



ELECTRIC POWER
RESEARCH INSTITUTE

EPRI Source Term Reduction Program Update



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Overview

Source Term Program Focus

BWR Source Term Reduction Results

- Cobalt quantification
- BWR shutdown calculations

PWR Source Term Reduction Results

- PWR Source Term Reduction Technology Evaluations

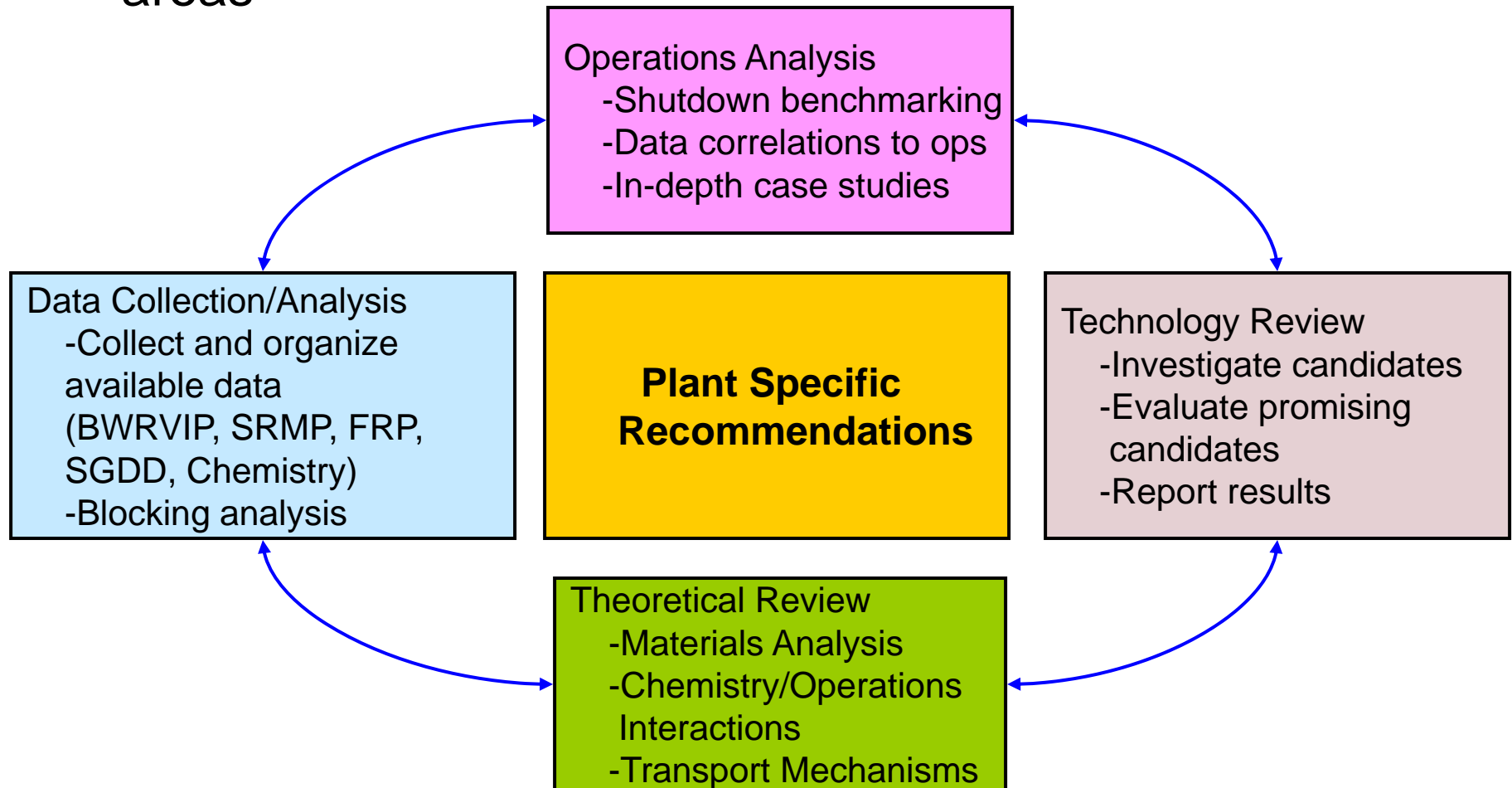
Source Term Reduction Project Plan

Program Goals

- **Primary Goal:** Minimize ex-core radiation fields to reduce radiation exposure as safely, economically, and quickly as possible.
- **Secondary Goal:** Minimize activity releases and provide guidance to cleanup as safely and efficiently as possible

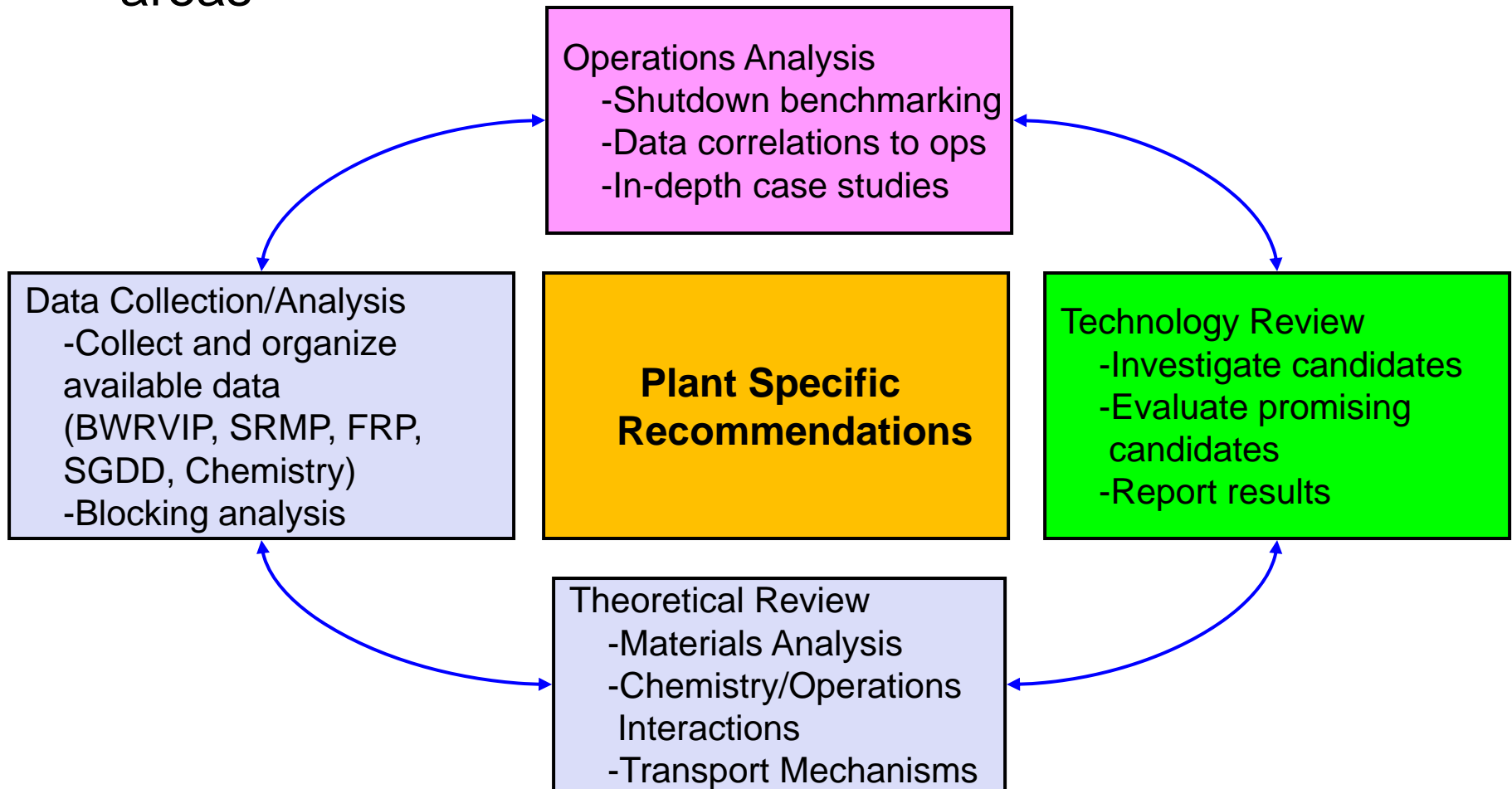
Source Term Reduction Program Strategy

- EPRI Source Term Reduction Program focuses on four areas



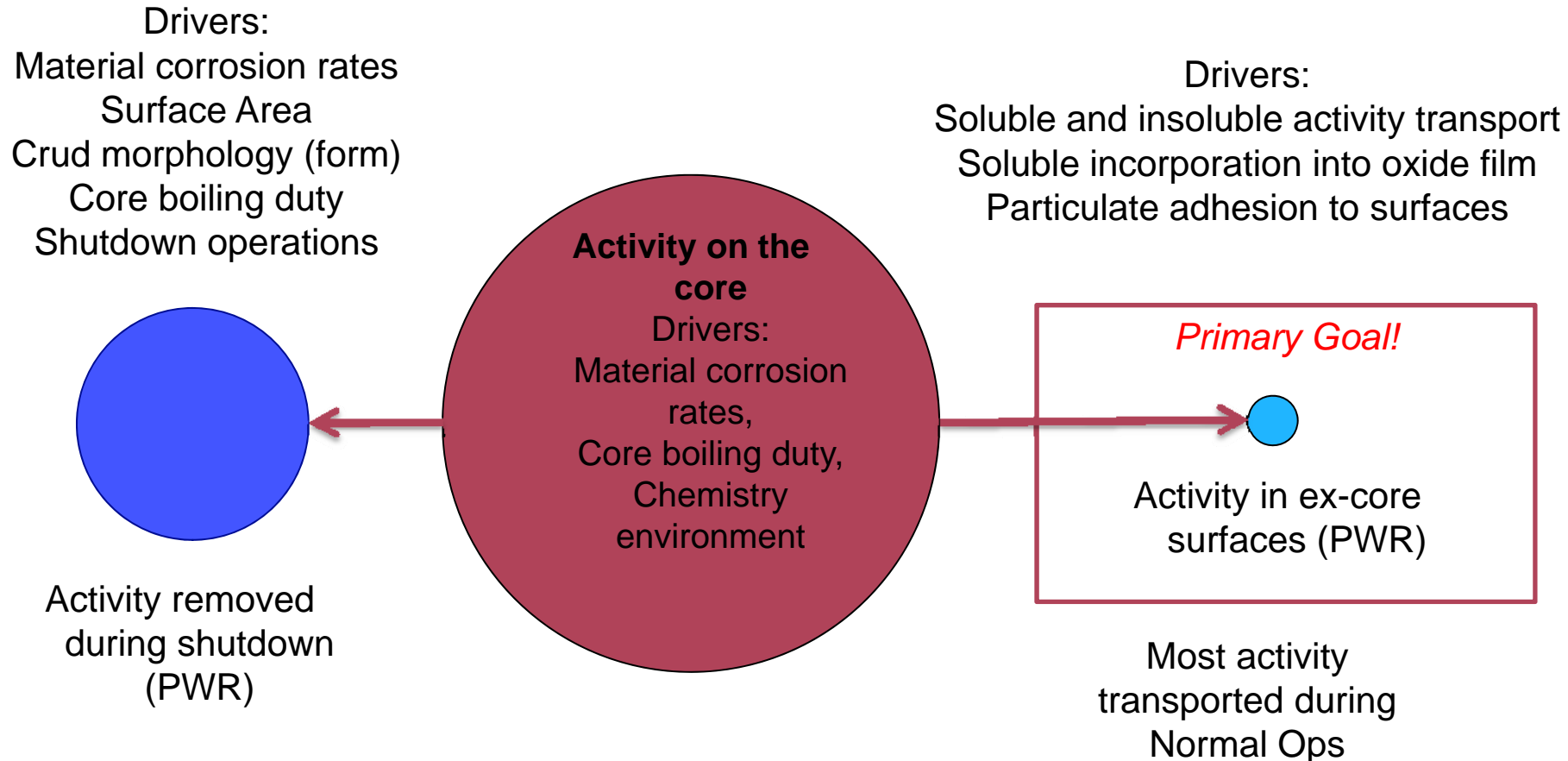
Source Term Reduction Program Strategy

- EPRI Source Term Reduction Program focuses on four areas



Source Term Definitions

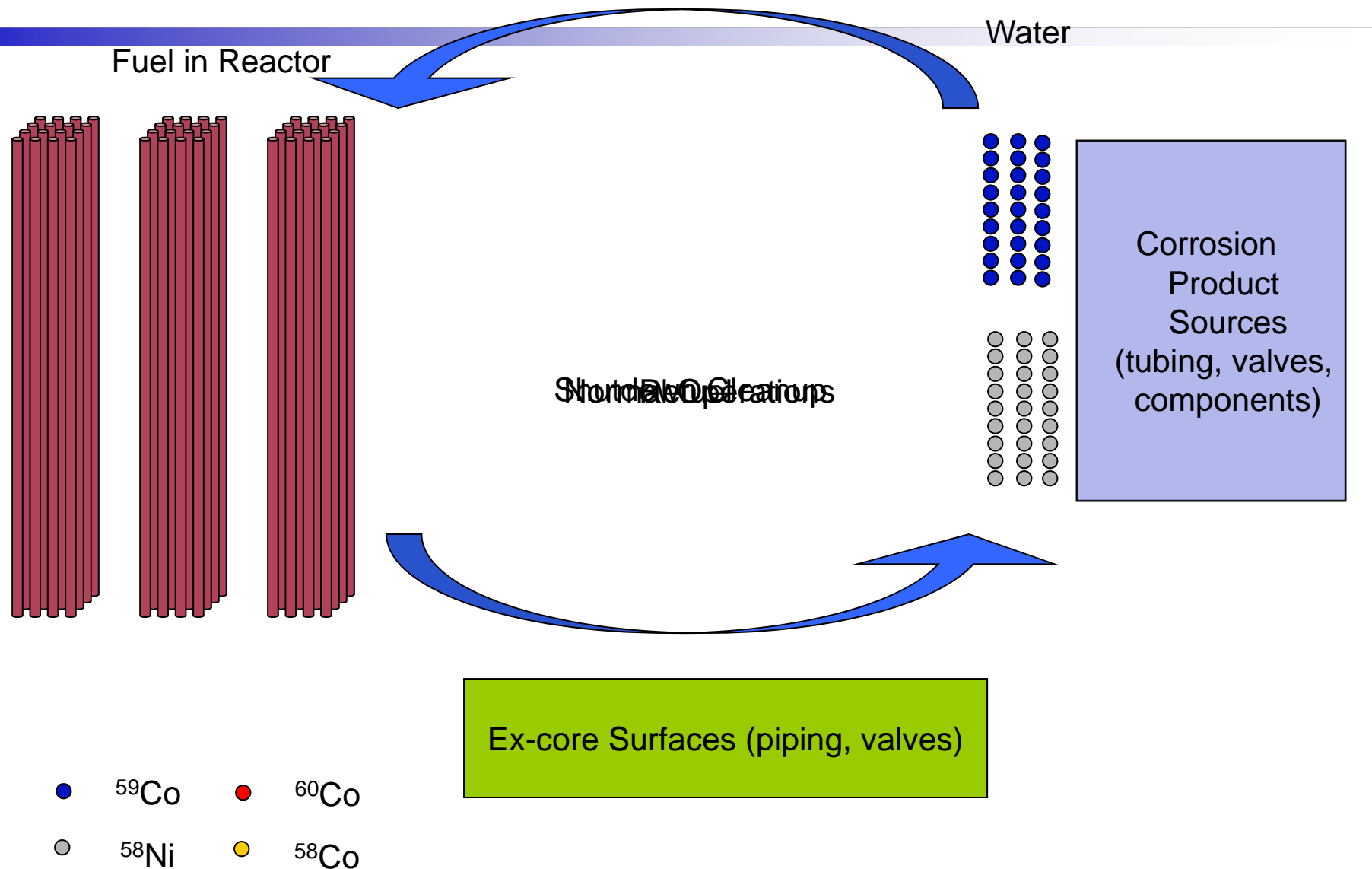
Comparisons in Scale—PWR Case



Radiation Transport Mechanism

- Five step pathway to radiation fields
 1. Corrosion of parent nuclide from ex-core surfaces
 2. Transport of the parent nuclide to the fuel
 3. Deposition and activation of parent nuclide to activity on the fuel
 4. Transport of the active nuclide to the ex-core surfaces
 5. Incorporation or deposition of activity in/on ex-core surfaces

Source Term Activation and Transport



Potential Mitigation Strategies for Source Term Mechanisms

Corrosion and release

- Core design modifications
- Zinc injection
- Fuel cleaning
- Surface preconditioning of corroding surfaces/fuel surfaces

Corrosion product transport

- Chemistry environment
- Temperature
- Corrosion product composition

Deposition and activation on the fuel

- Distribute boiling on the fuel
- Zinc injection (prevent incorporation, crud stability)
- Fuel cleaning

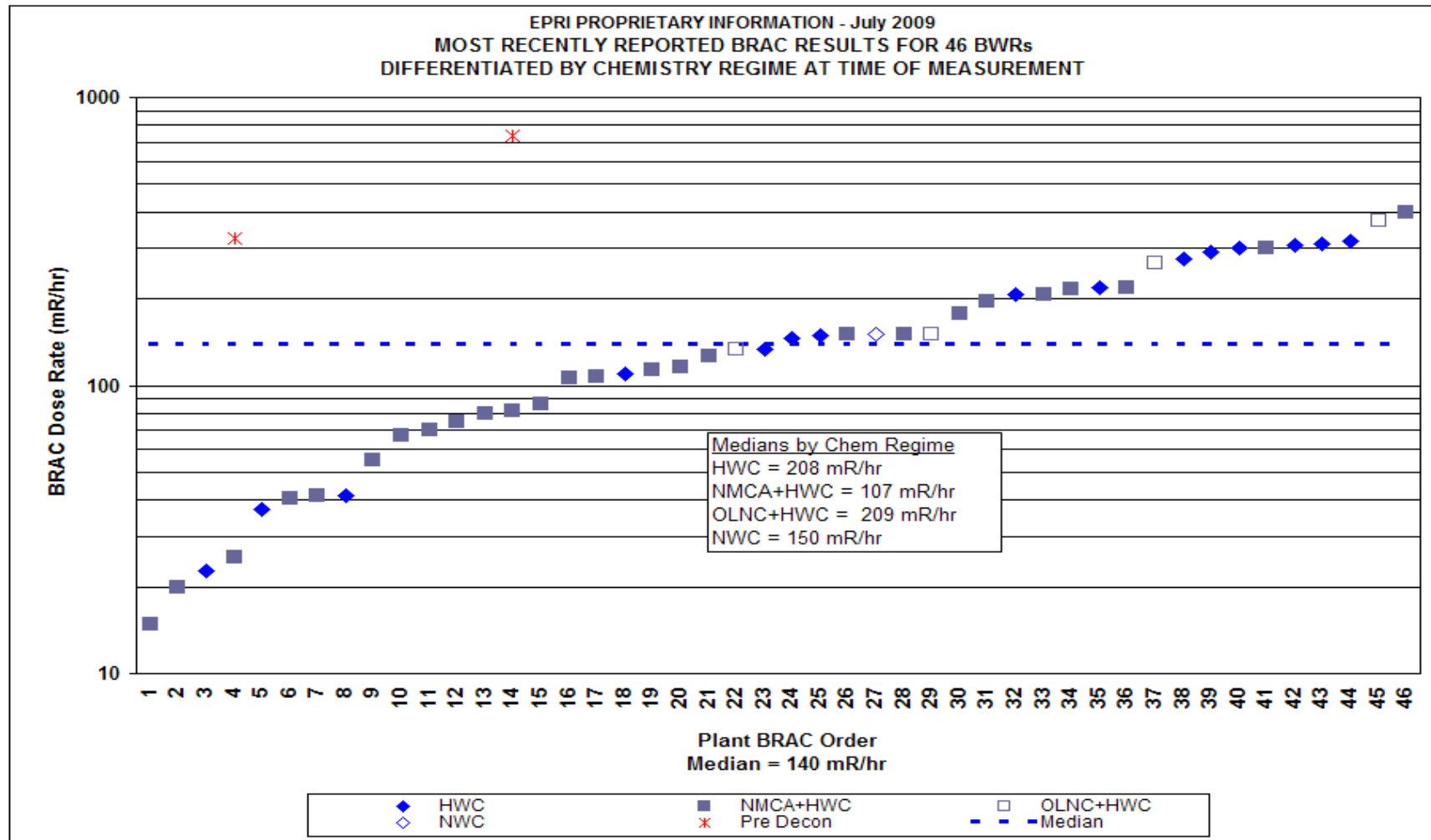
Activated product transport

- Chemistry environment
- Temperature
- Crud morphology

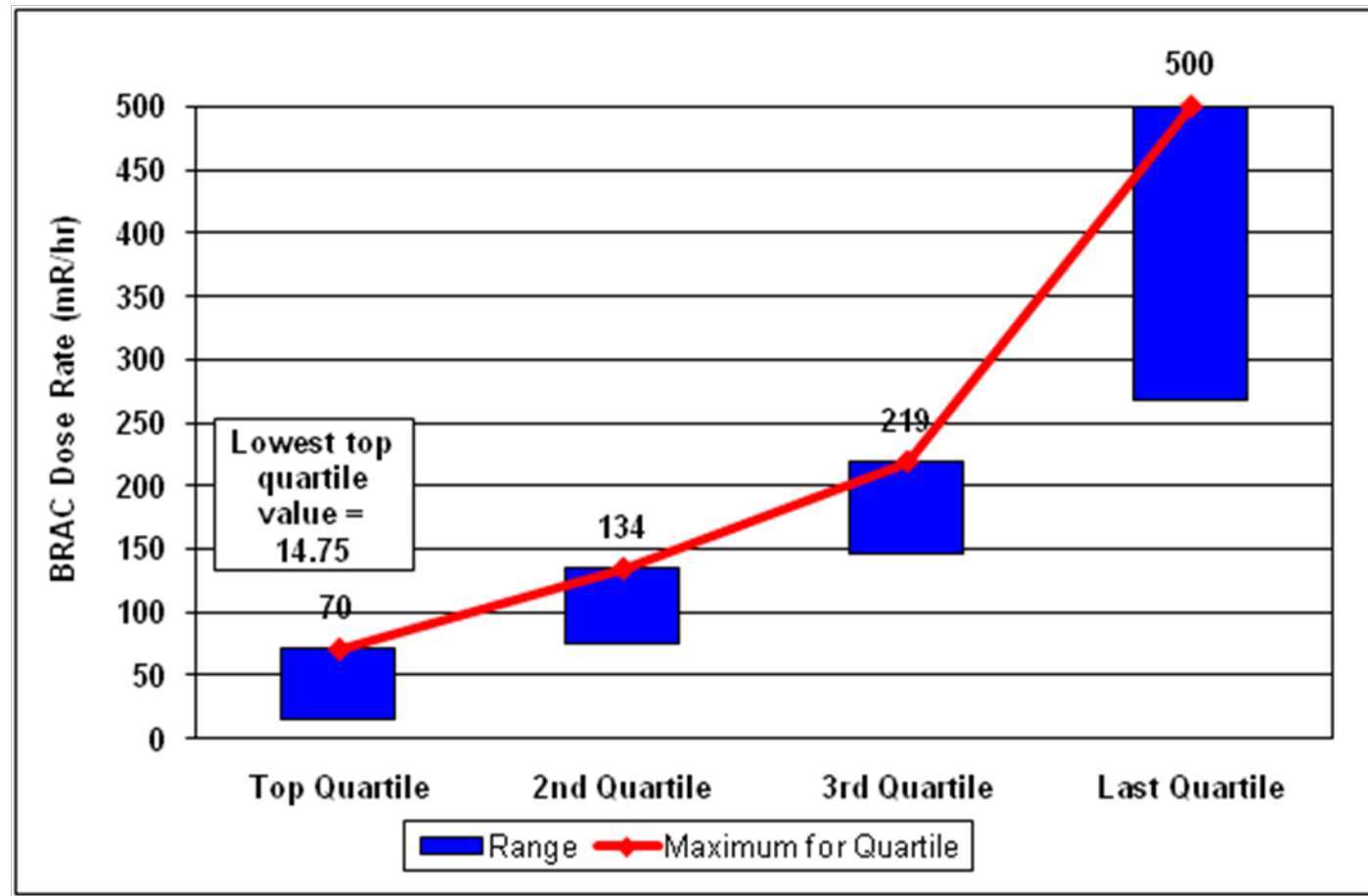
Deposition and incorporation into surfaces

- Zinc injection
- Decontamination/Flushing
- Electropolishing/Stabilized Chrome
- Chemistry Environment/Shutdown Ops/Fuel Cleaning

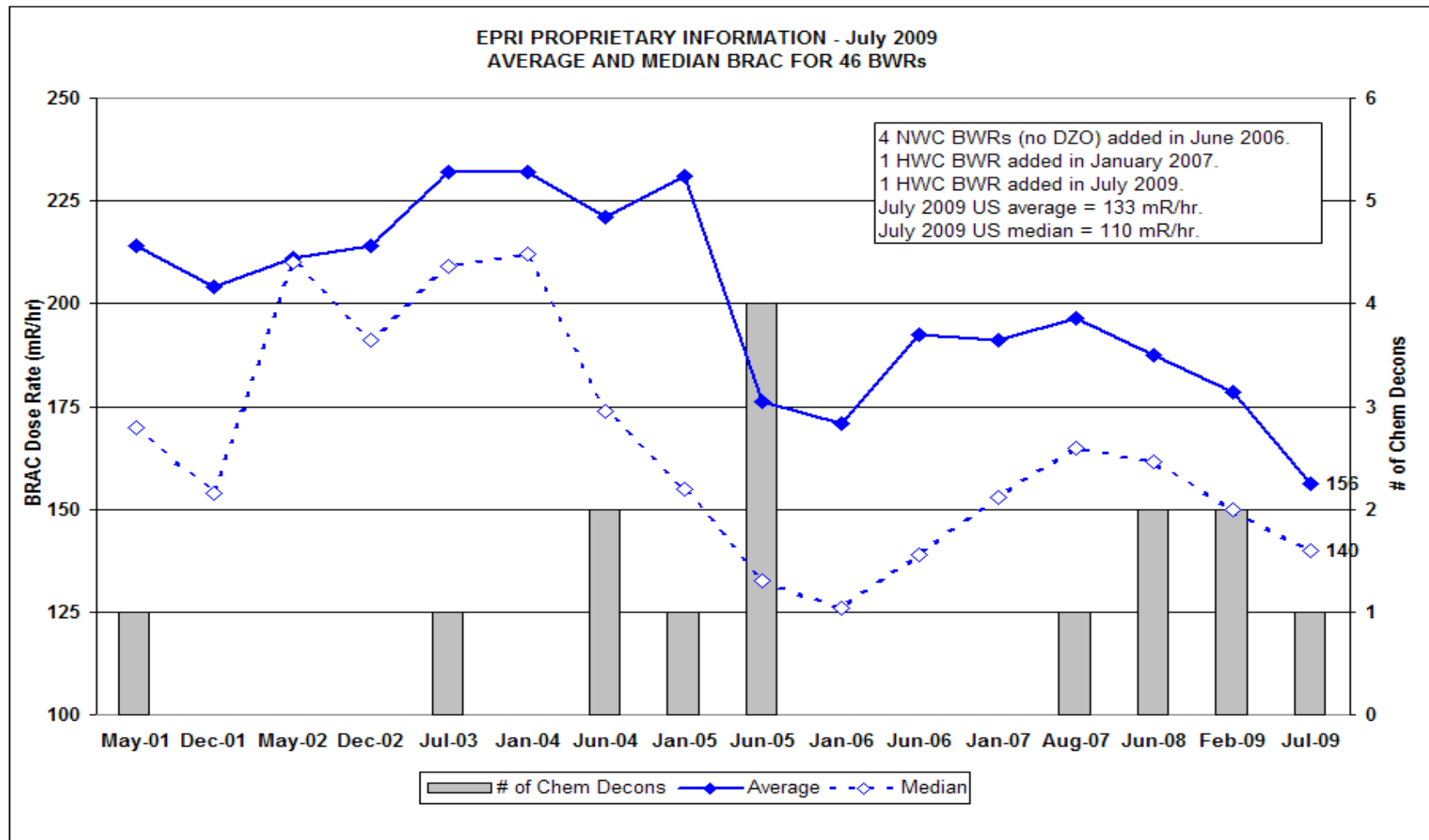
Latest BWR BRAC Data



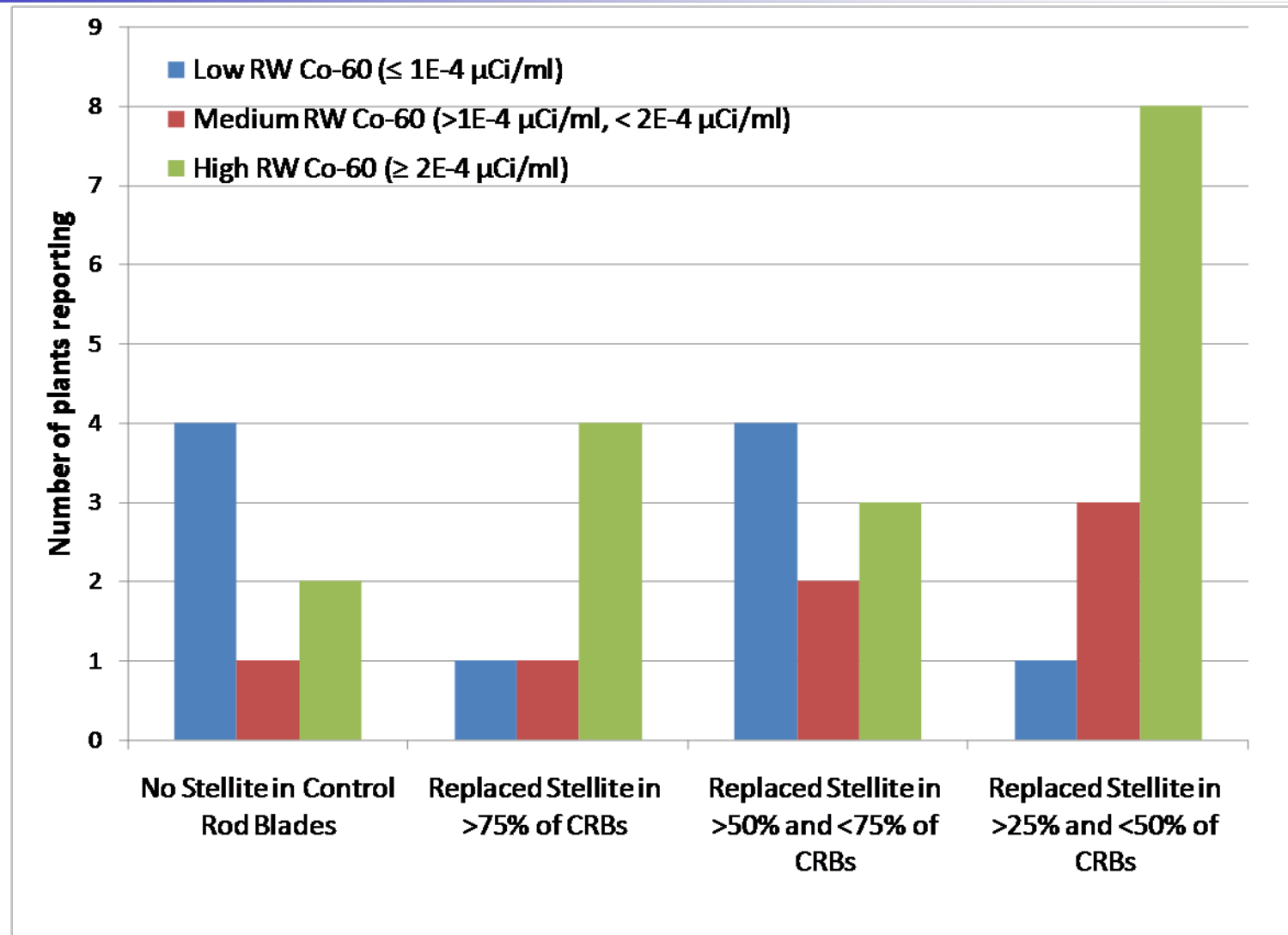
Quartile Distribution of Most Recent BRAC Average Dose Rates



BWR BRAC Dose Rate Trends



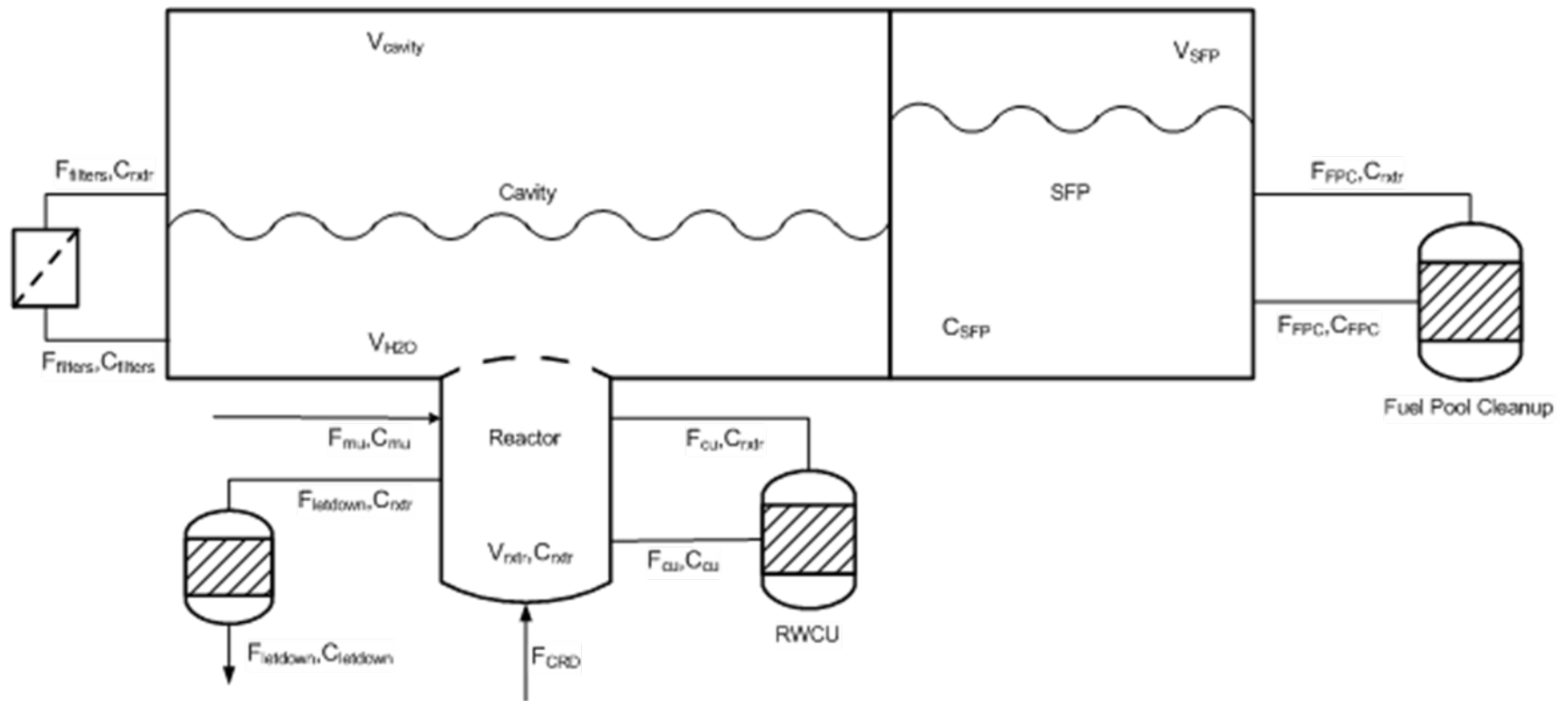
Impact of Control Rod Blade Replacement on Reactor Water Cobalt



BWR Shutdown Calculator

- Shutdown Calculator contains two modules;
 - Shutdown Release Module calculates the activity released and removed during a RFO;
 - Shutdown Analyzer Module estimates the coolant “cleanup” curve from peak activity concentration
- Major data inputs:
 - Outage milestones; activity data; flows, volumes; system status
 - Peach Bottom 2 and Dresden 2 RFOs selected; (completed shutdown data templates available)

BWR Shutdown Calculator



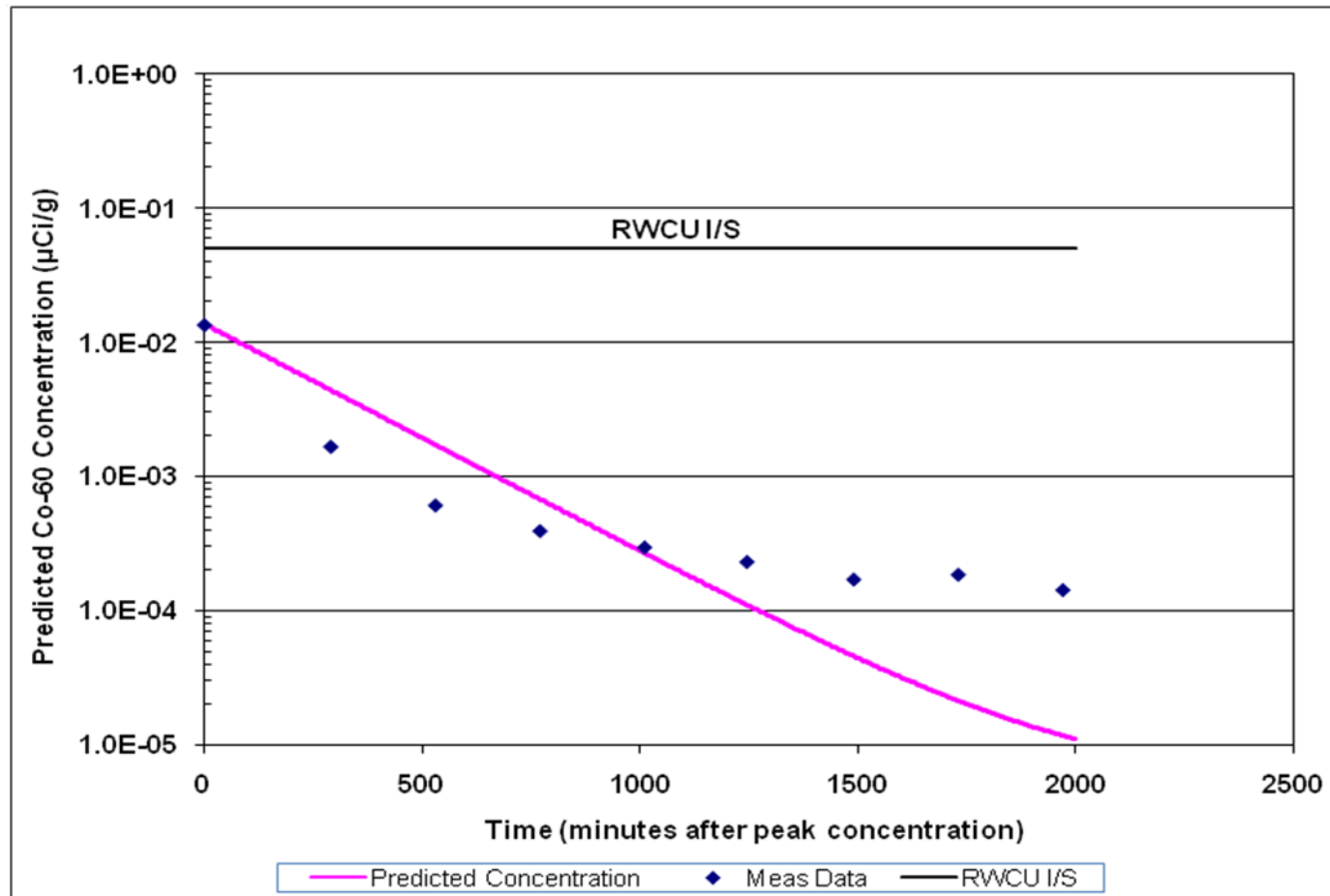
BWR Shutdown Calculator

➤ PB2 RFO16 Shutdown Release Results for Co-60

	Released (Ci)	Removed, RWCU (Ci)	Removed, Letdown (Ci)	Removed, Filters (Ci)	Removed, FPC (Ci)
Total Activity before flood-up, Ci	7.4	4.2	2.9	0.0	0.0
Total Activity after flood-up and before opening the gates, Ci	4.0	0.5	0.2	1.8	0.0
Total Activity after opening the gates, Ci	319.0	14.9	10.6	108.3	174.0

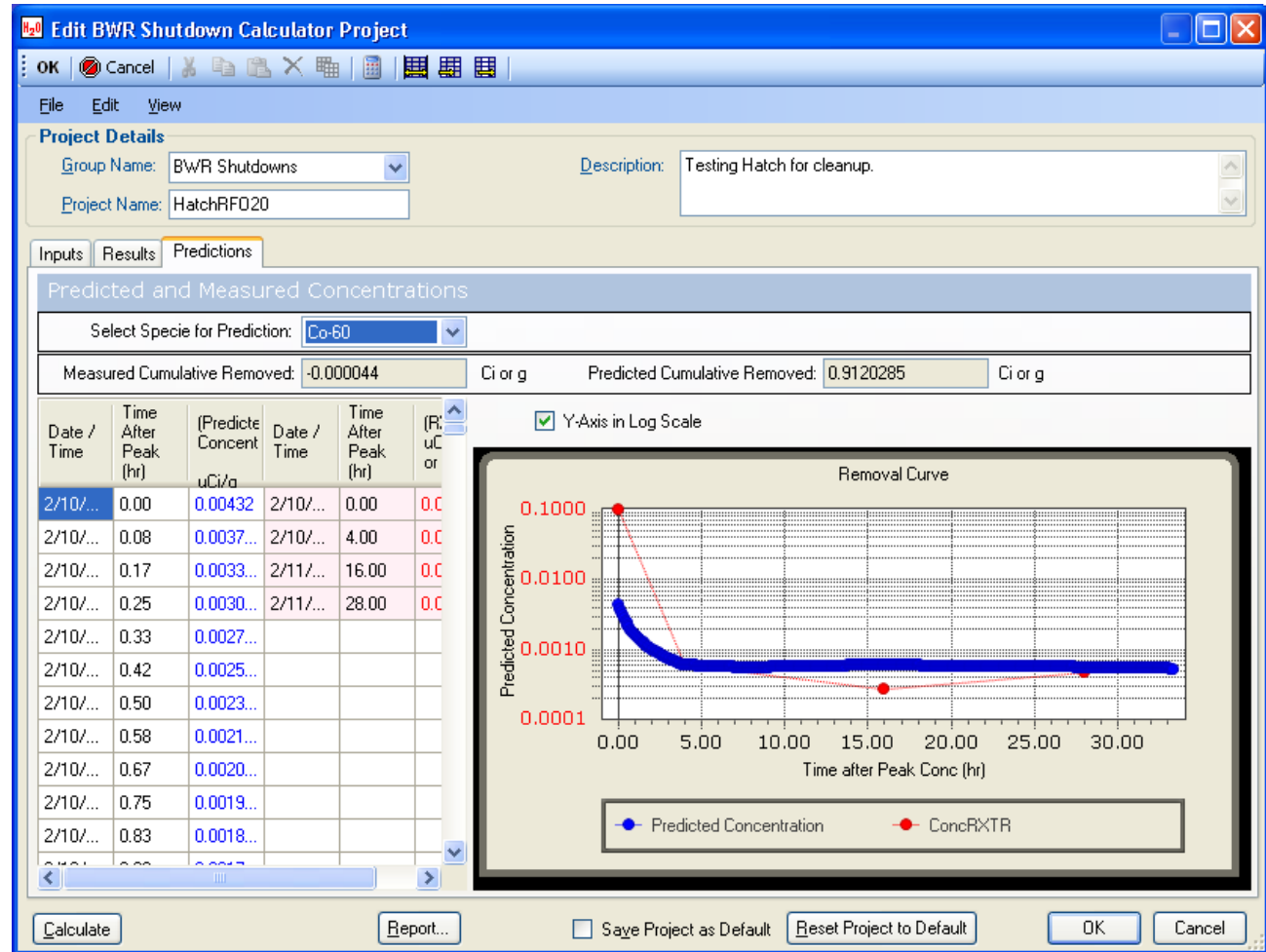
BWR Shutdown Calculator Results

➤ PB2 RFO16 Shutdown Analyzer Results for Co-60



ChemWorks Tools version 3.0 (BWR Shutdown Calculator)

- Download 1019238
- PWR and BWR Shutdown Calculators available
- Predicted concentrations from peak are calculated



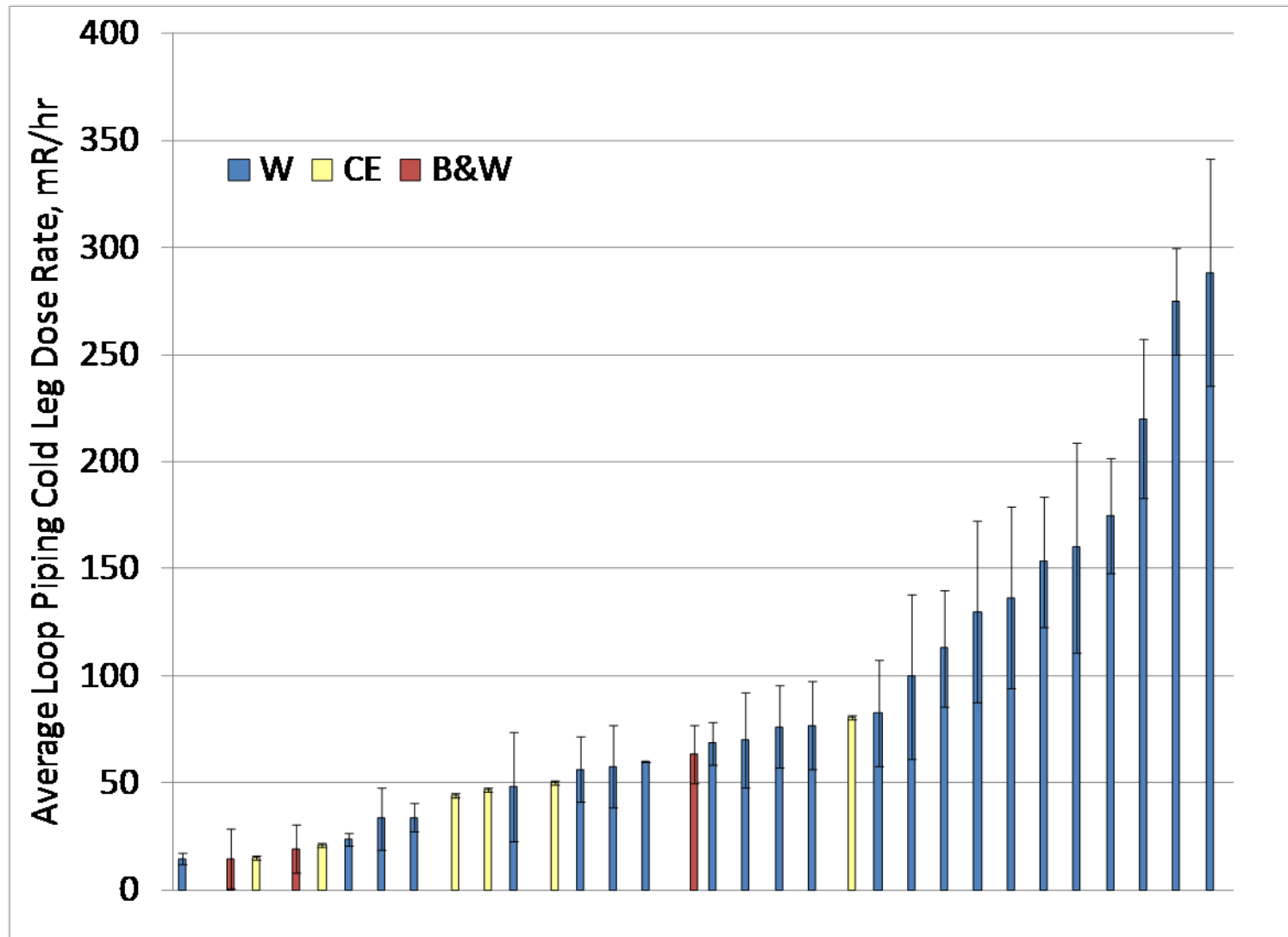
BWR Conclusions and Recommendations

- Conclusions
 - Dose rate range among quartiles varies significantly
 - Fleet BRAC median and average drop with the number of decontaminations
 - Stellite in control rod blades is a significant contributor to RW Co-60
 - Shutdown calculators available for EPRI members

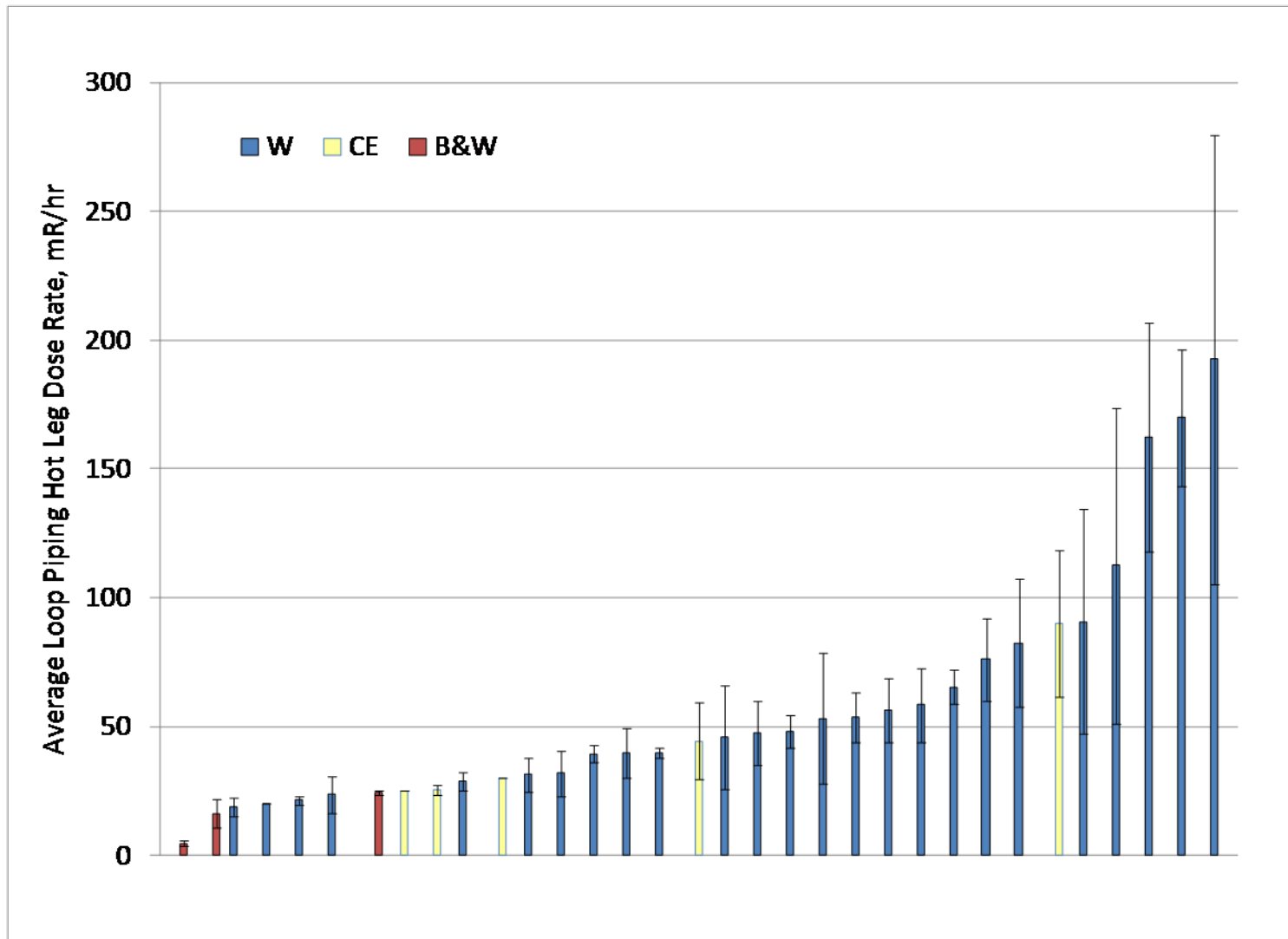
PWR Source Term Reduction *Technology Evaluations*

- Report #1019225
- Key Results
 - Zinc continues to show significant radiation benefits
 - pH effects noticed when comparing before and after PWR Primary Guidelines
 - Long term benefits of electropolishing are noted
 - Activity release magnitude has additional correlation to **core boiling duty** and **tubing surface area**
 - Manufacturing method impact is less clear

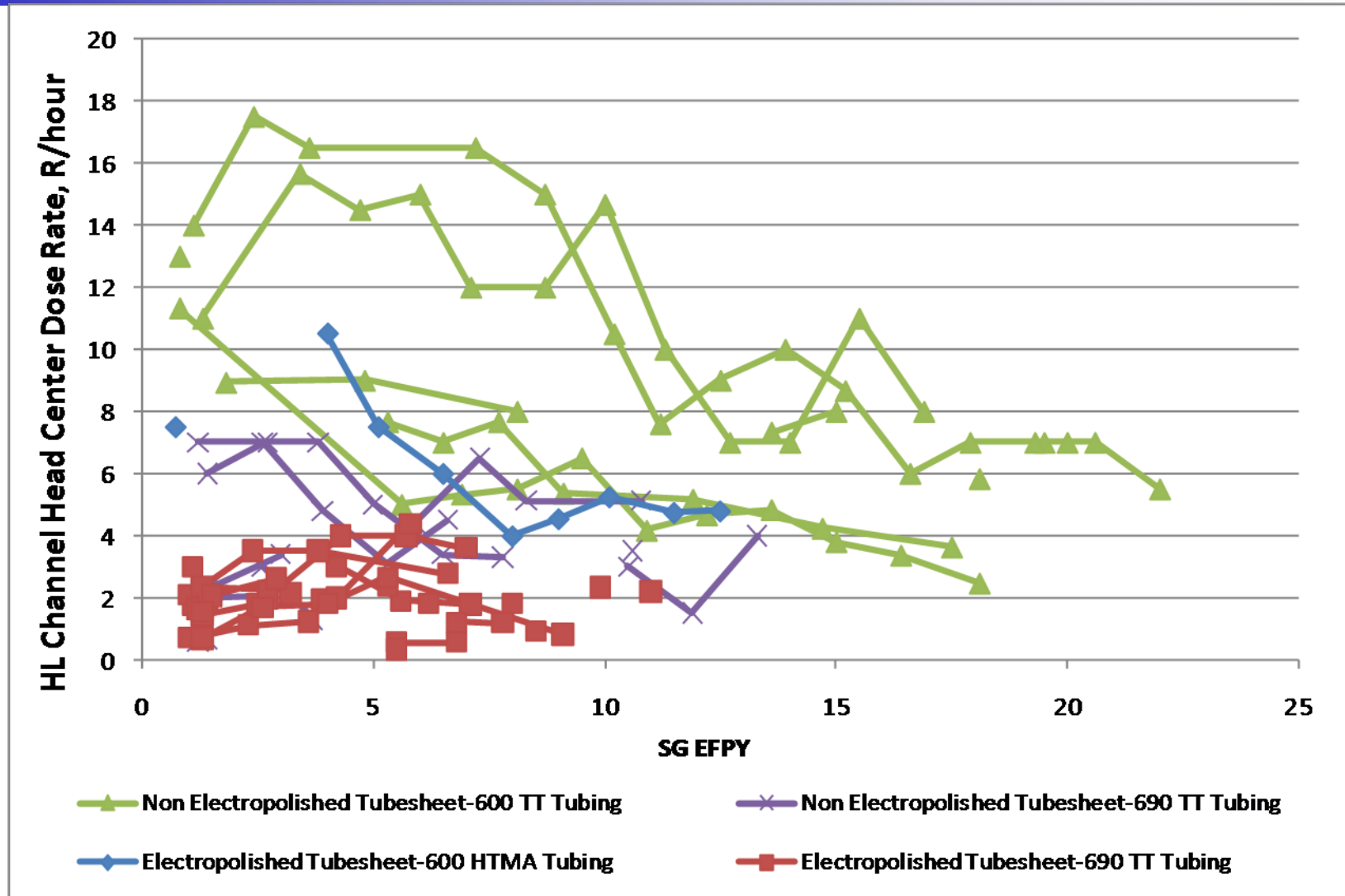
SRMP Most Recent Results—Loop Piping Cold Leg



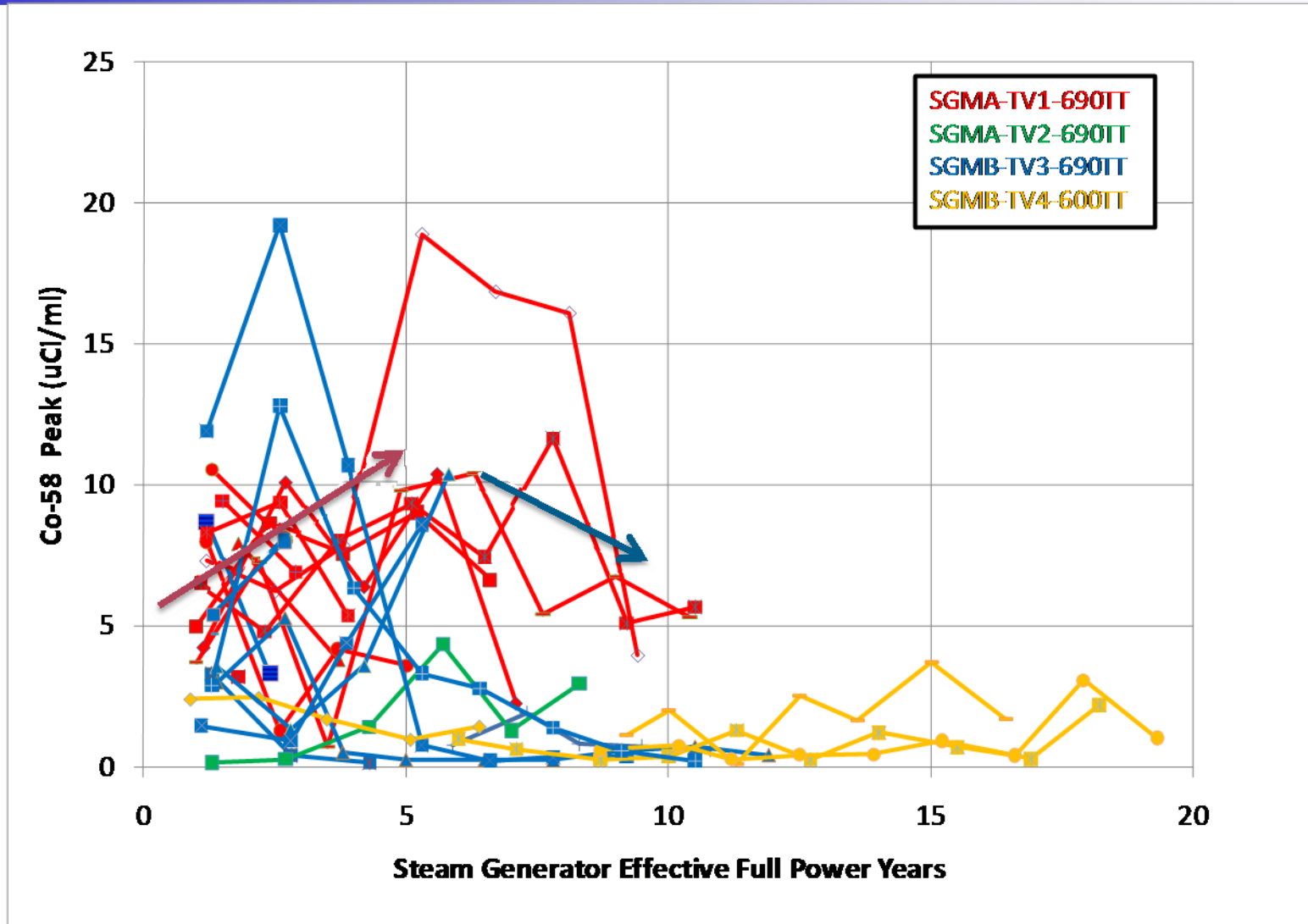
SRMP Most Recent Results—Loop Piping Hot Leg



Impacts of Tubing Material and Electropolishing on Radiation Fields

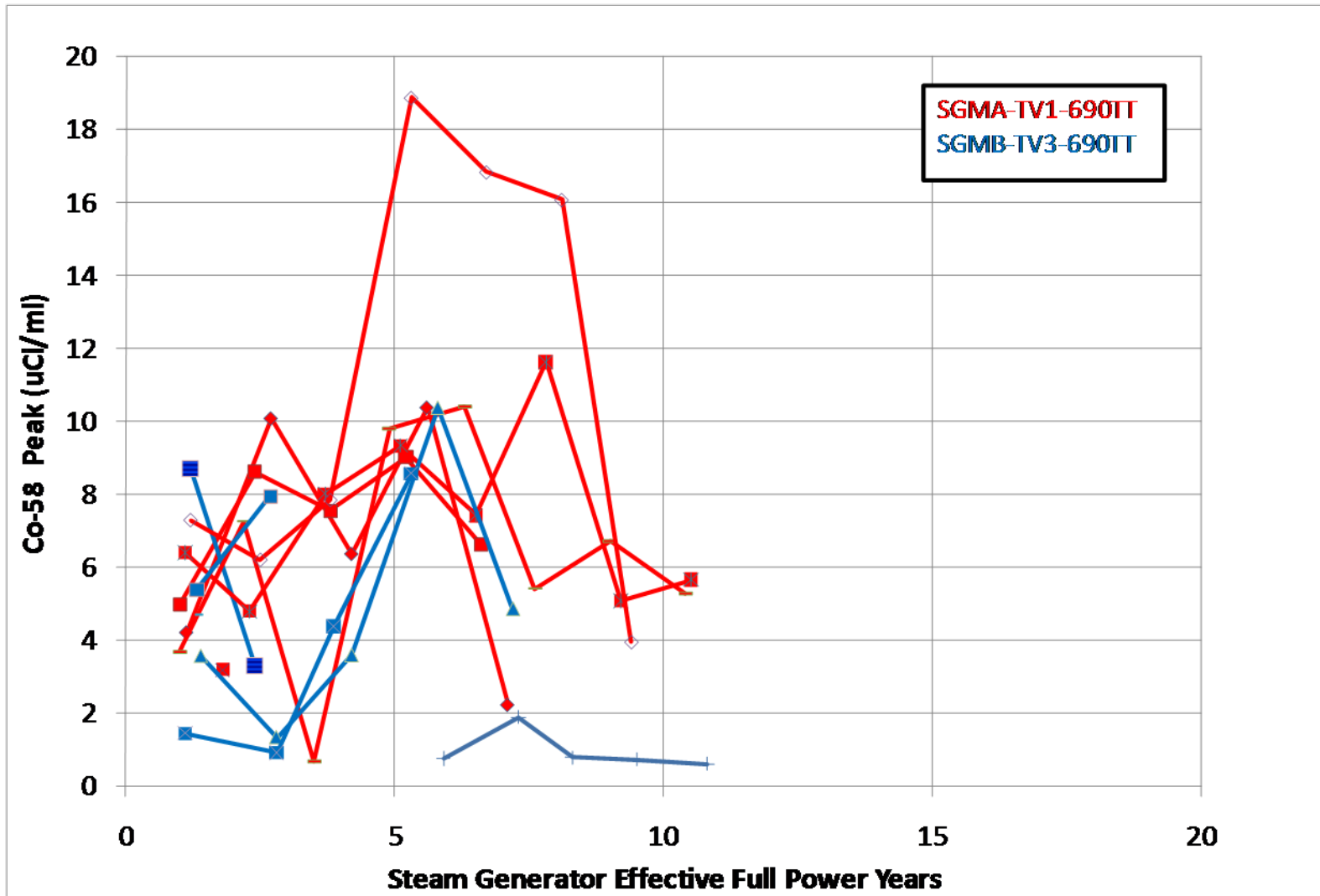


Replacement PWR Crud Burst Peaks Over Time Grouped by Tubing Vendor and Alloy

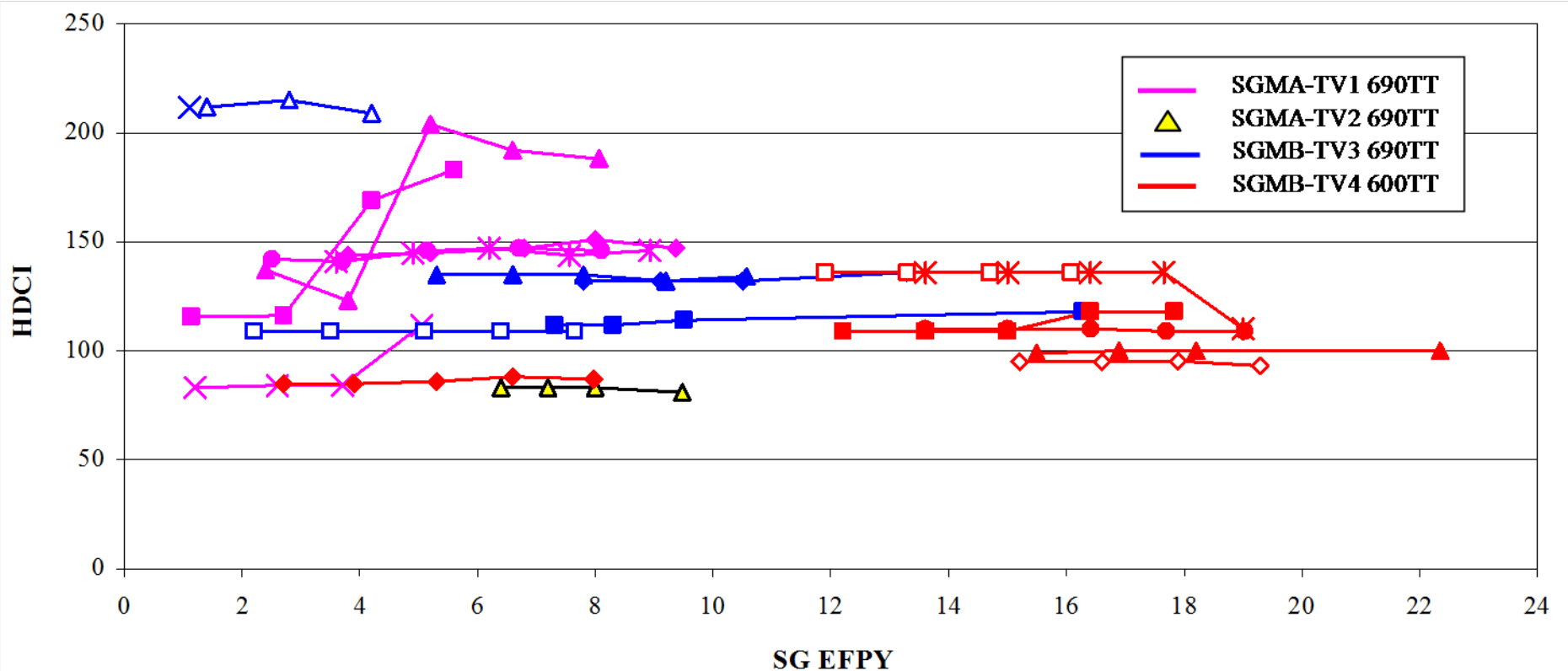


Replacement PWR Crud Burst Peaks Over Time

Four Loop Westinghouse



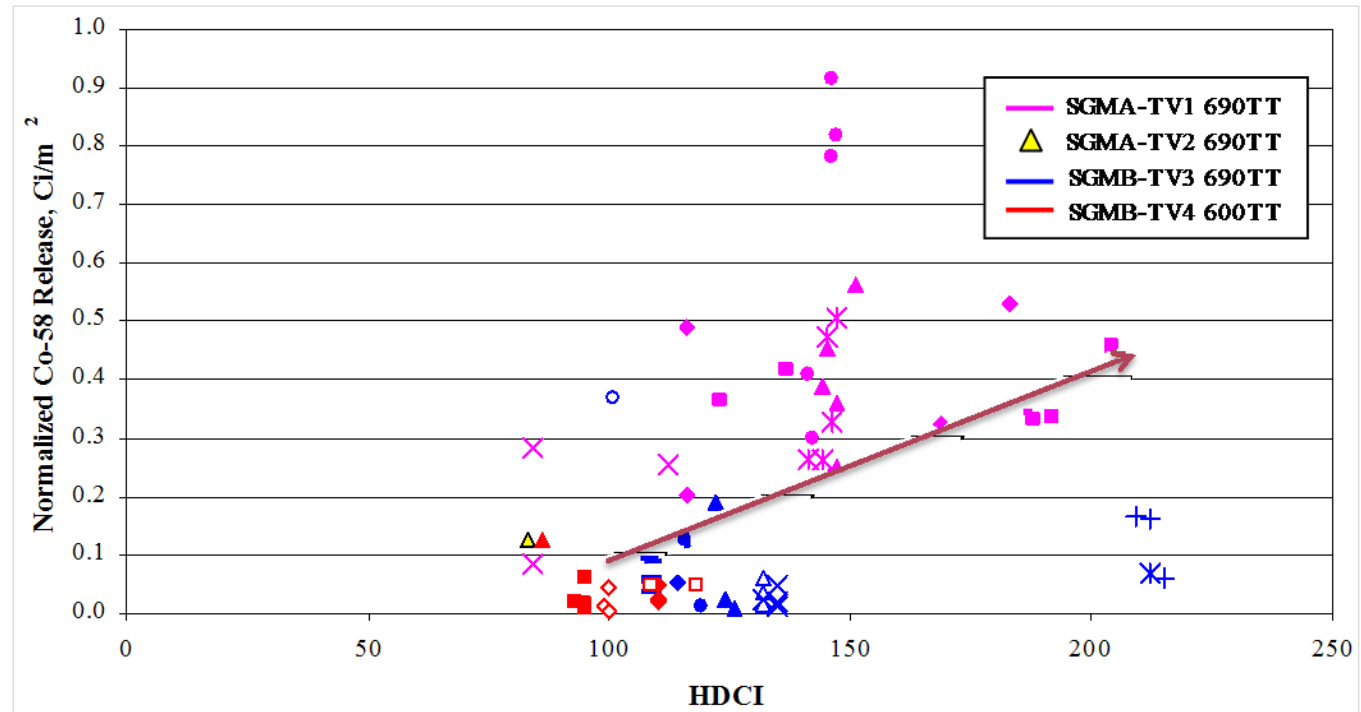
PWR High Duty Core Index Trends for Replacement SG Plants



Plants with high HDCI often had larger activity releases

Normalized Releases (Surface Area, Volume, Corrosion Rate) and HDCI

- General increasing trend as a function of HDCI
- Tubing vendor separation less clear



PWR Source Term Conclusions

- Dose Rate Reduction Technology Conclusions
 - Crud Burst Activity Level
 - Correlates To Boiling Duty And Surface Area
 - Impact Of Manufacturing Method Is Less Clear
 - Tubing Material Has Impact On Cobalt Source (690/600)
 - Zinc Continues To Show Significant Benefits
 - pH
 - Coordinated pH Program Shows Positive Impact
 - Elevated pH Shows Improvements At Some But Not All Plants
 - Electropolishing Has Continued Benefits For Channel Heads