

## Attachment 2

### Risk-Informed GSI-191 AADB RAI 3 Response



# Risk-Informed GSI-191 AADB RAI 3 Response

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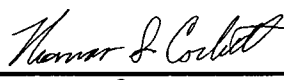
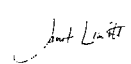
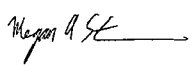
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## TECHNICAL DOCUMENT COVER PAGE

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Client: STP Nuclear Operating Company		
<p>Document Purpose/Summary: Request for additional information 3 (RAI 3) inquired about the potential for pH changes arising from sump acidification through radiolysis of water and plastic sheathing on cabling. This document provides an explanation for variation of calculated pH and experimentally measured pH as well as expected ECCS performance effects. This document is not considered safety-related.</p> <p>This report includes 8 total pages.</p>		

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## REVISION HISTORY LOG

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	STP Risk-Informed GSI-191 AADB RAI 3 Response		
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## I Risk Informed GSI-191 AADB RAI 3

*The LOCA analysis assumes that iodine will be removed from the containment atmosphere by containment spray and natural diffusion to the containment walls. As a result of these removal mechanisms a large fraction of the released activity will be deposited in the containment sump. The sump water will retain soluble gases and soluble fission products such as iodines and cesium, but not noble gases. The guidance from RG 1.183 specifies that the iodine deposited in the sump water can be assumed to remain in solution as long as the containment sump pH is maintained at or above 7.*

*The AST application indicates:*

*"After the first day, the containment sump pH will begin to decrease, reaching 6.8 by the end of the 30-day duration of the radiological consequence analysis for the DBA LOCA, and the impact of that decrease has been reflected in the Control Room and offsite doses."*

*It is noted that the AST application further indicates:*

*"The design inputs for calculating the containment sump pool pH were conservatively established by the licensee to maximize the acidic contribution to sump pH and minimize the basic contribution."*

*The GSI-191 application indicates the possibility that debris generated during a LOCA could clog the containment sump strainers in pressurized-water reactors (PWRs) and result in loss of net positive suction head (NPSH) for the ECCS and CSS pumps, impeding the flow of water from the sump.*

*Discuss the exemption justification as they relate to the effects on sump water pH, radiological consequences, and loss of the containment spray system.*

## 2 Response

### 2.1 Sump Water pH; Calculated vs. Measured

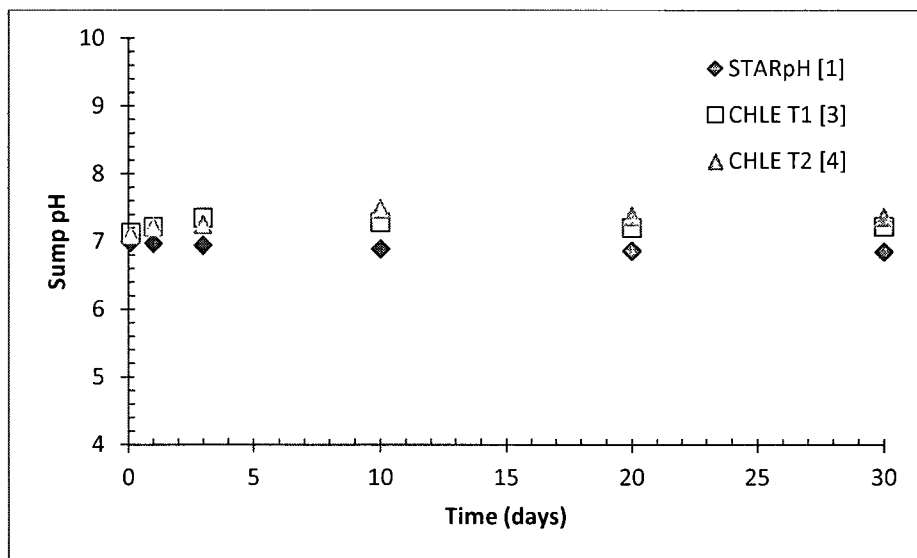
In the following, the pH values resulting from the STP Licensing Basis (LB) alternative source term (AST) calculation [1,2] and the Chemical Head Loss Experiment (CHLE) 30 day tests [3,4] are compared and the differences analyzed. Table 1 summarizes the solution chemistry considered in both the LB calculation and CHLE test [3,4]: concentrations of boric acid; trisodium phosphate (TSP); and radiolysis generated acid. Boric acid and TSP concentrations used to establish initial LB (calculated) sump pH were determined by deterministic analysis. The boric acid and TSP concentrations used for the CHLE experiments were determined from risk-informed analysis of historical plant data [5] and would not be considered conservative in the same sense as the LB AST calculations. Also, unlike the LB calculation, the 30 day CHLE experiments [3,4] reflect pH trends with the inclusion of corrosion material and fibrous debris. In summary, the observed CHLE pH trend has no effect on potential sump blockage assumed in the LB calculation.

**Table 1: Solution characteristics for both LB [1] and experimental (CHLE [6,7]) systems**

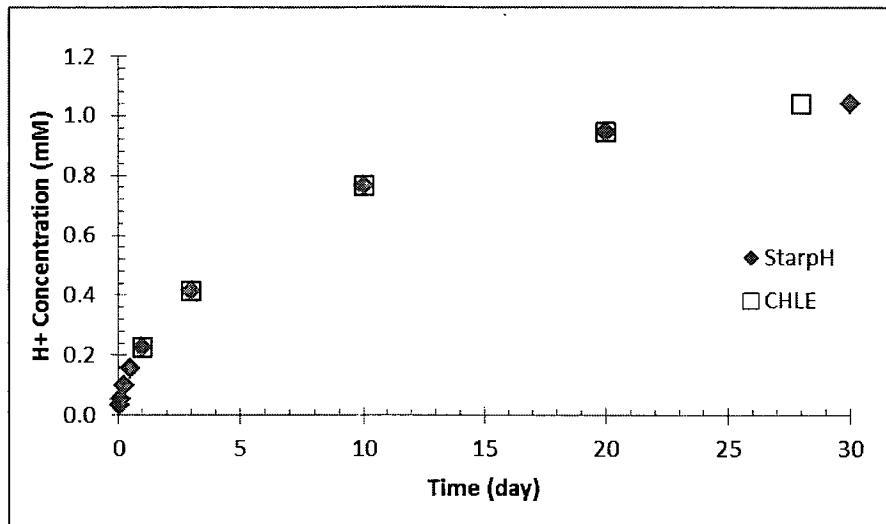
Chemical	Star pH Model	CHLE Tests
Boron (mM)	283.05	250.50
TSP <sup>1</sup> (mM)	5.63	8.87
Lithium hydroxide (mM)	0	0.06
30 Day HCl (mM)	0.81	0.81
30 Day HNO3(mM)	0.23	0.23
Initial pH <sup>1</sup>	7.0	7.1-7.2
30 day pH	6.8	7.2-7.4

<sup>1</sup> After complete dissolution of TSP

After complete TSP dissolution, the two inputs resulted in a difference of approximately 0.1 pH units as summarized in Table 1. The higher initial pH in the CHLE tests reflects the different boric acid and TSP concentrations used to define the systems. There is also a small quantity of lithium hydroxide, 0.06 mM Li, added to the CHLE system. The addition of iodine was not considered in either system. During the 30-day analysis, sump pH in both systems changed. As shown in Figure 1, the LB system predicted a decrease in pH of approximately 0.2 pH units resulting from acid addition over 30 days; however the experimental system produced a slight increase in pH of, on average, 0.18 units over 30 days using the same acid addition schedule used in the LB system (Figure 2).



**Figure 1: 30 day pH trend of LB [1] and experimental (CHLE [6,7]) systems.**



**Figure 2: Acid addition schedule for LB [1] and experimental (CHLE [6,7]) systems.**


## 2.2 Implications of Experimental Results

The initial pH difference between the LB system and the CHLE test systems [3,4] is expected, primarily due to the difference between the deterministically-assumed boric acid and TSP concentrations and risk-informed (realistic) concentrations. The difference between the LB calculated pH history and the CHLE observed pH history is likely reflective of uncertainty from the LB calculation. The LB calculation is a modeled solution and uncertainties from model development arise from missing reactions, activity corrections and temperature corrected equilibrium data. By neglecting buffering, activity and temperature corrections, the LB system exhibits a greater pH reduction. The additional buffering capacity in the CHLE test system not accounted for in the LB model is a function of the following; 1) greater contribution from TSP, with 8.87 mM TSP versus the 5.63 mM used in the LB system; 2) the presence of fiberglass solids that can contribute to alkalinity by adsorbing  $H^+$  [8]; 3) addition of a small quantity of lithium hydroxide; and 4) corrosion reactions, specifically aluminum and zinc corrosion.

## 2.3 Summary

The fact that pH in the CHLE system remains above 7.1 despite acid addition for a period greater than 30 days reflects the true buffering capacity of the system. Alkalinity in the CHLE system is augmented by increased initial concentration of TSP and lithium hydroxide, as well as solids such as fiberglass, and by metal corrosion. The LB system calculations fail to account for these factors. The minor acidic contributions from radiolysis of water and cabling assumed in the LB acid addition schedule would be mitigated by the higher pH as demonstrated in the CHLE experiments. The pH stability observed in the CHLE system indicates that acid additions resulting from radiation exposure will not affect sump blockage and thus are not expected to affect ECCS performance. Furthermore, these experimental results likely represent a lower realistic bound, since the LB case assumes core damage and the effect of strongly basic cesium oxide produced from fuel damage on the basicity of the sump solution [9] is ignored.



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