Application of Risk Assessment for VSD in Home Sewage Systems

Mark A. Tumeo, Ph.D., J.D., P.E.
Civil and Environmental Engineering
Cleveland State University

Outline of Presentation

- **Background of Approach**
- **Risk Assessment Review**
- **Application**
  - With focus on soil
- **Conclusions**

The Ohio "Situation"

- Early 2000, the Ohio Department of Health (ODH) began the updating the home sewage treatment system (STS) rules.
- In 2005, HB 231 passed and signed which required that new STS rules be adopted within one year.

The Ohio "Situation"

- ODH underwent public comment and review processes
- Promulgated new STS Rules on May 4, 2006
- Rules became effective on January 1, 2007,
- OAC Chapter 3701-29

The Ohio "Situation"

- Concerns soon arose over the implementation of new rules.
- One of the primary concerns was lack of sufficient scientific bases.
- Belief that the rules would drive up cost and restrict innovation.

The Ohio "Situation"

- As a result of concerted lobbying effort, Am. Sub. HHB 119 passed in June 2007.
- The law suspended most portions of ORC Chapter 3718 (STS rules), until July 1, 2009.
- Several uncodified provisions were enacted effective July 1, 2007.
- Several Modifications, continuations and amendments later, A new bill was passed in May 2010.

The Ohio "Situation"

- Extreme example of the multiple scientific, technical and political issues in rule making
- Highlights the need to transparently include multiple scientific, technical and social factors in the regulatory process.

The Ohio "Situation"

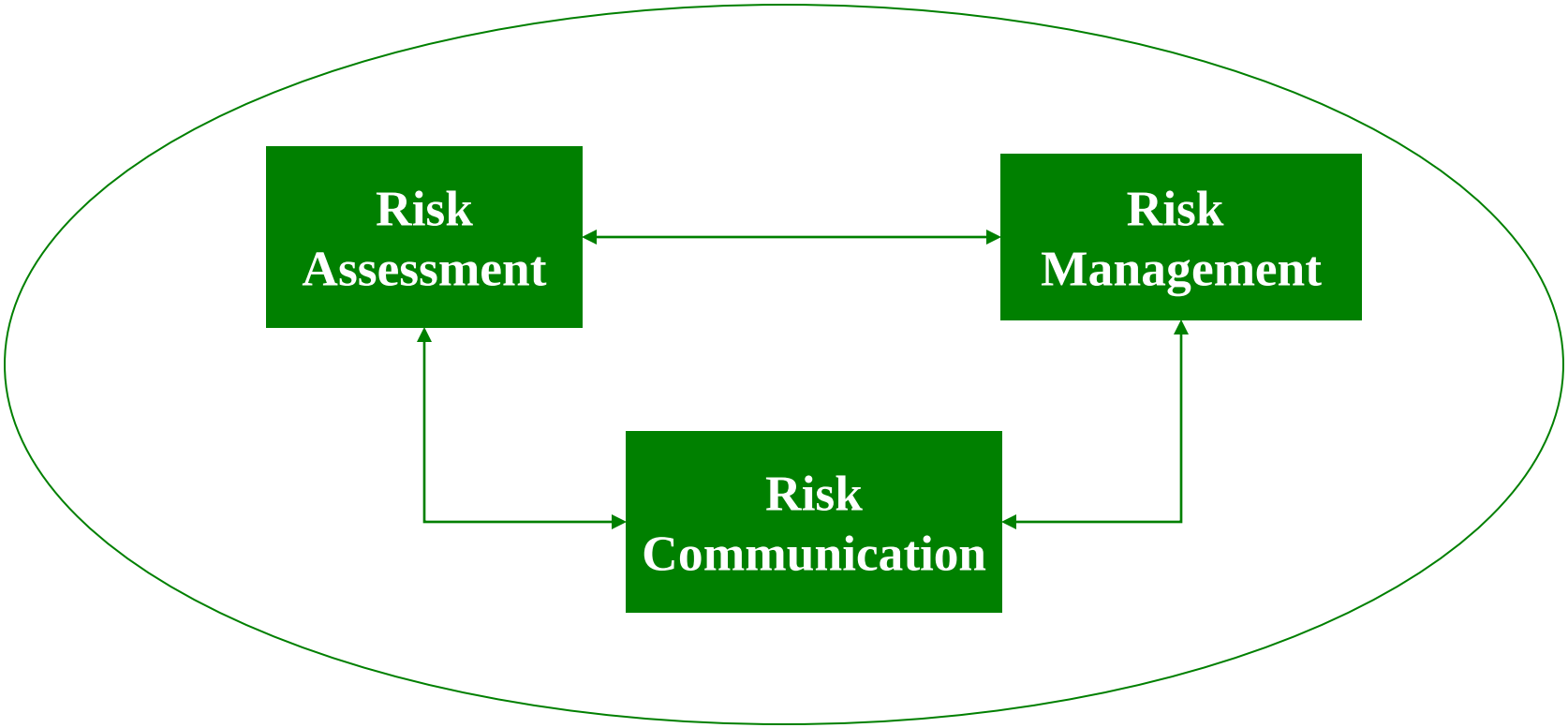
- **Also highlights an inherent conflict between science and policy**
  - Science is based in and built around uncertainty. Deals with probability, always needs more information
  - Policy requires certainty and support. Little tolerance for variation and sees information, after a certain point, too expensive and complicated.

Risk Assessment

- ***Risk Assessment*** **is the process of using scientifically-supported relationships to predict the magnitude and probability of adverse impacts on selected endpoints of specific actions, events or hazards/stressors.**

Risk Analysis

The overall name given to the application of risk concepts to decision making.



Risk Assessment and the Regulatory Process

- Application of Risk Assessment grew out of legal and political pressures to make the regulatory
- Executive Order 12291 (1981) made Risk Assessment a formal part of regulatory process.
- The requirement has been included in numerous statutes at the Federal level and continues to be driven by Federal policy and law.

Application of Risk Assessment to Onsite Sewage Treatment Systems

- Risk assessment has been well developed in the environmental area for determining the impacts of a variety of ***human stressors*** and ***management options.***
- Risk assessment frameworks have become widely accepted for ***watershed level analysis*** of the impacts of a large number of activities.

Application of Risk Assessment to Onsite Sewage Treatment Systems

- Daniel Jones and others (2001, 2004), developed a risk-based approach for the design and permitting of individual systems.
- Efroymson and others (2007) extended the approach of Jones to begin to answer the question of “acceptable levels” for nutrients.

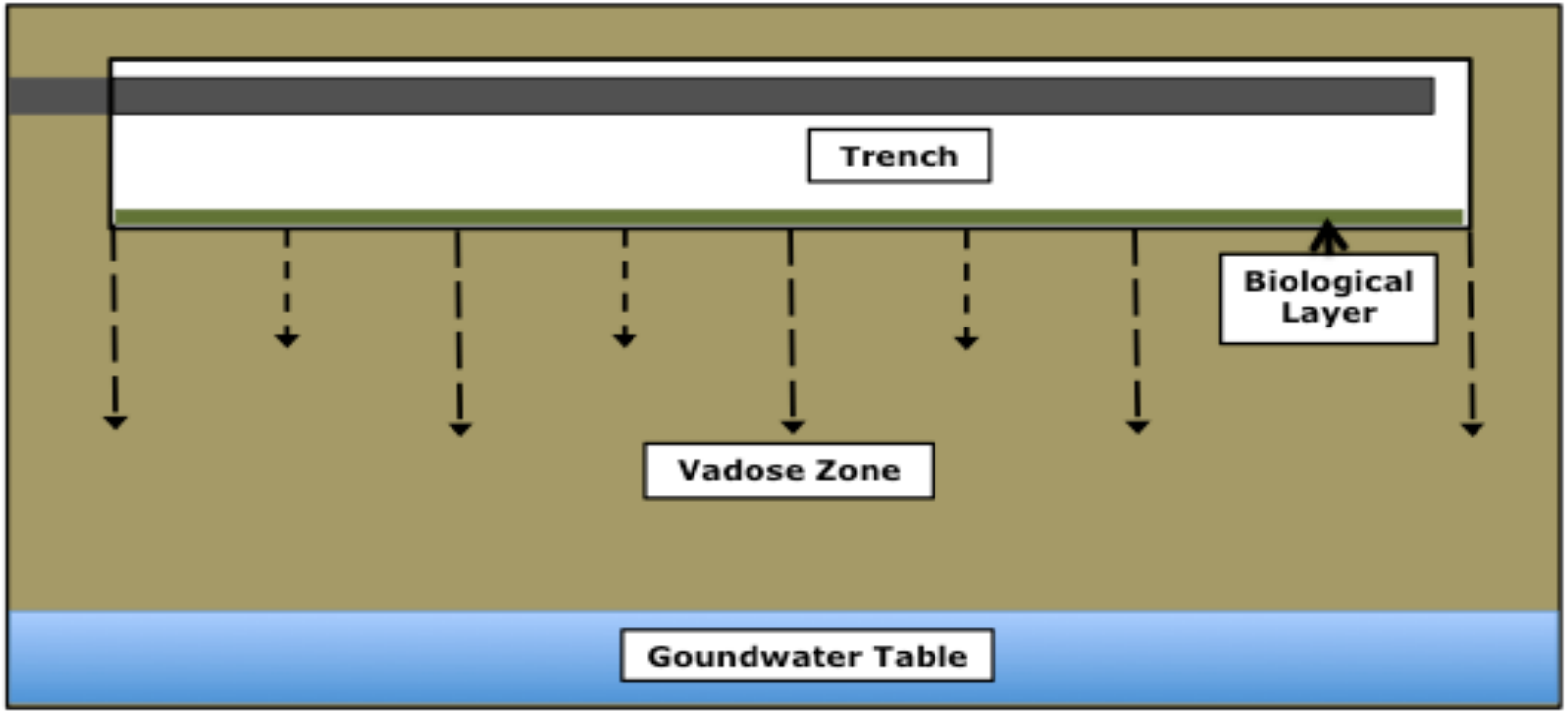
Application of Risk Assessment to Onsite Sewage Treatment Systems

- To be useful in regulatory development, approach must be simple, transparent and based on the strongest scientific data available.
- **This is especially tree in the development of Ohio's STS rules – because of the political controversy and the concerns of the regulated community.**

Conceptual Framework

- **Model focuses on establishing Vertical Separation Distances (VSD)**
  - Separation distance requirements in Ohio rationalized through concerns about fecal coliforms.
  - Approach would also work for nutrients with modifications.

Soil Absorption System



Conceptual Framework

- **Considers *transport* of fecal coliforms through the *soil column*.**
  - Based on Darcy's Equation and built off of the retention-time approach.
  - Initially, use estimate "K" (LTAR) from Tyler Table.
  - This allows calculation of the estimated velocity of the water through the soil and a "travel time" for any given distance.

Conceptual Framework

- For this application, had to recognize that the soil type, structure and conditions are the major source of variability.
- Added to the physical parameters, the biological variation includes fecal die-off, temperature effects, predation and filtering.

Conceptual Framework

- **An advantage of the risk approach is that it is possible, if focused on the end result, to "lump" variability into just a few parameters.**
- **Makes the model a cross between an empirical and a theoretical one.**

Model Development

- **Fecal Coliform Concentration**
  - Standard first-Order Die-off Equation

$$C(t) = C_o e^{-k_e t}$$

  - "t" is time to a given distance from the transport equation
  - "k_e" is an "effective" die-off
  - $\mathbf{C_o}$ is the initial concentration

Model Development

- However, variations in the soil, initial concentration, as well as the biological process cause the transport itself to vary *stochastically*.
- If we include this – result is a stochastic differential equation:

$$\frac{dC}{dt} = kC + k'C + kC' + k'C'$$

Model Development

- Using a stochastic expansion (Tumeo and Orlob, 1989), can separate the deterministic and stochastic portions of the process.
  - Deterministic Portion

$$C(t) = C_o e^{-k_e t}$$

  - Stochastic Portion

$$\sigma_c(t) = (\sigma_o)(e^{-k_e t})(e^{2t^2 2\sigma_k^2}) + C_o^2(e^{2t^2 2\sigma_k^2} - e^{t^2 2\sigma_k^2} + e^{0.5t^2 \sigma_k^2})$$

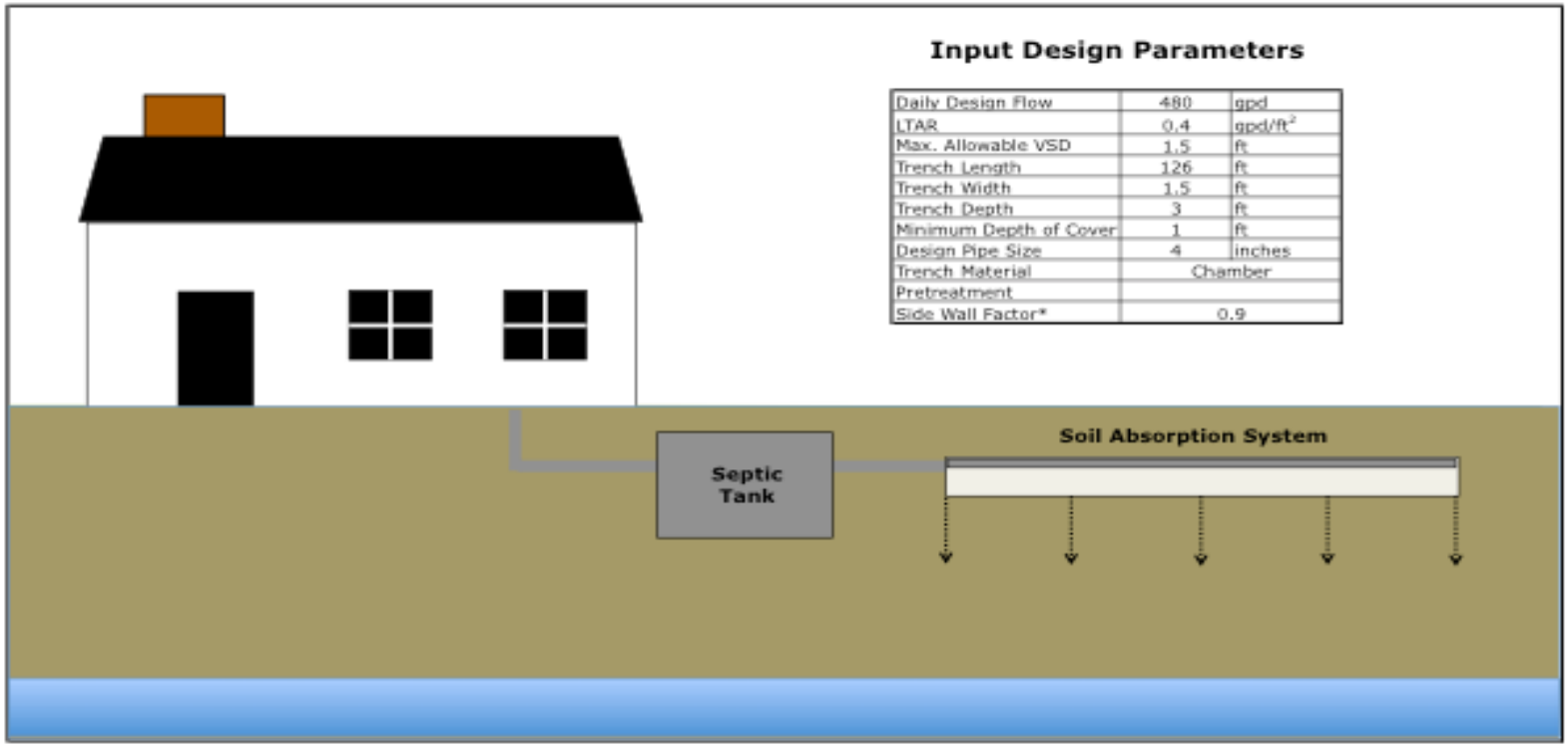
Model Development

- This is the analytic solution – no iteration required.
- Final "Risk"
  - **Concentration distribution at point of interest (e.g. surface water, groundwater table) directly from previous equation.**

Status of Development

- To meet objectives of simplicity and ease of use – put “model” into Excel Spreadsheet
- User interface a simple pull down menu to input parameters.
- Overall model validated against limited data available in the literature (Thesis work of Anthony Janicek)

User Interface



Status of Development

- **In addition to being based in science and easy to use, to be accepted in regulatory use, must also:**
  - Include an analysis of current data
  - Be subjected to peer review
  - Be iterative and flexible

Summary

- Tools are still needed that allow regulators to examine critical issues in regulation and/or management in light of current scientific knowledge.
- The risk analysis framework provides a way this can be done transparently while still representing the uncertainty inherent in natural systems.

Summary

- **Moving towards a "risk-based" regulatory framework that:**
  - Allows for flexible application;
  - Is based on scientific knowledge and data; and
  - Is transparent and consistent for the regulated community.

Thank You for Your Attention

I welcome your comments, suggestions and questions