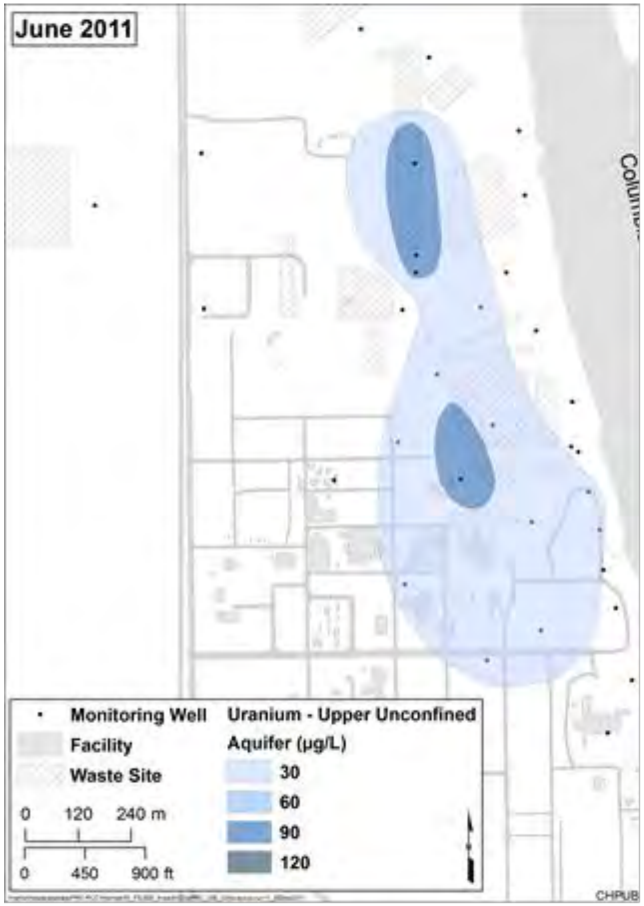
Uranium Sequestration via Phosphate Infiltration/Injection Test History Supporting the Preferred Alternative

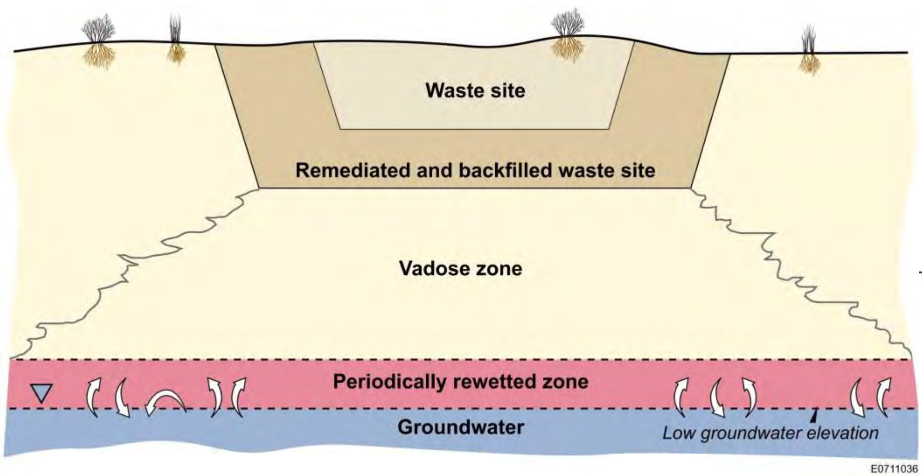
300 Area GW Concentrations - Uranium



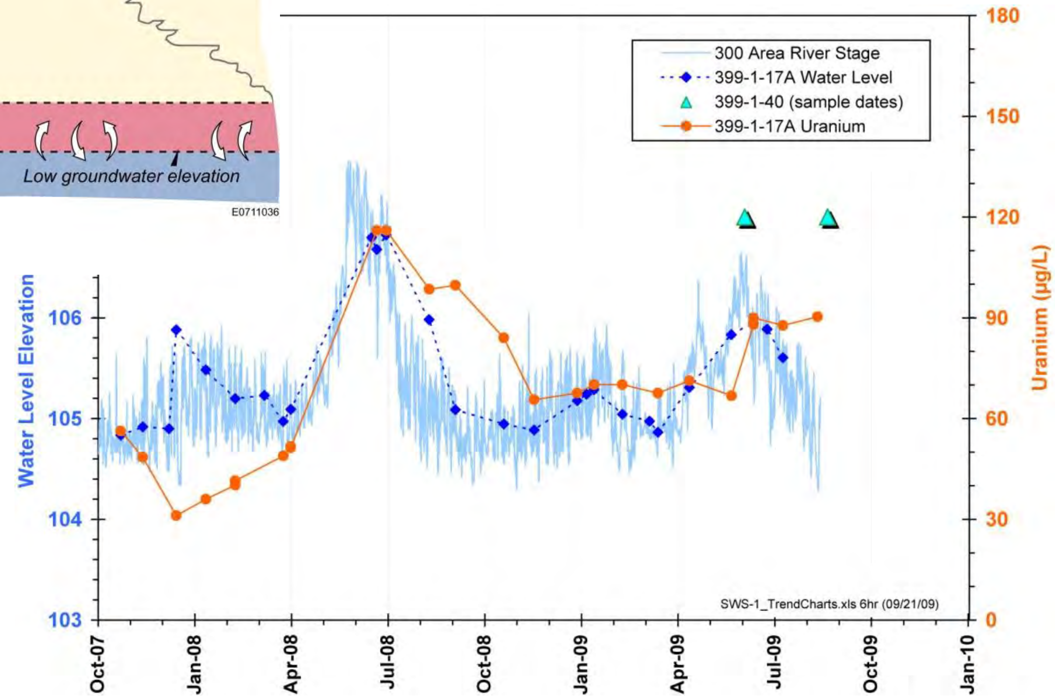
High River Stage – GW replenished with U from PRZ at liquid waste disposal facilities

Low River Stage – GW U plume migrates toward river; note 618-7 U plume created by RTD practices

Challenge = GW Cleanup Requires Addressing U in PRZ

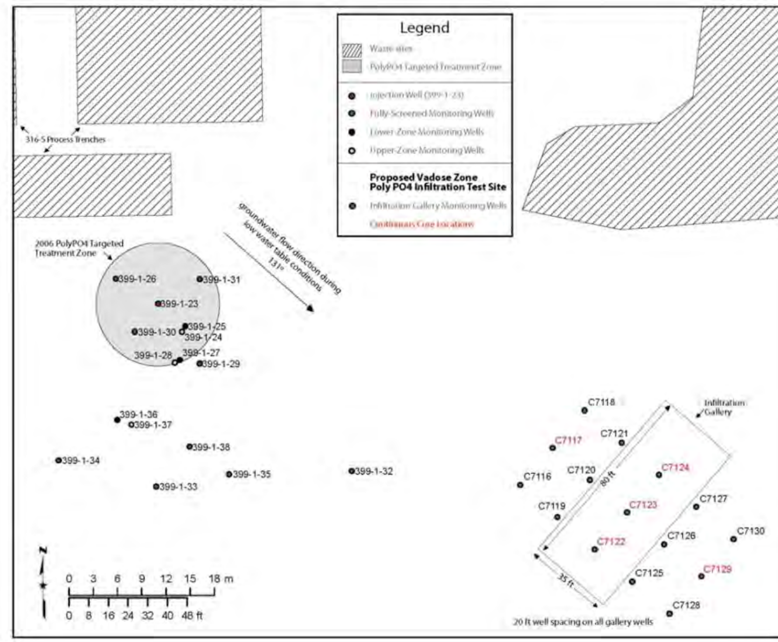


Primary source of U to GW is the PRZ; ~30% of remaining U inventory is periodically saturated with high bicarbonate GW, replenishing the U plume in GW

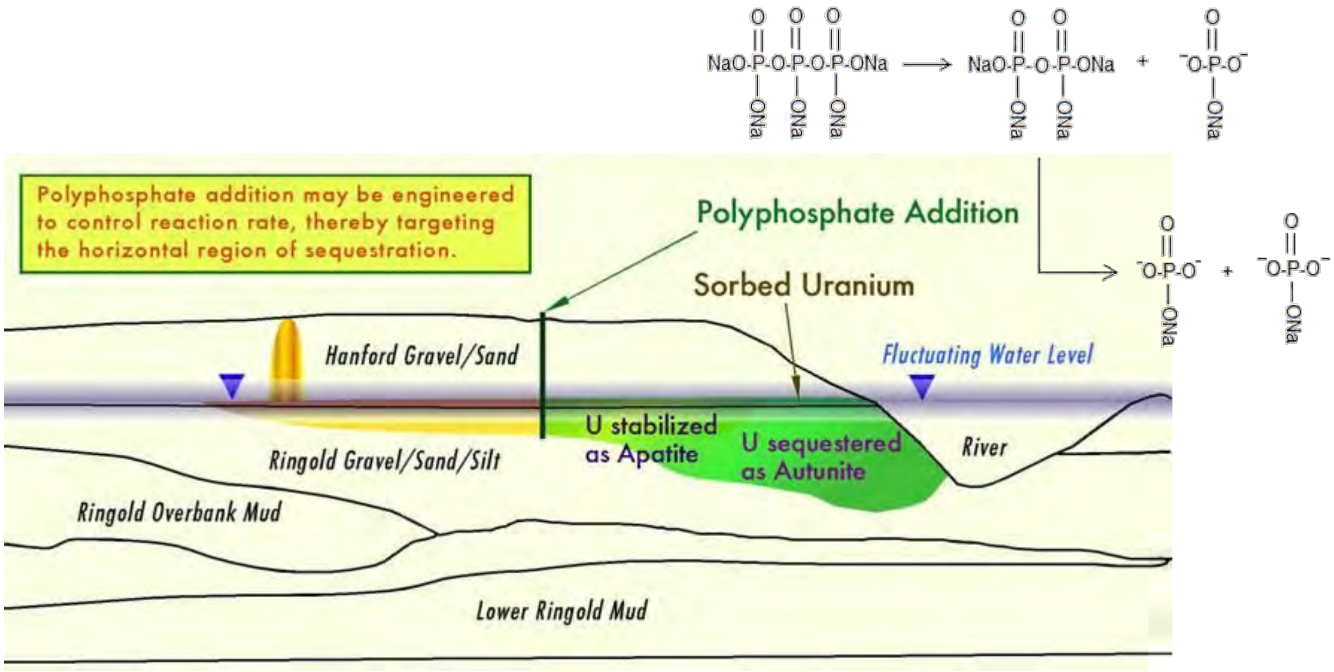


The "Tale of Two Tests"

1) Phosphate Injection into GW
2) Surface Infiltration



Field Treatability Test of Polyphosphate Addition to Sequester Uranium in the 300 Area

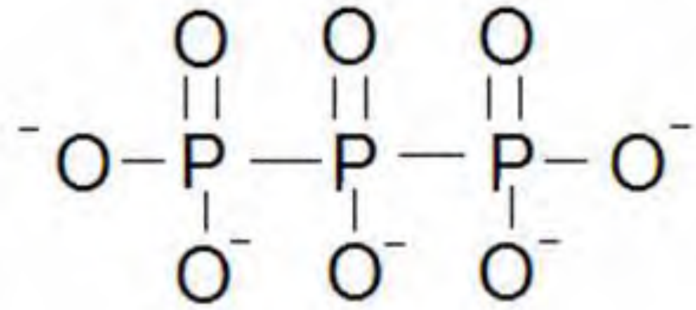


- Injection of soluble polyphosphate
- Lateral plume treatment
- Uranyl phosphate mineral (autunite) formation
  - Immediate sequestration
  - Stable mineral form
- Apatite formation
  - Sorbent for uranium
  - Conversion to autunite

- Phosphate Sequestration – Reduces groundwater uranium concentrations in by precipitating highly insoluble uranium phosphate minerals.
- Reduced Plugging - Polyphosphate acts as time-release of phosphate.

Advantages of Phosphate Technology

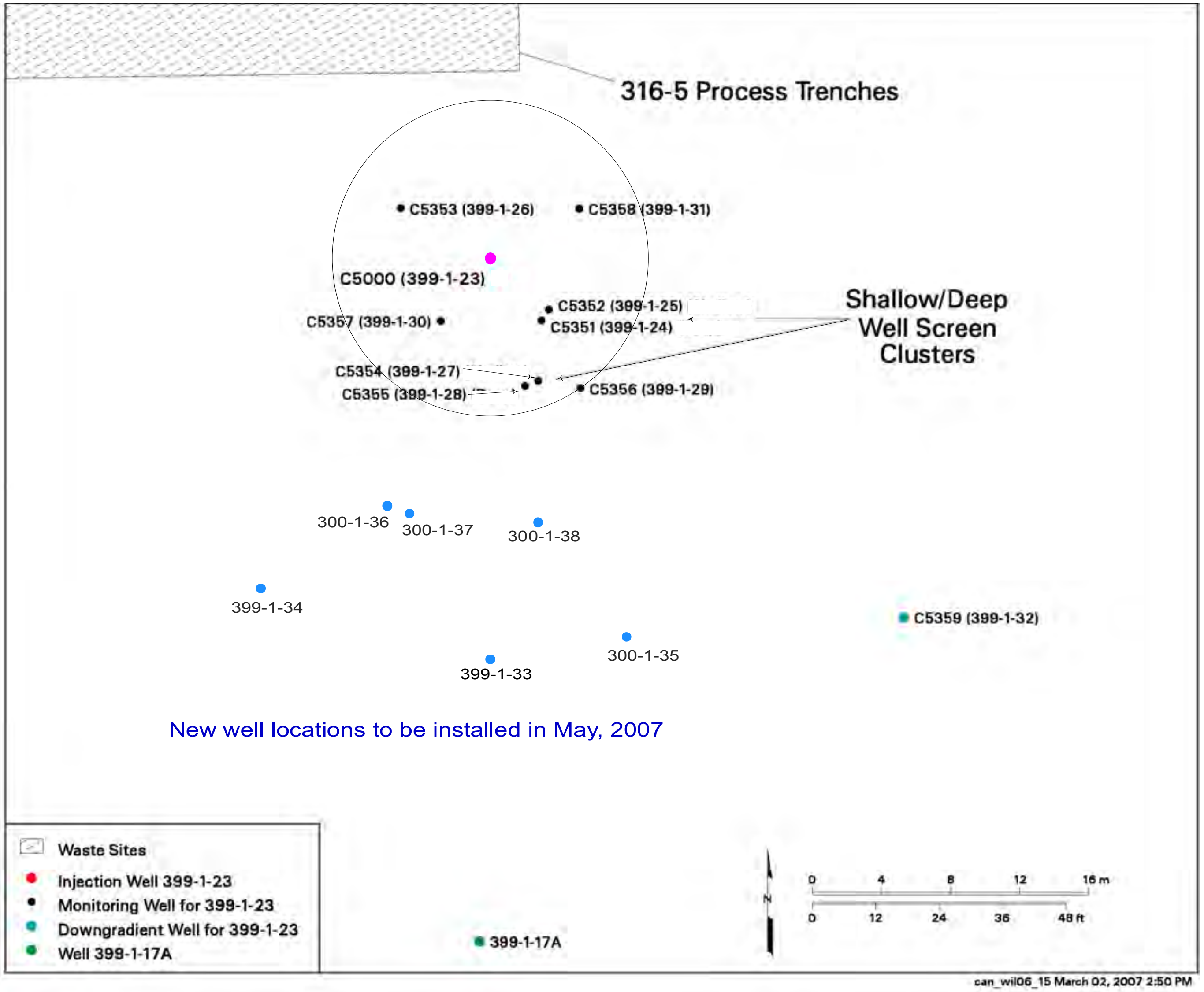
- Direct treatment of uranium
- Polyphosphate can be added to control the rate of precipitation
- Provides immediate and long-term control of aqueous uranium



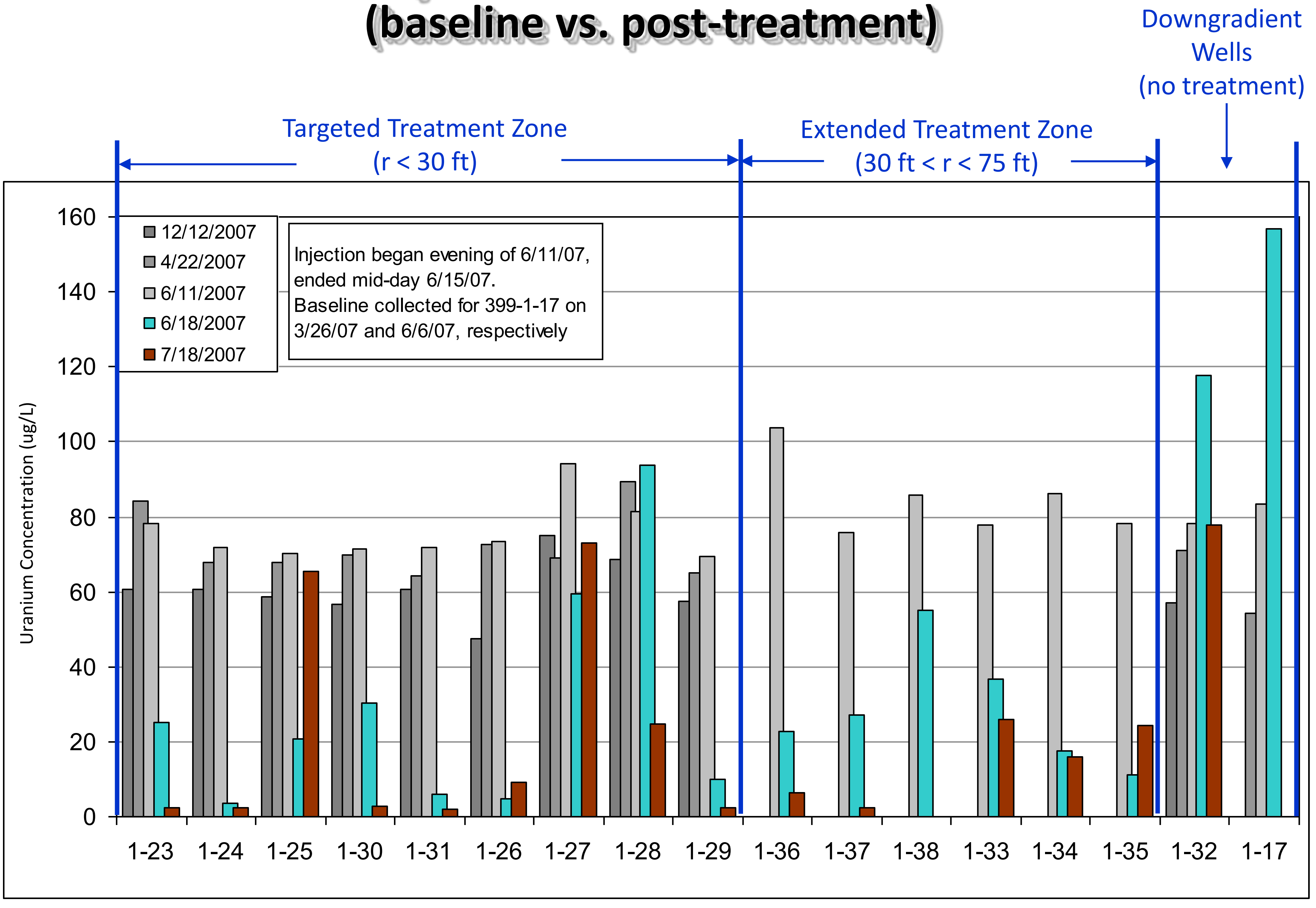
Treatability Testing Activities

- Bench-scale studies
  - Amendment formulations finalized
  - Phased treatment approach selected
- Site specific characterization
  - Installation of well network
  - Hydrogeologic characterization
  - Hydraulic/tracer injection testing
- Polyphosphate injection design
  - Development of local-scale flow and transport model
  - Determination of injection volumes, rates, and chemical mass requirements
- Polyphosphate injection test
  - Injection conducted in June 07
  - Performance assessment monitoring

Polyphosphate Test Wells



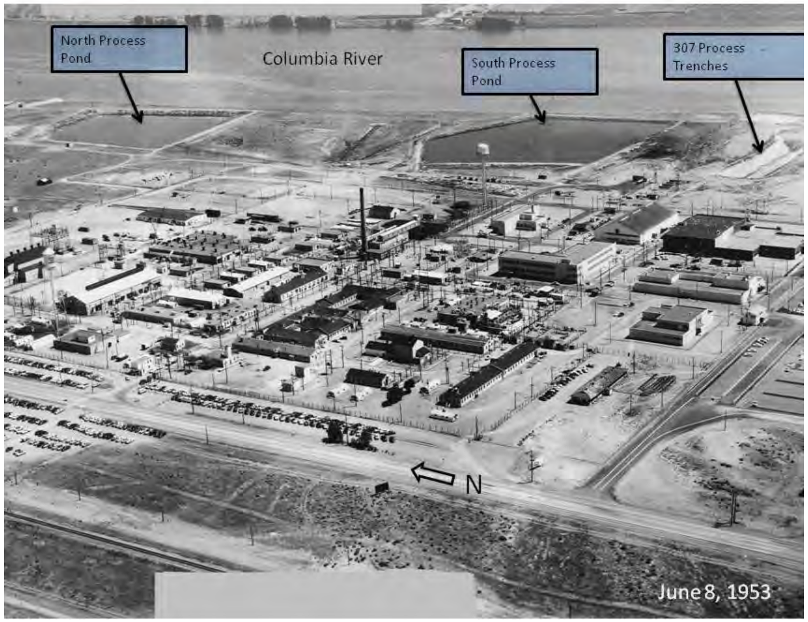
Preliminary Uranium Performance Data
(baseline vs. post-treatment)

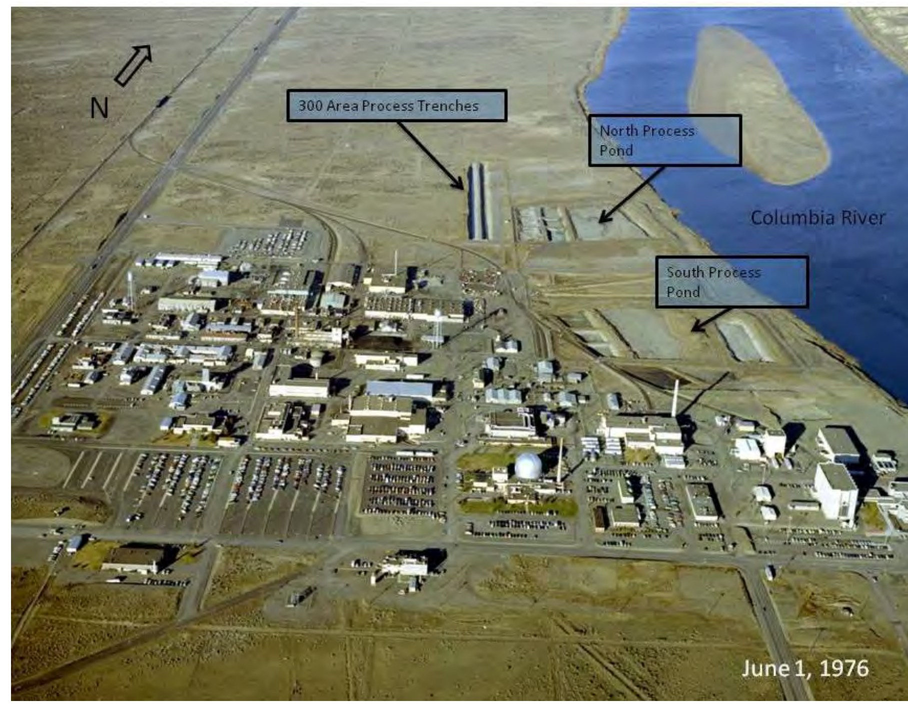


Test Results Were Mixed

- Sequestering U by formation of autunite in GW was successful. Initial groundwater performance monitoring data is promising
  - U concentrations lowered to below MCL in most wells within a radial distance of 75 ft., demonstrated formation of autunite
  - Treatment lasted until treated GW was replaced by untreated GW, an expected result
- Down-gradient apatite was intended to adsorb uranium as it slowly leached out of the PRZ, so that the source in the PRZ would not need to be treated. Apatite formation, and adsorption of uranium and conversion to uranium phosphates were low in intended treatment zone.
- Given the difficulties with apatite formation, focus switched from apatite barrier approach to treating the PRZ with phosphates to sequester uranium by the formation of autunite.

Liquid Waste Disposal Systems



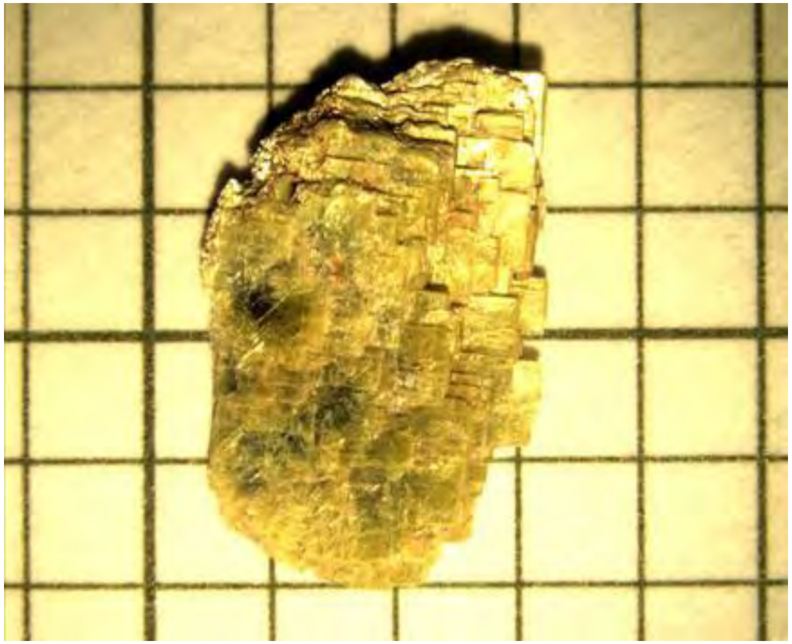


Liquid Waste Disposal Systems

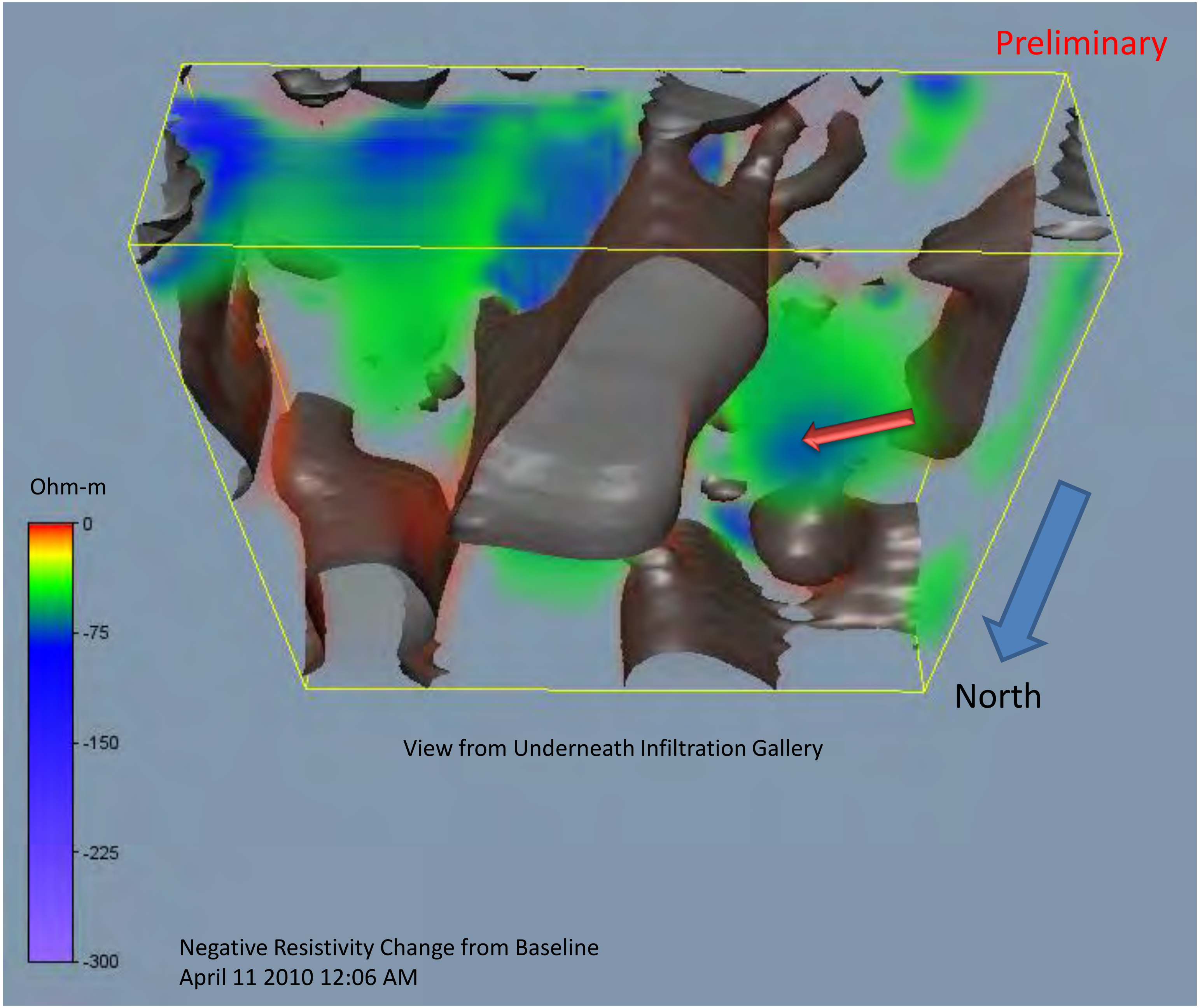
- **Liquid waste disposal sites were designed & used to infiltrate waste water**
- **~2.6 Million gallons/day disposal**
- **Precipitates formed at the pond bottoms that were periodically dredged to maintain infiltration & prevent dike failures**
- **300 Area Hanford Fm. Is highly porous & conductive**
- **RTD removed upper portion of VZ then backfilled**

Uranium-Phosphate (Autunite) Minerals

- Autunite [$Ca(UO_2)_2(PO_4)_2 \cdot nH_2O$] is a natural mineral characterized by a very low solubility.
- Formation does NOT depend on changing the redox conditions of the aquifer.
- Not subject to reversible processes such as reoxidation or desorption.

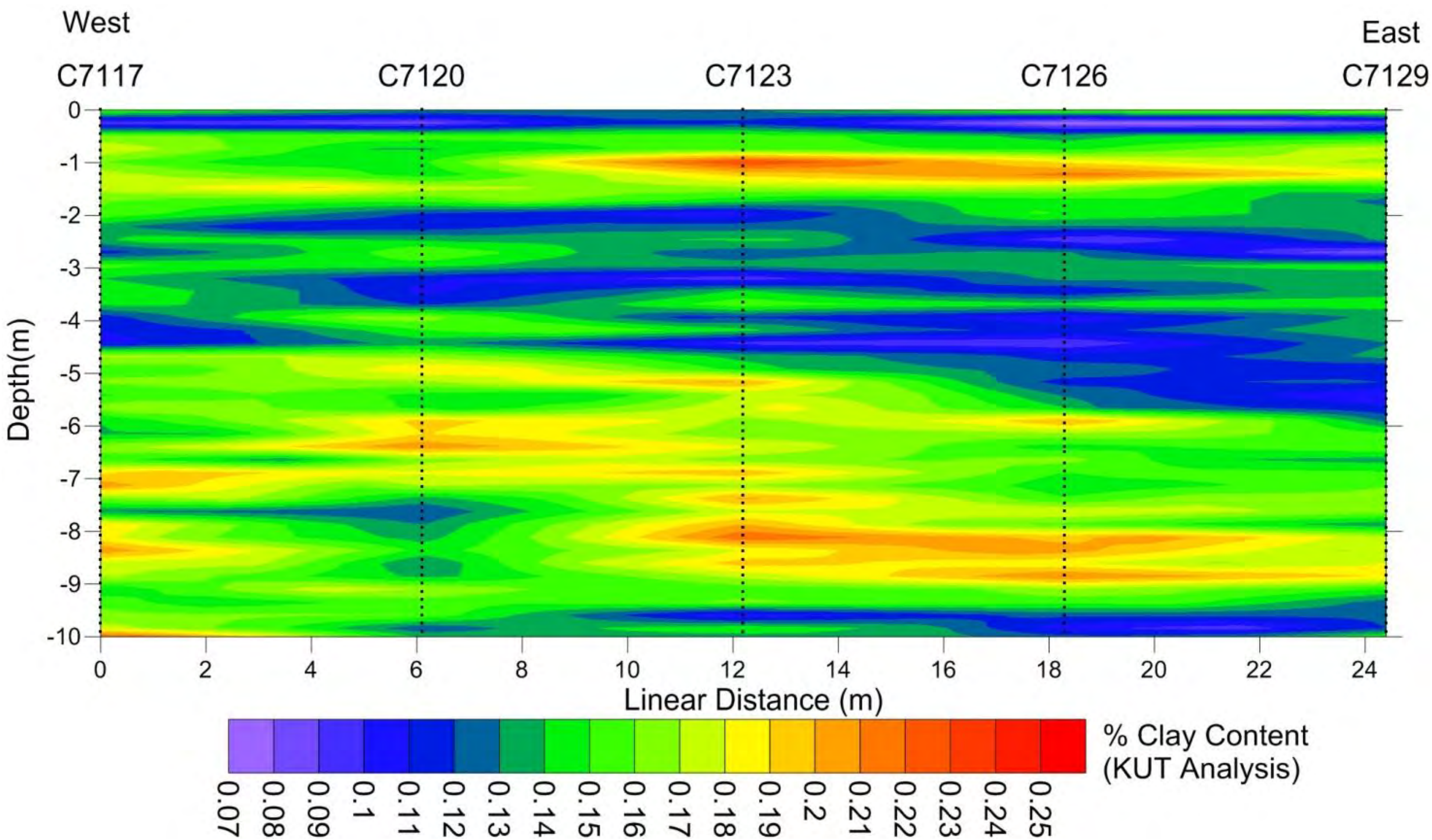


Ponding evident ~ 5 hours after test began. Picture: 17 hours into the test.



Preliminary
Ohm-m
0
-75
-150
-225
-300
North
View from Underneath Infiltration Gallery
Negative Resistivity Change from Baseline
April 11 2010 12:06 AM

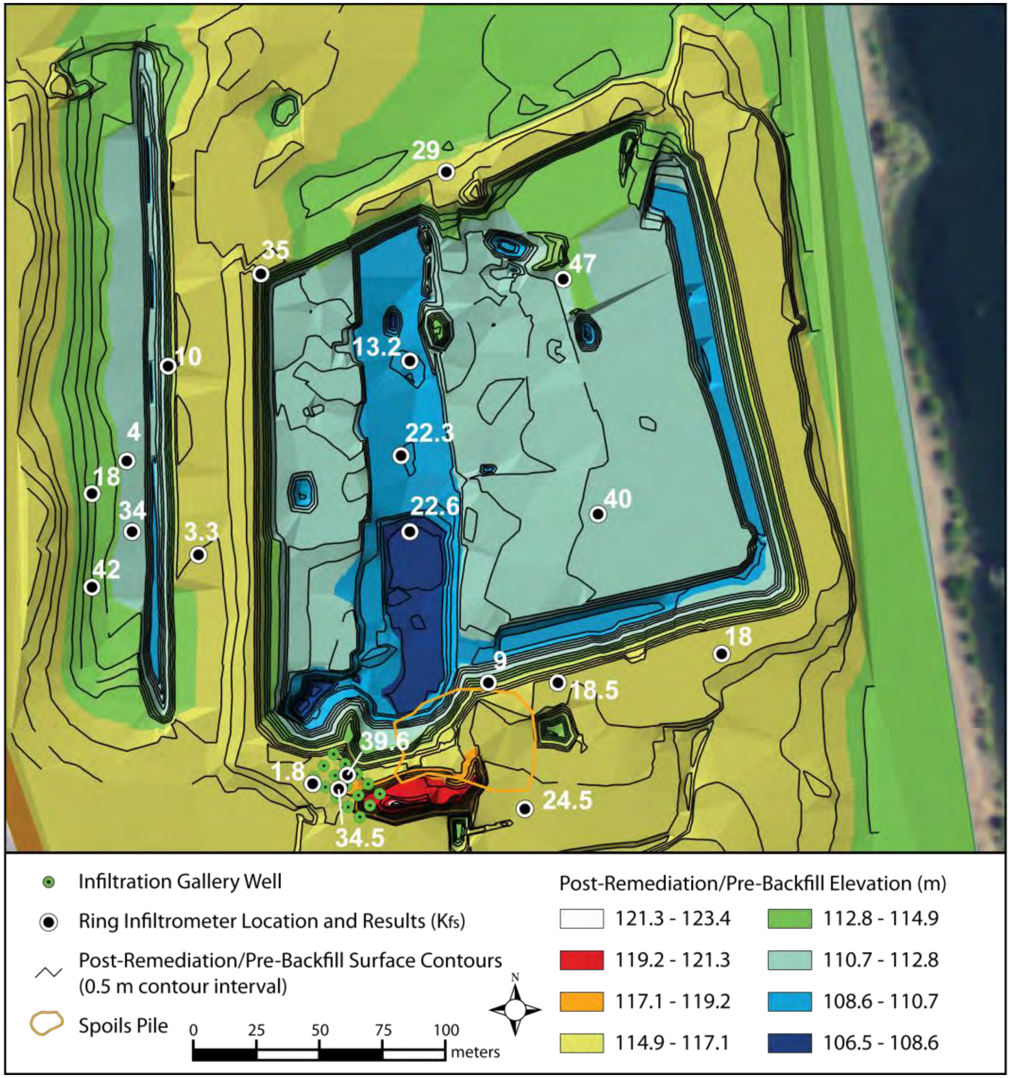
Clay Distribution at L2 (C7117 – C7129)



Infiltration Test

- 39 Hr. test; Tracer Solution was applied at 1.9 cm/hr
- Actual infiltration rate into the gallery was between 0.5 and 1 cm/hr. Recent unpublished laboratory tests have shown that this infiltration rate is sufficient for the formation of autunite in the 300 Area vadose zone.
- Increase in water level was still evident at the termination of the test. Total height of water on gallery was ~23 cm
- The infiltration was slow & heterogeneous
- A second test was run at a new location, with no surface removal. The infiltration rate was also low at this site.
- Results prompted a campaign of infiltrometer measurements & geophysics over the NPP
- Further Testing terminated due to budget constraints and insufficient time to incorporate results into FS/PP to meet TPA milestone

Ring Infiltrometer Results
field saturated hydraulic conductivity(cm/hr)



Treating 300 Area Uranium with Phosphate

- Infiltration & injection are simple to deploy to treat large areas
- Surface infiltration's strongest point is that it treats uranium from the surface down through the PRZ.
- Although early efforts at one site failed to achieve a high infiltration rate, there are reasons to believe infiltration rates across the area will be adequate. Recent lab studies (unpublished) show that it may be possible to achieve uranium sequestration at slower infiltration rates.
- Technology is enhanced by subsurface injection into PRZ with closely-spaced wells. Treatment solutions from injection will also treat a portion of the GW.
- "Success" will be based on sequestration of U as measured in boreholes. Monitoring wells will assess impacts to GW.

“Take-Away” Message

- The primary active source of U is the PRZ.
- The GW is estimated to reach EPC GW remediation goals in ~40 years for Alternative 2; Less time if U is sequestered (~20 years if 50% sequestered) as described in Alternative 3.
- After evaluating 32 technologies, sequestration of U continues to be the most viable alternative. There are recognized engineering challenges in the subsurface delivery system due to geologic heterogeneities; hence, a phased approach is proposed.
- The best method for delivering phosphate to the PRZ appears to be a combination of surface infiltration and direct injection into the PRZ. Approach will also treat VZ.

RTD Through VZ & PRZ

- May release more U to GW/river than other technologies including “no action”
- RTD of VZ will not meet remediation goals (Active source is the PRZ; ~30% U mass)
- RTD dust control is required for worker protection – Impact to GW (618-7 BG)
- RTD of PRZ is required to meet remediation goals – Digging in partially saturated material will release uranium-contaminated fines/colloids into GW & will be released to river
- Immense scope/cost of excavation & backfill
- Fossil fuel consumption/carbon emission