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NRC – CPNPP
Public Meeting
RAI 9 - Pool Fill Transport

Comanche Peak
Emergency Sump Performance
July 9th 2009

ALION
SCIENCE AND TECHNOLOGY

Updated: 7/6/09

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Slide 2

Debris Transport During Pool Fill Phase

- Following the blowdown, as the pool starts filling, debris would tend to be washed out of the two RCS Loop Bay doors.
- During the initial high velocity sheeting phase of the fill-up period, the only directional flow outside the secondary shield wall would be toward the inactive reactor cavity.
- Therefore, debris would be scattered around outside the secondary shield wall and carried into the reactor cavity.
- Water would not flow preferentially to the sump strainers until the water level rises above the top of the 12 inch debris interceptors (after the sheeting phase is over), and it would take less than a minute for the sump cavities to fill.

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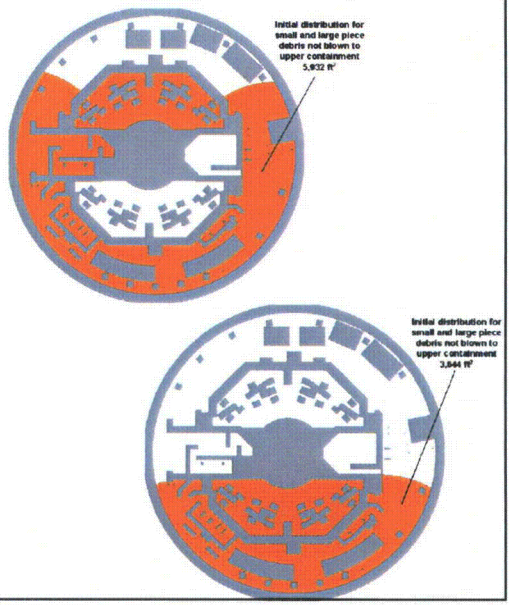
Slide 3

Debris Distribution at Beginning of Recirculation

- Although, debris in the pool would be more likely to be concentrated in the vicinity of the reactor cavity entrance and around the full area outside the secondary shield wall, the debris transport calculation conservatively assumed that the debris would be distributed along the shortest paths from the location of the break to the sump strainers.



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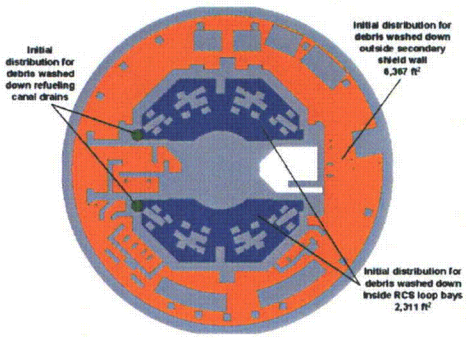
Slide 4

Debris Distribution at Beginning of Recirculation

- Due to the high spray flow, most debris in the path of the sprays would be washed down from upper containment relatively quickly and would reach the pool before the initiation of recirculation.



Debris Transport During Recirculation Phase

- Although it was not credited, the presence of RMI and other less transportable debris in the vicinity of the strainer would tend to trap more readily transportable debris reducing the overall recirculation transport.

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RAI 6 – Fiber Erosion Testing

Comanche Peak
Emergency Sump Performance
July 9th 2009

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RAI 6 - Erosion Testing

6. Please describe the testing performed to support the assumption of 10% erosion of fibrous debris pieces in the containment pool. Please specifically include the following information:

a. Please describe the test facility used and demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fibrous material present in the erosion tests to the analogous conditions applicable to the plant condition.

b. Please provide specific justification for any erosion tests conducted at a minimum tumbling velocity if debris settling was credited in the test flume for velocities in excess of this value.

c. Please identify the duration of the erosion tests and how the results were extrapolated to the sump mission time.

RAI 6 - Erosion Testing

Please describe the testing performed to support the assumption of 10% erosion of fibrous debris pieces in the containment pool.

•ALION-PLN-LAB-2352-77, Rev 3 – Test Plan for the Erosion Testing of Low Density Fiberglass Insulation and High Density Fiberglass Insulation.

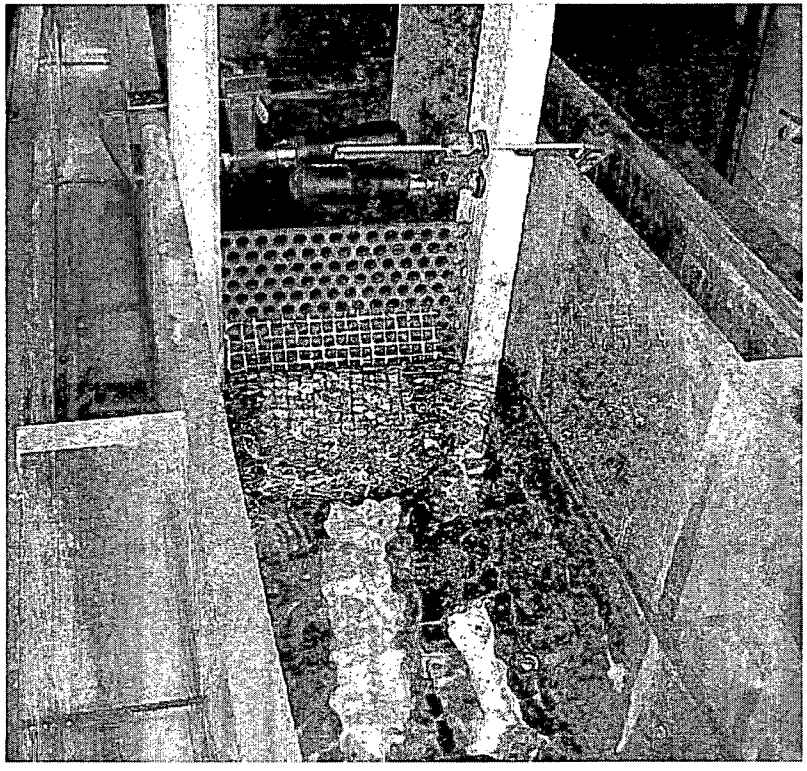
•ALION-REP-LAB-2352-77, Rev 3 – Test Report: Erosion Testing of Low Density Fiberglass Insulation.

•ALION-REP-TXU-4464-03, Comanche Peak Low Density Fiberglass Debris Erosion Testing Report"

***Alion issued* ALION-PLN-LAB-2352-77 and ALION-REP-LAB-2352-77 to the NRC on 070/8/09**

Please specifically include the following information:

RAI 6 - Erosion Testing



RAI 6 - Erosion Testing

RAI 6a: Please describe the test facility used and demonstrate the similarity of the flow conditions (velocity and turbulence), chemical conditions, and fibrous material present in the erosion tests to the analogous conditions applicable to the plant condition.

- Per Section 2.2 of "ALION-REP-TXU-4464-03, Comanche Peak Low Density Fiberglass Debris Erosion Testing Report", NUKON LDFG testing was performed in Alion's Hydraulic Test Lab Vertical Test Loop (VTL) and the lab's Transport Flume (TF). Details of these apparatuses can be found in "ALION-PLN-LAB-2352-77: Low Density Fiberglass Erosion Test Plan" which is Ref. 3 of ALION-REP-TXU-4464-03.
- The description of the Test is given in Section 3 of ALION-REP-TXU-4464-03 as well.
- Per Section 3.3 of ALION-REP-TXU-4464-03, since the incipient tumbling velocity is the velocity at which the debris would start moving, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being carried to the sump strainer. Therefore, it is considered the velocity that would produce the most insulation fines that would travel to the sump strainer while the piece of insulation itself would remain stationary in the pool.

RAI 6 - Erosion Testing

- Per Section 3.4 of ALION-REP-TXU-4464-03, the increased post-LOCA water temperature at Comanche Peak would have no effect on the flow erosion of fiberglass since the higher water temperature does not affect the chemical or physical reaction of the fibers with respect to physical erosion taking place. Per Ref. 1 of ALION-REP-TXU-4464-03, i.e. "ALION-REP-LAB-2352-77, Test Report: Erosion Testing of Low Density Fiberglass Insulation", the tests were conducted in tap water and not buffered or borated water that would be present in containment. The use of tap water is considered appropriate because the lack of chemicals such as aluminum, boron, or pH buffers will not affect the amount of fibers that would erode off of a Nukon sample with respect to flow erosion. On the contrary, the presence of some chemicals such as aluminum would actually bond to the fibers and increase the mass of the Nukon sample instead of aiding its erosion.
- Additionally, if turbulence is high enough to not allow settling, then the insulation debris will be transported to the sump strainers. In both cases, since the debris will be transported to the sump strainers, it will not be sitting in the containment pool and its flow erosion will not be taken into consideration as it will be irrelevant. The erosion factor is applied to the portion of the small and large pieces of fiber in the pool that are subjected to a low enough turbulence to allow settling and low enough velocity (i.e. a velocity lower than the corresponding incipient tumbling velocity) to avoid tumbling. A combination of the above two conditions applies to a portion of the pool that is calmer than the rest of the areas.

RAI 6 - Erosion Testing

- As discussed in Section 4.0 of ALION-REP-TXU-4464-03, it was observed that the term fiber "erosion" to describe the loss of weight is more aptly described as fiber "attrition." The fibers themselves that make up the samples do not actually erode down into fines as the water passes across them; the "erosion" is actually the release of loosely bound constituent fibers that are washed away by the flowing water. Alion's experience with fibrous debris during other types of tests is evident of this behavior. During testing, the following is usually observed that when the clumps of fiber subjected to a velocity such that an erosion factor is applicable (as discussed above) on the floor of a test pool:
  - Individual fibers tend to clump which is evident by the measures taken by the Alion Hydraulics Laboratory to keep them apart during testing.
  - Individual fibers released tend to re-clump or adhere to pieces of fiber present downstream.
- No credit is taken for the above.

RAI 6 - Erosion Testing

RAI 6b is: Please provide specific justification for any erosion tests conducted at a minimum tumbling velocity if debris settling was credited in the test flume for velocities in excess of this value.

•Per Section 3.3 of ALION-REP-TXU-4464-03, since the incipient tumbling velocity is the velocity at which the debris would start moving, this velocity bounds the greatest velocity that a piece of insulation lying in the containment pool would experience without being carried to the sump strainer. Therefore, it is considered the velocity that would produce the most insulation fines that would travel to the sump strainer while the piece of insulation itself would remain stationary in the pool.

RAI 6 - Erosion Testing

RAI 6c is: Please identify the duration of the erosion tests and how the results were extrapolated to the sump mission time.

•The results for small Nukon erosion testing did not require extrapolation due to having performed 30 day tests.

•Twenty two (22) erosion tests were performed on small pieces of NUKON™, each test consisting of 8-12 samples. Each such test is an average of the results obtained from the corresponding set of samples, i.e. each data point in Figure 3.2-1 of Reference 3 of ALION-REP-TXU-4464-03. The results are used to represent the entire size distribution of the insulation material that the erosion factor will be applied to. This is conservative because Alion testing has shown that smaller pieces that have a higher relative surface area (i.e. higher surface to mass ratio which means more expected erosion per gram) erode more than larger pieces; therefore, the larger pieces in containment would typically erode less than the bounding value that this report applies. Note that by the large amount of data represented by Figure 3.2-1, although a disparity of results is not expected, but because of the small size and mass of the samples, a substantial data scatter is expected.

RAI 6 - Erosion Testing

- The erosion factor is based on the pre-test and post-test mass differences of each sample, so any handling losses also are represented by the erosion factor, since there isn't a way of differentiating the handling losses from the actual erosion during testing. This results in an additional potential conservatism. But because of gained experience by the Alion testing team, the later testing resulted in more consistent data. So while the 30 day samples exhibit lower results then some of the earlier samples, they were in fact the last set of tests performed and due to the number of test performed and the experience of the test staff are considered the most consistent/accurate.
- Four (4) of the samples exhibited greater than 10% erosion which is attributed to some expected randomness and since the erosion factor will be applied to many randomly sized pieces of fiberglass one would expect some to exhibit greater and others lower amounts. Note that for thirteen (13) of the twenty two (22) samples (more than half of the samples) showed an erosion factor of less than 5% (half of the erosion factor that will be applied) which introduces an additional conservatism.

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Preliminary Assessment of Containment Pool with respect to Erosion Testing

Comanche Peak
Emergency Sump Performance
July 9th 2009

ALION
SCIENCE AND TECHNOLOGY

Updated: 7/6/09

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Erosion Testing – Flume Turbulence vs. Plant Turbulence

- Velocity in flume tests set to approximately 0.12 ft/s, which is the tumbling velocity for small pieces of fiberglass
- Flume turbulence levels during erosion testing were not directly measured, but can be estimated using CFD
- Comanche Peak Loop 4 break, two train operation: 100% transport of small fiberglass debris (small piece fiberglass erosion is not applicable for this case)
- Comanche Peak Loop 4 break, single train Sump B: partial transport of small fiberglass debris

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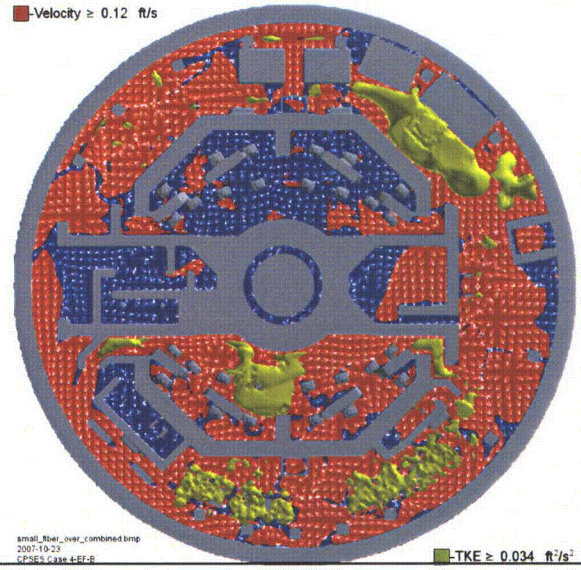
Slide 3

TKE and velocity with limits set at suspension/tumbling of small pieces of fiberglass (Loop 4 LBLOCA Single Train Sump B)



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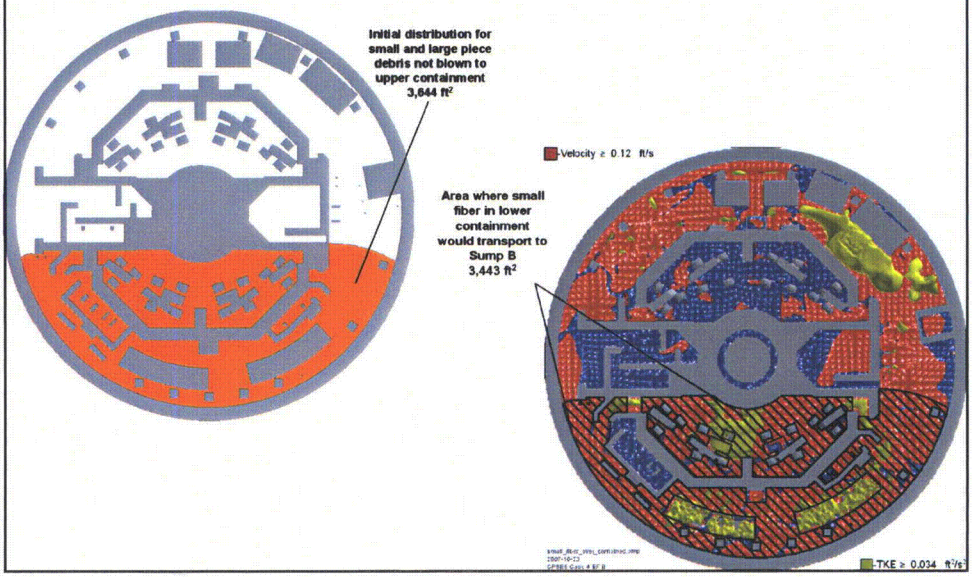
Slide 4

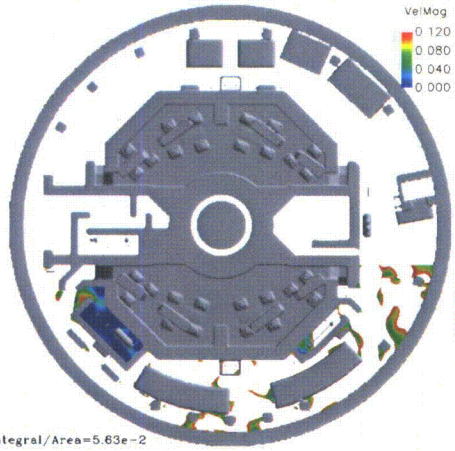
Area where small fiberglass in lower containment would transport (Loop 4 LBLOCA Single Train Sump B)



Aligned with your needs.

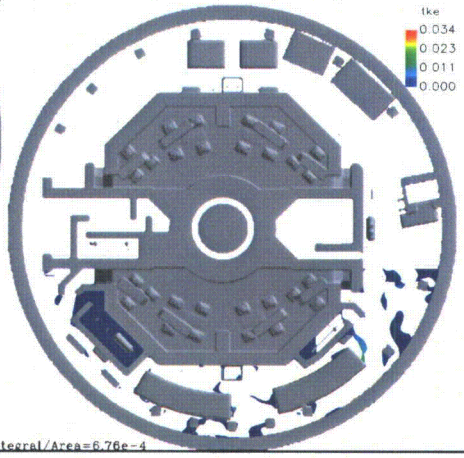
Slide 5

Preliminary Average Velocity and Turbulence for Small Pieces of Fiberglass Debris in Lower Containment that do not Transport (2% of Small Fiberglass Debris Generated)



Average Velocity = 0.056 ft/s

Average Turbulence = 0.00068 ft²/s²



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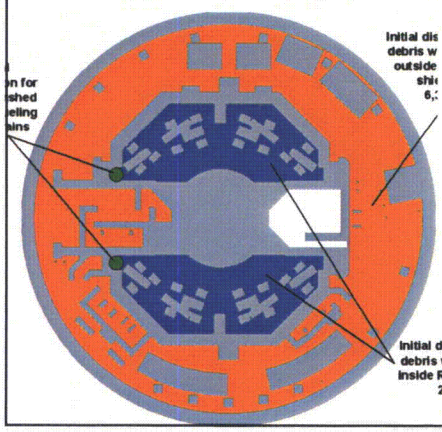
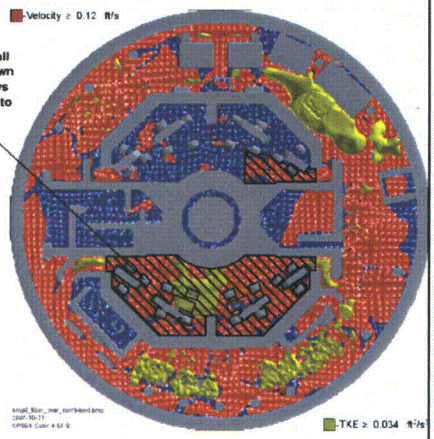
Slide 6

Area where small fiberglass washed down to lower containment inside the RCS loop bays would transport (Loop 4 LBLOCA Single Train Sump B)



Initial distribution for debris washed down inside RCS loop bays 2,311 ft²

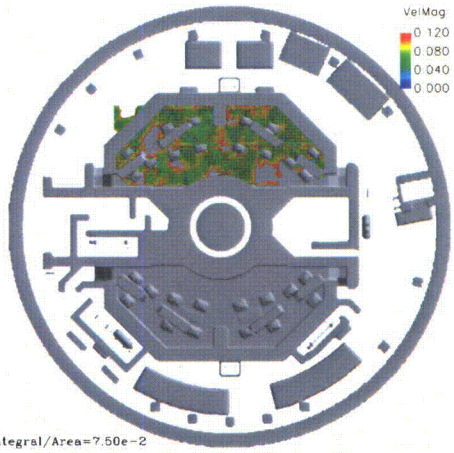


Area where small fiber washed down in RCS loop bays would transport to Sump B 1,319 ft²

Aligned with your needs.

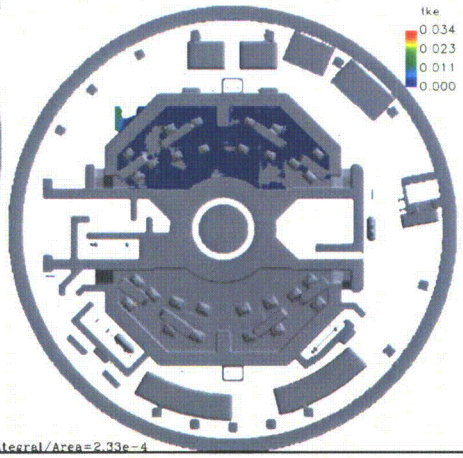
Slide 7

Preliminary Average Velocity and Turbulence for Small Pieces of Fiberglass Debris Washed Down Inside RCS Loop Bays that do not Transport (4% of Small Fiberglass Debris Generated)



Average Velocity = 0.075 ft/s

Average Turbulence = 0.00023 ft^2/s^2



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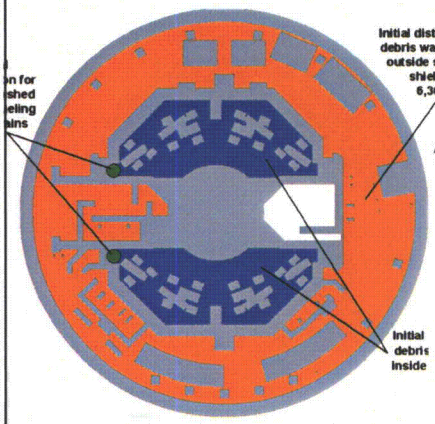
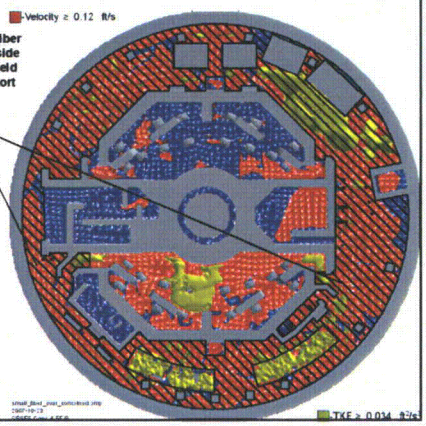
Slide 8

Area where small fiberglass washed down to lower containment outside the secondary shield wall would transport (Loop 4 LBLOCA Single Train Sump B)





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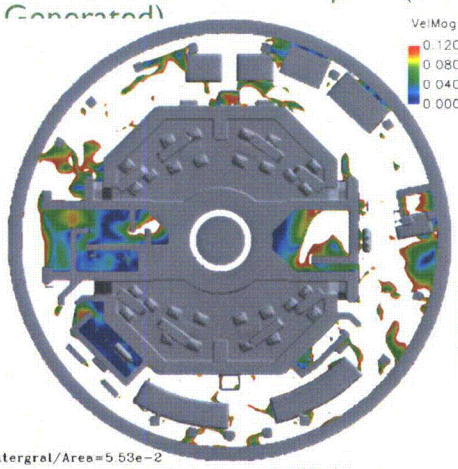
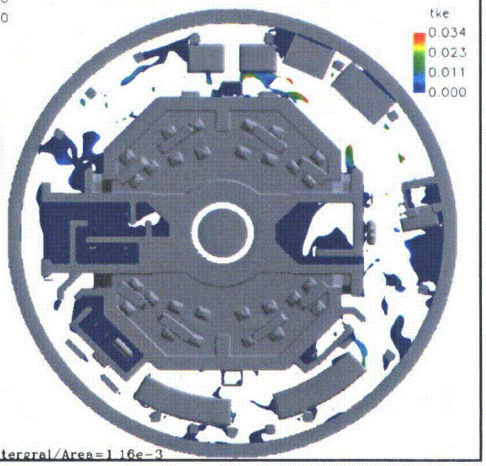
Slide 9

Preliminary Average Velocity and Turbulence for Small Pieces of Fiberglass Debris Washed Down Outside Secondary Shield Wall that do not Transport (5% of Small Fiberglass Debris Generated)



Average Velocity = 0.055 ft/s

Average Turbulence = 0.0012 ft^2/s^2



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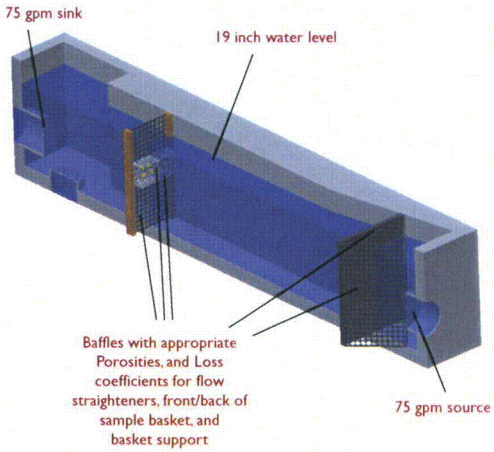
Slide 10

CFD Model of Flume Small Fiberglass Erosion Test



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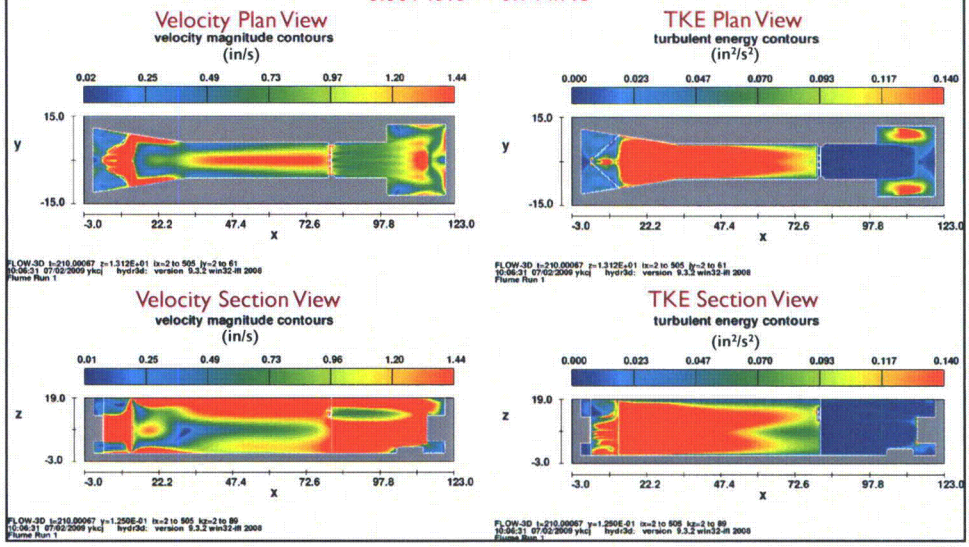
Slide 11

Preliminary Flume Velocity and Turbulence

0.12 ft/s = 1.4 in/s
0.001 ft^2/s^2 = 0.14 in^2/s^2



Aligned with your needs.

Slide 12

Preliminary Comparison of Comanche Peak Pool Velocity/Turbulence to Flume Velocity/Turbulence

Comanche Peak Pool

- Average Velocity for Small Pieces that do not Transport
  - Lower Containment: 0.056 ft/s
  - Washed to Loop Bays: 0.075 ft/s
  - Washed outside Loop Bays: 0.055 ft/s
- Average Turbulence for Small Pieces that do not Transport
  - Lower Containment: 0.00068 ft^2/s^2
  - Washed to Loop Bays: 0.00023 ft^2/s^2
  - Washed outside Loop Bays: 0.0012 ft^2/s^2

Alion Test Flume

- Velocity: Approximately 0.12 ft/s at sample basket
- Turbulence: Slightly less than 0.001 ft^2/s^2 at sample basket

Conclusions

- The velocity in the flume during the erosion tests was approximately double the average velocity for which non-transporting pieces of small fiberglass in the Comanche Peak pool would be exposed.
- The turbulence in the flume during the erosion tests was approximately equal to the average turbulence for which non-transporting pieces of small fiberglass in the Comanche Peak pool would be exposed.