

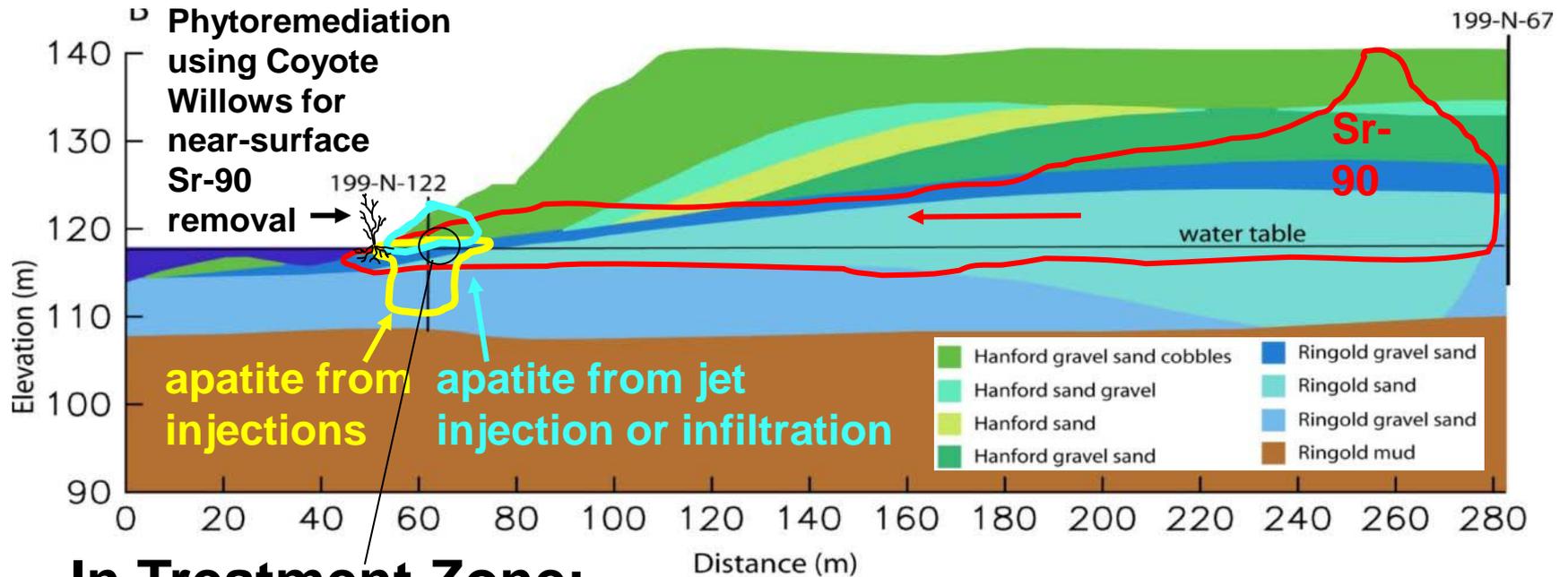


100-NR-2 Operable Unit Apatite Barrier History, Status, and Schedule

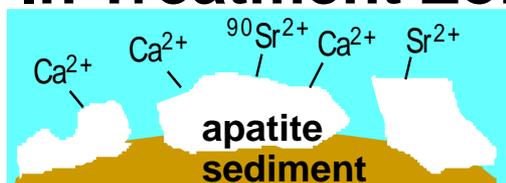
Presented to: 100-NR-2 OU – RI/FS Work
Plan Addendum Workshop

Presented February 17, 2010, by: N.A. Bowles, D.J.
Alexander, and B.P. Esparza – 100-NR-2 OU Team

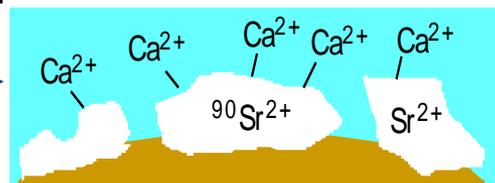
Apatite Barrier Conceptual Approach



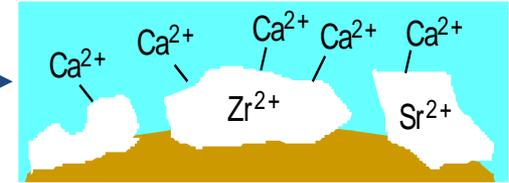
In Treatment Zone:



⁹⁰Sr adsorbs (minutes)



⁹⁰Sr incorporates into apatite (months, yrs)



decay (10s, 100s yrs)

⁹⁰Sr $\xrightarrow[t_{1/2}]{29.1\text{yr}}$ ⁹⁰Y $\xrightarrow{60\text{hr}}$ ⁹⁰Zr

Historical Apatite Barrier Tests and Installations

- 2005
 - Original apatite barrier injection wells installed
 - Wells spaced at 30 ft and screened across both the lower Hanford fm. and the upper Ringold Fm.
- 2006
 - Tracer Test in the Pilot Test 1 area (upriver end of the current apatite barrier) using sodium bromide
 - Pilot Test 1 injections using Calcium-Citrate-Phosphate
 - 4 mM Ca, 10 mM Citrate, and 2.4 mM PO₄
 - High river level
 - Pilot Test 2 (downriver end of current barrier) injections using Ca-Citrate-PO₄
 - 2 mM Ca, 5 mM Citrate, and 2.4 mM PO₄
 - Low river level

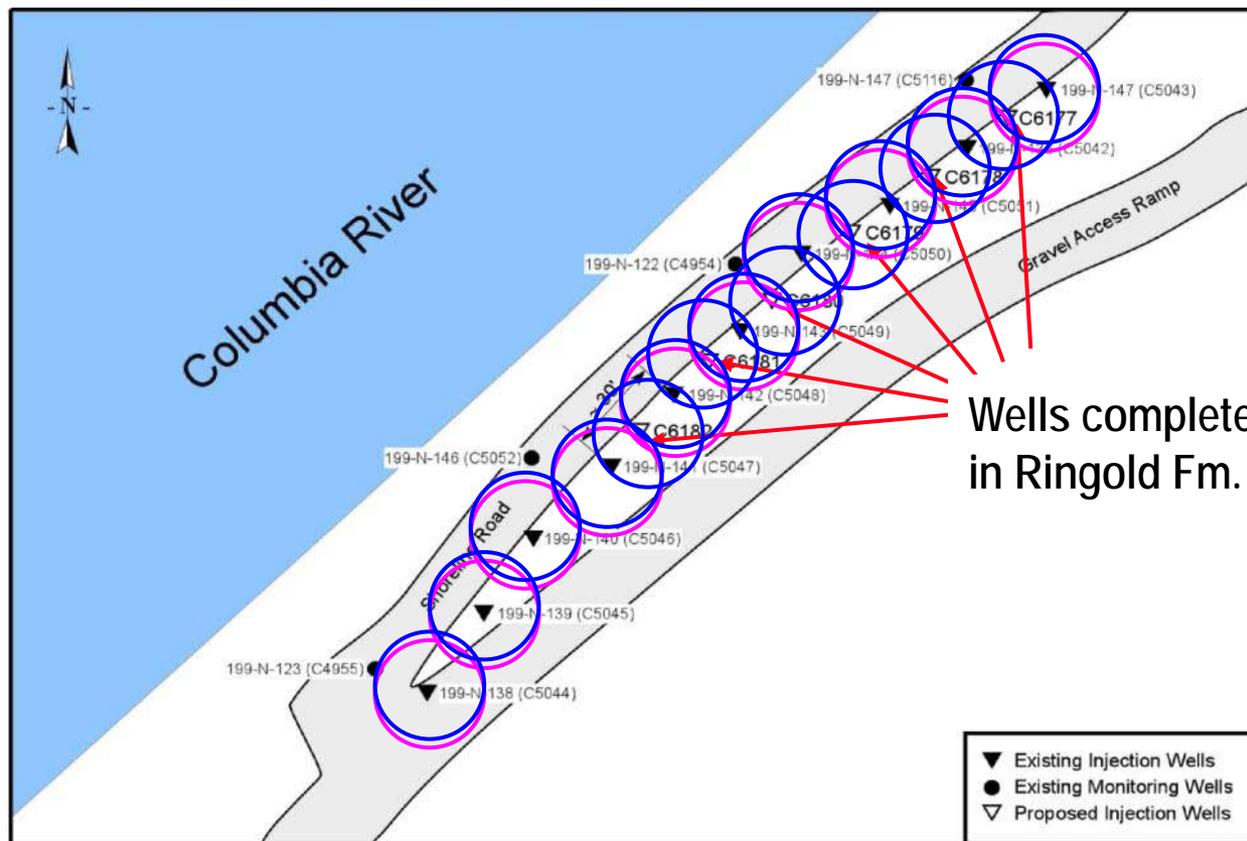
Historical Apatite Barrier Tests and Installations (continued)

- 2007
 - Presentation of laboratory results of Ca-Citrate-PO₄ solution injection and Sr-90 immobilization in sediments
 - Results presented in PNNL report (PNNL-16891)
 - “Low concentration” injections using Ca-Citrate-PO₄
 - 1 mM Ca, 2.5 mM Citrate, and 10 mM PO₄
 - Both high and low river levels
 - Results presented in PNNL interim report (PNNL-17429)
 - Pilot Test 3 injections using Ca-Citrate-PO₄
 - 1 mM Ca, 2.5 mM Citrate, and 10 mM PO₄
 - High river level
 - Additional apatite barrier injection wells installed
 - Wells spaced at 15 ft and screened in the upper Ringold Fm.

Historical Apatite Barrier Tests and Installations (continued)

- 2008
 - “High concentration” injections using Ca-Citrate-PO₄
 - 3.6 mM Ca, 9.0 mM Citrate, and 40 mM PO₄
 - Both high and low river levels
 - Results presented in PNNL interim report (PNNL-SA-70033)
 - Final PNNL report expected in summer 2010 will include core sampling results

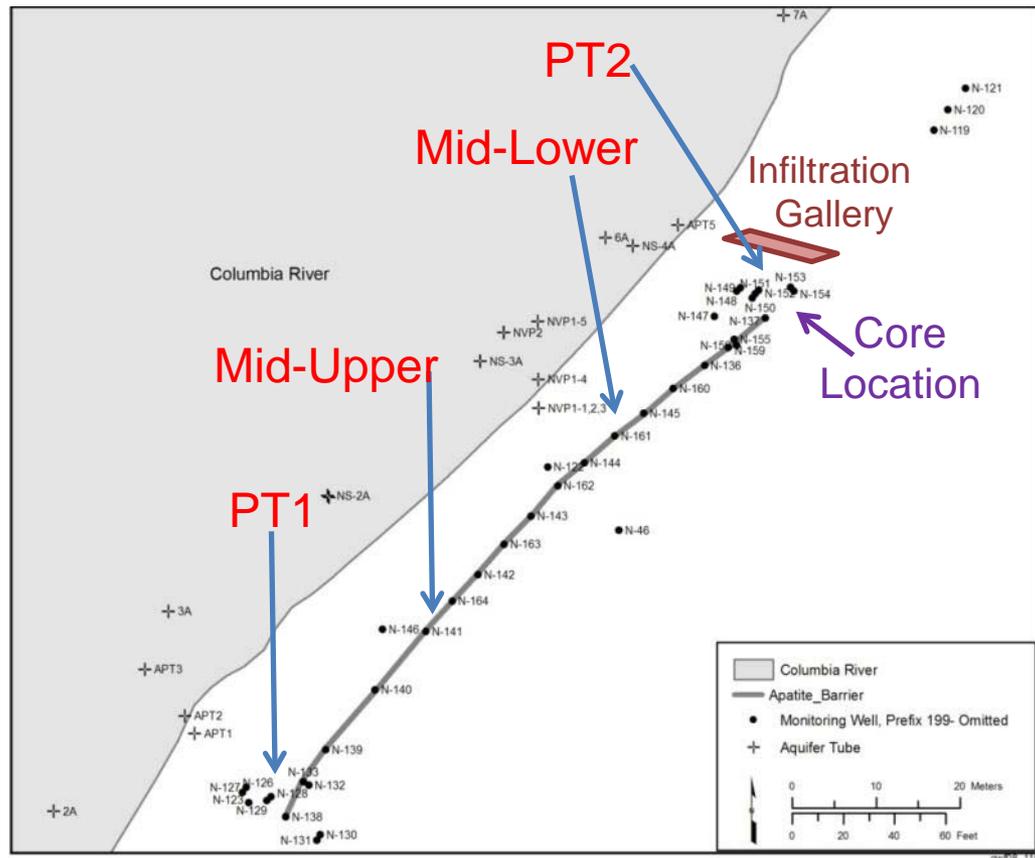
Historical Apatite Barrier Tests and Installations (continued)



- • 2006-07 -- Low conc. injections (10 mM PO₄)
- • 2008 -- High conc. injections (40 mM PO₄)

Current Apatite Barrier Layout and Monitoring Activities

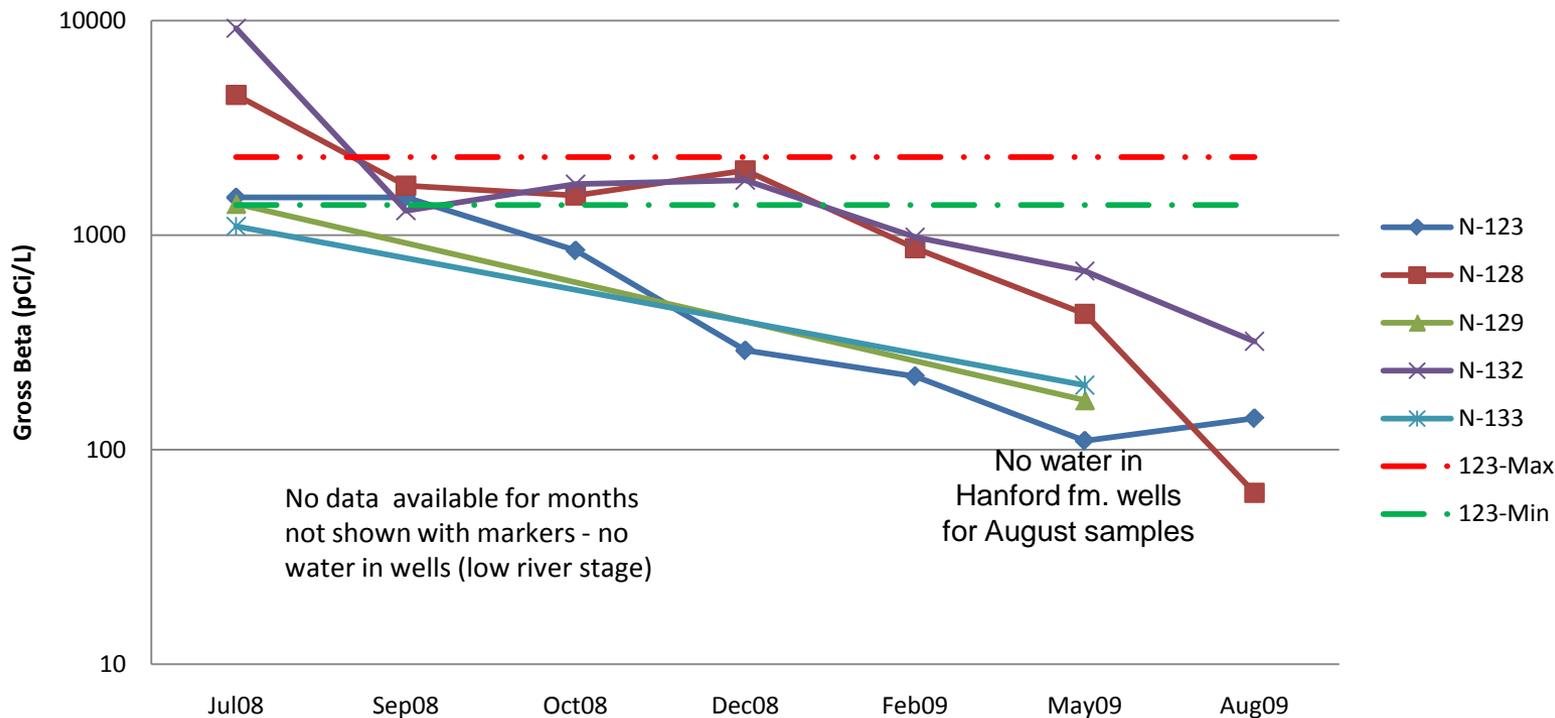
- Performance monitoring
 - Four zones along barrier: upriver end (PT1); two in middle; and down river end (PT2)
 - Capture both vertical and areal extent of treatment by looking at Hanford fm. and Ringold Fm. and in between barrier wall and river
 - Cores collected at PT2 end; 5, 10, and 15 ft out from well 199-N-137



Apatite PRB Performance Monitoring – Jul 2008 to Aug 2009

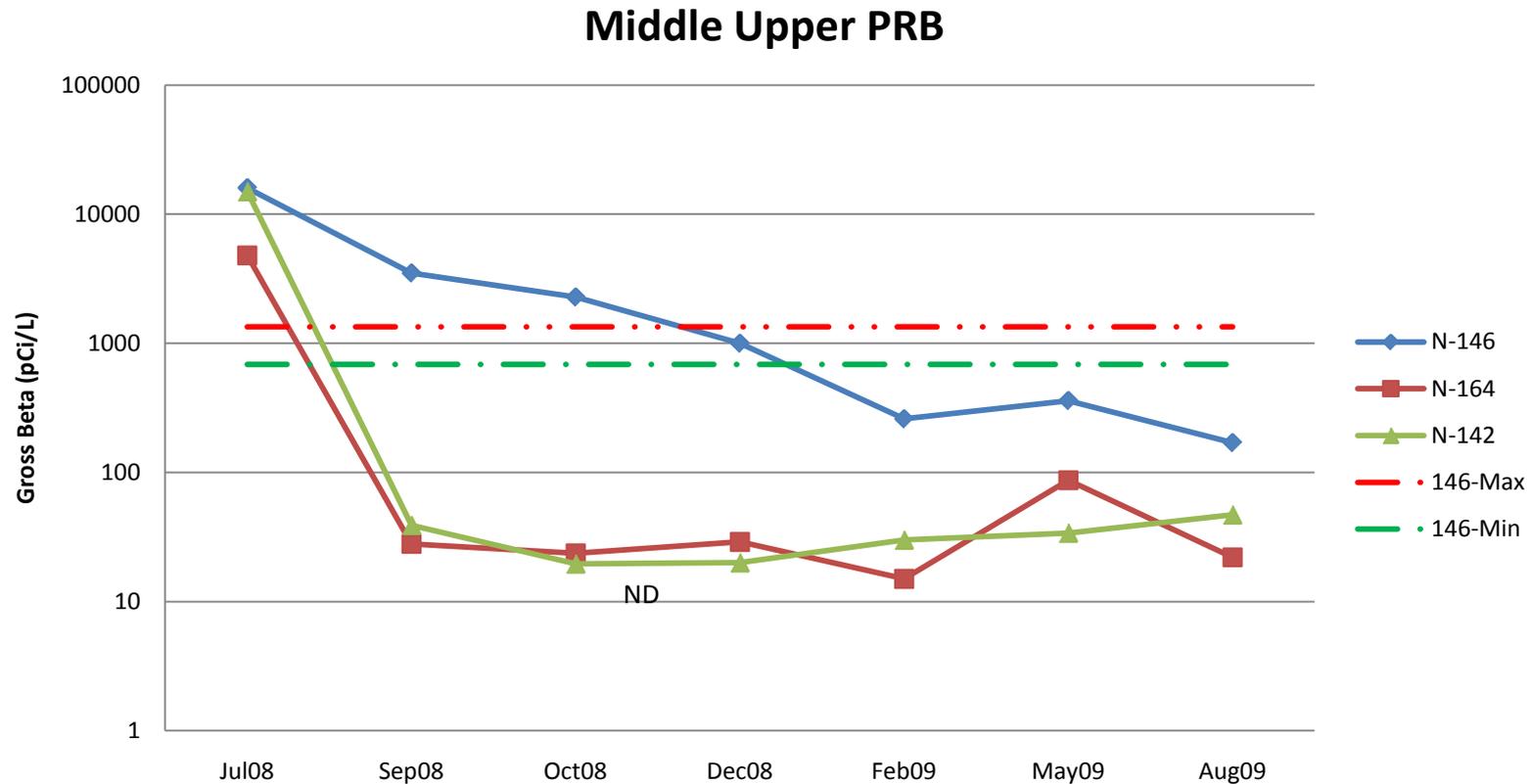
- Results for upper permeable reactive barrier (PRB) Pilot Test 1 site

Upper PRB - Pilot Test 1 Site



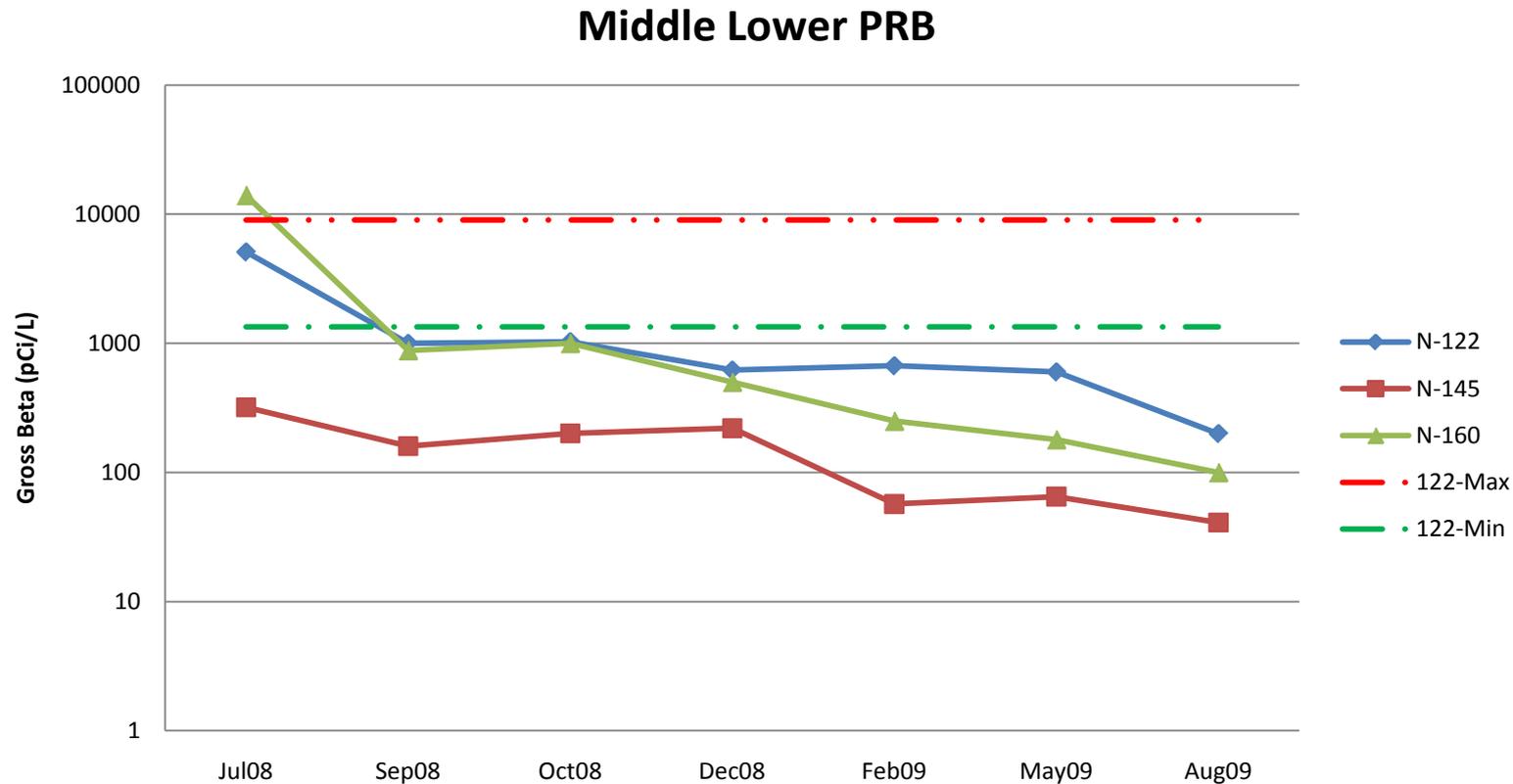
Apatite PRB Performance Monitoring – Jul 2008 to Aug 2009

- Results for middle upper PRB



Apatite PRB Performance Monitoring – Jul 2008 to Aug 2009

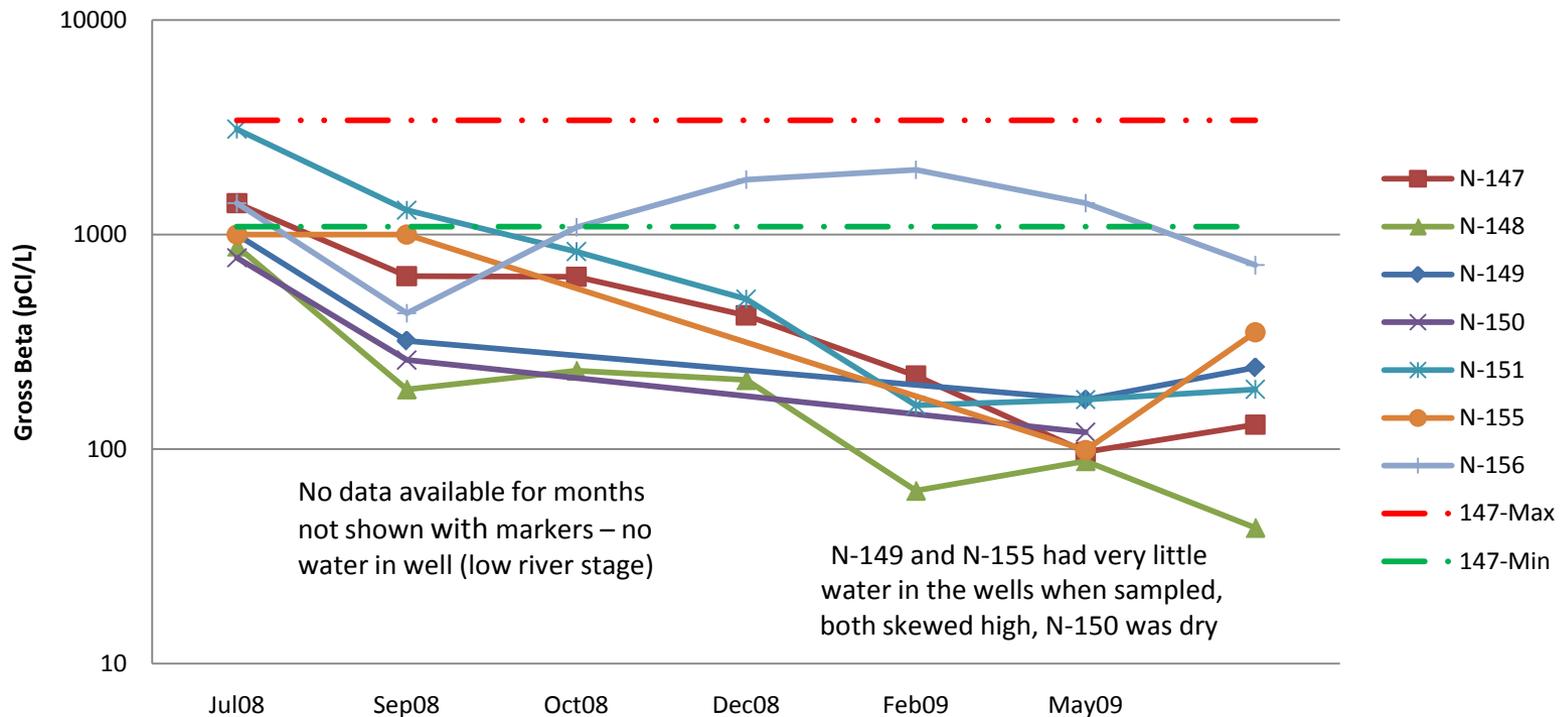
- Results for middle lower PRB



Apatite PRB Performance Monitoring – Jul 2008 to Aug 2009

- Results for lower PRB Pilot Test 2 site

Lower PRB - Pilot Test 2 Site



Well Installations

- Well drilling to support proposed Apatite PRB Expansion
 - 171 wells being drilled along 100N shoreline, including 146 injection wells and 25 monitoring wells
 - Sonic drilling technology allows wells to be installed faster and more efficiently than previous drilling operations – over 87 new wells drilled and constructed so far – over 50% complete
 - 3 monitoring wells were cored in late 2009 to evaluate existing apatite barrier (Pilot Test 2-downriver end)
 - 4 injection wells were cored in February 2010 to support jet injection test evaluation
 - All core samples at PNNL for phosphate and apatite analysis

Well Installations (continued)



Drilling on downriver end of existing Apatite PRB



Cones by new wells, view of shoreline with Jet Injections
and drilling extension sites active

Jet Injection Testing

- Jet Injection technology being tested for emplacement of phosphate and pre-formed apatite
 - Pilot-scale test includes three ~10 x 20-foot test plots
 - One plot injected with pre-formed fish bone apatite
 - One plot injected with phosphate solution
 - One plot injected with both pre-formed fish bone apatite and phosphate solution
 - Injection activities completed in December 2009 with successful injection of fluids in all three test plots
 - Injection depths were from just below ground surface to ~17 to 25 feet (through entire vadose zone and into groundwater)
 - Injections completed in spite of extreme weather conditions (sustained below-freezing temperatures)

Jet Injection Testing (continued)

- Soil core sampling in test plots included as part of 171-well drilling campaign, with one core hole drilled in each of the phosphate and pre-formed apatite test plots and two core holes in the combination plot (completed in February 2010)
- As part of test, aquifer tube sampling was conducted for first 6 weeks following start of test, and final sampling event will take place at 3 months (early March 2010)
- PNNL analysis of core samples expected to be complete by spring 2010
- Final report will present results of test (2010)

Jet Injection Testing (continued)



Jet Injection drilling rig , rig positioning at test plot, and support equipment on hill above



Rig tower tilting into place at test pit



Rig in position to drill and inject in test pit

Jet Injection Testing (continued)



- Rig during injections -



Rig during injections



Support equipment located on hill above rig

Infiltration Gallery Testing

- Infiltration gallery testing will evaluate passive infiltration of apatite-forming chemicals into upper vadose zone
 - 8 wells already in place
 - Laboratory-based test conducted on soil collected from 8 infiltration gallery wells
 - Infiltration trench to be excavated and prepared
 - First field test will be a water/tracer (sodium bromide) infiltration test (similar test to PRB tracer test at PT1)
 - Possible future testing may include chemical (apatite-forming) infiltration test (contingent on success of water/tracer infiltration test)

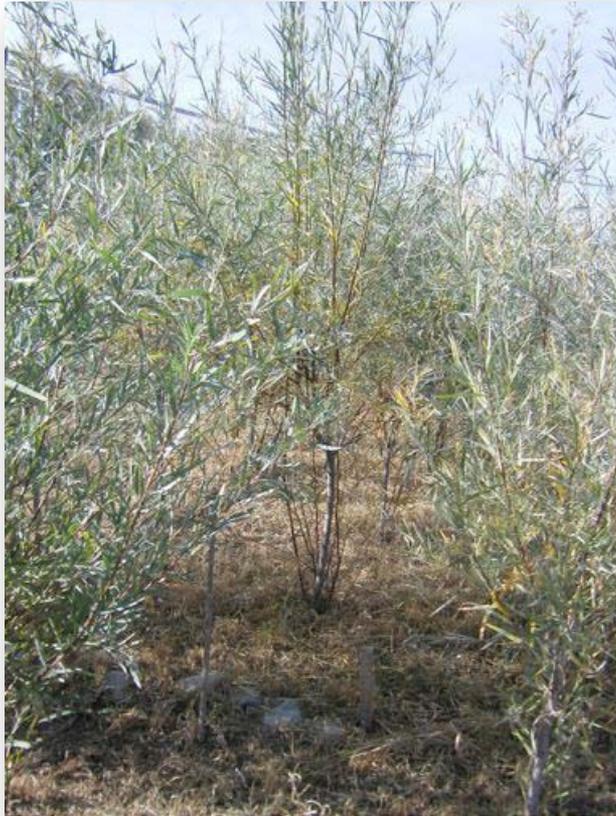
Planned Work Schedule

- **Near-Term Field Activities**
 - Jet Injection Testing – Pilot scale test currently underway, (beginning in 2009) and running through early 2010
 - Apatite PRB Expansion – Wells installed in 2009 continuing through 2010; Injections to support goal of 600 ft barrier expansion tentatively planned for mid-year 2010 pending approval of associated treatability test plan (production underway)
 - Apatite infiltration gallery – Water/tracer infiltration test planned for late summer through early fall 2010

Other Activities: Phytoremediation Study

- Most recent study involved a Coyote Willow test plot located at 100K to evaluate phytoremediation application under non-laboratory field conditions
 - During three years of test, trees survived multiple flooding events (including total immersion), no trees were uprooted or displaced, and most survived entire three years
 - Biomass production followed typical growth curve for first two years and went exponential in third year
 - No intrusion of large or small herbivores occurred at test plot over three years; site had fencing around plot
 - Observed Ca and Sr concentrations found in harvested biomass suggest trees could prove effective in removing Sr-90 in riparian zone
 - Results presented in PNNL report (PNNL-19120)

Other Activities: Phytoremediation Study (continued)



Coyote Willows before harvesting biomass

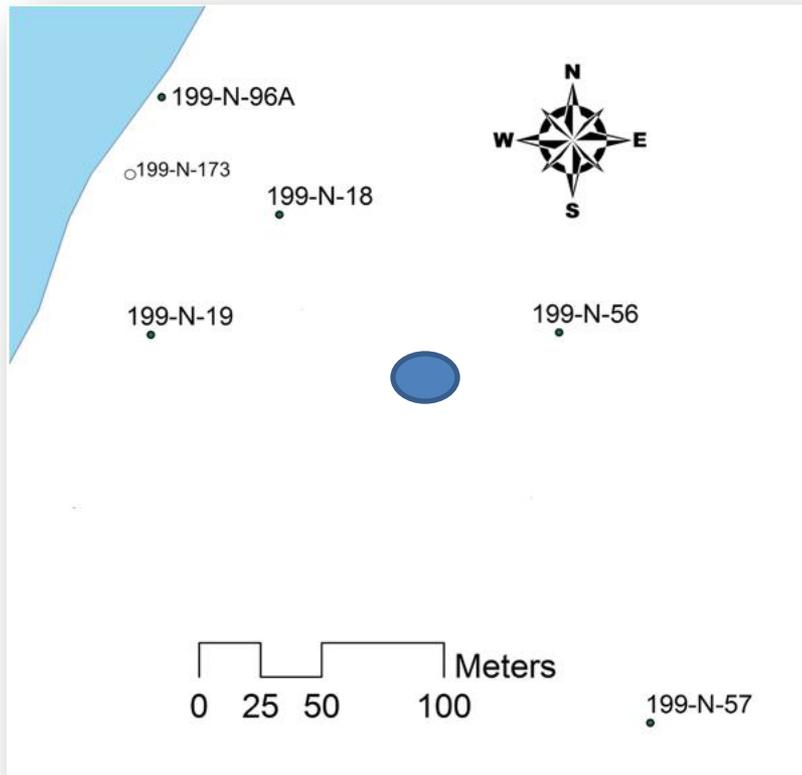


Coyote Willows after harvesting biomass

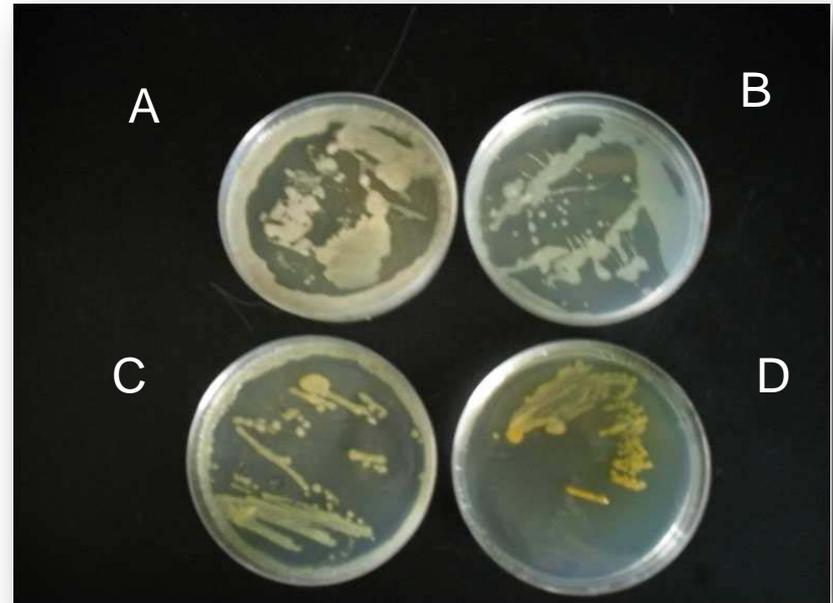
Other Activities: TPH Plume Characterization

- PNNL performing study to refine total petroleum hydrocarbons (TPH) conceptual site model and evaluate potential remediation options
 - PNNL collected additional samples; support from WSU
 - 5 wells sampled in August and September
 - Future groundwater sampling planned for early 2010 (from recently installed injection and monitoring wells) to provide more data for characterization
 - Results promising for diesel-degrading microbes being present in 100N Area soils based on WSU research
 - PNNL report expected in mid-year 2010

Other Activities: TPH Plume Characterization (continued)



Spill location relative to wells



Diesel-degrading microbes, shown above in samples from well 199-N-173, are present in 100N Area soils

Sample A is 35 feet below ground surface (bgs), Sample B is 17 feet bgs, Sample C is 15 feet bgs, Sample D is 17.5 to 20 feet bgs