

# ACCOUNTING FOR UNCERTAINTY IN SITE-SPECIFIC GUIDELINE ADJUSTMENTS

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# OUTLINE

1. Review of guideline adjustments
2. Challenges selecting parameter values
3. Assessing parameter uncertainty
4. Case studies



# GUIDELINE ADJUSTMENTS

## Guidelines

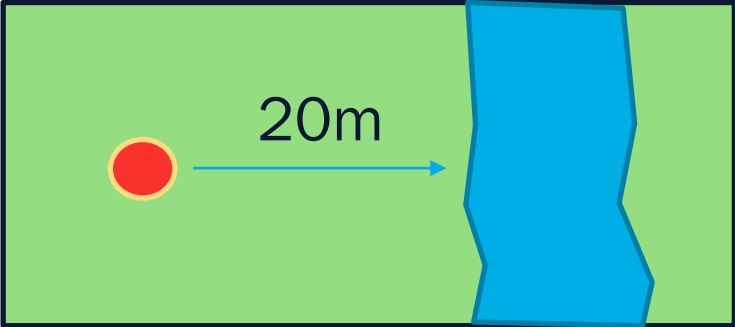
- Intended to protect receptors

## Guideline Adjustments

- Account for distance between impacts and receptor

## Guideline Calculations

- Input single-values for various site-specific parameters
  - Such as porosity, degradation, and hydraulic conductivity





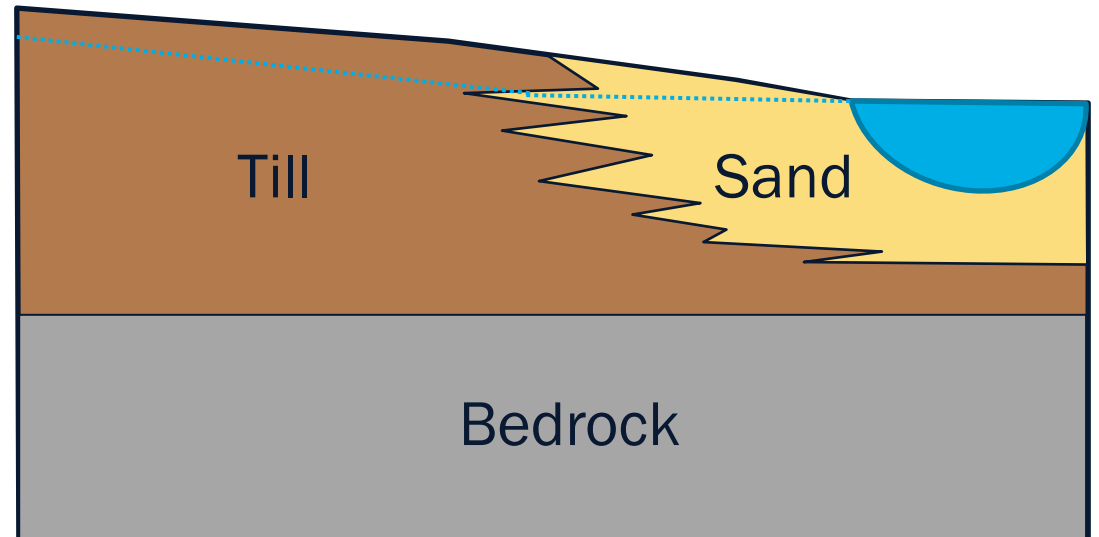
# SELECTING SINGLE PARAMETER VALUES

## Parameter Variation

- Some parameters subject to spatial and temporal variations (e.g., hydraulic conductivity and hydraulic gradient).
- Some parameters not practically measurable at the site (e.g., infiltration rate).
- Literature provides a range of values.

## Common Practice

- Select “representative” or “conservative” parameter values to be used in the model.
- Due to non-linear interactions between parameters, these value **do not guarantee** the most “conservative” guidelines.





# ACCOUNTING FOR PARAMETER VARIABILITY

## Sensitivity Analysis

- Based on Monte Carlo simulations
- Multi-column analysis

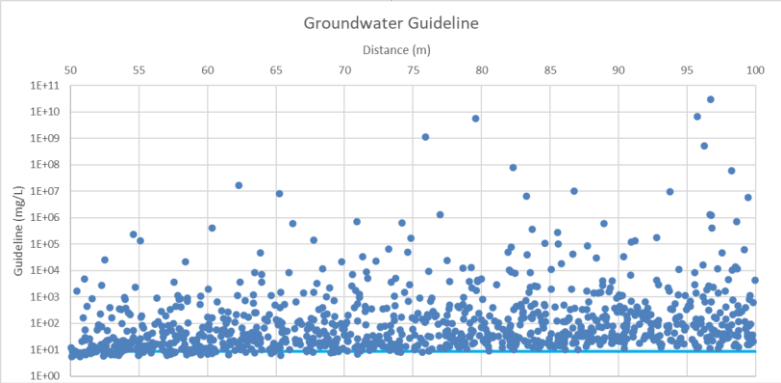
## Set Realistic Range of Values for Parameters

- Based on site characteristics and literature values
- Selected Parameters:
  - Distance to receptor
  - Degradation half-life
  - Hydraulic conductivity
  - Hydraulic gradient

Calculated guidelines for 1000 sets of parameters

Compared to historic data

Distance (m)	Half-Life (y)	K (m/s)	Gradient
50	5	1.00E-07	0.01
100	30	1.00E-06	0.05
98.8532899	16.74839594	3.20E-07	0.029382
72.23055633	29.48961891	4.89E-07	0.024118
97.44150156	13.16378314	3.56E-07	0.033253
57.54379362	13.88560619	1.37E-07	0.021817



Site-Specific Guideline

# CASE STUDY

### Site Characteristics:

- Former fertilizer facility
- Fine-grained soil
- Nitrate exceeds Tier 1 Guideline

Contaminant of Concern: Nitrate

Key Receptor: Stream located to SE





# KEY INPUT PARAMETERS

Distance to receptor: 50 – 100 m

Nitrate Degradation Half-Life: 5 – 30 years

Hydraulic Conductivity: 3.2 – 32 m/y ( $10^{-7}$  -  $10^{-6}$  m/s)

Hydraulic Gradient: 0.01 – 0.05



# CALCULATED GUIDELINES (GW)

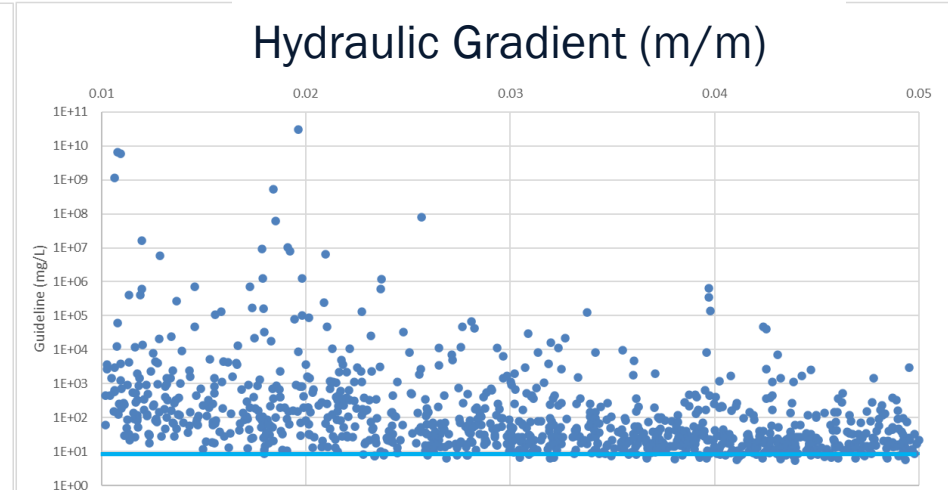
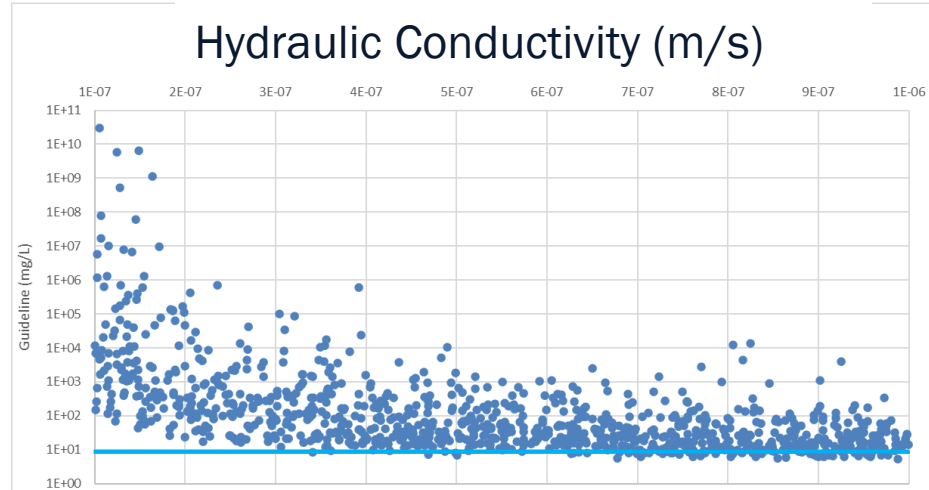
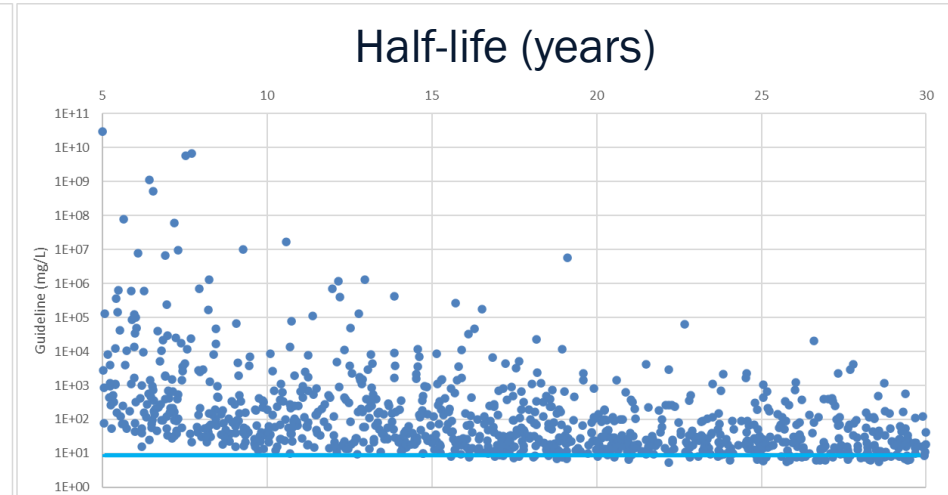
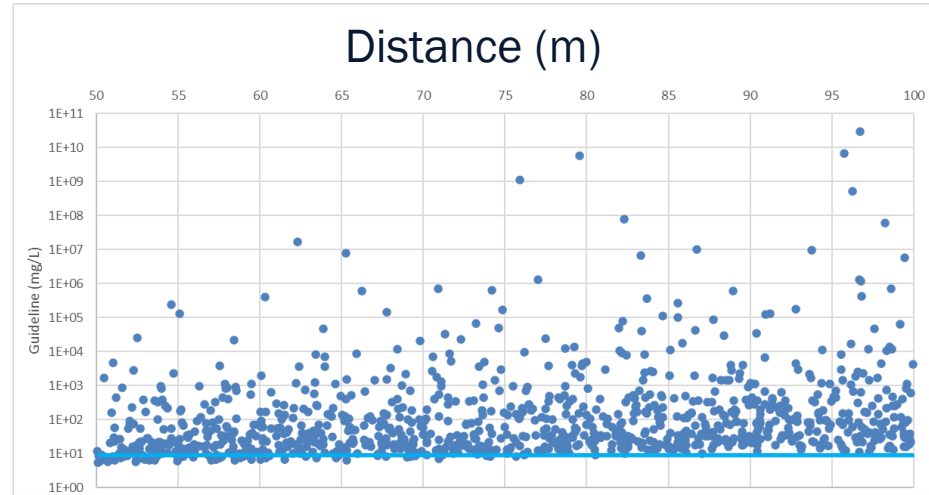
For a realistic range of parameters based on site specific data and literature.

1000 guidelines calculated based on range for each key parameter.

95<sup>th</sup> percentile represents a reasonably conservative guideline value: 8 mg/L

Minimum calculated guideline: 5 mg/L

- Calculated Guideline
- 95<sup>th</sup> Percentile







# CALCULATED GUIDELINES (SOIL)

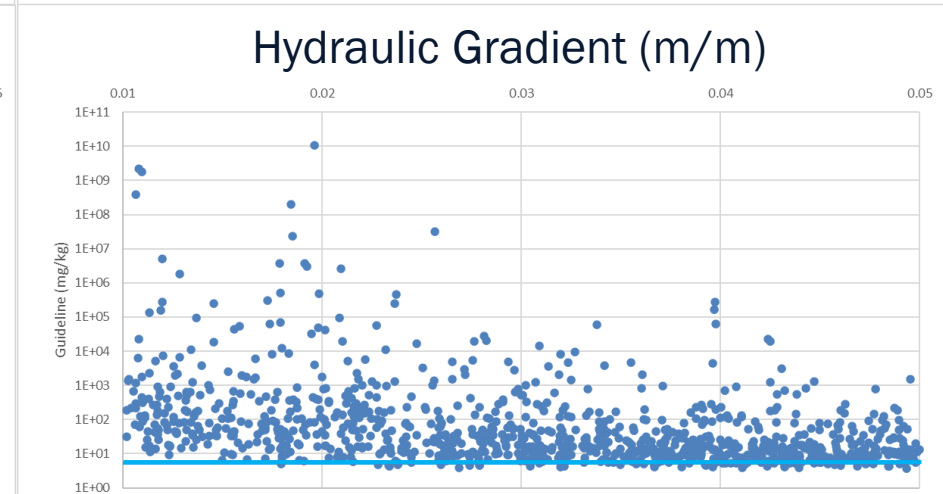
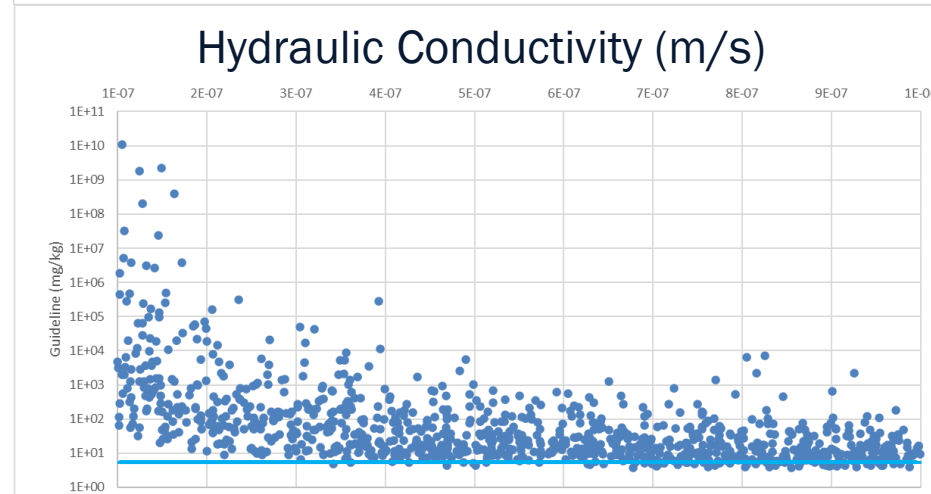
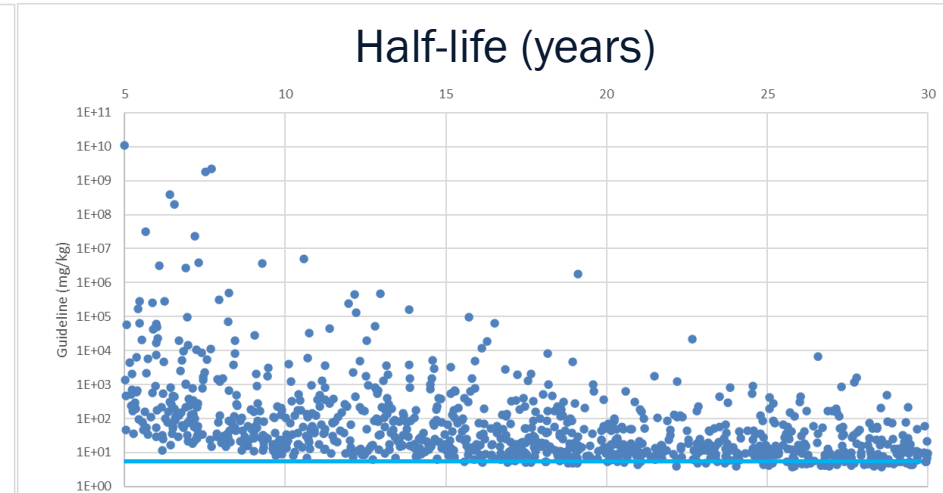
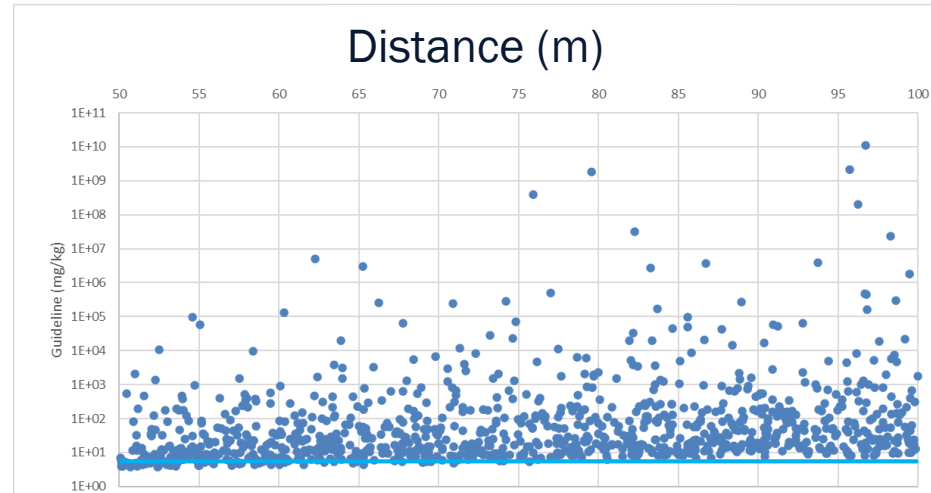
For a realistic range of parameters based on site specific data and literature.

Sensitivity of each parameter revealed in trend of the data

95<sup>th</sup> percentile represents a reasonably conservative guideline value: 5 mg/kg

Minimum calculated guideline: 4 mg/kg

- Calculated Guideline
- 95<sup>th</sup> Percentile





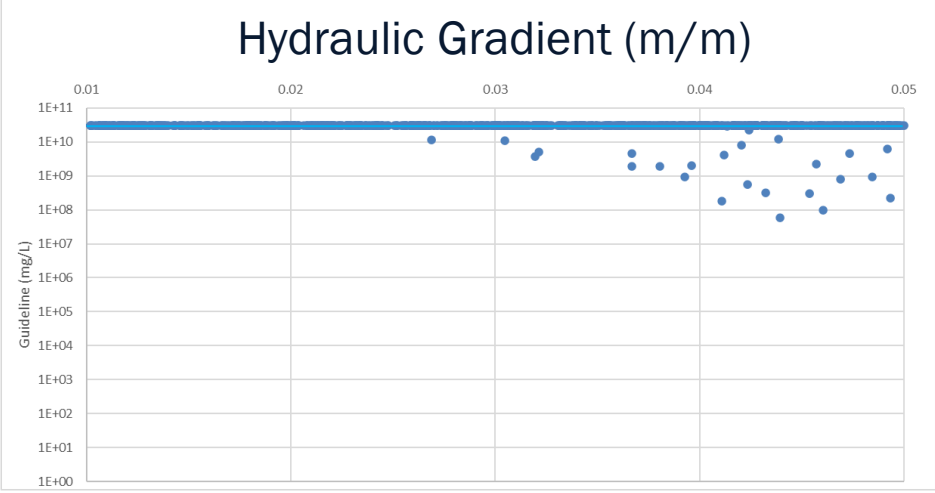
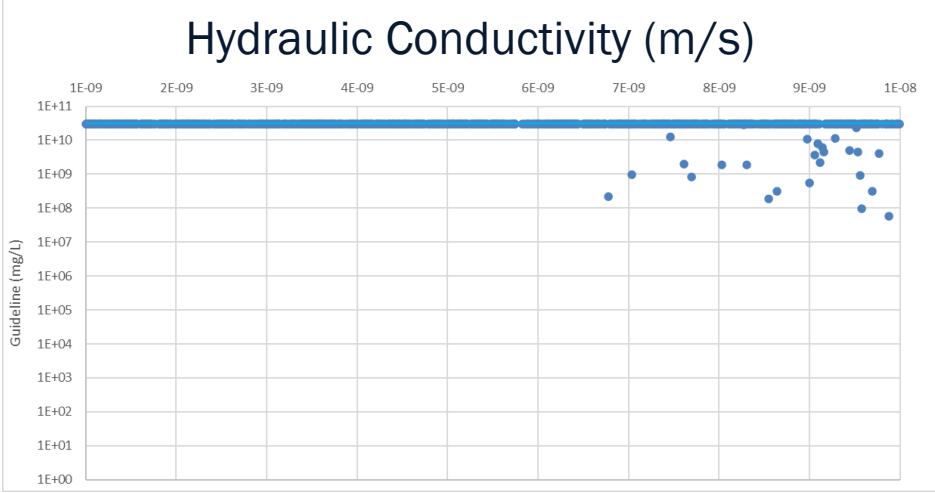
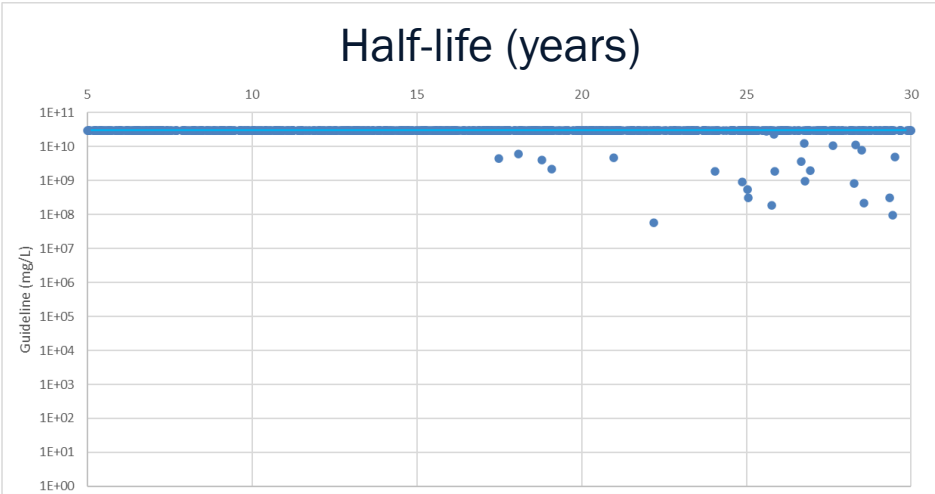
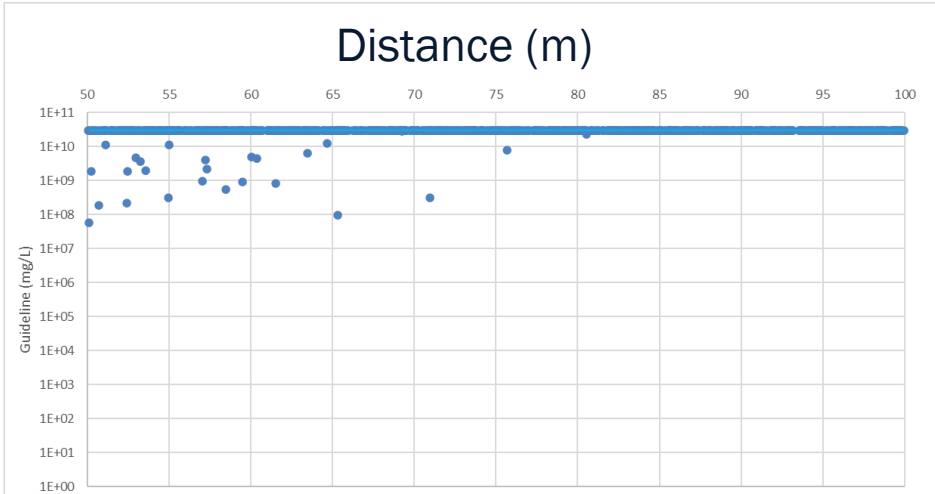
# CALCULATED GUIDELINES FOR REDUCED K (GW)

For a realistic range of parameters based on site specific data and literature, with K values reduced.

K-value range reduced to  $10^{-9}$  -  $10^{-8}$  m/s (previously  $10^{-7}$  -  $10^{-6}$  m/s), all other parameters kept the same.

May limit need to spend resources constraining other parameters.

- Calculated Guideline
- 95<sup>th</sup> Percentile



# INCORPORATE SITE SPECIFIC DATA

Run same model, but using DF4 value (i.e., expected concentration) at MW2).

Compare expected to observed concentration to assess site specific parameters and further constrain parameter values.





# EXPECTED VS OBSERVED CONCENTRATIONS (GW)

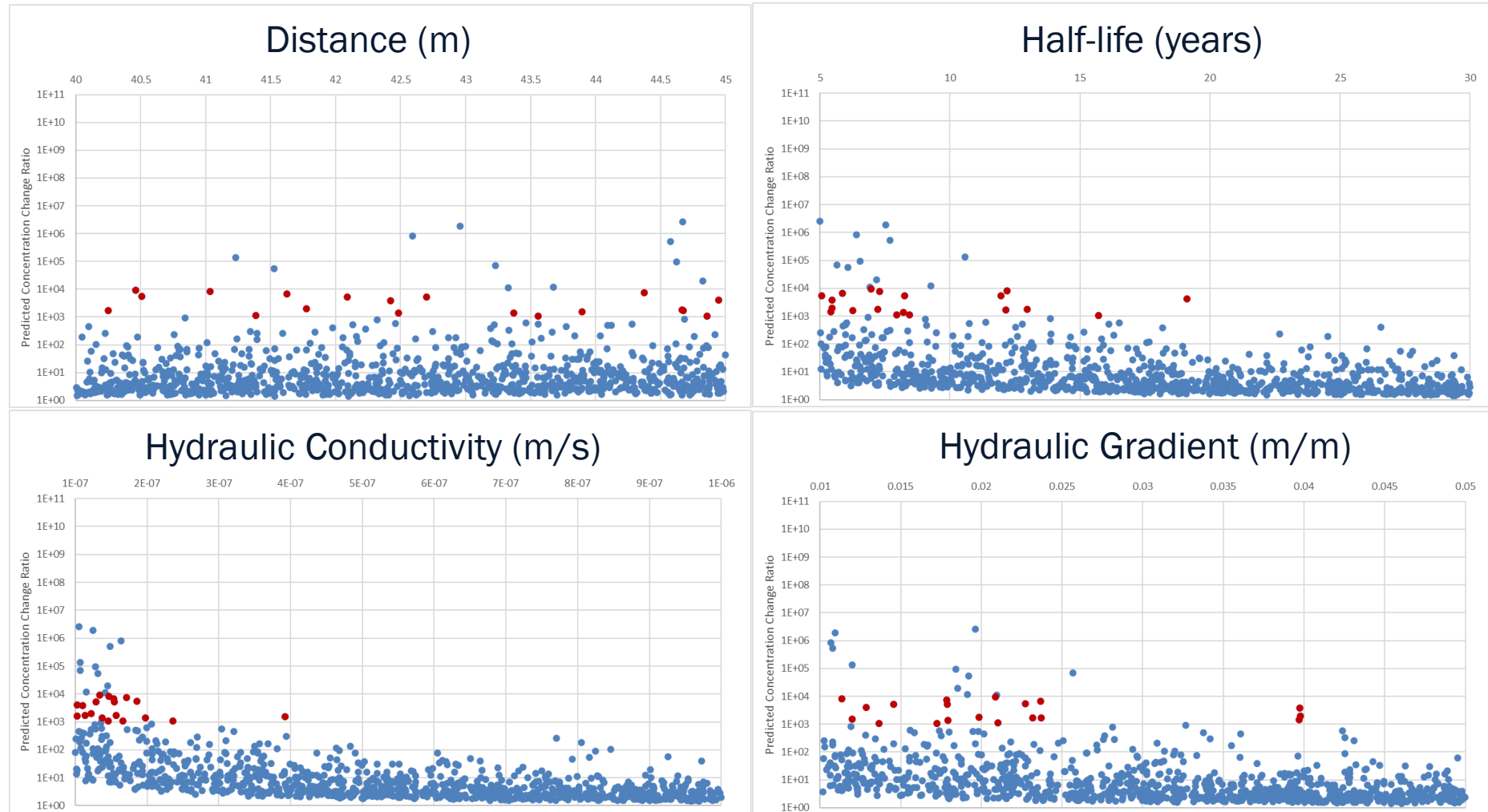
DF4 calculated value compared to site observations.

Offsite monitoring well located 40 - 45 m downgradient.

Concentrations in MW2 diluted by a factor of  $10^3 - 10^4$  relative to MW1.

Further constrains ranges for input parameters.

- Calculated Values
- Calculated Matching Observed Values





# MODIFIED GUIDELINE ADJUSTMENT (GW)

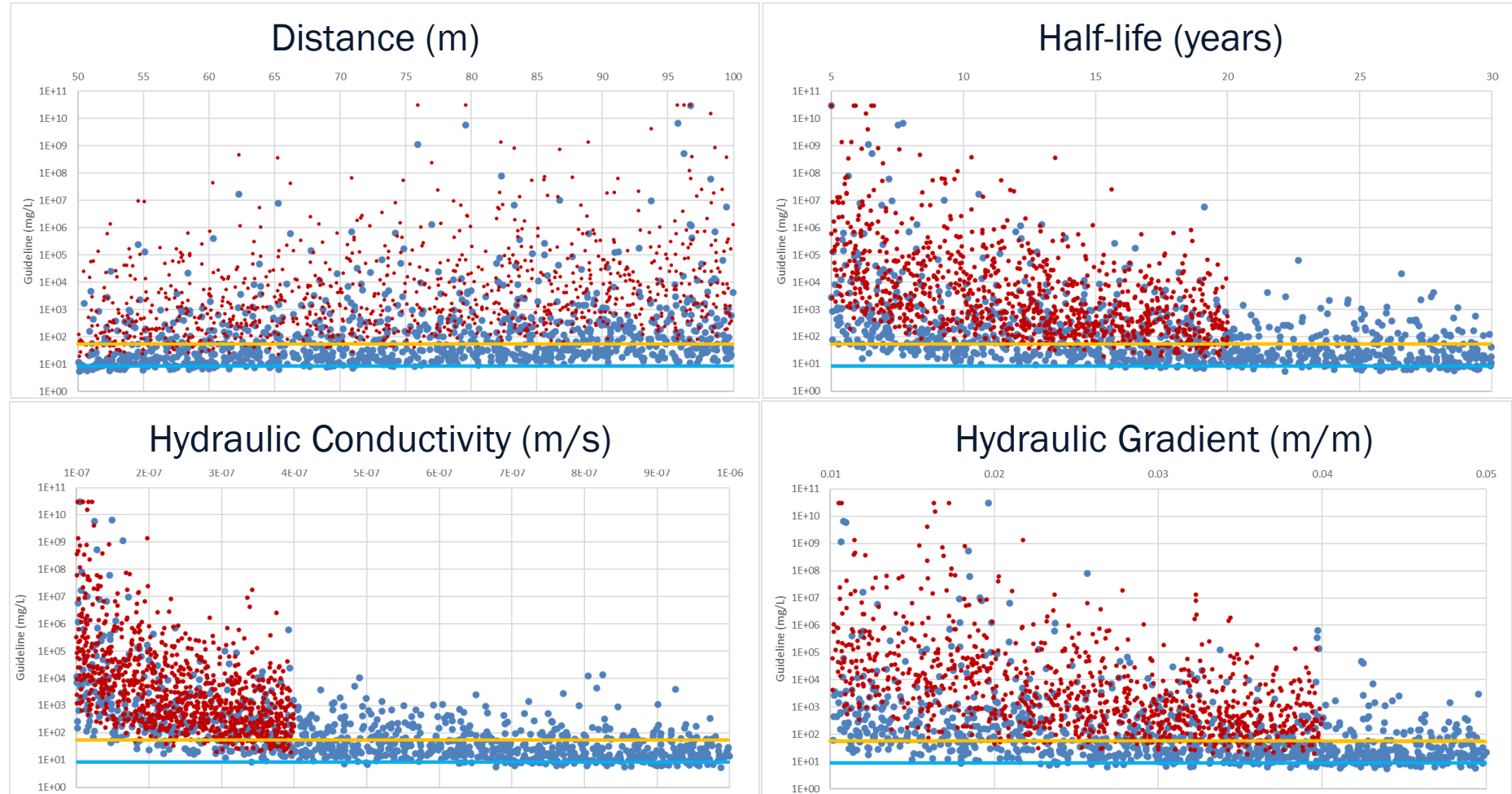
Modified based on expected and measured concentrations.

Model ran again using parameter values constrained by site data.

Original 95<sup>th</sup> percentile guideline: 8 mg/L

Modified 95<sup>th</sup> percentile guideline: 54 mg/L

- Original Value
- Modified Value
- Original 95<sup>th</sup> Percentile
- Modified 95<sup>th</sup> Percentile



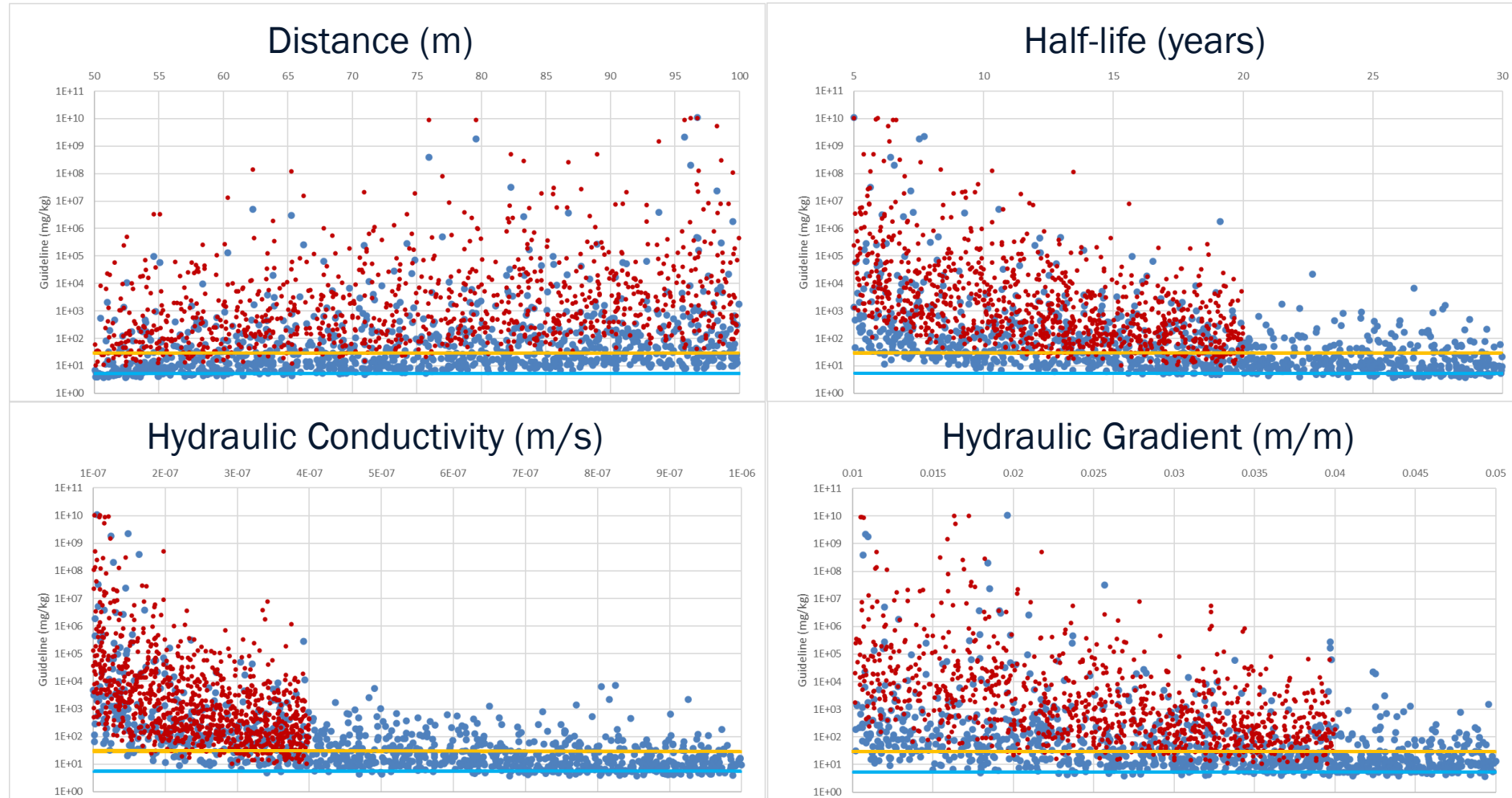


# MODIFIED GUIDELINE ADJUSTMENT (SOIL)

Modified based on expected and measured concentrations.

Original 95<sup>th</sup> percentile guideline: 5 mg/kg

Modified 95<sup>th</sup> percentile guideline: 29 mg/kg

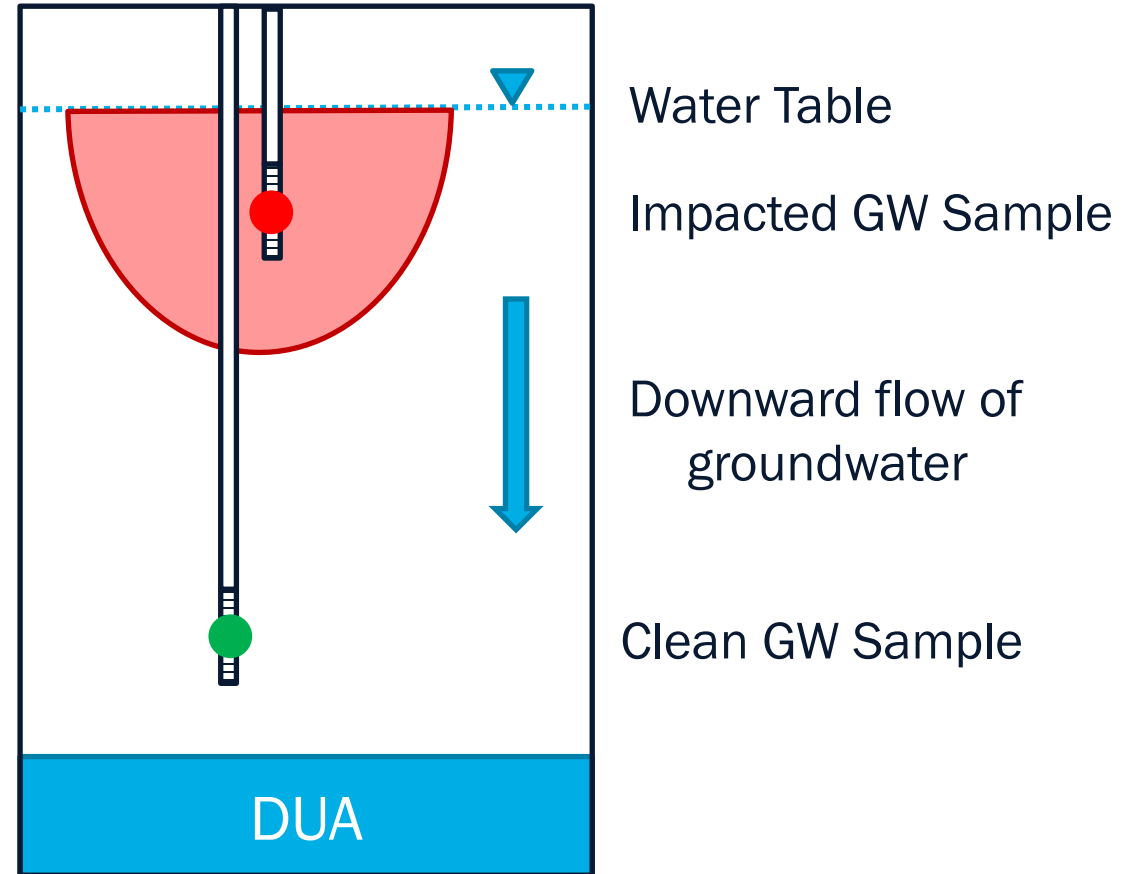


- Original Value
- Modified Value
- Original 95<sup>th</sup> Percentile
- Modified 95<sup>th</sup> Percentile



# PRACTICAL EXAMPLE

Petroleum hydrocarbon impacted site.  
DUA applicable with aquifer at depth.  
Used nested wells to constrain the site-specific guideline.

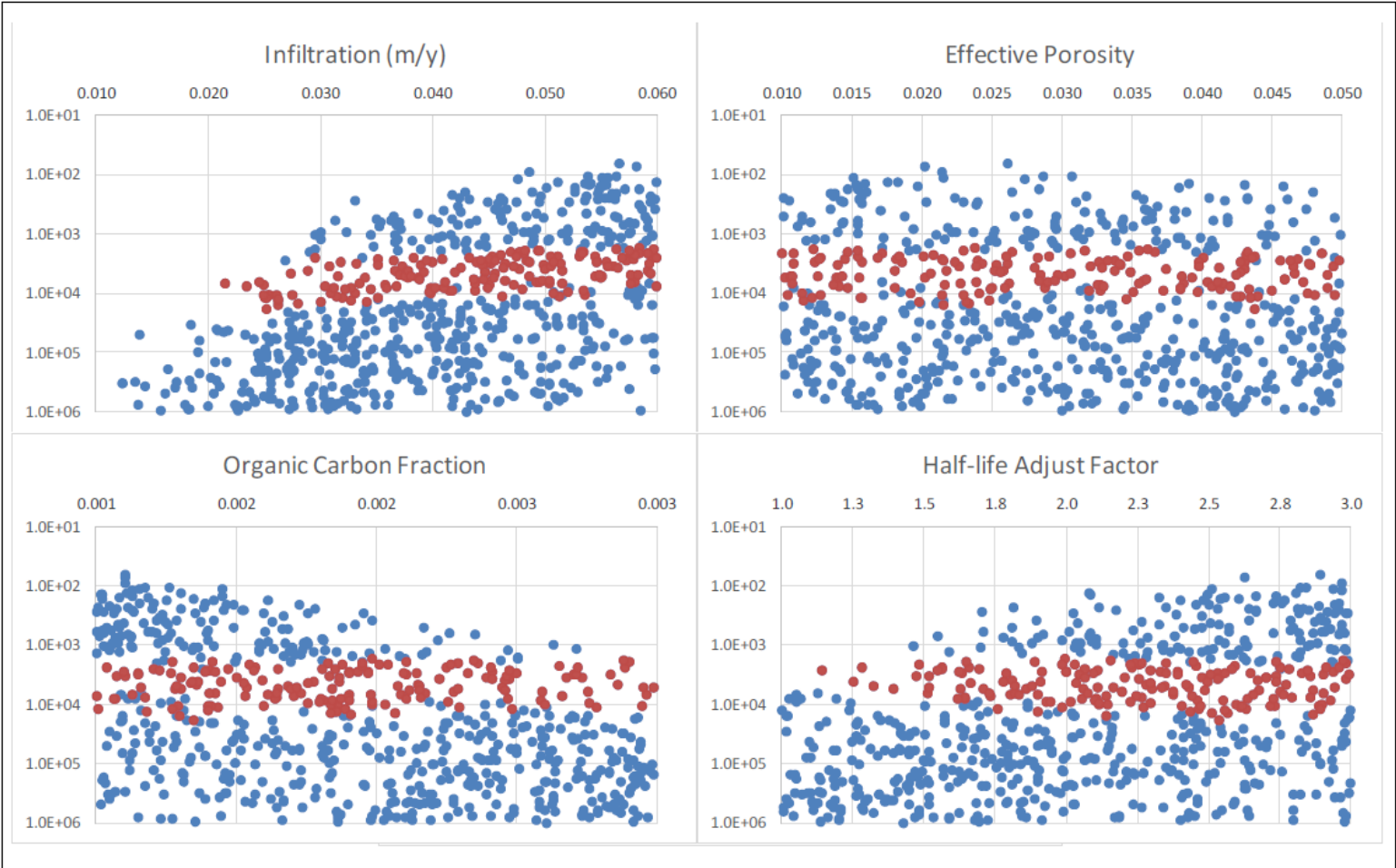




# APPLIED METHODOLOGY

Methodology used to calculate site-specific guidelines and meet regulator's original requirement to provide sensitivity analysis for guideline adjustment calculations.

- Original Guideline Value
- Modified Guideline Value





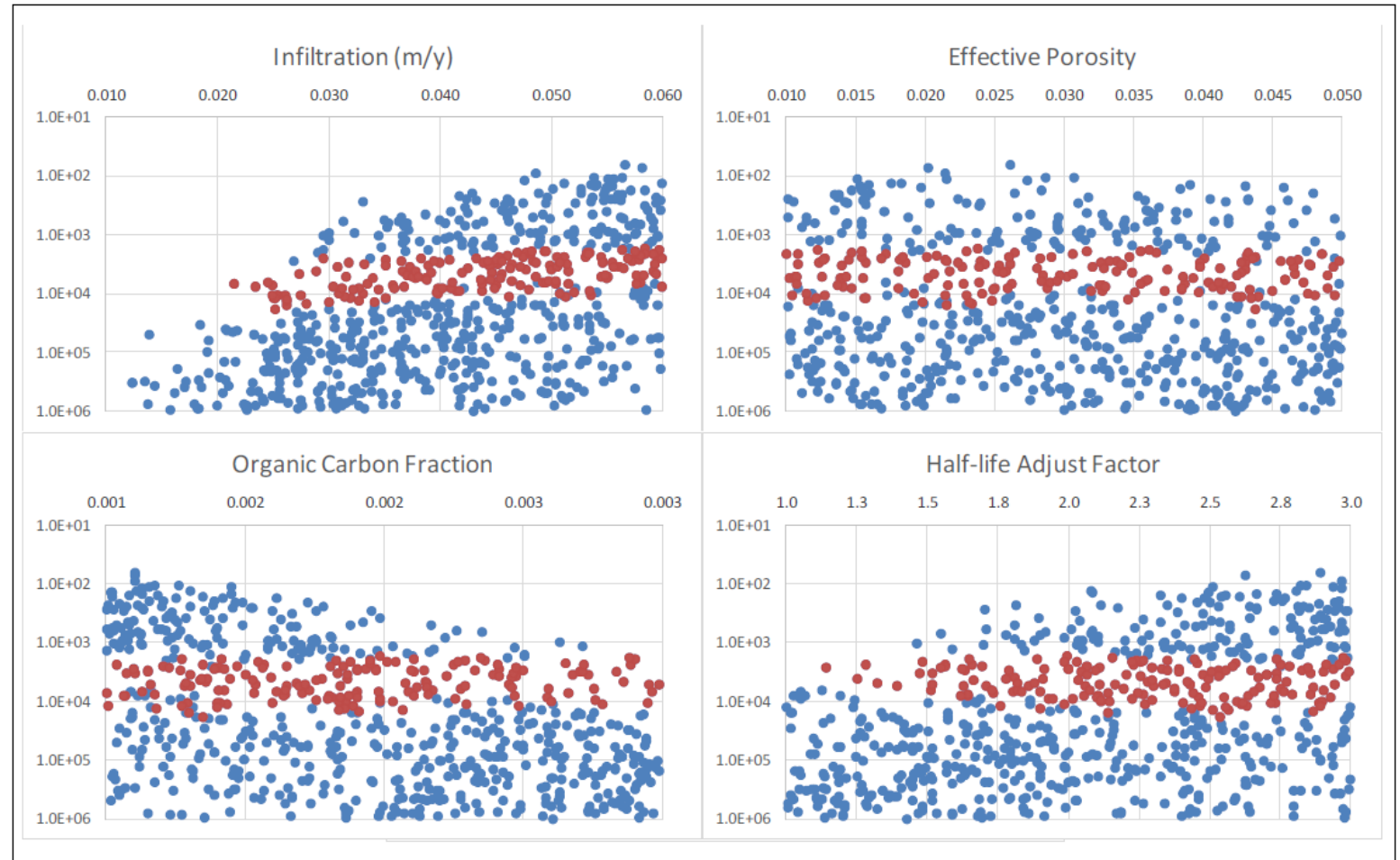


# REGULATOR RESPONSE

Submission reviewed after two years.

Received comments on other issues for the site, but did not receive feedback for this specific methodology.

- Original Guideline Value
- Modified Guideline Value





# CONCLUSIONS

Methodology can be used to assess sensitivity of various parameter and produce reasonably conservative site-specific guidelines that account for variability.

However, additional discussion needed to assess value and opportunities for improvement.



QUESTIONS?