U.S. Nuclear Regulatory Commission Long-Term Research: FY 2009 Activities
Comments from the Center for Nuclear Waste Regulatory Analyses
May 25, 2007

The comments that follow are provided in response to the May 16, 2007 invitation from Brian Sheron, Director of the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research (RES). The Center for Nuclear Waste Regulatory Analyses (CNWRA) was identified as one of the NRC-RES "External Stakeholders," from which comments were specifically elicited. These comments are provided in the context of "U.S. Nuclear Regulatory Commission Long-Term Research: FY 2009 Activities," dated March 2007, and are intended to support the planned public meeting on this subject June 1, 2007. The CNWRA appreciates this opportunity to comment.

The following comments are organized in three categories. The first two categories address the two areas for which comments were specifically elicited in the May 16, 2007 letter: (i) potential gaps in the planned research and (ii) potential areas for collaboration between our organizations. Comments in these two categories are preceded by general observations and suggestions. Although not specifically elicited, the CNWRA trusts these comments will be useful as NRC-RES finalizes this important plan.

<u>General Observations and Suggestions</u>

1. Organization and Context. The plan is generally well conceived and well organized. Placing the proposed work within the overall "research-related strategies" context is important. A summary table, perhaps as an appendix, could be used to correlate each area of proposed research to (i) the regulatory objectives of NRC, (ii) these research-related strategies, (iii) time frame when results are needed, and other factors that will drive what eventually is funded and conducted.

2. Responsiveness to User Needs. Although the document repeatedly emphasizes that the proposed research is need driven, yet the role of the supported offices (i.e., the users) in identifying the research topics is not explicit in the plan. The CNWRA recognizes the merit of NRC-RES taking a forward-looking and somewhat independent perspective. However, it is important that a significant component of the research meet the often time-critical needs of the licensing offices. This is particularly true in areas that are immediately before the NRC, such as extending licenses for aging reactors, the new reactor program, new technology advances, and the like. Explicit recognition of immediate research needs versus more forward looking research needs may enhance the plan.

3. Time-Phasing of Research. Delineating between "regulatory research" and "long-term regulatory research" (i.e., greater than 5 years) will be helpful as priorities are set and budgets established. NRC-RES should consider as part of this process the lead time needed to complete the research; results may not be needed for 5 years, but if it takes 5-6 years to complete the anticipated investigations, the work may have to be given priority for funding.

4. Comprehensiveness and Integration. The apparent omission from this plan of research related to the high-temperature gas-cooled reactors raises doubts about whether full integration has been achieved in delineating research needs. Although it may be

convenient to address the HTGR in a separate more detailed plan, the basic elements of all research should be presented in a coherent way in a single plan.

5. Test Facilities (Section 2.3). Programmatically, it is not clear whether certain proposed activities are most appropriately led by NRC or should remain in the purview of licensees and associated trade organizations (e.g., the Electric Power Research Institute). To the extent that they are used to support the safety analysis for one or more licensed facilities, it may be more appropriate for NRC to take a secondary role in some of these areas, allowing the industry to develop the facilities and conduct the preponderance of the work. NRC-RES should also consider the budget consequence of developing such large-scale test facilities, because the "big science" could overwhelm its ability to conduct the large range of relatively small but focused research investigations outlined throughout the plan.

Potential Gaps in the Planned Research

1. Reactor License Renewal Beyond 60 Years (Section 2.2). Fundamental understanding of processes, techniques for assessing site characteristics, and methods for incorporating processes and data into risk assessments have continued to evolve since existing reactors were first licensed. In some cases (e.g., seismic risk), the regulatory framework has been revised to incorporate advancing knowledge. In other cases, this does not appear to be so. Examples include recognition of new mechanisms for creation of tsunamis, increased awareness of reactor-head corrosion mechanism, advanced techniques for subsurface geophysical investigations, etc. Suggest that the research plan be expanded to address this broad area.

2. Technical Areas and Activities (Section 2.2.3). As NRC moves toward risk-informed, performance-based (RIPB) licensing, it may be necessary to assess to what extent RIPB licensing is applicable for license renewals. For example, during original licensing of an existing nuclear power plant the concept of safety margin was emphasized whereas a RIPB review for license renewal may not focus on margin of safety. Research may be beneficial in developing a sound technical basis to support a transition between the two licensing paradigms.

3. Technical Areas and Activities (Section 2.2.3). In addition to its focus on new nuclear power plants, NRC-RES also should evaluate use of new and/or advanced components, software, etc. in existing power plants that are being considered for license renewal. License renewal may involve assessing whether components are obsolete and need to be replaced with more modern/advanced technology components. While new technologies may be compatible in a new nuclear power plant, inconsistencies may arise when advanced technology-based components (e.g., digital control systems) are introduced to aging nuclear power plants. Research may be needed to understand the operational interfaces between aging power plants and advanced-technology-based components that may be added for life extension, as well as the possible safety implications of these interfaces.

4. Cross-Cutting Research (Section 2.4). A number of potentially significant research topics are identified in this section of the plan. The area of Advanced Analytical Capabilities (Section 2.4.4) would benefit significantly by being preceded by a retrospective examination of historical research in this area. Specifically, NRC-RES

should consider examining (i) what tools have been developed over the past 10-20 years; (ii) whether and how these tools were used; (iii) to the extent they were superseded, why; (iv) to the extent they are still in use and/or have evolved, why; (v) whether the benefits met or exceeded the life-cycle costs incurred developing and using the tools; etc.

5. Advanced Analytical Capabilities (Section 2.4.4). Various programs may benefit from NRC-RES rigorously examining the trade-offs associated with moving toward increased realism. Two overarching NRC objectives are affected by the degree of realism that is pursued (and may be required by regulation): maintaining safety and avoiding undue regulatory burden. Increased realism can build confidence in safety, but has the potential to undermine safety if the underlying science, engineering, and data are not sufficiently well developed. Similarly, increased realism can reduce the regulatory burden associated with unnecessarily high levels of conservatism, but more realistic approaches carry with them the "burden" of more extensive data and thorough analysis.

6. Advanced Fabrication Techniques (Section 2.4.5). Several important observations are made in this section about potential unexpected [negative] consequences of advanced fabrication techniques. NRC-RES should look more broadly at this issue, however, to include how modern design, construction, fabrication, and maintenance practices could have unintended consequences. Matters to consider include potential new failure modes, reduction in safety margins, new component and subsystem interactions that could decrease overall system performance, etc. Examples from the last century include the transition from gravity dams to curved arch dams and introduction of suspension bridges—the latter which presented challenges as recently as with the Millennium Bridge in London.

<u>Potential Areas for Collaboration</u>

1. Reactor License Renewal Beyond 60 Years (Section 2.2). CNWRA and Southwest Research Institute (SwRI) staff have developed considerable laboratory and modeling expertise in materials science and sensor development that can be used to evaluate material performance for extended periods. These include experiments to develop protocols for high-temperature oxidation properties of alloys, coating degradation mechanisms, internal research and development programs for corrosion sensor development, and state of the art non-destructive evaluation techniques. In addition, CNWRA staff have conducted thermodynamic modeling of debris formation associated with Generic Safety Issue (GSI)-191. Collaboration in such areas may be appropriate, especially when license extension may be associated with modernized components.

2. Advanced Analytical Capabilities (Section 2.4.4). Considerable research has been conducted for other industries that may be applicable to the nuclear industry. Probabilistic structural integrity modeling, techniques underlying "retire-for-cause" decision making and the like have potential for application. The NRC-RES program may benefit from an assessment of technology availability for transfer from other industries and applications. The computer code NESSUS, developed by SwRI may be an area for potential collaboration.

3. Advanced Analytical Capabilities (Section 2.4.4). Section 2.4.4 discusses research priorities for multi-phase Computational Fluid Dynamics (CFD), but does not address

single-phase CFD. Although single-phase CFD is relatively mature, issues related to using single-phase CFD in safety-significant applications remain. Specific topics that warrant further research include (i) accurate yet tractable representation of turbulence and turbulence-induced heat transfer, (ii) strategies for using CFD results in the system-level thermal-hydraulics code TRACE, and (iii) fluid-structure interactions. Under the SwRI Internal Research and Development program, CNWRA is currently developing better representations of turbulence in CFD models of reactor components. Representation of turbulence and other considerations in CFD are areas for potential collaboration.

4. Advanced Offsite Consequences Codes (Sections 2.4.4). The benefits of greater realism in models and the effectiveness of pursuing greater realism are recognized in this section. NRC-RES could extend the overall concept of greater realism to the bases for dose standards. Developing more realistic "phantoms" for health-effect computations would assist the process. There is potential for continued collaboration to extend work previously funded by NRC at the CNWRA on VARSKIN.

5. Extended In-Situ and Real-Time Inspection and Monitoring Capabilities (Section 2.4.6). The staff of SwRI and CNWRA have developed and continue to enhance an innovative multi-electrode array sensor (MAS) for *in situ* real-time monitoring of localized corrosion conditions. This is an area of potential collaboration.

6. Extended In-Situ and Real-Time Inspection and Monitoring Capabilities (Section 2.4.6). With the advent of new nuclear power plant and nuclear waste storage technologies, there will be greater demand for highly accurate but non-invasive, non-destructive inspection and measurement techniques. CNWRA and SwRI are advancing technologies in these areas (e.g., for flaw detection and characterization), with a focus on very thick-walled vessels. This is an area for potential collaboration.

7. Risk Assessment for Advanced Reactor and Fuel-Cycle Facilities (Section 2.4.10). Under contract to the NRC, as well as within the SwRI Internal Research and Development Program, CNWRA continues to advance the state of the art in several listed areas. These include (i) empirical data for risk assessment, (ii) HRA methods for advanced facilities, and (iii) advanced quantitative risk assessment methods. These are areas for potential collaboration.

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