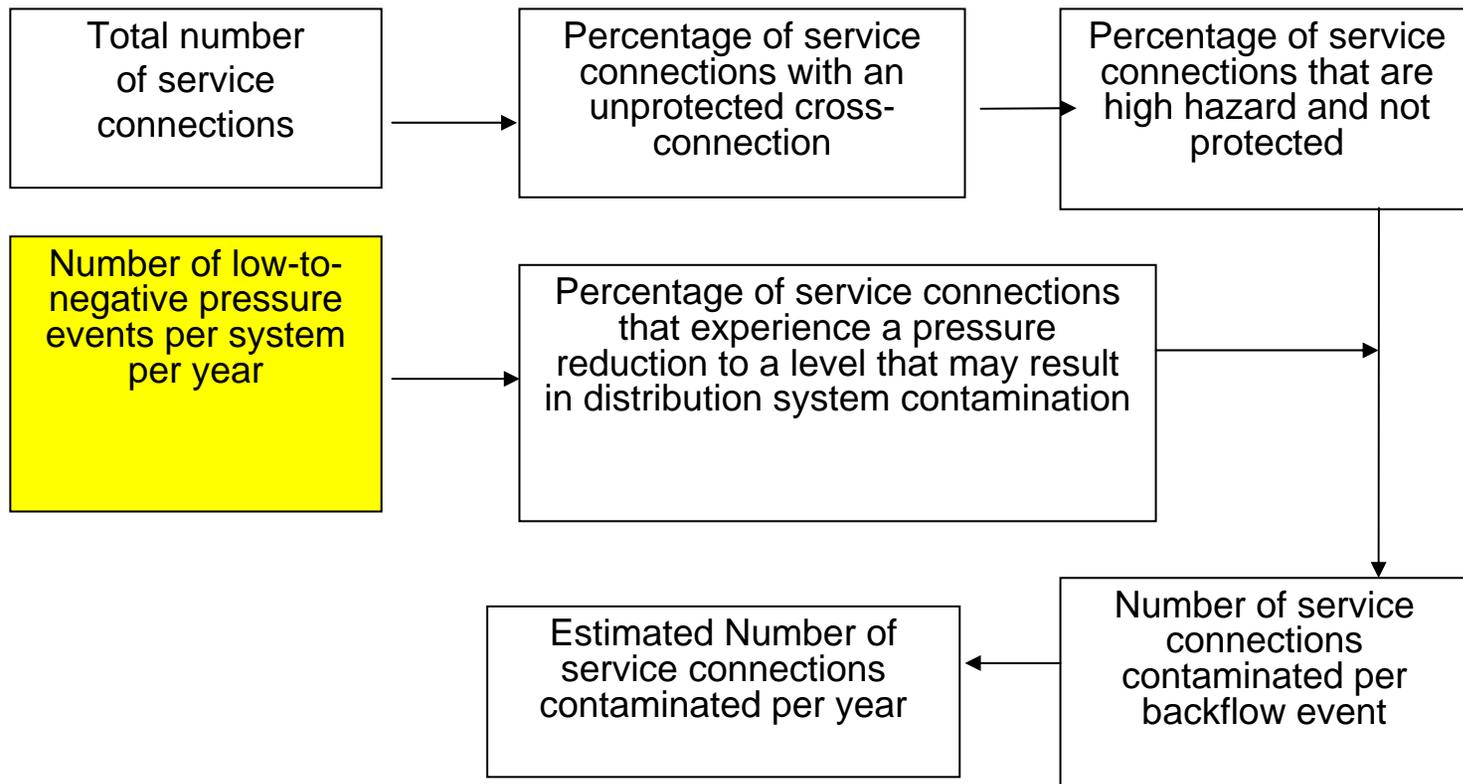


- Proportion of Service Connections with Unprotected Cross-Connections that are Considered High-Hazard
 - System information from Philadelphia Water Department and 63 systems from 2000 ABPA Survey, as well as State-wide data from Washington DOH on percentage of service connections state wide that are high hazard and unprotected

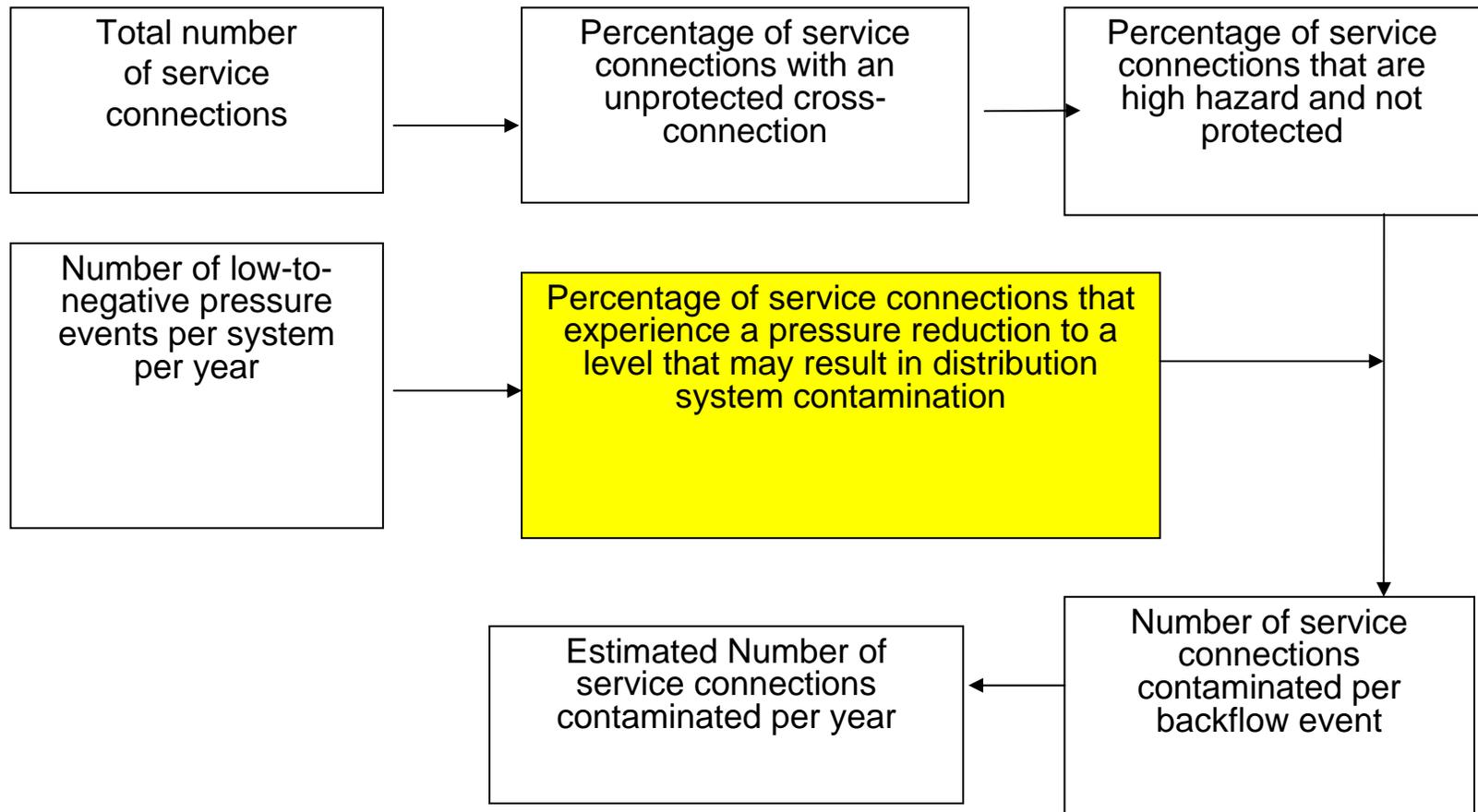


- Occurrence of Low-to-Negative Pressure Events

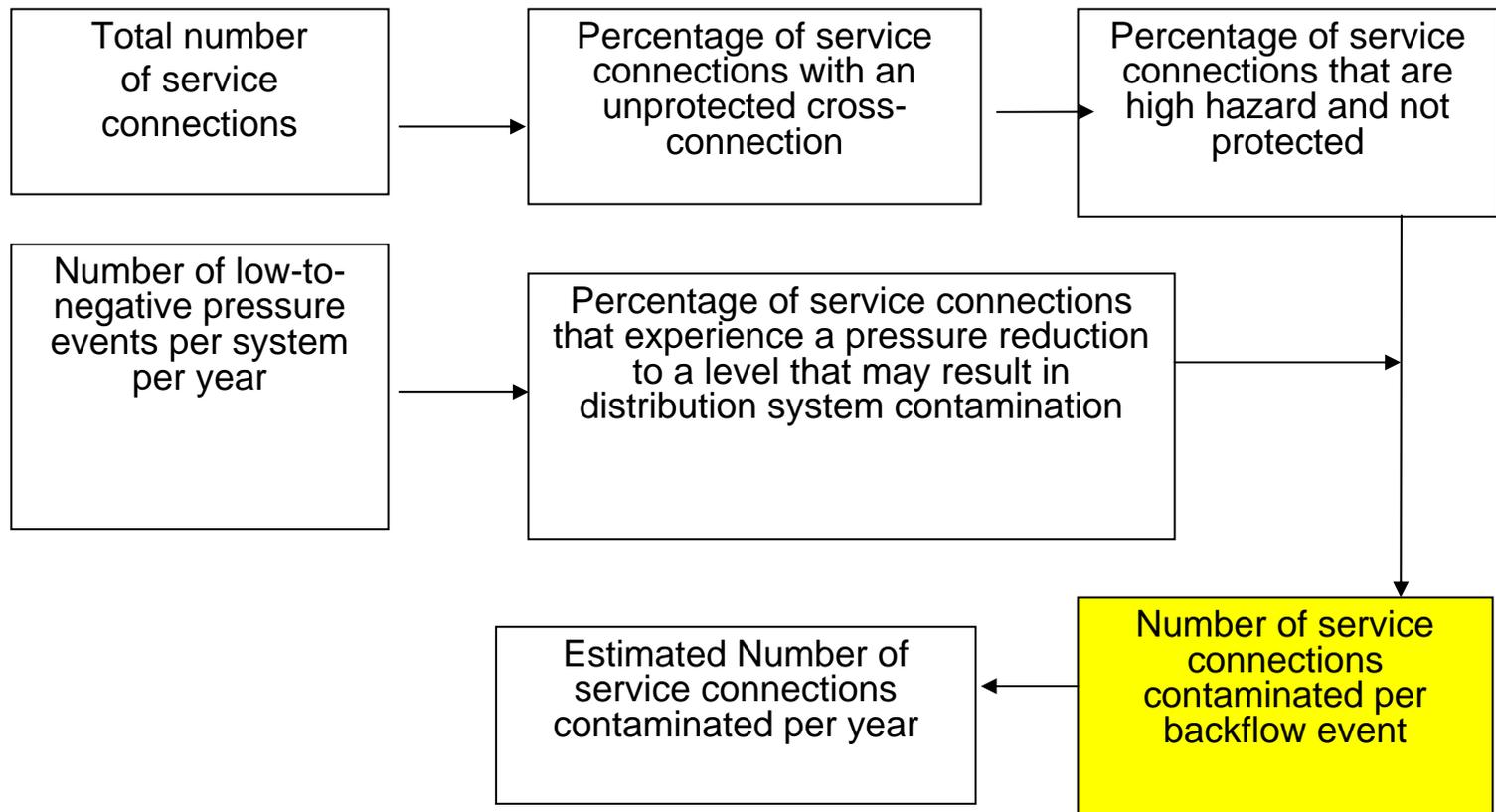
- Data from 66 systems in the 2000 ABPA Survey on number of events per system per year
- Kirmeyer et al., survey 1994 of 20 medium and large systems
- Data from intrusion studies and hydraulically-modeled systems



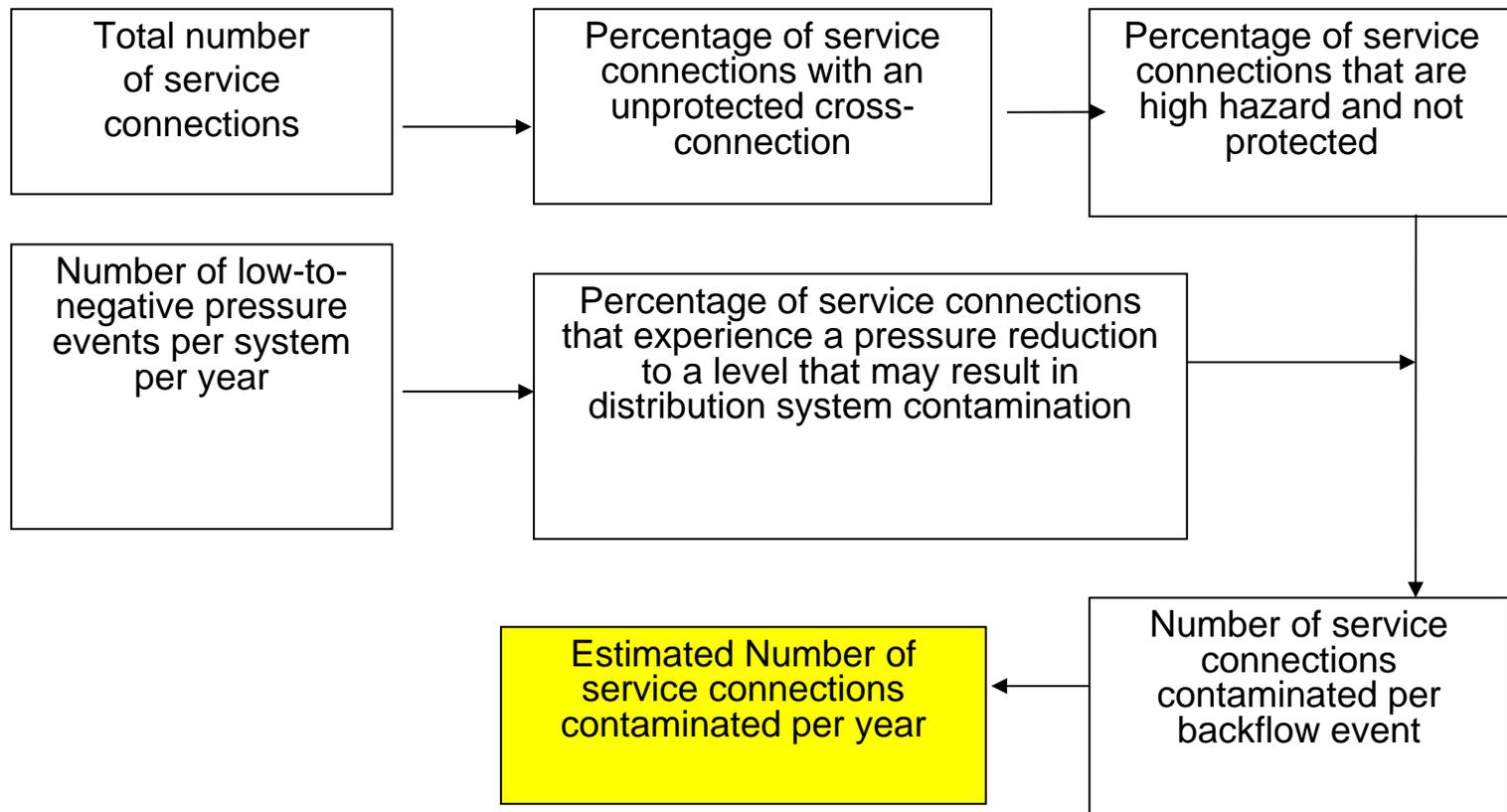
- Percentage of Service Connections that Experience a Pressure Reduction that May Result in Contamination
 - Data from Lee et al., 2003 and the 2002 Community Water System Survey
 - Data from intrusion studies and hydraulically-modeled systems



- Estimation of the Number of Contaminated Service Connections per Event
 - Derived from EPA-compiled data on documented backflow events from 1970-2001 (421 events)



- Estimation of the Number of Contaminated Service Connections Annually in the United States
 - Derived from number of service connections contaminated per event and the number of estimated events annually



Example Calculations for Estimating the Exposure

A. Backflow Exposure Assessment - Target Outputs

1. Number of backflow contamination events per year ($B * C$)
2. Number of service connections contaminated per year ($A.1 * D$)
3. Example for CWS size category serving 100k-500k people

B. Cross-Connections - Inputs

1. Percent of service connections with a cross-connection (42%)
2. Percent of high hazard service connections (0.82%)
3. Percent of high hazard service connection with no backflow prevention (30%)

C. Pressure Reductions Events - Inputs

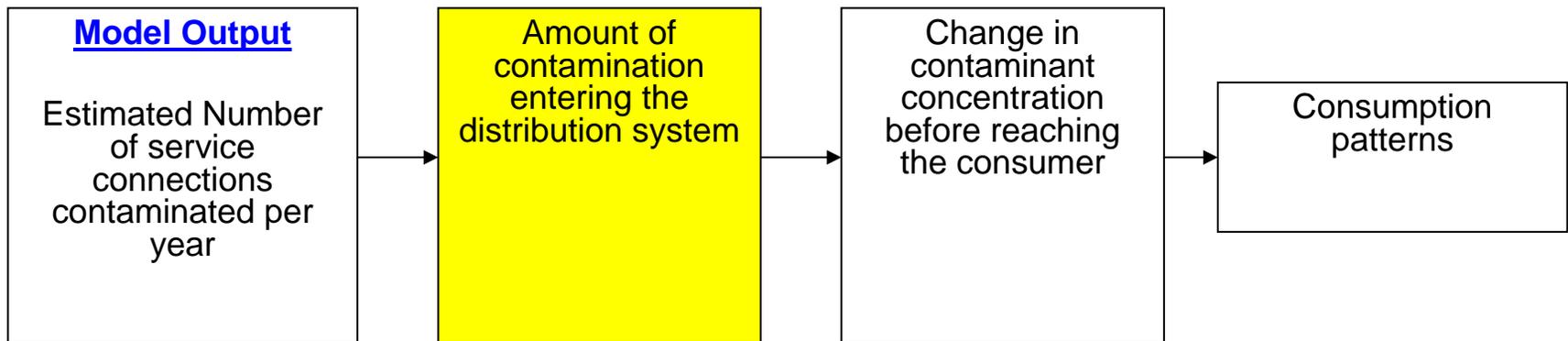
1. Number pressure reduction events per system per year (186)
2. Percent of pressure reduction events that can lead to contamination (1%)

D. Average Number of Service Connections Contaminated due to an Event – Inputs (144)

E. Results – 76,000+ events, contaminating almost 11 million s.c.

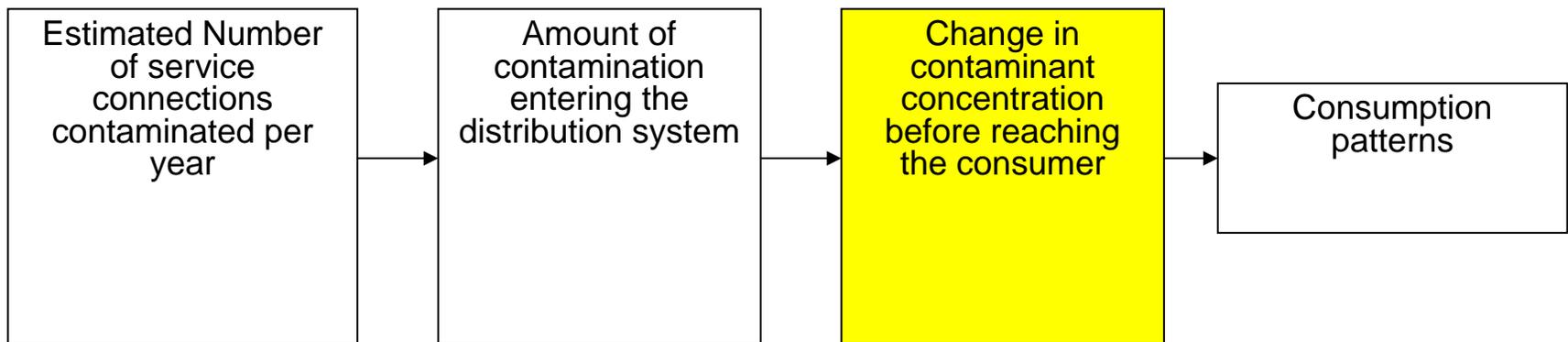
Exposure Aspects Not in Model

- Determination of Contaminant Concentrations Entering the System
 - Estimation of volumes of contaminated substances that enter the distribution system during an event
 - Estimation of concentrations of contaminants in sources of contamination



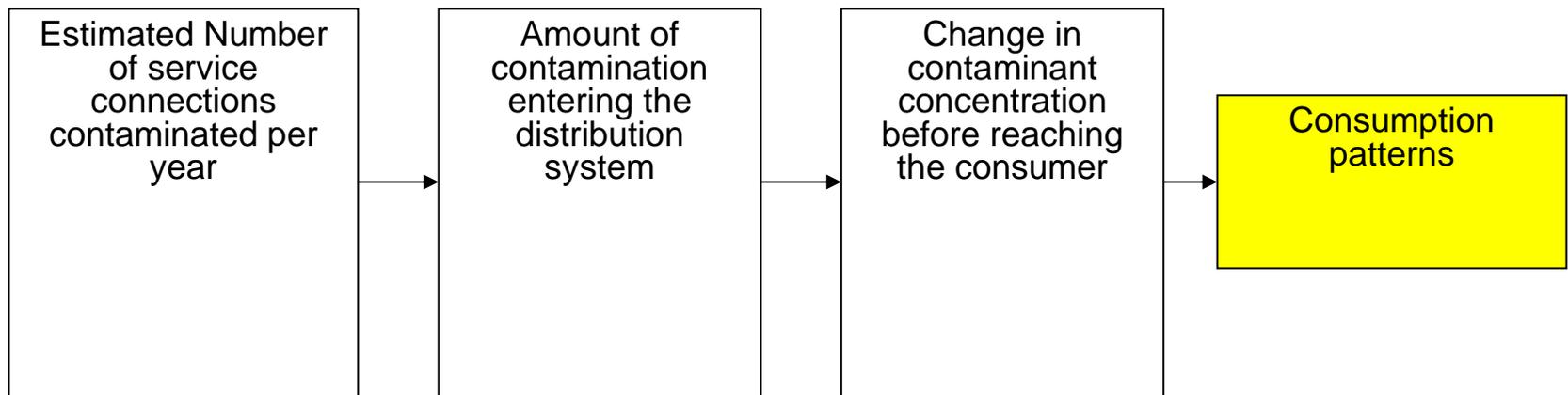
Exposure Aspects Not in Model

- Contaminant Concentration Change Before Reaching Consumer
 - Determination of the flow and mixing dynamics of the contaminant after entering the distribution system
 - Effect of disinfectant residuals, biofilms, reactions with materials, degradation



Exposure Aspects Not in Model

- Estimation of Proportion of Contaminated Water Consumed through Ingestion Versus Other Uses



Next Steps for Exposure Assessment

- Include Additional Relevant Available Data
- Revise Model to Incorporate Inputs not Currently Included
- Determine How to Incorporate Estimates of Backflow from Backpressure Events
- Model Some Fate and Transport Scenarios to Determine Expected Changes in Contaminant Concentrations within the Distribution System
- Determine the Importance of Non-Ingestion Pathways of Exposure

Dose-Response Assessment

- Methodology Components
 - Incorporate dose-response parameters for the narrowed list of contaminants of concern
 - Apply dose-response functions to fraction of time the service connections are contaminated
 - Determine health outcomes from available health effects information
- Available Data
 - Dose-response functions for some microbial contaminants
 - *E. coli*, *Cryptosporidium*, *Giardia*, *Salmonella*, *Shigella*, norovirus
 - Health effects documents prepared for some contaminants under consideration

Dose-Response Assessment

- Next Steps
 - Examine dose-response information for chemical contaminants
 - Determine the feasibility of examining contaminant mixtures
 - Identify additional factors for consideration in dose-response assessment
 - Conduct literature search for a full range of published health effects for the contaminants of concern
 - Estimate the range of risks related to a particular health effect

Risk Characterization

- Methodology Components
 - Integration of outcomes from hazard identification, exposure assessment and dose-response assessment to determine magnitude of risks

Estimating Risk Reductions

Estimating Risk Reductions

- Methodology Components
 - Estimate change in doses received by consumers based on the effectiveness of risk reduction strategies
- Available Data
 - Effectiveness of some strategies has been examined
- Next Steps
 - Determine the effectiveness of other corrective and preventive strategies
 - Focus on strategies included in State regulations, industry practices and international standards
 - To what extent are they being implemented
 - Which strategies address common contamination pathways

Next Steps

- Determine the Usefulness of the Methodology in Estimating Public Health Risk
- Examine Similar Model Constructs for Estimating the Public Health Risks from Other Pathways
 - Intrusion
 - Covered Storage
 - Main Repairs

Summary

- Cross Connections and Backflow may be of Significant Public Health Concern
- Several Challenges Exist in Developing a Risk Assessment for Distribution System Issues
 - Multiple contaminants, contaminant mixtures, and intermittent contamination, with very limited contaminant occurrence information
- EPA Developing a Risk Assessment Methodology for Consideration in Estimating Distribution System Contamination Risks
 - Developed draft methodology to estimate risks from cross-connections and backflow
 - Methodology follows established risk assessment protocols