Environmental Fate and Exposure Assessment in the U.S.

Topics

- Purpose of Environmental Fate Assessments
- Environmental Fate Studies and Data Flow
- Aquatic Exposure Assessment the U.S.
  - Ground water
  - Surface water
  - Spray drift
- Information Exchange with US EPA

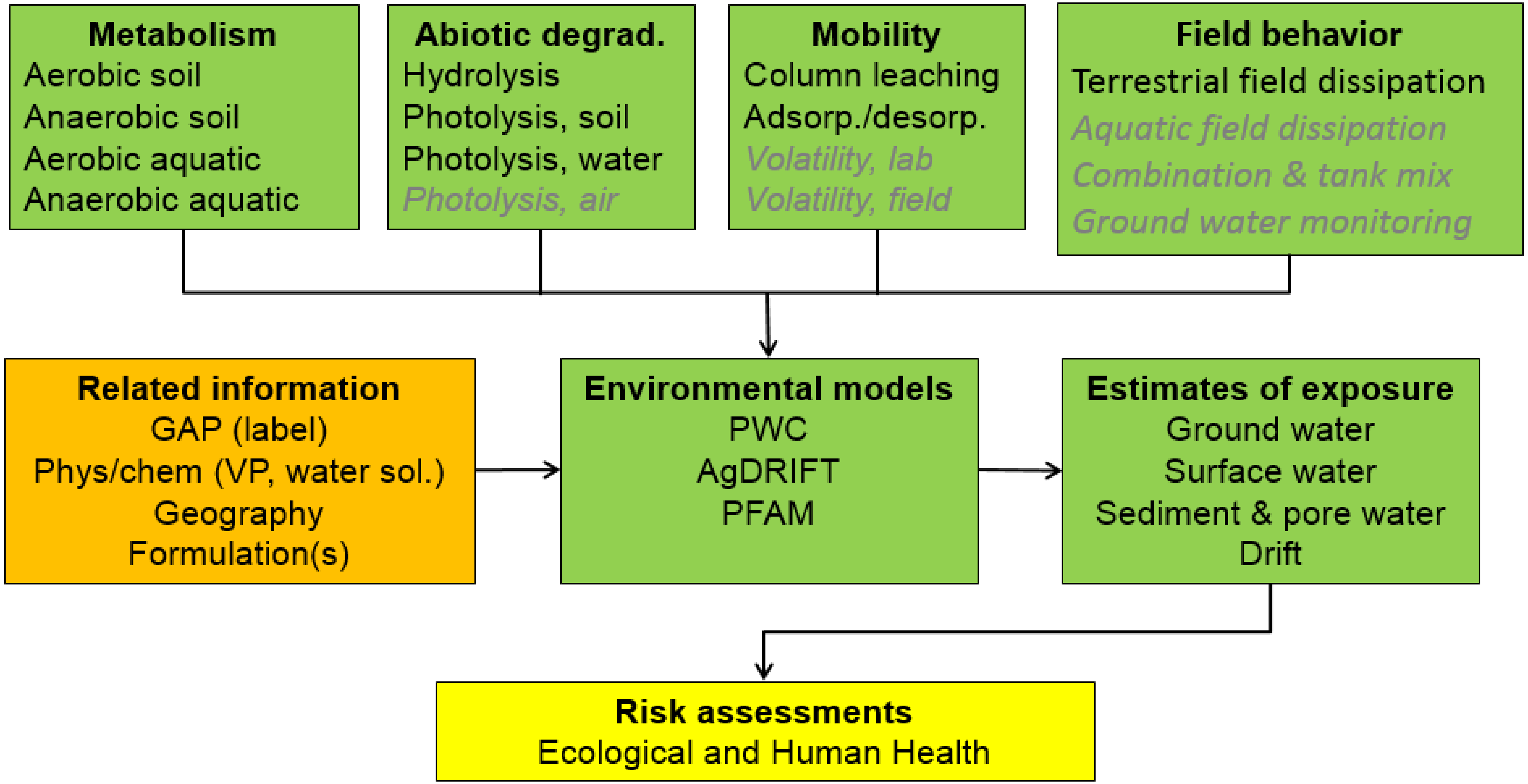
Purpose of Environmental Fate Assessments

- A typical agricultural chemical application may deliver approximately 10^{15} (1 quadrillion) molecules/cm^2
- These molecules are subject to both transfer and transformation processes, as are their degradation products
- Environmental fate (Efate) assessments help address the following questions…

  Where does the compound go?
  How long does it stay there?
  In what form (or forms) is it present?
  What are the concentrations?

- Measures of exposure for risk assessments

Environmental Fate Studies and Data Flow



Required studies (top row of boxes) are based on a terrestrial use pattern, with conditionally required studies listed in gray italics. Unlike in Europe, terrestrial field dissipation half-lives are not considered as a direct input for US EPA exposure models.

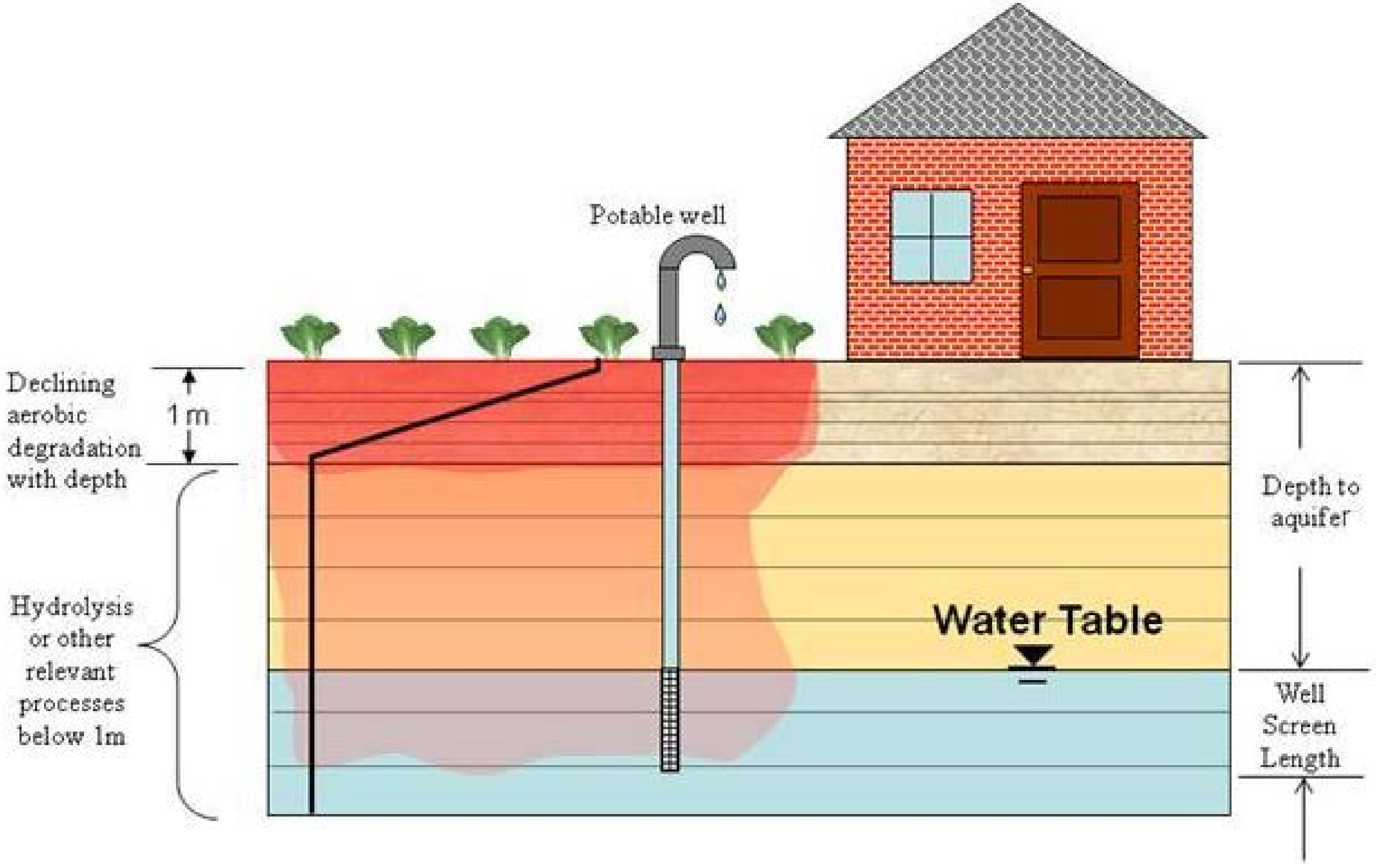
Aquatic Exposure Assessment

- **Human Health Risk Assessment**
  - Exposure from drinking water
    - Ground water
    - Surface water
- **Ecological Risk Assessment**
  - Exposure in an organism's environment
    - Surface water
    - Sediment / pore water

Pesticide in **W**ater **C**alculator (PWC)

(https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/models-pesticide-risk-assessment)

Ground water modeling concept



Representation

Designed to represent vulnerable private drinking water wells adjacent to treated fields

Mechanistic Model

- Degradation
- Transport

Modeled processes

- Meteorological
- Crop
- Biological
- Chemical
- Management

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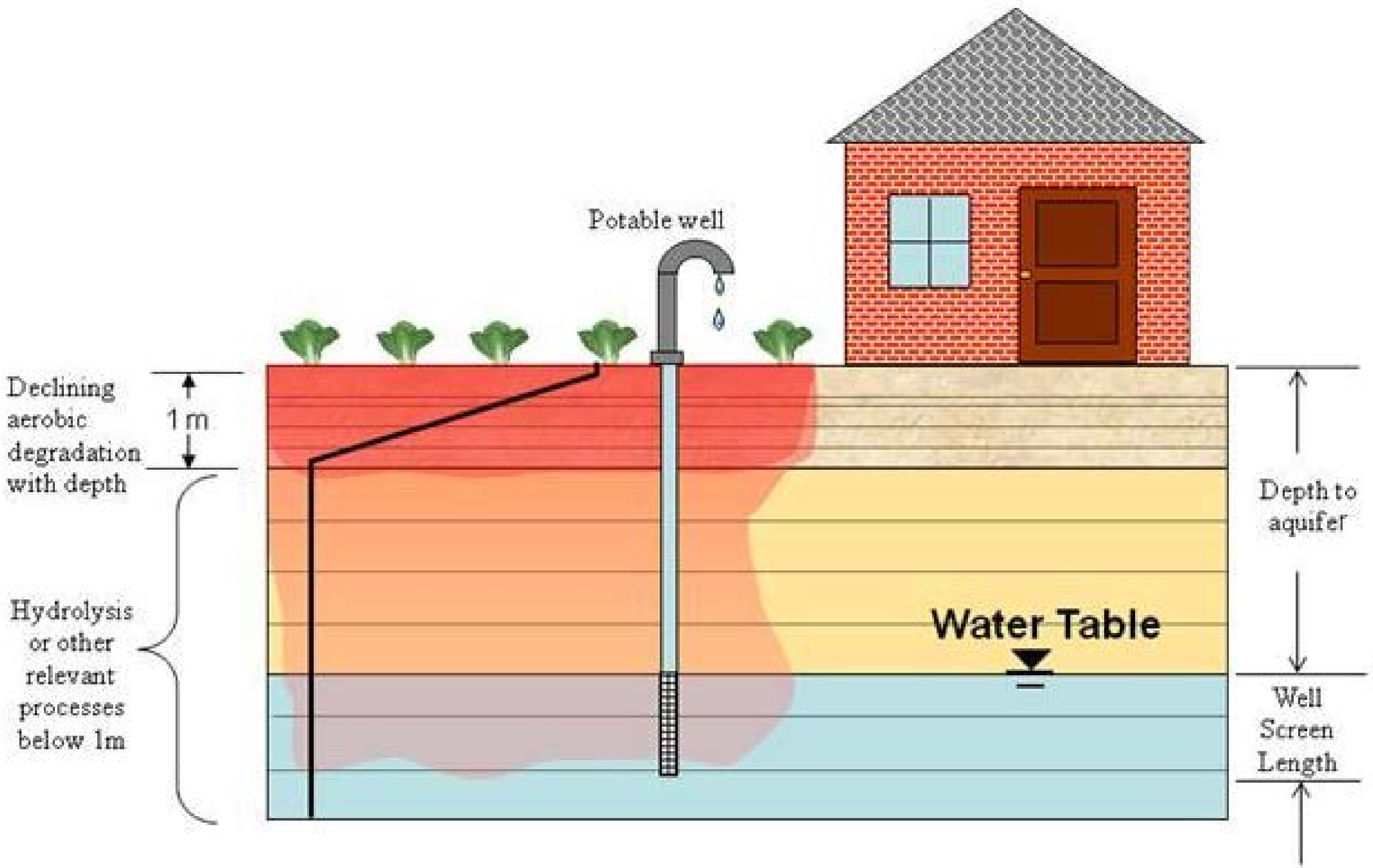
Ground water modeling key components



Key chemical inputs

- Aerobic soil half-life
- Linear soil adsorption Kd
- Hydrolysis half-life

Key use inputs

- Application rate and number
- Application timing
- Application method

Scenarios

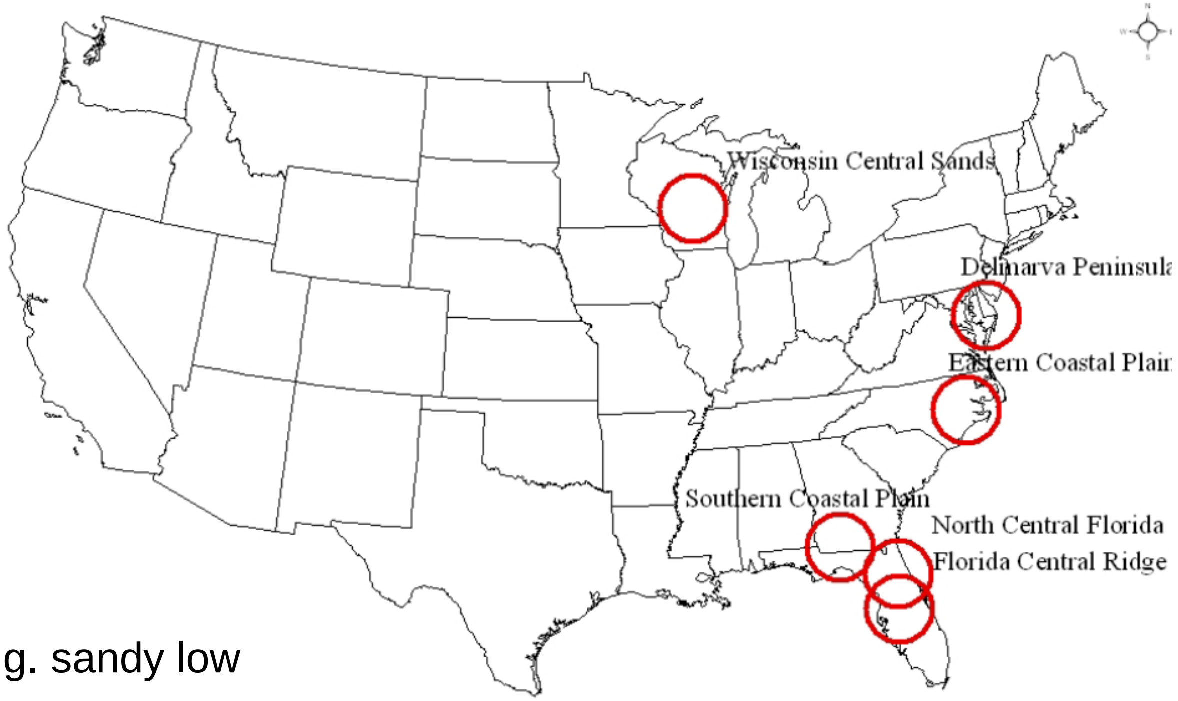
- Six defined scenarios

Key outputs

- Peak concentration
- Post breakthrough average concentration

Ground water modeling scenarios

- **Six Standard Scenarios**
  - Delmarva Peninsula
  - North Central Florida
  - Florida Central Ridge
  - Georgia Southern Coastal Plain
  - North Carolina Eastern Coastal Plain
  - Wisconsin Central Sands



- **Scenario selection**

  All scenarios represent sites vulnerable to leaching (e.g. sandy low organic matter), and were identified based on previous ground water monitoring programs

- **Conservative and protective "Tier 1" screen**

  Results from these vulnerable scenarios are viewed as protective for less vulnerable sites in other areas of the country

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Ground water modeling conservatism and refinement

Input conservatism

- 90th percentile upper bound on soil half-life
- Laboratory half-life (field half-life not used)
- Only hydrolysis degradation beyond 1 m

Model conservatism

- Scenarios mainly sandy soils, vulnerable to leaching
- Only linear sorption processes considered

Refinements

- Somewhat limited options
- Efate endpoint refinement (aerobic soil degradation, soil adsorption, hydrolysis)
- Well setbacks
- Refined use directions (timing, method, rate, etc.)
- Refined scenarios might be possible
- Further possible refinements require close consultation with EPA

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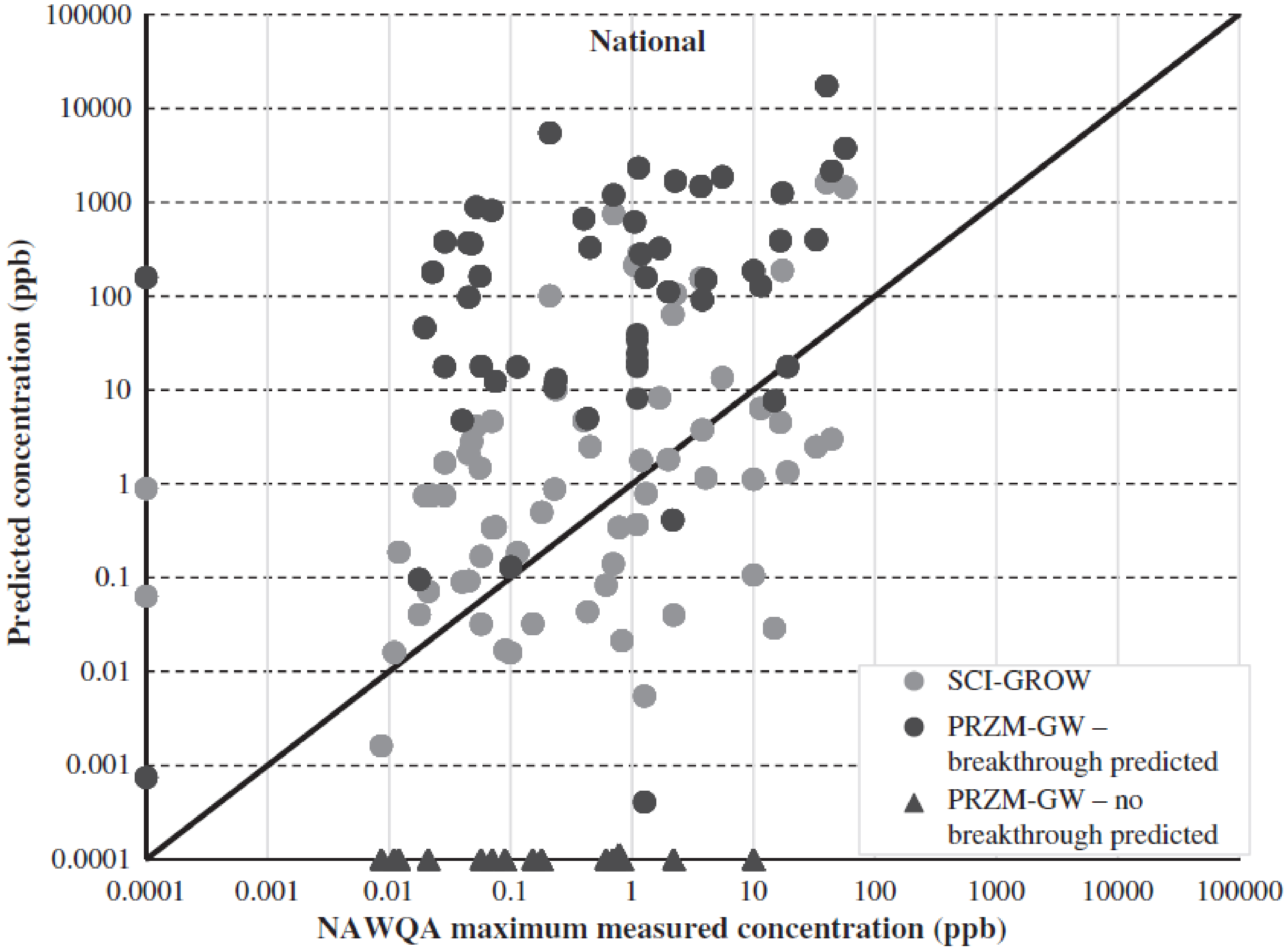
Predicted ground water concentrations are conservative



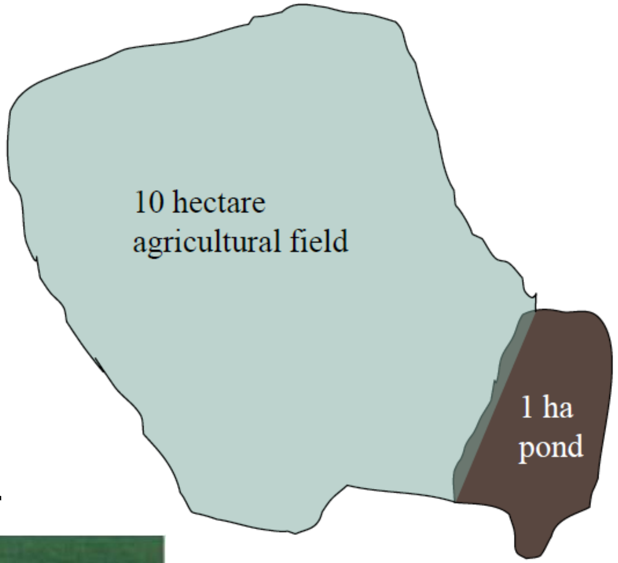
Adapted from Table 1 of Estes et al. 2016. Comparison of predicted pesticide concentrations in groundwater from SCI-GROW and PRZM-GW models with historical monitoring data. Pest Manag Sci 2016; 72: 1187–1201.

Surface water modeling

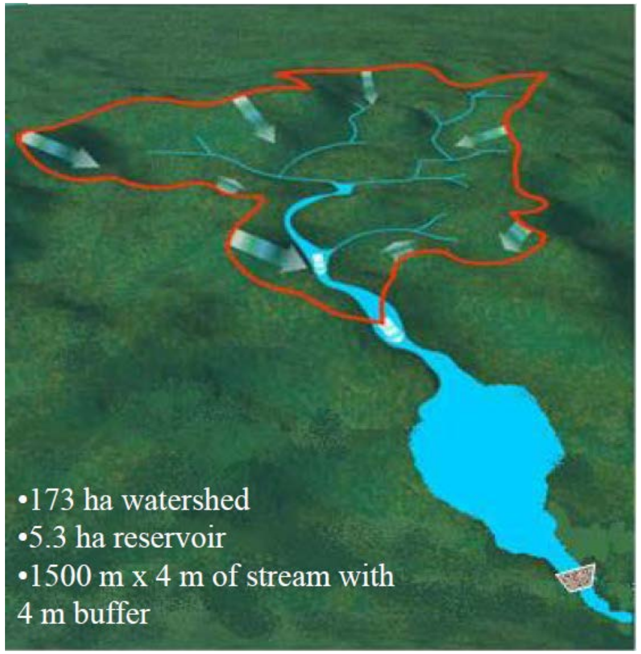
- **Human Health and Ecological Risk Assessments both consider surface water**
  - Modeling is identical
  - Watersheds and surface water bodies are different
    - Ecological: Farm Pond
    - Human Health: Index Reservoir

- **Three key inputs to surface water bodies**
  - Spray Drift
  - Runoff
  - Erosion

Farm Pond



Index Reservoir



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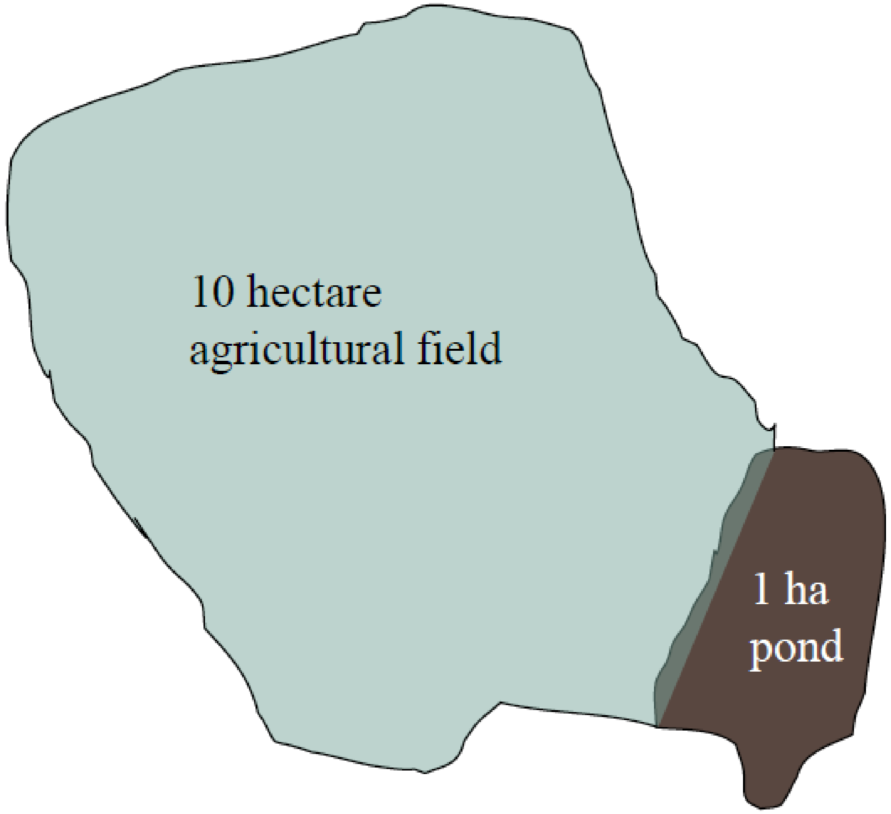
Surface water exposure for ecological assessments

- **Farm Pond**
  - 1-ha pond, 2-m deep (typical farm pond)
  - 10-ha field
  - Located at edge of a pesticide treated field (no buffer between pond and treated field)
  - Drift, erosion, and runoff occurs into the pond
  - STATIC water body (no flow, constant volume)
    - Model is fully capable to represent variable volumes
  - Pesticide can be dissolved into pond water up to the limit of solubility



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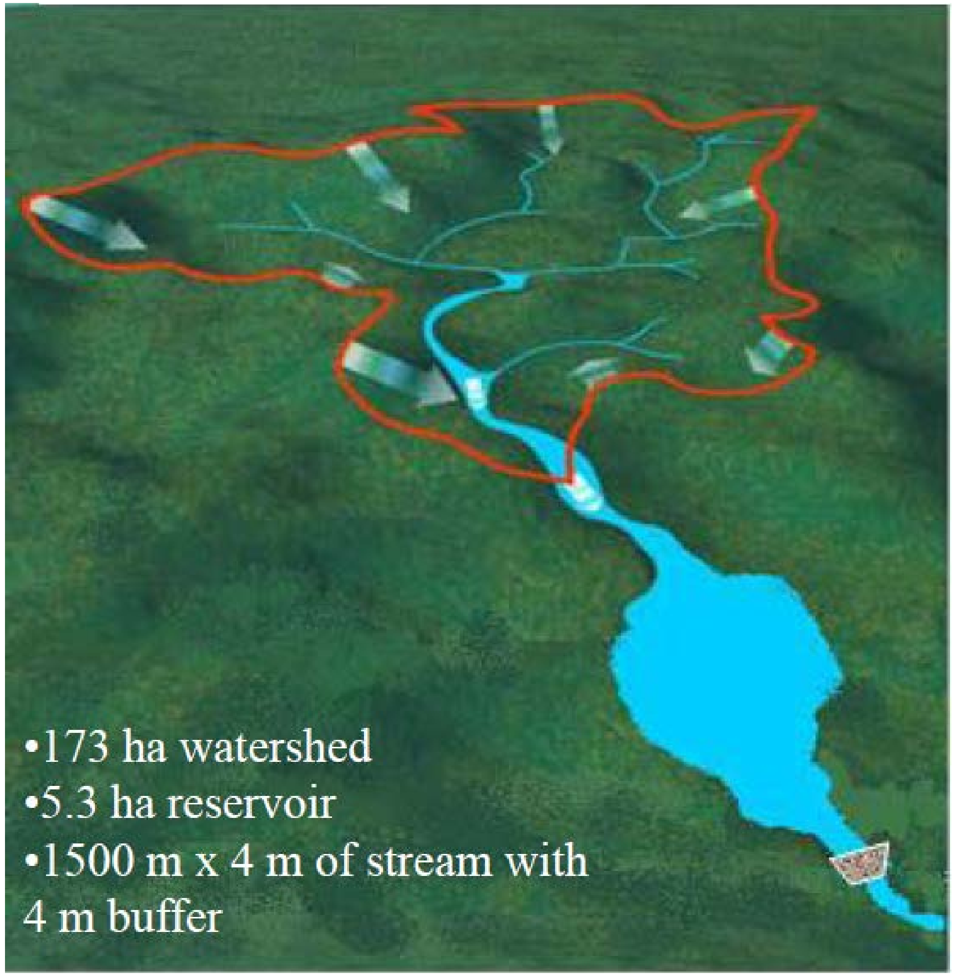
Surface water exposure for human health assessments

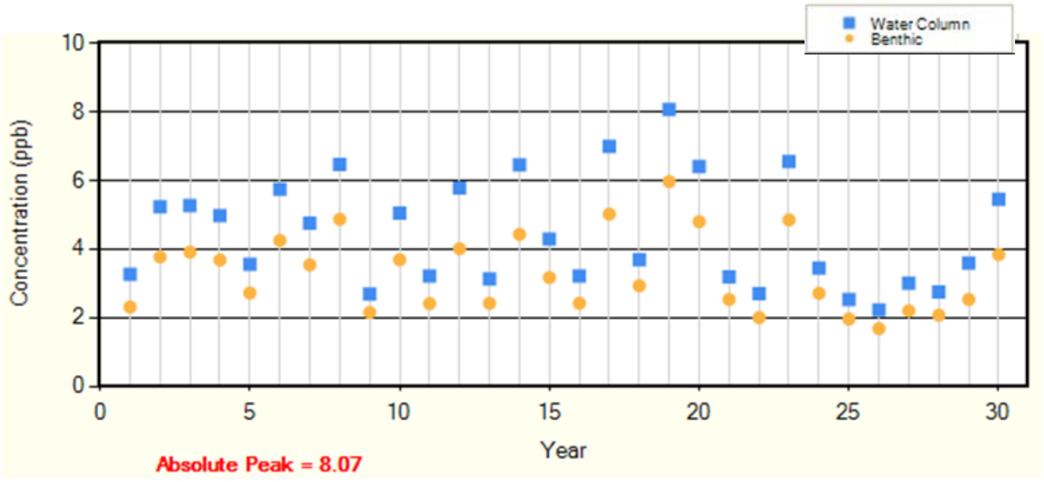
- **Index Reservoir**
  - Used for drinking water assessment
  - Based on drinking water reservoir in Shipman City Lake, Illinois
  - Representative of a number of reservoirs in the central Midwest, known to be vulnerable to pesticide contamination
  - Index reservoir: 82.2 m wide, 640 m long, 2.74 m depth
  - Watershed: 172.8 ha
  - Constant volume, site-specific long-term average runoff



Surface water modeling key inputs and outputs

Key chemical inputs

- Biotic half-lives (soil, water, sediment)
- Abiotic half-lives (aqueous photolysis, hydrolysis)
- Mobility (soil adsorption Kd)
- Physical/chemical properties (vapor pressure, water solubility)



Key use inputs

- Application information (rate, number of applications, timing, method)
- Application type determines default spray drift input setting

Key outputs

- Human health assessments: 1-in-10 year peak and 365-day average water concentrations
- Ecological assessments: 1-in-10 year peak and averages (e.g. 1, 4, 21, 60, 90 and 365-day) water concentrations
  - In addition to surface water, sediment and pore water concentrations are also determined for ecological assessments.

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Surface water scenarios

- There are over 100 crop-location scenarios for surface water assessments

- A variety of use patterns are represented
  - Row crop
  - Vegetables
  - Orchard
  - Turf
  - Pasture/meadow
  - Other (e.g. residential, impervious surface, right-of-way)

- Scenarios may include irrigation, cover a range of soil conditions favoring runoff, and are linked to location-relevant weather data

Surface water modeling refinements

Runoff and Erosion

- No runoff or erosion mitigation options are currently implemented in EPA guidance
- Efficacy of vegetated filter strips (VFS) have been under discussion for some time

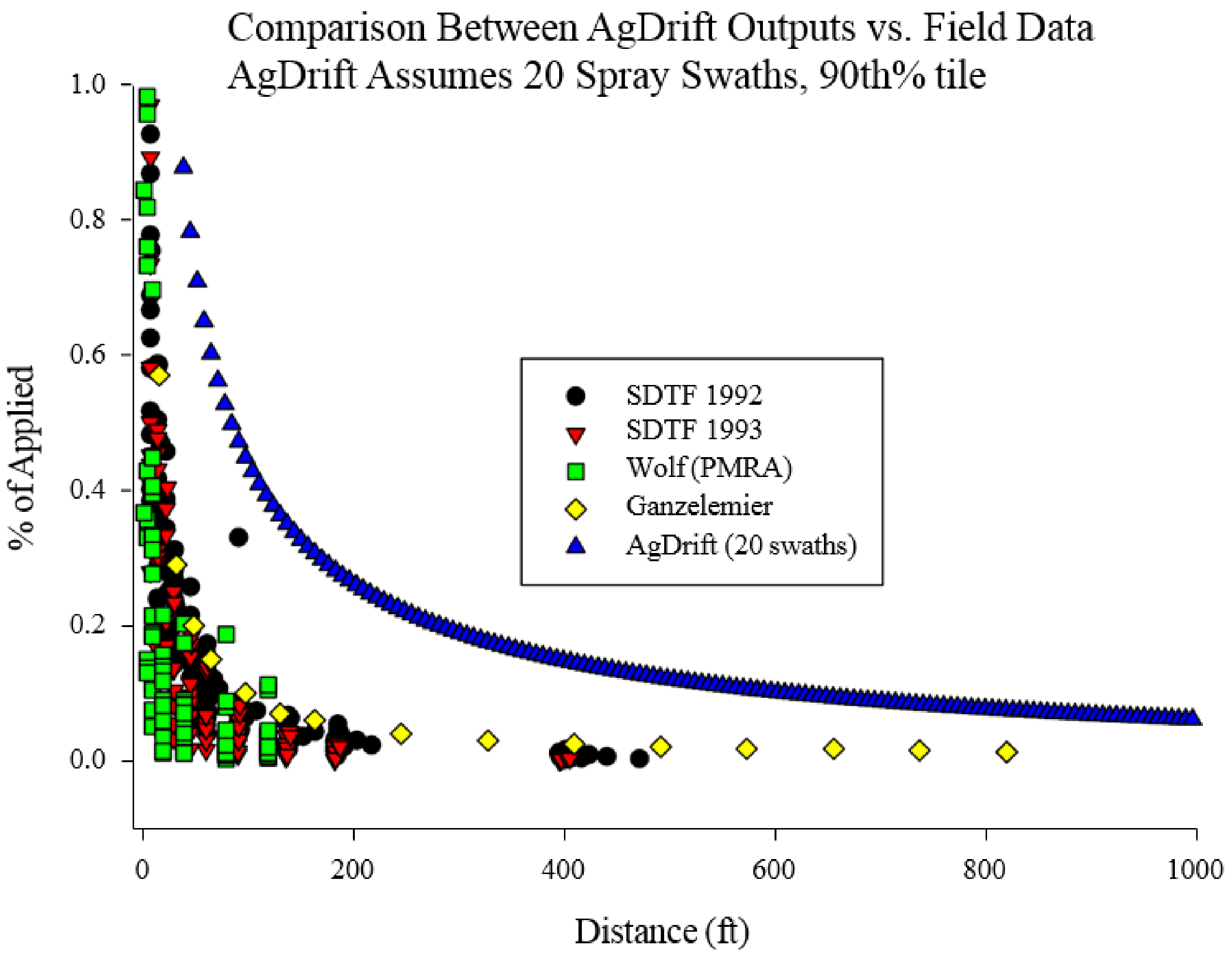
Spray drift

- Adjustment of spray drift is the primary refinement option for surface water assessments
- Buffer zone distance determines drift loading
- AgDRIFT is the regulatory tool accepted by EPA
- Tier I drift assessments using AgDRIFT are highly conservative
  - Empirically based on spray drift data sets using older spray technology
  - Grouping of drift data across broad droplet size classes and wind speeds prevents further refinement
- Other models, such as REGDISP and PMRA’s Buffer Zone Calculator overcome many of the AgDRIFT limitations, though not currently accepted by EPA
- Drift reducing technology (DRT) programs promote reduced drift

Others

- Adjustment of the percent cropped area (PCA) is possible, with justification

AgDRIFT provides highly conservative drift estimates



Adapted from Dyer, D. 2014. Accurate modeling for drift reduction: General overview and regulatory status. Presented on behalf of the CLA Spray Drift Issues Management Team. April 11, 2014.

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Interactions with EPA

- Open and regular dialogue with EPA is key to continuous improvement of risk assessments

- There are a variety of avenues for discussion and cooperation
  - Environmental Modeling Public Meetings (EMPM)
  - CropLife America meetings
  - Participation in professional meetings (e.g. ACS, SETAC)
  - Direct registrant-agency dialogue on assessments

- Goal is to maintain robust, scientifically sound (risk-based) assessment methods to protect human health and the environment, while allowing grower access to effective pest management tools.

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