Variations on a Theme, Groundwater Sensitivity

Amy Ritter, Waterborne Environmental, Inc.
Mark Cheplick, Waterborne Environmental, Inc.
Isha Khanijo, Waterborne Environmental, Inc.

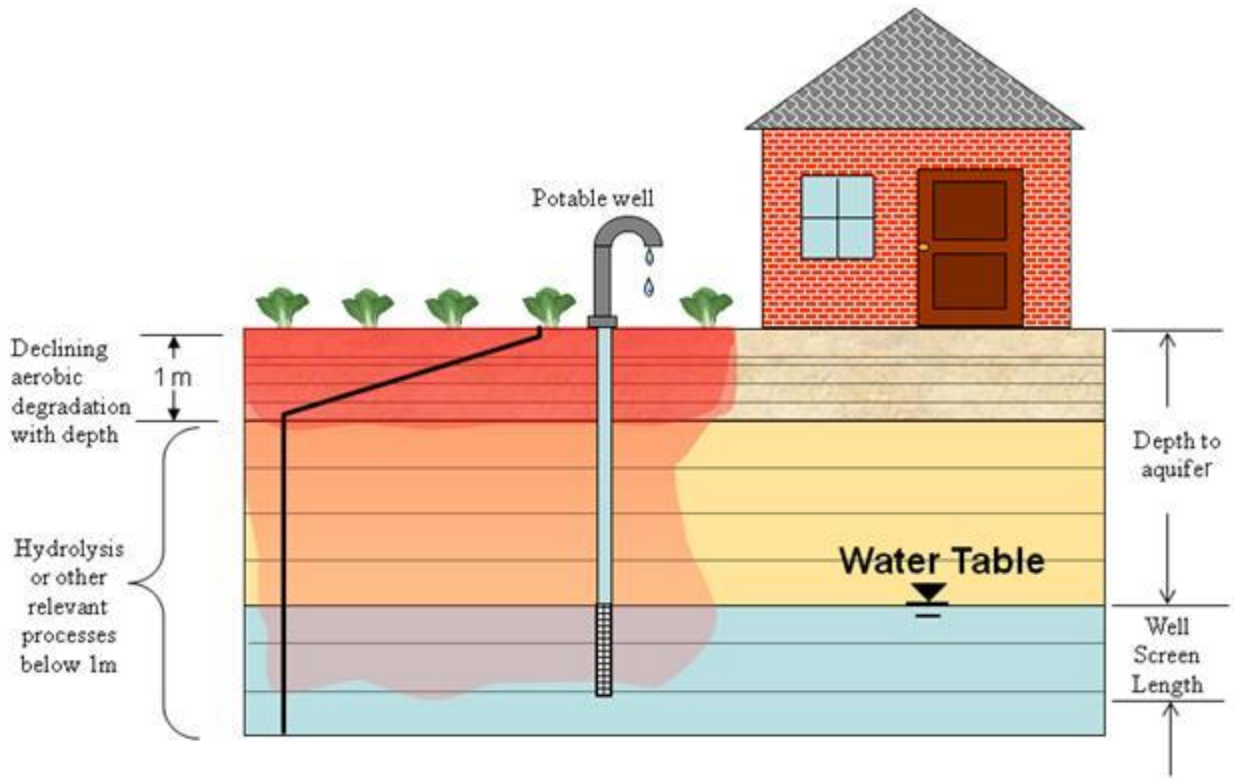
Overview

- PWC (GW) conceptual model
- Background
- Sensitivity of the interaction of e-fate parameters and PWC GW model assumptions
  - DT50 interactions
  - Application type
  - Layer thickness (dispersion)
  - Volatilization
  - PRZM5 Freundlich implementation (non-linear sorption) and a comparison to FOCUS WINPRZM (based on PELMO/PEARL implementation)
  - Application timing (rainfall timing)
- Conclusions

USEPA Drinking Water Assessment

- Current EFED model in PWC (Version 1.52, PRZM5)
- Six standard scenarios run for Tier-1 evaluation
  - WI Corn Sands, Delmarva, GA Coastal, NC Coastal, FL Potatoes, and FL citrus
- Post breakthrough average and maximum concentration from 30 year run (repeated applications and 30-year climate) used for chronic and acute assessment, respectively
- Previous EFED models for GW
  - Sci-Grow (Tier I screening model)
  - PRZM-GW (version 1.07, PRZM-3.12.2)

PRZM-GW/PWC Conceptual Model

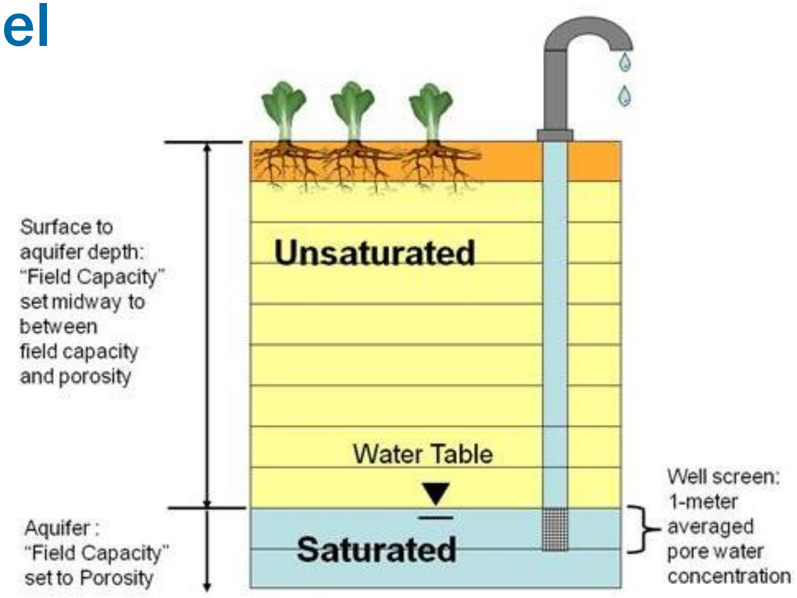


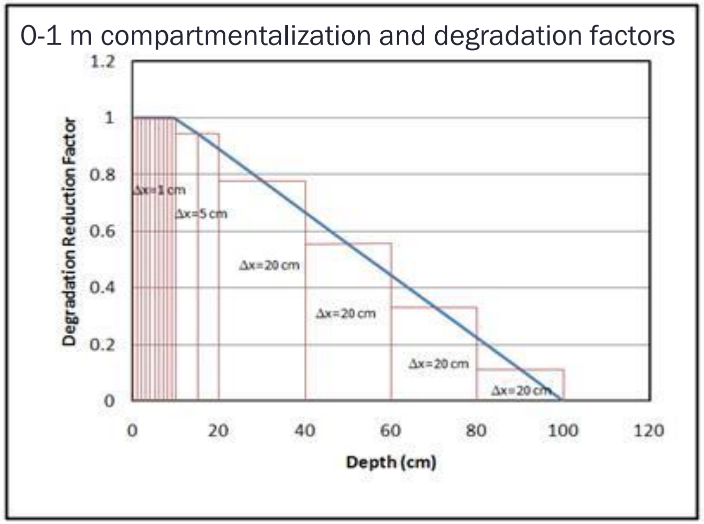
A drinking water well beneath an agricultural field which draws water from a shallow unconfined, high water-table aquifer with a well screen.

Source: https://www.epa.gov/pesticide-science-and-assessing-pesticide-risks/about-water-exposure-models-used-pesticide#przmgw

PWC (GW) Conceptual Model

- Processes include water flow, chemical degradation and sorption, rain, irrigation and crop specific factors including transpiration, pesticide interception and management practices.
- Soil temperature simulated
- Slower aerobic soil degradation with depth up to 1m
- Only Hydrolysis below 1 m
- Compartment size 50cm from 1m – 8m





WATERBORNE ENVIRONMENTAL

Source: http://www.epa.gov/oppefed1/models/water/przm_gw/wqtt_przm_gw_guidance.htm

Background

- Pesticide with < 1 day aerobic soil half-life and no hydrolysis was run using EPA’s groundwater model with six standard scenarios with maximum label use rate
- WI sand was worst case scenario
- High groundwater concentrations were predicted, when in field studies chemical was not seen below 12 inches.
- Sensitivity runs were done for WI corn scenario
  - Figure out what's causing high concentrations
  - To see impact of modeling assumptions used in conceptual model

WATERBORNE ENVIRONMENTAL

WI Corn Scenario (Selected for GW Sensitivity)

- Located in Central Sands region in South Central Wisconsin
- Corn for grain was the second largest crop by area for the state of Wisconsin
- Vulnerable groundwater that may be used by private wells
- Texture for the Coloma series is Loamy sand, and is classified as hydrologic soil group B (60 to 80% sand), organic carbon from .07% to 0. 46% (surface)
- Meteorological File – La Crosse, WI (W14920)
- Curve number = 10
- Crop emergence on May 1 and harvest on October 20
- Core depth = 1000 cm (10 m)

Five Case Studies for Sensitivity

Case Study 1 – Subsurface Degradation Parameterization
Case Study 2 – Application Type
Case Study 3 – Compartment Thickness
Case Study 4 – Degradation including Volatilization and Non-linear Sorption
Case Study 5 – Rainfall on Application Day

Variety of Chemical Properties used in Case Studies

Parameter	Type of Value	Value
Koc (L/kg)	Small	10
Hydrolysis (days)	Stable, Medium	0.0, 100.0
Soil Half-life (days)	Fast, Medium, Long	1.0, 10.0, 1000.0
Volatilization	On/Off	Hk=0.00154
Freundlich, 1/n	On/Off	0.9

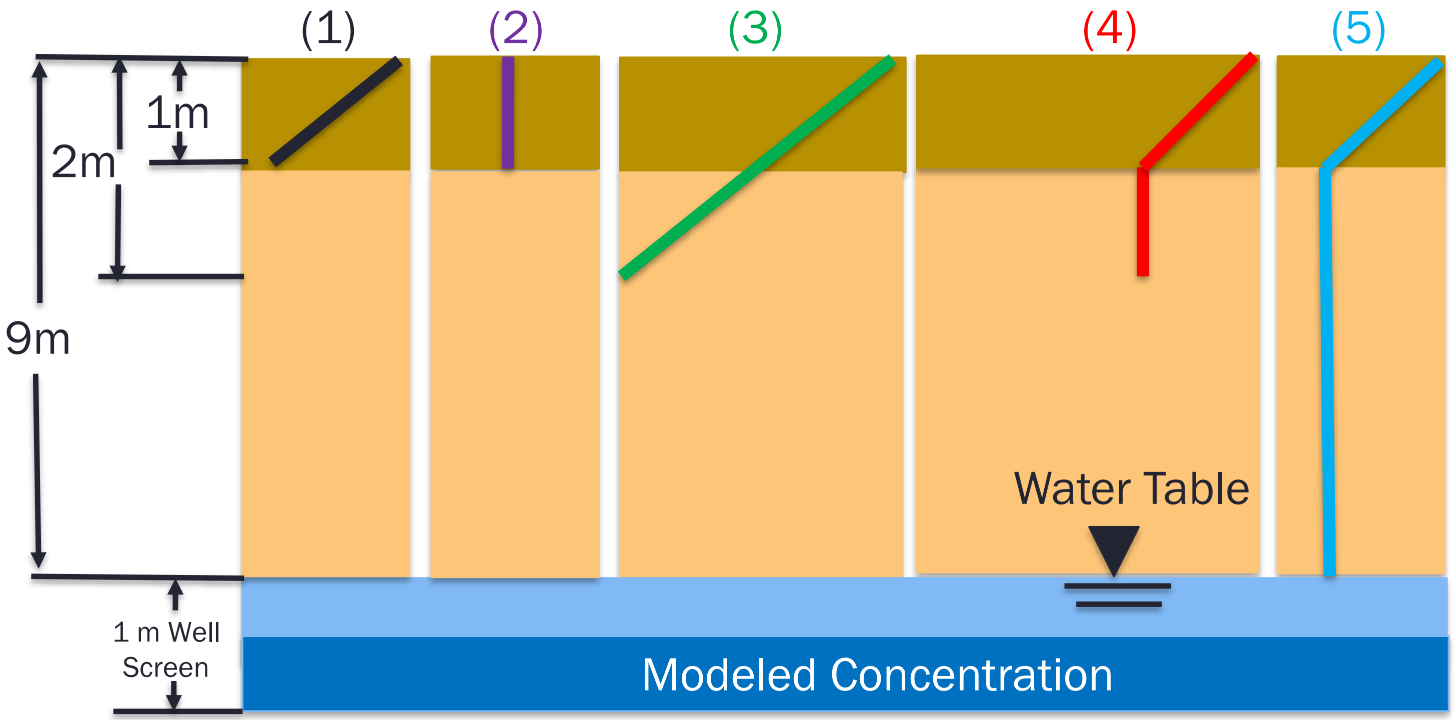
Example Application Timing

- 1 pre-emergent application of 1 kg/ha on April 15

Case Study 1 – Subsurface Degradation Parameterization

- Degradation properties:
  - 1-day aerobic soil degradation
  - Stable hydrolysis

Impact of Soil DT_{50} Simulation in the Model (WI Corn Scenario)

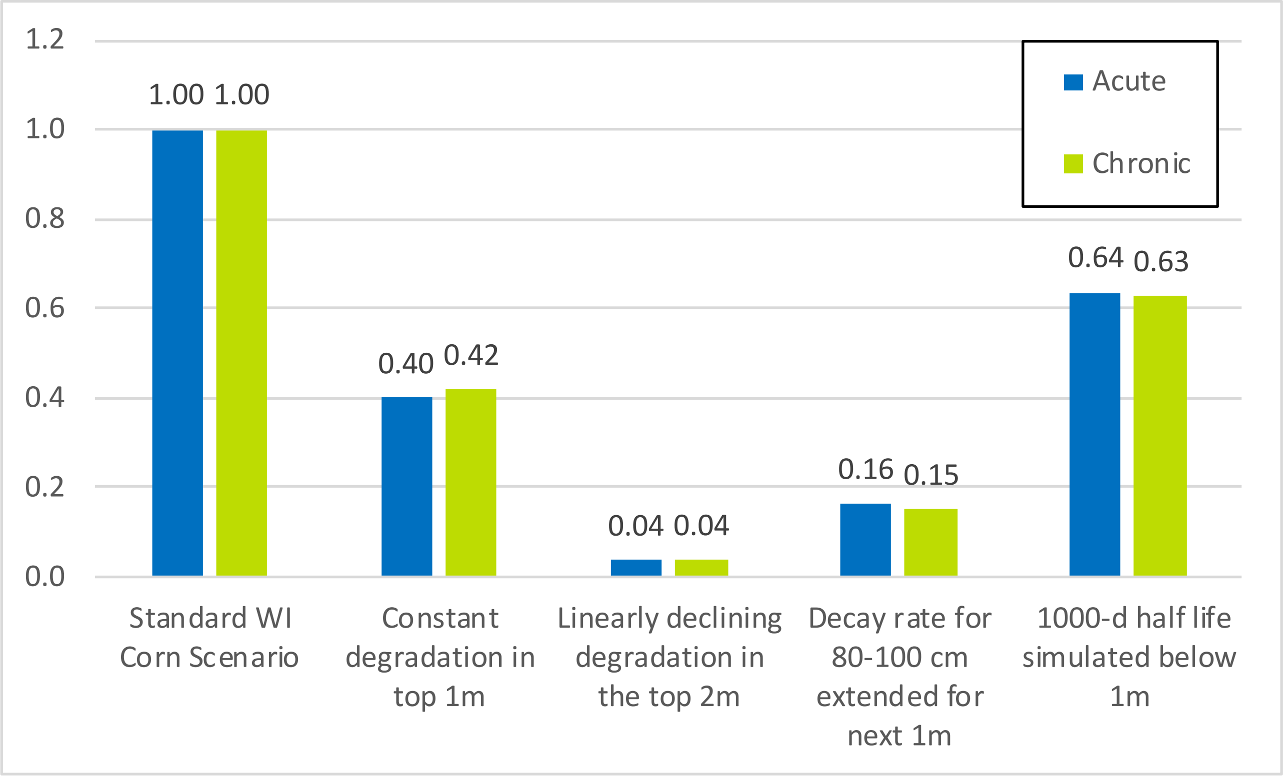


(1) PWC (linearly declining degradation in the top 1m, no hydrolysis)
(2) Constant degradation in top 1m
(3) Linearly declining degradation in the top 2m
(4) Decay rate for 80-100 cm extended for next 1m
(5) Linearly declining degradation in the top 1m, 1000-d half life simulated below 1m

Figure not to scale

Impact of Soil DT_{50} Degradation in the Model

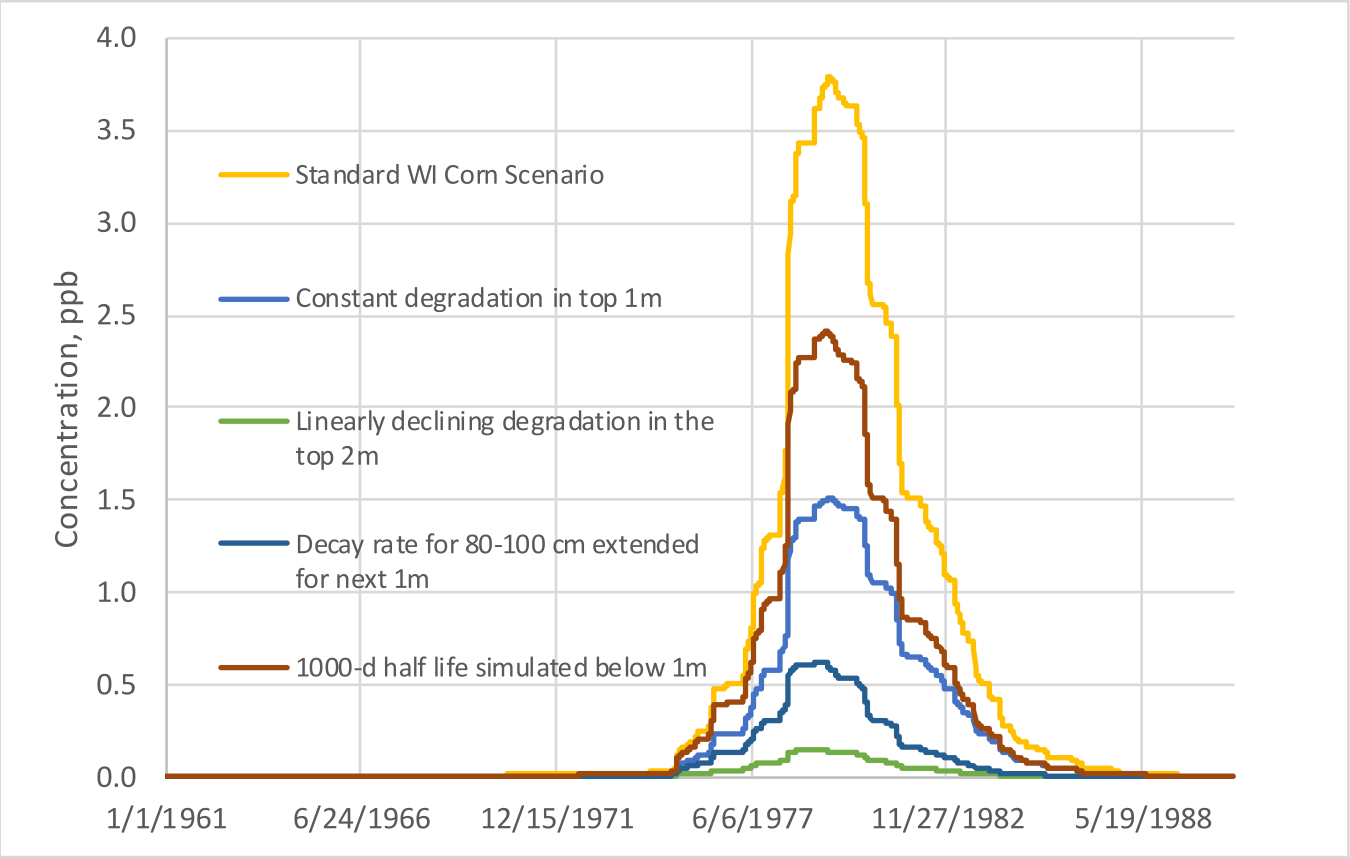
Normalized concentrations (ppb) compared for different methods of simulating soil DT50 in PWC model



Soil Half-life = 1 day, Hydrolysis = 0 (stable), Koc =10 L/kg
All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

WATERBORNE ENVIRONMENTAL

Impact of Soil DT_{50} Degradation in the Model

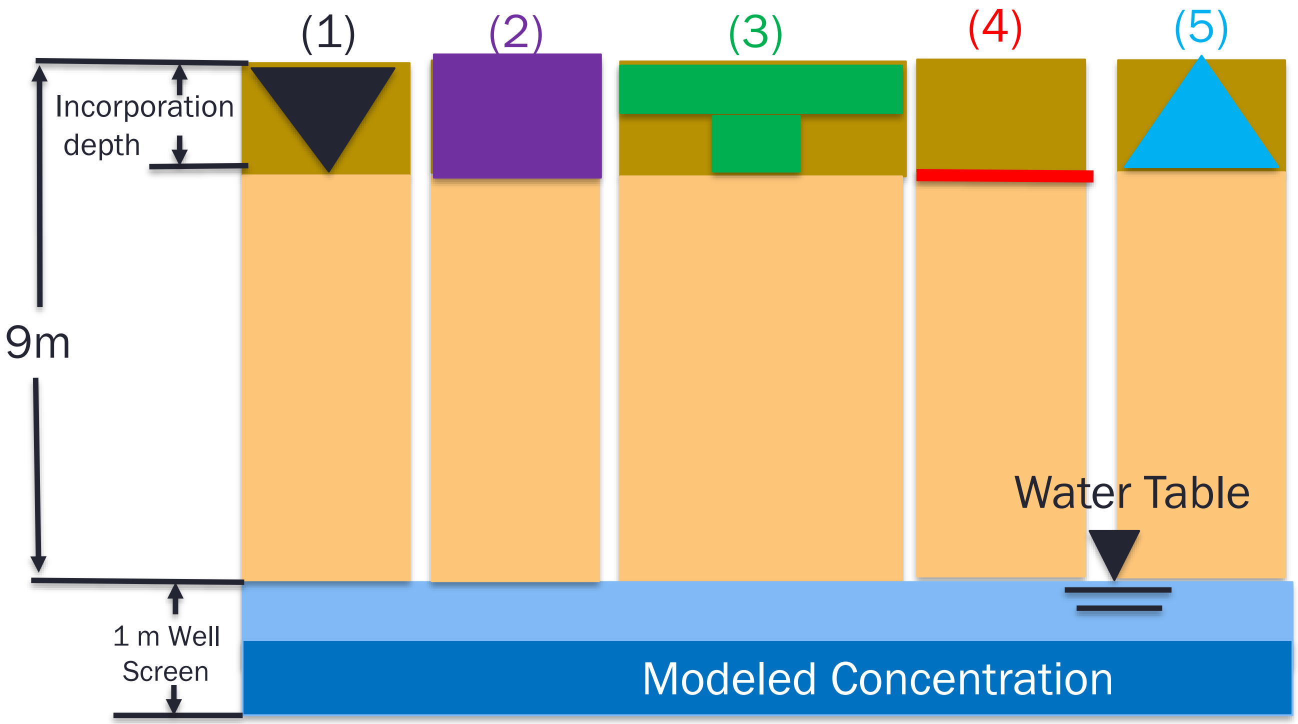


Soil Half-life = 1 day, Hydrolysis = 0 (stable), Koc =10 L/kg
All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

Case Study 2 – Application Type

- Degradation properties:
  - 1-day aerobic soil degradation
  - Stable hydrolysis

Impact of Application in the Model (WI Corn Scenario)

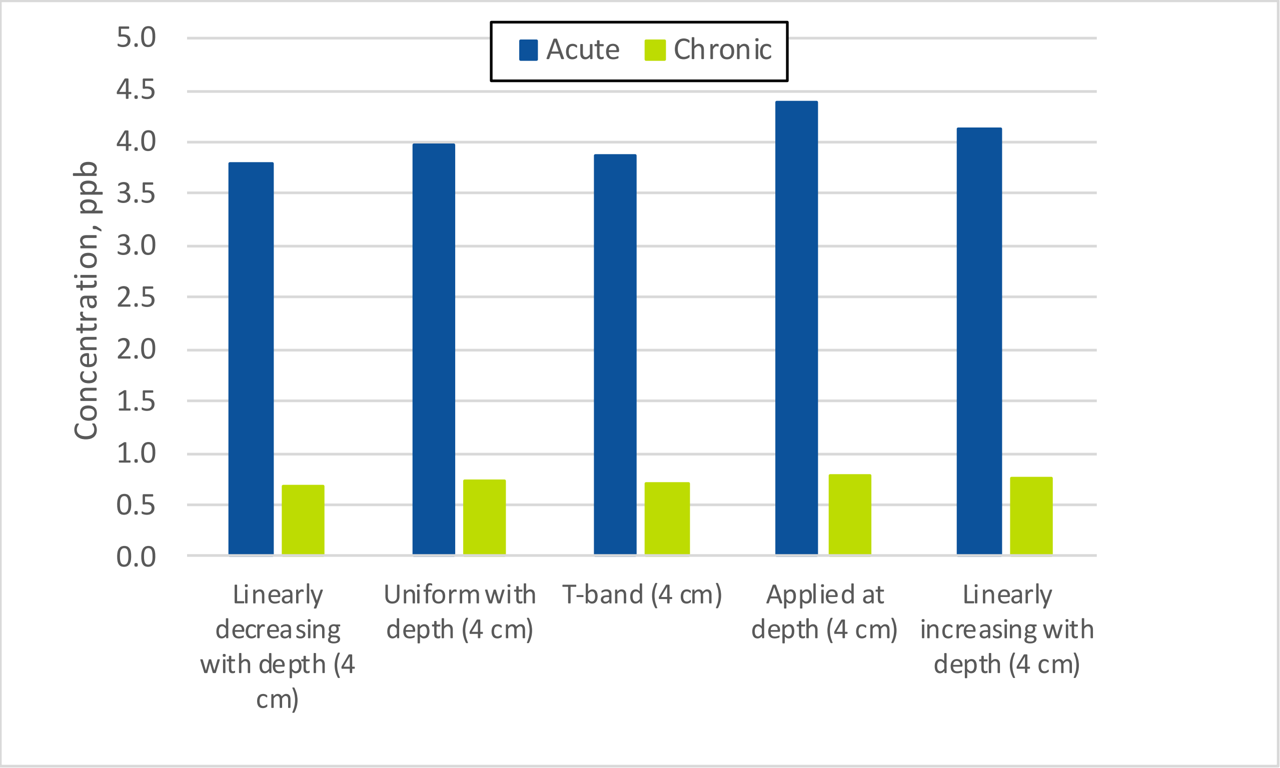


(1) Linearly decreasing with depth
(2) Uniform with depth
(3) T-band
(4) Applied at depth
(5) Linearly increasing with depth

Figure not to scale

Impact of Application Type in the Model

Concentrations compared for different methods of application in PWC model

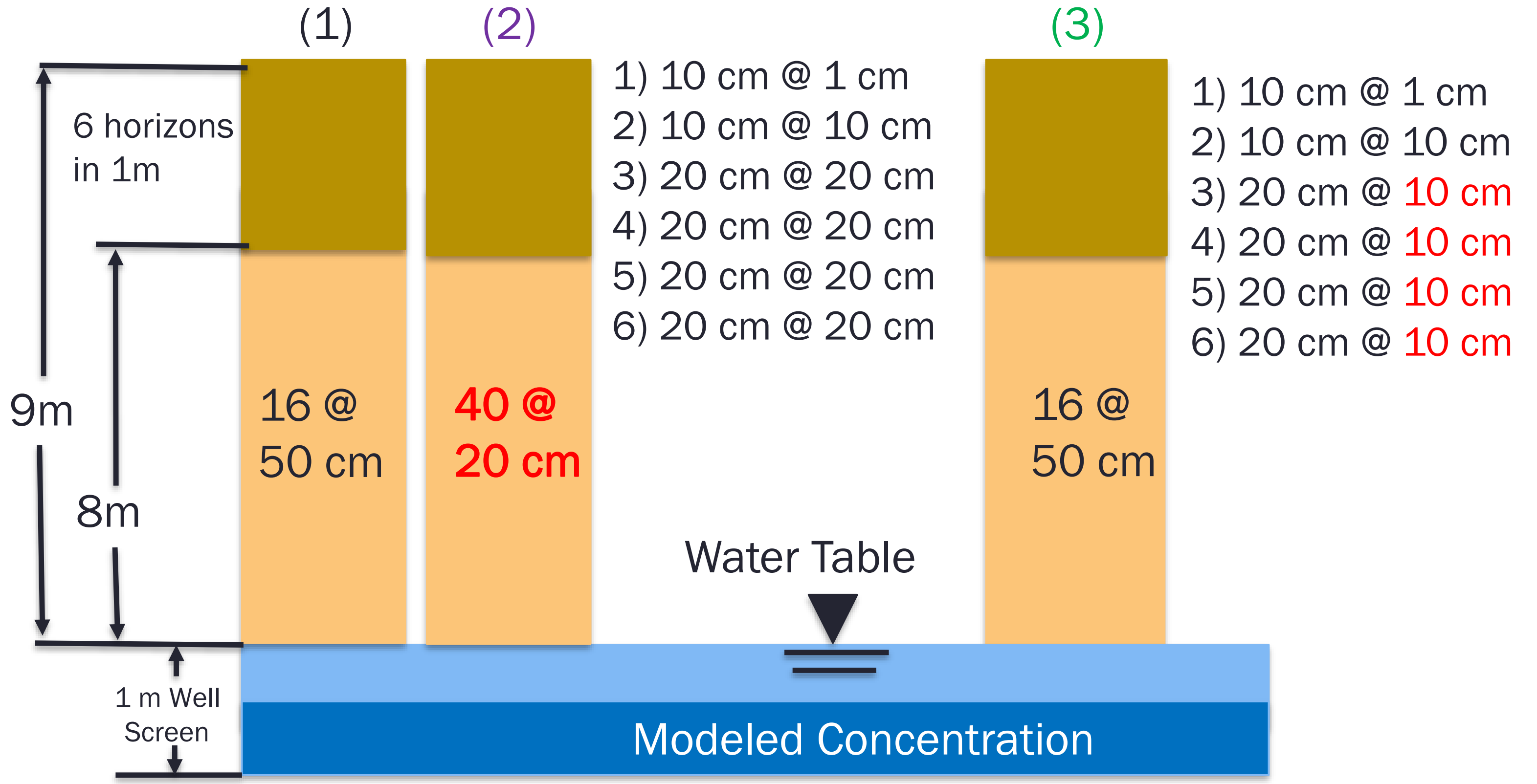


Soil Half-life = 1 day, Hydrolysis = 0 (stable) , Koc = 10 L/kg
All runs done with: WI Sand Scenario; Applied at a rate of 1 kg/ha at 2 weeks before emergence.

Case Study 3 – Compartment Thickness (Dispersion)

- Chemical 1 Degradation properties:
  - 1-day aerobic soil degradation
  - Stable hydrolysis
- Chemical 2 Degradation properties:
  - 1000-day aerobic soil degradation
  - 100-day hydrolysis

Impact of Compartment Thickness in the Model (WI Corn Scenario)

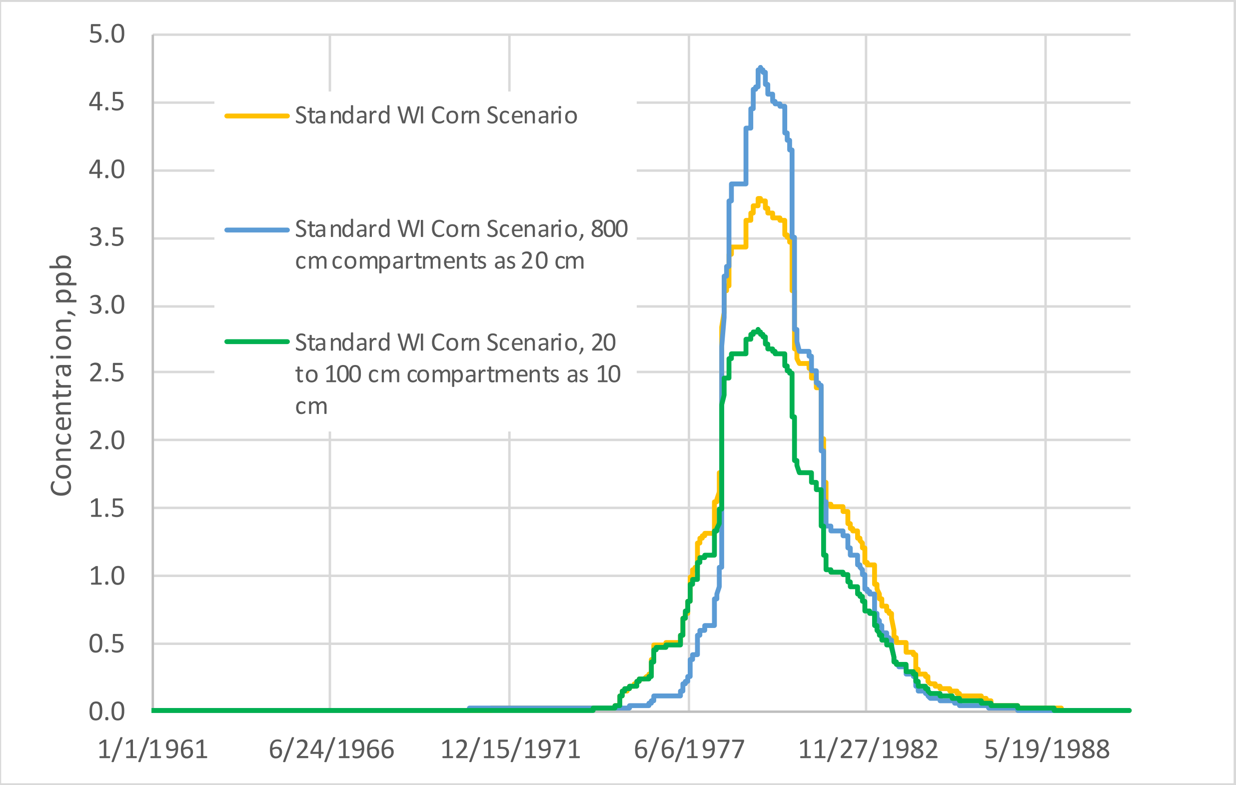


(1) Standard Scenario
(2) Standard WI Corn Scenario, 800 cm compartments as 20 cm
(3) Standard WI Corn Scenario, 20 to 100 compartments as 10 cm

Figure not to scale

Impact of Dispersion in the Model

Comparison for different compartment thicknesses in PWC model

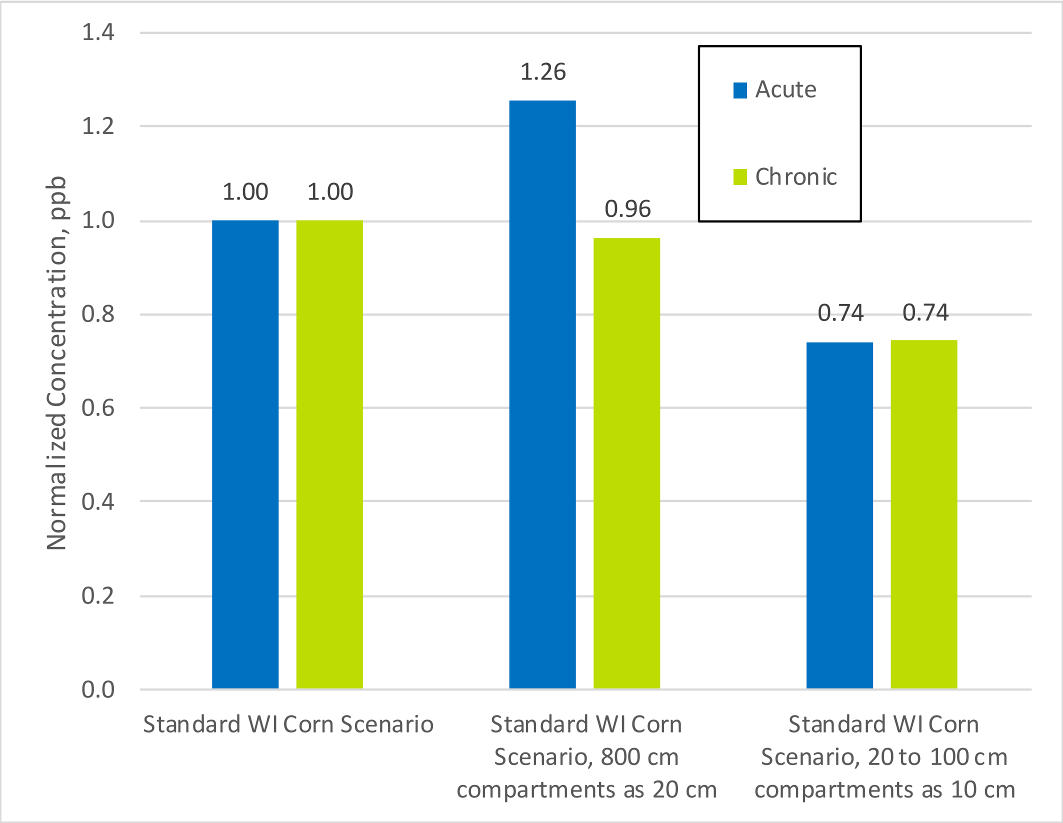


Soil Half-life = 1 day, Hydrolysis = 0 (stable), Koc = L/kg
All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

WATERBORNE ENVIRONMENTAL

Impact of Dispersion in the Model

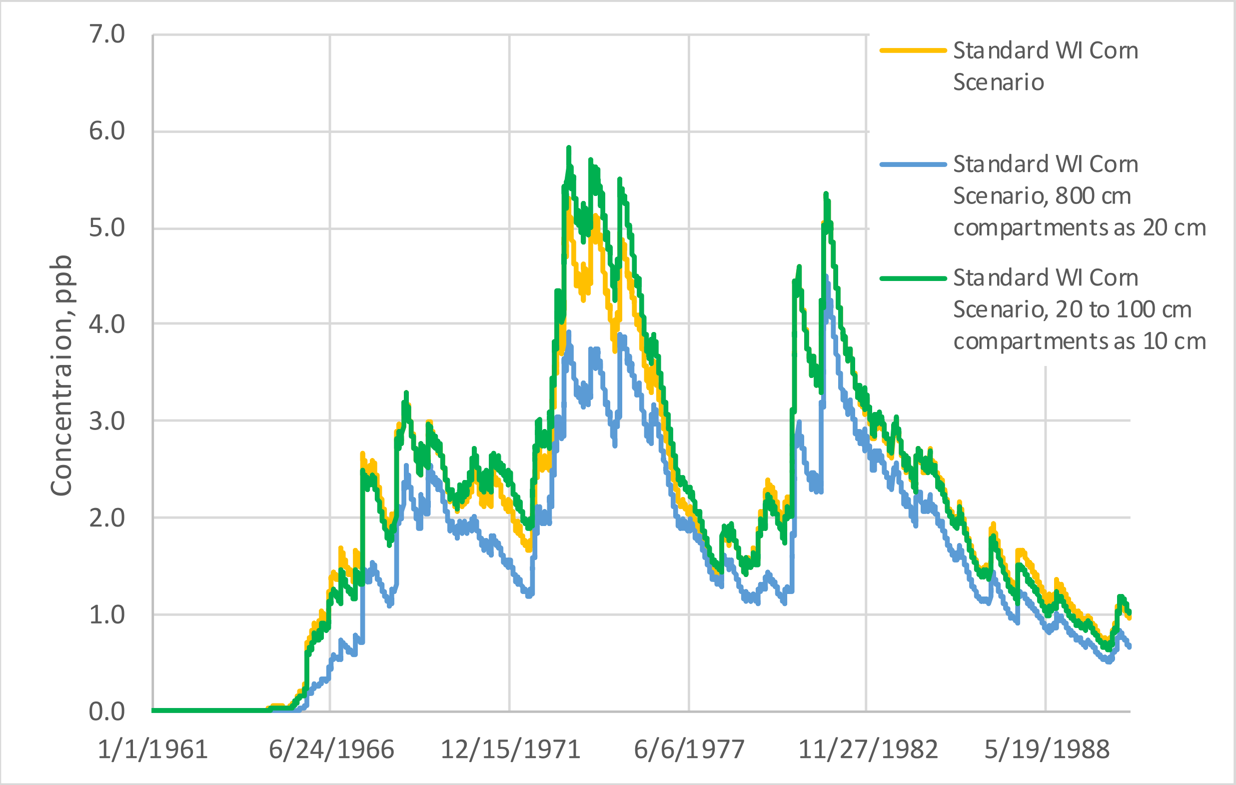
Comparison for different compartment thicknesses in PWC model



Soil Half-life = 1 day, Hydrolysis = 0 (stable), Koc = 10 L/kg
All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

Impact of Dispersion in the Model

Comparison for different compartment thicknesses in PWC model



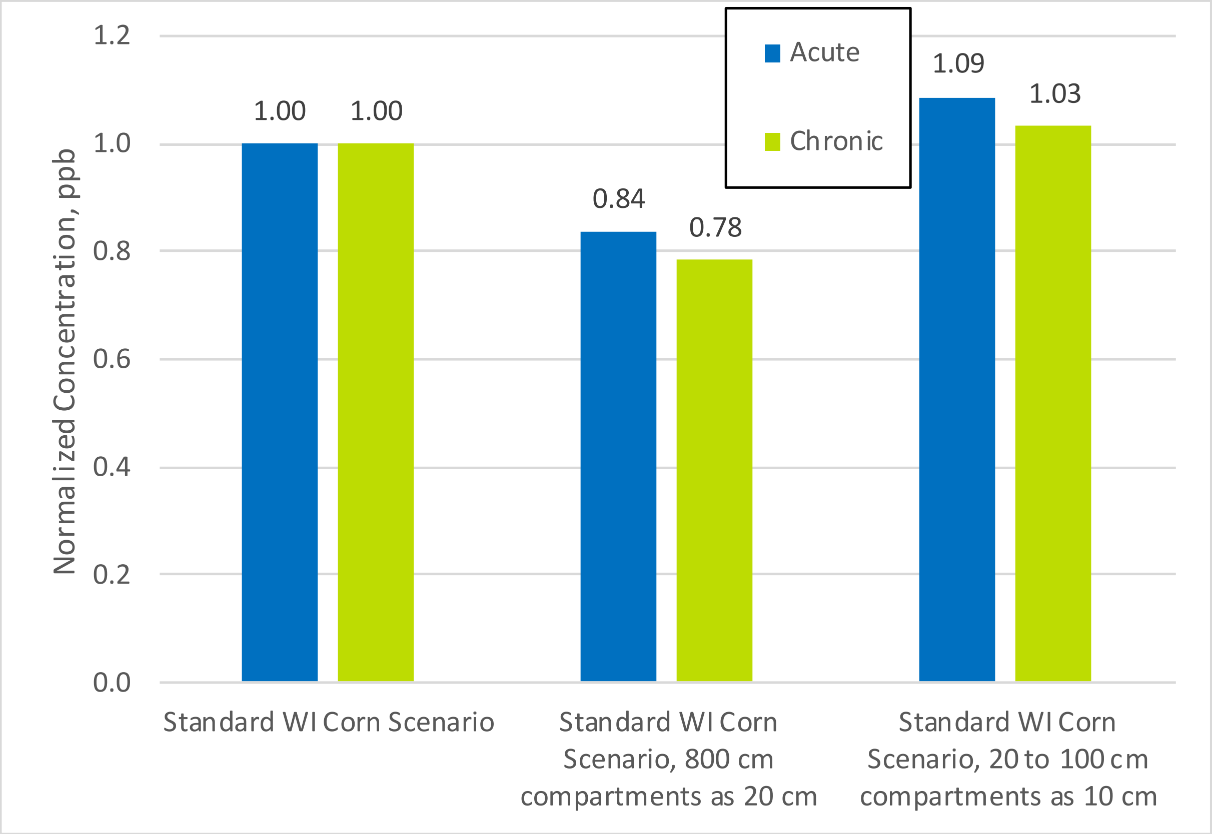
Soil Half-life = 1000 day, Hydrolysis = 100, Koc = 10 L/kg

All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

WATERBORNE ENVIRONMENTAL

Impact of Dispersion in the Model

Comparison for different compartment thicknesses in PWC model

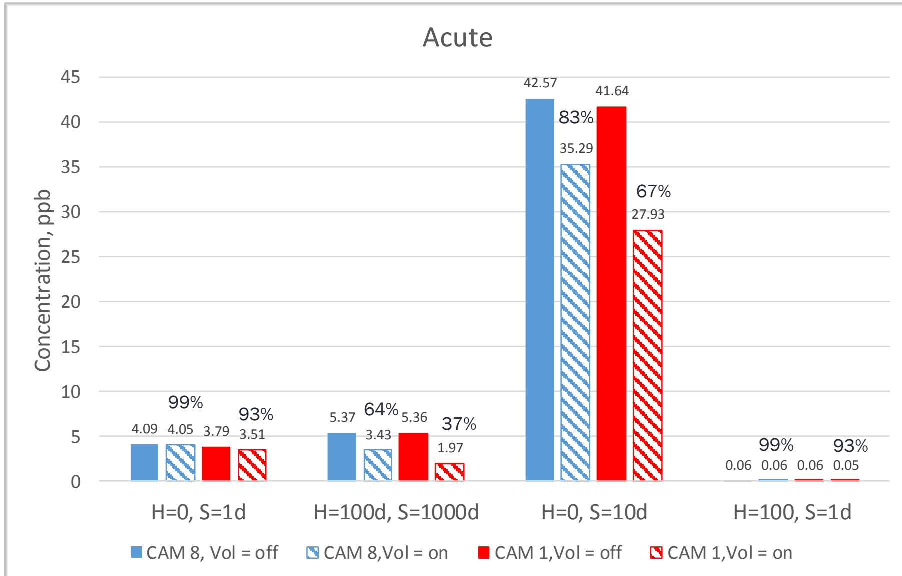


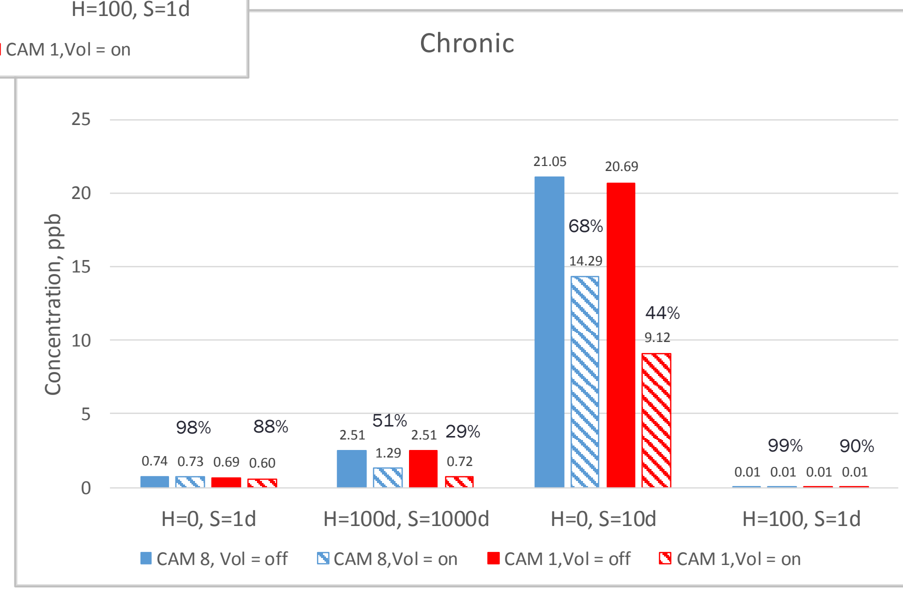
Soil Half-life = 1000 day, Hydrolysis = 100, Koc = 10 L/kg
All runs done with: WI Corn Scenario; CAM 1 application (linearly decreasing with depth). Applied at a rate of 1 kg/ha at 2 weeks before emergence.

Case Study 4 – Degradation including Volatilization and Non-linear Sorption

- Chemical 1 Degradation properties:
  - 1-day aerobic soil degradation
  - Stable hydrolysis
- Chemical 2 Degradation properties:
  - 1000-day aerobic soil degradation
  - 100-day hydrolysis
- Chemical 3 Degradation properties:
  - 10-day aerobic soil degradation
  - Stable hydrolysis
- Chemical 4 Degradation properties:
  - 1-day aerobic soil degradation
  - 100-day hydrolysis

Impact of Volatilization

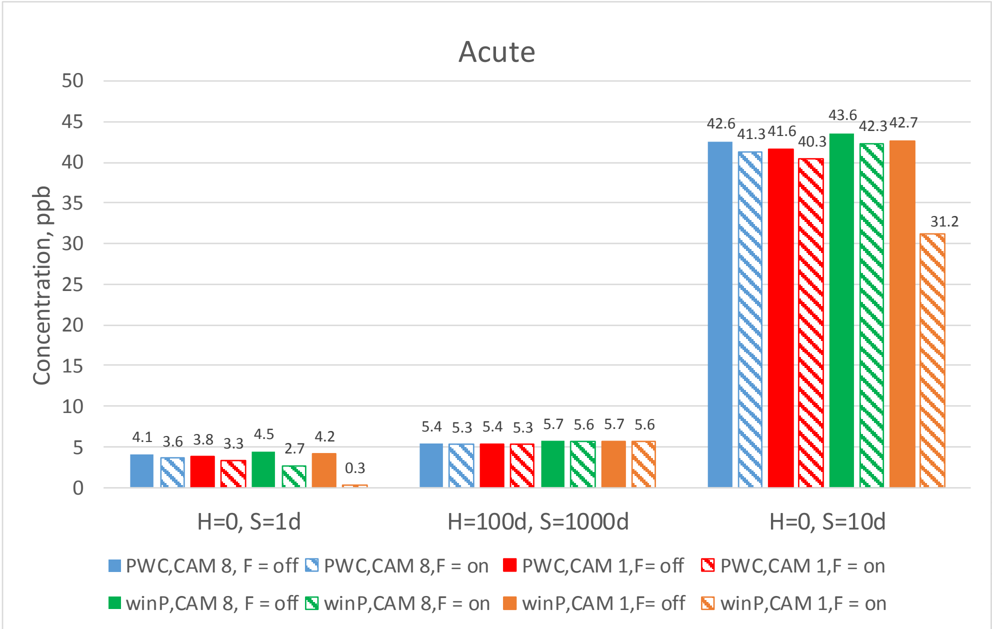


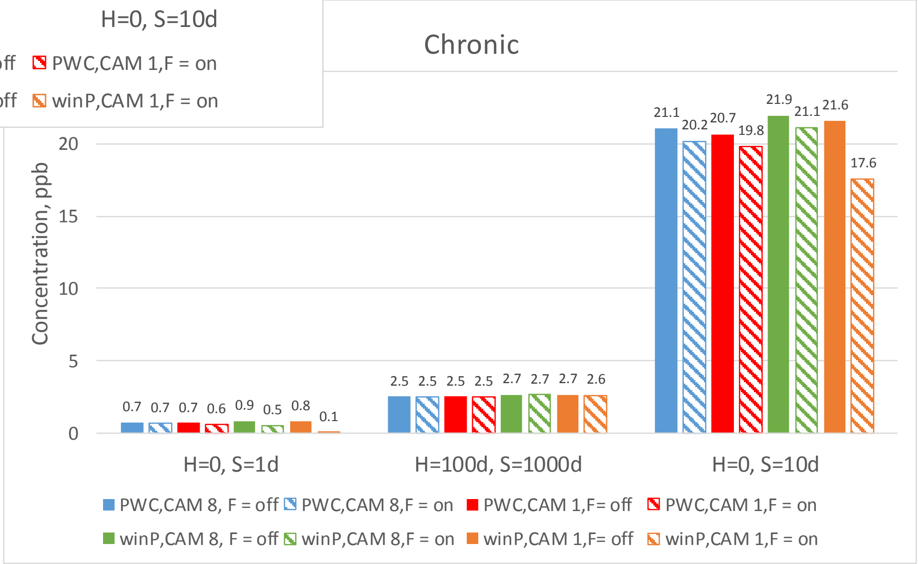


WATERBORNE ENVIRONMENTAL

All runs done with: WI Corn Scenario; Applied at a rate of 1 kg/ha at 2 weeks before emergence.

Impact of Freundlich (Nonlinear Sorption)





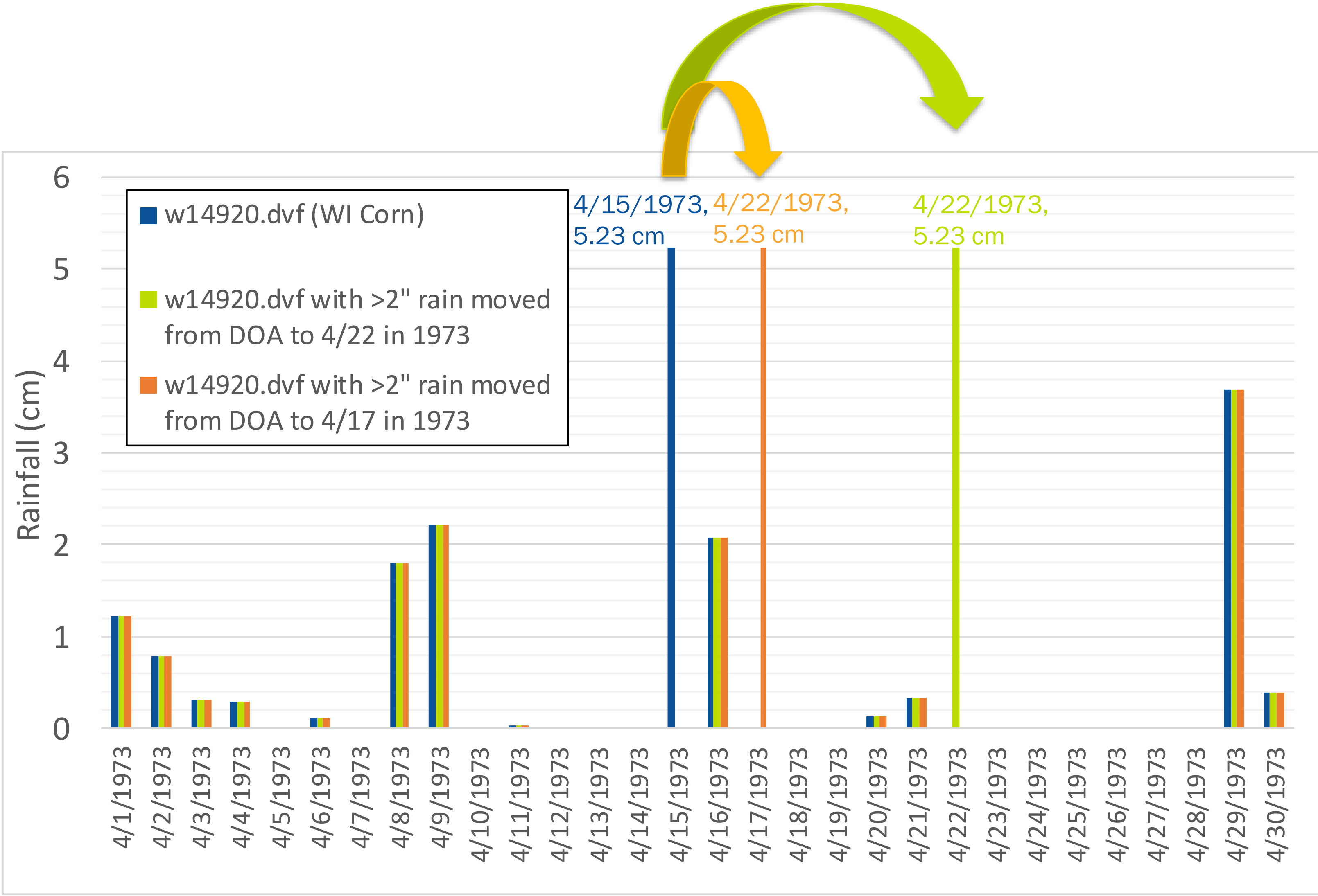
All runs done with: WI Corn Scenario; Applied at a rate of 1 kg/ha at 2 weeks before emergence.

WATERBORNE ENVIRONMENTAL

Case Study 5 – Rainfall on Application Day

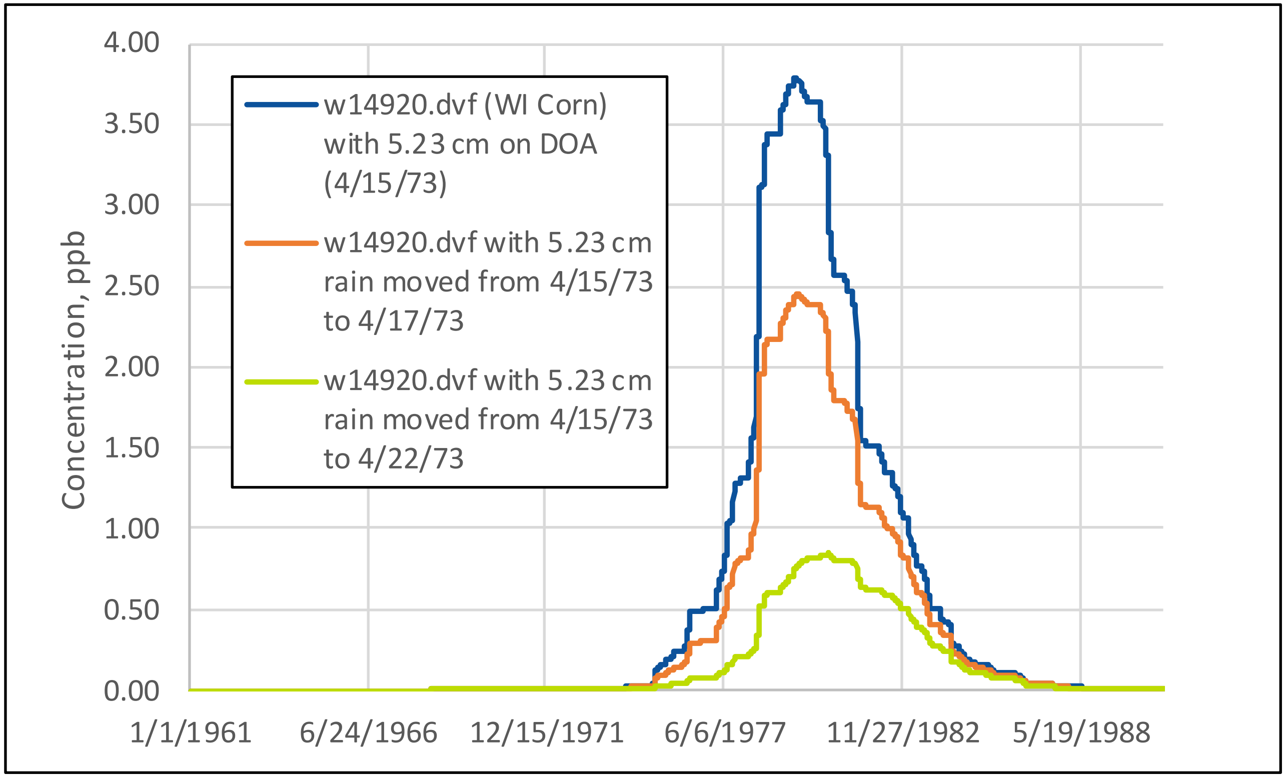
- Chemical 1 Degradation properties:
  - 1-day aerobic soil degradation
  - Stable hydrolysis
- Chemical 2 Degradation properties:
  - 1000-day aerobic soil degradation
  - 100-day hydrolysis
- Chemical 3 Degradation properties:
  - 10-day aerobic soil degradation
  - Stable hydrolysis

Impact of Heavy Rain (> 2 inch) on Application Day



WATERBORNE ENVIRONMENTAL

Impact of Heavy Rain on Application Day

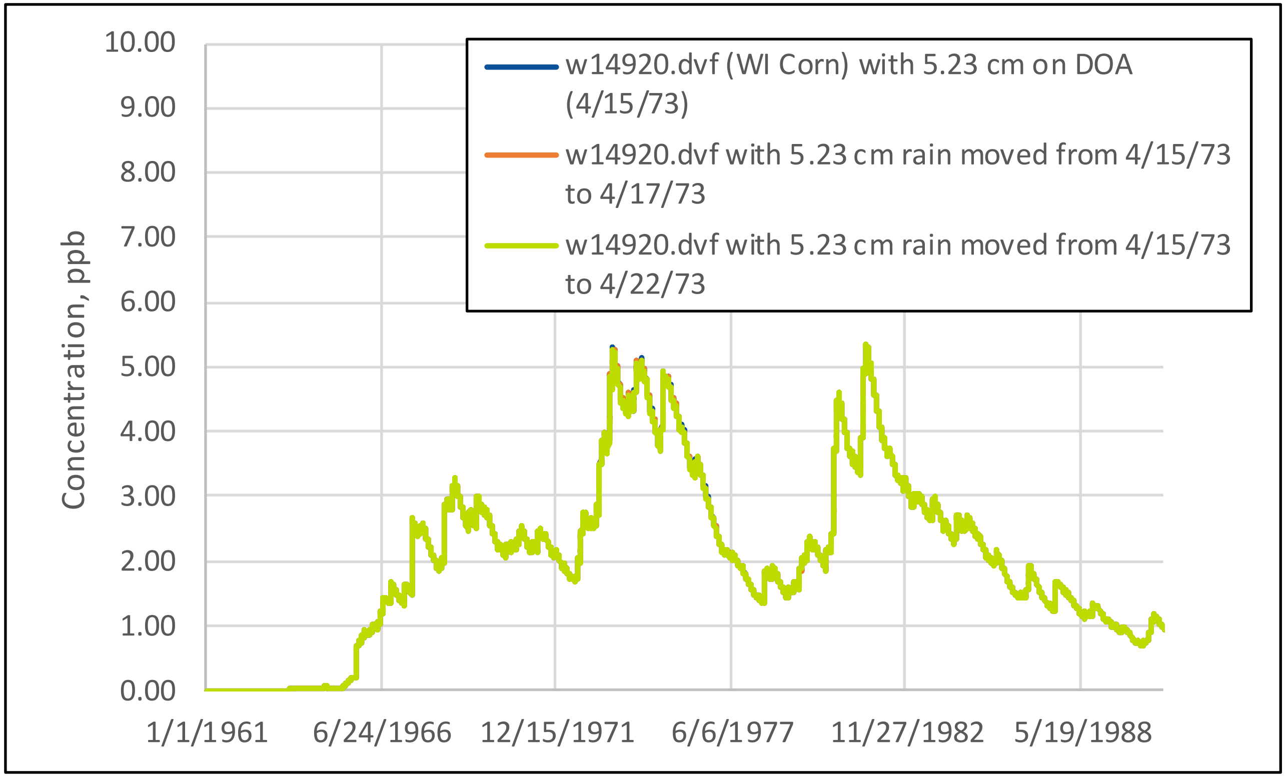


Parameter	Value
Hydrolysis (days)	0
Soil Half-life (days)	1
Application type	CAM 1

Weather	Acute (ppb)	Chronic (ppb)
w14920.dvf	3.79	0.69
5.23 cm rain 4/17	2.44	0.47
5.23 cm rain 4/22	0.84	0.19

WATERBORNE ENVIRONMENTAL

Impact of Heavy Rain on Application Day

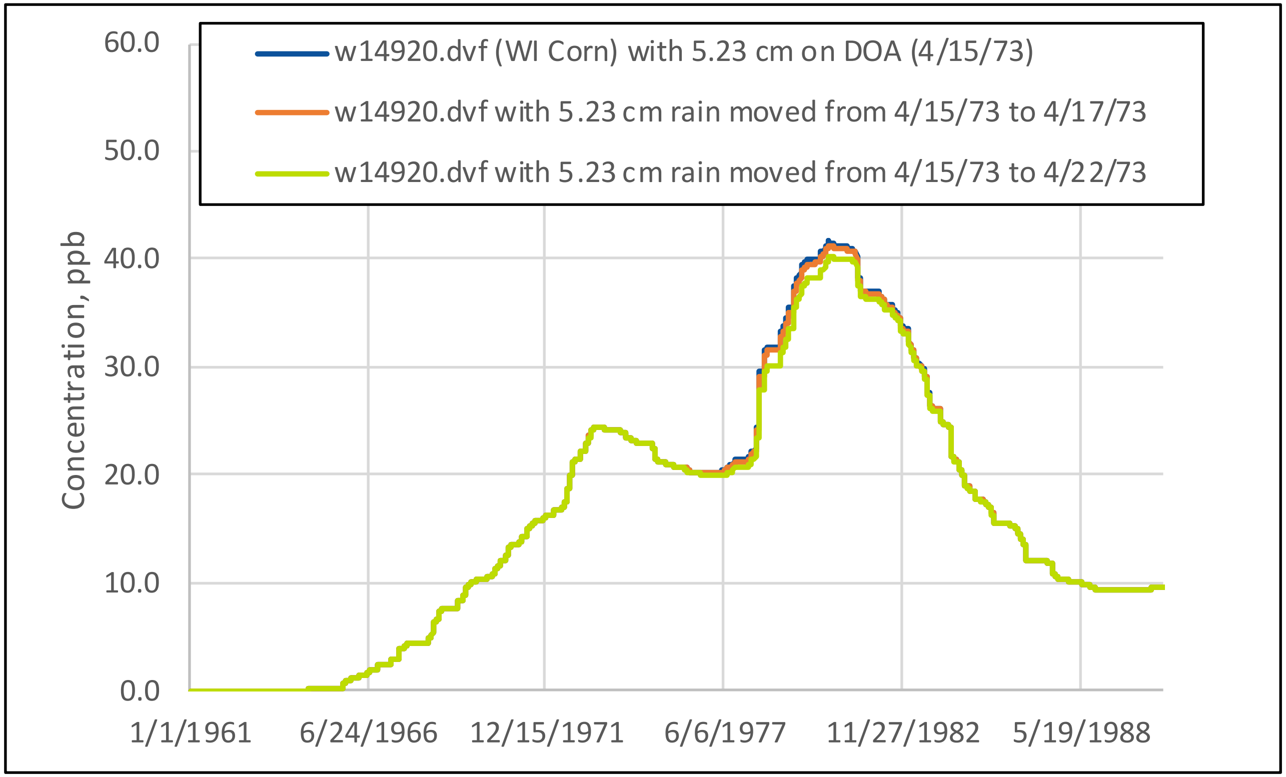


Parameter	Value
Hydrolysis (days)	100
Soil Half-life (days)	1000
Application type	CAM 1

Weather	Acute (ppb)	Chronic (ppb)
w14920.dvf	5.36	2.51
5.23 cm rain 4/17	5.36	2.51
5.23 cm rain 4/22	5.36	2.50

WATERBORNE ENVIRONMENTAL

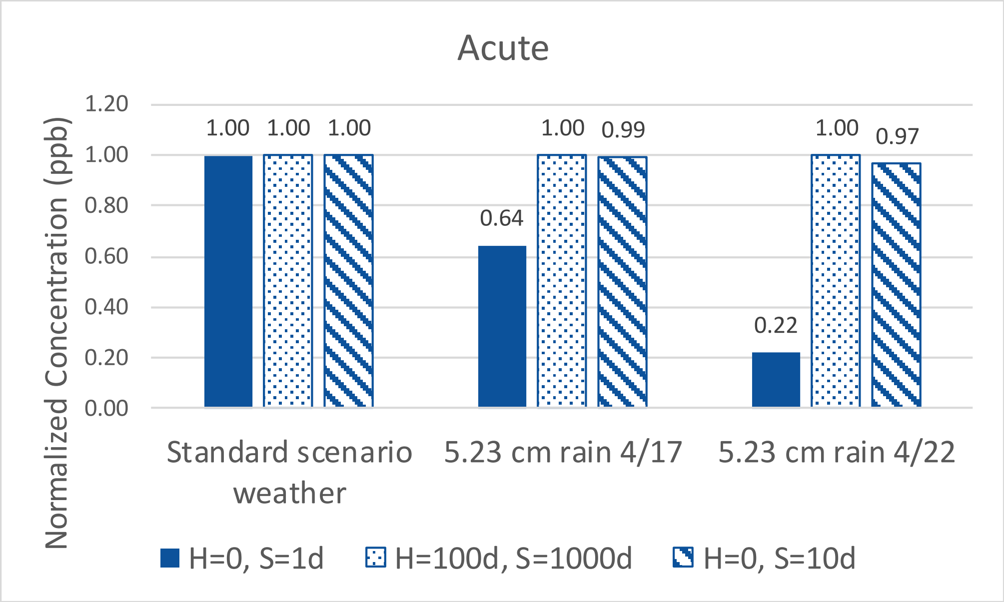
Impact of Heavy Rain on Application Day

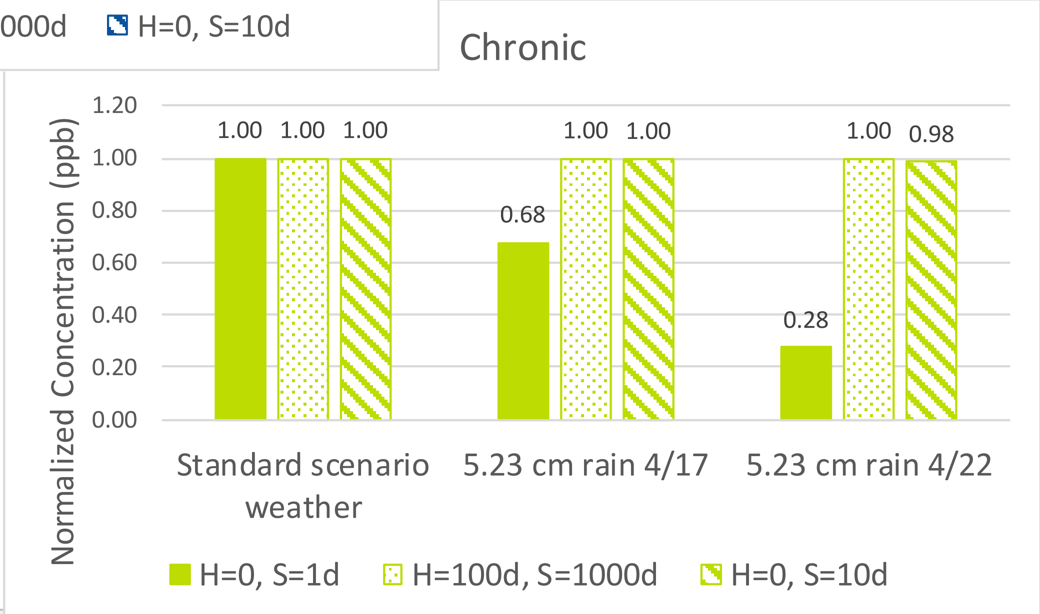


Parameter	Value
Hydrolysis (days)	0
Soil Half-life (days)	10
Application type	CAM 1

Weather	Acute (ppb)	Chronic (ppb)
w14920.dvf	41.64	20.69
5.23 cm rain 4/17	41.31	20.62
5.23 cm rain 4/22	40.25	20.37

Impact of Heavy Rain on Application Day





WATERBORNE ENVIRONMENTAL

Conclusions

- Of the 5 cases, the degradation factor profile in the 0-1m zone and hydrolysis only from 1m to GW is the most sensitive. This approach for Tier 2 may be appropriate but given the high sensitivity on model predictions further investigation may be warranted to whether the result is not overly conservative for some chemicals
- Application method is largely non-sensitive for PRZM5 GW - depth of incorporation can increase the concentrations.
- Numerical dispersion in PRZM5 can have different effects based on properties of chemical for both acute and chronic concentrations by spreading out the center of mass. This spreading out changes the chemical mass interacting with the degradation factors in the 0-1 m zone.

Conclusions (cont)

- Volatilization lowers concentrations for three reasons. First from mass lost directly from system due to the volatilization. Secondly, by spreading the center of mass throughout profile. Finally, from upward movement of gas phase which then repartitions into solution phase and subjected to the faster degradation of upper profile
- PRZM5 implementation of NLS appears to generate answers that are quite different than the FOCUS model implementation of NLS (PEARL, PELMO, WINPRZM, MACRO). It is especially apparent in CAM 1 applications (linearly decreasing with depth) with short aerobic soil half-lives.
- Modeling application on heavy rainfall day on has a multi-fold impact on groundwater concentrations of low persistence compounds compared to persistent compounds.

Thank you!

Any questions?