U.S. Department of Energy Natural Phenomena Hazards Workshop
October 25-26, 2011

Location: Cloverleaf Building, Germantown, Maryland, Room 1300

Tuesday, October 25

7:30 a.m. Registration; coffee and bagels will be served

8:00 a.m. Welcome and introductions

8:10 a.m. Workshop Overview – Chip Lagdon, CNS

Theme 1: Soil-structure interaction issues

8:30 a.m. SASSI Subtraction Method Effects at Various DOE Projects
Greg Mertz, Michael Costantino, Thomas Houston, and Andrew Maham

9:00 a.m. Application of the Computer Program SASSI for Seismic SSI Analysis for DOE Facilities
Farhang Ostadan and Raman Venkata

9:30 a.m. BREAK

9:45 a.m. SASSI Analytical Methods Compared with SHAKE Free-Field Results
Dennis Niehoff, Jayprakash Amin, Shawn Carey, and J. Bhatt

10:15 a.m. Structure Soil Structure Interaction Effects: Seismic Analysis of Safety-Related Collocated Structures
Shawn Carey, Dennis Niehoff, Nick Kennedy, Natalie Doulgerakis, and Leslie Sprague

10:45 a.m. Non-Linear Soil-Structure Interaction Analysis in the Time Domain
Justin Coleman

11:15 a.m. Time for Said Bolourchi on "low frequency" SASSI issue, and open discussion on SSI issues

Noon-1:15 p.m. LUNCH (on your own)

Theme 2: Structural and geotechnical modeling

1:15 p.m. The Uranium Processing Facility Finite Element Meshing Discussion
Loring Wyllie and Arne Halterman

1:45 p.m. Criteria for Selection of Seed Motions to Envelop Design Response Spectra
Michael Costantino, Greg Mertz, Andrew Maham, Carl Costantino, and Thomas Houston

2:15 p.m. Addressing Uncertainty in Design Inputs: A Case Study of Probabilistic Settlement Evaluations for Soft Zone Collapse at SWPF
Tom Houston, Greg Mertz, and Carl Costantino

2:45 p.m. BREAK

3:00 p.m. Enhanced CPT Shear Wave Velocity Measurement at the Savannah River Site
D. Bruce Nothdurft, Alec McGillivray, and Brent Gutierrez

3:30 p.m. Liquefaction Triggering Evaluations at DOE Sites
Michael Lewis, Michael McHood, Rucker Williams, and Brent Gutierrez

4:00 p.m. Open discussion on structural and geotechnical modeling

4:30 p.m. Adjourn

Wednesday, October 26

Breakout session on current SASSI issues and potential actions, 8:00 a.m. to 11:45 a.m., in Cloverleaf room 2073. Brent Gutierrez will moderate.

Theme 3: NPH characterization and 10-year reviews

8:00 a.m. Best Practices in Literature Research for the 10-Year Extreme Wind Update at the DOE Pantex Site
Jim Nunley, John Baker, and Andrew Tinsley

8:30 a.m. Storm Water Modeling for the 10-Year Update at the DOE Pantex Site
Jim Nunley and Jeff Alcorn

9:00 a.m. Summary of the Revised Tornado, Hurricane, and Extreme Straight Line Wind Characteristics at Nuclear Facility Sites
John D. Stevenson

9:30 a.m. BREAK

9:45 a.m. A Method for Evaluating Fires After Earthquake Scenarios for Single Buildings
Raymond Tell and Elizabeth Kelly

10:15 a.m. The Need for an Integrated Risk Model
Michael Salmon and Lawrence Goen

10:45 a.m. Summary of New DOE-STD-1020-2011 (Proposed) Natural Phenomena Hazards Analysis and Design Criteria for DOE Facilities
Quazi Hossain, Joe Hunt, Robert Kennedy, Carl Mazzola, Steve McDuffie, and Gerald Meyers

11:15 a.m. Open discussion on NPH characterization and 10-year reviews

11:45 a.m.-1:00 p.m. LUNCH (on your own)

Theme 4: SSC classification and design

1:00 p.m. Seismic Analysis of Existing Facilities and Evaluation of Risk (SAFER)
Michael Salmon and Lawrence Goen

1:30 p.m. The Adequacy of Department of Energy Natural Phenomena Hazards Performance Goals from an Accident Analysis Perspective
Jeff Kimball

2:00 p.m. Critical Issues in NPH Categorization and Limit State Selection of Structures, Systems, and Components
Quazi Hossain

2:30 p.m. BREAK

2:45 p.m. Seismic Capacity of Threaded, Brazed, and Grooved Pipe Joints
Brent Gutierrez and George Antaki

3:15 p.m. Open discussion on SSC classification and design

4:00 p.m. Future actions and wrap-up

4:30 p.m. Adjourn

Workshop Summary

Steve McDuffie of the DOE Office of the Chief of Nuclear Safety (CNS) opened the Natural Phenomena Hazards (NPH) workshop at 8:00 am on October 25. He noted that this is the first such workshop held by DOE in at least 15 years; the events were held nearly annually in the early 1990s. DOE committed some missteps with seismic hazard characterization and design on some high-profile projects in the last decade, and as a result, one of the goals of the CNS has been to drive better DOE performance in seismic and other NPH hazard characterization and design. Re-establishing the DOE NPH workshop is one means toward that end. Mr. McDuffie noted that the Chief of Defense Nuclear Safety, which serves a counterpart role for National Nuclear Security Administration facilities, co-sponsored the workshop.

Planning for the workshop began in December 2010, before the Great Tohoku earthquake, tsunami, and subsequent disaster at the Fukushima Daiichi nuclear plant. That tragedy further highlighted the importance of NPH work. As the workshop agenda evolved, the heightened interest in issues with SASSI (A System for Analysis of Soil-Structure Interaction) led to adding a breakout session on Day Two to discuss the issues.

Mr. McDuffie introduced Chip Lagdon, the DOE CNS, who provided additional welcoming remarks. Mr. Lagdon stated that he searched for information from past NPH workshops, and the most recent information he could find was from a fourth workshop in 1993. Clearly, such a workshop is long overdue. He stated that the primary purpose of the workshop is to promote thinking and collaboration, and to foster improvements in how DOE sites perform NPH characterization and design activities. Immediately following Mr. Lagdon's remarks, the first technical session, Soil-Structure Interaction Issues, began.

The first presentation was provided by Greg Mertz of CJC & Associates on the SASSI subtraction method. He explained the subtraction method and its anomalies, as well as the modified subtraction method, with its additional nodes along the top layer of the finite element mesh. The analysis confirms that the subtraction method anomalies do not result from the mesh sizing, but from vibration of the excavated soil volume. Mr. Mertz found that certain nodes may show subtraction method anomalies, while others do not. Thus, he favors showing "spaghetti plots" that show the transfer functions for all nodes. He provided several sample analyses for the PF-4 and Chemistry and Metallurgy Research Replacement (CMRR) facilities at Los Alamos, the Uranium Processing Facility (UPF) at Oak Ridge, and a building at a generic western soil site. In summary, he found that the modified subtraction method is not a panacea for the subtraction method anomalies, but can extend the range of usefulness of the subtraction method if properly benchmarked against the direct method results.

The second presentation was made jointly by Raman Venkata of DOE's Office of River Protection, and Lisa Anderson of Bechtel. They provided an overview of the SASSI subtraction method and its application at Waste Treatment Plant facilities at Hanford. In particular, the subtraction method was benchmarked against the direct method at the High-Level Waste (HLW) facility. They created a hybrid finite element model and stick model of the building core structure. The results revealed essentially no difference between the direct and subtraction methods for horizontal motions, but the subtraction method provided slightly higher values at

high frequencies for vertical motions. This resulted in a slightly higher in-structure response spectrum. Venkata and Anderson concluded that the subtraction method provides conservative results at the HLW facility, but SASSI results should always be verified. Moreover, such analyses should be performed by experienced individuals, and any results after a modification to the SASSI software must be particularly scrutinized.

Dennis Niehoff of Savannah River Nuclear Solutions provided a comparison of SASSI analytical methods with SHAKE results. He examined results at Savannah River, a deep soil site, and Hanford, a shallow, stiff soil site. His methodology was to de-convolve surface motions to the bottom of the soil column using SHAKE, then bring the motions back to the surface in a SASSI embedded box model, with structural properties equal to those of the surrounding soil. For both soil profiles, response spectra at the surface and foundation levels obtained from SASSI match those derived from SHAKE. Mr. Niehoff also found that the SASSI direct and modified subtraction methods produced nearly identical results in these examples. This presentation engendered a lively discussion, with Said Bolourchi pointing out that no true structure is present since the embedded structural properties equal those of the surrounding soil. In addition, Jeff Kimball of the Defense Nuclear Facilities Safety Board (DNFSB) questioned whether a 25-foot square structure is appropriate for modeling. Mr. Niehoff replied that the aim of the study was to show that just one aspect of SASSI does not have shortcomings.

The fourth presentation was provided by Shawn Carey of Savannah River Nuclear Solutions on structure-soil-structure interactions at the Savannah River Site. He examined interaction between the relatively small exhaust fan building and the much larger process building. Mr. Carey found that the fan building nodes closest to the process building have de-amplified responses to match the process building, while the nodes farther from the process building have higher motions. The presence of the fan building has no effect on the motions within the process building.

Justin Coleman of CH2M-WG discussed non-linear soil-structure interaction (SSI), proposing a method for implementing non-linear SSI at nuclear facilities. He discussed the benefits of non-linear, time-domain SSI in comparison to linear frequency-domain SSI. For example, Mr. Coleman finds that the non-linear SSI approach may potentially provide a more realistic representation of facility response during seismic motion, with a better understanding of margin against failure. A variety of commercially available software packages can provide the necessary structural elements. He provided a demonstration of the explicit time-domain capabilities with a two-dimensional model of the calcine disposition process at the Integrated Waste Treatment Unit at Idaho. The demonstration modeled contact and allowed waves to travel through the soil and structure during an earthquake. He provided a video of the model. Mr. Coleman discussed methods of validating non-linear SSI models, then his proposed approach to developing a non-linear SSI model. This presentation inspired several comments; Carl Costantino was critical of the approach, since modeling real soils after several motion cycles is very difficult. Mr. Bolourchi had positive words for Mr. Coleman's approach to modeling concrete, and Paul Rizzo commented that measurements from Fukushima are showing motions very similar to those predicted by existing models.

The second workshop session, Structural and Geotechnical Modeling, followed the lunch break. Loring Wyllie and Arne Halterman of Degenkolb Engineers discussed the finite element mesh for the UPF. They discussed the ASCE 4-98 mesh criteria, which rely somewhat on past experience and engineering judgment to determine proper mesh size. They performed a dynamic analysis using GT STRUDL®, version 32. Their original, coarse mesh used over 11,000 nodes, whereas the final mesh used nearly 29,000 nodes. They ultimately concluded that the original mesh was adequate for design, but the final mesh and associated studies were necessary to justify the design and satisfy peer reviewers. They concluded that universal mesh criteria should not be required; the complexities of a building should dictate the mesh size. Mr. Bolourchi commented that mesh refinements should be based on the loads and load path.

The second presentation of the session came from Michael Costantino of CJC & Associates on criteria for selecting seed motions to envelop design response spectra. This study primarily examined how the seed record can affect computed structural response. Mr. Costantino evaluated seed records through SSI analyses for multiple sites and structures, and site-specific SSI transfer functions were developed for each. He found that the spectral shape of a seed is important in linear response analysis, but not the seismological characteristics (e.g., magnitude, distance, direction). The correct spectral shape ensures that a seed record has energy in the frequency range of interest. He recommends that a suite of input motions from at least five time histories should be used, as the average response from five provides stable results. Mr. Costantino provided some illustrative results from the CMRR and UPF projects, and he concluded with some insights on how the draft revision to ASCE 4, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary,* addresses time history variability.

Tom Houston of CJC & Associates followed with a discussion of probabilistic settlement evaluations for soft zone collapse at Savannah River, a study conducted largely to support the Salt Waste Processing Facility (SWPF) design. This evaluation is important because of the large uncertainties in the geotechnical parameters of soft zone surface manifestations. The probabilistic evaluation gives a distribution of building demands. Deterministic analyses use conservative estimates of parameters and can result in overly conservative designs, whereas probabilistic analyses employ expected values and ranges of parameters. An advantage of a probabilistic approach is that it affords estimates of the margin against a facility not performing its required function. Mr. Houston found a strong relationship between the structural demands and the subgrade modulus. Structural demands have a modest dependence on soft zone width and thickness and are influenced little by the depth to the top of the soft zone.

Brent Gutierrez of DOE-Savannah River reported on frequent-interval, seismic cone penetration test (CPT) results at the Savannah River Site. The motivation for these tests was to obtain rapid, thorough characterization of shear wave velocities. The distance interval is approximately 0.2 meters for frequent-interval CPTs, versus about 1 meter for traditional CPTs. The technique uses three orthogonal sets of geophones spaced 0.45 meters apart. Although the frequent-interval technique had been demonstrated as successful only to a depth of 30 meters in prior work, this study made successful pushes to a depth of 50 meters. The frequent-interval technique provides Vs profiles much more accurate than those from typical CPTs, and it was particularly successful through the low-velocity soft zones.

The final presentation on Day One was by Mike Lewis of Bechtel on liquefaction evaluations at DOE sites, with a primary focus on the Savannah River Site. This study compared results from three liquefaction evaluation methods (Youd, Cetin, and Idriss & Boulanger) with respect to liquefaction factor of safety. Youd is the most widely used in the community. Cetin consistently yields the lowest (most conservative) factor of safety for the Savannah River Site, while Youd and Idriss & Boulanger give comparable results. The triggering relationships are the most important difference between the methods. At Paducah, the three methods give more similar results, with Cetin still slightly more conservative. Mr. Lewis finds that the Youd method is most widely accepted and recommends its use, but recognizes that site-specific correlations can be quite beneficial. He also suggests using an aging correction factor with the Youd method on Savannah River soils. During the discussion, it was noted that the Idriss & Bolanger (2008) report has an excellent appendix of case histories from which one can draw some general conclusions; for example, liquefaction does not appear to occur below a depth of about 12 meters or in earthquakes of magnitude 5.75 and below.

At the conclusion of the day, Steve McDuffie solicited general comments from participants. Jeff Kimball suggested that DOE compare how seismic monitoring is performed across the DOE sites. DOE guidance on adequate monitoring equipment might be appropriate, especially in light of the poor instrumentation at the North Anna plant revealed by the August 23 Mineral earthquake. Mr. McDuffie took an action to compile an inventory of existing seismic monitoring equipment and methods across the DOE complex.

Day Two of the NPH Workshop convened at 8:00 am on October 26. The workshop divided into two tracks for the morning: a session on the SASSI code issues and potential actions, and one on NPH characterization and 10-year reviews. The SASSI session was an open discussion of current issues with the SASSI code, moderated by Brent Gutierrez. A separate summary from that session is available. Steve McDuffie hosted the NPH characterization session.

The first presentation in the NPH characterization session was from Andrew Tinsley of Eastern Kentucky University on best practices derived from the 10-year update of the extreme wind hazard at the Pantex Site. Mr. Tinsley first mentioned the forthcoming changes to the wind section of DOE-STD-1020, as well as the new ANSI/ANS-2.3-2011 standard on wind hazard analysis and design. He discussed the appropriate data to characterize straight-line winds, as well as the modeling of tornadic winds. He mentioned that the analyses from the original Fujita scale overestimated wind speeds as compared to the new, enhanced Fujita scale. Mr. Tinsley noted that probabilistic analyses of windblown missiles must consider the existence and availability of missiles in the area. He finds that, overall, the new standard simplifies wind hazard analyses.

Jeff Alcorn of Pro2Serve described the process of completing the 10-year update of the flood hazard analysis at Pantex. Three flood hazards must be considered: submergence, hydrostatic load, and dynamic/flash flood load. Depth of inundation is the most relevant measure of flood severity. Soon after the flood hazard analysis was updated, a major precipitation event affected Pantex on July 7-8, 2010. The highest estimated 12-hour rainfall on site was approximately 11 inches, corresponding to a 2,000-year return period precipitation event. The observed flooding was similar to that predicted by hazard modeling. The July 2010 flood led Pantex management

to expand the flood modeling to include the entire site for the purpose of improving emergency planning, such as designating flood response pathways.

John Stevenson, a consultant to DNFSB, provided an overview of the new ANSI/ANS-2.3-2011 standard. He began with a review of the historical definition of a design basis tornado and the standards used prior to ANSI/ANS-2.3-2011, along with the design wind speeds for DOE sites. The new standard adopted the enhanced Fujita scale and changed some of the wind velocity definitions. Mr. Stevenson noted that the wind velocity data for hurricane and straight winds are taken from an extension of the return period given in the commentary for wind loads in ASCE 7-95, *Minimum Design Loads for Buildings and Other Structures*. He also cautioned that ANSI/ANS-2.3-2011 provides wind loads that are incompatible with the load combination methods in the ACI-349 (*Code Requirements for Nuclear Safety-Related Concrete Structures*) and AISC N-690 (*Specification for Safety-Related Steel Structures for Nuclear Facilities*) standards. As a result, the existing 2006 version of the ACI and AISC standards should continue to use the ASCE 7-95 wind load definition until they are modified to be in agreement with the changes in the ASCE 7-10 standard. Finally, Mr. Stevenson stated that ANSI/ANS-2.3-2011 is consistent with NRC Regulatory Guide 1.76, *Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants*, so he sees no reason that the U.S. Nuclear Regulatory Commission should not adopt the new standard. The values derived from the new standard are conservative, and a facility should need to perform a site-specific study only in the event that lower design values are desired.

The next presentation, on evaluating fire-after-earthquake scenarios for single buildings, was provided jointly by Elizabeth Kelly and Raymond Tell of Los Alamos National Laboratory (LANL). This work was initiated in response to safety analyses indicating very high offsite doses from certain LANL facilities in the event of seismically induced fires. Kelly and Tell noted that excessive conservative assumptions can lead to implausible accident scenarios that are unnecessarily alarming. They developed a model to predict the number of ignitions based on building area affected and earthquake peak ground acceleration (PGA). A simple relationship between ignitions per area as a function of PGA was elusive with unacceptable uncertainties, but modeling ignitions as a negative binomial regression was more successful. Their method also reviews processes within facility rooms that may have an unusual propensity to ignite after an earthquake and categorizes rooms with higher ignition likelihood as deterministic fire compartments. This work is described in detail in their LANL publication LA-UR-11-01857.

Mike Salmon of LANL discussed the need for an integrated risk model. His intent was to highlight some observations stemming from the LANL SAFER (Seismic Analysis of Existing Facilities and Evaluation of Risk) project and encourage discussion on the use of an integrated risk model. He noted that DOE sites do not generally do well at developing the prioritized schedule for upgrades called for in DOE O 420.1B, *Facility Safety,* when NPH design deficiencies are identified. Common-cause initiating events are often not considered, and upgrade investments are not based on quantitative estimates of risk reduction. At LANL in the past, items with a demand/capacity ratio greater than 1.0 have been upgraded based on subjective, very conservative consequence estimates. Mr. Salmon believes a better approach is to use probabilistic risk assessment (PRA) or other risk-informed scenario, and, ideally, seismic risk should be integrated with other initiators. He noted that RISKMAN commercial off-the-

shelf software has successfully supported risk management models at numerous nuclear facilities. Mr. Salmon has proposed a pilot study of risk evaluation that is awaiting funding.

Quazi Hossain of Lawrence Livermore National Laboratory summarized the revised Technical Standard DOE-STD-1020 on NPH analysis and design criteria that is nearing completion. The new Standard is being issued alongside the revised DOE O 420.1C on facility safety, and it will supersede the existing DOE-STD-1020, -1021, -1022, and -1023, as well as DOE G 420.1-2. The new STD-1020 will serve as a single characterization and design standard for all DOE nuclear facilities. The revision incorporates recently issued voluntary consensus standards for seismic hazard characterization and design as well as extreme wind characterization. STD-1020 will use five design categories—rather than four performance categories—for all NPH, mimicking the approach in ANSI/ANS-2.26-2004 for categorizing structures, systems, and components. In citing ANS-2.26 as a requirement for seismic, the new STD-1020 adopts limit states in seismic design. STD-1020 adopts slightly more conservative return periods for straight-line, tornado, and hurricane winds, while the criteria for flood hazards are little changed from the current standard. The existing STD-1020 series has no guidance on lightning and volcanic hazards, whereas the new STD-1020 provides some high-level criteria for design against lightning and characterizing volcanic hazards. The new standard contains criteria for design against precipitation hazards, considering both flooding and structural loading from ponding. Finally, the new STD-1020 provides guidance on performing 10-year NPH reviews and on whether changes to data, models, or methods warrant an update to an NPH assessment.

After lunch on Day Two, participants from the two parallel tracks came together for the final session on Structure, System, and Component (SSC) classification and design. Mike Salmon of LANL began with a presentation on LANL's SAFER project. This project began after the LANL site-wide seismic hazard increased as a result of the updated probabilistic seismic hazard assessment (PSHA) completed in 2007. LANL first identified a site-wide, positive unreviewed safety question for the nuclear facilities, then submitted for DOE approval a justification for continued operation for facilities determined to be outside their safety basis. The facilities developed seismic equipment lists (SELs), which are compilations of all SSCs that provide a seismic safety function. Walkdowns of SSCs on the SELs were then performed, and SSCs were screened on their ability to withstand 1.2*g* acceleration, per the criteria in DOE/EH-0545 (title?). SSCs not meeting the criteria had their seismic failure probability calculated using the hazard curves from the new PSHA. SSCs were also sorted into four categories: far below performance goals, somewhat below goals, close to goals, and met performance goals. Mr. Salmon's key lessons from this project are that the SELs are very valuable; they should contain every component important to safety in a seismic event, and facility system engineers need to be involved early in such a system review.

Jeff Kimball of DNFSB discussed the adequacy of DOE NPH performance goals from an accident analysis perspective. He first noted that ANSI/ANS-2.26 defines five seismic design categories with numerical performance goals, and it provides guidance for assigning components to one of the five categories and one of four deformation limit states. However, this performance goal approach might be inadequate, from the perspective of accident analyses, to ensure that risks to offsite individuals are adequately mitigated in severe seismic events. Mr. Kimball considered the seismic risk to be approximately equal to the risk of seismic collapse, then

compared the frequency of collapse to the various combinations of seismic design category and limit state. He used an analytical approach in accord with the ASCE/SEI 43-05 Commentary (Section C) to gain first-order insights on collapse frequency. Mr. Kimball found that two hypothetical DOE facilities that design to SDC-4 and SDC-3, based on their relative offsite doses, may not have comparable risks. The SDC-4 design may not adequately compensate for the higher offsite doses from that facility, especially if the offsite doses exceed the DOE evaluation guideline (25 rem) by more than a factor of 10. Mr. Kimball suggests the link between unmitigated accident consequences and the performance goals of the seismic design categories be revisited, and that DOE work with the American Nuclear Society in developing a more appropriate link.

The next presentation, by Quazi Hossain of LLNL, examined some critical issues in NPH design categorization and limit state selection for SSCs. Mr. Hossain first laid out the steps of an ideal NPH design process for SSCs. In general, this process calculates unmitigated dose consequences, selects appropriate NPH design categories, performance goals, and limit states for SSCs and then designs SSCs based on demands calculated from site characterization hazard analyses. Mr. Hossain then identified and discussed the following concerns associated with this process:

- Differentiating facility risk by projected service life
- Consideration of adverse effects of multiple (nonidentical) SSC failures
- Consideration of the number of adversely affected workers or members of the public
- Impact of SSC downtime from one NPH event on design category selection for a different NPH event
- Selection of limit states for SSCs that have only indirect safety functions
- Design of non-structural SSCs

Joel Blackman of DNFSB recommended that Mr. Hossain and DOE prioritize the issues and take steps to address them. Stuart Jensen of Idaho National Laboratory noted that analyses cannot be highly quantitative when multiple SSC failures are considered; unmitigated consequence analyses are general estimates. He suggested that the best analytical improvement would be the use of probabilistic risk assessments.

The final workshop presentation, on seismic capacity of pipe joints, was provided by Brent Gutierrez of DOE-Savannah River. He presented results of both static and shake table tests on pressurized pipe with threaded, brazed, and mechanical joints. Static tests were performed on grooved coupling joints on pipes of 2" and 4" diameter, as well as brazed and threaded joints on 2" pipes. The dynamic shake table tests examined threaded and mechanical coupling joints on 4" pipes oriented vertically, with weight on top to simulate moment loads similar to the static bending moments. The mechanical joints had superior performance in the dynamic tests. The threaded joints leaked at the onset of shaking, even though the threads later showed no visible damage. Mr. Gutierrez and co-author George Antaki performed these analyses several years ago, but the results have not yet been published. They expect to publish the results soon.

At the conclusion of the workshop, Mr. McDuffie again solicited comments from participants. Mr. Blackman commented that the forthcoming change to DOE-STD-1020 is significant, and a

workshop in several years just to discuss experiences from using the new Standard would be useful. Asa Hadjian of DNFSB suggested that requiring written papers to accompany presentations would be beneficial. Participants generally agreed that the workshop was helpful, and it should again be held regularly. The CNS is planning to ensure that the NPH workshop occurs biennially.