Investigation and Remediation Strategy for a Fast-Moving 1,4-Dioxane Plume at a Military Site

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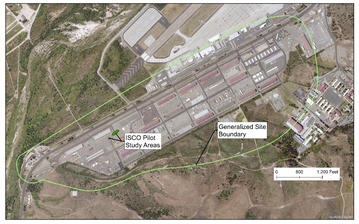
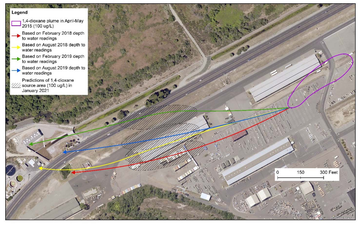
Site Setting

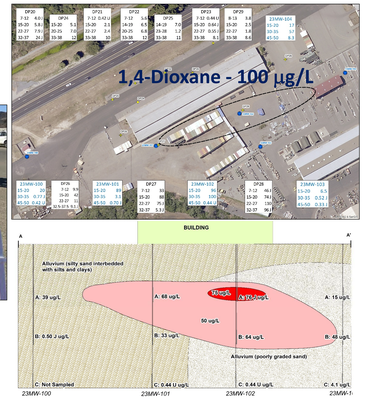
- Investigation and remediation of a 1,4-dioxane plume in groundwater (**plume > than 500 ft long**).
- Objective to complete additional investigations and full-scale ISCO in the same field season due to the rapid plume movement threatening downgradient receptors.
  - Previous pilot scale treatment had been misaligned due to the rapid plume movement.
  - The remedial design used groundwater monitoring to show a plume movement migration of 200 feet/year.
- Rapid design, review, approval, and implementation required to prevent the 1,4-dioxane mass from migrating beneath a major roadway and into a river, where difficulties in treating the plume would increase significantly.





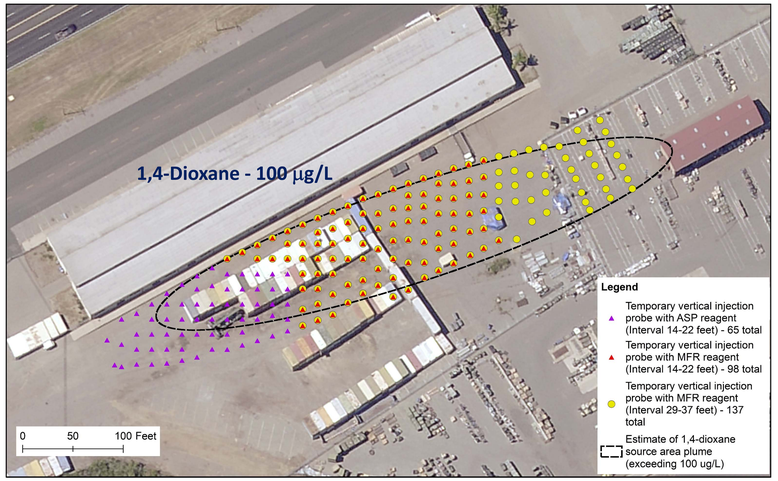
Remedial Design Investigation

- The remediation design investigation was performed to verify the 2021 plume center of mass and extent of full-scale treatment.
- Plume is migrating at **200 ft/year**
- Multi-depth groundwater sampling conducted with temporary groundwater samples and monitoring well clusters.
- 1,4-dioxane vertical zones delineated
- 2017 pilot study indicated MFR could degrade 1,4-dioxane at the Site.
- Water injection test in 2021 used to assess drilling and injection tools and optimize injection rates.

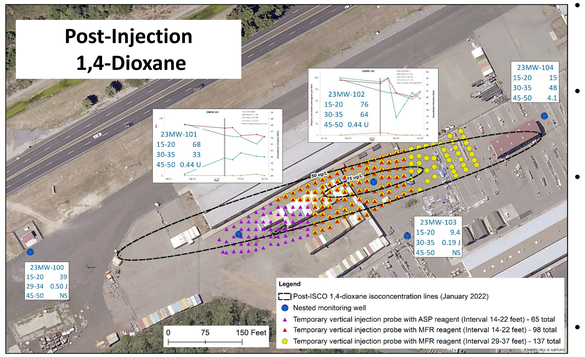


Remediation Design

- Treatment targeted 1,4-dioxane concentrations **at or above 100 µg/L**.
- The remedial design utilized two different chemical oxidants
  - Modified Fenton's Reagent (stabilized hydrogen peroxide catalyzed by chelated iron) – effectively degrades 1,4-dioxane
  - Base + Carbohydrate Activated Sodium Persulfate – supplemental oxidant
- Original remedial design included three ISCO delivery mechanisms: 158 temporary direct-push locations; 3, 200+ foot long horizontal wells; and a permeable reactive barrier in the path of the migrating source.
- Based on remedial design investigation, final design consisted of 300 vertical injection points screened across two depth zones (MFR injected in 235 points and ASP injected in 65 points).
- ISCO direct-push injection points at **300 points** to reduce 1,4-dioxane mass migrating was completed in July-August 2021.
- Additional remedial alternatives to further degrade the 1,4-dioxane mass are currently being finalized.



ISCO Injections



- Stronger oxidizer MFR injected in 98 probes (14-22 ft) and 137 probes (29-37 ft) in the central portion.
- The longer-lasting ASP injected in 65 probes (14-22 ft) in the downgradient portion of the plume.
- A reduction of up to 50% seen in the plume core area. The fast-moving plume and short-residence time for the oxidizers are impediments to injection in temporary probes.
- 1,4-dioxane reduced to less than 100 ug/L in all wells.

Next Steps

- Additional wells to further refine residual 1,4-dioxane impacts.
- Design remedial options to overcome short-residence time of oxidizers to counter the fast-moving plume.
- Long-term monitoring of the 1,4-dioxane plume.