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Impact of Operational Events on Particulate Transport and Radiation Fields

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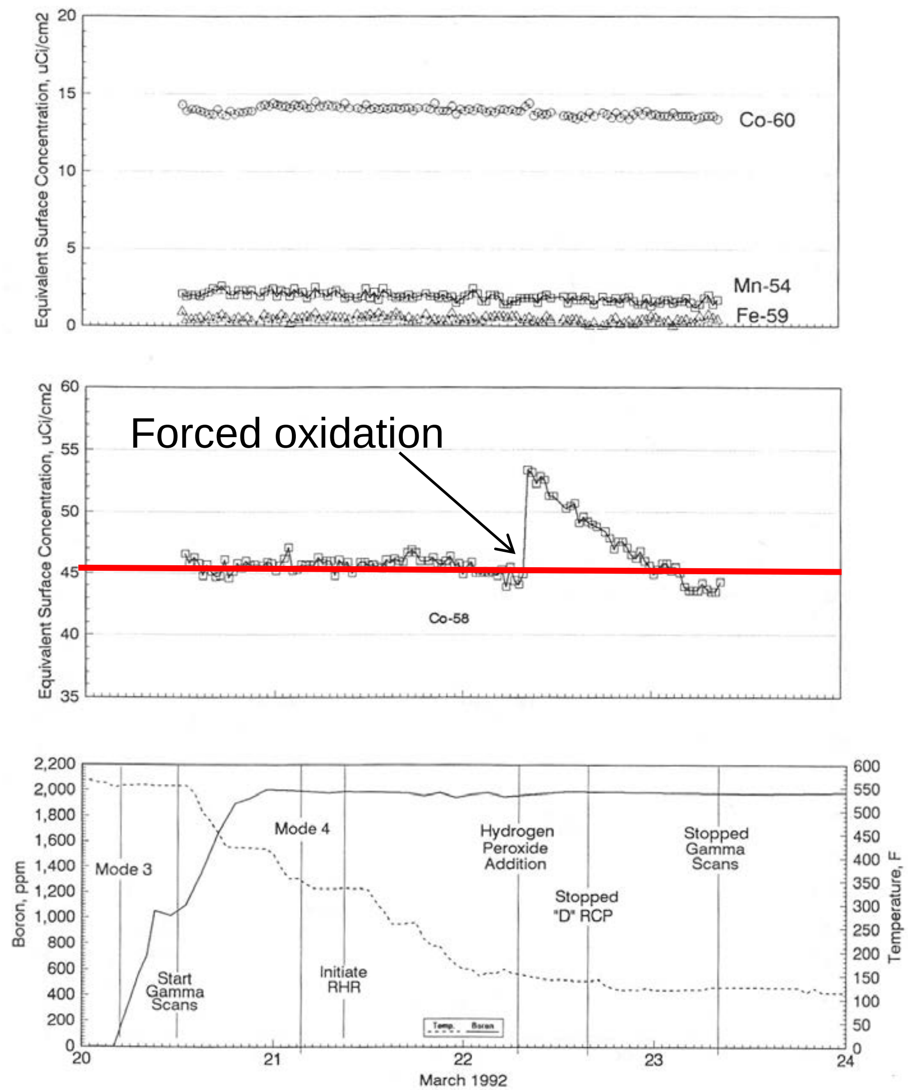
High Flow Area Activity Uptake
Background

- In large piping surfaces, surface activity stays the same before and after shutdown
- Activity incorporation occurs during normal operation
  - Gamma spectroscopic studies have demonstrated no activity increase during outage maneuvers*



PWR Activity Transport and Source Term Assessment: Surface Activity Concentrations by Gamma Scanning. EPRI, Palo Alto, CA: 2011. 1023027.

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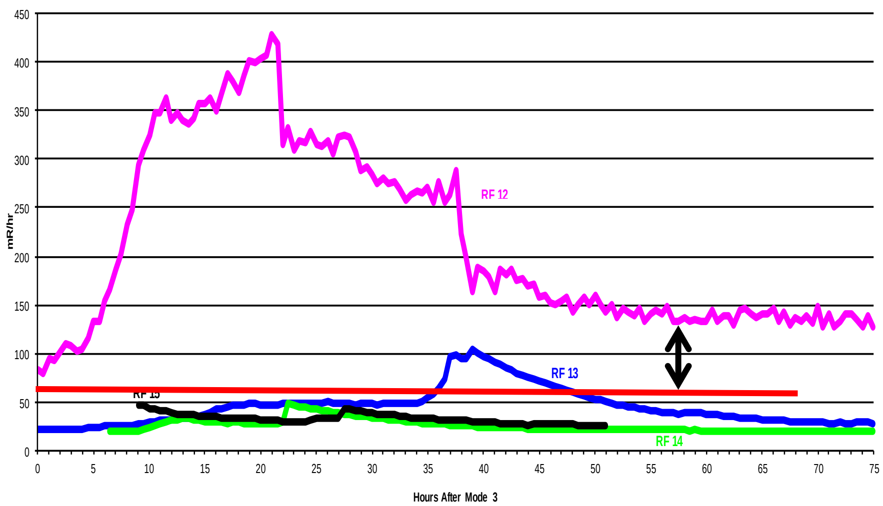
Low-Flow Area Activity Uptake
Background

Increased Dose Rate after Shutdown
(high duty core, 2nd cycle after SGR)



- Electronic dosimetry studies of low-flow systems shows higher dose rates after shutdown
  - Particulate transport after SG replacement is suspected
  - Uprated cores may change transport mechanisms
  - Plant trips and non-standard operations
- Trends observed in PWRs and BWRs

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Modeling the Impact of Insoluble Deposition
Re-entrainment and wall shear

*Kern-Seaton Equation**

$$\frac{dW}{dt} = vC - EW$$

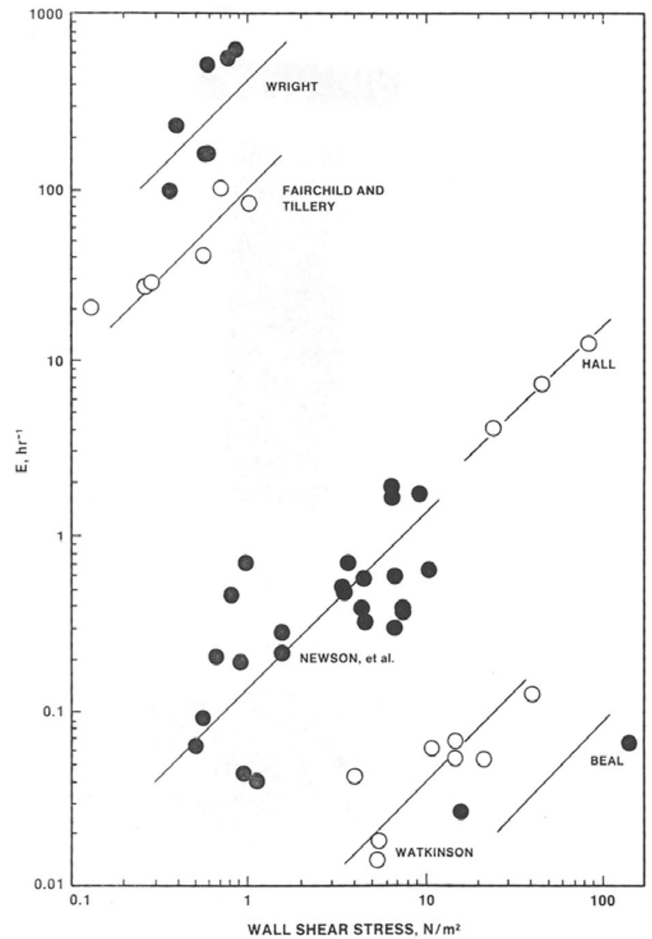
W	=	Deposit weight per unit area
t	=	Time
v	=	Deposition velocity
C	=	Concentration in fluid
E	=	Re-entrainment coefficient

Re-entrainment (E) directly proportional to wall shear

$$\tau_W = \frac{f}{2} \rho V^2$$

f	=	Fanning friction factor
ρ	=	Fluid density
V	=	Average fluid velocity
τ_W	=	Wall shear stress

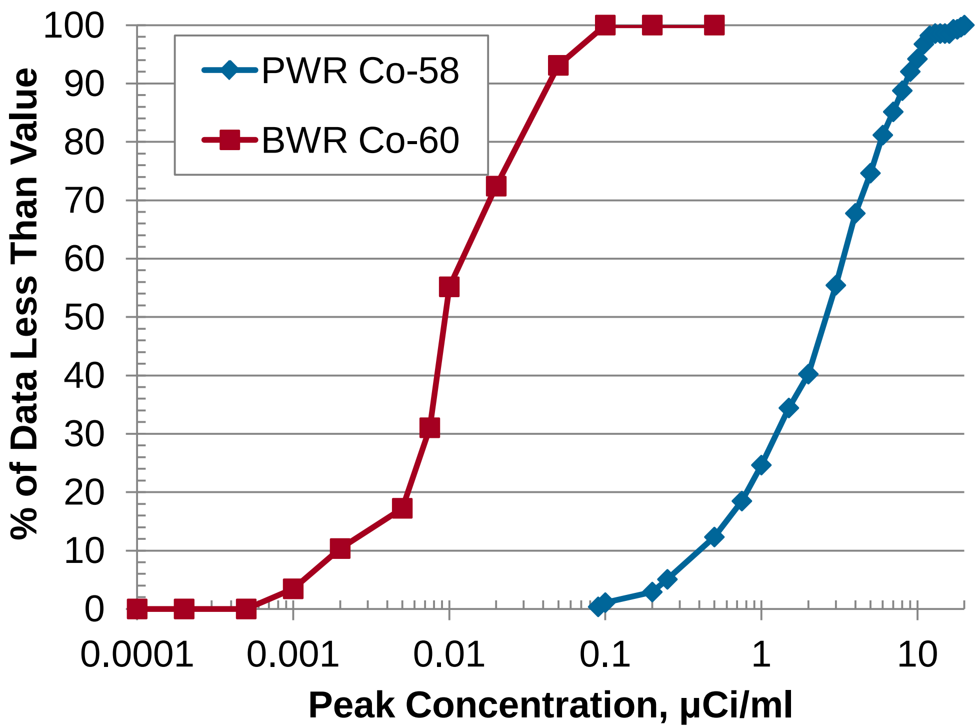
Re-entrainment Coefficient Versus Wall Shear Stress



*Kern, D. Q., Seaton, R. E., "A Theoretical Analysis of Thermal Surface Fouling," British Chemical Engineering; pp 258-262, 1959

Impact of SDs on BWR Dose Rates

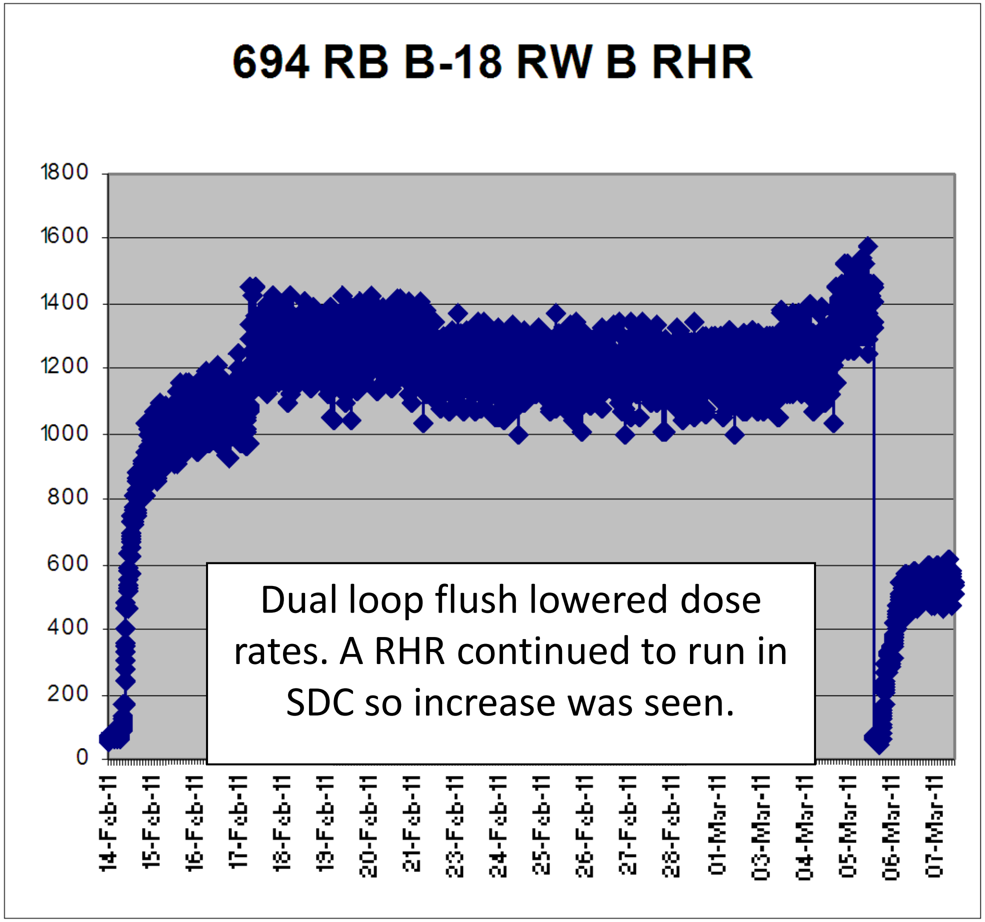
- Minimal effect expected in high wall shear regions
- Insoluble deposition expected in low shear regions; however, reactor water concentrations relatively low



- Standard RP monitoring provides limited data
- Installed electronic dosimeters (ED) monitoring facilitates assessments

Installed Remote Technology in BWRs
Electronic Dosimetry

- Provides time dependent information about changes in dose rate
- Expands understanding of impact of operations and corrective actions
- Limited data available from BWRs



Impact of SDs on PWR Dose Rates
*1025305 (June 2012)**

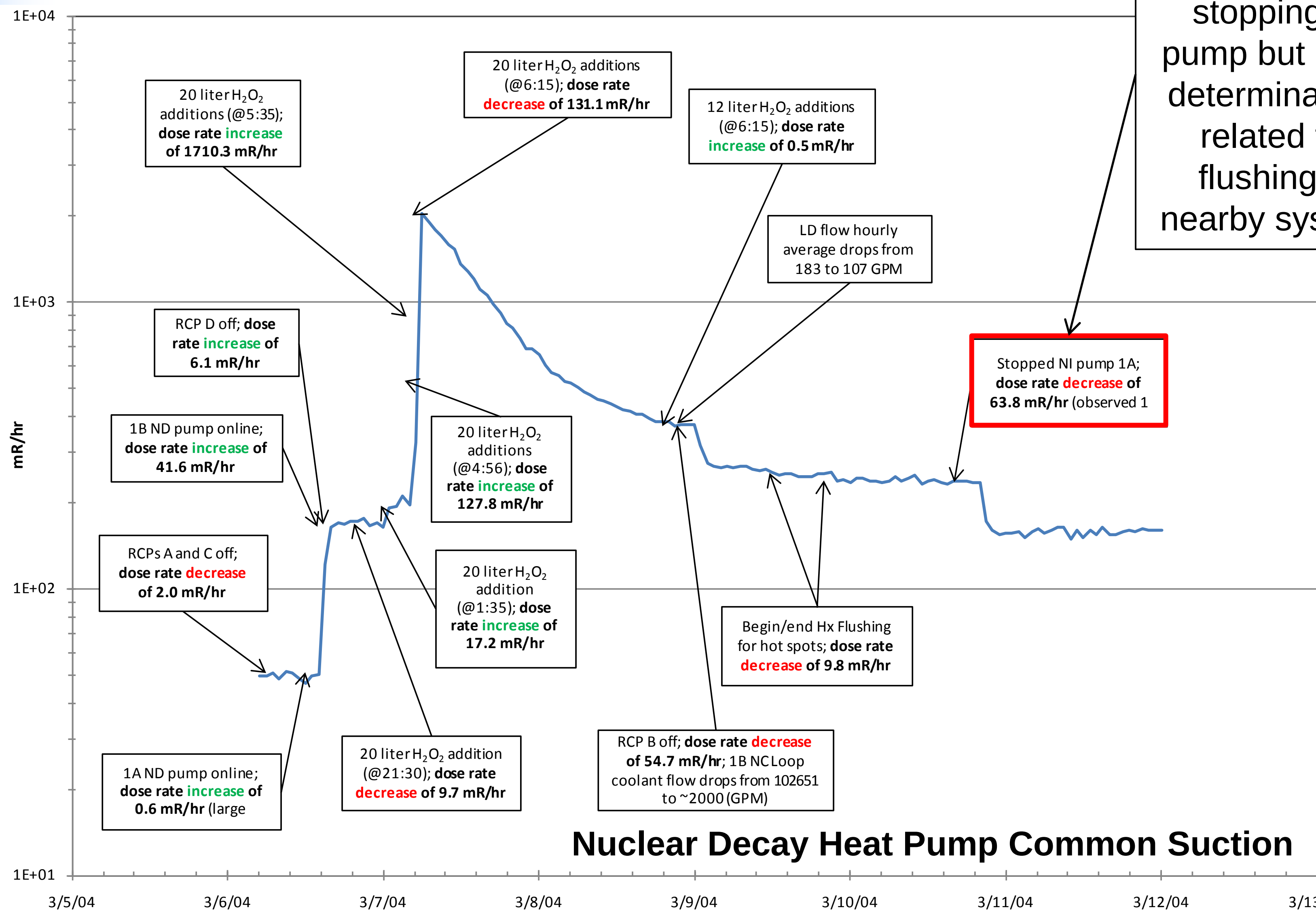
- No significant impact of shutdowns on piping or steam generator dose rates in high shear regions
  – Compared to BWRs, Co-58 and Co-60 releases are very high and primarily soluble
- Limited dose rate increases observed in low fluid shear regions:
  – Shutdown cooling
  – Letdown system
- Electronic dosimetry is valuable assessment tool; extensive database available

*Impact of PWR Operational Events on Particulate Transport and Radiation Fields. EPRI, Palo Alto, CA: 2012. 1025305.

Installed Remote Technology in PWRs

Electronic Dosimetry

Drop originally attributed to stopping a pump but later determination related to flushing a nearby system



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Correlating Piping Dose Rates to Particulate Concentrations*

Method

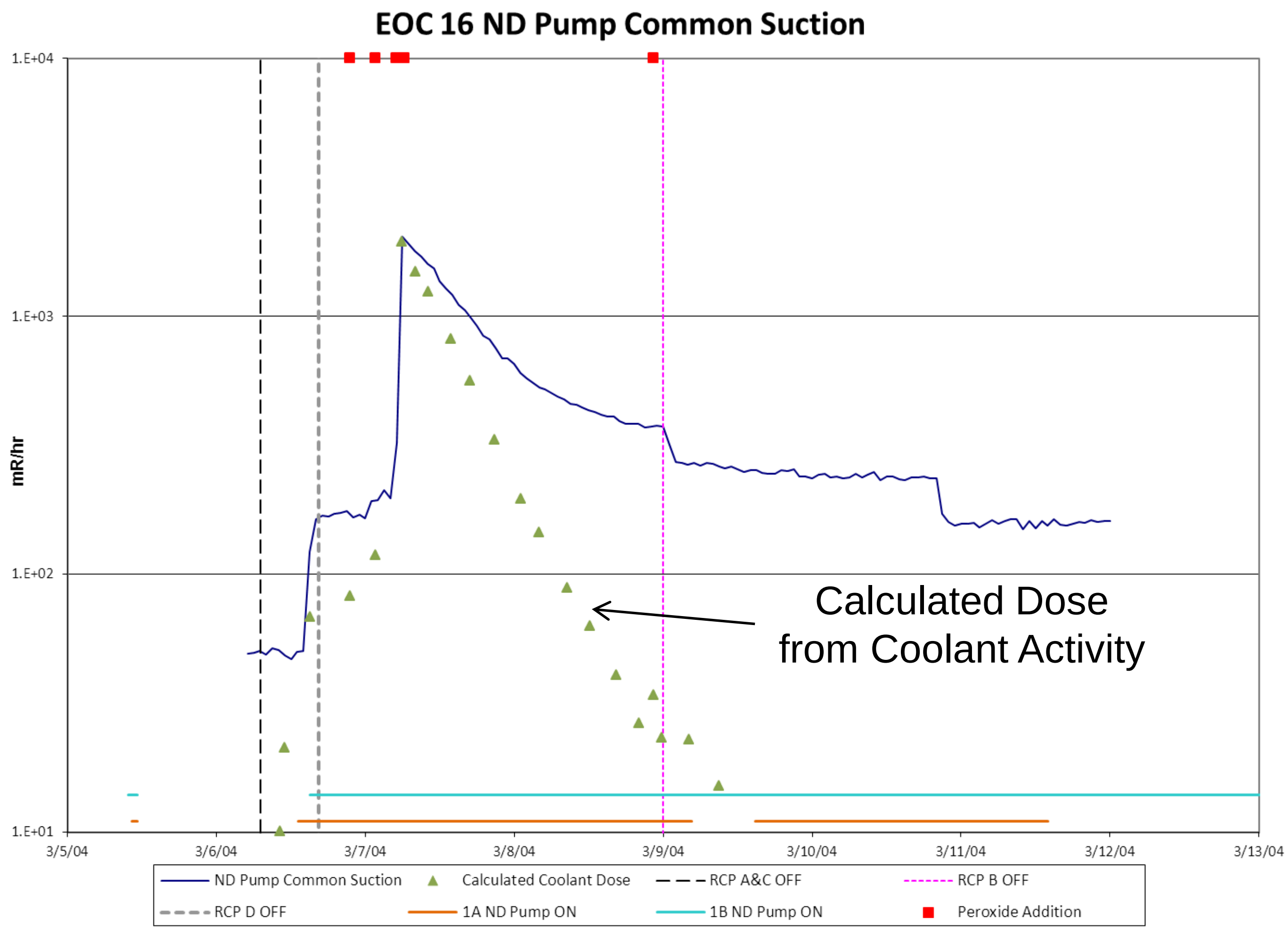
1. Correct ED data for impact of coolant activity
2. Estimate (mR/h)/(μCi/ml) based on total Co-58 immediately before and after peroxide injection
3. Assess piping dose rate buildup as function of time, operations and coolant particulate concentrations

- Extensive PWR database available; BWR database appears limited
- Can process be modeled using Kern-Seaton approach?

*Impact of PWR Operational Events on Particulate Transport and Radiation Fields. EPRI, Palo Alto, CA: 2012. 1025305.

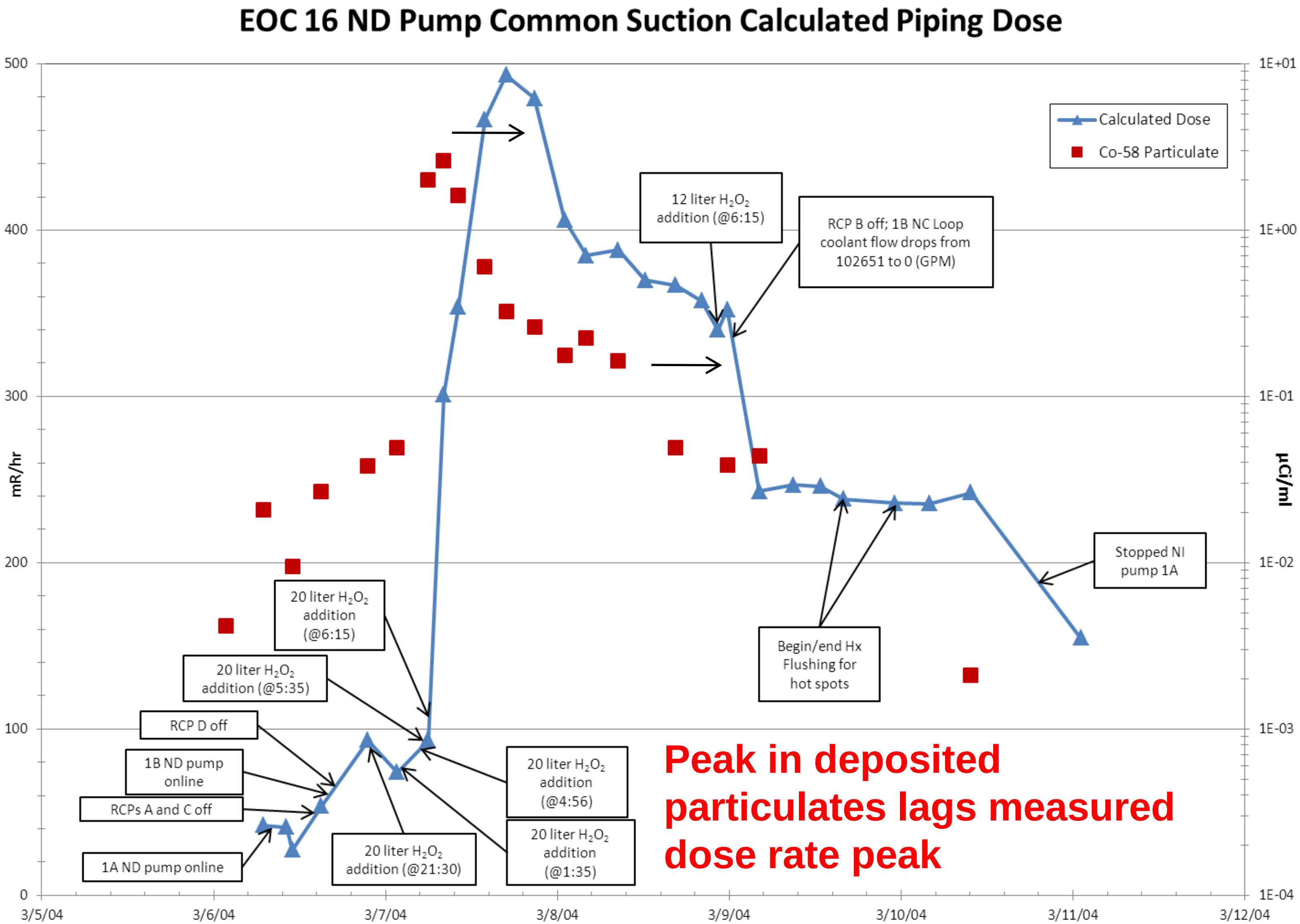
Determining the Impact of Particulates

- Dose rate from coolant activity calculated and subtracted from raw data



*Impact of PWR Operational Events on Particulate Transport and Radiation Fields. EPRI, Palo Alto, CA: 2012. 1025305.

Correlating Measured Particulates to Calculated Impact on Dose Rate



Peak in deposited particulates lags measured dose rate peak

Summary

- Piping dose rates primarily controlled by incorporation of soluble radionuclides <u>during power operation</u>
  - Additional incorporation of solubles expected to be minimal during shutdown evolutions
- <u>Insoluble deposition in dead legs and regions of low fluid</u> shear during shutdown transients lead to <u>increased dose rates</u>
- <u>Electronic dosimetry significantly improves</u> capability to assess impacts of insoluble deposition as well as corrective actions to mitigate associated dose
  - Guidance incorporated into the Revision of BRAC and SRMP (2012-2013 Project).

*Impact of PWR Operational Events on Particulate Transport and Radiation Fields. EPRI, Palo Alto, CA: 2012. 1025305.

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