

IN-PERSON EVENT | Involving. Informing. Inspiring

A Risk-Based Tool That Accounts for Uncertainty in Water Quality Studies

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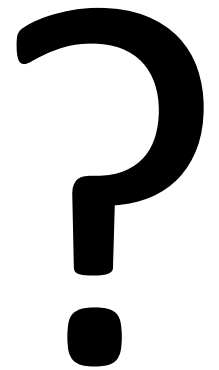
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The importance of future thinking to support the industry



Aim of PhD:

Investigating the interaction of measurement uncertainty and people personal risk appetite with threshold-based regulation where there is a binary outcome altering investment decisions.



Ecological harm defined by **Fundamental Intermittent Standards (FIS)**

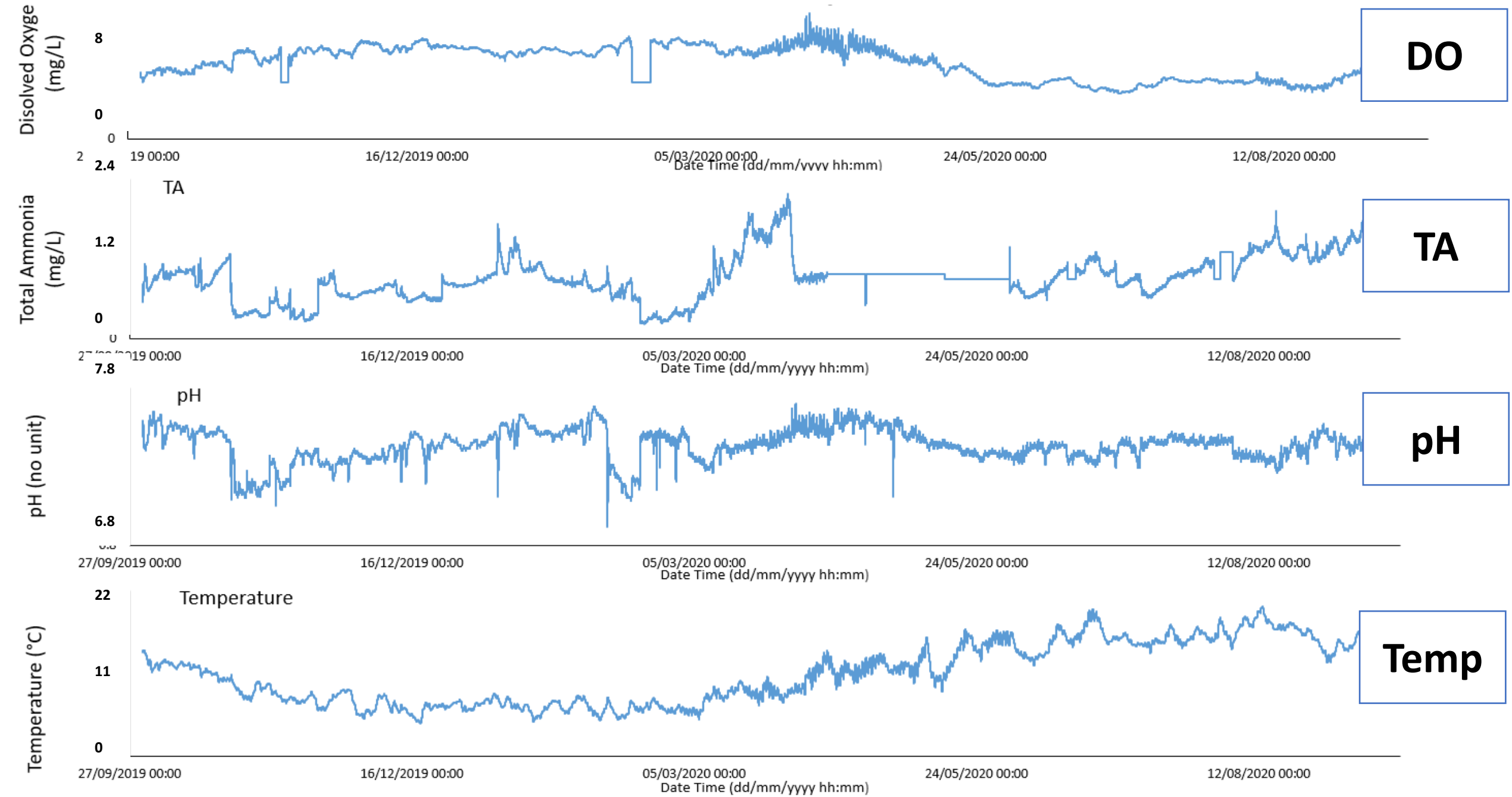
- Concentration-Duration-Frequency based regulatory framework
- FIS is 'directly related to conditions that cause stress in freshwater ecosystems' (UPM, 2019)
- Research late 80s – Published early 90s
- Linked to Water Framework Directive and **Environment Act 2021**
 - Environment Act 2021 calls for continuous water quality monitoring both **upstream** and **downstream**
- **Low** Dissolved Oxygen and **Elevated** Un-ionised Ammonia
- Dynamic Thresholds which requires:
 - Dissolved Oxygen, Total Ammonia, pH and Temperature

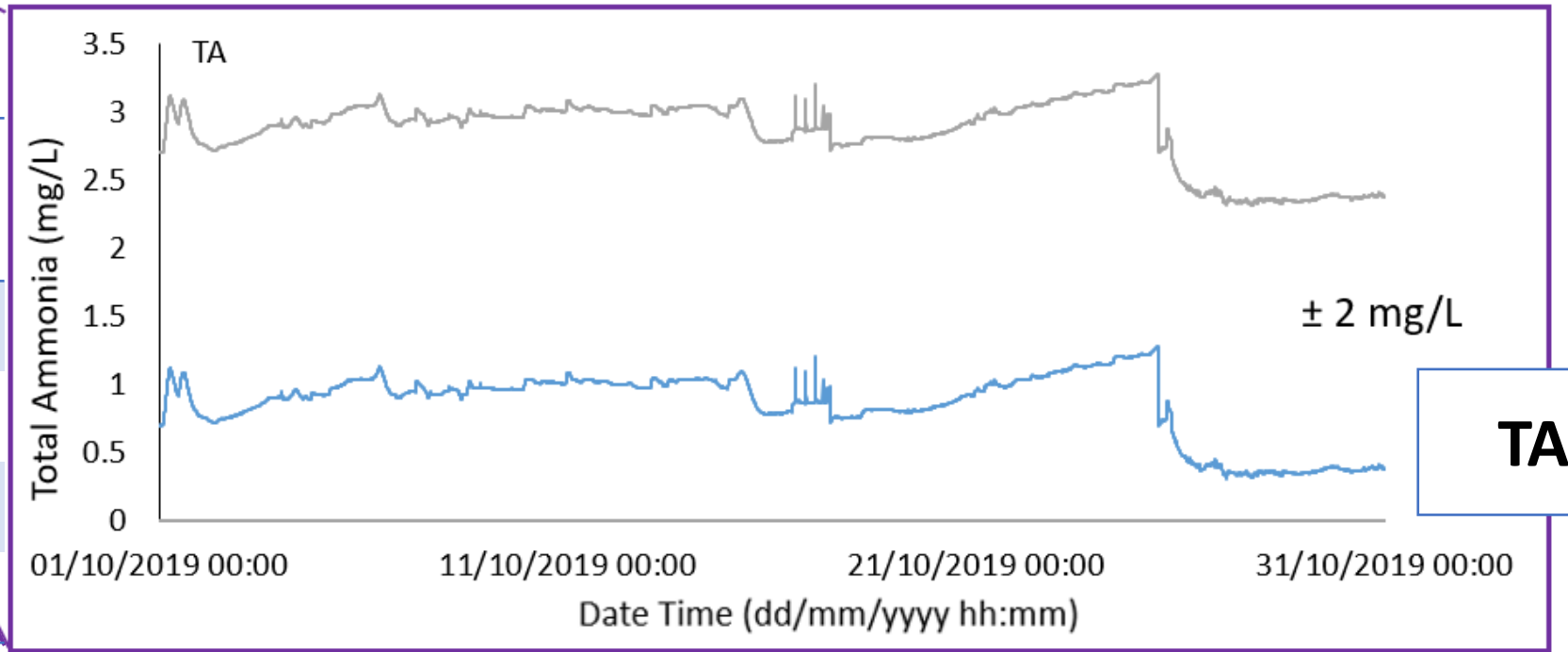
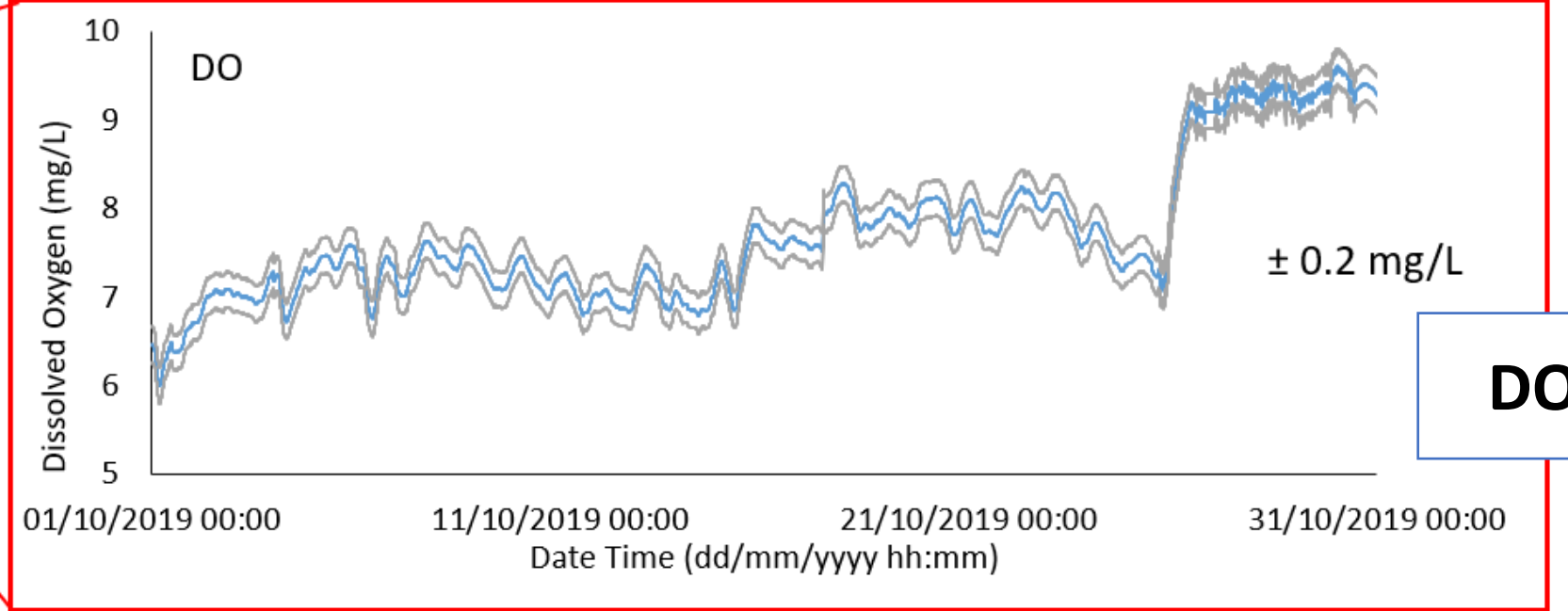
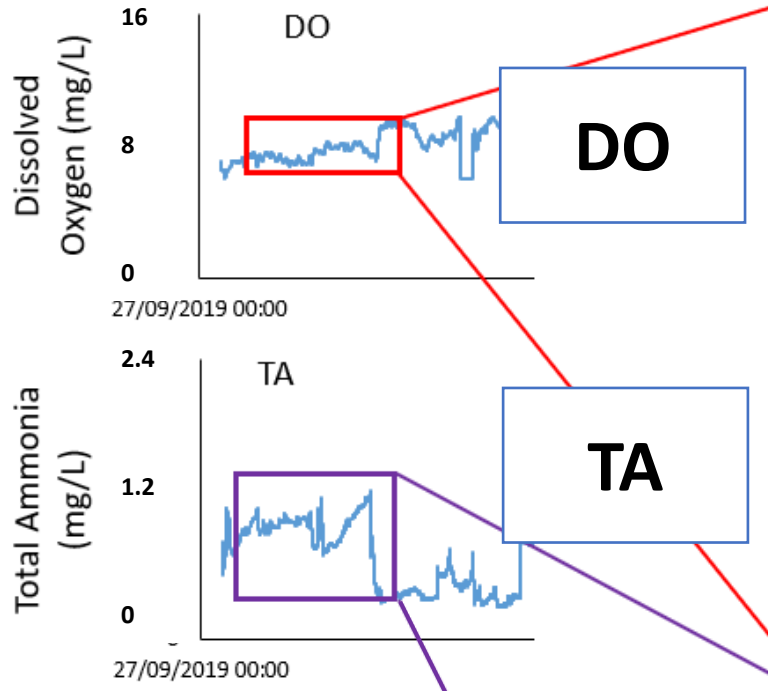




Understanding the Data

12 month time series of Dissolved Oxygen, Total Ammonia, pH & Temperature

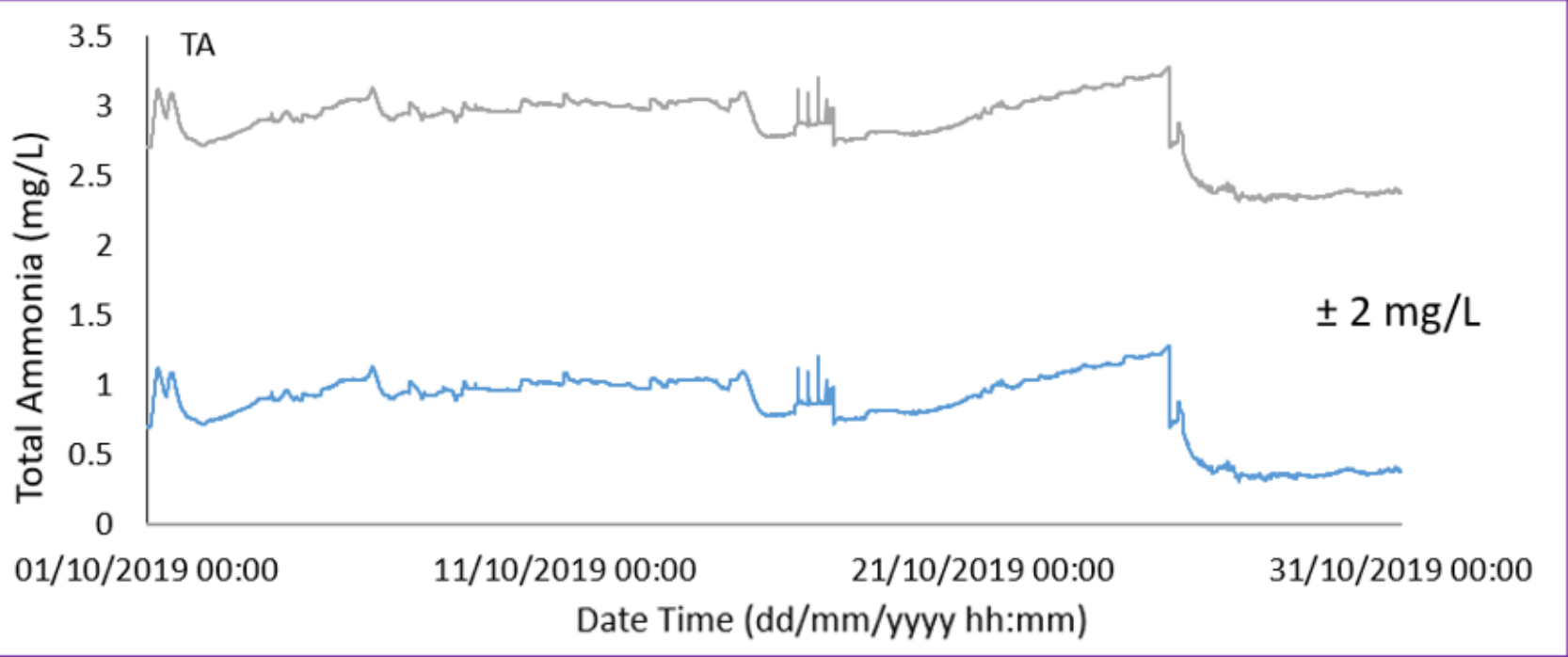




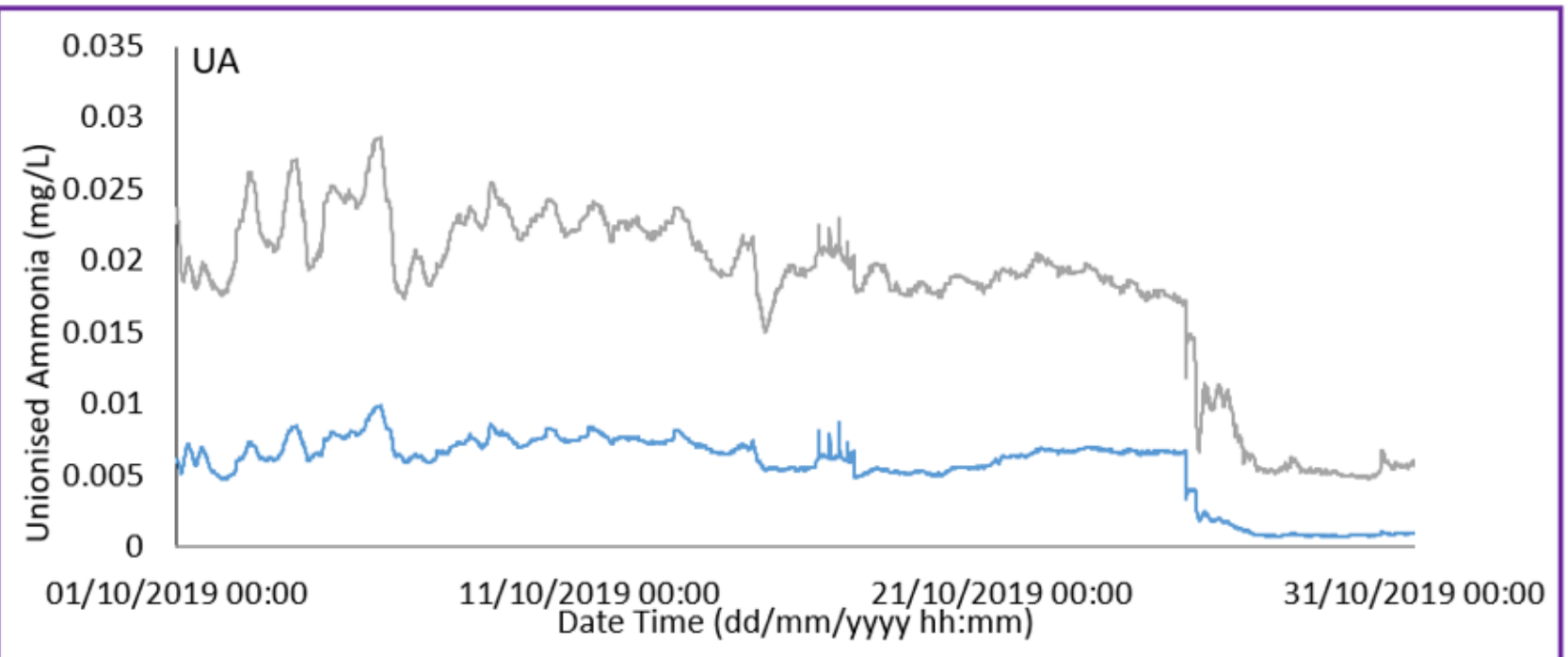
Parameter Manufacture Accuracy

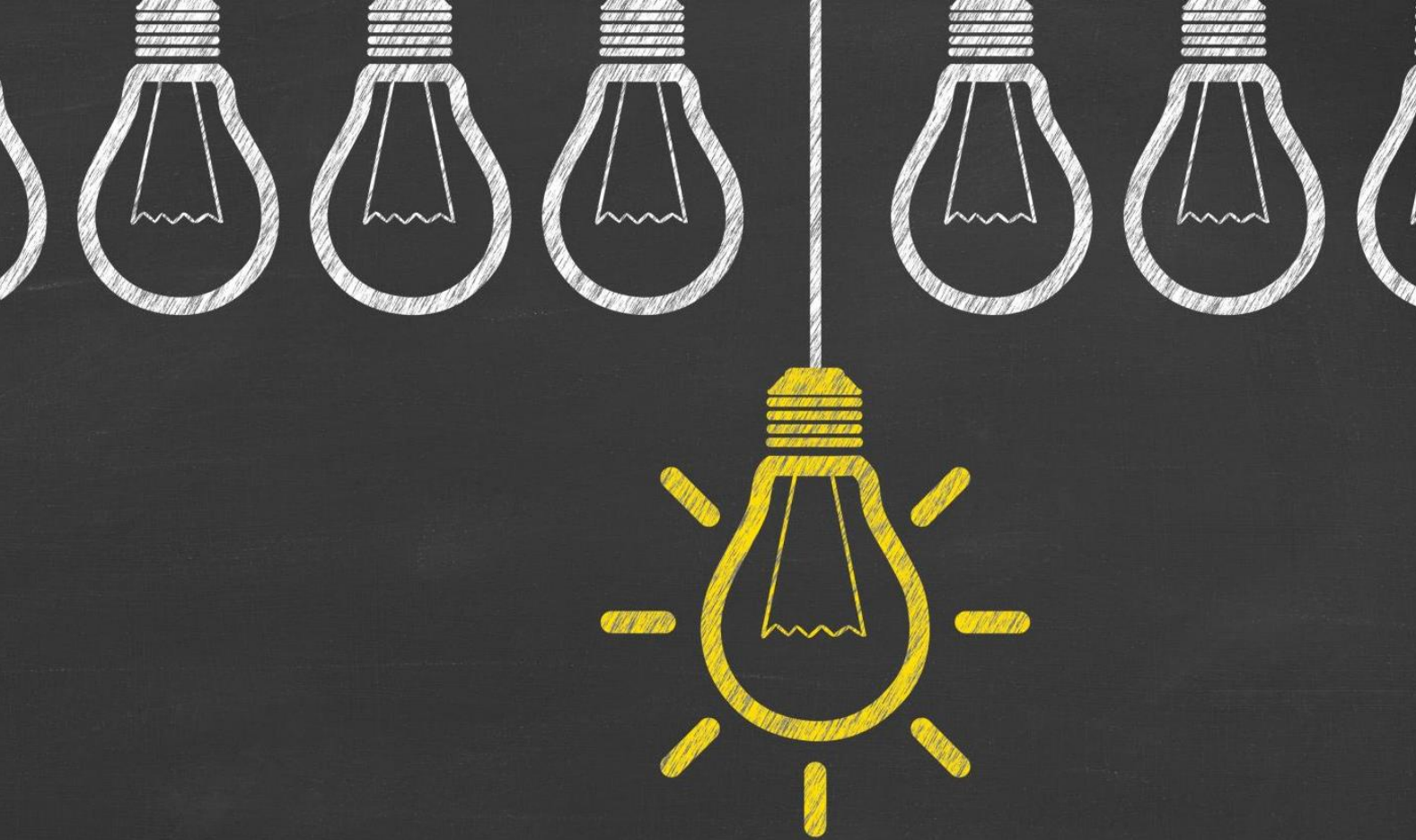
| | |
|-------------|--------|
| DO (mg/L) | ± 0.2 |
| TA | ± 2.0 |
| pH | ± 0.2 |
| Temperature | ± 0.15 |

$$\textit{Unionised Ammonia} = \frac{\textit{Total Ammonia}}{1 + 10^{10.055 - (0.0324 * \textit{Temperature}) - \textit{pH}}}$$



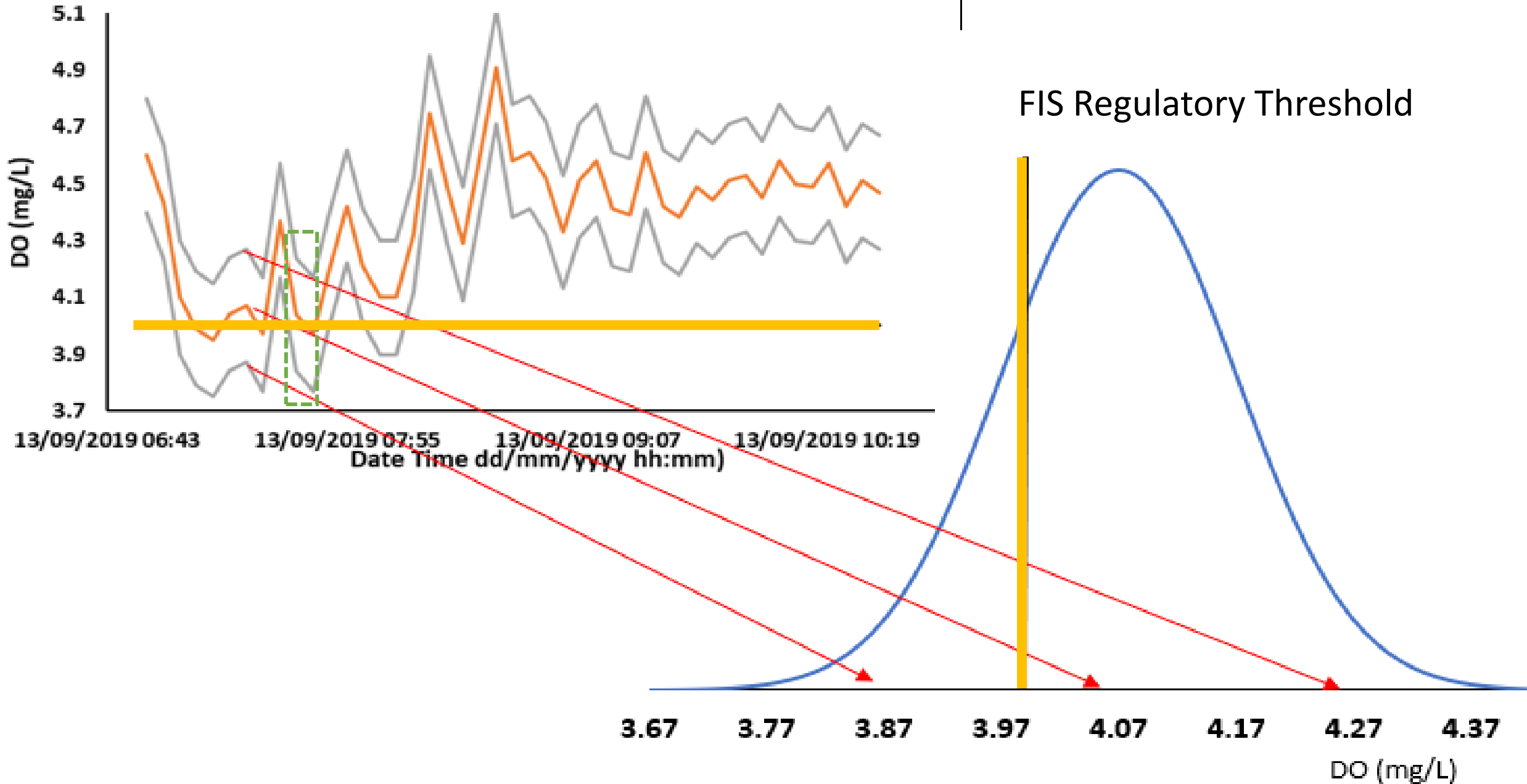
- No total ammonia = no unionised ammonia
- Peaks and troughs exaggerated in upper limit
- No uniform uncertainty band



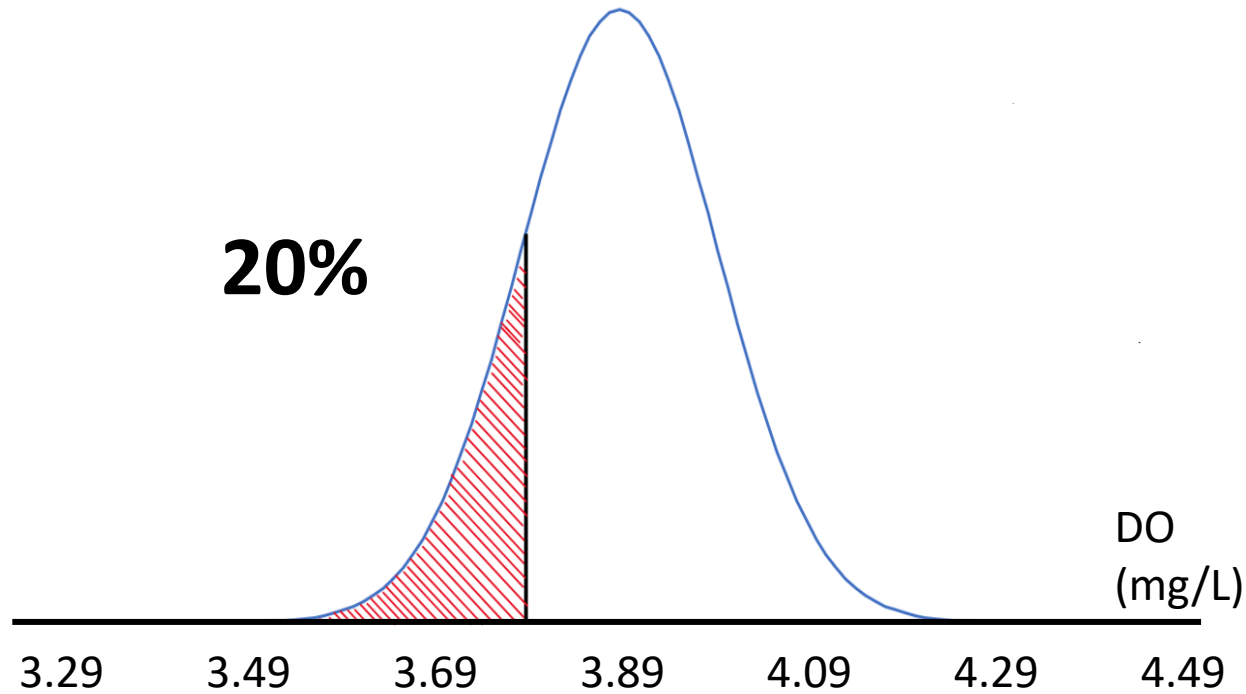


Analysis of the Data

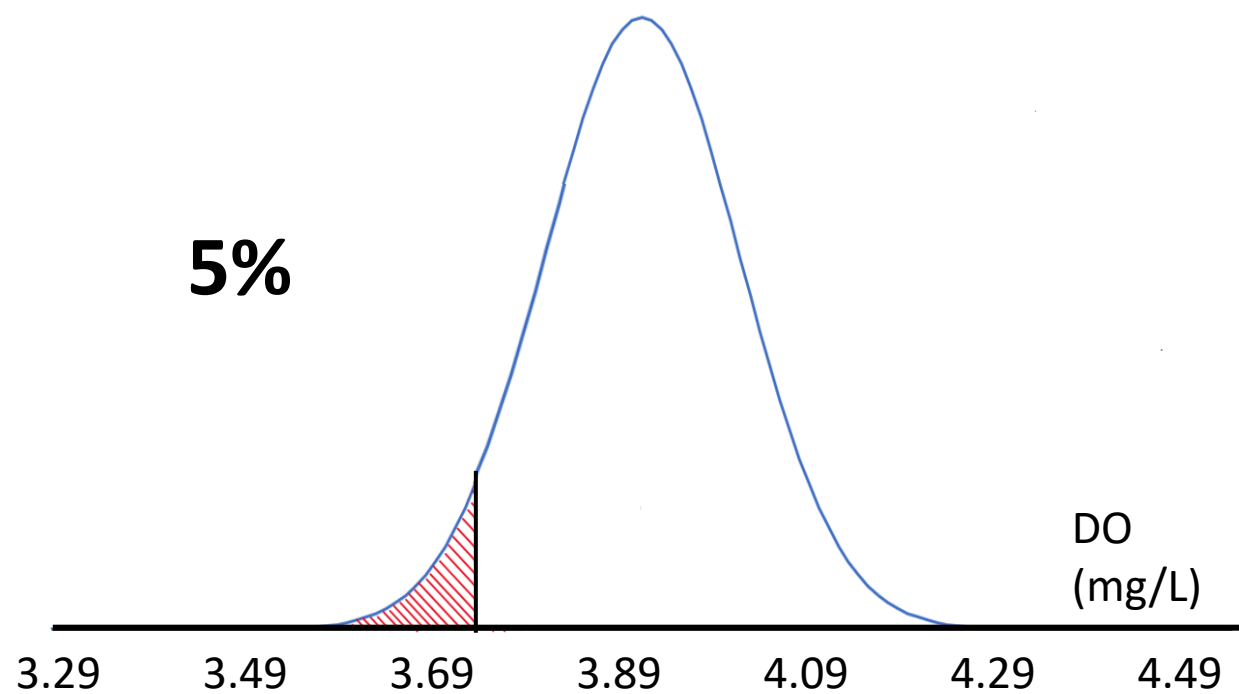
Adding Uncertainty Bands to Data used to perform FIS



Application of Environmental Risk



| | |
|--------------------------|------------------|
| Measured Value | 3.89 mg/L |
| Uncertainty Reported | +/- 0.2 mg/L |
| Value taken for analysis | 3.81 mg/L |



| | |
|--------------------------|------------------|
| Measured Value | 3.89 mg/L |
| Uncertainty Reported | +/- 0.2 mg/L |
| Value taken for analysis | 3.70 mg/L |

Parameter Threshold Ratio (PTR)

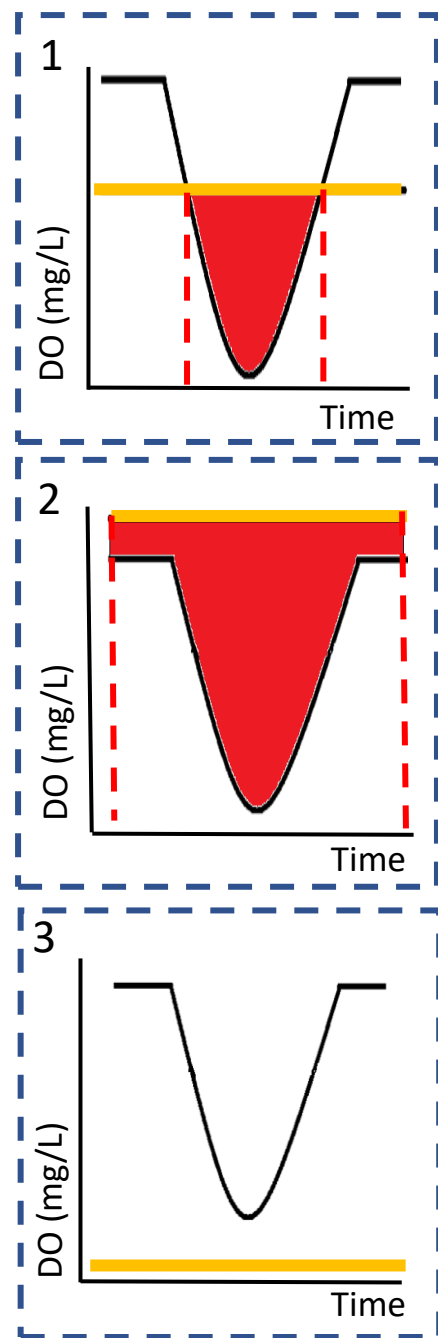
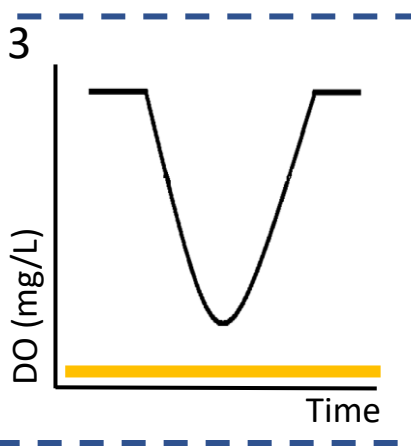
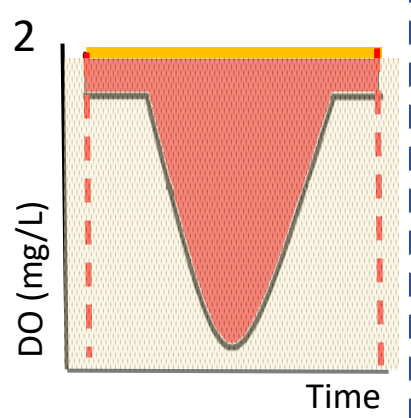
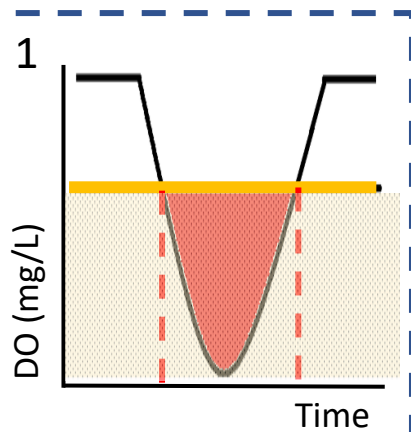


Figure 4. Illustration of ecological harm defined by FIS.

Parameter Threshold Ratio (PTR)

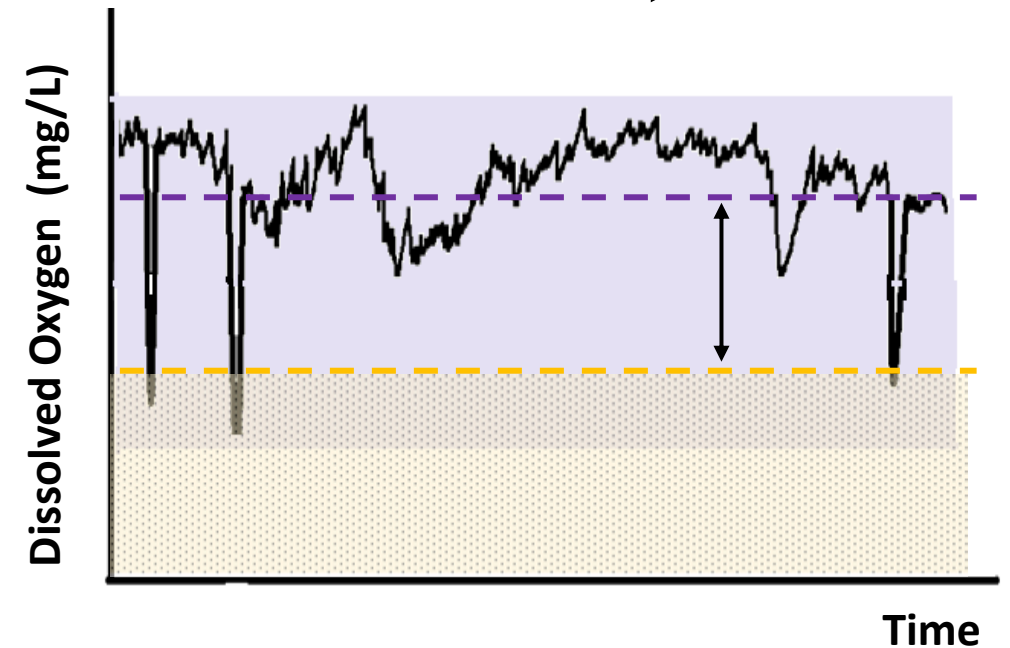
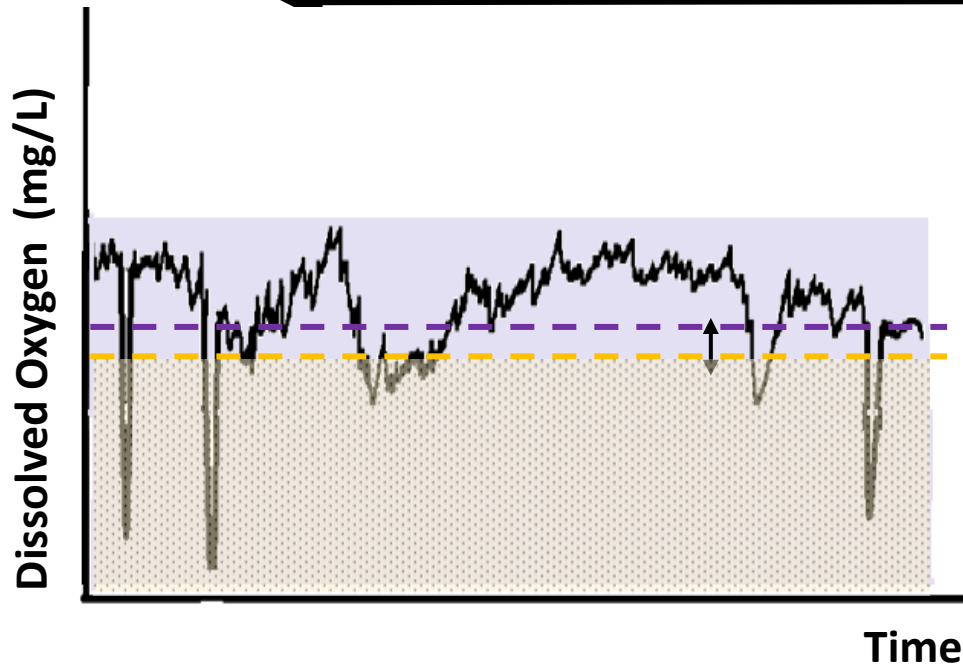
PTR can be measured by averaging the parameter measured points and dividing it by the averaged parameter threshold.



Low
PTR



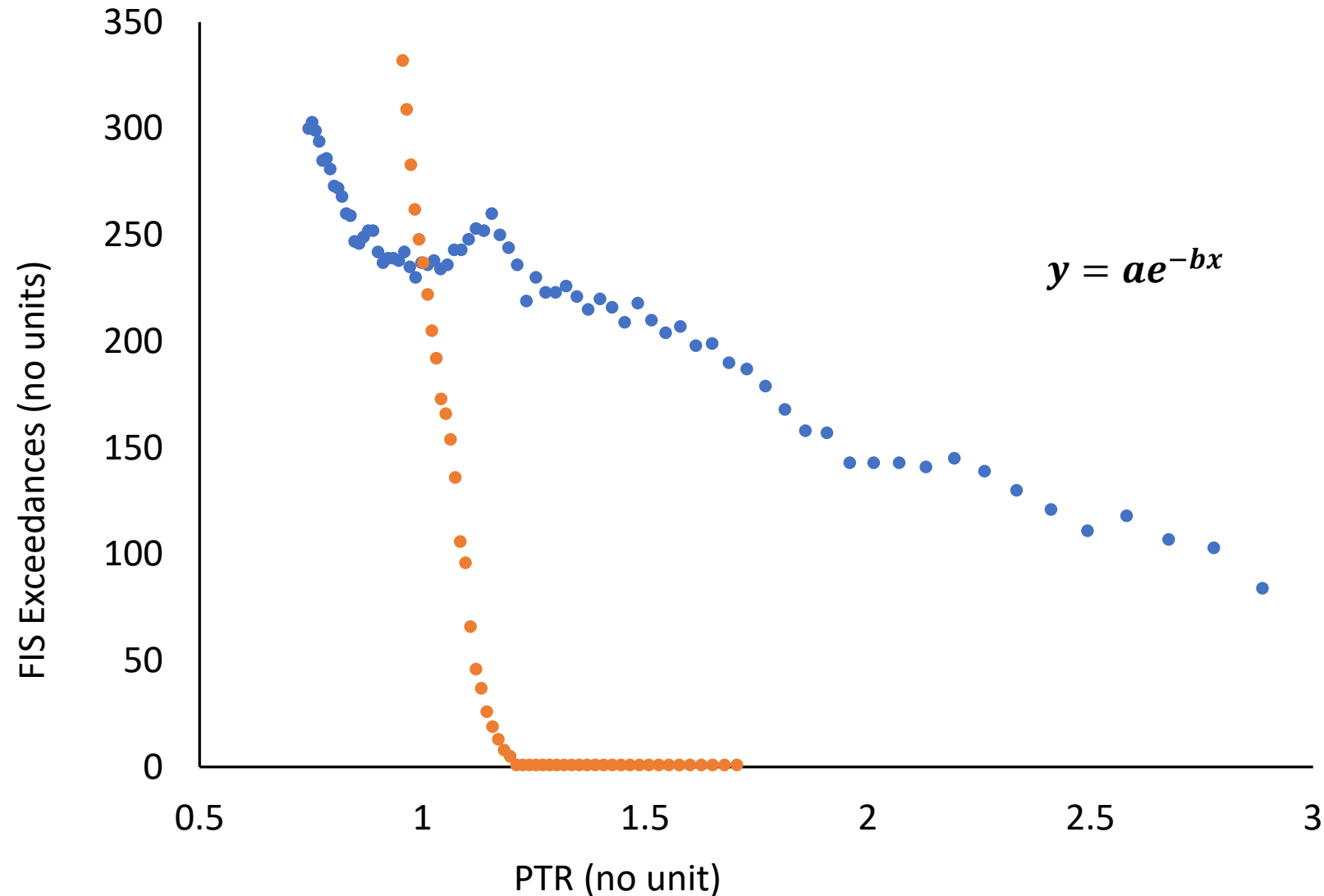
High
PTR





Results

Results: DO PTR graph based on real data from different locations



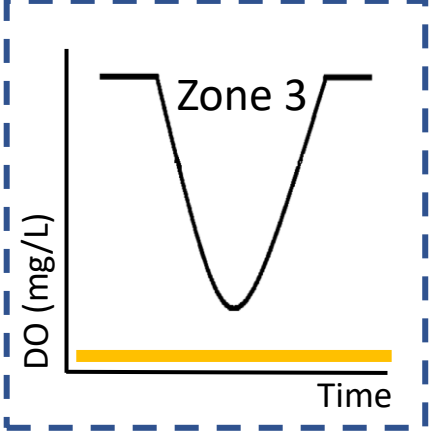
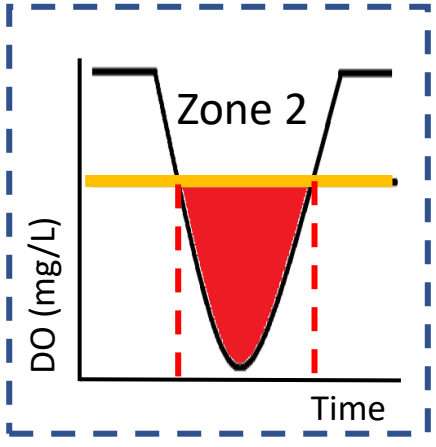
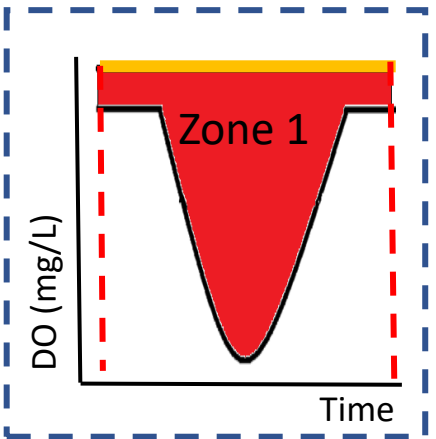
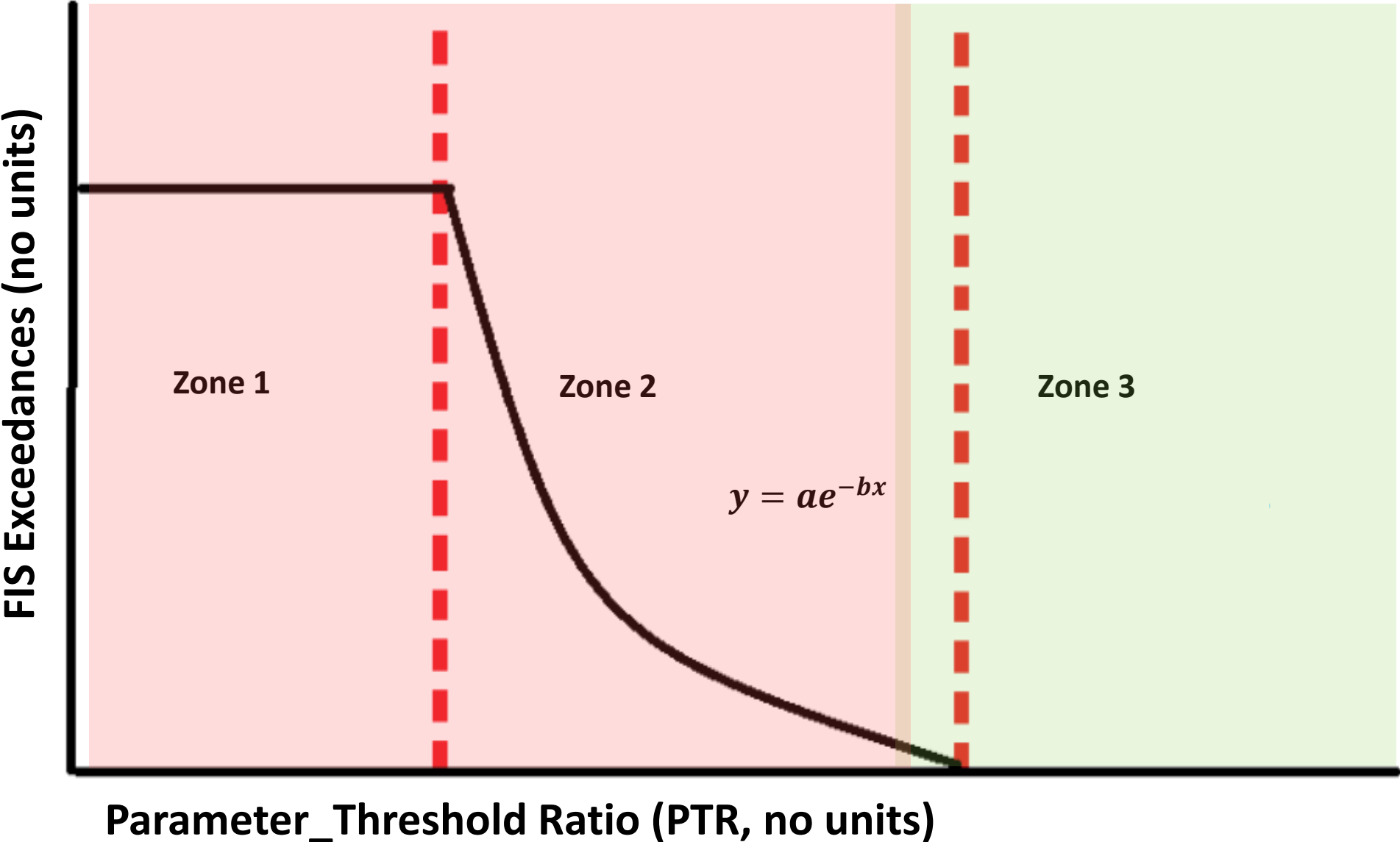
FIS exceedance count recorded at different PTR for the location CB3 for two different uncertainty bands.

| PTR | Blue Location | |
|-----|---------------|-------------|
| | ± 0.13 mg/L | ± 0.40 mg/L |
| 1.0 | 235 | 239 |
| 2.0 | 140 | 145 |

FIS exceedance count recorded at different PTR for the location O21 for two different uncertainty bands.

| PRT | Orange Location | |
|------|-----------------|-------------|
| | ± 0.13 mg/L | ± 0.40 mg/L |
| 1.13 | 43 | 86 |
| 1.23 | 1 | 3 |

Results: DO PTR Diagram



Results: UA PTR Diagram

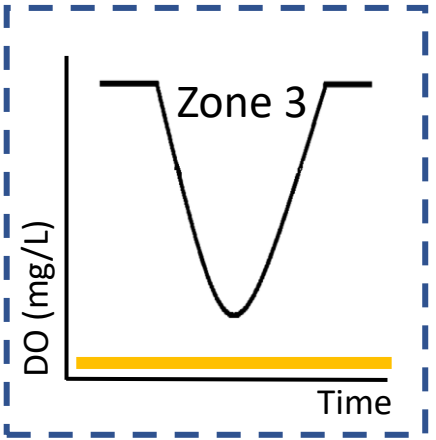
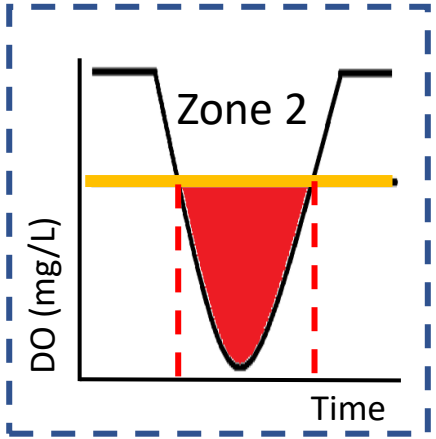
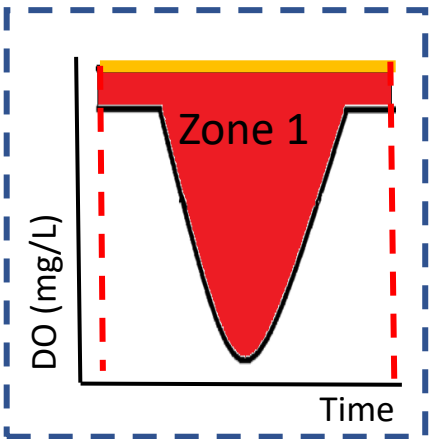
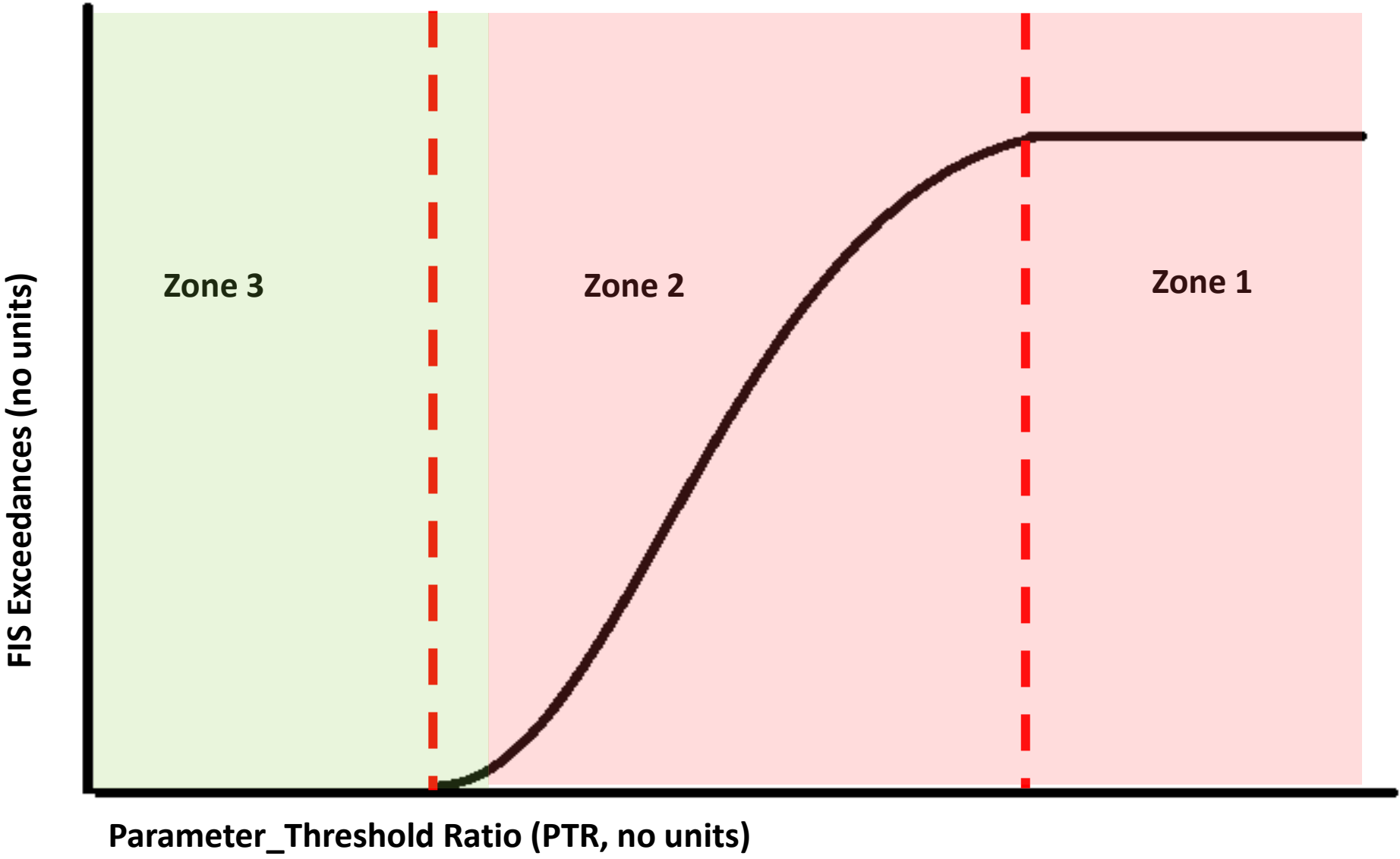
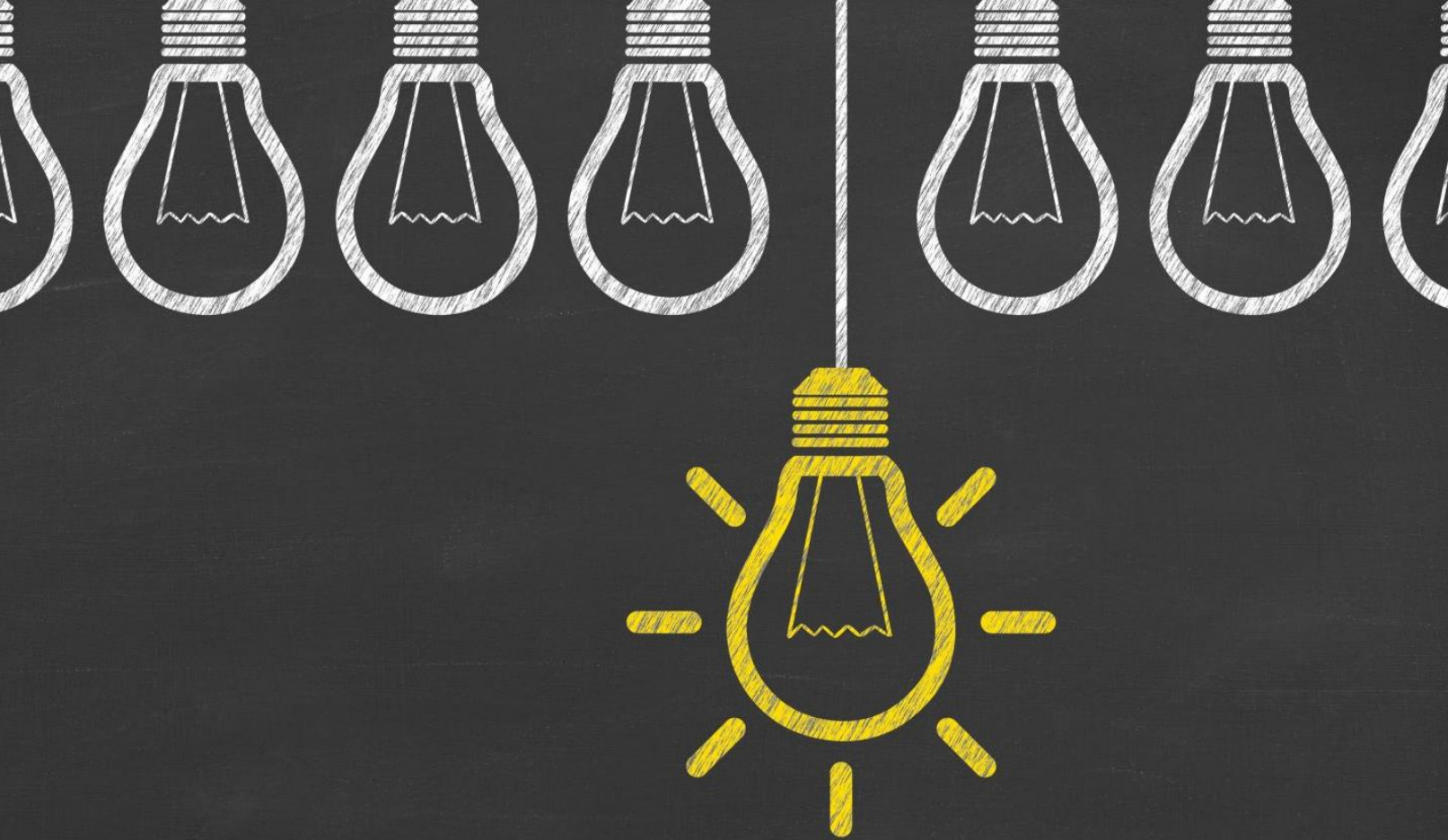


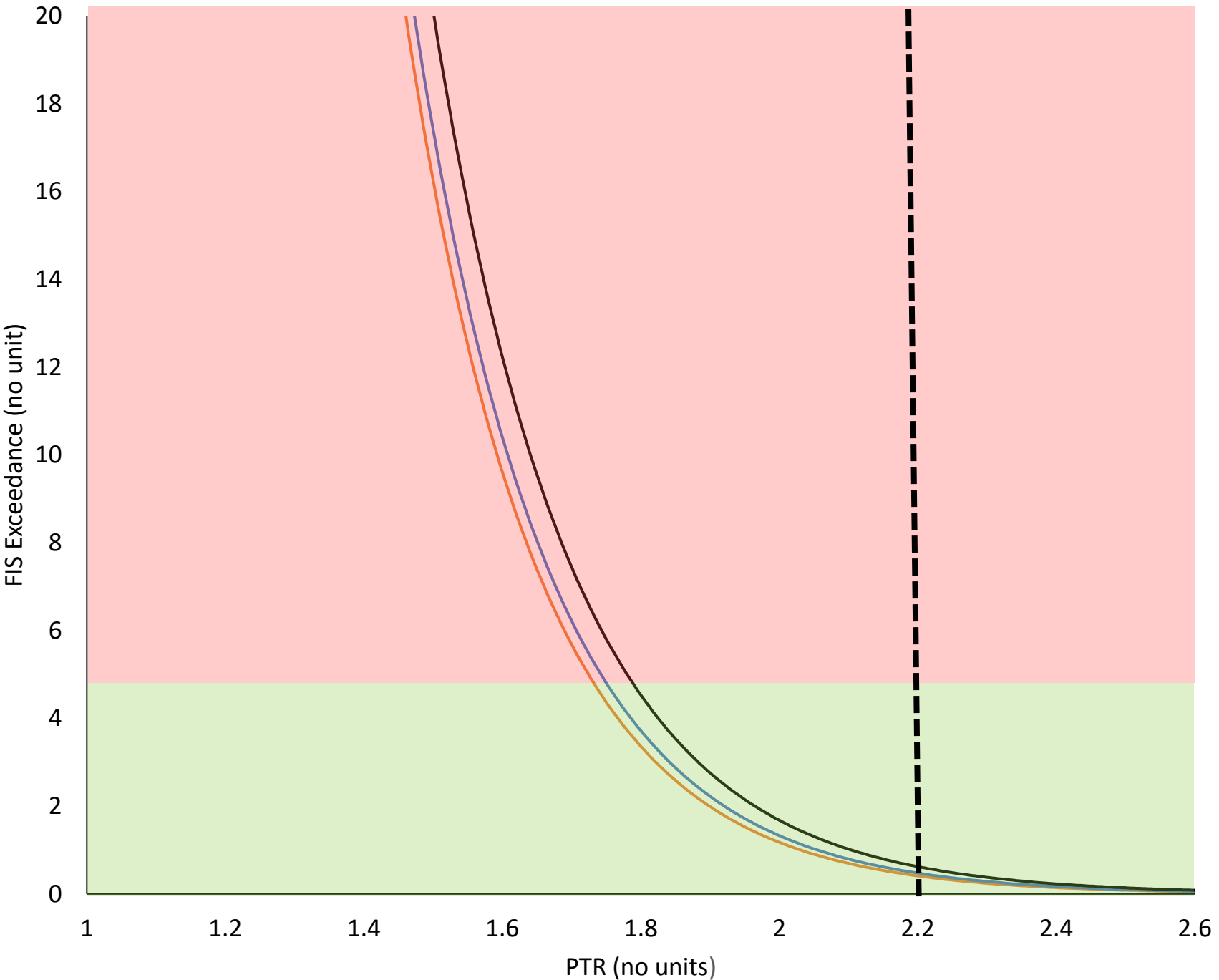
Figure 8. Diagram of the effect of PTR will have on reported number of DO FIS exceedance.



What does this mean for the water industry?

Dissolved Oxygen Example

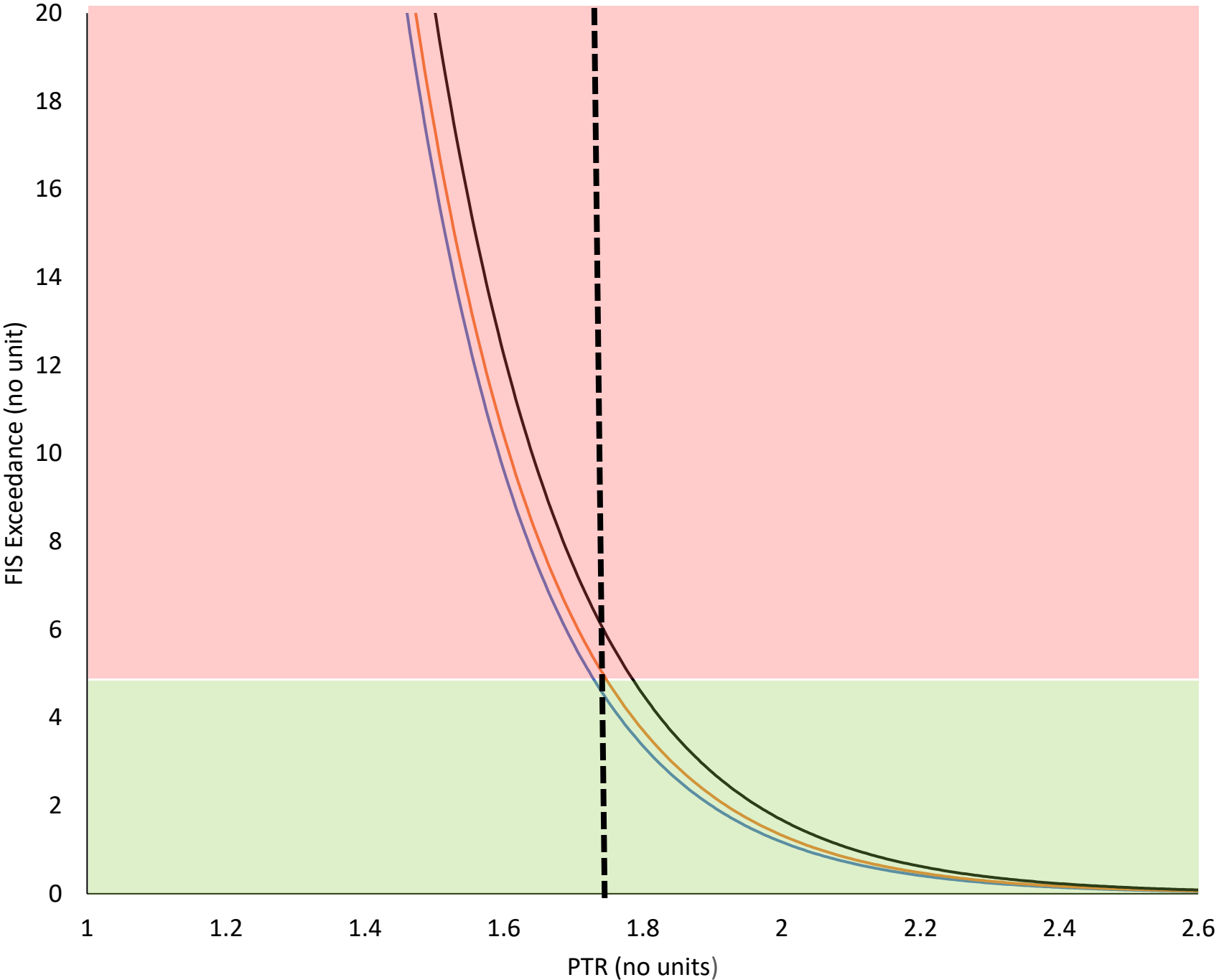
- 1. Choice of Sensor
- 2. Choice of maintenance regime
- 3. Decision on whether a solution is required
- 4. Implications on on solution size



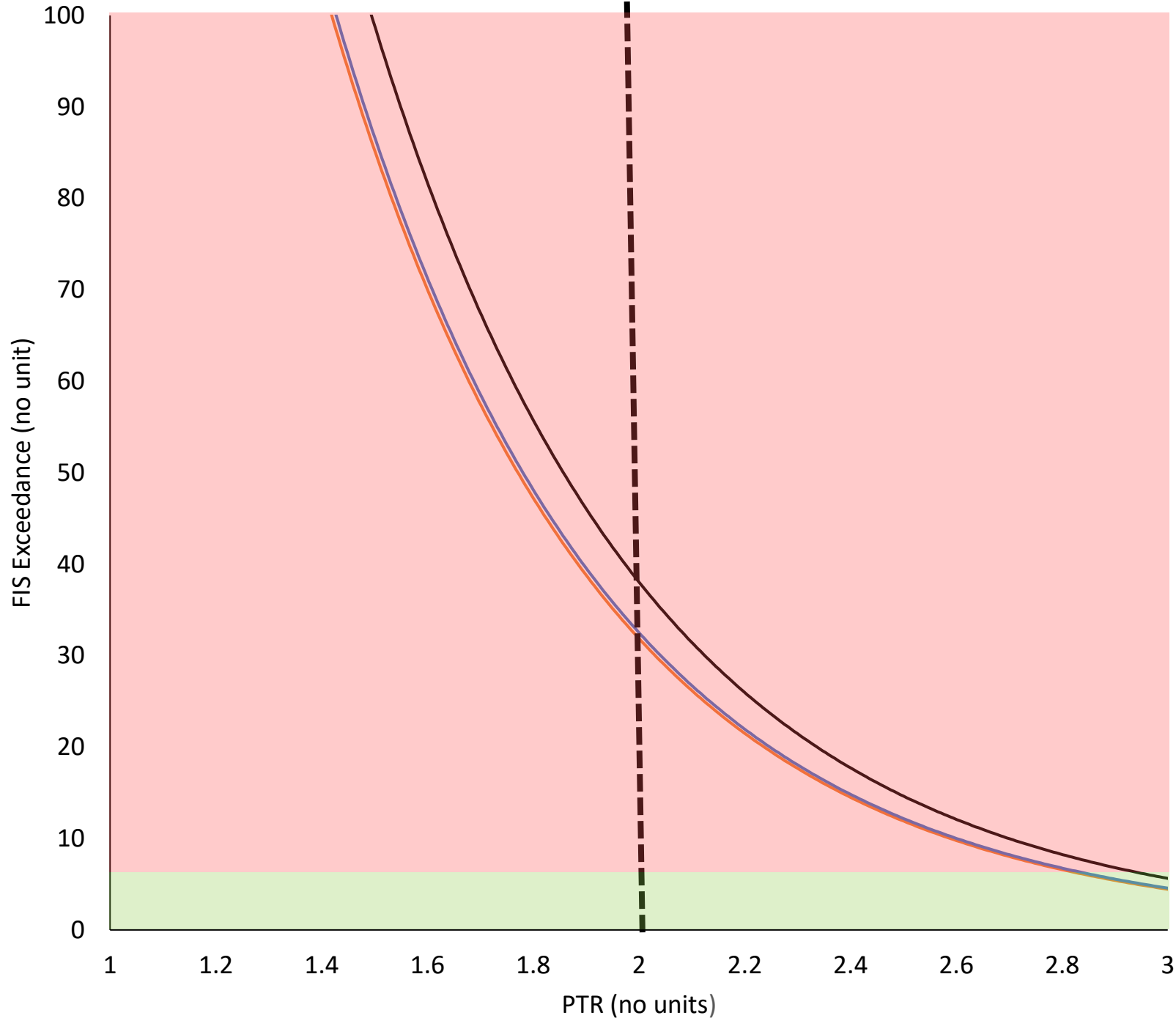
| Line Colour | Accuracy (mg/l) |
|-------------|-----------------|
| Orange | +/- 0.1 |
| Blue | +/- 0.2 |
| Black | +/- 0.5 |

Dissolved Oxygen Example

- 1. Choice of Sensor
- 2. Choice of maintenance regime
- 3. **Decision on whether a solution is required**
- 4. Implications on on solution size



| Line Colour | Accuracy (mg/l) |
|-------------|-----------------|
| Orange | +/- 0.1 |
| Blue | +/- 0.2 |
| Black | +/- 0.5 |



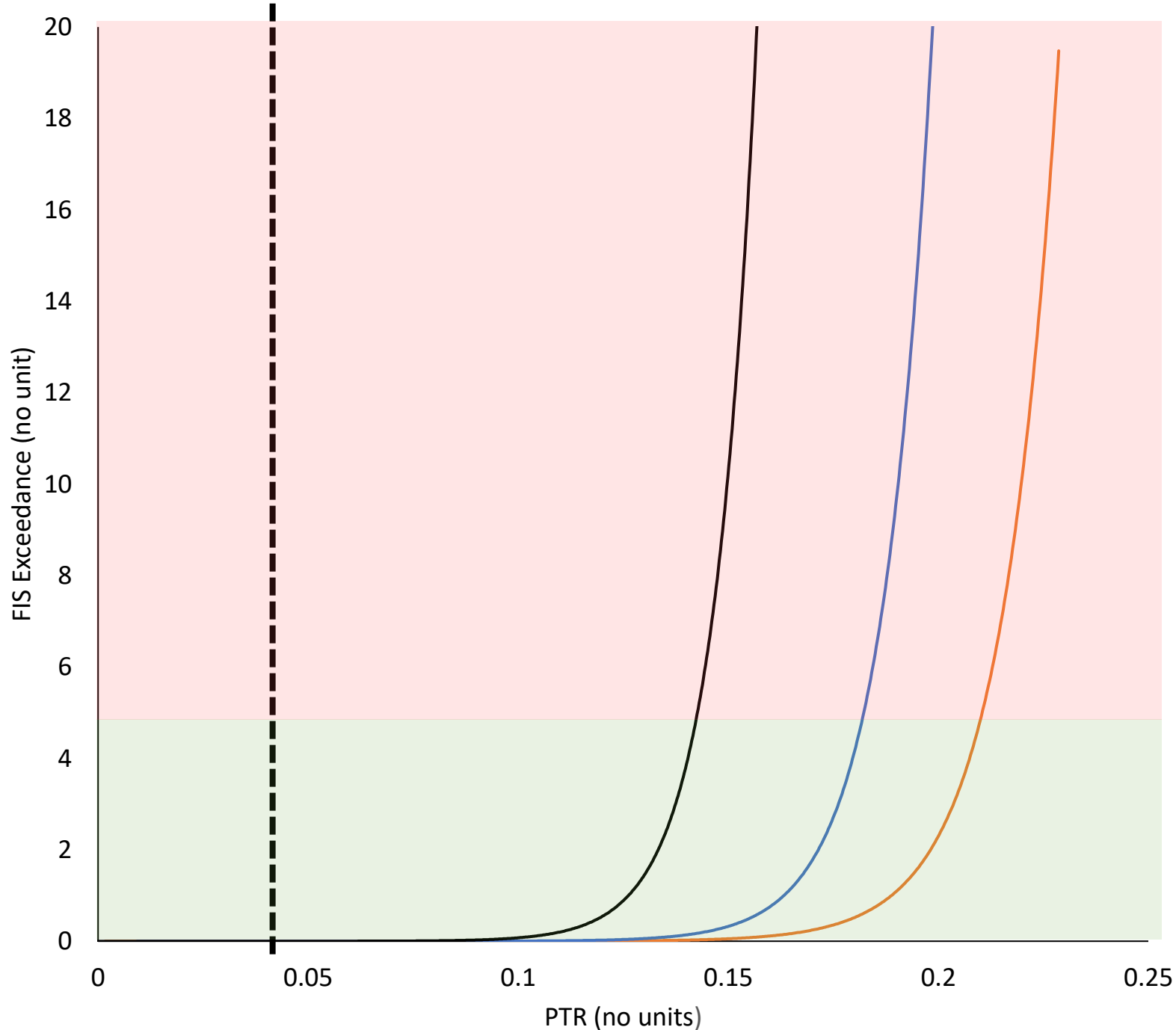
Dissolved Oxygen Example

1. Choice of Sensor
2. Choice of maintenance regime
3. Decision on whether a solution is required
- 4. Implications on on solution size**

| Line Colour | Accuracy (mg/l) |
|-------------|-----------------|
| Orange | + - 0.1 |
| Blue | + - 0.2 |
| Black | + - 0.5 |

Un-ionised Ammonia Example

1. Choice of Sensor
- 2. Choice of maintenance regime**
3. Decision on whether a solution is required
4. Implications on on solution size



Line Colour Accuracy
 (mg/l)

Orange +/- 0.5

Blue +/- 1.0

Black +/- 2.0

Re- cap

- Currently, FIS is used as a surrogate for defining ecological harm
- Multiparameter sondes have an accuracy bandwidth
- To consider uncertainty one must also consider risk
- Parameter threshold ratio (PTR) is a term created to indicate a parameter's relative position to the point of ecological harm
- Plotting PTR against FIS exceedances can provide understanding into a location's sensitivity to uncertainty
- Understanding a location's sensitivity to uncertainty has multiple economic implications such as choice of sensor required and the size/type of the solution