In Situ Hex-Chrome Reduction at a Complex Site

NEBC NW REMEDIATION CONFERENCE, MAY 2024

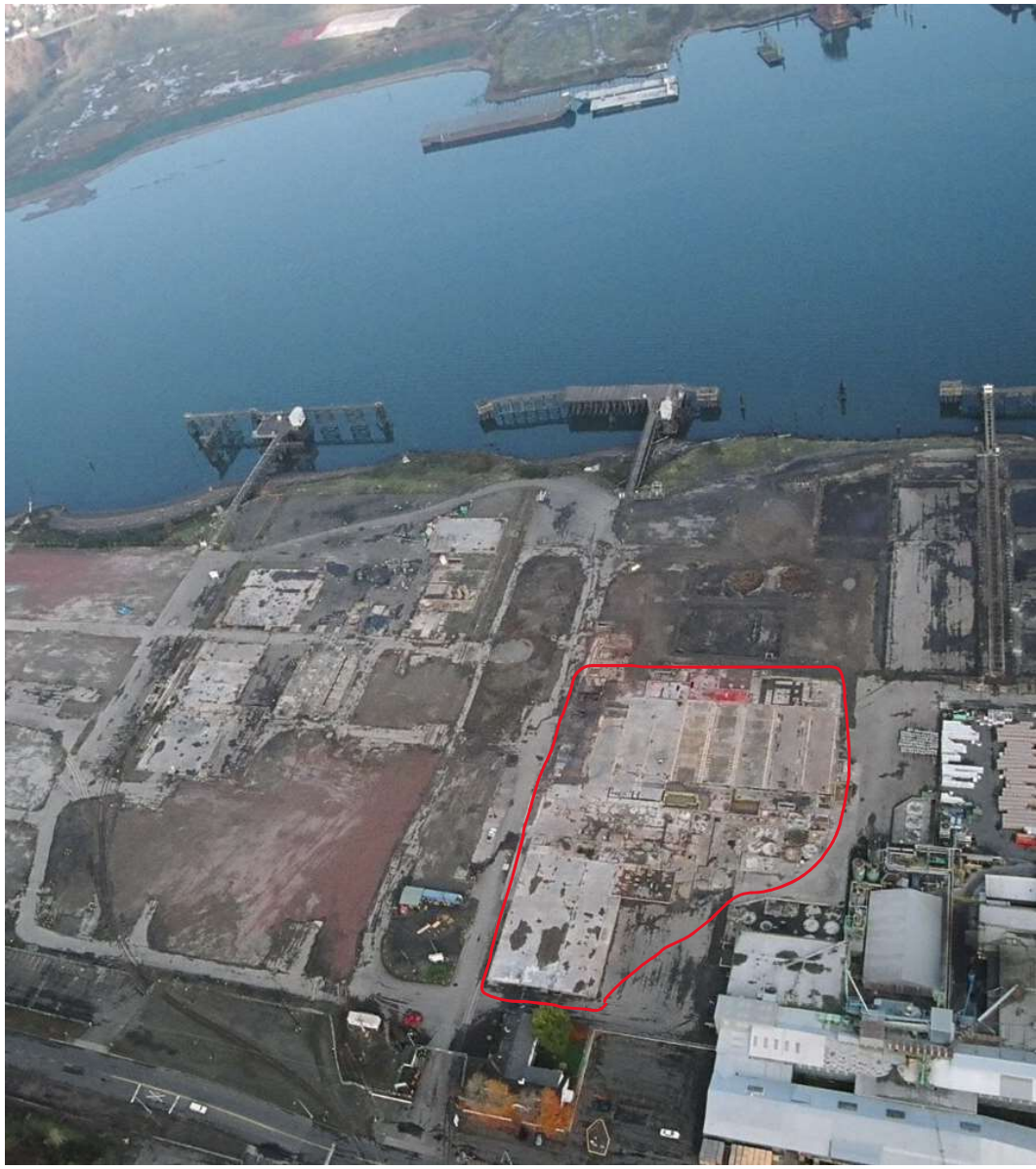
PRESENTED BY: JOSH HYRMAN

Sustainability is our business

© Copyright 2024 by The ERM International Group Limited and/or its affiliates ('ERM'). All rights reserved. No part of this work may be reproduced or transmitted in any form or by any means, without prior written permission of ERM.

Site History

- Sodium Chlorate Production – 1941-2001
- Electrolysis of a sodium chloride brine solution
- Sodium dichromate ($Na_2Cr_2O_7$) was added as a corrosion inhibitor and to improve the electrical efficiency of the process.
- Chromium(VI) is toxic, carcinogenic, and soluble at all pHs.
- Historical releases of sodium dichromate have resulted in the presence of Cr(VI) in soil and groundwater in the Chlorate Plant area.



Site Complexity

- Multiple contaminants
- Situated between the Tualatin Mountains and Willamette River
- Hydraulic gradient is towards the river
- Adjacent to Portland Harbor superfund site

Esri, NASA, NGA, USGS, FEMA | Esri Community Maps Contributors, County of Clark, WA, Oregon Metro, Oregon State Parks, State of Oregon GEO, WA State Parks GIS, © OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, US Census Bureau, USDA, USFWS

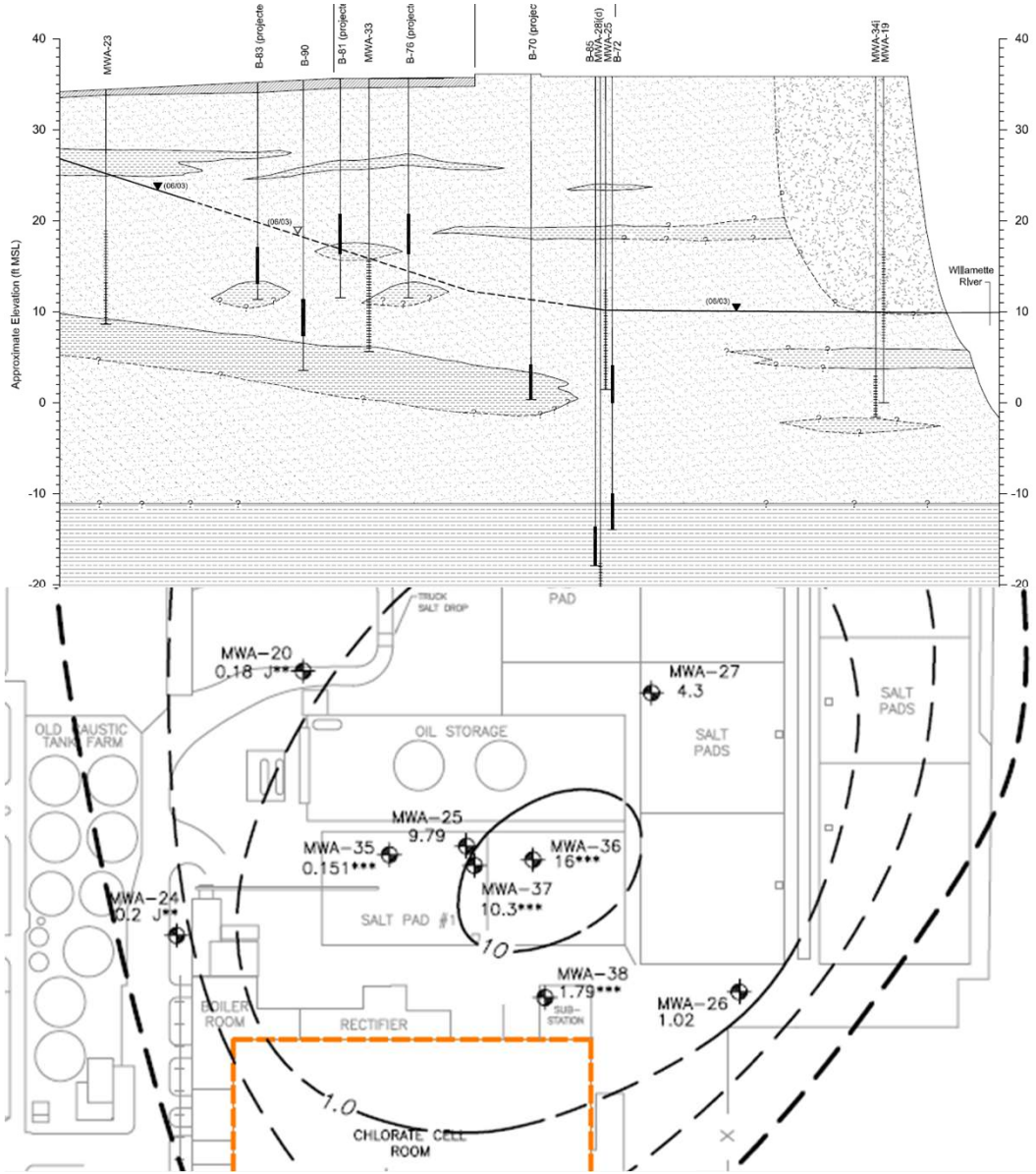
Remediation Design

Goals

- Immobilize Cr(VI) in groundwater
- Stop migration of Cr(VI) into surface water
- Keep Cr(VI) immobilized during future work

Decisions Making

- Interim Action
- Convince Regulators
- Technological Risks



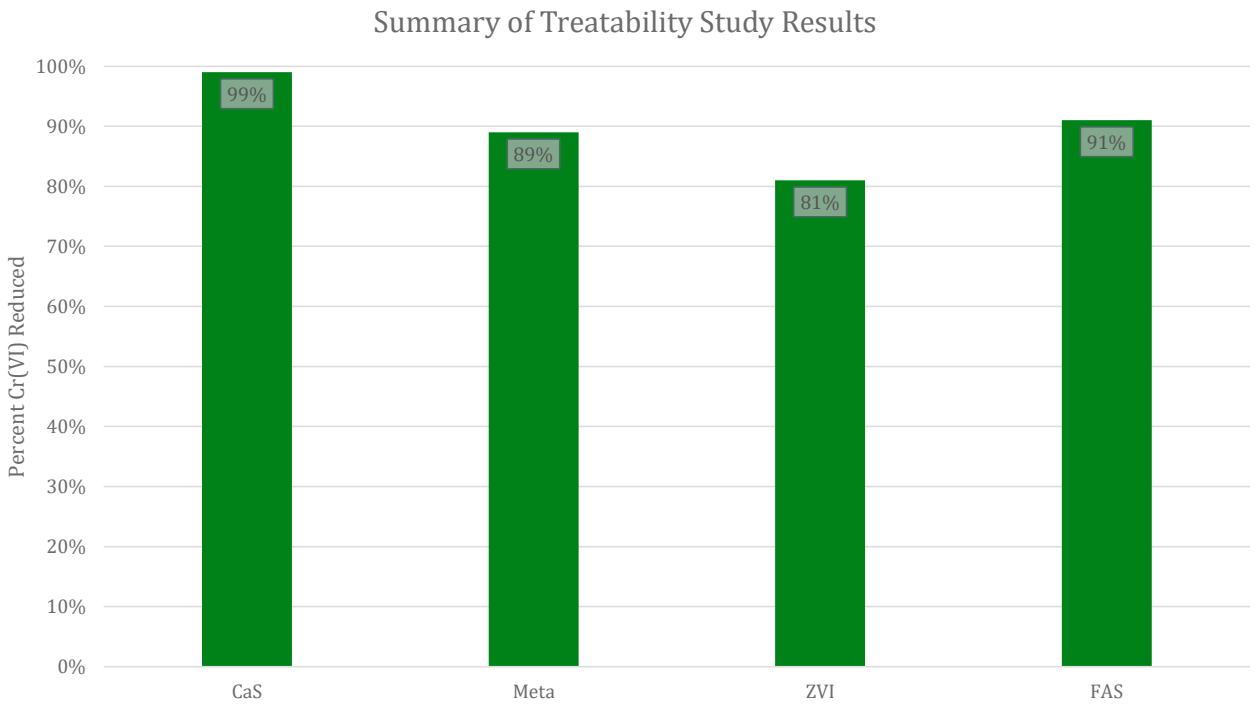
Bench Scale Testing

Objectives

- Identify candidates
- Verify immediate effectiveness
- Verify long-term effectiveness

Calcium Polysulfide

- Availability
- Material Handling



Simplified Reaction:

$$3S^{2-} + 2Cr^{6+} \rightarrow 3S^{0} + 2Cr^{3+}$$

Complete Reaction:

$$3CaS_2 + 4Cr_2O_7^{2-} + 32H^{+} \rightarrow 3S^{0} + 3SO_4^{2-} + 8Cr^{3+} + 15H_2O + 3Ca^{2+}$$

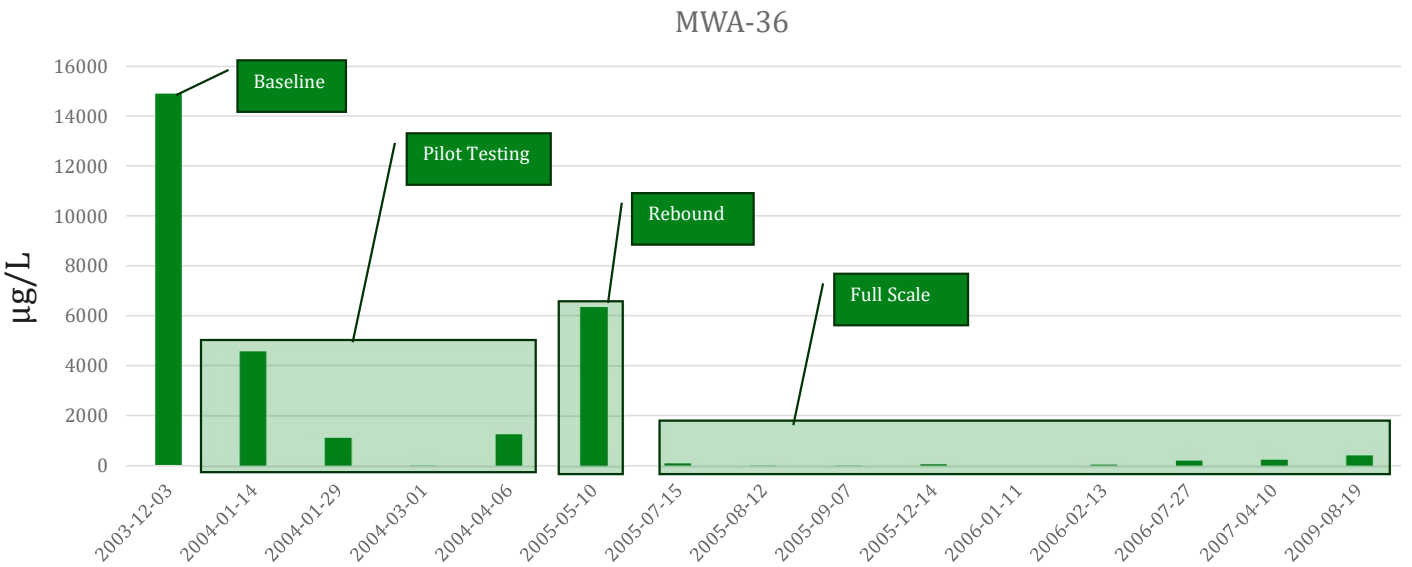
Reverse Reaction:

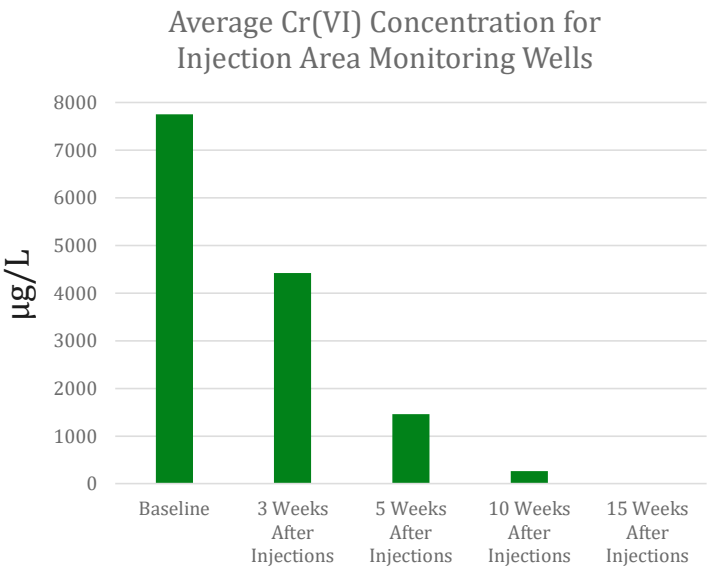
$$2Cr(OH)_6^{3-} + 3H_2O_2 \rightarrow 2CrO_4^{2-} + 2OH^{-} + 8H_2O$$

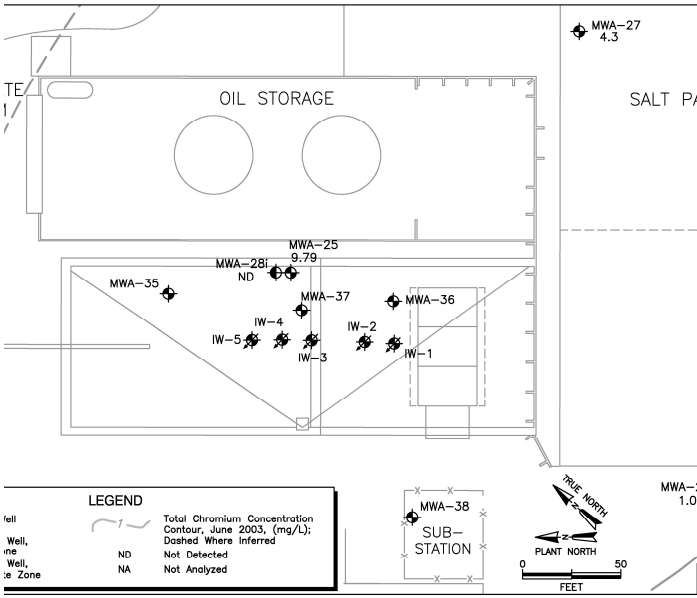
Chemical Injection Process

Pilot Scale Testing

- Objectives
  - Confirm bench scale results
  - Develop full-scale plan
- Method
  - Place five wells
  - Inject 12,500 gallons 10% CaS
  - Gravity feed
- Results
  - 95% decrease from baseline



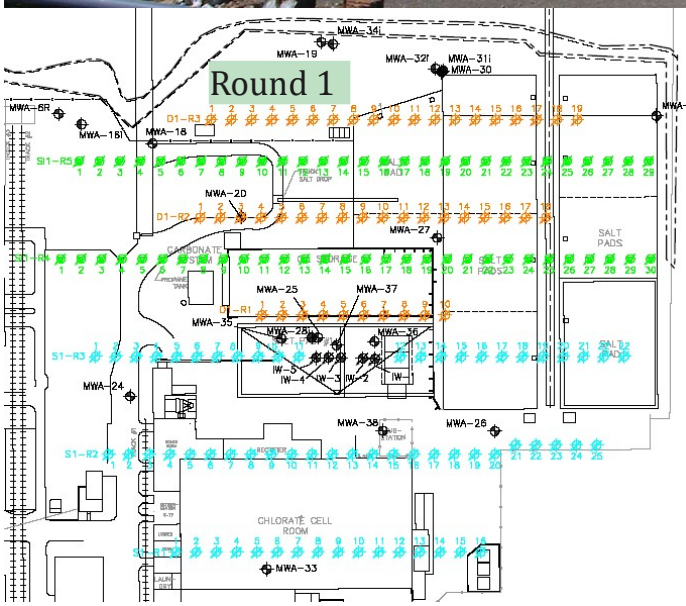


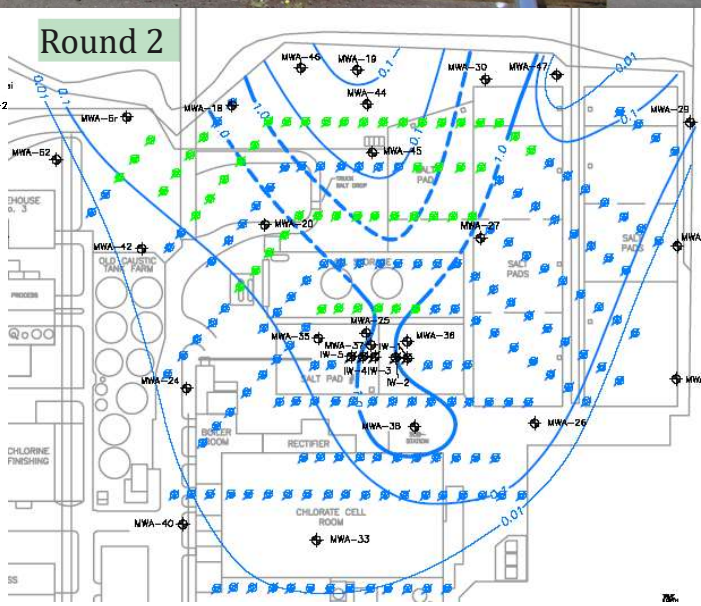


Chemical Injection Process

Full Scale Implementation

- Objectives
  - Decrease solubility/toxicity
  - Meet regulatory requirements
- Methods
  - Direct push – 379 injection points
  - Pressurized feed
  - 1.3 million gallons over 2 rounds





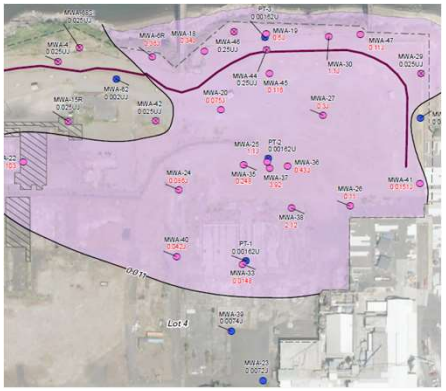
Round 1 Shallow
Round 1 Intermediate
Round 1 Deep
Round 2 Shallow
Round 2 Intermediate

Chemical Injection Process

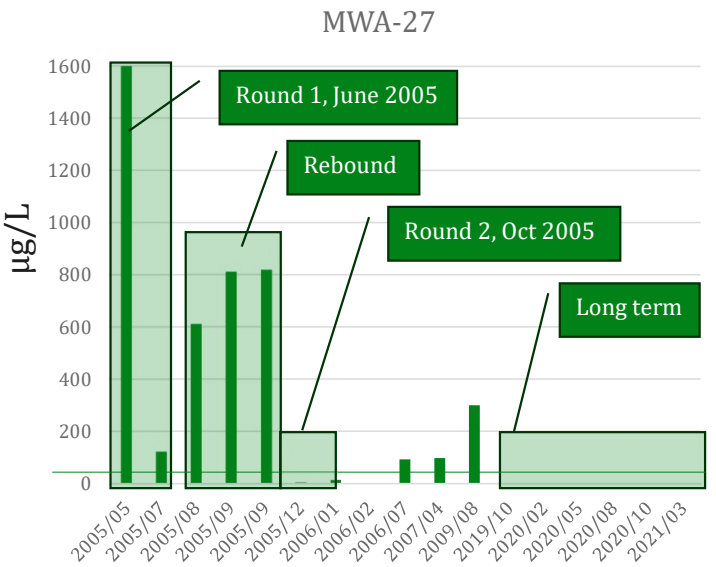
Full Scale Implementation - Results

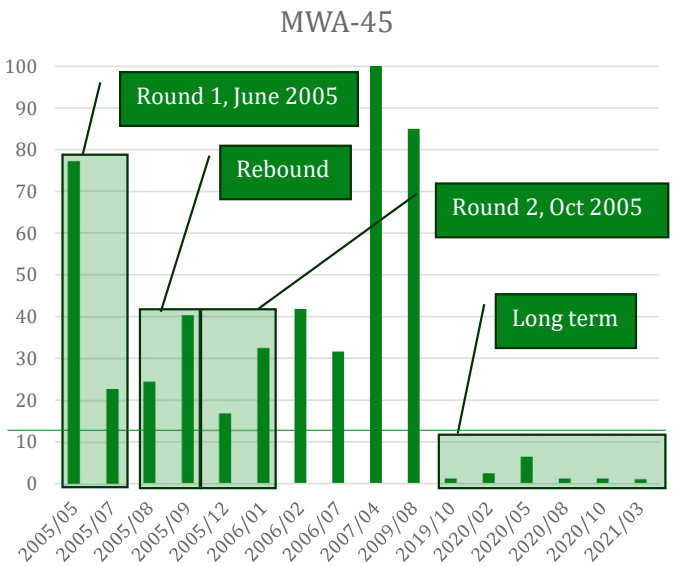
- Results

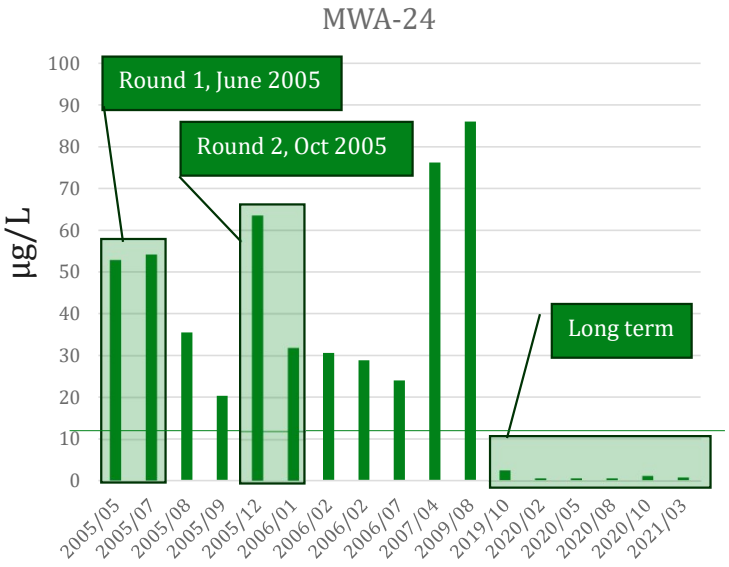
2007

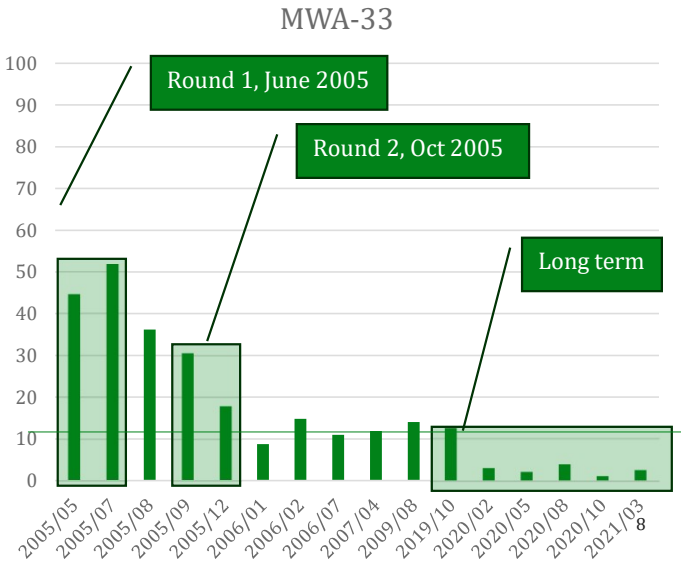


2019









Current Status

Current Status

- Barrier wall
- Hydraulic capture
- Monitoring

Lessons Learned

- Treatment selection
- Injection manifold
- Monitoring frequency
- Treatment chemistry

Thank you