Lessons Learned from Treatability Testing for Effective and Sustainable Water Treatment

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Outline

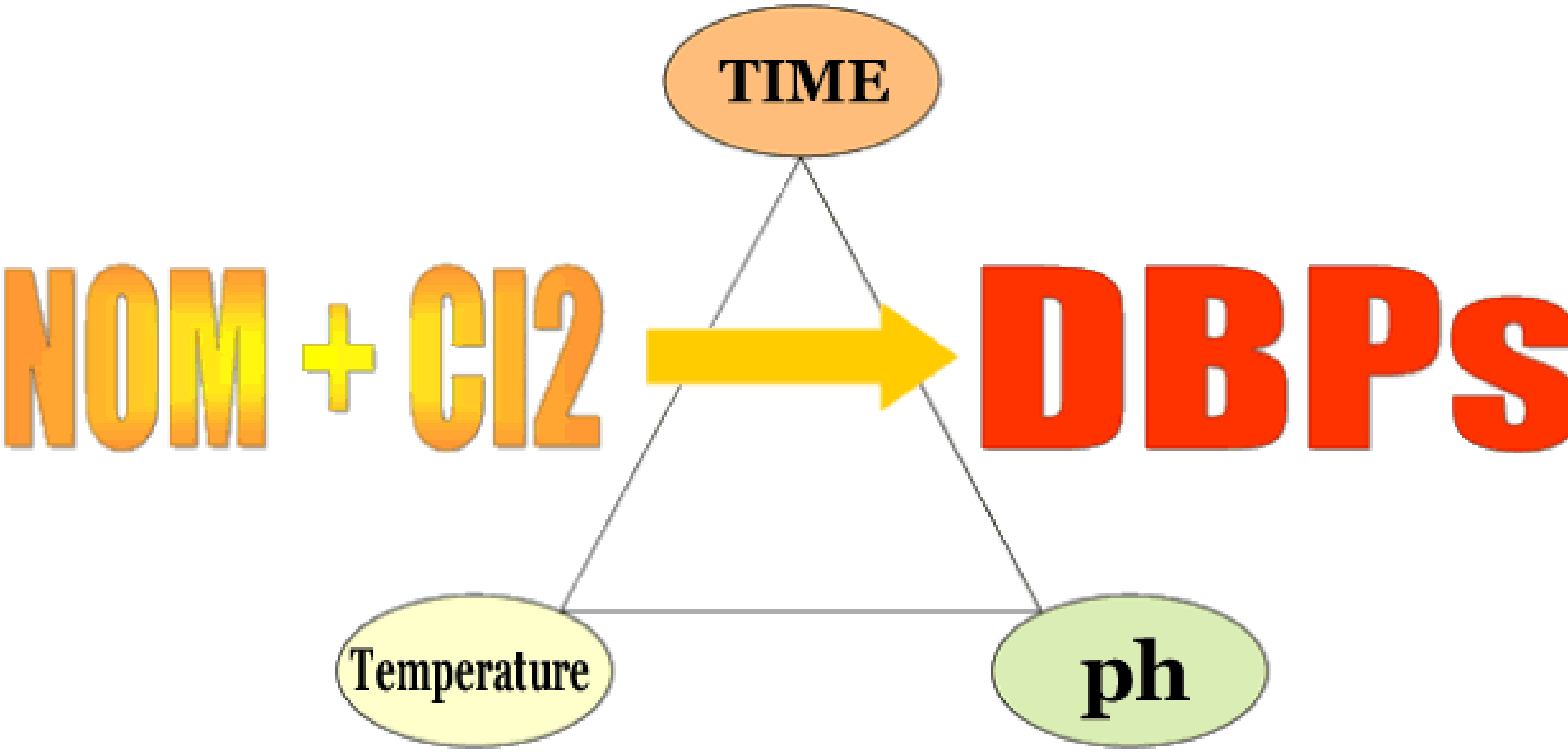
- Understanding Water Quality Regulations and Challenges
- Treatability Testing Conditions
- Results and Discussion
- Lessons Learned for Sustainable Water Treatment

Drinking Water Quality Challenges

- Compliance with the disinfection by-product (DBP) regulations has been identified as a problem in many smaller communities across Canada

- Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ) for DBPs include:
  - Trihalomethanes (THM): 100 µg/L
  - Haloacetic Acids (HAA_5): 80 µg/L

DBP Formation



Eastern Canada Case Study - Review of Water Quality

Data collected over a 5 year period for five surfacewater supplies

Water Quality Parameter	%of Population Affected w Exceedance
THM	24
HAA_5	48
Turbidity	31

Significant upgrades required to existing treatment plants

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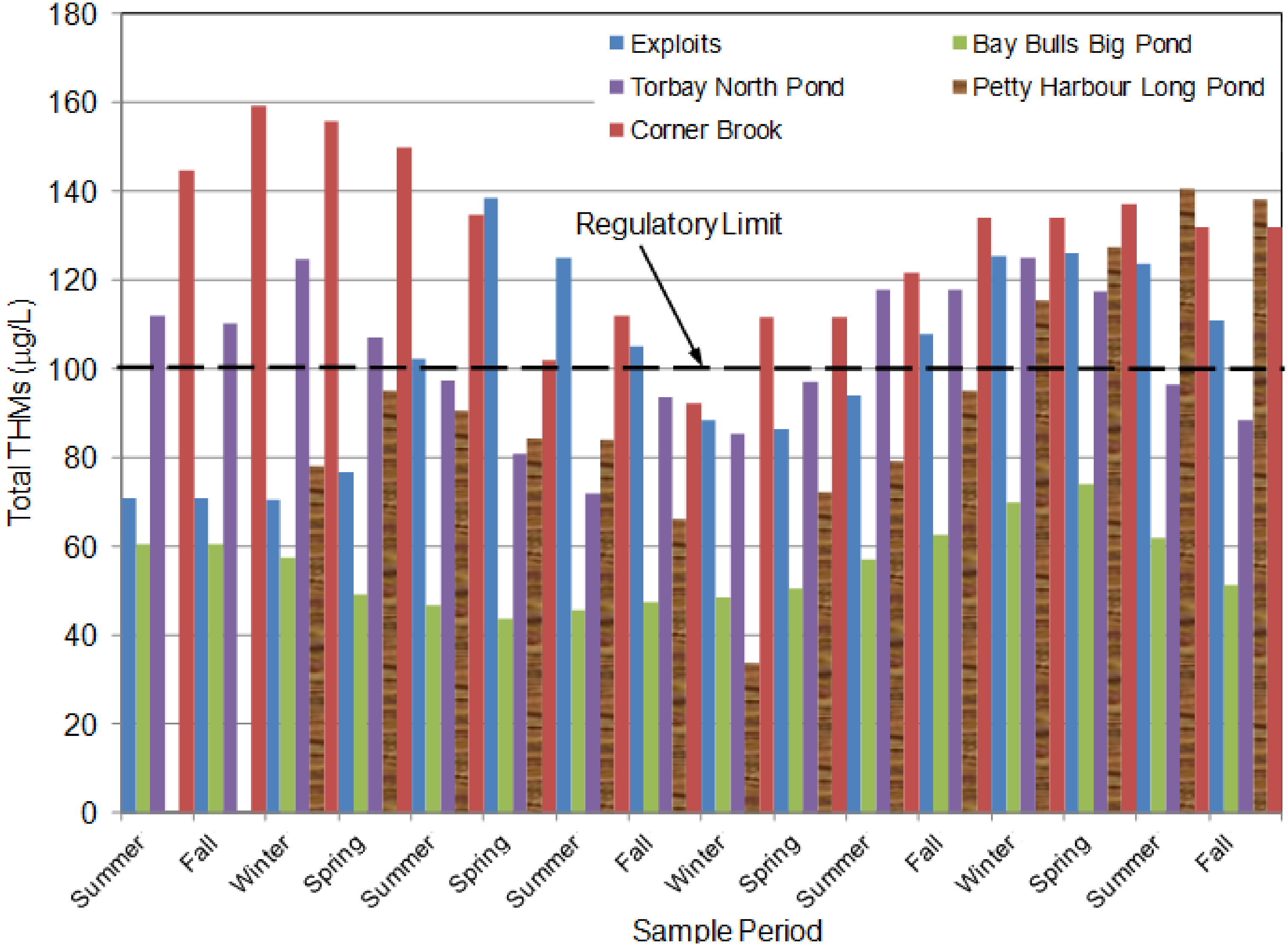
Implications for Water Treatment Process Selection

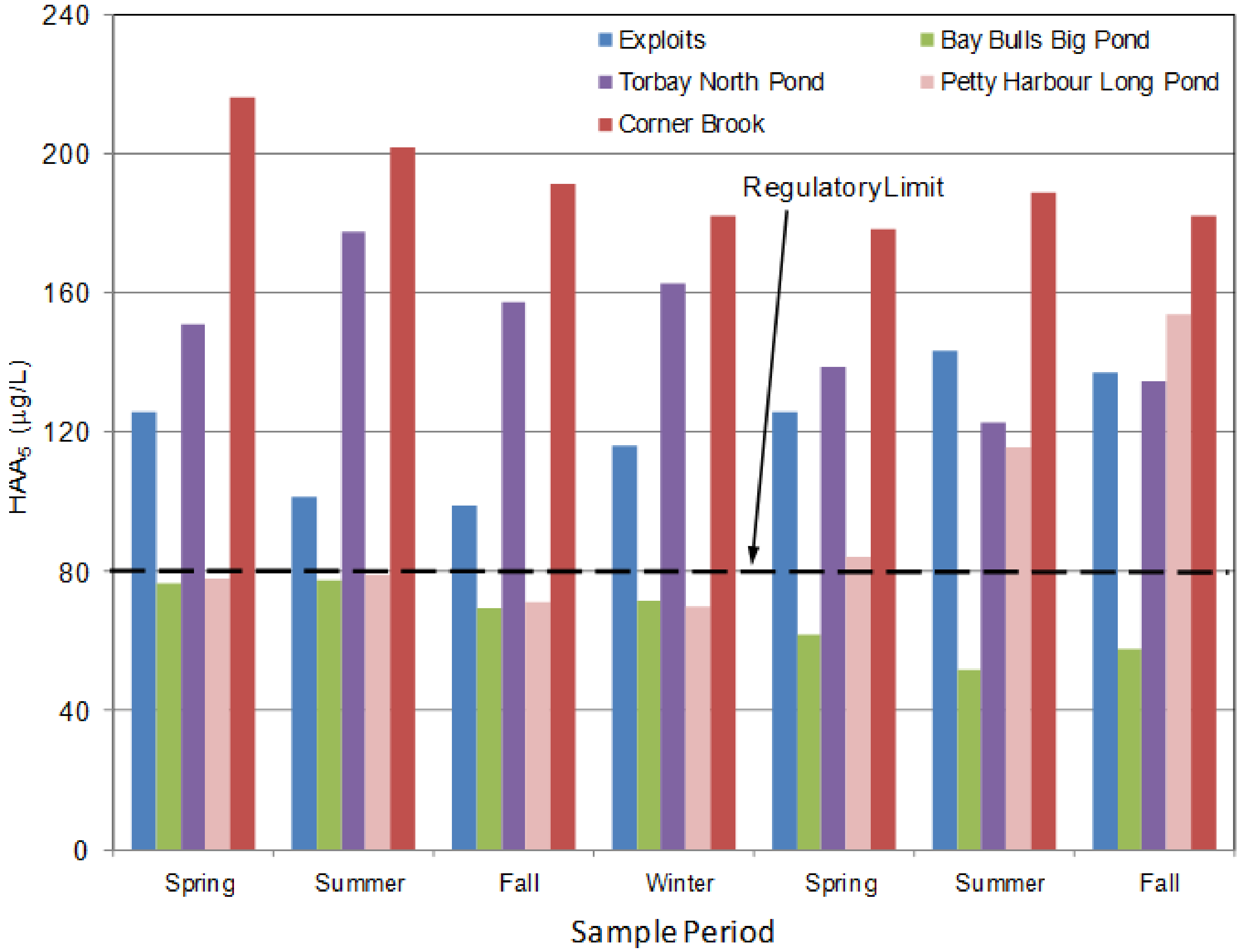
- Compliance with both DBP and turbidity regulations
- NOM removal is required to minimize DBP formation during disinfection
- Typical technologies used for treating surface waters include:
  - Slow sand filtration (↓ organics removal)
  - Membranes (↓ organics removal)
  - Conventional coagulation/clarification/granular media filtration

*Coagulation is typically required to meet DBP regulations when disinfecting with chlorine

Historical THM Formation Data

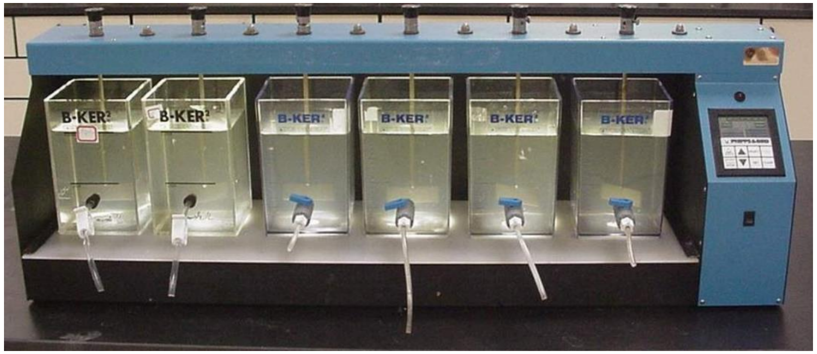


Historical HAA_5 Formation Data



Jacobs/CH2M Treatability Testing Objectives

- Bench-scale coagulant jar testing and simulated distribution system (SDS) conducted on six surface waters



- Objectives of this work were to:
  - Evaluate the need for and effectiveness of coagulation for DBP control
  - Estimate the coagulant doses needed for NOM removal and DBP compliance
  - Examine the use of standard jar tests with the addition of simple measurements such as UV absorbance as indicators of NOM removal

Raw Water Characterization

- In general, these water can be described as:
  - Low to neutral pH (5.5 to 7.5)
  - Low alkalinity (<10 mg/L as CaCO3)
  - Moderate to high NOM (2.9 mg/L to 6.4 mg/L TOC)
  - Low turbidity (<1.7 NTU)
  - Moderate to high specific ultraviolet absorbance, SUVA (2.6 to 4.9 L/mg-m)

$$SUVA = \frac{UVA(m^{-1})}{DOC(mg/L)} x\,100$$

    - Indicates that NOM would likely control the coagulation doses required for effective treatment
    - Good levels of organics removal can be achieved (>50%)

Jar Testing Conditions

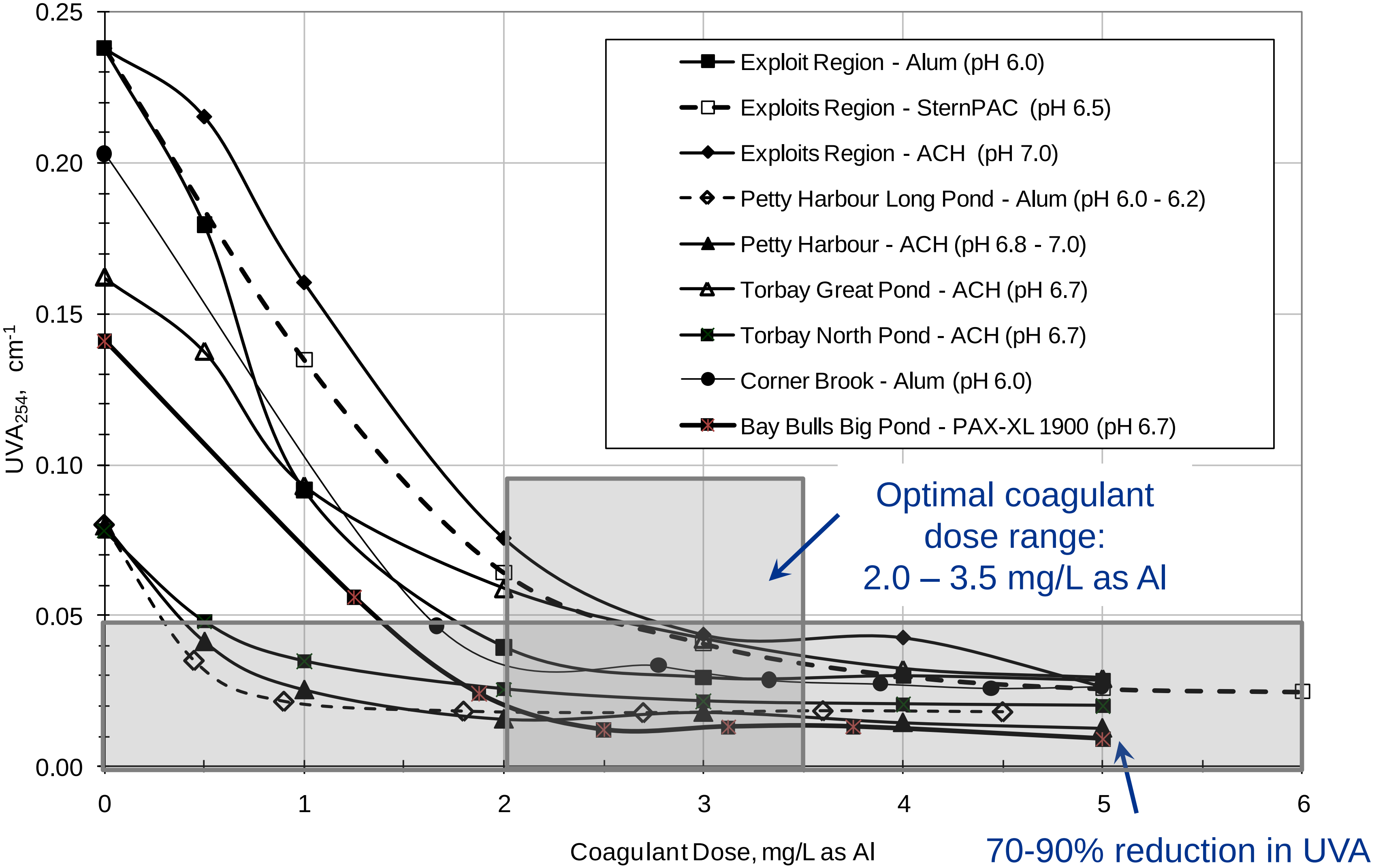
- Bench-scale testing conducted by Jacobs/CH2M
- Protocols for testing followed USEPA Enhanced Coagulation and Enhanced Precipitative Softening Guidance Manual
- Chemicals:
  - pH control:
    - Sodium hydroxide (NaOH)
  - Coagulants:
    - Aluminum Sulfate (Alum)
    - Polyaluminum Chloride (PACl)
    - Aluminum Chlorohydrate (ACH)

Coagulation Jar Testing Parameters

- Jar testing conducted for each supply to determine:
  - Coagulant type
  - Coagulant dose
  - Coagulation pH

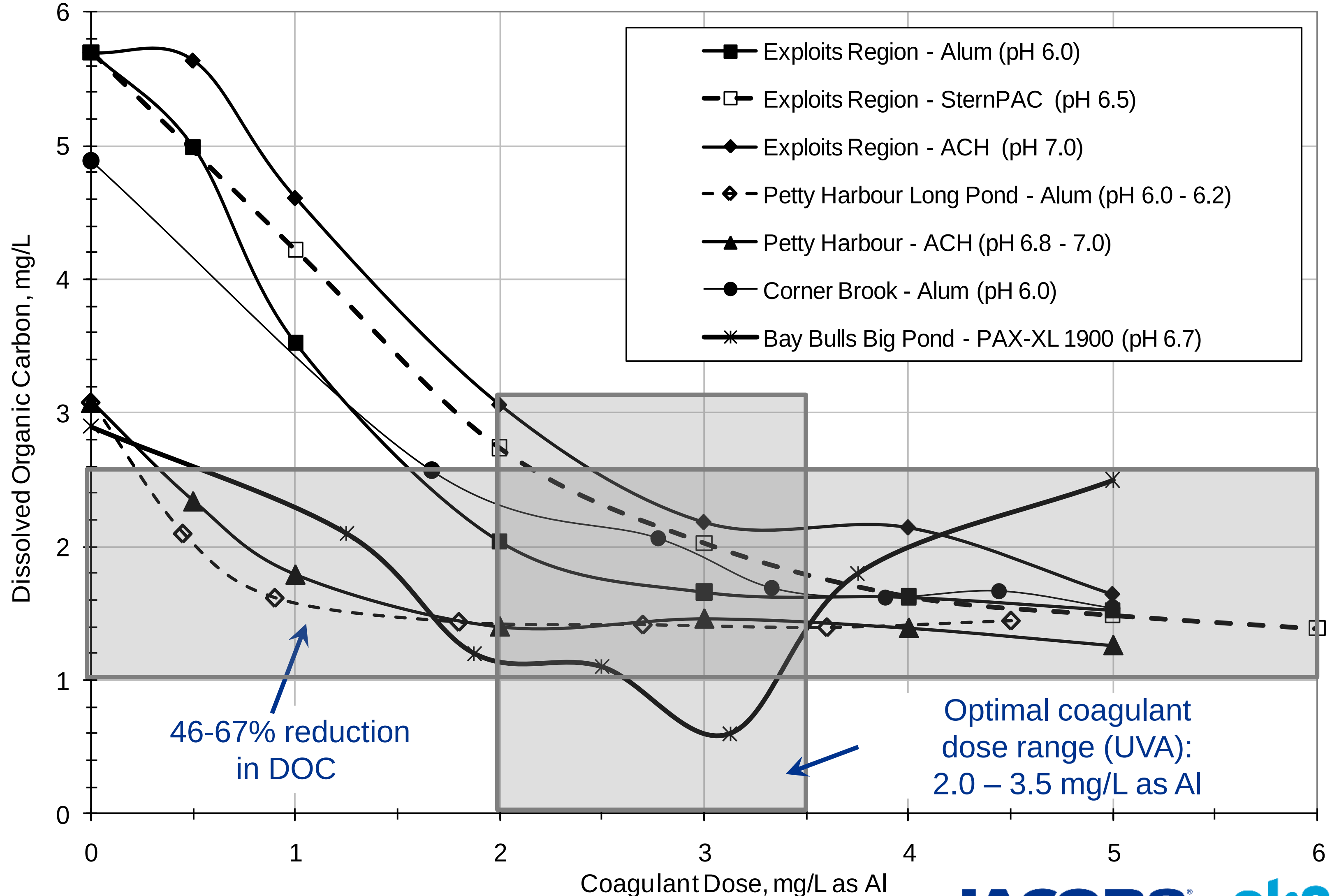
- Coagulation conditions selected by identifying the “point of diminishing returns” for NOM removal, evaluating:
  - UV absorbance (UVA)
  - Dissolved organic carbon (DOC)
  - Colour
  - Turbidity was also considered

Ultraviolet Absorbance



Dissolved Organic Carbon

Confirms UVA as a quicker, cheaper surrogate for DOC



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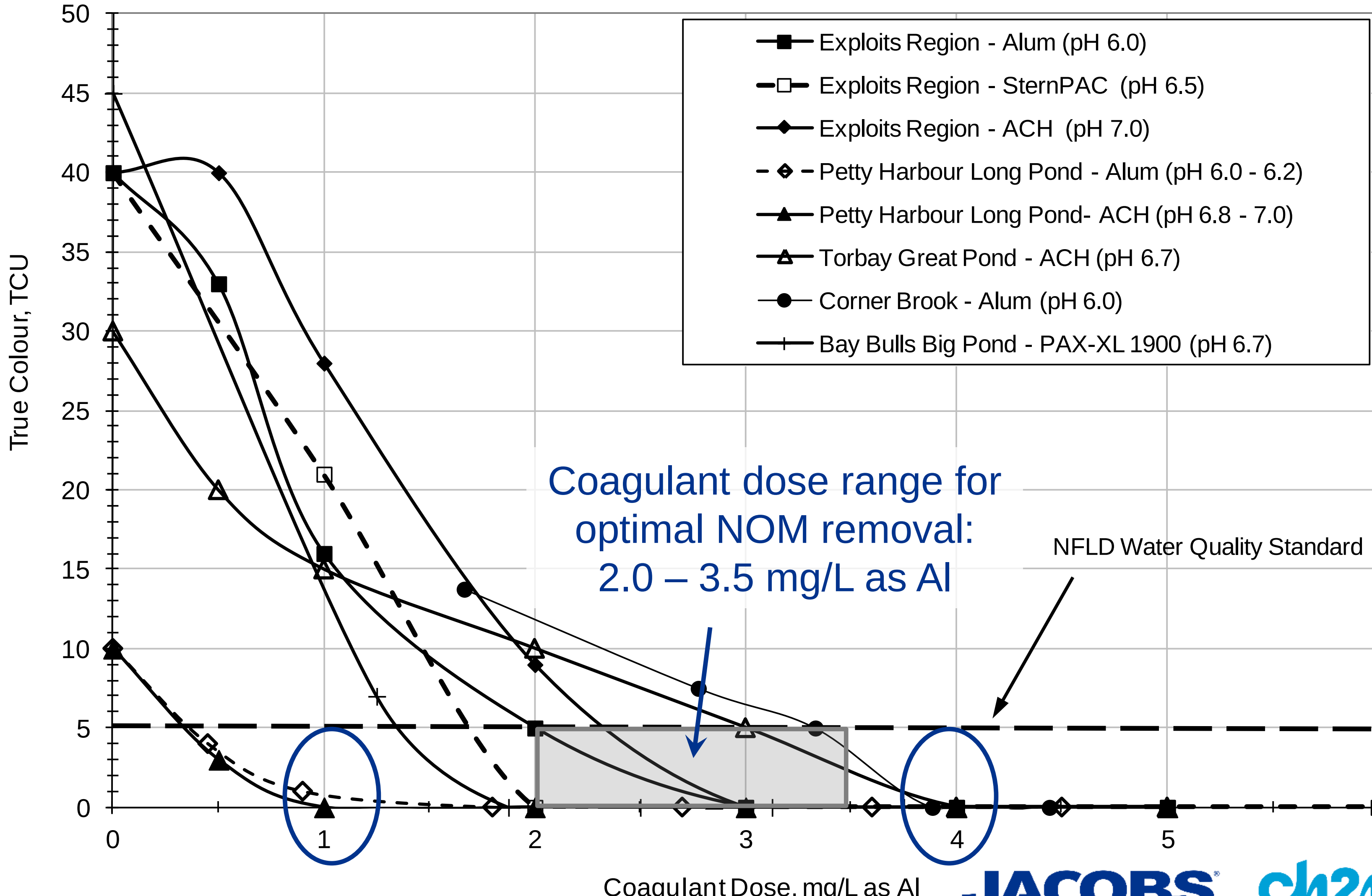
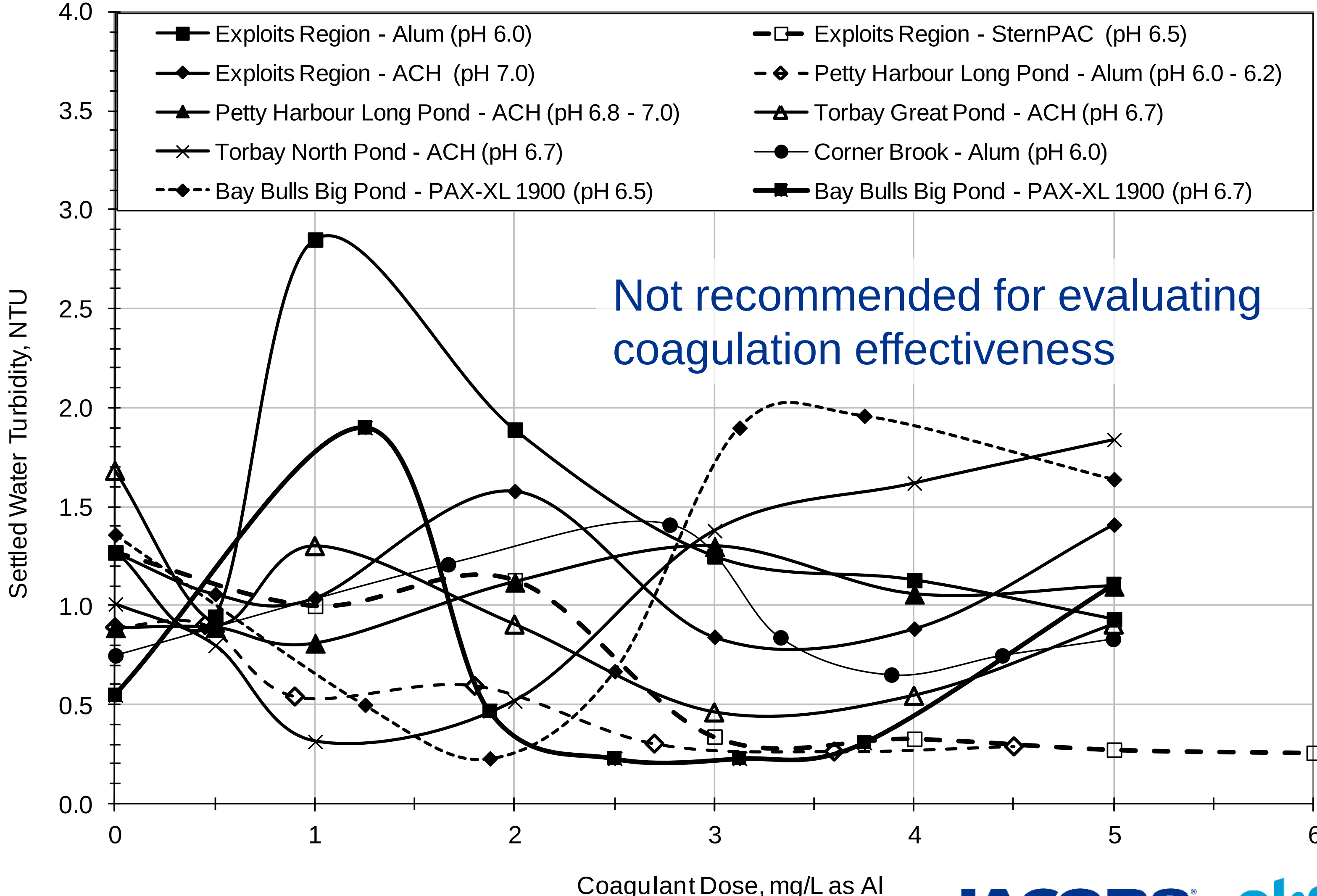
True Colour



True Colour, TCU
50
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
6
Coagulant Dose, mg/L as Al
Exploits Region - Alum (pH 6.0)
Exploits Region - SternPAC (pH 6.5)
Exploits Region - ACH (pH 7.0)
Petty Harbour Long Pond - Alum (pH 6.0 - 6.2)
Petty Harbour Long Pond- ACH (pH 6.8 - 7.0)
Torbay Great Pond - ACH (pH 6.7)
Corner Brook - Alum (pH 6.0)
Bay Bulls Big Pond - PAX-XL 1900 (pH 6.7)
Coagulant dose range for optimal NOM removal: 2.0 – 3.5 mg/L as Al
NFLD Water Quality Standard

Settled Water Turbidity



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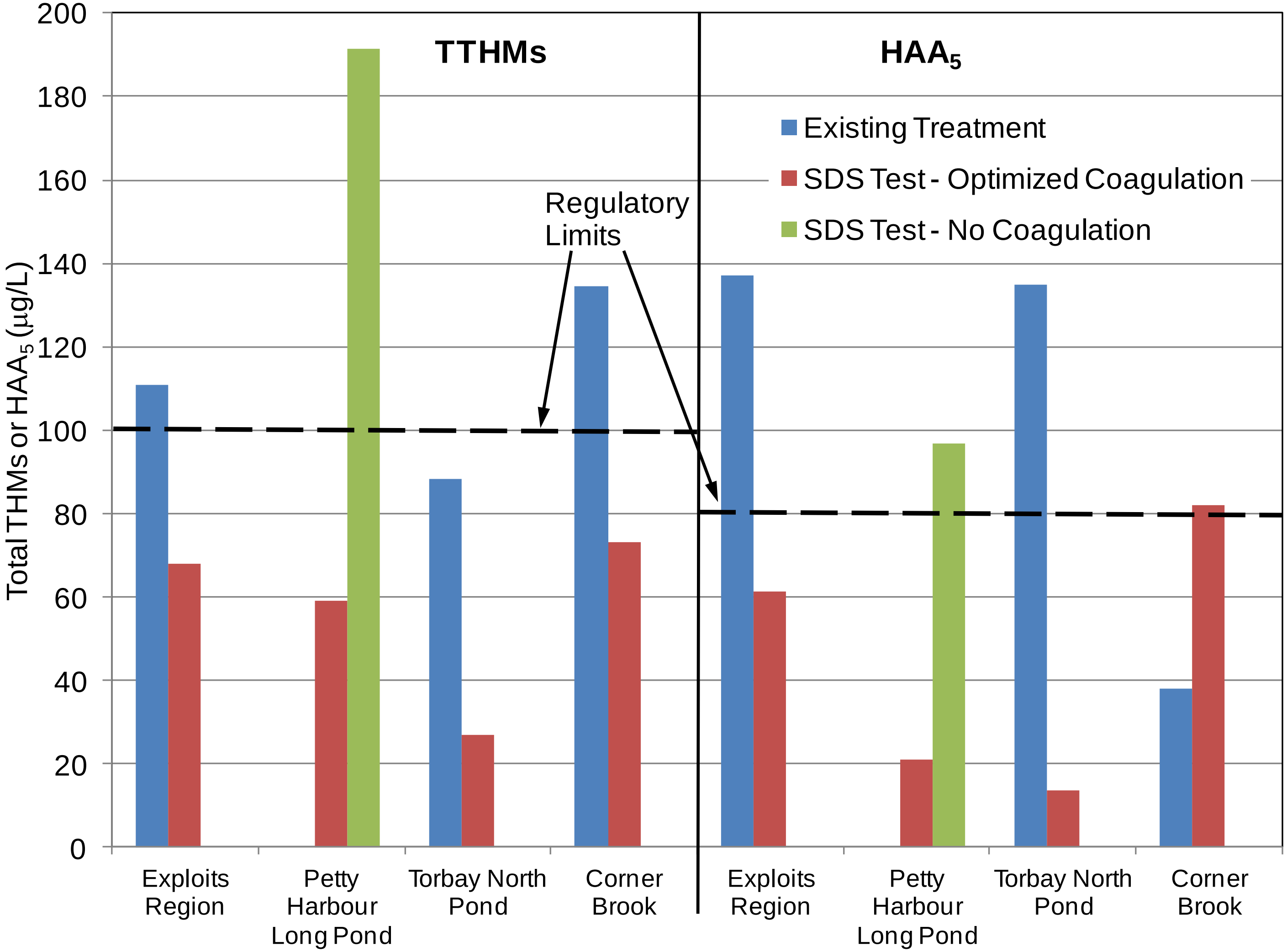
Simulated Distribution System DBP Testing

- Testing conducted projected distribution system DBP formation both with and without coagulation
- For testing without coagulant, raw water was filtered then chlorinated (Simulates membranes or slow sand filtration)
- Testing with coagulant was conducted based on optimal conditions determined from jar testing
- Measured levels of THMs and HAAs formed after 72 hours
  - Applied projected chlorine dose required to have a residual >0.2 mg/L after 72 hours
  - Samples were initially pH adjusted to simulate distribution system pH

Disinfection By-products Formation



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Lessons Learned for Sustainable Water Treatment

- Treatment processes to target NOM with coagulant to reduce DBP precursors

- Coagulation was effective for DBP control in the waters tested
  - High levels of NOM removal (>50%)
  - Consistently able to reduce DBPs levels below guidelines

- The optimal coagulant dose range was 2.0 - 3.5 mg/L as Al
  - Can be used to develop operating cost estimates
  - Starting point for coagulant dosing in future jar testing

- UVA measurements over turbidity measurements for NOM removal estimates

QUESTIONS?

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