Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, D.C. 20555

Direct tel: 412-374-6206
Direct fax: 412-374-5005
e-mail: sisk1rb@westinghouse.com

Your ref: Docket No. 52-006
Our ref: DCP_NRC_002535

June 17, 2009

Subject: Regulatory Guide 1.82, Revision 3 Assessment, Revision 1

Westinghouse is submitting the enclosed matrix that provides an assessment of the AP1000 design with respect to Regulatory Guide 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident." The matrix provides a summary response to each RG 1.82 item and a reference to the AP1000 DCD and/or to one of the detailed reports that we have recently submitted. As such, this assessment does not provide new information but rather provides a reference to facilitate the NRC review and acceptance of the AP1000 Containment Recirculation and IRWST screens.

Detailed Containment Recirculation and IRWST screens information is contained in the following documents:

1. APP-GW-GLN-147, Revision 2, "AP1000 Containment Recirculation and IRWST Screen Design," Technical Report 147, May 2009

2. WCAP-16914-P, Revision 1, "Evaluation of Debris Loading Head Loss Tests for AP1000 Recirculation Screens and In-Containment Refueling Water Storage Tank Screens," to be issued to the NRC in June 2009

3. APP-GW-GLR-079, Revision 4, Technical Report 26, "AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a LOCA," to be issued to the NRC in June 2009

4. APP-GW-GLE-002, Revision 2, "Impacts to AP1000 DCD to Address Generic Safety Issue (GSI)-191," May 2009

5. APP-PXS-GLR-001, Revision 1, "Impact on AP1000 Post-LOCA Long Term Cooling of Postulated Containment Sump Debris," May 2009

6. WCAP-17028-P, Revision 1, "Evaluation of Debris Loading Head Loss Tests For AP1000 Fuel Assemblies During Loss of Coolant Accidents"; to be issued to the NRC in June 2009

DO63
NRO

This letter is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information provided in this report is generic and is expected to apply to all Combined Operating License (COL) applicants referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Questions or requests for additional information related to content and preparation of this information should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of letter.

Very truly yours,

D. A. Lindgren /For

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Attachment

1. AP1000 Regulatory Guide 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident" Assessment Matrix, Revision 1

cc:	P. Donnelly	-	U.S. NRC	1A
	E. McKenna	-	U.S. NRC	1A
	T. Spink	-	TVA	1A
	P. Hastings	-	Duke Power	1A
	R. Kitchen	-	Progress Energy	1A
	A. Monroe	-	SCANA	1A
	P. Jacobs	-	Florida Power & Light	1A
	C. Pierce	-	Southern Company	1A
	E. Schmiech	-	Westinghouse	1A
	G. Zinke	-	NuStart/Entergy	1A
	R. Grumbir	-	NuStart	1A
	J. Monahan	-	Westinghouse	1A
	T. Schulz		Westinghouse	1A

ATTACHMENT 1

AP1000 Regulatory Guide 1.82, Revision 3, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident" Assessment Matrix

Revision 1

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1	**PRESSURIZED WATER REACTORS**	The AP1000 is a Pressurized Water Reactor (PWR). Therefore, this section is the appropriate section to perform a comparison between Regulatory Positions stated in the Regulatory Guide, the applicability of those positions to the AP1000 and how the AP1000 design addresses those regulatory positions.
C-1.1	**Features Needed To Minimize the Potential for Loss of NPSH** The ECC sumps, which are the source of water for such functions as ECC and containment heat removal following a LOCA, should contain an appropriate combination of the following features and capabilities to ensure the availability of the ECC sumps for long-term cooling. The adequacy of the combinations of the features and capabilities should be evaluated using the criteria and assumptions in Regulatory Position 1.3.	The AP1000 does not use pumps to provide core or containment cooling during a LOCA. As a result this section does not apply to the AP1000.
C-1.1.1	**ECC Sumps, Debris Interceptors, and Debris Screens**	
C-1.1.1.1	A minimum of two sumps should be provided, each with sufficient capacity to service one of the redundant trains of the ECCS and CSS. Distribution of water sources and containment spray between the sumps should be considered in the calculation of boron concentration in the sumps for evaluating post-LOCA sub criticality and shutdown margins. Typically, these calculations are performed assuming minimum boron concentration and minimum dilution sources. Similar considerations should also be given in the calculation of time for Hot Leg Switchover, which is calculated assuming maximum boron concentration and a minimum of dilution sources.	1. The AP1000 provides for two separate containment recirculation (CR) screens. Each screen is associated with one Passive Core Cooling System (PXS) subsystem. In order to increase margins the two screens have an interconnection between them so that in case one PXS subsystem does not draw recirculation water both screens are available to support the one functioning PXS subsystem. The screen testing performed for the AP1000 (Reference 2) demonstrates that the screens have significant margin. 2. The AP1000 does not have a containment spray system that would be used during a design basis LOCA. Therefore issues associated with containment spray are not applicable to the AP1000 design. The AP1000 does have a non-safety containment spray feature. This feature is only permitted to be used during a severe accident. 3. Boric acid dilution evaluation for the AP1000 has previously demonstrated acceptable boric acid concentrations in both the recirculating pool volume and the reactor vessel post-accident. Refer to DCD section 15.6.5.4C.4. Note that because of the effectiveness of ADS stage 4 in carrying over water from the RCS, the AP1000 does not have Hot Leg Switchover.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.2	To the extent practical, the redundant sumps should be physically separated by structural barriers from each other and from high-energy piping systems to preclude damage from LOCA, and, if within the design basis, main steam or main feedwater break consequences to the components of both sumps (e.g., trash racks, sump screens, and sump outlets) by whipping pipes or high-velocity jets of water or steam.	The AP1000 CR screens are separate screens that are located next to each other in one of the AP1000 loop compartments. This location is dictated by the location of the PXS sub-compartments and the large size of the screens The location of these screens has been evaluated to demonstrate that they are not impacted by whipping pipes or high-velocity jets of water or steam. DCD subsection 3.6.4.1 states that an evaluation was performed (APP-GW-GLR-074) to determine the method of protection to be used for safety-related targets located in the vicinity of postulated high-energy pipe breaks. DCD Table 3.6-3 shows that the PXS CR screens in Room 11202 are protected by pipe whip restraints from the effects of three postulated pipe breaks in Rooms 11302 and 11602. Note that all of these breaks are secondary side breaks and the CR screens are not expected to be used during non-LOCA accidents; however for plant design margin it is assumed that the CR screens do have to be protected from such breaks. Due to a design change, the heat exchanger (HX) that is used to remove heat from the reactor coolant pump (RCP) was changed from an internal HX to an external HX. As a result, there are now two 3" pipes that connect each RCP motor to its HX. There are 4 potential break locations associated with these lines (per RCP). For three of these break locations, the orientation of the connection and routing of the pipe prevents pipe whip and jet impingement on the CR screens. For the other break location, it is expected that pipe whip restraints or jet shields will not be required because of the design of the piping and the RCP internals. The RCP has a labyrinth restriction located along the RCP shaft next to the pump casing and the volume of cold water contained in the RCP is small. Following a break of a cooling water line, the labyrinth immediately reduces the pressure in the RCP motor (to less than about 1100 psia) and the break flow (to about 13% of what it would be without the labyrinth). The limited volume of cold water results in a very short duration of cold water jetting; once a two phase mixture starts to flow out the pipe break, the distance to the screens prevents jet impingement damage. Since these RCP lines are not expected to require pipe whip restraints or jet shields they do not need to be added to DCD Table 3.6-3.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.3	The sumps should be located on the lowest floor elevation in the containment exclusive of the reactor vessel cavity to maximize the pool depth relative to the sump screens. The sump outlets should be protected by appropriately oriented (e.g., at least two vertical or nearly vertical) debris interceptors: (1) a fine inner debris screen and (2) a coarse outer trash rack to prevent large debris from reaching the debris screen. A curb should be provided upstream of the trash racks to prevent high-density debris from being swept along the floor into the sump. To be effective, the height of the curb should be appropriate for the pool flow velocities, as the debris can jump over a curb if the velocities are sufficiently high. Experiments documented in NUREG/CR-6772 and NUREG/CR-6773 have demonstrated that substantial quantities of settled debris could transport across the sump pool floor to the sump screen by sliding or tumbling.	1. The AP1000 CR screens are located near the floor of the loop compartment. Note that the containment floodup level is significantly higher in AP1000 than in operating plants. This allows for the use of a high curb (24 inch) and still have the water level rise ~10 feet above the top of the screen during post LOCA recirculation operation. This screen curb is very effective in the AP1000 due to the very limited amount of debris and low flows / velocities allowed by the plant design. DCD section 6.3.2.2.7.3 describes these elevations. Reference 1 provides detailed descriptions and drawings of these screens. 2. The In-containment Refueling Water Storage Tank Screens are located at the floor of the tank. A 6 inch curb is provided in front of the screens. The IRWST is a closed tank that contains very limited sources of debris. DCD section 6.3.2.2.7.2 describes these elevations. Reference 1 provides detailed descriptions and drawings of these screens. Reference 3 provides an evaluation of the debris that could be transported to the IRWST Screens. 3. The screens are constructed of perforated stainless steel plate that is used to formed pockets. The structural integrity of this configuration is well in excess of screen-like material that was typically used in PWR sump screens prior to actions taken to close Generic Safety Issue GSI-191 and respond to Generic Letter GL 2004-02. As is the case with current operating plants, the structural integrity of the AP1000 screens precludes the need for trash racks. Reference 1 provides additional discussion of the design of the AP1000 screens.
C-1.1.1.4	The floor in the vicinity of the ECC sump should slope gradually downward away from the sump to further retard floor debris transport and reduce the fraction of debris that might reach the sump screen.	The AP1000 loop compartment is 29 feet from the wall near the reactor vessel to the wall behind the SG. The floor extends 12 foot from the RV wall and then drops 3 foot. The floor under the SG is at this lower elevation to facilitate reactor coolant pump removal. Although the floor in the vicinity of the CR screens is not sloped, the initial spill of water will result in water and any debris flowing away from the screens and into the lower portion of the loop compartment. Also note that the protective plate located above the screens extends out to where the floor drops to the lower level. This plate prevents debris from falling into the recirculation water close to the screens. Reference 1 provides additional information about CR screens and the floor elevations around them.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.5	All drains from the upper regions of the containment should terminate in such a manner that direct streams of water, which may contain entrained debris, will not directly impinge on the debris interceptors or discharge in close proximity to the sump. The drains and other narrow pathways that connect compartments with potential break locations to the ECC sump should be designed to ensure that they would not become blocked by the debris; this is to ensure that water needed for an adequate NPSH margin could not be held up or diverted from the sump.	The AP1000 does not have a containment spray system that would operate during a design basis LOCA and as a result does not have a large amount of water that needs to be drained from the operating deck down to the CR screens. Most of the water that flows to the CR screens will come out of the ADS stage 4 valves. These ADS Stage 4 valves discharge into both loop compartments. As a result, the only passage with significant flow is the corridor that connects the two loop compartments. This corridor is level and more than 8 feet wide. The AP1000 does have three rooms located below the normal post-LOCA containment flood level that do not normally flood. These rooms include the two PXS subsystem rooms and the CVS purification room. These rooms are discussed in the DCD flood hazards analysis (DCD section 3.4.1.2.2.2). These rooms are designed so that they do not normally flood during a LOCA. The rooms drain to the containment sump through redundant series check valves. One of the PXS rooms can initially flood if there is a LOCA of a direct vessel injection (DVI) line in one of these rooms. Such an event is considered in the long term cooling analysis performed in DCD Chapter 15 (DCD 15.6.5.4C). In addition, it is conservatively assumed that leakage will eventually cause all of these rooms to flood. This "wall-to-wall" case is also considered in Chapter 15 (DCD 15.6.5.4C.3).
C-1.1.1.6	The strength of the trash racks should be adequate to protect the debris screens from missiles and other large debris. Trash racks and sump screens should be capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under design-basis flow conditions. When evaluating impact from potential expanding jets and missiles, credit for any protection to trash racks and sump screens offered by surrounding structures or credit for remoteness of trash racks and sump screens from potential high energy sources should be justified.	The response to item C-1.1.1.2 discusses the design of the screen relative to whipping pipes and jet impingement. The AP1000 design precludes the generation of missiles inside containment as discussed in DCD section 3.5.1.2. The screen testing demonstrated that they will not see a significant head loss while operating with design basis flow / debris conditions (Reference 2). In addition, the screens will be designed to withstand a significant head loss.
C-1.1.1.7	Where consistent with overall sump design and functionality, the top of the debris interceptor structures should be a solid cover plate that is designed to be fully submerged after a LOCA and completion of the ECC injection. The cover plate is intended to provide additional protection to debris interceptor structures from LOCA-generated loads. However, the design should also provide means for venting of any air trapped underneath the cover.	The top of the cassettes for the AP1000 CR and IRWST screens is a solid plate that is vented. In addition, the AP1000 employs another plate that extends out 10 feet in front of the CR screens as well as 7 foot to the side. This plate prevents debris from falling into the water just in front of the screens. This plate is discussed in the DCD in subsection 6.3.2.2.7.3 and shown in detail in Reference 1.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.8	The debris interceptors should be designed to withstand the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.	The AP1000 screens are designed to mitigate the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.
C-1.1.1.9	Materials for debris interceptors and sump screens should be selected to avoid degradation during periods of both inactivity and operation and, should have a low sensitivity to such adverse effects as stress-assisted corrosion that may be induced by chemically reactive spray during LOCA conditions.	The CR screens for the AP1000 are constructed of stainless steel. This material's ability to withstand degradation during both periods of inactivity and activity is well known. The AP100 has no spray system that will be used during design basis LOCAs to challenge the CR screens.
C-1.1.1.10	The debris interceptor structures should include access openings to facilitate inspection of these structures, any vortex suppressors, and the sump outlets.	The design of the AP1000 screens is presented in Reference 1. This reference includes drawings that show access panels to allow such inspections. Also note that the pockets can be removed in groups if needed to provide additional access.
C-1.1.1.11	A sump screen design (i.e., size and shape) should be chosen that will avoid the loss of NPSH from debris blockage during the period that the ECCS is required to operate in order to maintain long-term cooling or maximize the time before loss of NPSH caused by debris blockage when used with an active mitigation system (see Regulatory Position 1.1.4).	The AP1000 CR screens were designed very conservatively relative to the amount of debris expected in the AP1000. As shown in Reference 3, the calculated head loss is low, less than the head loss shown to be acceptable in Ref. 5. This agrees with the AP1000 screen test results (Reference 2). The AP1000 does not use ECCS pumps.
C-1.1.1.12	The possibility of debris-clogging flow restrictions downstream of the sump screen should be assessed to ensure adequate long term recirculation cooling, containment cooling, and containment pressure control capabilities. The size of the openings in the sump debris screen should be determined considering the flow restrictions of systems served by the ECCS sump. The potential for long thin slivers passing axially through the sump screen and then reorienting and clogging at any flow restriction downstream should be considered. Consideration should be given to the buildup of debris at downstream locations such as the following: containment spray nozzle openings, HPSI throttle valves, coolant channel openings in the core fuel assemblies, fuel assembly inlet debris screens, ECCS pump seals, bearings, and impeller running clearances. If it is determined that a sump screen with openings small enough to filter out particles of debris that are fine enough to cause damage to ECCS pump seals or bearings would be impractical, it is expected that modifications would be made to ECCS pumps or ECCS pumps would be procured that can operate long term under the probable conditions.	The AP1000 PXS post LOCA recirculation lines do not use pumps, heat exchangers, throttle valves, spray nozzles or orifices (DCD Section 6.3). As a result, the AP1000 has eliminated many of the potential problems associated with debris passing through the ECCS. As discussed in Reference 3, a downstream effects evaluation was performed for the AP1000 PXS. The results of the evaluation demonstrated that debris-clogging, wear and abrasion have negligible impact on the post-accident operation of the PXS. Testing was performed for the AP1000 fuel assembly (Ref. G) that demonstrates that the head loss is less than that which has been shown to be acceptable (Ref. 5).

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.13	ECC and containment spray pump suction inlets should be designed to prevent degradation of pump performance through air ingestion and other adverse hydraulic effects (e.g., circulatory flow patterns, high intake head losses).	The AP1000 design does not have core or containment cooling pumps. Therefore, this regulatory position does not apply to the AP1000 design. Note that the post LOCA containment flood up water level is about 10 feet above the top of the CR screens.
C-1.1.1.14	All drains from the upper regions of the containment building, as well as floor drains, should terminate in such a manner that direct streams of water, which may contain entrained debris, will not discharge downstream of the sump screen, thereby bypassing the sump screen.	This issue is addressed in the response to item C-1.1.1.5.
C-1.1.1.15	Advanced strainer designs (e.g., stacked disc strainers) have demonstrated capabilities that are not provided by simple flat plate or cone-shaped strainers or screens. For example, these capabilities include built-in debris traps where debris can collect on surfaces while keeping a portion of the screen relatively free of debris. The convoluted structure of such strainer designs increases the total screen area, and these structures tend to prevent the condition referred to as the thin bed effect. It may be desirable to include these capabilities in any new sump strainer/screen designs. The performance characteristics and effectiveness of such designs should be supported by appropriate test data for any particular intended application.	The AP1000 design uses an advanced strainer design, such as that described in this regulatory position, for its CR screens. Therefore, the AP1000 design complies with this regulatory position. The details of the AP1000 screen design are provided in Reference 1.
C-1.1.2	**Minimizing Debris** The debris (see Regulatory Position 1.3.2) that could accumulate on the sump screen should be minimized.	The AP1000 design greatly reduces the amount of debris generated and transported to the CR screens. The use of insulation that can be damaged by LOCA forces and generate fibrous debris is precluded (DCD subsection 6.3.2.2.7.1 item 3). Coatings applied to walls, floors, structures, and engineered components are required to be high density such that should they detach they will settle out and not be transported to the screens. Signs and tags used inside containment are high density such that if they detach they will settle out and not transport to the screens (DCD subsection 6.3.2.2.7.1, item 10). The CR screens employ protective plates that prevent debris from falling into the water close to the screens (DCD subsection 6.3.2.2.7.3). A cleanliness program is required as discussed in C-1.1.2.1
C-1.1.2.1	Cleanliness programs should be established to clean the containment on a regular basis, and plant procedures should be established for control and removal of foreign materials from the containment.	The AP1000 COL holder is required to define a cleanliness program to limit the debris that might be left in the containment following refueling and maintenance outages (DCD subsection 6.3.8.1). Note that the resident debris analysis presented in Reference 3 uses data from operating plants that have typical cleanliness programs.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.2.2	Insulation types (e.g., fibrous and calcium silicate) that can be sources of debris that is known to more readily transport to the sump screen and cause higher head losses may be replaced with insulations (e.g., reflective metallic insulation) that transports less readily and causes less severe head losses once deposited onto the sump screen. If insulation is replaced or otherwise removed during maintenance, abatement procedures should be established to avoid generating latent debris in the containment.	The AP1000 design specifies the use of metal reflective insulation in the containment that are subject to damage by LOCA jet impingement forces (DCD subsection 6.3.2.2.7.1 item 3).
C-1.1.2.3	To minimize potential debris caused by chemical reaction of the pool water with metals in the containment, exposure of bare metal surfaces (e.g., scaffolding) to containment cooling water through spray impingement or immersion should be minimized either by removal or by chemical-resistant protection (e.g., coatings or jackets).	Minimizing post-accident chemical effects was considered in the AP1000 design. The largest amount of base metal surface that would react with the AP1000 post LOCA water chemistry is the ex-core instrumentation. DCD Tier 1 Table 2.2.3 Item 8c) xiv) ensures that these sensors are enclosed in stainless steel (Reference 4). The amount of exposed aluminum permitted below the containment floodup level is limited to 60 lbs. Reference 3 presents the results of evaluations of the potential for generating chemical precipitants and also on down stream chemical effects. The results show that the AP1000 has effectively reduced the chemical effects.
C-1.1.3	**Instrumentation** If relying on operator actions to mitigate the consequences of the accumulation of debris on the ECC sump screens, safety-related instrumentation that provides operators with an indication and audible warning of impending loss of NPSH for ECCS pumps should be available in the control room.	Operator action is not relied upon to mitigate the consequences of the accumulation of debris on the post LOCA screens because of the design of the AP1000 passive systems and the aggressive approach to reducing potential debris sources and providing large / advanced design screens. In addition, the AP1000 does not use pumps for post LOCA core or containment cooling.
C-1.1.4	**Active Sump Screen System** An active device or system (see examples in Appendix B) may be provided to prevent the accumulation of debris on a sump screen or to mitigate the consequences of accumulation of debris on a sump screen. An active system should be able to prevent debris that may block restrictions found in the systems served by the ECC pumps from entering the system. The operation of the active component or system should not adversely affect the operation of other ECC components or systems. Performance characteristics of an active sump screen system should be supported by appropriate test data that address head loss performance.	The AP1000 design does not use an active sump screen system. Therefore, this regulatory position is not applicable to the AP1000 design.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.5	**Inservice Inspection** To ensure the operability and structural integrity of the trash racks and screens, access openings are necessary to permit inspection of the ECC sump structures and outlets. Inservice inspection of racks, screens, vortex suppressors, and sump outlets, including visual examination for evidence of structural degradation or corrosion, should be performed on a regular basis at every refueling period downtime. Inspection of the ECC sump components late in the refueling period will ensure the absence of construction trash in the ECC sump area.	The design of the AP1000 CR screens and IRWST screens provides for inspection as identified in this regulatory position. Refer to Reference 1 for details of the AP1000 screen design including access features. The AP1000 Technical Specifications contained in DCD section 16.1 (SR 3.5.6.8) require inspection of these screens every 24 months.
C-1.2	**Evaluation of Alternative Water Sources** To demonstrate that a combination of the features and actions listed above are adequate to ensure long-term cooling and that the five criteria of 10 CFR 50.46(b) will be met following a LOCA, an evaluation using the guidance and assumptions in Regulatory Position 1.3 should be conducted. If a licensee is relying on operator actions to prevent the accumulation of debris on ECC sump screens or to mitigate the consequences of the accumulation of debris on the ECC sump screens, an evaluation should be performed to ensure that the operator has adequate indications, training, time, and system capabilities to perform the necessary actions. If not covered by plant-specific emergency operating procedures, procedures should be established to use alternative water sources that will be activated when unacceptable head loss renders the sump inoperable. The valves needed to align the ECCS and containment spray systems (taking suction from the recirculation sumps) with an alternative water source should be periodically inspected and maintained.	As discussed in item C-1.1.3 operator actions are not relied upon for the AP1000 to prevent the accumulation of debris on post LOCA screens. This item does not apply to the AP1000.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3	**Evaluation of Long-Term Recirculation Capability** The following techniques, assumptions, and guidance should be used in a deterministic, plant-specific evaluation to ensure that any implementation of a combination of the features and capabilities listed in Regulatory Position 1.1 are adequate to ensure the availability of a reliable water source for long-term recirculation following a LOCA. The assumptions and guidance listed below can also be used to develop test conditions for sump screens. Evaluation and confirmation of (1) sump hydraulic performance (e.g., geometric effects, air ingestion), (2) debris effects (e.g., debris transport, interceptor blockage, head loss), and (3) the combined impact on NPSH available at the pump inlet should be performed to ensure that long-term recirculation cooling can be accomplished following a LOCA. Such an evaluation should arrive at a determination of NPSH margin calculated at the pump inlet. An assessment should also be made of the susceptibility to debris blockage of the containment drainage flow paths to the recirculation sump; this is to protect against reduction in available NPSH if substantial amounts of water are held up or diverted away from the sump. An assessment should be made of the susceptibility of the flow restrictions in the ECCS and CSS recirculation flow paths downstream of the sump screens and of the recirculation pump seal and bearing assembly design to failure from particulate ingestion and abrasive effects to protect against degradation of long-term recirculation pumping capacity.	Refer to applicable items below.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.1	**Net Positive Suction Head of ECCS and Containment Heat Removal Pumps**	
C-1.3.1.1	ECC and containment heat removal systems should be designed so that sufficient available NPSH is provided to the system pumps, assuming the maximum expected temperature of pumped fluid and no increase in containment pressure from that present prior to the postulated LOCA. (See Regulatory Position 1.3.1.2.) For sump pools with temperatures less than 212°F, it is conservative to assume that the containment pressure equals the vapor pressure of the sump water. This ensures that credit is not taken for the containment pressurization during the transient. For sub atmospheric containments, this guidance should apply after the injection phase has terminated. For sub atmospheric containments, prior to termination of the injection phase, NPSH analyses should include conservative predictions of the containment atmospheric pressure and sump water temperature as a function of time.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.2	For certain operating PWRs for which the design cannot be practicably altered, conformance with Regulatory Position 1.3.1.1 may not be possible. In these cases, no additional containment pressure should be included in the determination of available NPSH than is necessary to preclude pump cavitation. Calculation of available containment pressure and sump water temperature as a function of time should underestimate the expected containment pressure and overestimate the sump water temperature when determining available NPSH for this situation.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.3	For certain operating reactors for which the design cannot be practicably altered, if credit is taken for operation of an ECCS or containment heat removal pump in cavitation, prototypical pump tests should be performed along with post-test examination of the pump to demonstrate that pump performance will not be degraded and that the pump continues to meet all the performance criteria assumed in the safety analyses. The time period in the safety analyses during which the pump may be assumed to operate while cavitating should not be longer than the time for which the performance tests demonstrate that the pump meets performance criteria.	Not applicable since the AP1000 has no containment spray or safety injection pumps.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.1.4	The decay and residual heat produced following accident initiation should be included in the determination of the water temperature. The uncertainty in the determination of the decay heat should be included in this calculation. The residual heat should be calculated with margin.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.5	The hot channel correction factor specified in ANSI/HI 1.1-1.5-1994 should not be used in determining the margin between the available and required NPSH for ECCS and containment heat removal system pumps.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.6	The calculation of available NPSH should minimize the height of water above the pump suction (i.e., the level of water on the containment floor). The calculated height of water on the containment floor should not consider quantities of water that do not contribute to the sump pool (e.g., atmospheric steam, pooled water on floors and in refueling canals, spray droplets and other falling water, etc.). The amount of water in enclosed areas that cannot be readily returned to the sump should not be included in the calculated height of water on the containment floor.	The calculation of NPSH is not applicable to the AP1000 because there are no containment spray or safety injection pumps. AP1000 does use the elevation of water in the containment to drive the recirculation of water back into the RCS. As a result, a similar calculation of minimum containment water level was performed that considered the effect of: • Steam in the containment atmosphere • Water pooled on floors • Water film on the inside surface of the containment vessel due to operation of the passive containment cooling system • Water trapped in areas that are not readily returned to the containment • Water that fills one PXS room in case of a LOCA pipe break in that room DCD section 15.6.5.4C provides some discussion of this level.
C-1.3.1.7	The calculation of pipe and fitting resistance and the calculation of the nominal screen resistance without blockage by debris should be done in a recognized, defensible method or determined from applicable experimental data.	The head loss across the PXS recirculation piping system is simple and straight forward. The head loss across the CR screens under clean conditions was determined by test (Reference 2).
C-1.3.1.8	Sump screen flow resistance that is due to blockage by LOCA-generated debris or foreign material in the containment which is transported to the suction intake screens should be determined using Regulatory Position 1.3.4.	The screen head loss was estimated in Reference 3. Testing performed for AP1000 has confirmed that the head across the AP1000 screens will be low, less than the head loss shown to be acceptable in Ref. 5, with the AP1000 flow / debris conditions (Reference 2).
C-1.3.1.9	Calculation of available NPSH should be performed as a function of time until it is clear that the available NPSH will not decrease further.	Not applicable since the AP1000 has no containment spray or safety injection pumps.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2	**Debris Sources and Generation**	
C-1.3.2.1	Consistent with the requirements of 10 CFR 50.46, debris generation should be calculated for a number of postulated LOCAs of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated LOCAs are calculated. The level of severity corresponding to each postulated break should be based on the potential head loss incurred across the sump screen. Some PWRs may need recirculation from the sump for licensing basis events other than LOCAs. Therefore, licensees should evaluate the licensing basis and include potential break locations in the main steam and main feedwater lines as well in determining the most limiting conditions for sump operation.	Because the AP1000 design eliminates the use of fibrous insulation that can be damaged by LOCA forces (DCD subsection 6.3.2.2.7.1 item 3), the search for the most severe LOCA considers the amount of resident debris that would be transported to each screen. Refer to Reference 3 for additional discussion on debris amounts. The AP1000 does not use the CR screens for non-LOCA accidents.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.2	An acceptable method for estimating the amount of debris generated by a postulated LOCA is to use the zone of influence (ZOI). Examples of this approach are provided in NUREG/CR-6224 and Boiling Water Reactor Owners' Group (BWROG) Utility Resolution Guidance (NEDO-32686 and the staff's Safety Evaluation on the BWROG's response to NRC Bulletin 96-03). A representation of the ZOI for commonly used insulation materials is shown in Figure 3. • The size and shape of the ZOI should be supported by analysis or experiments for the break and potential debris. The size and shape of the ZOI should be consistent with the debris source (e.g., insulation, fire barrier materials, etc.) damage pressures, i.e., the ZOI should extend until the jet pressures decrease below the experimentally determined damage pressures appropriate for the debris source. • The volume of debris contained within the ZOI should be used to estimate the amount of debris generated by a postulated break. • The size distribution of debris created in the ZOI should be determined by analysis or experiments. • The shock wave generated during the postulated pipe break and the subsequent jet should be the basis for estimating the amount of debris generated and the size or size distribution of the debris generated within the ZOI. Certain types of material used in a small quantity inside the containment can, with adequate justification, be demonstrated to make a marginal contribution to the debris loading for the ECC sump. If debris generation and debris transport data have not been determined experimentally for such material, it may be grouped with another like material existing in large quantities. For example, a small quantity of fibrous filtering material may be grouped with a substantially large quantity of fibrous insulation debris, and the debris generation and transport data for the filter material need not be determined experimentally. However, such analyses are valid only if the small quantity of material treated in this manner does not have a significant effect when combined with other materials (e.g., a small quantity of calcium silicate combined with fibrous debris).	This criteria does not apply to the AP1000 in the sense that no debris which is generated by the LOCA is transported to the screens as a result of the insulation signage/tags and coatings design approach (DCD subsection 6.3.2.2.7.1 item 3). There is a zone of influence identified in this section of the DCD that used just to determine that there is no fibrous insulation damaged by a LOCA.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.3	A sufficient number of breaks in each high-pressure system that relies on recirculation should be considered to reasonably bound variations in debris generation by the size, quantity, and type of debris. As a minimum, the following postulated break locations should be considered. • Breaks in the reactor coolant system (e.g., hot leg, cold leg, pressurizer surge line) and, depending on the plant licensing basis, main steam and main feedwater lines with the largest amount of potential debris within the postulated ZOI, • Large breaks with two or more different types of debris, including the breaks with the most variety of debris, within the expected ZOI, • Breaks in areas with the most direct path to the sump, • Medium and large breaks with the largest potential particulate debris to insulation ratio by weight, and • Breaks that generate an amount of fibrous debris that, after its transport to the sump screen, could form a uniform thin bed that could subsequently filter sufficient particulate debris to create a relatively high head loss referred to as the 'thin-bed effect.' The minimum thickness of fibrous debris needed to form a thin bed has typically been estimated at 1/8 inch thick based on the nominal insulation density (NUREG/CR-6224).	This criteria does not apply to the AP1000 because no debris is generated by the LOCA as a result of the insulation design approach (DCD subsection 6.3.2.2.7.1 item 3). The only variable is the amount of resident debris transported to each screen. The report discusses the most severe LOCAs relative to resident debris transport.
C-1.3.2.4	All insulation (e.g., fibrous, calcium silicate, reflective metallic), painted surfaces, fire barrier materials, and fibrous, cloth, plastic, or particulate materials within the ZOI should be considered a debris source. Analytical models or experiments should be used to predict the size of the postulated debris. For breaks postulated in the vicinity of the pressure vessel, the potential for debris generation from the packing materials commonly used in the penetrations and the insulation installed on the pressure vessel should be considered. Particulate debris generated by pipe rupture jets stripping off paint or coatings and eroding concrete at the point of impact should also be considered.	The only insulation in the ZOI is metal reflective insulation which will not be transported to the AP1000 screens with the low AP1000 flow rates, as discussed in Reference 3. Data presented to the NRC indicates that PWR LOCA jets will not strip off paint. However, this characteristic is not credited in the AP1000. Although the AP1000 uses safety qualified coatings inside containment, other than the coating used on the inside of the containment vessel they are nonsafety in their application and inspections. As a result, it is assumed that they can detach following a LOCA. Note that as discussed in DCD subsection 6.1.2.1.5 and Table 6.1-2, these nonsafety coatings used inside containment are required to have a dry film density > 100 lbn/ft3 so that transport with the low water velocity in the AP1000 containments is limited

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.5	The cleanliness of the containment during plant operation should be considered when estimating the amount and type of debris available to block the ECC sump screens. The potential for such material (e.g., thermal insulation other than piping insulation, ropes, fire hoses, wire ties, tape, ventilation system filters, permanent tags or stickers on plant equipment, rust flakes from unpainted steel surfaces, corrosion products, dust and dirt, latent individual fibers) to impact head loss across the ECC sump screens should also be considered.	Refer to the response to item C-1.1.2.1.
C-1.3.2.6	In addition to debris generated by jet forces from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) should be considered in the analyses. Examples of this type of debris would be disbondment of coatings in the form of chips and particulates or formation of chemical debris (precipitants) caused by chemical reactions in the pool.	Refer to the response to item C-1.3.2.4 for a discussion of coating debris. Reference 3 specifically addresses the potential for formation of chemical debris. In addition, the testing performed for AP1000 included chemical debris and demonstrated that they produced acceptable head loss with AP1000 flows / debris amounts (Reference 2).
C-1.3.2.7	Debris generation that is due to continued degradation of insulation and other debris when subjected to turbulence caused by cascading water flows from upper regions of the containments or near the break overflow region should be considered in the analyses.	Because of the approach used in the AP1000 to use metal reflective insulation and that AP1000 does not have a containment spray system this consideration will not generate additional debris in the AP1000. Also see response to item C-1.1.1.5.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.3	**Debris Transport**	
C-1.3.3.1	The calculation of debris quantities transported from debris sources to the sump screen should consider all modes of debris transport, including airborne debris transport, containment spray washdown debris transport, and containment sump pool debris transport. Consideration of the containment pool debris transport should include (1) debris transport during the fill-up phase, as well as during the recirculation phase, (2) the turbulence in the pool caused by the flow of water, water entering the pool from break overflow, and containment spray drainage, and (3) the buoyancy of the debris. Transport analyses of debris should consider: (1) debris that would float along the pool surface, (2) debris that would remain suspended due to pool turbulence (e.g., individual fibers and fine particulates), and (3) debris that readily settles to the pool floor.	Because of the approach used in the AP1000 to use metal reflective insulation, high density coatings, and high density signs and tags, all of the AP1000 debris is resident debris. In Reference 3 it has been conservatively assumed that all the resident debris will be transported to an AP1000 screen.
C-1.3.3.2	The debris transport analyses should consider each type of insulation (e.g., fibrous, calcium silicate, reflective metallic) and debris size (e.g., particulates, fibrous fine, large pieces of fibrous insulation). The analyses should also consider the potential for further decomposition of the debris as it is transported to the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.3	Bulk flow velocity from recirculation operations, LOCA-related hydrodynamic phenomena, and other hydrodynamic forces (e.g., local turbulence effects or pool mixing) should be considered for both debris transport and ECC sump screen velocity computations.	Refer to the response to item C-1.3.3.1. The long term cooling analysis (DCD 15.6.5.4C) was used to determine the velocities through the screens.
C-1.3.3.4	An acceptable analytical approach to predict debris transport within the sump pool is to use computational fluid dynamics (CFD) simulations in combination with the experimental debris transport data. Examples of this approach are provided in NUREG/CR-6772 and NUREG/CR-6773. Alternative methods for debris transport analyses are also acceptable, provided they are supported by adequate validation of analytical techniques using experimental data to ensure that the debris transport estimates are conservative with respect to the quantities and types of debris transported to the sump screen.	Refer to the response to item C-1.3.3.1.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.3.5	Curbs can be credited for removing heavier debris that has been shown analytically or experimentally to travel by sliding along the containment floor and that cannot be lifted off the floor within the calculated water velocity range.	Refer to the response to item C-1.3.3.1.
C-1.3.3.6	If transported to the sump pool, all debris (e.g., fine fibrous, particulates) that would remain suspended due to pool turbulence should be considered to reach the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.7	The time to switch over to sump recirculation and the operation of containment spray should be considered in the evaluation of debris transport to the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.8	In lieu of performing airborne and containment spray washdown debris transport analyses, it could be assumed that all debris will be transported to the sump pool. In lieu of performing sump pool debris transport analyses (Regulatory Position 1.3.3.4), it could be assumed that all debris entering the sump pool or originating in the sump will be considered transported to the sump screen when estimating screen debris bed head loss. If it is credible in a plant that all drains leading to the containment sump could become completely blocked, or an inventory holdup in containment could happen together with debris loading on the sump screen, these situations could pose a worse impact on the recirculation sump performance than the assumed situations mentioned above. In this case, these situations should also be assessed.	Refer to the response to item C-1.3.3.1. AP1000 uses hallways and stairwells as flow paths; their blockage is not credible considering the small amount of debris in the AP1000. Refer to the response to item C-1.1.1.5.
C-1.3.3.9	The effects of floating or buoyant debris on the integrity of the sump screen and on subsequent head loss should be considered. For screens that are not fully submerged or are only shallowly submerged, floating debris could contribute to the debris bed head loss. The head loss due to floating or buoyant debris could be minimized by a design feature to keep buoyant debris from reaching the sump screen.	This consideration does not apply to the AP1000 screens. The post LOCA containment floodup level is about 10 feet above the top of the AP1000 CR screens (DCD 6.3.2.2.7.3).

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.4	**Debris Accumulation and Head Loss**	
C-1.3.4.1	ECC sump screen blockage should be evaluated based on the amount of debris estimated using the assumptions and criteria described in Regulatory Position 1.3.2 and on the debris transported to the ECC sump per Regulatory Position 1.3.3. This volume of debris should be used to estimate the rate of accumulation of debris on the ECC sump screen.	Reference 3 provides the evaluation of the AP1000 debris amounts and their transport to the AP1000 screens consistent with these criteria as discussed above. The total amount of debris has been assumed to accumulate in the time it takes to pass the containment floodup volume through the screens once.
C-1.3.4.2	Consideration of ECC sump screen submergence (full or partial) at the time of switchover to ECCS should be given in calculating the available (wetted) screen area. For plants in which containment heat removal pumps take suction from the ECC sump before switchover to the ECCS, the available NPSH for these pumps should consider the submergence of the sump screens at the time these pumps initiate suction from the ECC sump. Unless otherwise shown analytically or experimentally, debris should be assumed to be uniformly distributed over the available sump screen surface. Debris mass should be calculated based on the amount of debris estimated to reach the ECC sump screen. (See Revision 1 of NUREG-0897, NUREG/CR-3616, and NUREG/CR-6224.)	The AP1000 CR Screens are fully submerged at the time that they start recirculating water from the containment back into the RCS. The AP1000 does not use pumps for post LOCA core or containment cooling.
C-1.3.4.3	For fully submerged sump screens, the NPSH available to the ECC pumps should be determined using the conditions specified in the plant's licensing basis.	Refer to response for item C-1.3.4.2.
C-1.3.4.4	For partially submerged sumps, NPSH margin may not be the only failure criterion, as discussed in Appendix A. For partially submerged sumps, credit should only be given to the portion of the sump screen that is expected to be submerged, as a function of time. Pump failure should be assumed to occur when the head loss across the sump screen (including only the clean screen head loss and the debris bed head loss) is greater than one-half of the submerged screen height or NPSH margin.	Refer to response for item C-1.3.4.2.

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.4.5	Estimates of head loss caused by debris blockage should be developed from empirical data based on the sump screen design (e.g., surface area and geometry), postulated combinations of debris (i.e., amount, size distribution, type), and approach velocity. Because debris beds that form on sump screens can trap debris that would pass through an unobstructed sump screen opening, any head loss correlation should conservatively account for filtration of particulates by the debris bed, including particulates that would pass through an unobstructed sump screen.	Testing has been performed for the AP1000 (Reference 2). This testing included resident debris (fiber and particle) as well as chemical precipitants. The test results show that the head loss across the AP1000 screens is less than the values shown to be acceptable for long term cooling analysis (Ref. 5).
C-1.3.4.6	Consistent with the requirements of 10 CFR 50.46, head loss should be calculated for the debris beds formed of different combinations of fibers and particulate mixtures (e.g., minimum uniform thin bed of fibers supporting a layer of particulate debris) based on assumptions and criteria described in Regulatory Positions 1.3.2 and 1.3.3.	As discussed above the AP1000 does not have a variety of debris types for different break locations. It just has resident debris.

REFERENCES

1. APP-GW-GLN-147, Revision 2, "AP1000 Containment Recirculation and IRWST Screen Design" Technical Report 147
2. WCAP-16914-P, Revision 1, "Evaluation of Debris Loading Head Loss Tests for AP1000 Recirculation Screens and In-Containment Refueling Water Storage Tank Screens"
3. APP-GW-GLR-079, Revision 4, Technical Report 26, "AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a LOCA"
4. APP-GW-GLE-002, Revision 2, "Impacts to AP1000 DCD to Address Generic Safety Issue (GSI)-191"
5. APP-PXS-GLR-001, Revision 1, "Impact on AP1000 Post-LOCA Long Term Cooling of Postulated Containment Sump Debris"
6. WCAP-17028-P, Revision 1, "Evaluation of Debris Loading Head Loss Tests For AP1000 Fuel Assemblies During Loss of Coolant Accidents"